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The Effects of Korean Domestic Environmental Regulations on Trade Performance: Evidence from Korean Manufacturing Industries

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이 연구는 환경규제가 무역에 미치는 영향에 대해 실증분석하는 것을 목적으로 한다. 환경규제는 기업에게 비용으로 작용하여 기업의 경쟁력에 부정적인 영향을 미친다는 의견과 기업에게 혁신을 초래하여 경쟁력을 강화시킨다는 의견이 존재하지만 무역과 같은 거시적 수준에 대한 연구는 부족한 실정이다. 이 연구는 한국을 대상으로 분석하였으며 자료의 범위는 2006년부터 2014년까지이다. 패널다이나믹 모델과 difference-GMM to estimation을 활용하여 분석한 결과 환경규제는 무역에 부정적인 영향을 미치는 것으로 나타났다. 이는 한국의 환경규제가 명령과 통제중심의 환경규제로 인하여 나타난 결과로 해석하고 있다.

핵심어: 환경규제, 무역, 패널다이나믹 모델, general method of moment

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I. Introduction

With scarce resources and a dense population, Korea has placed particular emphasis on the expansion of exports since the early 1960s to overcome poverty and accelerate economic growth. The Asian financial crisis in 1997-98 cast new light on increasing exports. Before the crisis, it was thought that only an increase in exports could lead to the development of the Korean economy. The shortage of foreign exchange holdings at the time of the crisis, however, threw emphasis on the level of net exports (trade performance). It was believed that even though exports were growing annually, a faster import growth might have a negative effect on the sustainable growth of the Korean economy. Thus, after the crisis, aiming for trade surpluses became a major constituent of trade policies. Meanwhile, some analyses and studies[1)] were apprehensive of the increasing stringency of environmental regulations in Korea. In particular, there were concerns that such restrictions could negatively affect the achievement of the Korean Government's trading aims: export expansion and trade surpluses. Environmental regulations on economic activity remains an important academic issue (Kahouli and Omri, 2017).

In this study, we analysed the impact of environmental stringency on

1) Korean Prime Minister's Office (2015, 2016), Lim (2004), Lim & Oh (2007).

Korean trade performance. This approach suggests two further studies. This study tests the relationship between the Korean domestic environmental regulations and trade performance. The main aim of this analysis is to show whether or not domestic environmental restrictions have a significant effect on Korean trade performance. The outcome of this work should provide important information for establishing appropriate trade and economic policies.

In the Korean case, few studies deal with the relationship between the domestic environmental regulations and Korean trade. Kim (1997, 2001, 2004) studied the relationship by using only cross-sectional data and found a negative influence of environmental regulations on Korean export. Song and Sung (2014) analyzed the relationship in terms of thirteen industries using panel data from 1991-2009; they established a dynamic equation using pollution abatement capital expenditure which they created. Employing difference-GMM of Arellano and Bond (1991) found that environmental stringency has a positive effect on Korean export, thus, supporting the Porter Hypothesis[2].

Considering data structures, this study establishes a dynamic panel model using environmental protection expenditure (EPE) which is officially surveyed by the Ministry of Environment. The time period for analysis is 2006 to 2014 because the strength of environmental stringency has increased since 2000s. The number of environmental regulations expanded from 569 in 2009 to 848 in 2014; the growth rate (19.1%) exceeded the rate of increase of total governmental regulations (15.9%) by 3.2% during the period. This period is important to analyse the effects of Korean domestic environmental regulations on Korean trade performance

2) Porter Hypothesis argues that environmental regulations have a positive influence on productivity by inducing innovation, thereby leading to increased competitiveness.

considering the strength of environment stringency.

This study is ordered as follows. Section 2 conducts a review of the extant literature that report research on the effects of trade determinants, including stringent environmental regulations on trade. Section 3 explains the dynamic panel model and estimation methods. Section 4 describes a panel data-set consisting of nine sectors. Section 5 presents the results of the estimations and finally, section 6 puts forward the conclusion including policy suggestions for the Korean Government.

II. Literature Review

Analyzing the relation between environmental regulation and trade performance can be considered as a process of carrying out empirical tests and checking their trade outcome, where green regulatory costs might increase the production cost of regulated firms, resulting in an elevated price of their goods and a potential reduction in their trade competitiveness. This approach claims that environmental regulations have negative impact on economic activities. The rational is that environmental policies levy additional costs on production and lead to a slowdown in economic activities (Ederington and Minier, 2003; Kalt,1988; Kim and Choi, 2013; Gray and Shadbegian, 2003; Greenstone et al., 2012; Lee, 2013). Expanding this view to international trade, it is plausible to understand that firms will be incentivized to begin production in the country with relatively weaker environmental regulations and firms will become concentrated in such regions or countries where environmental regulations are weak (Copeland and Taylor, 2004). For example, Kalt (1988) regarded domestic environmental regulation as one of the determinants of trade. That is, governmental environmental intervention levies additional production costs on the regulated firms, resulting in higher costs, which could hamper the competitiveness of the affected companies in export markets. Kalt (1988) borrowed the frameworks developed by Branson and Monoyios (1977) and Stern and Maskus (1981) to establish a trade component model that included environmental regulation. Kalt(1988) added pollution abatement costs as a proxy variable of the stringency of environmental intervention into the four-factor trade model. The results showed that the environmental regulatory costs negatively and significantly affected the US's net export figures. In addition, using the method proposed by Leamer (1980), based on Vanek's generalised Hecksher-Ohlin theorem, Kalt(1988) found that, in 1977, the environmental resources in the US were an insufficient factor relative to other input factors. Thus, environmental regulation was regarded as a source of comparative disadvantage in the US. Kalt's model might be reasonable, because the introduction of pollution abatement costs did not contravene the widespread research results concerning the character of unskilled labour, capital, human capital, and R&D as determinants of trade structure. The cost caused by the new regulations should be separable from other capital costs directly linked to production.

Kim and Choi (2013) analysed 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, this research carried the empirical tests with fixed effect estimation methods for total industries, non-pollution industries, pollution industries, and also 16 individual pollution industries. The Environmental Performance Index (EPI) is used as the proxy variable for the environmental regulation. The empirical result shows that the environmental regulation of the importing country would be a definite trade barrier to the Korean pollution industries.

Levinson and Taylor (2008) established a theoretical estimation model to analyse the influence of the stringency of environmental regulations on trade flows. In the model, they assume that even though pollution is produced as a by-product, the output can be a Cobb-Douglas framework of pollution and production factors (i.e., labour and capital), since companies distribute some of their factors to abate the pollution. Therefore, production costs also consist of pollution abatement and factor costs. They thought that if a home country's cost is less than the foreign country's cost, then the home country will produce and export more, and so they derived a criteria point to determine the level of exports and imports which was dependent on the costs and environmental regulations of the home and foreign countries. They also assumed that the pollution abatement costs are endogenous. Then, they employed income and pollutant emissions as instrumental variables and showed that there is positive relationship between pollution abatement costs and net imports. It is worth noting that they also provided a theoretical model for testing the pollution haven effect.

Ederington and Minier (2003) hypothesised that environmental restrictions could serve as a second trade barrier. That is, they believed that just as trade is a function of environmental regulations, the stringency of the environmental control measures is dependent on trade performance. Thus, unlike previous studies that regarded the policies as exogenous, Ederington and Minier (2003) considered that the stringency of the environmental control measures could be decided endogenously. Moreover, to capture the unobservable effects, they employed panel data.

Through this new approach, Ederington and Minier(2003) showed that there is a positive relationship between net imports and the stringency of environmental policies. Thus, they showed that environmental regulations could be endogenous and that some dummy variables (i.e., industry and time) should be included to capture the unobservable effects, which could otherwise distort the estimation if not captured.

The second position is based on Porter Hypothesis (Porter and van der Linde, 1995). The logic underlying this view is that environmental regulations have a positive influence on productivity by inducing innovation, leading to competitiveness advantage. Based on this proposition, environmental regulations will increase firms' competitiveness and lead to expansion of exports. For example, Song and Sung (2014) tried to analyse the relationship between stringency of domestic (Korean) environmental regulations and Korean export performance in terms of thirteen industries. Using panel data from 1991-2009, they established a dynamic equation assuming that filed lagged trade performance has an influence on present trade results. The model consisted of pollution abatement capital expenditure (costs of installing equipment for preventing pollution), physical capital, and human capital as explanatory variables. Employing difference-GMM of Arellano and Bond (1991), they found that environmental stringency has a positive effect on Korean export, thus, supporting the Porter Hypothesis. It is notable that unlike previous Korean studies dealing with partial equilibrium analysis, they used panel data, established a dynamic model, and then apply difference-GMM to consider the unobserved characteristics, dynamic adjustment of economic activity, and endogenous problems. Pollution abatement capital cost however, is artificially created by authors. Specifically, they use the 5-year interval survey data collecting investment plan and then multiply this data by capital price[3] related to environmental capital, which is obtained by dividing net value-added by the real value of tangible assets (Lee, 2007, 2011[4]). That is, unlike pollution abatement cost of the US, the cost is not officially announced by the Korean Government. In addition, it does not reflect operation costs for environmental equipment. It therefore is likely that the cost could not comprehensively represent a burden which Korean industries face.

However, other studies indicate that an economic growth can stimulate demand for environmental quality, that is, the extent to which environmental stringency is driven by economic growth. In an attempt to deal with this issues, Antweiler et al. (2001) showed that environmental regulations are affected by trade flow. Their original research aim was to investigate whether or not international trade had an effect on pollution intensity. They utilised an improved theoretical model to classify the influence of international trade on sulphur dioxide intensity into scale, composition, and technique effects and estimated the theoretical equation by employing panel data, which allowed them to analyse the scale and technique effects separately. They showed that a trade-induced expansion of economic activity (i.e., a scale effect) and an increase in the capital ratio to labour (i.e., a composition effect) could lead to an increase in the pollution intensity, while trade-raised increase of GDP per person lead to stricter environmental regulations, resulting in a reduction in pollution emission intensity (i.e., a technique effect). Overall, the mixed effect result says that trade liberalisation is good for the environment.

3) Physical capital is created by similar method to calculation of pollution abatement capital costs.
4) Lee (2007, 2011) analysed the effects of environmental regulations on Korean manufacturing productivity and showed how to calculate physical capital and pollution abatement capital costs.

Through literature review, we refer that the effect of environmental policies on macroeconomic such as trade is far from clear. One additional complication for empirical analysis is the potential reverse causality. However, this study aims to analyse the effect of environmental restrictions on Korea trade performance and refers to the component of Levinson and Taylor(2008) and Song and Sung (2014). Specifically, trade performance (export/import ratio) will be the dependent variable. Lagged dependent variable, traditional factors (physical and human capital), tariff, and some factors which might affect trade intuitionally will be included as explanatory variables. In terms of estimation method, to deal with a dynamic panel equation, a different GMM will be used. Then to test the appropriateness of the model, overidentification and Arellano-Bond tests will be done.

III. Environment policy in Korea

After the end of the Korean War, the society of South Korea began a massive shift from agrarian to industrial, and the most important target of the Korean Government was economic growth. On the base of relative cheaper product factors (i.e., labour), the Government strived for industrialization at the expense of environment. Once a fledgling industrial nation, South Korea's economy grew 10% each year through the 1980's and 1990s, driven by large export-oriented manufacturing sector.

As South Korea became a developed economy, the country's priorities have changed. As a result, South Korean government has passed numerous environmental laws in1988-99, dealing with various causes of contamination. These include: the Environmental Policy Act; the Clean Air

Conservation Act; the Water Quality & Aquatic Ecosystem Conservation Act; the Waste Control Act; the Noise-Vibration Regulation Act; the Toxic Chemicals Control Act; and the Environmental Dispute Mediation & Arbitration Act.

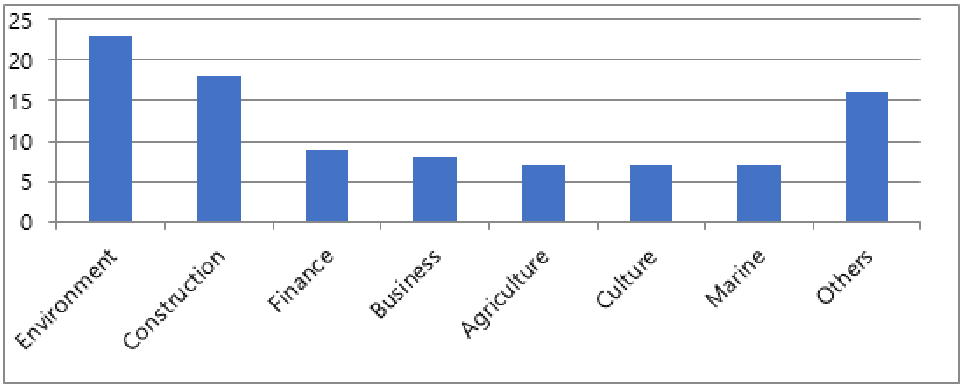
Koreas' level of interest in environmental issues has fluctuated but is generally increasing. In 2000s, the strength of environmental stringency has been increased. In January, 1990, Environment Administration was promoted to the Ministry of Environment under the Office of Prime Minister, in order to efficiently integrate and coordinate environmental issues. In December, 1994, the Ministry of Environment was given greater authority to establish and implement its own policies. The number of environmental regulations expanded from 712 in 2009 to 848 in 2014(Ministry of Strategy and Finance). The growth rate (19.1%) exceeded the increasing rate (15.9%) of total governmental regulations by 3.2% at the same period (Table 3-1).

〈Table 3-1〉 The number of Regulations (unit: numbers, %)

	2009	2010	2011	2012	2013	2014	Growth rate
Environmental regulations	712	732	775	810	844	848	19.1
Total regulations	12,616	13,104	13,752	14,525	14,888	14,618	15.9

The number of charges, which is the amount of penalties by Ministry of Environment also held the top level in comparison to other charges in different Ministries. For example, according to Ministry of Strategy and Finance information, the environmental charge (23) accounted for 24.2% of total charges (95) in 2014 (Figure 3-1). The MOE operates 24 environmental charges or fees that generate 1 trillion KRW or 30 percent of the annual ministry budget.

〈Figure 3-1〉 The number of Charges (unit: numbers)



Ⅳ. Econometric Specification & Estimation Method

1. Specification of Dynamic panel model

This study adopts a dynamic panel model with the inclusion of lag dependent variable as a regressor, providing dynamic adjustment in an econometric model. It is rational to consider that companies refer to the past export and import patterns and networks when deciding current trade volume (Kahouli & Omri, 2017). That is, the companies with already established distribution networks, personnel connections, and branch offices and employees which could be called as barriers to entry and exit under irremediable situation. They therefore could not stop export and import. Additionally, consumers in domestic and foreign countries are already familiar with the imported goods, leading to ceaseless and increased trade flow (Kahouli & Maktouf, 2015). Therefore, it is likely that companies will continue to export and/or import products in the following year. Thus, we can conclude that the past trade flow is a basis for current international business activities (Kahouli & Omri, 2017).

For other determinants of trade, we will refer to the components of Levinson and Taylor (2008) and Song and Sung (2014). Levinson and Taylor's (2008) equation can be represented as follows:

$$N_{it} = \alpha_0 + \alpha_1 s_{it} + \alpha_2 C_{it}^F + \alpha_3 C_{it}^{F*} + \alpha_4 \tau_{it} + \alpha_5 \tau_{it}^* + \varepsilon_{it} \tag{4.1}$$

where N_{it} is the net import scaled by production, C_{it}^F is the typical production cost (labour and capital), C_{it}^{F*} is the foreign production cost, τ_{it} and τ_{it}^* are the pollution tax at home and in the foreign country, and ε_{it} is both an approximation error and a standard measurement error. For the empirical test, Levinson and Taylor(2008) replaced the variables of equation (4.1) with the observable and dummy variables and applied the pollution abatement costs (θ_{it}). Likewise, they used a tariff rate (T_{it}= the ratio of duties paid to customs value) to capture the effects of C_{it}^F, except for the tariff rates. In terms of C_{it}^F, they did not consider specific costs because they believed that traditional costs (i.e., labour and capital) adjust slowly over time. Instead, they assumed that the industrial fixed effects reflect the effect of C_{it}^F. Additionally, Levinson and Taylor believed that sector and time dummies could be used to capture changes in the unobservable elements (i.e. s_{it}, τ_{it}^*). Song & Sung (2014) in their equation, expressly included physical and human capital as determinants of the Korean export. Their model consisted of export as a dependent variable; physical and human capital, and pollution abatement capital costs as explanatory variables.

In this study, we will create our own dynamic panel model using trade performance (export/import ratio) as a dependent variable, which is selected in order to consider importance of export relative to import.

$$\frac{Export}{Import}\,ratio_{\mathrm{it}}$$

$$= \beta_0 + \beta_1 \frac{Export}{Import}\,ratio_{\mathrm{it-1}} + \beta_2 ln\ \text{physical capital per output}_{\mathrm{it}}$$

$$+ \beta_3 ln\ \text{human capital per output}_{\mathrm{it}} + \beta_4 ln\ \text{EPE per output}_{\mathrm{it-1}}$$

$$+ \beta_5\ industrial\ export\ ratio_{\mathrm{it-1}} + \beta_6\ Size_{\mathrm{it}} + \beta_7\ tariff_{\mathrm{it}}$$

$$+ \beta_8\ industrial\ real\ effective\ exchange\ rate_{\mathrm{it}} + \theta_i + \theta_t + \mathrm{e}_{\mathrm{it}}$$

(4.2)

where, i is industry and is calculated by using industrial capital stock, scaled by output. is calculated by multiplying employee by average wag e[5] in each industry (Lee, 2007, 2011, 2013). *industrial export ratio*$_{it-1}$ represents importance of i industry in terms of manufacturing at t-1. It is calculated by i industry export over total manufacturing industry exports (Shin, 2007). If i industry constitutes a high portion of total manufacturing sector at t-1, it would have increased export at current year. We therefore guess positive sign. *Sizeit* shows the portion of firms with more than 300 employees in I industry.

Considering that the firms have export potential, the sign will be positive. *tariff*$_{it}$ is a barrier of import leading to positive sign of $\frac{\mathrm{Export}}{Import}$ *ratio*$_{it}$. *industrial real effective exchange rate*$_{it}$ is said to be the relative price of exports and imports. The sign is likely to be dependent on the

5) To consider high level wage which skilled workers could receive, we used average wage of firms with over 500 employees which is larger than total average wage.

reactivity of export and import to exchange rate changes. The greatest interest lies on EPE per output$_{it-1}$. To avoid $\frac{Export}{Import} ratio$□ being endogenously related to EPE_t, we employ lagged EPE_{t-1}.

2. Estimation Method

In the dynamic panel model, there should be a correlation between the variables and error term violating condition for consistent estimators. To solve the problem, both difference GMM and system GMM are recommended. The two models must pass two tests to be used: the Sargan and Arellano-Bond test. The former checks whether the overidentified model of GMM is valid. If the condition is not satisfied, we cannot use GMM. The latter tests the autocorrelation of error term. If the null hypothesis (no autocorrelation) at first order is rejected or accepted while the hypothesis at second order is not rejected, using lagged level and difference variables as instrumental variables are correct. In this study, we employ the system GMM.

V. Data Description

The empirical equation consists of export, physical capital, human capital, environmental protection costs, tariff, and industrial real effective exchange rate. Information on each variable is available from the Korean Government, Bank of Korea, and OECD. The panel data-set consists of nine industries and covers the period 2006-2014. Data sources are presented in table 5-1.

〈Table 5-1〉 Data sources

Variable	Source
Trade	Korea International Trade Association
Environmental protection expenditure	Ministry of Environment
Real effective exchange rate - Trade between Korea and other countries - Nominal exchange rate	The Bank of Korea, the OECD, Korea International Trade Association
Tariff	Korean Customs Service
Size	Ministry of Labour Ministry of Trade, Industry and Energy
Physical and Human capital	The Bank of Korea Ministry of Labour

1. Trade Data

To obtain annual trade data for the period 2006-2014, we utilised the export data from the Korea International Trade Association (KITA). However, as the information from Ministry of Knowledge Economy(MKE) and KITA followed the goods category system, reclassification in terms of industry was needed. Its classification follows three code criteria: the Harmonised System of Korea code (HSK), Ministry of Trade and Industry code (MIT[6)]), and Standard International Trade Classification code (SITC). We utilised the HSK code, which consisted of over 500 commodities, mostly because its grouping was most similar to the industry category. The last task was to distribute the data from 6,500 goods during 2006-2014 sample into the relevant industry categories following the classification system of the EPE.

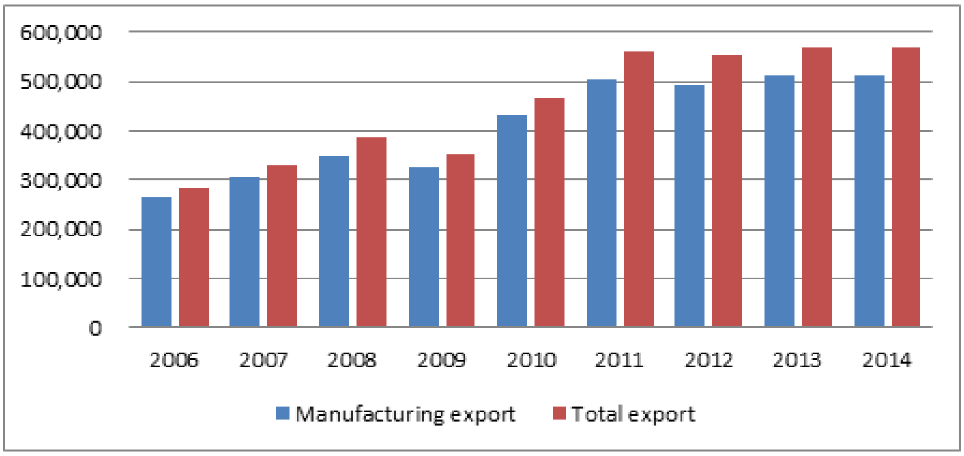
The Korean trade data during 2006-2014, in terms of real price[7)], shows

6) This ministry is now called Ministry of Trade Industry and Energy.
7) Base year is 2010 (100).

that exports increased rapidly until 2008 due to the boom in the world economy – for example, the volume ($386,575 million) of Korean exports in 2008 was almost double to the figure ($172,268 million) in 2000. In 2009, however, export went down sharply by 13.9% because of the US and Europe financial crisis, and world economic recession. The Korean export rebounded from 2010. Recently, the volume of export represented static increase.

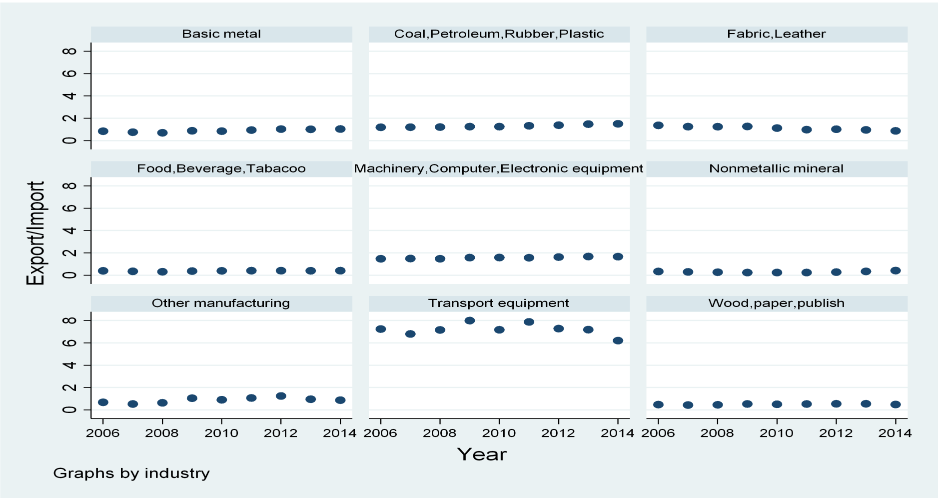
With regard to the data, the manufacturing sector exports accounted for an average of 91% of the total export volume during 2006-2014. Therefore, the change in competitiveness of the manufacturing sector had a great impact on the Korean export performance. Figure 5-1 shows that during the 2006-2014 period, manufacturing, exports, and total were positive. As mentioned above, the blip in 2009 is due to the US and Europe financial crisis.

〈Figure 5-1〉 Export Data in 2006-2014 (unit: USD million)



The analysis of each industry sector's export/import shows that mainly "transport" industry had the highest value in 2006-2014. Additionally, "coal, petroleum, rubber, plastic" and "machinery, computer, electronic equipment" experienced relatively better values than other industries. From the graph, we can think that "transport," "machinery, computer, electronic equipment," and "coal, petroleum, rubber, plastic" were the most important goods in the Korean exports(Figure 5-2)

〈Figure 5-2〉 Export/Import in terms of Industry in 2006-2014



2. Industrial Real Effective Exchange Rate

The industrial real effective exchange rate (IREER) measures the weighted average value of a country's currency relative to the currencies of its major trade partners. The rate is adjusted for the effects of inflation of the trading countries. The weights are dependent on the relative trade balance between the country and other countries. Goldberg (2004) presented a method for creating an IREER. By using Goldberg (2004), Lee and Lee (2005) and Bang (2010) were able to determine the Korean industrial real effective exchange rates and then analyze the relationship between the Korean exports and this exchange rate. They reported that the exchange rate had an important role in increasing exports before 1999, but after 2000, it had little influence on changes in exports.

For determining the IREER, like Lee and Lee (2005) and Bang (2010), this study employed the export-weighted way of Goldberg (2004) in order to consider exports:

[Trade-weighted]

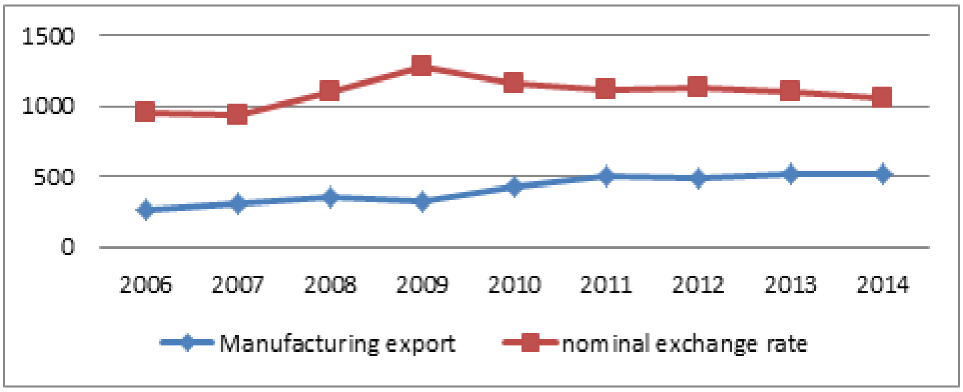
$$xer_t^i = \sum_c[(\frac{x_t^{ic}}{\sum_c x_t^{ic}}) * rer_t^c] \quad (5.1)$$

where, x_t^{ic} is the exports of sector i to the trading counterpart c at time t and rer_t^c is the bilateral real exchange rate of each Korean trading partner c.

For selecting the set of trading partners with Korea, 11 countries[8] were chosen, based on the trade volume in 2014. Figure 5-3 shows the relationship between manufacturing exports and nominal exchange rate. We can identify that there is little negative relationship between them. It implies that unlike the general thinking, increasing exchange rate could

〈Figure 5-3〉 Exchange rate and Exports in 2006-2014

(exchange rate: KW one, trade : USD billion)

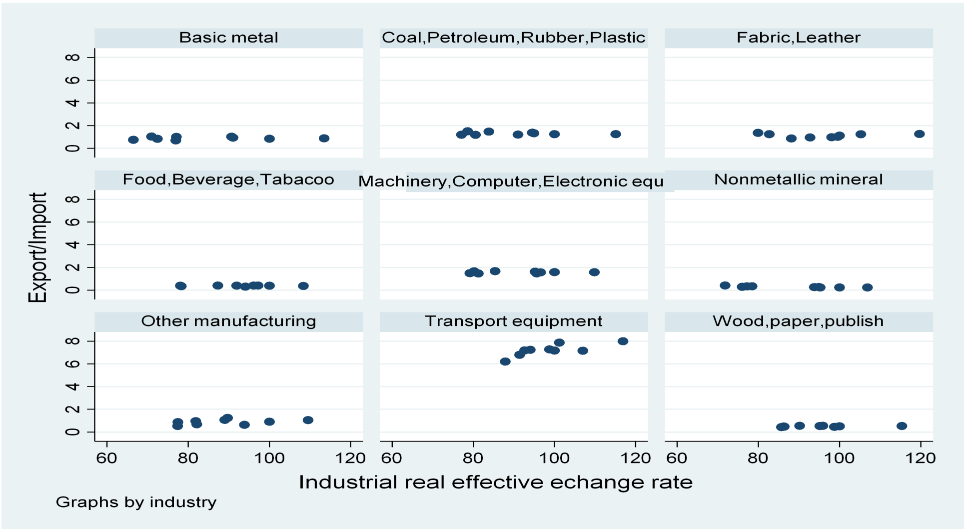


give negative influence on export. The correlation coefficient is -0.17.

Figure 5-4 shows the relationship between export/import and industrial real effective exchange rate, for individual industry sectors. It indicates that except for the transport industry, we could not find any systematic relationship. This result is similar to the research results of Lee and Lee (2005) and Bang (2010). The correlation coefficient is 0.08.

〈Figure 5-4〉 Exchange rate and Export/Import ratio in 2006-2014

(exchange rate: 2010=100)



3. Tariff Rate

Levinson and Taylor (2008) employed the tariffs as a variable for foreign countries' production costs. For the empirical tests, they used the effective tariff rates, which refer to the ratio of the duties paid to the customs value, which is also the rate favoured by the US Customs Service.

8) China, USA, Vietnam, Hong Kong, Japan, Australia, India, Mexico, Germany, UK and India.

$$\text{Effective rariff rate} = \frac{\text{Duties paid}}{\text{Customs value of imported goods}} \quad (5.2)$$

This study also employed the Korean effective tariff rate. To determine the industrial effective tariff rate for the panel data, the duties paid and customs values need to be available. The Korean Customs Service, however, has only production type data, and no information on the industry breakdown is available. Therefore, we had to do this task manually, and consequently distributed the data of over 130,000 goods into the relevant industry categories and then calculated the industrial effective tariff rate. Figure 5-5 shows that the average effective tariff rates showed decreasing trend over the period 2006 to 2014. This means that the openness of trade in Korea increased gradually during the time period.

〈Figure 5-5〉 The average effective tariff rate in 2006-2014 (unit: %)

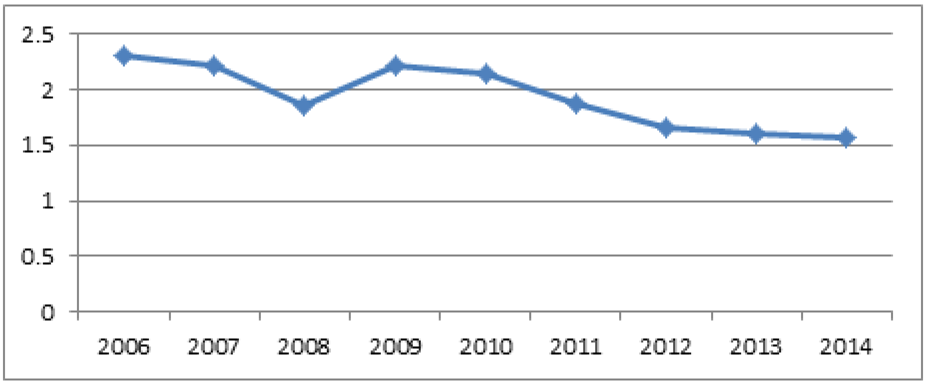
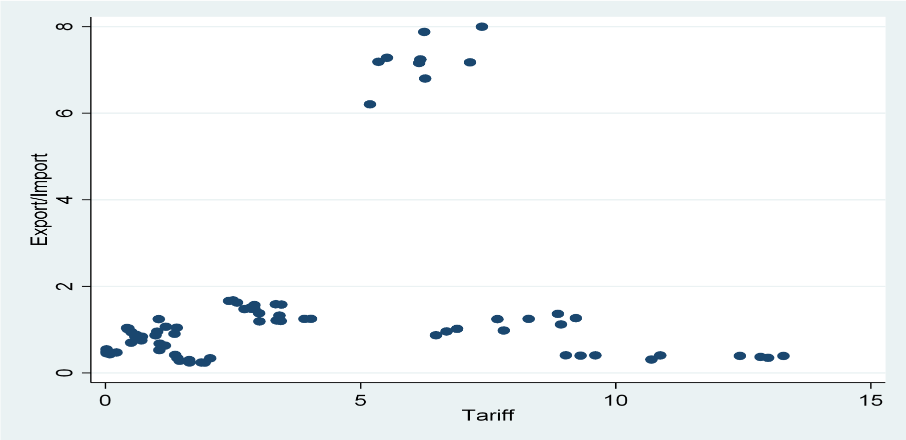


Figure 5-6 says the relationship between tariff rate and export/import. We can find out low positive appearance. The correlation coefficient is 0.2063.

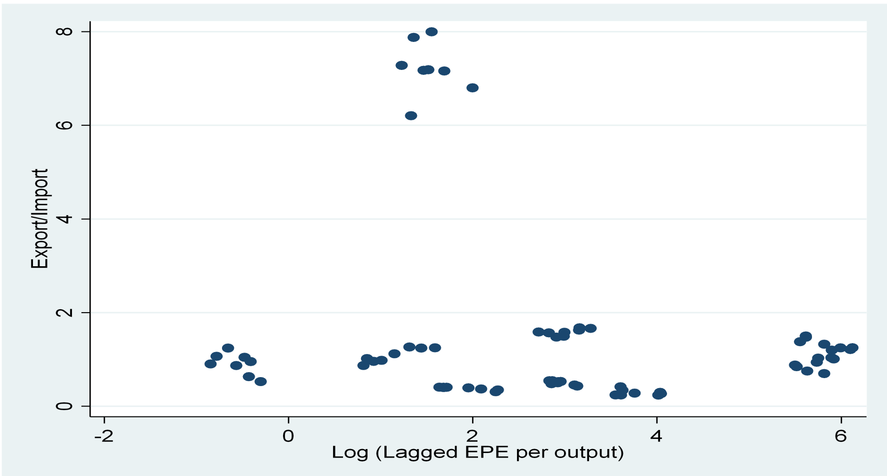
〈Figure 5-6〉 The industrial tariff rate (unit: %) and Export/Import ratio in 2006-2014



4. Environmental Protection Expenditure

The EPE represents the costs to prevent, reduce, and eliminate pollution. We employ the industrial values and find that the relationship between the EPE and Export/Import in Figure 5-7 is quite similar to negative shape. The correlation coefficient is -0.1989.

〈Figure 5-7〉 Lagged EPE per output and Export/Import ratio in 2006-2014



Data descriptive statistics are presented in table 5-2.

〈Table 5-2〉 Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Export/Import	81	1.574991	2.056425	0.240795	7.997765
Physical capital (KW billion)	81	85047.41	87943.46	7287.089	361195.2
Log (physical capital per output)	81	-0.51529	0.23788	-1.06331	-0.07086
Human capital (KW billion)	81	4274.056	1264.387	2285.127	7965.406
Log (human capital per output)	81	-3.79715	0.60006	-4.93474	-2.85187
Export of an individual industry/total Manufacturing export	81	0.111111	0.144089	0.003053	0.48441
Industrial Real Effective exchange rate (2010=100)	81	91.77336	11.68674	66.4738	119.698
Industrial Tariff (%)	81	3.871016	3.658411	0.020108	13.2869
Size (%) (Portion of firm with more than 300 over total firms)	81	15.6178	13.00848	1.125798	48.18618

VI. Empirical results

Table 6-1 shows the estimation results. The Sargen test does not reject the null hypothesis (Ho: overidentifying restrictions are valid), which implies that the overidentifed model of system GMM is valid. The Arellano-Bond test shows zero autocorrelation in first-difference errors. This means that the export/import ratio at t-2 and that after it can be employed as instrumental variables for the difference ratio at t-1. Such test results argue that system GMM is an appropriate approach for this study.

The estimate of the first variable shows significant influence. It implies that the past proportion of export to import affects current ratio. That is, the estimate meets the assumption that we established to use the dynamic panel model. Human capital has also a significant result. Human capital is related to the knowledge stock and high skill which could lead workers to achieve higher performance (Gendron 2004; Song & Sung 2014). Human capital therefore is an important factor of TPF growth leading to increasing competitiveness for profitability and export growth, which are the necessary economic drivers for new industrialized countries (Griliches & Regew, 1995; Teixeiraaa & Anabela, 2016). From this view, a significantly positive estimate of human capital is appropriate (Song & Sung 2014). Other things being equal, for a 10% increasing in human capital, the difference in the expected mean of export/import ratio will be 0.057[9].

Industrial export/manufacturing export ratio at t-1 represents the importance of a certain industry in the manufacturing sector in terms of export (Shin, 2007). Intuitionally, if the status of an industry in terms of export at t-l increases, we understand that the export of the industry would increase during the current year. The estimate reflects such thinking. Holding all other variables constant, 0.1 unit (10%) increase of the ratio at t-1 leads to 0.78 increase in current export/import ratio. Size has a positive coefficient. That is, when other variables are held constant, for one unit increase in portion (unit: %[10]) of firms with more than 300

9) 1.397*log(1.1)=0.057
10) Size variable has % value

in total firms, there will be 0.104 difference in the dependent variable. This means that middle sized or larger companies make a good contribution to the Korean exports. Tariff also has a positive sign. Considering that tariff plays a barrier against import, it is natural that the ratio of export/import increases. Specifically, holding the other predictor variables constant, a 1% increase in tariff[11] leads to a difference of 0.126 in the dependent variable.

The main interest of this research is in the results of the EPE per output at t-1. Unlike other significant variables, the sign is negative and significant. Specifically, holding other things equal, 10% increase of the EPE per output at t-1 results in a difference of -0.022[12] in the current value. The impressive point lies in the minus sign. It implies that the increase in the domestic environmental costs in an industry negatively affects the trade performance in the sector. That is, the expenditure caused by the command and control system of the Korean environmental regulations could be a burden on the competitiveness of the manufacturing sector.

〈Table 6-1〉 Estimations in terms of Trade Performance

Dependent variable (Export/Import ratio)	
Export/Import ratio t-1	0.292* (0.153)
Log(Physical capital per output) t	-0.441 (0.684)
Log(Human capital per output) t	1.397** (0.612)
Log (EPE per output) t-1	-0.537* (0.305)

11) Tariff variable also has % value.
12) - 0.537*log(1.1)= - 0.022.

Industrial export/manufacturing export ratio t-1	7.804** (3.451)
Size t	0.104*** (0.028)
Tariff t	0.126* (0.072)
Industrial real effective exchange rate t	-0.001 (0.011)
Observations	63
Sargan test	44.78782 [0.1021]
Arellano-Bond test	
First order	-1.6059 [0.1083]
Second order	1.1608 [0.2457]

note: ***; ** and * denote significance at the 1%, 5% and 10% respectively. ( ) is standard error. [ ] is p-value. Industry and year effects controlled.

VII. Conclusions

Export is a very important driver of the Korean economic growth. After the Korean financial crisis of 1998, trade performance (surplus) has also been considered as one of crucial factors for sustainable economic development. To involve trade performance, the study set up export/import ratio as a dependent variable and then adopted the industrial EPE as a proxy for stringency of environmental regulations.

From the estimates of the dynamic panel model, we found that expenditure has a significant negative effect on trade performance. This implies that higher stringency of Korean environmental restrictions lowers the export/import ratio. As generally known, it is likely that increasing additional costs like the EPE could raise the production costs in the concerned industries (Lee, 2013), leading to reduction in their competitiveness in the domestic market. For example, the raised production cost could weaken competition against the imported goods. Such influence could lead to an increase in imports and fall in trade performance.

To date, the Korean environmental regulations have focused on compulsory the command & control system. In this way, an increasing environmental stringency could become a serious burden for the firms' business activities. The Korean Government therefore should try to transform its direct regulatory system into market friendly methods which would not distort the firms' management excessively but give them some elbowroom.

Although this study provides empirical evidence and implications for the effect of environmental stringency on trade performance, it has some limitations, necessitating further studies. First, environmental stringency can be measure with diverse proxy variables, such as pollution abatement cost, specific regulation and composite indicator. To measure environmental stringency, this study uses environmental protection expenditure. To enhance empirical evidence of research, further studies are needed that utilize other proxy variables. Second, while this study analyses the effect of environmental regulation on trade performance, estimation is needed on the effect of environmental policies on import and export separately. Trade performance as a ratio of export/import which is used in this research, might generate complex effects. Analysing the effects of environmental stringency on import and export can reconcile results.

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The Effects of Korean Domestic Environmental Regulations on Trade Performance: Evidence from Korean Manufacturing Industries

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This study analyzes the relationship between Korea's environmental stringency and trade performance. According to the pollution haven hypothesis, environmental stringency levies additional cost on firm and burden to economic activity. While, according to Porter's theory, well designed environmental policies might actually enhance productivity and lead to export. Using panel data from 2006 to 2014, panal dynamic model and difference-GMM estimation provides the results that environmental stringency has a negative impact on trade performance. This results potentially reflect that the Korean environmental regulations have focused on compulsory the command & control system.

Keywords: Environmental regulation, Trade performance, Panel dynamic model, General method of moment

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