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Environmental Regulations and Korean Trades†

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ABSTRACT : This paper analyzes the three issues related to the effect of environmental regulations on the Korean trades with gravity equation model: the effect on the Korean exports, the bilateral trade flows between the Korea and the trade partners, and the Korean international competitiveness. For all three issues we carried the empirical tests with fixed effect estimation methods for total industries, non-pollution industries, pollution industries, and also 16 individual pollution industries. We use industry panel data for the 120 largest trading countries with Korea for the years 2000-2010. The Environmental Performance Index (EPI) is used as the proxy variable for the environmental regulation. The empirical result shows that while GDPs of both Korea and its trading partners are very important factors affecting positively the Korean trades for all industries, the environmental regulation of the importing country would be a definite trade barrier to the Korean pollution industries, but not a definite one for the non-pollution industries. In addition, the stricter environmental regulations of Korea's trade partners would weaken the Korean international competitiveness of Korean pollution industries. In this regard, the Porter Hypothesis would have not appeared in the Korean trades of pollution industries during the period observed in this study.

Keywords : Environmental Regulations, Korean Trades, Pollution Industries, Porter Hypothesis

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요 약 : 본 논문은 중력모형을 이용해서 환경규제가 한국의 수출량, 총무역량 및 국제경쟁력에 어떤 영향을 미치는가를 규명해 보는 것이다. 고정효과 추정방법을 이용해서 전 산업, 비 환경오염산업, 16개 환경오염산업을 대상으로 추정하였으며, 자료는 한국과 교역량이 많은 120개 국가를 선정하여 2000년-2010년 사이의 산업패널자료와 환경성과지수(EPI)를 환경규제의 대리변수로 사용하였다. 분석 결과 한국과 교역상대국의 국내총생산량이 한국의 무역을 신장시키는데 큰 영향을 미친 변수라면, 교역상대국의 환경규제는 한국의 오염산업의 수출과 무역량을 감소시키고 국제경쟁력을 떨어뜨리는 무역장벽의 역할을 하는 것으로 나타났다. 그러나 분석기간 동안 비 오염산업에서는 이러한 환경규제효과가 극명하게 나타나지 않았다. 개별 산업에 대한 분석 결과 상당한 비중의 오염산업들이 교역상대국의 환경규제에 영향을 받는 것으로 나타났다. 이런 관점에서 동기간 사이에 한국의 무역에 있어서는 포터가설은 성립하지 않는 것으로 보인다.

주제어 : 환경규제, 한국의 무역, 환경오염산업, 포터가설

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I. Introduction

A group of economists as well as policy makers and businessmen have paid attention to the issue of environmental regulation and international competitiveness in both academic and real world. The overall question is: Are the environmental regulations harmful for the international competitiveness of the firms or not? Some insist the stringent environmental regulations seem to be harmful since the more stringent environmental regulations raise the production cost of the firms, resulting in the negative effects on its exports (Brock and Taylor(2005), Copeland and Taylor(2003)). On the other hand, the Porter Hypothesis, initiated by Porter(1991) and Porter and van der Linde (1995), argued that the harmful effect of the environmental regulations would be short run, and a country would become a net exporter potentially due to the positive technological innovation effect induced by more stringent environmental regulations in the long run.[1)]

There have been extensive empirical studies on the interaction between the environmental regulation and international competitiveness. However, their results vary with the models, data, methodologies used for the analysis. Many of them failed to find the univocal evidence on the subject (Jaffe et al.(1995), (2003), (2005), Palmer et al.(1995), Wally and Whitehead(1994), Cole and Elliott(2003)), while some provided evidences on the Porter Hypothesis with specific industries or firms (Mulatu, Florax and Withagen(2004)).

Among many models used for this issue of environmental regulation effect, the gravity equation model is one of the very popular models used in empirically testing the effect of stringent environmental regulations on the trade flows. A notable study using the gravity model is van Beers and van den Bergh(2003),

1) Pollution haven hypothesis is another view with this issue of environmental regulations and international competitiveness. But it is not directly relevant issue to the purpose of this paper, so that we do not introduce the literature of it here.

which tests the impact of environmental stringency on bilateral exports. They show OECD countries' exports are negatively and significantly affected by more stringent regulations, whereas those tighter regulations are also reducing imports. Jug and Mirza(2005) also show the export elasticity of relative environmental stringency is negative at 5% significant level and environmental stringency matters more for Eastern European exporters. Many of these studies, however, failed to find significant evidence of the environmental stringency effect on the trade flows (Grether and Melo(2003), Xu(1999)). One interesting result from these studies is that more empirically significant findings come from the specific industries rather than from the broader sectors or national levels (Albrecht(1998), Murty and Kumar(2003), Harris, Kónya and Mátyás(2002), Constani and Crespi(2008)). Oh and Myung(2005) carry an empirical study on this issue with Korean exports. They show that more stringent environmental regulations of the trade partners have positive effect on the Korean exports due to their negative effect on the price competitiveness using the Environmental Sustainable Index (ESI) as the proxy variable of environmental regulation. This paper, however, was just a cross sectional analysis without time series data since data they used were the ones only for the year 2001. So under the assumption that only the trade partners strengthen the environmental regulation while Korean intensity of environmental regulation stays the same, their study could not take into consideration the long term effect of environmental regulations on the trade flows. Shim and Jeong(2009) tried to test Porter Hypothesis by comparing the effects of environmental regulations of 41 importing countries on technology exports of renewable energy and energy saving industries between Korea and Japan for the years 2001, 2002, and 2005. They used some items of ESI, such as ENCON, innovation and CO2 damage, as proxy variables of environmental regulation. They proposed their results supported the Porter Hypothesis in the sense that the environmental regulation of the trade partners reduced the exports of both countries to their trade partners. However this

may not be true since its negative effect on the technology exports to the importing countries would not always mean increase in the exports of regulating countries.

This paper also takes up this issue of the effect of a country's environmental regulations on the international competitiveness and trade flows, with the case between Korea and its trade partners and gravity equation model. We know from GATT Article 3 National Treatment that the environmental regulation of a country would apply to both its domestic firms and the foreign exporting firms, affecting the production costs and thus international competitiveness of both domestic and foreign firms. Its effect would be harmful or beneficial to business firms of both domestic and foreign firms. Following the Porter hypothesis, it would increase the cost of production in the short run and reduce it in the long run through the technological innovation procedure, etc. If it is true, it would weaken the international competitiveness in the short run, and strengthen it in the long run. It may also be inferred that it would reduce the trade flows between two countries in the short run and increase it in the long run. This effect, however, would vary with countries, depending on the relative stringency of their current environmental regulations. If a country's environmental regulation is currently more stringent than its trade partner's, then it would be naturally said that the stricter environmental regulation of the country affects the business firms of the trade partner more than its own domestic firms in terms of costs as well as international competitiveness.

The purpose of this paper is to test three issues related to the effect of environmental regulation --that is, how the trade partner's environmental regulation affects the Korea's exports to it, trade flows between Korea and trade partners, and Korea's relative competitiveness with the trade partner. We test these three issues with three categories of industries--- total industries, non-pollution industries, and pollution industries. In addition, we also test these three issues with 16 individual pollution industries since these industries would be more sensitive to the environmental regulations than other non-pollution industries. In particular, the last

two issues of the environmental regulation effect on the international competitiveness as well as the trade flows would be related to the Porter Hypothesis.

In section II the gravity equation models adopted are introduced. Three gravity equations will be used for testing three issues considered in this paper. The Section III discusses dataset. The Section IV describes the result of the empirical analyses, and the concluding remarks are followed in Section V.

II. Model

The gravity equation model has widely been used for testing the relationship between the environmental regulations and trade flows since Tinbergen (1962) used it for testing the determinants of the international trade. Similar to the functional form of Newton's Law of Universal Gravitation, it is based on the assumption that the trade flows have positive relationship with economy sizes of trade partners and negative relationship with the distances between them. In addition, the model may also include many other determinants characterizing the countries such as the role of trade openness and other policy instruments like environmental regulations.

The typical gravity equation is as follows.

$$TF_{ij} = \alpha \frac{Y_i Y_j}{D_{ij}} \cdot Z_{ij} \tag{1}$$

where TF_{ij} is the amount of the trade flow from country i to country j, Y_i is economy size of country i, Y_j is economy size of country j, D_{ij} is the distance between country i and j, Z_{ij} is any other factor(s) affecting trade flows between country i and country j.

We modify the equation (1) in three ways to test the three issues discussed in

the section Ⅰ. The following formulations of gravity equations are very similar to many other models using the gravity equations related to the environmental stringency, especially for example, Costantini and Crespi(2008).

Equation (2) below is to set up for testing the first issue of trade partner's environmental regulation on Korea's exports. In addition to the factors affecting the trade flows in equation (1), the equation (2) includes some other determinants such as the existence of FTA, environmental regulations and so on, transforming it in the log terms to facilitate the empirical analysis.

$$\ln EX_{kit} = \beta_0 + \beta_1 \ln KGDP_t + \beta_2 \ln GDP_{it} + \beta_3 \ln DIS_{ki} + \beta_4 \ln EPI_{it} + \beta_5 FTA_{kit} \quad (2)$$

In equation (2), EX_{kit} is the exports of Korean industries to country i, $KGDP_t$ is real gross domestic products of Korea at time t, GDP_{it} is real gross domestic products of country i at time t, DIS_{ki} is the distance between Korea and country i, and EPI_{it} is the Environmental Performance Index of the country i at time t, which is used as the proxy variable of country i's environmental regulation, assuming that the country i's environment performance is proportional to its environmental regulation. FTA_{kit} is the dummy variable of free trade agreement between Korea and country i at time t, indicating the economic openness. EX_{kit}, $KGDP_t$, GDP_{it} , DIS_{ki} and EPI_{it} take log terms to linearize the original gravity equation, alleviate the heteroskedasticity and the influence caused by the differences of units of variables. The gravity equation generally predicts that Korean exports, EX_{kit}, have positive relationship with the economy size, say $KGDP_t$ and GDP_{it}, and economic openness, FTA_{kit} and negative relationship with distance between two trading countries, DIS_{ki}. It can also be predicted that it has negative relationship with the EPI_{it} of country i, which means that the higher the EPI_{it}

of country i is, the less the Korean exports to country i is since the higher EPI_{it} of country i would imply the more stringency of its environmental regulation and so the higher cost of firms of country i.

We may modify the equation (2) to be more realistic in the following two ways. First, we take into consideration the fact that Korean exports may vary with the relative stringency between Korean and country i's environmental regulation. We include the dummy of EPI, $EPIDUM$, in the equation (2) to examine it. Secondly, it may be interesting to know what relationship the difference in GDP per capita between trade partners would have the trade flows with. So we include the absolute value of difference in GDP per capita between Korea and the country i, $DPGDP_{kit}$ in equation (2), Equations (3) is the modified one of (2).

$$\begin{aligned}\ln EX_{kit} &= \beta_0 + \beta_1 \ln KGDP_t + \beta_2 \ln GDP_{it} + \beta_3 \ln DIS_{ki} + \beta_4 \ln EPI_{it} \\ &\quad + \beta_5 EPIDUM_{it} + \beta_6 FTA_{kit} + \beta_7 \ln DPGDP_{kit}\end{aligned} \tag{3}$$

$EPIDUM_{it}$ is the dummy variable, which shows the relative stringency of environmental regulations between Korea and country i at time t. If the country i's environmental regulation is more stringent than Korea's, then $EPIDUM_{it}$ is one, and zero otherwise. It can be expected that the coefficient β_5 would have a negative value, which implies Korean exports would be smaller for a country of stricter environmental regulation than Korea.

The coefficient of $DPGDP_{kit}$ would have both positive and negative values. If it is positive, it means that Korean exports become larger for the trade partner with larger income difference. But if it has a negative value, the Korean exports would be larger with the country of similar income, which may support the theory of representative demand and intra-industry trade in the international trade theory.

Environmental regulation of country i virtually affects both exports and imports

of the country. It means that the environmental regulations of the country would influence the bilateral trade flow(i.e. total trade volume) between the two countries, which is the sum of Korea's exports and imports. So we modify equation (3) using the total trade volume, TR_{kit} as dependent variable. Then equation (3) becomes equation (4)

$$\begin{aligned}\ln TR_{kit} &= \theta_0 + \theta_1 \ln KGDP_t + \theta_2 \ln GDP_{it} + \theta_3 \ln DIS_{ki} + \theta_4 \ln EPI_{it} \\ &\quad + \theta_5 EPIDUM_{it} + \theta_6 FTA_{kit} + \theta_7 \ln DPGDP_{kit}\end{aligned} \tag{4}$$

where TR_{kit} is total trade volume between Korea and its trade partner i at time t.

The third issue we would like to examine is the effect of environmental regulations of Korea and its trade partners on the international competitiveness of Korea. We test this through the equation (5).

$$\begin{aligned}\ln(EX_{kit}/IM_{kit}) &= \delta_0 + \delta_1 \ln(KGDP_t/GDP_{it}) + \delta_2 \ln(EPI_{it}/KEPI_t) \\ &\quad + \delta_3 \ln(KPGDP_t/PGDP_{it})\end{aligned} \tag{5}$$

Here EX_{kit}/IM_{kit} is Korea's exports per dollar of imports at time t, which stand for the international competitiveness of Korea. If it is larger than one, it can be said that Korea is a net exporter. $KGDP_t/GDP_{it}$ is the Korea's relative GDP to trade partner's at time t. $KEPI_t$ is Korean environmental performance index, so that $EPI_{it}/KEPI_t$ means the relative environmental stringency between the trade partner and Korea at time t. If δ_2 is positive, Korean exports per dollar of imports is meant to increase with a rise in the relative environmental stringency of trade partner's to Korea's, which implies that Korea's international competitiveness relative to trade partners would be strengthened despite the more stringency of trade partner's environmental regulation. $KPGDP_t$ is GDP per capita in Korea,

and $PGDP_{it}$ is GDP per capita in Korea's trade partner i, So $KPGDP_t / PGDP_{it}$ is Korea's relative GDP per capita to trade partner's.

III. Data

We include in our analysis 120 largest importing countries from Korea for the years 2000-2010. We select them after eliminating the countries with deficiencies in data.[2] Among them fourteen countries have Free Trade Agreement with Korea.[3] Data for Korean exports are extracted from UN Comtrade[4], and data for real GDP and GDP per capita of each country from UNCTAD database for the years 2000-2010.[5] The distance between two countries is measured in km between capital cities of two countries, whose data are extracted from CEPII[6]. This paper focuses on product groups of the pollution industries in Korea, which was classified as pollution industries by Low and Yeats(1992).

The Environmental Performance Index(EPI) is used as the proxy variable for the environmental regulation. This index is produced for evaluating environmental improvement performance of countries, by a team of environmental experts at Yale and Columbia University, in collaboration with the World Economic Forum's(WEF) Center on Global Competitiveness and Performance, and released by WEF every year. EPI is a weighted average of 25 indicators representing 10 policy categories of environmental health and ecosystem vitality.[7] The policy categories encompass

2) Those countries encompass the 21 in Asia, 13 in Middle East, 39 in Europe, 3 in North America, 20 in South America, 22 in Africa, 2 in Oceania, etc.

3) They are Brunei, Cambodia, Chile, India, Indonesia, Iceland, Malaysia, Myanmar, Norway, Philippines, Singapore, Switzerland, Thailand, Viet Nam. (Source: Ministry of foreign affairs and trade (http://www.mofat.go.kr))

4) http://comtrade.un.org/

5) UnctadSTAT, http://unctad.org

6) Centered 'Etudes Prospectives et d'Informations internationales

7) It can be found from http://www.weforum.org and Appendix1.

all the important environmental policy targets such as environmental burden of disease, the effects of air pollution and water quality on the human health and ecosystem, and environment state such as biodiversity and habitat, forestry, fisheries and agriculture, and finally climate change including greenhouse gas emissions. It may be reasonably said that EPI would represent a country's degree of environmental regulation under the following assumptions: Business firms would not internalize the externality they generate without any environmental regulation, and would try to respond minimally to the environmental regulation, although there would be some exceptions. In addition, the pollution abatement activities of business firms would influence the cost of production, and thus production and the trade volumes as well as their competitiveness, regardless of whether business firms take pollution abatement actions voluntarily, or in response to the environmental regulation. In this regard this paper uses the EPI as the proxy of environmental regulation. We use EPI for the years 2000-2010.

IV. Empirical Results

The most popular methods for considering an unobserved effect of individual country data that affects dependent variable, i.e. the individual heterogeneity, in the estimation of panel data are the fixed effect model and the random effect model. The choosing criterion for more appropriate model out of these two models is related to whether there exist the correlations between the explanatory variables and unobserved effect. The fixed effect model treats this unobserved effect as a fixed unknown parameters, not random variable. In the process of estimating coefficients in the regression model, we can eliminate this unobserved effect through difference or within transformation. Accordingly the consistency of the estimated coefficients is guaranteed in the fixed effect model even in the case that the explanatory variables are correlated with the unobserved effect. On the other hand, the consistent

estimates can be obtained only with the uncorrelated case between the explanatory variables and the unobserved effect in the random effect model since the model treats the unobserved effect as random variable and assumes the explanatory variables and the unobserved effect are uncorrelated to each other. Accordingly, if the latter assumption is not satisfied, we cannot use the random effect model.

The choice between these two models can be done through the Hausman test. The Hausman test is to test $H_0 : Cov(X_{kit}, \alpha_{kj}) = 0, H_1 : Cov(X_{kit}, \alpha_{kj}) \neq 0$. Here X_{kit} is the explanatory variable, α_{kj} is the unobserved effect of individual country data. If we reject the null hypothesis that the unobserved effect of individual country data and the explanatory variable are uncorrelated to each other, we will choose the fixed effect model, and vice versa. The result of the Hausman test shows that the fixed effect model is more appropriate than the random effect

〈Table 1〉 Pollution Industries

SITC	Commodity	SITC	Commodity
251	Pulp and waste paper	634	Veneers, plywood, particle board, and other wood, works, n.e.s.
322	Briquettes, lignite and peat	635	Wood manufactures, n.e.s.
334	Petroleum oil and oils obtained from bituminous minerals(other than crude)	641	Paper and paperboard
515	Organo-inorgano compounds, heterocyclic compounds, nucleic acids and their salts, and sulphonamides	642	Paper and paperboard, cut to size or shape, and articles of paper or paperboard
516	Other organic chemicals	661	Lime, cement, and fabricated construction materials (except glass and clay materials)
524	Other organic chemicals: organic and inorganic compounds of precious metals	67	Iron and steel
525	Radioactive and associated materials	68	Non-ferrous metals
562	Fertilizers (other than those of group 272)	69	Manufactures of metals, n.e.s.
598	Miscellaneous chemical product, n. e.s.		

Source : Low and Yeats(1992)

model since the null hypothesis is rejected with 1% significance level in our study, so that most of our analyses will be carried with the fixed effect model. As mentioned before, however, we cannot estimate the coefficients of the time-invariant explanatory variables such as distance between two countries with the fixed effect model. So we also tested with the random effect model just for the purpose of examining the distance effect.

We examine Variance Inflation Factor(VIF) through regression analysis among independent variables used in the models to test the multicollinearity problem. The VIFs of most independent variables have the values of a little over one which proves no problem of multicollinearity.[8)]

We now analyze the three issues related to the effect of environmental regulations on the Korean trades: the effect on the Korean exports, the trade flows between the Korea and the trade partners, and the international competitiveness. For all three issues we carried the empirical tests for total industries, non-pollution industries, pollution industries, and also 16 individual pollution industries.[9)]

1. The Effect of the Trade Partner's Environmental Regulation on the Korean Exports

The empirical results for the effect of the trade partner's environmental regulation on the Korean exports are shown in <Table 2>. All variables except FTA and EPIDUM take the log terms, so that the estimated values of their coefficients can be interpreted as export elasticities of the independent variables.

8) It is known that there is no problem of multicollinearity if VIF is less than 5. The VIF of three variables--EPI, EPIDUM, and KPGDP/PGDP, are little over the 2, which does not also show multicollinearity problem.

9) We exclude SITC 322 Briquettes, lignite and peat from our analysis since data for this industry are not available sufficiently for the analysis.

〈Table 2〉 The Effects on the Korean Exports

Variable	Total Industries		Non-pollution Industries		Pollution Industries	
	Fixed	Random	Fixed	Random	Fixed	Random
C	-22.736*** (-11.485)	-18.754*** (-8.682)	-19.696*** (-9.708)	-14.071*** (-6.113)	-44.206*** (-13.038)	-41.159*** (-12.114)
ln(KGDP)	1.732*** (8.327)	2.545*** (19.141)	1.501*** (7.043)	2.216*** (16.264)	4.012*** (11.265)	4.301*** (19.536)
ln(GDP)	1.732*** (12.399)	1.018*** (21.739)	1.751*** (12.233)	1.036*** (20.141)	1.764*** (7.374)	1.201*** (17.336)
ln(DIS)		-0.714*** (-4.073)		-0.593*** (-3.035)		-1.032*** (-4.052)
ln(EPI)	-0.754 (-1.123)	-0.774* (-1.899)	-0.778 (-1.131)	-0.856** (-1.971)	-4.348*** (-3.783)	-1.876*** (-2.980)
EPIDUM	-0.067 (-0.923)	-0.075 (-1.063)	-0.040 (-0.533)	-0.136* (-1.929)	-0.010 (-0.080)	-0.085 (-0.711)
FTA	-0.095 (-1.033)	-0.059 (-0.645)	-0.173* (-1.829)	0.003 (0.034)	0.124 (0.783)	0.191 (1.222)
ln(DPGDP)	0.278*** (4.099)	0.200*** (3.308)	0.263*** (3.784)	0.126** (2.048)	0.413*** (3.557)	0.285*** (2.859)
Observation	1320	1320	1320	1320	1320	1320
Pairs	120	120	120	120	120	120
Adj R^2	0.952	0.580	0.948	0.538	0.919	0.513

( ) t-value, * P<0.1, ** p < 0.05, *** p<0.01

For all three categories of industries considered, GDPs of both Korea and trade partners have positive relationships with Korea's exports, as expected, which is statistically significant at the 1% level of significance. While the effects of Korea's and its trade partners' GDP on Korea's exports look to be similar for both total industries and non-pollution industries, the Korea's GDP has a larger effect on the exports of Korean pollution industries than the GDP of the trade partners.

The differences in GDP per capita between Korea and trade partners have positive relationships with Korean exports for all three categories of total industries, all of which are statistically significant at the 1% level of significance. So it may

be said from these results that the Korea's exports would be larger for the trade partners with greater income differences although their magnitudes are not so big.

EPI of a trade partner has negative relationship with Korean exports for all three categories of total industries. However the negative relationships between trade partner's EPI and Korean exports are statistically significant only for pollution industries, not for total industries and non-pollution industries. This implies that more stringent environmental regulation of the importing country would be a trade barrier to the Korea's exports, especially for the Korean pollution industries. This result would be reinforced with the negative coefficient of EPIDUM. This, however, would not be robust except for the pollution industries since it is statistically significant only for pollution industries.

We have also tested this model for 16 individual pollution industries. It can be seen from <Table A3. 1> that EPIs of the trading partners have negative relationships with Korean exports for 13 industries. But statistical significances of the relationships are shown only for 6 industries among them---Pulp and Waste Paper(SITC 251), Radioactive and Associated Materials(SITC 525), Miscellaneous Chemical Product (SITC 598), Veneers, Plywood, Particle Board, and Other Wood, Works(SITC 634), Iron and Steel(SITC 67), and Manufactures of Metals(SITC 69). These six industries look to be vulnerable to environmental stringency. The result also shows that the more stringent environmental regulation of the trade partners would increase Korean exports of 3 industries such as Petroleum Oil and Oils obtained from Bituminous Minerals(other than crude)(SITC 334), Other Organic Chemicals (SITC 516), and Wood Manufactures(SITC 635). But we cannot say for sure these positive relationships for these industries since they are not statistically significant.

These results are quite different from Oh and Myung(2005), which shows the positive relationship between a country's environmental regulation and Korean exports for the total industries with statistical significance. They argue that the trade partner's stringent environmental regulation would reduce the productivity of their

domestic industries, resulting in an increase in Korean exports to the country. This fact occurred in 13 out of 16 pollution industries as well as in total industries.

FTA did not play an important role with affecting the Korean exports during the periods observed since the coefficients of FTA for all three cases of total industries are very small without statistical significance.

As mentioned before, we cannot include one of the important variables in the gravity model but time-invariant variable, the distance between Korea and a trading partner in fixed effect model. So we tried to test it with random effect model. The result shows that distances have negative relationship with Korean exports for all three categories of industries with statistically significance, as expected.

2. The Effect of the Trade Partner's Environmental Regulations on the Bilateral Trade Flows between Korea and Trade Partners

The empirical results for the effect of the environmental regulation on the bilateral trade flows(i.e. total trade volume) between Korea and its trade partners are shown in <Table 3>.

GDPs of both Korea and trade partners have positive relationships with bilateral trade flows between Korea and its trade partners for all three categories of industries considered, which is statistically significant at the 1% level of significance. Like their effects on the Korea's exports, the effects of Korea's and its trade partners' GDPs on their bilateral trade flows also turn out to be similar for both total industries and non-pollution industries. On the other hand, the Korea's GDP has a very larger effect on the bilateral trade flows of the pollution industries than the GDPs of the trade partners as the former case of export effect.

The differences in GDP per capita between Korea and trade partners have also positive relationships with bilateral trade flows between them for all three categories of total industries with small coefficient value, all of which are

〈Table 3〉 The effects on the Bilateral Trade Flows

Variable	Total Industries		Non-pollution Industries		Pollution Industries	
	Fixed	Random	Fixed	Random	Fixed	Random
C	-21.243*** (-10.717)	-17.048*** (-7.548)	-17.835*** (-9.008)	-14.071*** (-6.113)	-39.346*** (-11.705)	-34.318*** (-10.334)
ln(KGDP)	1.966*** (9.441)	2.387*** (17.636)	1.777*** (8.542)	2.216*** (16.264)	3.255*** (9.217)	3.445*** (15.876)
ln(GDP)	1.410*** (10.079)	1.035*** (20.685)	1.435*** (10.269)	1.036*** (20.141)	1.651*** (6.961)	1.271*** (19.015)
ln(DIS)		-0.626*** (-3.309)		-0.593*** (-3.035)		-1.031*** (-4.205)
ln(EPI)	-0.751 (-1.117)	-0.670 (-1.569)	-0.952 (-1.419)	-0.856** (-1.971)	-2.604** (-2.285)	-0.850 (-1.389)
EPIDUM	-0.278*** (-3.826)	-0.265*** (-3.748)	-0.144** (-1.989)	-0.136* (-1.929)	-0.306** (-2.488)	-0.353*** (-2.990)
FTA	-0.042 (-0.456)	-0.008 (-0.084)	-0.029 (-0.314)	0.003 (0.034)	0.040 (0.255)	0.111 (0.719)
ln(DPGDP)	0.226*** (3.325)	0.171*** (2.789)	0.171** (2.519)	0.126** (2.048)	0.492*** (4.272)	0.380*** (3.883)
Observation	1320	1320	1320	1320	1320	1320
Pairs	120	120	120	120	120	120
Adj R^2	0.955	0.569	0.955	0.538	0.925	0.498

( ) t-value, * P<0.1, ** p < 0.05, *** p<0.01

statistically significant. So these results would imply that the Korean trades be smaller for the trade partners with similar incomes although the GDP difference does not look to be a strong factor affecting the Korean trades.

EPI of a Korea's trade partner has negative relationship with Korea's trade volume with the country for all three categories of industries. As is in the export effect, however, the negative relationships between trade partner's EPI and the trade volume are statistically significant only for pollution industries, not for total industries and non-pollution industries. This implies that the environmental stringency of a Korea's trade partner reduces Korean trade volume with it, especially of the pollution industries. This result would be reinforced for the countries with stricter

environmental regulation, as we can notice from the negative coefficient of EPIDUM. This negative relationship with Korean trades, unlike the former case of export effect, is statistically significant for all three categories of industries.

<Table A3. 2> shows the empirical results for the 16 individual pollution industries. The environmental regulations of the trading partners have negative effects on Korean trades for 11 industries, and positive for 5 industries. But none with the positive effects is statistically significant and 5 industries with the negative effects are statistically significant. The industries with statistical significances are Pulp and Waste Paper(SITC 251), Other Organic Chemicals: Organic and Inorganic Compounds of Precious Metals(SITC 524), Radioactive and Associated Materials (SITC 525), Miscellaneous Chemical Product(SITC 598), and Manufactures of Metals(SITC 69). On the other hand, EPIDUM has a negative relationship with Korean trades for 5 industries and positive one for 11 industries. Only Non-ferrous Metals(SITC 68) among the former is statistically significant, and 4 industries out of the latter 11 industries are statistically significant. They are Other Organic Chemicals(SITC 516), Radioactive and Associated Materials(SITC 525), Paper and Paperboard(SITC 641), and Manufactures of Metals(SITC 69). It is notable that while the relationships of EPI and EPIDUM with trade volume are opposite to each other for the industries--Radioactive and Associated Materials(SITC 525) and Manufactures of Metals(SITC 69), both relationships are positive for Other Organic Chemicals(SITC 516) and Paper and Paperboard(SITC 641). So we can not say for sure whether the environmental stringency has negative or positive effect on Korean trades for the former two industries.

These results imply that Porter Hypothesis does not seem to appear in Korean trades, except two pollution industries--Other Organic Chemicals(SITC 516) and Paper and Paperboard(SITC 641). As we saw, the environmental stringency has negative effect on Korean trades in all categories of total industries. And no individual industry with positive effect shows statistical significance. This would be

the evidence of rejecting Porter Hypothesis in most of the industries in Korea. However it may be said with some reservation that the Porter Hypothesis may occur in Other Organic Chemicals (SITC 516) and Paper and Paperboard(SITC 641), in which both relationship of EPI and EPIDUM with Korean trades are positive although the former one is not statistically significant.

FTA was not also an important factor affecting the Korean trades for the observed periods like its effect on the Korean exports discussed before. Among the 14 FTA countries with Korea, 10 countries with about 70% trade volume to the total trade volume began FTA with Korea since 2009, and 3 countries with about 25% trade volume to the total trade volume since 2006. Taking into consideration the economic downturn and thus a decline in the trade volume of Korea in 2009, the result must be natural. This result would be changed in the future.

As we did for the case of the environmental effect on the Korean exports, we tried to test time-invariant variable, distance, with random effect model. The result shows that distances have negative relationship with Korean trades for all three categories of industries with statistical significance, although the effect was not so large.

3. The Effect of the Trade Partner's Environmental Regulation on the Korean International Competitiveness

The third issue we tested with the equation (5) is the effect of environmental regulations of both Korea and its trade partners on the international competitiveness of Korea. The empirical results for the effect are shown in <Table 4>.

We use the ratio of Korean exports to Korean imports as an index of the Korean international competitiveness, which means Korea's exports per dollar of imports. The Korea's relative GDP to trade partner's(KGDP/GDP) is shown to have a negative relationship with Korea's exports/imports for total industries and a positive

relationship for pollution industries without statistical significance, and negative relationship for non-pollution industries with 5% level of significance. And also the Korea's relative GDP per capita to the trade partner's one(KPGDP/PGDP) has negative relationship with Korea's exports/imports for three categories of industries, but without statistical significance. And the coefficients of both KGDP/GDP and KPGDP/PGDP are all very small for all three categories of industries. This may imply that Korea's relative GDP as well as GDP per capita to the trade partner's ones are not the important factors affecting Korea's international competitiveness.

〈Table 4〉 The Effects on the Korean International Competitiveness (Export/Import)

Variable	Total Industries		Non-pollution Industries		Pollution Industries	
	Fixed	Random	Fixed	Random	Fixed	Random
C	3.930*** (4.387)	0.325 (1.286)	5.530*** (5.878)	0.533** (2.049)	1.039 (0.580)	-0.380 (-1.014)
ln(KGDP/GDP)	-0.739 (-1.469)	0.150 (1.538)	-1.167** (-2.208)	0.149 (1.481)	0.136 (0.131)	0.435*** (3.007)
ln(EPI/KEPI)	3.044*** (2.632)	1.392** (2.002)	2.559** (2.107)	0.750 (1.040)	-6.075** (-2.535)	-1.307 (-1.142)
ln(KPGDP/PGDP)	-0.455 (-0.905)	0.279** (2.295)	-0.639 (-1.210)	0.247** (1.964)	-0.454 (-0.433)	0.370** (2.001)
Obervations	1318	1318	1318	1318	1214	1214
Country Pairs	120	120	120	120	120	120
Adj R^2	0.711	0.012	0.753	0.009	0.629	0.039
Hausman Test $\chi^2(3)$	34.379***		55.203***		8.489**	

( ) t-value, * P<0.1, ** p < 0.05, *** p<0.01

The relative environmental stringencies of the trade partners to Korea are shown to have positive relationships with Korea's international competitiveness index, exports/imports, for total industries and non-pollution industries, and negative relationship with it for pollution industries, all with 5% or 1% significance levels.

The former result implies that the stricter environmental regulations of Korea's trade partners increase the international competitiveness of the non-pollution industries as well as total industries of Korea. This, however, does not seem to support the Porter Hypothesis, taking into consideration the environmental stringency effect on Korean trade volume. Rather, it seems to imply that the stringent environmental regulations of trade partners would weaken the competitiveness of their domestic firms more than the Korean exporting non-pollution firms. The latter result would be more obvious in the sense that the relative environmental stringency of the trade partners to Korea would reduce the international competitiveness of Korean pollution industries.

It is also found from <Table A3. 3> that the stricter environmental regulation of the trade partners weaken the international competitiveness of all Korean pollution industries except two industries--Wood Manufactures(SITC 635) and Manufactures of Metals(SITC 69)[10]. But this result is statistically significant only for 6 industries --Organo-inorgano Compounds, Heterocyclic Compounds, Nucleic Acids and Teir Salts, and Sulphonamides(SITC515), Other Organic Chemicals(SITC516), Radioactive and Associated Materials(SITC 525), Miscellaneous Chemical Product(SITC 598), Lime, Cement, and Fabricated Construction Materials(except Glass and Clay Materials) (SITC 661), Iron and Steel(SITC 665). It would be said that these industries are very vulnerable to environmental stringency of importing countries.

V. Concluding Remarks

This paper has discussed the issue of the effect of a country's environmental regulations on the international competitiveness and trade flows, with the case between Korea and its trade partners and gravity equation model. This issue is

10) The positive relationship between EPI/KEPI and EX/IM are not statistically significant for these two exceptional industries.

directly or indirectly related to the controversial Porter Hypothesis insisting the positive relationship between the environmental regulation and trade flows.

This paper tried to examine three issues related to the effect of environmental regulation--that is, how the trade partner's environmental regulation affects the Korea's exports to it, trade flows between Korea and trade partners, and Korea's relative competitiveness with the trade partner. We tested these three issues with three categories of industries--total industries, non-pollution industries, and pollution industries, and 16 individual pollution industries.

We used three gravity equations modified for our purpose and fixed effect model for most of our analyses. We used industry panel data for the 120 largest trading countries with Korea for the years 2000-2010. The Environmental Performance Index(EPI) is used as the proxy variable for the environmental regulation.

Important findings are the following.

First, GDPs of both Korea and its trading partners are very important factors affecting positively the Korean exports and total trades for all industries including both pollution and non-pollution industries. And the Korean exports as well as total trade volume would be larger for the trade partners with greater income differences although their magnitudes are not so big. In addition, FTA did not play an important role with affecting the Korean trades.

Second, both the relative GDP and GDP per capita of Korea to its trade partner were not also influential factors to Korean international competitiveness for most industries.

Third, the environmental regulation of the importing country are shown to be a definite trade barrier to the exports of the Korean pollution industries, but not definite one for the other non-pollution industries. The similar results are shown for the effect on the total trade volume between Kora and its trading partners. That is the negative relationships between trade partner's EPI and the trade volume are statistically significant only for pollution industries.

Fourth, the stricter environmental regulations of Korea's trade partners would reduce the international competitiveness of Korean pollution industries and would increase the international competitiveness of the Korean non-pollution industries. This, however, does not seem to support the Porter Hypothesis, but rather, the stricter environmental regulations of trade partners would weaken the competitiveness of their domestic firms more than the Korean exporting non-pollution firms.

The effects of the environmental regulations on the individual pollution industries would vary with their characteristics and situations in terms of cost, market and environmental regulation, etc. But one thing we can say definitely from this study is that the environmental regulations would affect considerable portion of pollution industries negatively for the international competitiveness. In this regard the Porter Hypothesis would have not appeared in the Korean trade flows of pollution industries, except a few pollution industries, during the period observed in this study.

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〈Appendix 1〉 Components of Environmental Performance Index

Objectives (weights: % of EPI)	Policy Categories (weights: % of EPI)	Indicators
Environmental Health (50)	Environmental burden of disease (25)	Environmental burden of disease
	Air pollution: effects on humans (12.5)	Indoor air pollution
		Outdoor air pollution
	Water: effects on humans (12.5)	Access to water
		Access to sanitation
Ecosystem Vitality (50)	Air Pollution: effects on ecosystem (4.2)	Sulfur dioxide emissions per populated land area
		Nitrogen oxides emissions per populated land area
		Non-methane volatile organic compound emissions per populated land area
		Ecosystem ozone
	Water: effects on ecosystem (4.2)	Water quality index
		Water stress index
		Water scarcity index
	Biodiversity & Habitat (4.2)	Biome protection
		Marine protection
		Critical habitat protection
	Forestry (4.2)	Growing stock change
		Forest cover change
	Fisheries (4.2)	Marine trophic index
		Trawling intensity
	Agriculture (4.2)	Agricultural water intensity
		Agricultural subsidies
		Pesticide regulation
	Climate Change (25)	Greenhouse gas emissions per capita (including land use emissions)
		CO2 emissions per electricity generation
		Industrial greenhouse gas emissions intensity

〈Appendix 2〉 EPI by country

Country	2000	2005	2010	AVG	Country	2000	2005	2010	AVG
Switzerland	76.17	77.28	76.69	77.18	Côte d'Ivoire	51.36	52.70	53.55	52.67
Norway	68.13	70.19	69.92	69.55	Ethiopia	51.57	53.47	52.71	52.53
Luxembourg	68.82	68.52	69.20	68.72	Dominican Rep.	50.70	52.61	52.44	52.41
Costa Rica	65.96	69.02	69.03	68.33	Myanmar	50.92	52.54	52.72	52.30
Austria	67.88	67.99	68.92	68.27	El Salvador	50.72	52.28	52.08	51.76
Latvia	63.80	69.81	70.37	68.07	Belarus	49.36	51.00	53.88	51.59
Italy	63.24	68.92	68.90	67.96	Paraguay	48.90	52.00	52.40	51.25
Sweden	66.36	67.32	68.82	67.34	Zimbabwe	49.47	50.25	52.76	50.74
France	62.30	67.92	69.00	66.90	Honduras	49.35	49.75	52.54	50.44
Germany	66.80	66.53	66.91	66.62	Saudi Arabia	50.97	50.37	49.97	50.41
United Kingdom	61.24	68.05	68.82	66.37	Benin	49.65	50.48	50.38	50.24
Iceland	63.95	64.77	66.28	64.93	Peru	46.66	51.71	50.29	50.17
Netherlands	64.06	64.75	65.65	64.81	Guatemala	47.53	51.82	51.88	50.15
Lithuania	61.89	64.79	65.50	64.11	Indonesia	47.48	49.76	52.29	49.97
Slovakia	60.09	64.02	66.62	63.77	Viet Nam	48.39	49.63	50.64	49.69
New Zealand	59.32	61.84	66.05	63.43	United Arab Emirates	43.98	50.52	50.91	49.63
Poland	62.02	62.52	63.47	63.21	Kenya	46.86	48.89	49.28	48.89
Finland	62.22	62.96	64.44	62.79	Algeria	46.81	48.96	48.56	48.45
Czech Rep.	60.52	62.96	64.79	62.73	Malta	47.85	47.77	48.51	47.71
Brunei	62.16	62.76	62.49	62.55	Togo	46.56	47.74	48.66	47.71
Japan	59.68	62.60	63.36	62.30	Congo	46.82	48.11	47.18	47.60
Denmark	60.88	63.01	63.61	62.24	Lebanon	47.37	47.83	47.35	47.40
Croatia	60.79	61.48	64.16	61.86	Mozambique	47.22	47.10	47.82	47.32
Malaysia	59.70	61.90	62.51	61.54	Mexico	43.28	47.36	49.11	46.74
Belgium	53.26	62.38	63.02	61.18	Senegal	46.43	45.73	46.73	46.64
Colombia	58.32	61.88	62.33	60.89	Russia	49.28	46.06	45.43	46.58
Slovenia	56.55	61.24	62.25	60.31	Ukraine	46.68	45.61	46.31	46.50
Ecuador	58.42	58.59	60.55	58.71	Kyrgyzstan	46.15	46.68	46.33	46.50
Greece	55.80	58.80	60.04	58.32	Qatar	46.11	46.42	46.59	46.30
Brazil	54.54	58.42	60.90	58.04	Angola	42.79	47.25	47.57	45.95
Spain	55.92	57.60	60.31	57.97	Ghana	44.98	46.65	47.50	45.66
Nicaragua	55.46	59.06	59.23	57.95	Tunisia	43.60	45.82	46.66	45.59
Uruguay	56.27	58.04	57.06	57.90	Trinidad and Tobago	43.34	45.54	47.04	45.48
Thailand	54.45	57.74	59.98	57.28	Romania	42.01	45.30	48.34	44.98
Canada	55.64	56.94	58.41	56.98	Morocco	42.97	44.74	45.76	44.83
Panama	56.44	57.63	57.94	56.97	Fmr Sudan	43.81	43.86	46.00	44.39
Cyprus	56.24	57.45	57.15	56.90	Oman	43.52	44.27	44.00	43.93
Ireland	54.42	57.02	58.69	56.83	Mongolia	41.77	43.68	45.37	43.76
Australia	56.33	56.40	56.61	56.73	Turkey	40.47	43.50	44.80	43.18
Estonia	55.62	55.96	56.09	56.17	Cameroon	41.85	42.75	42.97	42.88
Georgia	53.63	56.22	56.84	56.07	Iran	40.62	42.97	42.73	42.45
USA	54.27	55.43	56.59	55.49	China	41.24	41.92	42.24	42.14

Country	2000	2005	2010	AVG	Country	2000	2005	2010	AVG
Gabon	49.99	56.30	57.91	55.44	Syria	40.68	42.18	42.75	41.94
Hungary	52.36	56.50	57.12	55.33	Jordan	39.73	41.15	42.16	41.00
Singapore	52.82	55.58	56.36	55.30	Bangladesh	38.23	40.49	42.55	40.37
South Korea	52.15	56.04	57.20	55.20	Haiti	39.19	40.34	41.15	40.22
Chile	53.24	55.24	55.34	54.89	Azerbaijan	33.66	40.00	43.11	39.54
Venezuela	53.41	55.22	55.62	54.77	Pakistan	35.25	39.28	39.56	38.67
Israel	54.07	54.95	54.64	54.59	Nigeria	37.34	38.52	40.14	38.63
Bolivia	54.33	54.76	54.57	54.53	Bosnia Herzegovina	37.91	38.94	36.76	38.34
Nepal	50.86	52.80	57.97	54.49	Tajikistan	35.58	37.93	38.78	37.51
Portugal	51.65	52.80	57.64	54.37	Eritrea	34.83	37.21	38.39	36.79
Argentina	51.73	53.83	56.48	54.33	Libya	34.53	37.02	37.68	36.64
Zambia	53.57	51.99	55.56	54.15	Kuwait	37.26	36.05	35.54	36.38
Philippines	50.39	54.60	57.40	54.07	India	35.32	35.72	36.23	35.84
Bulgaria	48.65	54.31	56.28	53.97	South Africa	33.76	33.95	34.55	34.54
Cambodia	52.63	53.08	55.29	53.49	Yemen	32.70	34.29	35.49	34.17
Egypt	48.34	54.02	55.18	53.23	Kazakhstan	34.63	32.81	32.94	33.21
Tanzania	51.89	51.89	54.26	53.05	Uzbekistan	29.12	31.12	32.24	30.81
Sri Lanka	49.73	53.14	55.72	52.98	Iraq	25.58	25.93	25.32	25.52
Jamaica	51.97	53.01	54.36	52.84					

〈Appendix 3〉 The Results by Individual industry (Fixed Effect Model)

〈Table A3. 1〉 The Effects on the Korean Exports

Variable	SITC 251	SITC 334	SITC 515	SITC 516	SITC 524	SITC 525	SITC 562	SITC 598
C	22.308 (0.697)	-101.984*** (-8.193)	-2.794 (-0.461)	-60.936*** (-8.393)	-21.165** (-2.185)	-20.511 (-0.710)	-60.137*** (-3.299)	-55.243*** (-11.230)
ln(KGDP)	5.455 (1.180)	8.007*** (5.402)	1.424* (1.862)	3.038*** (3.393)	4.417*** (3.877)	5.113 (1.615)	9.615*** (3.019)	4.861*** (8.761)
ln(GDP)	1.027 (0.421)	0.252 (0.262)	0.195 (0.353)	1.469** (2.367)	-0.356 (-0.419)	3.037 (1.089)	-3.823** (-2.341)	1.692*** (4.537)
ln(EPI)	-34.913** (-2.556)	0.790 (0.188)	-0.648 (-0.301)	3.231 (1.243)	-4.799 (-1.390)	-17.372* (-1.711)	-2.955 (-0.365)	-4.181** (-2.403)
EPIDUM	1.681* (1.898)	-0.187 (-0.412)	-0.032 (-0.145)	0.411 (1.479)	0.097 (0.261)	1.369* (1.856)	-0.540 (-0.808)	0.168 (0.949)
FTA	0.787 (1.001)	-0.029 (-0.054)	-0.656*** (-2.615)	-0.130 (-0.442)	-0.098 (-0.275)	0.319 (0.500)	0.093 (0.165)	-0.296 (-1.333)
ln(DPGDP)	3.877** (2.242)	0.036 (0.084)	-0.370** (-2.006)	0.107 (0.483)	-0.433 (-1.455)	-1.115 (-0.378)	-0.056 (-0.075)	-0.056 (-0.346)
Obsertion	151	821	805	673	523	189	263	1215
Country Pairs	39	107	101	95	82	39	60	120
Adj R^2	0.639	0.725	0.821	0.798	0.756	0.571	0.776	0.852
H-T $\chi^2(6)$	29.174***	22.340***	16.298**	12.961**	26.958***	14.589**	9.010	48.932***

Variable	SITC 634	SITC 635	SITC 641	SITC 642	SITC 661	SITC 67	SITC 68	SITC 69
C	4.281 (0.334)	17.221* (1.692)	-56.558*** (-9.462)	-2.473 (-0.423)	6.389 (0.439)	-60.727*** (-11.548)	-35.181*** (-5.330)	-28.326*** (-7.223)
ln(KGDP)	1.450 (0.931)	-3.070*** (-2.665)	4.140*** (6.073)	-0.188 (-0.289)	-1.988 (-1.193)	5.217*** (9.347)	2.561*** (3.428)	2.146*** (5.175)
ln(GDP)	0.578 (0.543)	3.820*** (4.570)	0.983** (2.107)	2.001*** (4.629)	3.943*** (3.585)	1.436*** (3.832)	1.827*** (3.625)	2.235*** (7.985)
ln(EPI)	-7.182* (-1.760)	0.312 (0.091)	-0.672 (-0.322)	-0.260 (-0.129)	-5.516 (-1.165)	-3.588** (-1.990)	-2.307 (-1.018)	-2.909*** (-2.189)
EPIDUM	-0.128 (-0.259)	-0.331 (-0.795)	0.442** (2.067)	-0.008 (-0.038)	-0.003 (-0.006)	-0.169 (-0.866)	-0.086 (-0.353)	0.343** (2.381)
FTA	0.233 (0.491)	0.138 (0.366)	-0.666** (-2.521)	-0.346 (-1.304)	0.194 (0.348)	-0.287 (-1.210)	-0.187 (-0.642)	-0.004 (-0.023)
ln(DPGDP)	0.838 (1.540)	-1.199*** (-2.999)	0.527*** (2.765)	-0.483** (-2.454)	0.798 (1.076)	0.353** (2.015)	0.251 (1.193)	0.082 (0.619)
Obsertion	470	695	1165	1209	582	1222	1106	1306
Country Pairs	87	111	119	120	103	120	120	120
Adj R^2	0.585	0.657	0.813	0.776	0.586	0.854	0.828	0.885
H-T $\chi^2(6)$	16.374**	24.786***	11.204**	36.552***	23.904***	16.467**	13.652**	29.083***

( ) t-value, * p<0.1, ** p < 0.05, *** p<0.01

〈Table A3. 2〉 The effect on the Trade Flows

Variable	SITC 251	SITC 334	SITC 515	SITC 516	SITC 524	SITC 525	SITC 562	SITC 598
C	-21.078* (-1.876)	-68.566*** (-6.233)	8.024 (1.230)	-45.507*** (-7.434)	-4.996 (-0.707)	-19.130 (-1.220)	-20.537 (-1.452)	-48.968*** (-10.445)
ln(KGDP)	3.971*** (3.372)	7.619*** (6.047)	1.338* (1.654)	2.070*** (2.814)	3.397*** (4.068)	5.086*** (3.145)	-0.135 (-0.090)	3.702*** (6.998)
ln(GDP)	1.775* (1.897)	-0.688 (-0.818)	-0.819 (-1.381)	1.699*** (3.224)	-0.506 (-0.794)	-1.020 (-0.743)	1.830* (1.762)	2.224*** (6.194)
ln(EPI)	-10.205*** (-2.876)	-3.500 (-0.934)	0.510 (0.218)	1.609 (0.735)	-5.126** (-2.123)	-7.982* (-1.729)	4.567 (1.010)	-3.329** (-1.998)
EPIDUM	0.267 (0.716)	-0.036 (-0.091)	0.042 (0.171)	0.611*** (2.627)	-0.419 (-1.480)	1.124** (2.421)	-0.308 (-0.640)	0.208 (1.241)
FTA	-0.373 (-1.028)	0.231 (0.495)	-0.161 (-0.597)	0.074 (0.307)	0.248 (0.906)	0.564 (1.181)	0.375 (0.814)	-0.106 (-0.505)
ln(DPGDP)	-0.067 (-0.198)	0.105 (0.276)	-0.561*** (-2.722)	0.328* (1.698)	-0.239 (-1.169)	0.730 (0.850)	-0.548 (-1.177)	0.030 (0.197)
Obsertion	500	948	893	743	620	361	515	1242
Country Pairs	79	114	105	100	93	56	79	120
Adj R^2	0.798	0.752	0.835	0.881	0.843	0.772	0.715	0.665
H-T $\chi^2(6)$	20.048***	22.135***	19.702***	13.750**	26.383***	11.381*	5.142	39.783***

Variable	SITC 634	SITC 635	SITC 641	SITC 642	SITC 661	SITC 67	SITC 68	SITC 69
C	15.727* (1.838)	4.842 (0.593)	-57.738*** (-10.041)	-15.108** (-2.576	-5.160 (-0.454)	-54.377*** (-10.406)	-32.778*** (-5.055)	-26.578*** (-6.733)
ln(KGDP)	-0.127 (-0.131)	-1.523* (-1.682)	2.961*** (4.527)	1.062 (1.646)	-0.445 (-0.351)	4.646*** (8.369)	2.355*** (3.333)	2.234*** (5.375)
ln(GDP)	1.193* (1.715)	2.599*** (4.137)	1.500*** (3.327)	1.204*** (2.780)	3.174*** (3.657)	0.858** (2.300)	1.795*** (3.801)	2.291*** (8.184)
ln(EPI)	-4.542 (-1.603)	0.114 (0.039)	2.194 (1.092)	-0.005 (-0.002)	-4.066 (-1.057)	-1.302 (-0.725)	-2.314 (-1.064)	-3.726*** (-2.789)
EPIDUM	0.301 (0.959)	0.271 (0.875)	0.406** (1.974)	0.214 (0.985)	0.344 (0.780)	-0.197 (-1.009)	-0.426* (-1.792)	0.299** (2.064)
FTA	-0.139 (-0.436)	-0.283 (-0.840)	-0.616** (-2.422)	-0.18 (-0.691)	0.142 (0.318)	0.123 (0.518)	-0.054 (-0.182)	0.105 (0.573)
ln(DPGDP)	0.272 (0.946)	-0.421 (-1.504)	0.591*** (3.201)	-0.098 (-0.501)	0.284 (0.719)	0.280 (1.597)	0.489** (2.287)	0.071 (0.531)
Obsertion	748	823	1185	1227	773	1241	1163	1309
Country Pairs	107	115	119	120	112	120	120	120
Adj R^2	0.791	0.767	0.837	0.809	0.623	0.863	0.839	0.891
H-T $\chi^2(6)$	14.189**	18.019***	15.899**	20.625***	16.259**	13.245**	15.360**	27.597***

( ) t-value, * p<0.1, ** p < 0.05, *** p<0.01

〈Table A3. 3〉 The Effects on the Korean International competitiveness (Export/Import)

Variable	SITC 251	SITC 334	SITC 515	SITC 516	SITC 524	SITC 525	SITC 562	SITC 598
C	4.640 (1.328)	0.334 (0.141)	3.703*** (2.792)	-0.973 (-1.033)	1.099 (1.261)	-5.000 (-1.140)	-3.656* (-1.823)	4.209** (2.274)
ln(KGDP/ GDP)	3.526 (0.649)	-6.372*** (-3.046)	-7.221*** (-3.531)	1.762 (0.762)	-13.453*** (-2.849)	-3.664 (-0.293)	-3.973 (-0.999)	-1.569 (-1.085)
ln(EPI/KEPI)	-2.236 (-0.160)	-5.532 (-0.897)	-6.369** (-1.995)	-10.189*** (-2.737)	-3.791 (-0.726)	-22.233** (-2.219)	-3.919 (-0.374)	-8.237*** (-2.858)
ln(KPGD/ PGDP)	-10.471** (-2.174)	9.015*** (4.353)	6.575*** (3.620)	-1.366 (-0.661)	15.685*** (3.401)	-1.787 (-0.140)	7.141** (2.166)	-0.076 (-0.058)
Obsertion	110	482	465	390	287	115	161	754
Country Pairs	27	85	64	60	44	21	38	112
Adj R^2	0.717	0.677	0.727	0.736	0.723	0.733	0.805	0.773
H-Test $\chi^2(6)$	12.932***	21.009***	15.544***	1.331	16.547***	16.019***	5.527	11.335**

Variable	SITC 634	SITC 635	SITC 641	SITC 642	SITC 661	SITC 67	SITC 68	SITC 69
C	-5.109*** (-3.595)	6.048*** (3.618)	-2.275 (-1.432)	4.638** (2.554)	-1.435 (-0.891)	1.415 (0.840)	-3.851* (-1.955)	3.442** (2.099)
ln(KGDP/ GDP)	-1.874 (-0.388)	-8.771*** (-4.153)	5.797*** (3.062)	-1.184 (-0.774)	-0.900 (-0.223)	2.125 (1.570)	3.144* (1.861)	-0.462 (-0.463)
ln(EPI/ KEPI)	-6.569 (-1.283)	2.398 (0.594)	-4.284 (-1.240)	5.492 (1.611)	-23.986*** (-3.980)	-9.526*** (-3.119)	-3.163 (-0.987)	0.842 (0.352)
ln(KPGD/ PGDP)	3.978 (0.829)	5.952*** (2.989)	-4.832*** (-2.932)	-0.529 (-0.370)	-0.348 (-0.090)	-4.481*** (-3.476)	-2.485 (-1.620)	0.744 (0.752)
Obsertion	290	493	546	696	330	731	737	1029
Country Pairs	53	76	80	100	56	98	103	118
Adj R^2	0.705	0.582	0.810	0.675	0.687	0.746	0.672	0.671
H-Test $\chi^2(6)$	3.995	22.121***	12.647***	16.608***	8.880**	18.360***	3.952	5.183

( ) t-value, * p<0.1, ** p < 0.05, *** p<0.01