

Addressing Carbon Leakage by Border Adjustment Measures: A Global CGE Analysis

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Expert Workshop on Energy and Climate Change Modeling
November 17 2011, Seoul, Republic of Korea

Outline

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Background

- Annex I countries have to reduce GHG emissions while non-Annex I countries do not have to.
- This asymmetric obligation yields concerns on carbon leakage and international competitiveness.
- Recently, Japan proposed to introduce carbon tax.
- Non-Annex I countries will take Nationally Appropriate Mitigation Actions (NAMAs) following the Copenhagen Accord.
- Due to growing international trade and division of labor, the concept of embodied emission is becoming important.

Objective

- To quantify the effects of Japan's proposed carbon tax policy on economy and the environment by employing a global computable general equilibrium (CGE) model and embodied emission coefficients
- To examine the effects of NAMAs of China and India with the same model

Model and Data

■ Model: GTAP6inGAMS-based global CGE model

- ◆ Recursive dynamics (simulation from 2004 to 2020)
- ◆ Formulation of household behavior á la GTAP-EG by using per capita variables

■ Data:

- ◆ GTAP Database version 7 (Base year = 2004)
- ◆ Embodied emission coefficients (Zhou, Liu and Kojima, 2010)
 - Computed by using both GTAP Database (version 6) and Asian International Input-Output Table, 2000

Regional Classification

No.	Region
1	Indonesia (IDN)
2	Malaysia (MYS)
3	Philippines (PHL)
4	Singapore (SGP)
5	Thailand (THA)
6	China (CHN)
7	Taiwan (TWN)
8	South Korea (KOR)
9	Japan (JPN)
10	United States (USA)
11	India (IND)
12	European Union (EU)
13	Rest of the world (ROW)

Sector Classification

		AIIO 24 sector classification	GTAP 57 sector classification
	Symbol	Description	Code
1	PDR	Paddy	pdr
2	XAG	Other agricultural products	wht, gro, v_f, osd, c_b, pfb, ocr
3	LSP	Livestock and poultry	ctl, oap, rmk, wol
4	FRS	Forestry	frs
5	FSH	Fishery	fsh
6	CPG	Crude petroleum and natural gas	oil, gas
7	XMN	Other mining	coa, omn
8	FBT	Food, beverage and tobacco	cmt, omt, vol, mil, pcr, sgr, ofd, b_t
9	TEX	Textile, leather and the their products	tex, wap, lea
10	WDP	Timber and wooden products	lum
11	PPP	Pulp, paper and printing	ppp
12	CHM	Chemical products	crp
13	PTR	Petroleum and petro products	p_c
14	RBP	Rubber products	crp
15	NMM	Non-metallic mineral products	nmn
16	XMP	Metal products	i_s, nfm, fmp
17	MCN	Machinery	ele, ome
18	TRE	Transport equipment	mvh, otn
19	XMF	Other manufacturing products	omf
20	EGW	Electricity, gas, and water supply	ely, gdt, wtr
21	CNS	Construction	cns
22	TRT	Trade and transport	trd, otp, wtp, atp
23	SRV	Services	cmn, ofi, isr, obs, ros, dwe
24	PBA	Public administration	osg

Simulation Scenario (1)

- **S0: Baseline**
- **S1: Carbon tax in Japan (implemented to fossil fuels sector)**
 - ◆ From 2011 to 2012: US\$0.88 per ton-CO₂
 - ◆ From 2013 to 2014: US\$1.76 per ton-CO₂
 - ◆ From 2015 to 2020: US\$2.67 per ton-CO₂
- **S2: Carbon tax and import-tariff based border adjustment for EITE industries in Japan**
- **S3: Carbon tax and export-rebate based border adjustment for EITE industries in Japan**

Simulation Scenario (2)

- **S4: Carbon tax and import tariff levied on EITE industries in Japan plus Nationally Appropriate Mitigation Actions (NAMAs) for China and India**
 - ◆ NAMAs are introduced as reduction of carbon dependency.
- **S5: Carbon tax and export rebate for EITE industries in Japan plus NAMAs for China and India**

Global CO₂ Emissions: % Change from the Baseline

	S1	S2	S3	S4	S5
2011	0.00007	-0.00060	-0.00016	-10.81407	-10.81384
2015	0.00029	-0.00091	-0.00028	-16.12133	-16.12102
2020	0.00033	0.00023	0.00010	-21.76676	-21.76669

- Global CO₂ emissions increase by introduction of carbon tax in Japan.
- By implementation of border adjustment, global CO₂ emissions decrease; however they turn to increase after 2019.
- By decline in carbon dependency, global CO₂ emissions decline significantly.

Regional CO₂ Emissions: % Change from the Baseline

	S1				S2				S4		
	Japan	Korea	ROW		Japan	Korea	ROW		Japan	Korea	ROW
2011	-0.00170	-0.00004	0.00013		0.00021	0.00035	-0.00063		-0.00011	0.00022	-11.14965
2015	-0.00545	0.00009	0.00046		-0.00060	0.00150	-0.00092		-0.00174	0.00089	-16.59534
2010	-0.00556	0.00038	0.00050		-0.00229	0.00180	0.00030		-0.00320	0.00103	-22.37587
	S3				S5						
	Japan	Korea	ROW		ROW						
2011	0.00034	-0.00048	-0.00018		-11.14943						
2015	0.00173	-0.00137	-0.00034		-16.59513						
2010	0.00402	-0.00149	-0.00001		-22.37599						

Note: ROW includes Korea.

- Carbon leakage occurs by Japan's carbon tax (for S1, Japan's CO₂ emissions decline while other countries' rise basically).
- By Japan's border adjustments, some negative leakage is found.
- By carbon dependency decline in China and India, CO₂ emissions decrease in ROW.

Output in Pulp, Paper and Printing Sector: % Change from the Baseline

	S1				S2				S4		
	Japan	Korea	ROW		Japan	Korea	ROW		Japan	Korea	ROW
2011	-0.00054	-0.00070	-0.00045		0.00592	-0.00499	-0.00104		0.00517	-0.00515	-0.00108
2015	-0.00210	-0.00203	-0.00106		0.01779	-0.01364	-0.00188		0.01410	-0.01453	-0.00229
2010	-0.00238	-0.00196	-0.00079		0.01777	-0.01090	-0.00032		0.01192	-0.01257	-0.00102
	S3										
	Japan	Korea	ROW								
2011	0.00234	-0.00185	-0.00068								
2015	0.00741	-0.00562	-0.00177								
2010	0.00849	-0.00594	-0.00191								

Notes: ROW includes Korea. Results for S5 are almost the same as those for S3.

- By Japan's carbon tax, output in the pulp, paper and printing sector declines.
- The reverse occurs by introduction of border adjustments (plus NAMAs) for the case of Japan.
- Outputs in Korea and the ROW continue to decline.

Output in Metal Products Sector: % Change from the Baseline

	S1				S2				S4		
	Japan	Korea	ROW		Japan	Korea	ROW		Japan	Korea	ROW
2011	-0.01401	-0.00150	0.00093		0.02331	0.01453	-0.00840		0.01761	0.01095	-0.01064
2015	-0.04566	-0.00432	0.00365		0.04671	0.03769	-0.02239		0.02753	0.02424	-0.03106
2010	-0.04753	-0.00340	0.00345		0.00707	0.02336	-0.02087		-0.00548	0.01164	-0.02881
	S3										
	Japan	Korea	ROW								
2011	0.01554	-0.01005	-0.00421								
2015	0.05601	-0.03351	-0.01351								
2010	0.07727	-0.03965	-0.01723								

Notes: ROW includes Korea. Results for S5 are almost the same as those for S3.

- By Japan's carbon tax, outputs of metal products sector in Korea and Japan decline. By contrast, that in the ROW rises.
- Introduction of border adjustments basically helps Japan to increase its output.
- Outputs in Korea and the ROW decline for the case of export rebate while that in Korea increases for the case of import tariff.

Equivalent Variation (US\$ Billions)

	S1		S2		S3		S4	
	Japan	Korea	Japan	Korea	Japan	Korea	Japan	Korea
2011	0.19557	0.00318	0.17350	0.00756	0.21192	0.00597	0.17741	0.00664
2015	0.62542	0.01298	0.57125	0.03041	0.68415	0.02362	0.58464	0.02362
2010	0.73378	0.01790	0.69564	0.03815	0.81899	0.03335	0.70729	0.03335

Note: Results for S5 are almost the same as those for S3.

- Surprisingly, welfare in both Korea and Japan improve in all scenarios.

Conclusion (1)

- **By introduction of Japan's carbon tax, international carbon leakage occurs and global CO₂ emissions increases slightly.**
- **Border adjustments help to alleviate international carbon leakage to some extent and to maintain international competitiveness of some EITE industries.**

Conclusion (2)

- Decline in carbon dependency in China and India would greatly reduce global and regional CO₂ emissions.
- In order to reduce CO₂ emissions globally/nationally, fall in carbon dependency would be quite effective.

Conclusion (3)

- Although this violates our intuition, welfare improves in Korea and Japan regardless of simulation scenarios.

Future Research Topics (1)

- **Further analysis on the causes of sectoral and regional variations in output of energy-intensive industries as well as the causes of welfare change**
- **Different formulation of NAMAs**
 - ◆ Improvements in energy efficiency, decline in carbon dependency, or both
- **Inclusion of cost to implement NAMAs**
 - ◆ Investment, carbon tax, emission trading and so on

Future Research Topics (2)

- **Re-computation of embodied emissions which include NAMAs**
- **Specification of firm behavior**
 - ◆ What are rational reasons/backgrounds for complex nesting functions to describe firm behavior in GTAP-E/GTAP-EG model?
 - ◆ Is the complex nesting empirically tested/confirmed?

Thank you for your attention.

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