

A quantitative analysis of the environmental impact induced by free trade between Korea and Japan

Sang In Kang¹, Jae Joon Kim²

7th annual Conference on Global Economic Analysis

Trade, Poverty, and the Environment

June 17 - 19, 2004, Washington, D.C., United States

Abstract

This study analyzed the air pollution impact in Korea induced by trade liberalization between Korea and Japan. A standard multi-region CGE model based on GTAP database Ver. 5.0 and Korean air pollution inventories in 1998 were used to give a quantitative feature of trade and environment linkage in Korea. The simulation result shows that the aggregated environmental effect depends on the change of specialization structure between pre and post trade liberalization. The inter-industrial difference of emission coefficients and of disposal cost by air pollutants plays a major role in determining the scale of the aggregated environmental effect. The free trade agreement between Korea and Japan reduces the overall air pollution emission by 0.36% but increases the pollution disposal cost slightly by 0.06%. The rate of disposal cost increase is much smaller than that of the real GDP(0.28%). This type of quantitative analysis can provide useful environmental policy guidelines for pursuing "win-win strategy" in trade

¹ Research Fellow and Team leader, Global Environment Research Center, KEI, Korea

² Researcher, Global Environment Research Center, KEI, Korea

and environment linkage.

I. Overview and Introduction

1. Trade and Environment Linkage

Globalization has led to accelerated growth of world economy. However, economic growth has been accompanied with environmental degradation such as global warming, deforestation, depletion of the ozone layer, and so on.

So far, the trade and environmental linkage is at the center of many international fora discussing trade cum development, environmental protection, and sustainable development. Recently, WTO Ministerial Declaration inaugurating a new trade round(Doha Round) in 2001 took notes of Members' efforts to conduct national environmental assessments of trade policies on a voluntary basis. Since the World Summit on Sustainable Development in 2002 endorsed the importance of mutual supportiveness between environmental protection and promotion of sustainable development under the open and non-discriminatory multilateral trading system, the environmental impacts of trade liberalization have become a theme of heated debate at global, regional and national level.

In understanding overall linkage between trade and environment, we need to recognize that trade is not the major factor which causes the environmental degradation. The relation between trade and environment depends on the specialization structure and the inter-industrial difference in induced environmental impacts from production. It is generally accepted that, without appropriate environmental policy intervention, the economic growth driven by trade liberalization may speed up the environmental degradation. But in the long run, international trade could contribute to the environmental protection by facilitating the worldwide diffusion of environment-friendly technologies and goods. It means that we cannot establish a general conclusion on whether trade liberalization brings a positive environmental impact or not. So, there are more and more multilateral, regional, or bilateral trade liberalization negotiations dealing with various trade and environmental issues to make free trade systems be

supportive to environmental protection. And this is the reason why the WTO Ministerial Declaration recommends conducting environmental impact assessments of trade policies at national level.

2. Free Trade Agreement and Korea-Japan FTA

In parallel with the trade liberalization under the GATT multilateral trade system, the number of regional or bilateral trade agreements is continuously increasing all over the world. The rush to conclude regional trade agreements has gained further momentum since 1995, the inauguration year of the WTO. The WTO reports that the total number of notified regional trade agreements in force as of December 2002 amounts to 177.

The WTO Annual Report 2003 observed that most WTO members are now party to at least one regional free trade agreement and many to several. And the upward surge in regional trade agreements was most strongly felt in the Asia Pacific region, where countries long in favor of multilateral-only liberalization have whole-heartedly embraced the regional option. Japan, with the entry of its free trade agreement with Singapore in November 2002, became the latest regional trade agreement convert among the WTO members. And Korea, having signed a free trade agreement with Chile, follows Japan. The free trade agreement between Korea and Chile is under ratification process in Korea.

Recently Korea and Japan organized a joint research group and conducted several studies examining the feasibility and desirability of establishing a Korea-Japan free trade agreement. And intergovernmental negotiation for Korea-Japan free trade agreement will start in the very near future. The studies of joint research group concluded in general that Korea-Japan free trade agreement would bring substantial economic benefits in terms of GDP increase in both parties. The Korea-Japan free trade agreement, the first free trade agreement among Northeast Asian countries, is expected to bring us an unified market value of roughly US\$ 5 trillion in terms of GDP. The Korea Institute for International Economy Policy(KIEP) estimated that with the total trade balance increase 1.48%, the real GDP in Korea would be increased by 2.81% after the free trade agreement. The gains of free trade result from the combined effects of tariff elimination and productivity enhancement under the Korea-Japan free trade

agreement. Most of studies are based on multi-regional computable general equilibrium analysis.

3. Environmental Review of Trade Policy in Korea and Japan

Having concluded the Japan-Singapore free trade agreement, Japan is working to introduce a kind of environmental review process in its free trade agreement policy. Japanese Ministry of Environment constructed a working group with some experts in academia to examine the possibility of introducing the environmental impact assessment for trade liberalization under the free trade agreement. Also, Korea takes a similar approach in its environmental review process on free trade agreement policy.

From the trade and environment linkage point of view, a quantitative approach to the environmental impact of free trade agreement provides decision-makers with more helpful policy reference than a qualitative analysis. In this study, we used, like other researchers above, a standard multi-region computable general equilibrium model based on the Global Trade Analysis Project(GTAP) Data Base(DB) to estimate at first the aggregated and sectoral economic effects of Korea-Japan free trade agreement. We calculated emission coefficients per output in different industrial sectors and disposal cost of major air pollutants from the sectoral pollution and abatement cost inventory in Korea, and obtained the aggregated impact on air pollution induced by trade liberalization under bilateral free trade agreement between Korea and Japan.

This study focused on the role of the interindustrial difference of emission coefficient combined with the change in interindustrial specialization structure after the free trade agreement. The analysis concerns mainly the disposal cost and emission of air pollutants, as they occupied a large part of total environmental cost resulted from industrial activities. We believe that this study could serve as a starting point for more advanced and complete quantitative analysis on environmental impacts of bilateral trade liberalization from the trade and environment linkage point of view.

4. Computable General Equilibrium Approach

Applied general equilibrium model has been constructed incorporating various modern macro and micro theoretic elements. Supported by the development of recent computer technology and optimization algorithm, the numeric solution for an applied general equilibrium model can easily be calculated without any practical difficulties.

Until now, computable general equilibrium model has been used in quantitative analysis of an enormous variety of economic questions, such as the effects of tax, industrial, labor market, or trade policies on the variety of micro and macro variables. Recently, various computable general equilibrium models serve as useful quantitative tools in analyzing environmental policy effects on economy, as they do in the case of greenhouse gas emission restriction under the UNFCCC and the Kyoto Protocol. They are also used for the economic analysis of intertemporal dynamic general equilibrium for open economies.

The table 1 shows major computable general equilibrium analysis recently conducted for the linkage among economic growth, trade liberalization, and environmental impacts at global or national level.

<Table 1> Recent computable general equilibrium analysis and its scope

Authors(published year)	Scope	Economic impact	Environmental impact	Application of trade liberalization
Shoven and Whalley(1973, 1984, 1992)	Global	○	×	○
Harrison, Rutherford(1995), Hertel. T(1997)	Global	○	×	○
Dessus(1999), Gabaccio(2000)	Global	○	○	×
Kuit(2001), Tsigas, Hertel(2002)	Global	○	○	○
n. g. Choi(1993, 2000, 2002)	K-Global	○	×	○
j. h. Ko(1994), I. k. Cheong(1999, 2002)	K-Global	○	×	○
g. l. Cho(1999), Lim and Kang(2000)	K-Global	○	○	×
Jorgenson(1990),Burniaux and Troung(2002)	National	○	×	○
I. j. Kim and Shin(1997)	K-National	○	○	×
s. j. Kang(1999), Cho(2000)	K-National	○	○	×

Tsigas et. al.(2002) provide us a good quantitative analysis framework for the environment and trade interaction in Western Hemisphere. They illustrated the economic mechanisms through which trade policy affect the environment. To capture all features of trade and environment linkage, they introduced international dependency into parties, economy-wide resource competition, and sectoral input-output relationships with production functions. They also explicitly incorporated environmental quality variables into consumer's utility functions. Internalizing environmental consideration into the economic decision making process, especially in a consumer sector, Tsigas et.

al.(2002) made a great contribution to a quantitative trade and environment linkage analysis. But in their study, the environmental effects are estimated by extrapolating U.S. pollution information to other countries, and this requires much attention in interpreting the simulation results. In abatement cost, also, they assumed that wealthy regions spend more on pollution abatement than less wealthy region based on the U.S. data set. In this regard, it may be said that their study is more appropriate in estimating the regional effect of free trade agreement, such as NAFTA rather than a single country effect.

II. Model description

1. Data and Model Structure

We used a standard multi region computable general equilibrium model based on the GTAP data base ver.5 and the emission coefficient of the three major air pollutants to estimate the aggregated environmental impact of Korea-Japan Free Trade Agreement.

The GTAP data base contains bilateral trade, transport, and protection data characterizing economic linkages among regions, together with individual country input-output data bases that account intersectoral linkages within each region. The base year difference in GTAP data base is appropriately adjusted to ensure international consistency among each national data. Therefore, it can serve as a useful data base for general equilibrium modeling framework destined to the analysis of integrated international linkage between trade and environment.

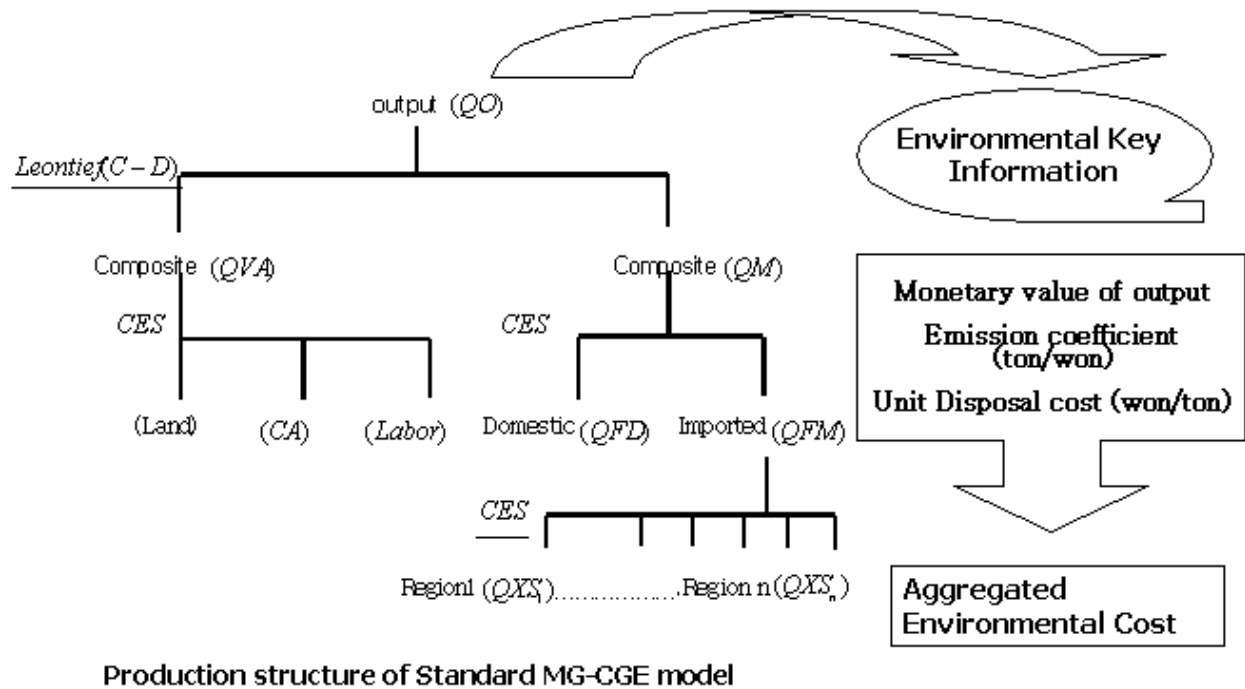
The problems related to the behavioral parameters used in the standard multi region computable general equilibrium model are well documented in Hertel(1997). Most behavioral parameters in GTAP are based on constant elasticity specification, which simplifies model calibration. But one can raise a question on the appropriateness of such elasticity parameters not tested in behavioral equation of economic agents in each country. We accept that our simulation results are no more free from this kind of practical restrictions.

Despite of these weaknesses, the GTAP data base is the most popular and useful tool to computable general

equilibrium modeler who mainly long for analyzing international impact of trade liberalization or any other policy implementation with multi-regional general equilibrium framework. This is one of the reasons why we used a standard multi region computable general equilibrium model based on the GTAP data base.

The figure 1 shows simplified feature of the model used in our analysis. The analysis framework is a conjunction of computable general equilibrium module for economic analysis and pollutant emission module for induced environmental impact analysis. The pollutant emission module is attached exogenously to the economic module. With this simplified framework, we can estimate the impact of trade liberalization on environment. But this kind of exogenous conjunction does not permit an analysis of the effect of environmental policy response on international trade.

<Figure1> Analysis framework of trade and environment linkage



Analysis progress is in four steps. First, we take a standard computable general equilibrium model with appropriately aggregated regions and sectors from the GTAP data base. Secondly, we estimate air pollutant emission coefficient per output and unit disposal cost by industrial sectors. Thirdly, we calculate the change in pollution emission and disposal cost by connecting the sectoral output change to the unit disposal cost via air pollutant emission coefficient per output. Fourthly, we interpret the quantitative linkage between trade and environment and deduce the conclusion.

In the model, final goods are produced by Leontief production technology using composite good of production factor and intermediary good in Armington composite. However, a few GTAP-CGE models assume more flexibility and one can choose Cobb-Douglas production technology which is more suitable for long-run effect. The composite factor goods are produced by Constant Elasticity of Substitution (CES) technology using land, labor, capital.

Armington goods are produced by CES technology with domestic and imported goods. Imported goods are generated by CES technology using each regional goods. The accounting relationships in computable general equilibrium model are expressed in value terms reflecting complex nonlinear equations. In GTAP, the accounting relationships are expressed in percentage terms which do not preclude solution of the true nonlinear problem.

To connect economic result with environmental impact, we employed established environmental key information. Our study calculate the emission effect from monetary level of output estimated by model simulation times emission coefficient per unit of output(won). We only considered air pollutants such as Sox, Nox, TSP, of which the emission data by sectors are available. Even though the disposal cost of the three air pollutants takes a large part of total environmental disposal cost, there still exists a possibility of underestimation on the environmental impacts of trade liberalization by excluding other pollution factors. Emission coefficients are calculated based on Kim and Choi(1998). The table 1 shows sectoral classification and emission coefficient the aggregation used. The unit disposal cost of each air pollutant is detailed in appendix 1. The shaded area in the table 2 represents top 5 air pollution intensive sectors.

<Table 2> Emission coefficient by air pollutants and Industry sectors

(unit: ton/million won)

description	code	emission coefficient		
		SOx	NOx	TSP
1.agriculture_fishing_forest	1 AG_FI_FO	0.0014610	0.0005050	0.0000990
2.mining	2 Mining	0.0002840	0.0003600	0.0001900
3.Food products	3 FPWP	0.0013432	0.0003437	0.0001073
4.Textiles	4 PFB_TEX	0.0026410	0.0005230	0.0002320
5.wearing apparel	5 WAP	0.0001500	0.0000630	0.0000150
6.Leaner product	6 LEA	0.0016760	0.0003500	0.0001210
7.Wood Product	7 LUM	0.0006230	0.0001590	0.0000550
8.Pulp, paper product, publishing	8 PPP	0.0028385	0.0005042	0.0002175
9.Petroleum, coal product	9 P_C	0.0122800	0.0020290	0.0009230
10.Chemical, rubber, plastic product	10 CRP	0.0017593	0.0004756	0.0002113
11.Mineral Product	11 NMM	0.0058090	0.0038490	0.0017760
12.Ferrous metals	12 I_S_NFM	0.0074010	0.0060440	0.0029130

13.Metals n.e.c and Metal products	13 FMP	0.0003010	0.0001010	0.0000230
14.Machinery and equipments	17 OME	0.0000641	0.0000245	0.0000058
15.Electronic equipments	16 ELE	0.0004720	0.0000951	0.0000348
16.Motor vehicles and parts	14 MVH	0.0003080	0.0000670	0.0000230
17.Other Transport Equipment n.e.c	15 OTN	0.0000160	0.0000050	0.0000010
18.Furniture and Manufactures n.e.c	18 OMF	0.0001600	0.0001000	0.0000190
19.Electricity	19 ELY	0.0293290	0.0119270	0.0119730
20.Gas manufacture, Water	20 GDT_WTR	0.0014210	0.0028620	0.0001340
21.Construction	21 CONS	0.0000960	0.0000480	0.0000080
22.Trade	22 TRD	0.0003103	0.0000921	0.0000205
23.Transport	23 OTP_WA	0.0083150	0.0032690	0.0005540
24.Communication	24 CMN	0.0000400	0.0000120	0.0000020
25.Financial Services and insurance	25 OFI_ISR	0.0000310	0.0000140	0.0000010
26.Other services	26 Others	0.0001066	0.0000261	0.0000177

Electricity and transport service have more large emission coefficient than the other industries which are from about thousand times to hundred times of other transport equipments or communication. The output change in these 5 air pollution intensive sectors play a key role in determining the total induced air pollution after trade liberalization. As we see in appendix 1, the pollution disposal cost is also different by sector. This results in a large cost gap in treating certain type of air pollution, such as Nox.

2. Scenario and Simulation

In the comparative static analysis, we take the case of removing import tariff and non tariff barriers measured by the market price difference between Korea and Japan, and we calculate the economic and environmental effects after free trade. Our experiment was conducted with a multi-country general equilibrium closure. The general equilibrium closure is appropriate for capturing the substitution effect in production and consumption that occurs between goods and the resulting changes in trade flows and values. In the closure, the global bank's allocation of investment is fixed. The experiment involves the complete removal of ad valorem import tariff and tariff equivalents of bilateral non-tariff barriers between Korea and Japan. Therefore, the free trade agreement of Korea and Japan scenario analyzes all involved import protection instruments. Considered it unlikely that a free trade

agreement would result in the complete removal of all import barriers, this scenario provides an upper bound of the benefit of Korea-Japan FTA.

III. The Simulation Results

1. Economic Impacts

The Economic impacts show that the complete removal of all import barriers gives gains from trade to two countries. The effect of Korea Japan FTA on some macroeconomic variables are summarized in the table 3.

<Table 3> Overall Economic Effects of a Korea-Japan FTA

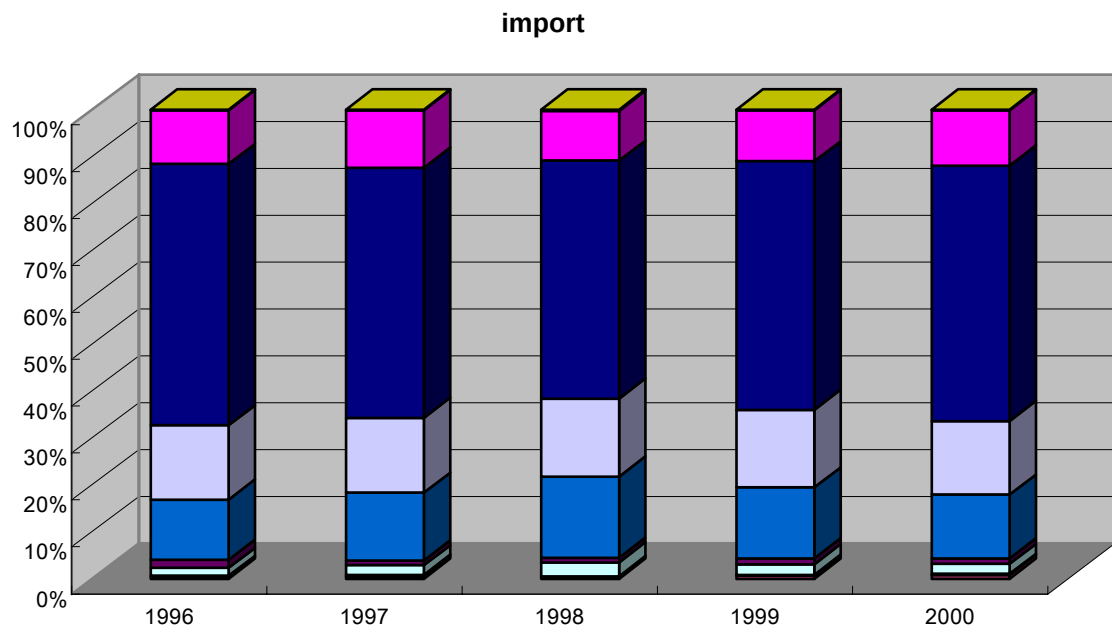
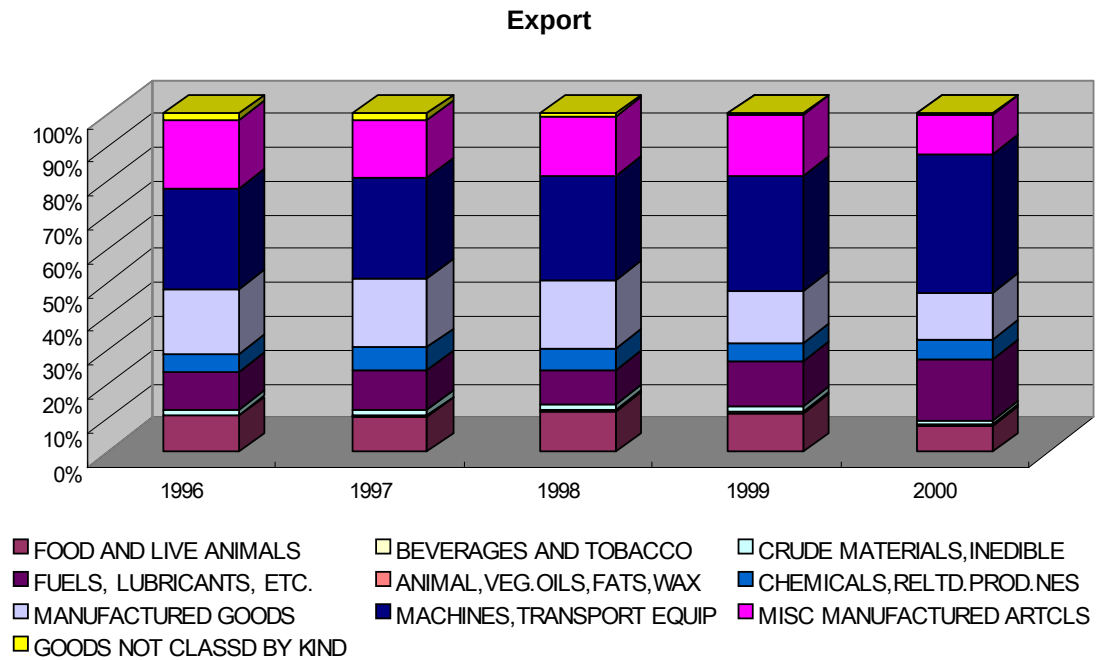
(unit : %, US million \$)

	u	EV	Change in Value of GDP	Terms of Trade
NAFTA	-0.01	-968.9	-0.08	-0.037
EU	-0.01	-663.0	-0.07	-0.0102
chn	-0.09	-657.6	-0.17	-0.1315
jpn	0.07	2490.3	0.21	0.2624
kor	0.52	2033.2	1.18	0.3891
Oth_ASIA	-0.05	-691.3	-0.12	-0.0635
ROW	-0.02	-931.6	-0.1	-0.0434
total		611.1		0.3659

For GDP, our result shows a rise in Korea's GDP by about 1.18%, which is different from that of KIEP, KEIT. This difference comes from the difference of scenarios used in the studies. Taking the complete removal of all import barriers includes tariff equivalents of bilateral non-tariff barriers between Korea and Japan. We observe more profitable effect of Korea-Japan free trade agreement. The percentage change of GDP value of Korea(1.18%) is much higher than that of Japan(0.21).

In bilateral trade with Japan, Korea records a big trade balance deficit keeping a highly specialized import structure with more diversified export structure. Korea exports almost 60% in total export value of light industry sectors such as food and live animals commodities and imports about 30% in total import value of heavy industry sectors such as chemicals, machine, transport good and parts and so on. The figure 2 details the bilateral trade structure between Korea and Japan.

Figure 2. Export and Import structure with Japan by commodities

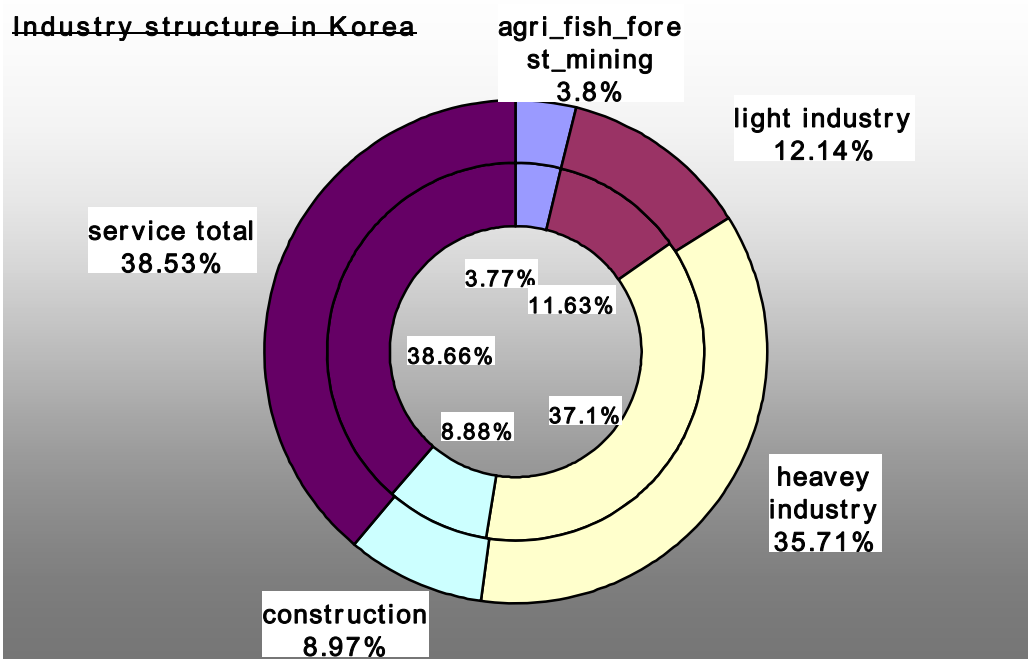


This type of trade structure was enhanced even after the free trade agreement simulation. Under the

Korea-Japan free trade agreement, Korea recorded a bigger deficit of bilateral trade balance after free trade with Japan. But the terms of trade and the overall trade balance went better by 0.39% and 5.41% respectively.

As we see in the figure 3, the Korea-Japan free trade agreement did not change the basic output structure. But we see increase of output in Agriculture, Fishery, and some light industries, and decrease in heavy industries. The sectors such as gas and water, construction, trade recorded increase of output. There was reduction of output of most service sectors, such as transport, communication, financial services and insurance, and other services.

Figure 3. Structural change in Korea after K-J FTA.



The table 4 details the change of industrial output and bilateral trade value in Korea after free trade agreement. The first two columns contain pre and post simulation output. The next two columns present pre and post overall trade balance by sectors. The last three columns show the scale of induced air pollution emission in terms of ton by

pollutant. The light industry sectors such as leather, food product and wearing apparel were major industries of growth. The heavy industry sectors were decreased except for electronic equipment part. This result determined the overall induced environmental effects. In our study, we will analyze the environmental induced effect using the linkage between industry output and environmental factors such as emission coefficient of air pollutant and its unit disposal cost.

<Table 4> Change of Output, Trade Balance and Pollution

(Unit: US million \$, ton)

	Output(qo)		Trade Balance		Emission Change		
	pre FTA	post FTA	pre FTA	post FTA	Sox	Nox	Tsp
1.Agriculture_fishing_forest	33,990	34,416	-9944	-11111	668	231	45
2.Mining	3,348	3,288	-22451	-22523	-18	-23	-12
3.Food products	50,768	54,675	-4281	-644	5,632	1,441	450
4.Textiles	23,718	23,856	9040	8930	392	78	34
5.Wearing apparel	10,659	11,220	1062	1636	90	38	9
6.Leaner product	5,477	6,210	1225	1763	1,318	275	95
7.Wood Product	3,980	3,959	-1632	-1659	-14	-4	-1
8.Pulp, paper product, publishing	20,535	20,501	-233	-288	-106	-19	-8
9.Petroleum, coal product	22,192	22,283	135	258	1,201	199	90
10.Chemical, rubber, plastic product	62,686	62,197	-808	-983	-923	-250	-111
11.Mineral Product	17,394	17,184	-1964	-2102	-1,308	-867	-400
12.Ferrous metals	50,530	49,651	-8024	-7917	-6,983	-5,703	-2,749
13.Metals n.e.c and Metal products	17,544	17,462	1045	951	-27	-9	-2
14.Machinery and equipments	75,618	73,384	-11864	-13152	-154	-59	-14
15.Electronic equipments	54,509	55,069	18339	18945	284	57	21
16.Motor vehicles and parts	46,912	46,148	8229	7557	-253	-55	-19
17.Other Transport Equipment n.e.c	11,145	10,900	3310	3033	-4	-1	0
18.Furniture and Manufactures n.e.c	8,513	8,456	312	253	-10	-6	-1
19.Electricity	17,882	17,832	0	0	-1,554	-632	-635
20.Gas manufacture, Water	1,386	1,389	-62	-64	4	9	0
21.Construction	87,961	89,029	-20	-22	110	55	9

22.Trade	59,669	59,744	396	266	25	7	2
23.Transport	44,078	43,825	7827	7665	-2,258	-888	-150
24.Communication	13,794	13,757	-113	-147	-2	0	0
25.Financial Services and insurance	37,228	37,190	523	471	-1	-1	0
26.Other services	208,839	208,584	-1123	-1591	-29	-7	-5
Total	990,355	992,207	-11075	-10475	-3,919	-6,133	-3,351

2. Environmental Impact

The induced environmental effect was calculated by joining industrial output change with the environmental pollution factors. First, we estimated the air pollutant emission effect by industry sectors using the emission coefficient of each air pollutant and then, computed the sectoral and aggregated environmental disposal cost change.

The result shows that the free trade between Korea and Japan reduces the total emission ton by pollutant, even if the total industrial output increases slightly by 0.187%. This result comes from the fact that the pollution reduction in shrinking sectors was more important than the pollution increase in expanding sectors. The total air pollution reduction records 3,919 tons for Sox, 6,133 tons for Nox, and 3,351 tons for Tsp.

The table 5 details the change of pollution disposal cost by industry sectors before and after Korea-Japan free trade agreement. This result is closely related to the industrial output changes presented in the table 4. The difference of the disposal cost per emission ton by industries and by pollutants plays a major role in determining total induced environmental cost effect in air pollution after trade liberalization.

<Table 5> Change of pollution disposal cost by industries

(unit: million won, %)

Aggregated commodities	base	SCENARIO
------------------------	------	----------

	TOTAL	Sox	Nox	TSP	TOTAL	%change	add_cost*
1.Agriculture_fishing_forest	692,718	48,067	647,344	5,993	695,417	1.25%	8,687
2.Mining	373,440	893	364,709	1,099	365,602	-1.80%	-6,740
3.Food products	644,154	70,207	613,194	10,322	683,412	7.69%	49,570
4.Textiles	415,432	60,228	347,888	9,736	408,125	0.58%	2,420
5.Wearing apparel	20,534	1,609	19,710	296	21,319	5.26%	1,081
6.Leaner product	63,397	9,950	60,606	1,322	70,557	13.37%	8,480
7.Wood Product	50,497	2,358	47,494	383	49,853	-0.51%	-262
8.Pulp, paper product, publishing	261,094	55,628	197,179	7,844	252,815	-0.17%	-443
9.Petroleum, coal product	785,935	261,589	491,394	36,180	753,019	0.41%	3,228
10.Chemical, rubber, plastic product	452,774	104,606	321,514	23,124	426,143	-0.78%	-3,530
11.Mineral Product	1,101,623	95,424	939,226	53,684	1,034,704	-1.21%	-13,288
12.Ferrous metals	1,387,386	351,282	757,545	254,421	1,109,081	-1.74%	-24,138
13.Metals n.e.c and Metal products	186,732	5,025	180,122	706	185,147	-0.47%	-879
14.Machinery and equipments	194,630	4,498	183,637	744	188,136	-2.95%	-5,750
15.Electronic equipments	557,568	24,850	535,072	3,375	559,925	1.03%	5,728
16.Motor vehicles and parts	239,664	13,587	220,302	1,867	233,892	-1.63%	-3,907
17.Other Transport Equipment n.e.c	4,160	167	3,883	19	4,050	-2.19%	-91
18.Furniture and Manufactures n.e.c	195,158	1,293	192,260	283	193,553	-0.68%	-1,323
19.Electricity	1,344,073	499,971	464,813	375,577	965,160	-0.28%	-3,712
20.Gas manufacture, Water	10,880	1,887	8,688	327	10,575	0.20%	22
21.Construction	826,607	8,170	827,218	1,253	835,389	1.21%	10,034
22.Trade	31,866	17,724	12,030	2,151	29,756	0.13%	40
23.Transport	3,032,651	348,357	2,624,181	42,709	2,972,581	-0.57%	-17,404
24.Communication	3,608	526	3,024	48	3,550	-0.27%	-10

25.Financial Services and insurance	2,308	1,102	1,138	65	2,240	-0.10%	-2
26.Other services	114,924	21,253	87,033	6,498	108,293	-0.12%	-140
Total	12,993,813	2,010,252	10,151,203	840,029	12,162,295	0.059%	7,671

Even though the industrial pollution emissions of all the three pollutants decrease, the industrial pollution disposal costs change differently by pollutant type. The table 6 details the aggregated disposal cost change by pollutant type. We note that total disposal cost change is smaller than the total economic change in Korea.

<Table 6> Aggregated Environmental Effects of FTA simulation

(unit: million won, ton, %)

	Pre FTA				Post FTA			A-cost total(change)
	Sox	Nox	TSP	Total	Sox	Nox	TSP	
cost	2,013,742	10,134,550	845,521	12,993,813	2,010,252	10,151,203	840,029	7,671(0.059)
emission	2,260,951	964,958	515,898	3,741,807	2,257,032	958,824	512,547	13,403(-0.358)
cost/ton	0.891	10.503	1.64		0.891	10.587	1.64	

We observe that the pollution disposal costs for Sox and TSP decrease slightly. But the pollution disposal cost for Nox increases after free trade agreement. This result comes from the interindustrial difference in pollution disposal cost for a given pollutant type, especially in the case of Nox. After the free trade between Korea and Japan, the output and resulted emission increase in most industries having relatively high disposal cost per emission ton. Most emission decrease occurs in the industries having low disposal cost. As a result, average disposal cost per ton of Nox increases from 10.503 to 10.587 million won, and we observe an increase of 0.06% for total air pollution disposal cost for all the three pollutants. In sum, the free trade agreement between Korea and Japan reduces the

overall air pollution emission by 0.36% but increases the pollution disposal cost slightly by 0.06%. And this result comes from the interindustrial difference of pollution emission coefficient by industry and of unit disposal cost for given pollutant type.

IV. Conclusion and Future Works

In this study, we analyzed the air pollution impact in Korea induced by trade liberalization between Korea and Japan with free trade agreement. A standard multi-region CGE model based on GTAP data base Ver. 5.0 and Korean air pollution inventories in 1998 were used to give a quantitative feature of trade and environment linkage in Korea. The bilateral elimination of import barriers gives economic benefits to both the trading partners. Korea gains more than Japan in terms of percentage change in real GDP. The bilateral trade structure between Korea and Japan will be enhanced after removal of import barriers. Even if Korea suffers big trade deficit with Japan, it experiences improvement of overall trade balance.

The simulation result shows that the aggregated environmental effect depends on the change of industrial specialization structure between pre and post trade liberalization. The interindustrial difference of emission coefficients plays a major role in determining the scale of the aggregated environmental effect in quantity. The free trade agreement between Korea and Japan reduces the overall air pollution emission by 0.36% but increases the pollution disposal cost slightly by 0.06%. The rate of disposal cost increase is much smaller than that of the real GDP(0.28%).

From the fact that the induced air pollution disposal cost takes only a part of total environmental cost and we do not consider the other pollution factors in water pollution and waste, this simulation result seems to underestimate the real environmental impacts of Korea-Japan free trade agreement. In former research, we found that the cost of air pollution occupied about 80% of total cost containing the other pollution induced by economic activities and its value shows a stable trend over time. Considering that the economic benefit from Korea-Japan free trade agreement in terms of real GDP was somewhat overestimated by supposing all the import barriers were

removed, it doesn't seem implausible to say that our simulation results present what we can expect on the total environmental cost after Korea Japan free trade agreement.

The simulation result shows that the trade liberalization under free trade agreement gives a certain environmental pressure to trading partners by increasing the pollution disposal cost. This means that, without appropriate environmental policy intervention, the economic growth driven by free trade may speed up the environmental degradation. By using a standard multi regional computable general equilibrium model in conjunction with various environmental variables, we can estimate the demand for pollution disposal cost by industry. We believe that this type of quantitative approach can provide useful environmental policy guidelines pursuing "win-win strategy" in trade and environment linkage.

This study could serve as a starting point for more advanced and complete quantitative analysis on environmental impacts of bilateral trade liberalization. To achieve this goal, we need more deep and detailed consideration on the theoretical and technical points as follows. First, we have to extend the standard computable general equilibrium model to reflect the trade-environmental linkage more exactly. Secondly, we also need more accurate and detailed estimation on the environmental disposal cost by sector and on the scope of pollutants. Thirdly, we will have to construct more complete trade and environment integrated model which permits us to analyze the possible endogenous feedback effect between economy and environment.

References

- Dixon, P. B and Parmenter., B. R, 1996, "Computable General Equilibrium Modeling for Policy Analysis and Forecasting" Chapter I. *Handbook of computational economics Vol I*, Elsevier Science.
- C. H. Sohn and Yoon. J, 2001, "Korea's FTA(Free Trade Agreement) Policy: Current Status and Future Prospects", KIEP discussion paper01-01, KIEP.
- G. L. Cho, 2002, "Endogenous technological progress with Uncertainty and Climate Change", Review of Energy Economics in Korea, Vol1. Num1, KEEI.
- Hertel, T. W., 1997, *Global Trade Analysis: Modeling and Application*, Cambridge University Press.

- I. G. Cheoung, 2001, "The economic effect and policy implecation of Korea-Japan FTA", Policy analysis 01-04, KIEP.
- I. G. Cheoung, 1996a, "The economic effect of APEC Trade Liberalization", Policy analysis 96-09, KIEP.
- J. D. Kim and Kang. I. S, 2000, "Economic Effects of Korea's Liberaliization of Trade in Services", Policy analysis I 00-02, KIEP.
- J. H. Ko, 2000, "Analysis of Economic Effects of a Free Trade Agreement among Korea, China and Japan", International Area Studies Review, Vol.4-2, pp. 177-209.
- Mercenier, J., 1994b, "Nonuniqueness of solutions in applied general equilibrium models with scale economies and imperfect competition - a theoretical curiosum?", Economic theory, forthcoming.
- N. G. Choi and Park. S. C, 2002, "Economic Effects of the Doha Development Agenda Negotiations According to Various Scenarios", Policy analysis 02-08, KIEP.
- OECD(1995), *Preliminary Conclusions on Selected Trade and Environment Issues*, COM/ENV/TD(95)12.
- Shoven, J. B and Whalley, J., 1984, "Applied General Equilibrium Models of Taxation and international Trade : An Introduction and Survey," Journal of Economic Literature 22, pp. 341 ~ 354.
- Shoven, J. B and Whalley, J., 1992, *Applying General Equilibrium*, Cambridge University Press, Cambridge.
- S. I. Kang and Min. D. G, Oct. 2002, "The research for the framework of System of Economic and Environmental Accounting", Unpublished final Report, KEI.
- S. I. Kang, Jan. 2003, "Analysis of the Environmental Effect of Doha Development Agenda(DDA) in Korea", mimeo, KEI.
- S. J. Kang, 1999, "The Study for the Energy-Economy-Environmental Modeling System", KEEI Research paper 99-12, KEEI.
- Study Group on EIA for Trade Liberalization, Nov. 2002, *Report of Study on Environmental Impact Assessment(EIA) for Trade Liberalization*, Ministry of Environment, Government of Japan.
- S. W. Kim and Choi. Y. J, Dec. 1998, "The Study for making Environment Pollution Accounting", KEI research paper series 17, KEI.
- Tsigas, M. E., Denice G, and Thomas W. H, June. 2002, "How to Assess the Environmental Impact of Trade Liberalization", 5th conference on Global Economic Analysis.
- T. Nakajima, 2002, "An Analysis of Japan-Korea FTA: Sectoral Aspect", 5th conference on Global Economic Analysis.
- WTO, 2001, *Ministerial Declaration*, WT/MIN(01)/DEC/1

WSSD, 2002, *Plan of Implementation*, para. 91.

WTO, 2003, *Annual Report 2003*.

Appendix1: The unit Disposal Cost of Air Pollutant Emission ton by industry

(unit: million won/ton)

	Sox*		Nox	TSP**	
1.Agriculture_fishing_forest	0.891		34.702	1.639	
2.Mining			287.074		
3.Food products			30.400		
4.Textiles			25.979		
5.Wearing apparel			25.979		
6.Leaner product			25.979		
7.Wood Product			70.294		
8.Pulp, paper product, publishing			17.772		
9.Petroleum, coal product			10.126		
10.Chemical, rubber, plastic product			10.126		
11.Mineral Product			13.231		
12.Ferrous metals			2.352		
13.Metals n.e.c and Metal products			95.155		
14.Machinery and equipments			95.155		
15.Electronic equipments			95.155		
16.Motor vehicles and parts			66.385		
17.Other Transport Equipment n.e.c			66.385		
18.Furniture and Manufactures n.e.c			211.842		
19.Electricity			2.036		
20.Gas manufacture, Water			2.036		
21.Construction			180.353		
22.Trade			2.036		
23.Transport			17.066		
24.Communication			17.066		
25.Financial Services and insurance			2.036		
26.Other services			14.897		

Appendix2: Trade Barriers

(unit :%)

Industry \ destination	1 NAFTA	2 EU	3 chn	4 jpn	5 kor	6 Oth_ASIA	7 ROW	Total
1.Agriculture_fishing_forest	297.50	117.09	300.77	86.05	69.84	151.80	173.10	1196.17
2.Mining	9.98	12.14	6.71	11.39	11.86	8.54	11.27	71.89
3.Food products	215.38	229.95	168.67	177.00	160.69	191.81	233.29	1376.79
4.Textiles	50.38	71.46	65.01	77.70	88.88	87.20	58.09	498.73
5.Wearing apparel	93.22	84.07	67.99	95.03	105.28	106.27	94.44	646.30
6.Leather product	67.04	60.34	74.06	59.88	72.05	82.06	63.38	478.82
7.Wood Product	38.19	42.30	27.11	60.17	49.68	48.02	36.89	302.35
8.Pulp, paper product, publishing	27.35	35.31	31.47	41.19	40.37	39.03	22.01	236.72
9.Petroleum, coal product	29.78	31.15	54.33	34.75	31.86	37.95	46.73	266.55
10.Chemical, rubber, plastic product	37.06	39.69	37.43	45.82	48.27	47.63	46.66	302.55
11.Mineral Product	50.37	57.59	44.33	45.26	46.09	59.42	64.61	367.66
12.Ferrous metals	27.14	34.37	23.54	41.57	28.65	29.87	34.29	219.43
13.Metals n.e.c and Metal products	44.84	45.50	43.76	50.19	66.16	53.25	52.79	356.49
14.Machinery and equipments	73.97	76.19	31.91	104.52	141.23	65.88	77.70	571.40
15.Electronic equipments	12.37	15.93	26.80	47.65	23.10	61.25	18.62	205.70
16.Motor vehicles and parts	32.35	30.25	28.93	36.02	31.66	32.44	39.42	231.07
17.Other Transport Equipment n.e.c	38.27	37.59	35.04	40.50	38.40	42.82	40.89	273.52
18.Furniture and Manufactures n.e.c	52.05	33.42	44.05	51.67	62.40	47.18	37.11	327.87
19.Electricity	0.48	0.18	-0.02	0.58	0.58	0.15	1.50	3.46
20.Gas manufacture, Water	1.14	1.08	1.39	0.66	0.75	1.43	1.17	7.62
21.Construction	0.38	0.37	0.38	0.38	0.41	0.36	0.38	2.67
22.Trade	0.57	0.59	0.56	0.54	0.56	1.55	0.59	4.96
23.Transport	0.41	0.40	0.48	0.31	0.41	0.45	0.42	2.89
24.Communication	0.69	0.70	0.64	0.64	0.71	0.65	0.68	4.71
25.Financial Services and insurance	0.68	0.71	0.69	0.69	0.73	0.69	0.73	4.92
26.Other services	0.91	1.11	0.97	1.00	0.77	1.21	1.08	7.05
Total	1202.49	1059.48	1117.00	1111.15	1121.41	1198.92	1157.84	7968.30

(unit :%)

Source \ destination	1. NAFTA	2. EU	3. Kor	4. Jpn	5. Chn	6. Oth_ASIA	7. ROW
1 NAFTA	26.4	98.9	235.3	151.1	314.8	129.5	245.9
2 EU	93.1	0.0	162.8	124.7	292.4	158.0	228.0
3 Kor	98.3	119.9	0.0	108.4	319.6	219.4	253.4
4 Jpn	89.1	119.1	183.3	0.0	315.8	174.0	230.3
5 Chn	98.3	118.6	377.3	128.2	0.0	138.2	256.6
6 Oth_ASIA	108.1	121.3	187.9	113.3	301.1	156.1	210.7
7 ROW	102.6	102.0	185.2	138.7	243.4	162.3	223.5

