The Case for International Emission Trade in the Absence of Cooperative Climate Policy

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Central ideas

The currency of international climate negotiations is not emissions, but tradable emission permits

- this changes countries' strategic incentives in "negotiations"
- helps to explain 'hot air' $\longrightarrow$ emission permits can be sold

countries show little willingness to adopt cooperative strategies and to make substantial voluntary contributions to the global public good of climate protection.

literature on climate coalitions assumes (inconsistently?)

- cooperative behavior of coalition members
- non-cooperative participation decisions

CGE model is useful since

- analytical model of coalition formation with heterogeneous countries not tractable
- general equilibrium effects (carbon leakage, spillovers) are important

Related literature

- Empirical analyses of the costs of abatement measures and the role of international permit markets in minimizing abatement costs (Manne and Richels, Oliviera-Martins et al., Jacoby eta al., etc.)
- Strategic analyses studying the determinants of effective international policy (Barrett, Carraro, Chander & Tulkens, Finus, Helm, Hoel)

A Game with Permit Trading Coalitions

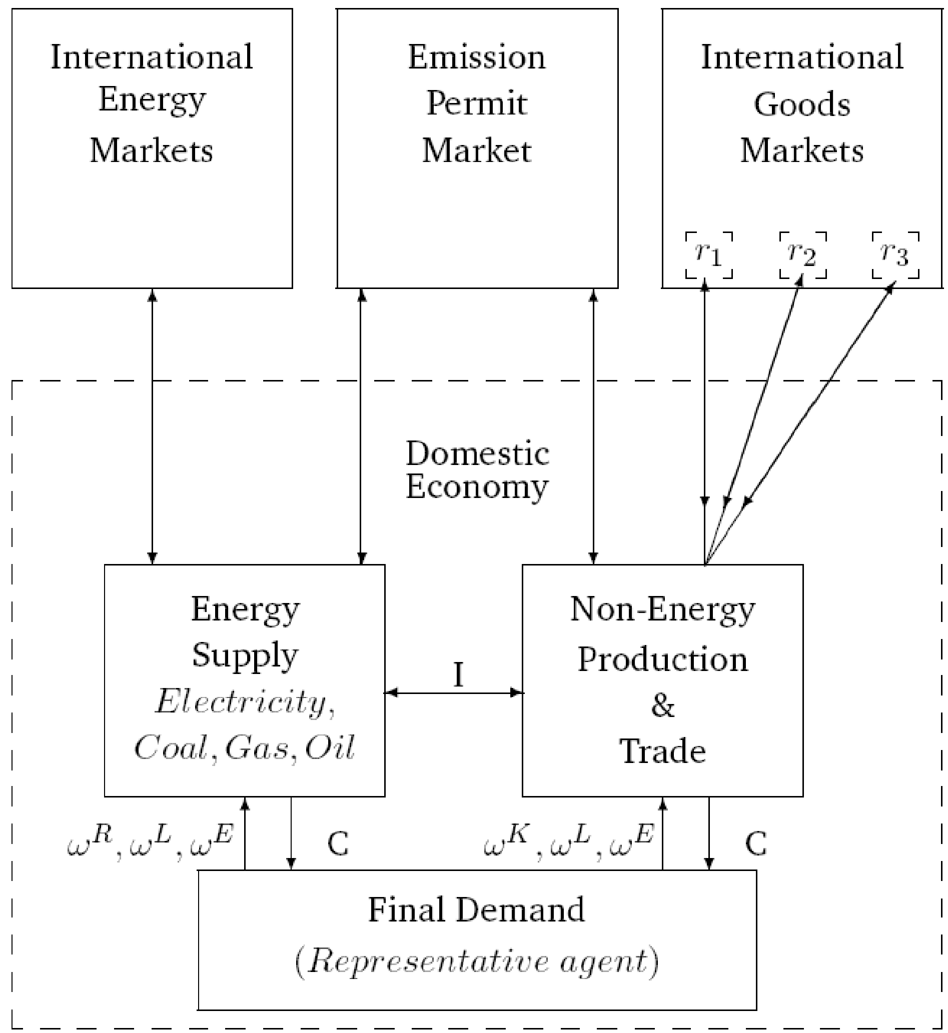
- **Stage 0:** International negotiations (which are treated as a black box) lead to a proposal specifying the members of a permit trading coalition.

- **Stage 1:** Potential coalition members simultaneously decide about their participation.

- **Stage 2:** Members of a trading coalition choose their permit endowment; all non-members choose their emissions. Permits – and all other goods in our economy – are traded on competitive markets and payoffs accrue.

- **Solution concept:** Subgame perfect Nash equilibrium, i.e. countries consistently adopt non-cooperative best-reply strategies.

Figure 1: Regional Flows of Goods and Factors



The Model

Economic equilibrium (for exogenously-specified emissions targets):

$$F(z; \omega^E) = 0$$

where:

$z = \begin{pmatrix} \pi \\ Y \end{pmatrix}$	is the vector of equilibrium prices and quantities
ω^E	is the vector of regional emission endowments
$F(\cdot)$	is the set of equations which define economic equilibrium

Global emissions:

$$e^G = \sum_r \omega_r^E$$

Regional welfare incorporates both economic well-being and environmental impact:

$$W_r = U_r(\pi, \omega_r) - \nu_r e^G, \text{ where}$$

ν_r are (constant) marginal damages in region r

$U_r = \frac{\sum_i (Y_{ir}\pi_{ir} - \sum_s I_{isr}\pi_{is})}{p_r^c(\pi)}$ is economic welfare

Y_{ir} is aggregate supply of good (or factor) i in region r

I_{isr} is aggregate intermediate demand for i imported from s to r

$\sum_i (Y_{ir}\pi_{ir} - \sum_s I_{isr}\pi_{is})$ is regional income, and

$p_r^c(\pi)$ is the unit expenditure function (the price index).

Nash equilibrium of stage 2 game defined by

$$\frac{1}{p_r^c}\left[\pi_E + \left(\omega_r^E - e_r\right)\frac{d\pi_E}{d\omega_r^E} + \Delta_r\right] - \nu_r\left(1 + \frac{de_{row}}{d\omega_r^E}\right) = 0 \quad , \quad \forall r \in \mathcal{C}$$

$$\frac{1}{p_r^c}\left[\pi_{Er} + \Delta_r\right] - \nu_r\left(1 + \frac{de_{row}}{d\omega_r^E}\right) = 0 \quad , \quad \forall r \notin \{\mathcal{C}, row\}$$

$$F(z;\omega^E) = 0$$

e_r is aggregate demand for emissions in region r

Δ_r describes the spillover effects associated with trade in all conventional goods

$$\Delta_r = \sum_{i \neq E}\left((Y_{ir} - C_{irr} - I_{irr})\frac{d\pi_{ir}}{d\omega_r^E} - \sum_{s \neq r}(C_{isr} + I_{isr})\frac{d\pi_{is}}{d\omega_r^E}\right)$$

Compare with the partial equilibrium formulation:

$$\pi_E + \left(\omega_r^E - e_r\right) \frac{d\pi_E}{d\omega_r^E} = \nu_i$$

In the partial equilibrium model, the marginal valuation of the environment (ν_i) alone determines whether a member state is a permit seller or a buyer. In the general equilibrium framework, a much wider range of impacts are possible.

Calibration of Willingness to Pay Parameters

empirical estimates of regional willingness to pay parameters, ν_{it}, are very unreliable (Tol 2002)

our approach based on idea that countries reveal their WTP through their position in negotiations (Maeler 1989)

Specifically, we assume WTPs of (1998, US-$ per ton of carbon):

Europe: 300; Japan and United States: 150; FSU: 50; China and ROW: 0

assumptions lead to global emission reductions in no-trade Nash equilibrium of 7.8% (compared to BaU)

We also present alternative scenario with FSU: 100; China: 50

GDP Statistics

	*Total (Billion $)** GDP			*$ / Capita** GDP per capita		
	2000	2020	%Δ	2000	2020	%Δ
usa	9,219	16,832	3.1	33,437	51,791	2.2
jpn	4,270	6,542	2.2	33,526	51,923	2.2
eur	9,168	14,786	2.4	23,482	38,104	2.5
chn	1,095	4,314	7.1	860	2,984	6.4
fsu	610	1,501	4.6	2,101	5,401	4.8
row	6,843	15,746	4.3	1,854	3,144	2.7

GDP – Value of total output in billions $1998
%Δ – Equivalent constant annual growth rate

Data sources:

- GTAP5 trade and production database provides, in addition to economic values, a consistent representation of energy markets in physical units
- The US DOE International Energy Outlook (2002) provides growth projections from for emissions by fuel and GDP are used to calibrate our simulation over a time horizon from 2000 to 2020.

Carbon Statistics

	*Carbon per capita $)**			*Carbon per $ GDP*		
	2000	2020	%Δ	2000	2020	%Δ
usa	5.6	6.4	0.7	167	124	-1.5
jpn	2.4	2.9	1.0	72	56	-1.3
eur	2.4	3.0	1.1	104	76	-1.6
chn	0.5	1.1	4.0	625	392	-2.3
fsu	2.1	3.1	2.0	1,021	589	-2.7
row	0.5	0.7	1.7	308	234	-1.4

Carbon per capita in tons per person
Carbon per GDP in grams per $1998
%Δ – Equivalent constant annual growth rate

Key Insights

Optimal coalition structures tend to be sub-global.

Additional members would choose high permit endowment.

"*Good*" equilibria tend to pair large developing world countries (low abatement cost and low demand for environment) as permit sellers with Europe and/or Japan as the major permit buyers.

Permit trade levels are typically heavy in these equilibria.

Regions gain for different reasons:

- EU: finding cheap way to reduce emissions
- China and FSU: selling permits

	% Equivalent Variation						*Global*	*Emission*
	USA	JPN	EUR	CHN	FSU	ROW	*%EV*	*Reduction*
First-Best	**1.2**	**6.2**	**4.7**	**-3.0**	**0.1**	**-0.1**	**1.7**	**21.4**
Shapley (EUR,CHN)	**1.0**	**3.6**	**0.5**	**0.5**	**5.6**	**0**	**1.2**	**15.4**
JPN,EUR,CHN,FSU	0.9	2.7	1.6	0.7	9.0	0	1.0	14.1
EUR,CHN,FSU**	**0.8**	**2.9**	**1.5**	**0.6**	**8.2**	**0**	**1.0**	**14.0**
EUR,CHN**	0.8	2.9	1.8	0.4	4.5	0	1.0	13.9
JPN,EUR,CHN	0.8	2.9	1.7	0.6	4.5	0	1.0	13.8
USA,EUR,CHN	0.8	2.7	1.2	1.7	4.3	0	1.0	13.6
USA,JPN,EUR,CHN,FSU	0.7	2.3	0.9	1.8	12.2	0	1.0	13.6
USA,JPN,EUR,CHN	0.8	2.7	1.2	1.8	4.2	0	1.0	13.5
USA,EUR,CHN,FSU	0.7	2.7	0.9	1.6	11.4	0	1.0	13.4
JPN,CHN**	0.7	1.8	1.7	0.2	3.6	0	0.8	12.7
USA,JPN,CHN	0.5	1.4	1.5	1.0	3.1	0	0.8	12.2
JPN,CHN,FSU	0.5	1.4	1.3	0.2	2.8	0	0.6	11.6
USA,JPN,CHN,FSU	0.3	1.1	1.3	0.9	5.5	0	0.7	11.5
USA,CHN**	0.3	1.6	1.2	0.7	2.3	0	0.6	11.2
USA,CHN,FSU	0.2	1.4	1.0	0.7	3.7	0	0.5	10.7
CHN,FSU*	0.3	1.1	0.8	0.1	0.9	0	0.4	10.2
EUR,FSU*	0.1	0.4	0.1	0	3.1	0	0.1	8.5
USA,EUR,FSU	0.1	0.3	-0.4	0	8.9	0	0.1	8.5
JPN,EUR,FSU	0.1	0.4	0	0	3.5	0	0.1	8.5
USA,JPN,EUR,FSU	0.1	0.4	-0.5	0	9.0	0	0.1	8.4
USA,EUR	0.2	0.3	-0.1	0	0.4	0	0.1	8.3
JPN,FSU**	0.1	0.1	0.2	0	0.7	0	0.1	8.3
USA,JPN,EUR	0.1	0.8	-0.3	0	0.2	0	0	8.1
No-Trade Nash	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**7.8**
JPN,EUR	0	0.2	-0.1	0	0	0	0	7.8
USA,JPN,FSU	-0.1	-0.4	0	0	3.7	0	0	7.7
USA,JPN	0	0	-0.1	0	-0.1	0	0	7.7
USA,FSU	-0.1	-0.2	-0.2	0	2.2	0	-0.1	7.4

* indicates that a coalition is a SPNE.

** indicates a SPNE coalition which satisfies the weak external stability condition.

Table 3: EUR-CHN-FSU Coalition Profile, 2015

Homogenous Trade $(\sigma_{DM}, \sigma_{MM}) = (8, 16)$

	No-Trade Nash Emissions	Coalition Emissions	Coalition Endowments	Permit Prices	Equivalent Variation
			Coalition Members		
EUR	80.6	91.5	27.8	79.7	1.5
CHN	95.6	48.6	77.3	79.7	0.6
FSU	95.1	84.5	120.8	79.7	8.2
			Outsiders		
USA	72.6	73.1	-	126.9	0.8
JPN	84.4	84.6	-	131.6	2.9
			Non-strategic		
ROW	106.7	108.7	-	0	0

No-Trade Nash Emissions: no-trade Nash emissions as % of BaU
Coalition Emissions: equilibrium emissions with coalition as % of BaU
Coalition Endowments: permit endowment as % of BaU emissions
Coalition Permit Prices: real permit price ($/Tons)
Equivalent Variation: EV as % change from no-trade Nash equilibrium

Hot air problem for FSU but not for China, despite lower WTP

Reason 1: strategic considerations w.r.t. permit price

- consider hypothetical situation where China and FSU choose permit endowment = BaU emissions
- China sells considerably more permits due to lower MAC
- China has stronger interest in lower permit price

Reason 2: GE effects

- less emissions lead to lower energy prices and higher prices for energy-intensive goods
- CHN and EUR are net importers of fossil fuels and net exporters of energy-intensive goods
- restricting permit endowment leads to positive trade spillovers
- FSU is a net exporter of fossil fuels and net importer of energy-intensive goods
- increasing permit endowment leads to positive trade spillovers

Permit trading is fairly successful. The best equilibrium outcomes produce nearly 1/2 of first-best abatement.

Alternative scenario: coalition members choose their abatement cooperatively (using the Shapley Value to allocate coalitional payoff), but coalitions need to satisfy internal and external stability.

Only modest increase of equilibrium abatement.

Suboptimal abatement is due more to the free-rider problem than to inefficient negotiations within the coalition.

Participation of Developing Countries

Common view: prospects for participation of DCs improve in the future as environment becomes higher priority

Alternative scenario with higher WTP (1998, US-$ per ton of carbon) for China (50) and FSU (100)

Permit trading system is less valuable, because it lives from asymmetries in WTP and MAC

Table 6: Coalitions by Emission Reduction and Welfare Change, 2015

High Developing-World MWTP (CHN = \$50 per ton, FSU = \$100 per ton)

	Baseline		*High MWTP*	
	Global % EV	Emission Reduction	Global % EV	Emission Reduction
EUR,CHN,FSU	1.0	14.0	0.4	14.7
No-Trade Nash	0	7.8	0	12.8

Emission Reduction: % reduction in global emissions from BaU.
Global %EV: global equivalent variation as % change from no-trade Nash.

Conclusions

Even with non-cooperative countries, permit trading system can achieve substantial emission reductions

Permit trading system can provide a stick to involve DCs into emission abatement

Permit trading provides natural burden sharing

- DCs contribute cheap abatement options
- ICs pay for emission abatement

Caveat: purely egoistic countries is an extreme scenario

Permit trading may help to develop a system of trust, in which even binding agreement may finally become feasible