Master's Thesis

The Effect of Environmental Regulation Stringency on the FDI of Korea's pollution intensive industry

환경규제가 한국의 오염집약적 산업의 해외직접투자에 미치는 영향

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지도교수 김 종 섭

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위 원 장 김 종 섭 (인)

부 위 원 장 김 태 균 (인)

위 원 홍 종 호 (인)

The Effect of Environmental Regulation Stringency on the FDI of Korea's pollution intensive industry

Thesis Advisor Chong-Sup Kim

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Graduate School of International Studies,
Seoul National University
International Cooperation Major
Joo Yeon Oh

Confirming the master's thesis written by Joo Yeon Oh
February 2014

Chair _____
Chong-Sup Kim

Vice Chair _____
Taekyoon Kim

Examiner _____
Jongho Hong

Abstract

Name: Joo Yeon Oh

Major: International Cooperation

Graduate School of International Studies

Seoul National University

There has been many studies investigating the effect of environmental regulation stringency under various measurements and different industries. However, many of previous research studies examined the case of other developed countries, and several studies that investigate Korea's case show limits on measuring the effect of environmental regulation. Therefore, this research analyzes the case of Korean pollution intensive industry under the Pollution Haven Hypothesis by measuring environmental regulation stringency with appropriate proxy. The result shows that Pollution Haven Hypothesis applies to Korea's case, and it is predicted that Korean pollution intensive industries will outflow to countries with lax environmental regulation.

Keywords: Pollution Haven Hypothesis, Industrial Flight Hypothesis, Environmental regulation, FDI, Pollution intensive industry

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I. Introduction

Global society, in particular developed countries, has been opting for sustainable development since late 20th century, strengthening their regulation to prevent from pollution and climate change. However, as production cost rises because of stricter environmental regulation, companies tend to move out to countries with laxer regulation, expecting to lower their production cost.

On the other hand, many developing countries make efforts to invite foreign direct investment from the developed world especially in manufacturing sector. They can enjoy economic development by hosting investment as they already hold comparative advantage in labor cost and regulation level. Therefore, many economists have shown their concern for developing countries 'race to the bottom,' to attract more FDI for economic development, thereby lowering their stringency of environmental regulation. This results in making developing countries as pollution havens of the developed world, but whether the Pollution Haven Hypothesis applies in the real world or not is still controversial.

Korean companies' investment abroad in manufacturing sector increased rapidly since 1990, and Korea's expenditure on environment and climate change also showed a sharp increase since then. These results show that Korean companies stretched out to other countries and that the government made a strong effort to protect the environment. Still, it is not sufficient to argue that there is a casual relationship between foreign investment and strict environmental regulation.

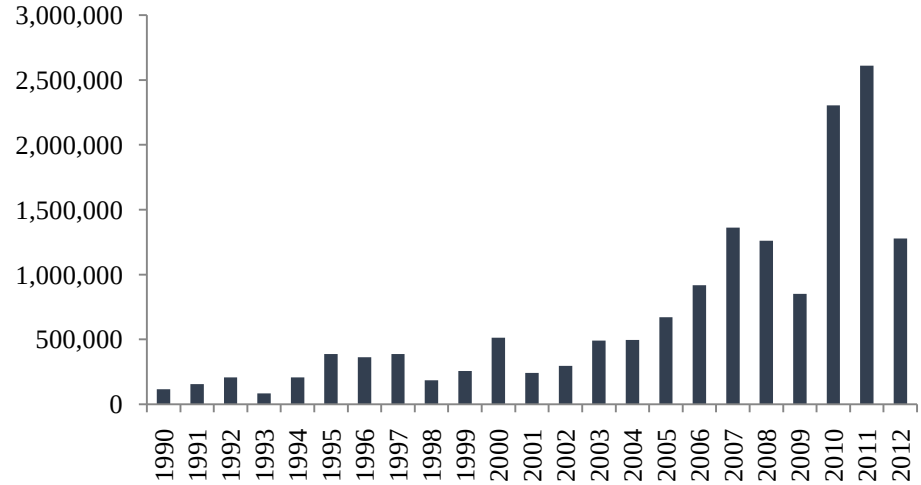

Figure 1: Korea's FDI outflow of pollution intensive industry

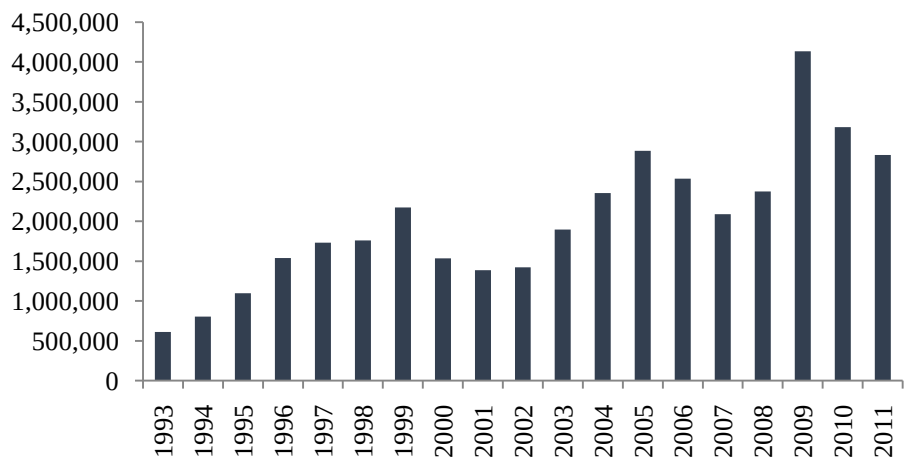

Figure 2: Korea's expenditure on environmental pollution prevention (Million Won)

Source: Ministry of Environment

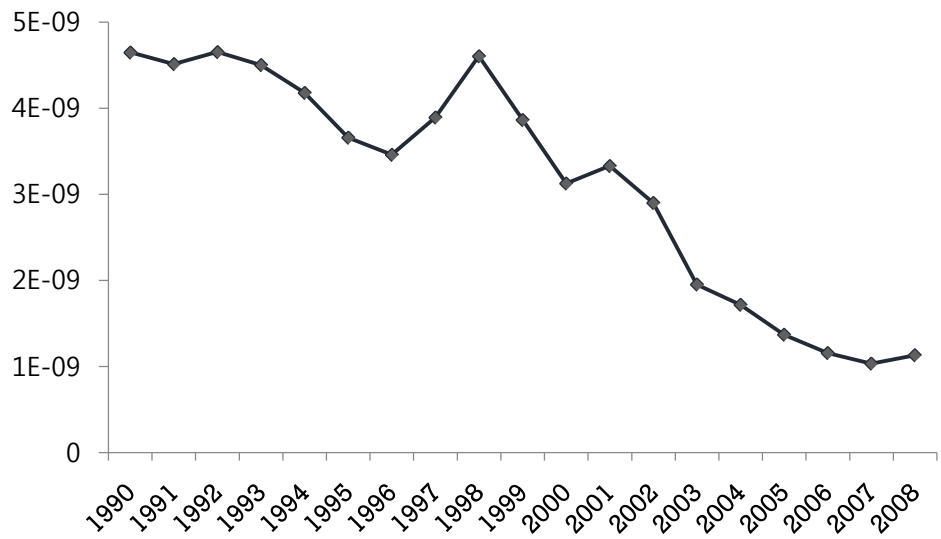

Figure 3: Korea's SO_2 emission per GDP

Source: UNESCAP

There have been several research papers about relocation of business in the United States and other countries, however only few studies exist regarding case of Korea. Moreover, existing case studies on Korea use proxies for environmental regulation stringency that are not commonly used academically. Therefore, this research paper attempts to investigate whether Korea's pollution intensive industries are affected by environmental regulation stringency of foreign countries by measuring environmental regulation stringency that has been economically proven.

To examine the effect of environmental regulation, the SO_2 emission over GDP of host countries are measured, and the gravity model is adopted for analysis. The gravity model is one of the most commonly used regression models in FDI studies, and additional determinants of FDI are run in regression to find out whether environmental regulation stringency holds significant effect when Korea's pollution intensive industry selects a country for foreign direct investment.

This paper is organized as follows: Section 2 reviews existing theoretical and empirical works on the Pollution Haven Hypothesis. Section 3 shows the data, and issues and analytical framework of this research. Section 4 presents the result of the analysis, and Section 5 concludes the research with findings and further discussion.

II. Pollution Haven Hypothesis

The Pollution Haven Hypothesis (PHH) assumes that, when there is a free trade, multinational firms will relocate their production of pollution-intensive goods to developing countries, which relatively has lax environmental regulation. As industries start to monitor pollution control cost as a serious matter in some countries, other countries with lower pollution control cost would gain comparative advantage in those industries.

In general, developed countries tend to show stronger support against climate change and have stricter environmental regulation than developing countries. There are three main underlying reasons for this. Firstly, developing countries feel the costs of monitoring and exerting pollution standards are relatively higher than developed countries. This can be due to a scarcity of trained personnel, the high costs of implementing new pollution standards, and the difficulty in obtaining modern equipment and corruption, relatively comparing with developed countries. Second, developed countries with high incomes have a greater demand for environmental welfare such as clean water and air. Low income countries are more focused on getting jobs and extra earning opportunities rather than health. Third, developing countries' economic growth leads to its shift of economic structure from agriculture to manufacturing, resulting in rapid urbanization and large investments in urban infrastructure. This increases the pollution intensity of the developing countries.

In line with the fact that developing countries likely have relatively lenient environmental regulation than developed countries, developing countries will gain a comparative advantage in pollution-intensive industries and become "havens" for the world's pollution-intensive industries. Thus, developed countries are expected to benefit in terms of environmental quality from trade, while developing countries will lose.

Temurshoev (2006) presents Pollution Haven Hypothesis with graphical illustration as shown in Figure 4. Denote *X* as dirty good, *Y* as clean good, and *e* as emission intensity in a country. Assuming a fixed emission intensity, the price of dirty good in the developing country is lower than that in the rich country, i.e. $Pp^X < Pr^X$. This is because the rich country taxes pollution more heavily on dirty goods, so that less dirty good is produced with higher price of *X* in autarky.

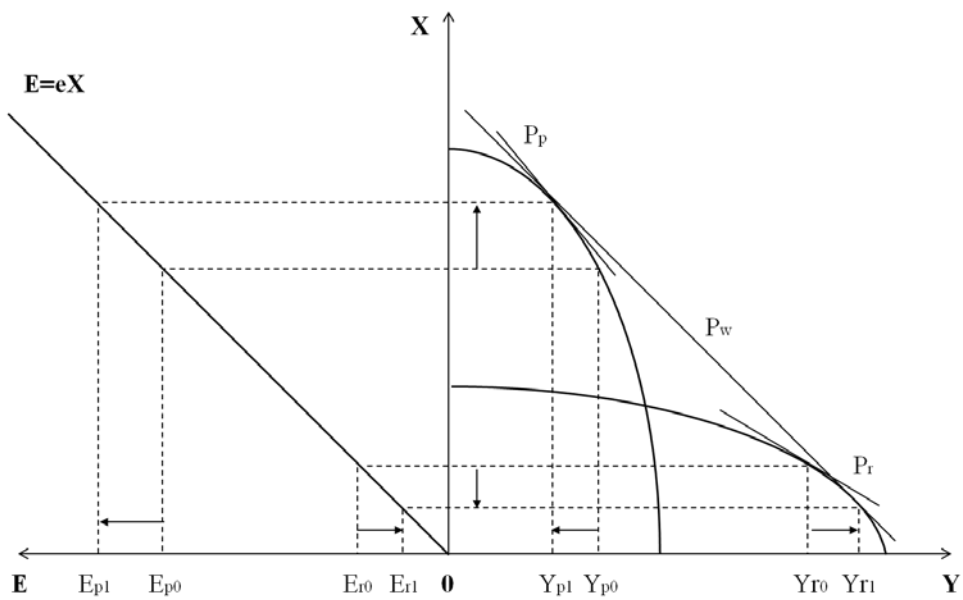

Figure 4: The PHH under the condition of production-generated pollution

Consequently, when price of clean good is given, the autarky price ratio in the less developed country, $Pp = Pp^Y / Pp^X$, is higher than that in the developed

country, $Pr = Pr^Y / Pr^X$. Developed countries have flatter production possibility line and poor country has a steeper one. And in autarky, the rich country produces more clean good, $Y_{r0} > Y_{p0}$, and less dirty good. Since the dirty good production is higher in the less developed country, the autarky pollution level is also higher in the less developed country, $E_{p0} > E_{r0}$. Developed country will import X (dirty good) from less developed country, and the less developed country will import Y (clean good) from the developed country. Hence, pollution increases in the poor country and decreases in the rich country, i.e. $E_{p1} > E_{p0}$ and $E_{r1} > E_{r0}$.

Case when pollution generates in the consumption process differs from production with trade. From the figure, the developed country consumes less clean good Y and more dirty good X, which means that pollution increases in the rich country. On the other hand, the poor country 17 consumes more clean good Y and less dirty good X. Thus, effect of trade is the opposite from the production, which had an increase of emission in the poor country and decrease in the rich country.

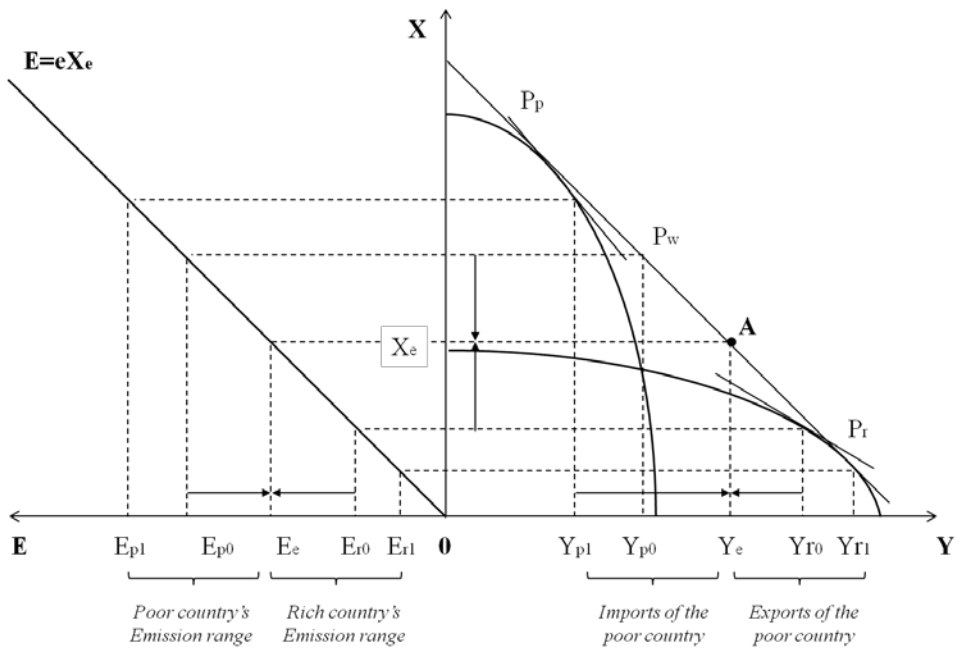

Figure 5: The PHH under the assumption of consumption-generated pollution

III. Literature Review

There are number of studies that have explored the effect of environmental regulation on trade and investment. However, results of these studies vary and controversy exists on the effect of environmental regulation. Definition of dirty industry, proxy used for environmental regulation, countries covered in analysis and the measure of investment or trade value all differ by studies, thus it is difficult

to conclude whether environmental regulation holds effect on FDI or not. Therefore, reviewing related literature is necessary before exploring Korea's case in detail.

Many of studies have found no or little support on Pollution Haven Hypothesis.

Bartik (1988) examines whether variations in state environmental regulation in the U.S. affects the location of manufacturing branch plants of Fortune 500 companies. Bartik does not find any statistically significant effect of state environmental regulation on the location of new branch plants. However, effect of environmental regulation varies in highly polluting industries.

Bartik (1989) investigates the effect of environmental regulation also with new small businesses in 19 manufacturing industries and found significant but small effects.

Leonard (1988) examines the relationship between policies toward pollution and investment patterns, but no significant relationship is found. However, Leonard finds that regulation may have effect on investment to overseas location when analysis is restricted to polluting industries.

Tobey (1990) also finds no evidence to support that the introduction of environmental control measures causes trade patterns to deviate from HOV model,

arguing that world distribution of ‘dirty industries’ is not affected by the different level of environmental stringency of countries.

McConnell and Wheeler (1990) analyzed with Motor-Vehicle assembly plants, and Friedman, Gerlowski, & Silberan (1992) investigated case of foreign multinational corporations in the U.S., and both found no significant effects of regional differences in environmental regulation.

Jaffe, Peterson, & Stavins (1995) find little evidence to support the hypothesis that environmental regulation has large effect on net exports, overall trade flows and plant location decisions.

Levinson (1996) uses pollution abatement costs to assess the effect of state environmental regulation, and examines whether environmental regulation affects location of new manufacturing plants in the U.S., but finds limited evidence on industry flight.

List and Co (2000) investigate inverse relationship between regulatory expenditure by manufacturer and the location decision of a new firm in West Virginia.

Wheeler (2001) investigates the relationship between air pollution regulation and FDI in Mexico, Brazil, India, and the U.S. Wheeler argues that race to the bottom does not exist in these countries, rejecting the relationship between environmental regulation and FDI.

Xu and Song (2000) concludes that no relationship exists between stringent environmental regulation and international competitiveness of environmentally sensitive goods.

Lho (2002) studies the Pollution Haven Hypothesis case of Korea. Loh suggests that Korea's FDI outflow is not affected by environmental regulation of the host country.

Eskeland and Harrison (2003) find almost no evidence that multinational flock to pollution havens in developing countries such as Cote d'Ivoire, Mexico, Morocco, and Venezuela. Moreover, the authors state that multinationals doing business in these four countries use more energy efficient and cleaner types of energy. They conclude that U.S. foreign investments are not skewed toward industries with higher abatement cost.

Dean, Lovely, & Wang (2009) rather shows opposite evidence from Pollution Haven Hypothesis. They assert that foreign direct investments flow into Chinese province with more stringent environmental regulations

Jung and Eun (2010) investigate Korea's case and conclude that Korea's pollution intensive industry does not flock to countries with lower environmental regulation. Lee and Han (2011) also study Korea's case and assert that host country's environmental regulation does not weaken the competitiveness of firms in Korea, forcing firms to move out to countries with laxer environmental regulation. However, the Pollution Haven Hypothesis appears to be true when non-

OECD countries are only included in the analysis.

On the other hand, there are research papers proving the Pollution Haven Hypothesis, and showing significant effect of environmental regulation on trade or foreign direct investment.

Hettige, Lucas, & Wheeler (1992) describe that stricter regulation against pollution intensive production in OECD countries appears to have significant locational displacement that may result in acceleration of industrial pollution intensity in developing countries. In addition, the poorest economies tend to have highest toxic intensity, but a causal connection is not proven.

Van Beers and Van den Bergh (1997) examine the impact of relatively strict environmental regulation by using UNCTAD survey results on enironmental policy strictness discussed in Walter and Ugelow (1979). They find out that a country that imposes stringent environmental regulation would export less pollution intensive goods due to rise in production cost, and import more to substitute foreign production for domestic ones.

Mani and Wheeler (1998) argue that pollution haven effect is transient and relatively unimportant in many countries, and no feasible policy exists to neutralize this effect. They suggest alternatives to narrow down disparity in environemntal control between developed and developing world.

Mani, Pagal, & Huq (1997) finds that effect of environmental spending occurring as a result of more stringent regulation, is likely to be higher in pollution intensive industries' new plant location in India.

Gray (1997) measures business pollution abatement spending, regulatory enforcement activity, congressional pro-environment voting, and index of state environmental laws, and finds out the partial effect of regulation. Gray asserts that states with strict environmental regulation have fewer new manufacturing plants however high-pollution industries show similar coefficients as other industry.

List and Co (2000) investigates the effects of environmental regulation on new plant location decision of foreign multinational corporations in the U.S. They estimate four measures of regulatory stringency, and assert that environmental policies in states do matter to new plant location.

Smarzynska and Wei (2001) find no support for the Pollution Haven Hypothesis in Eastern Europe and the former Soviet Union. They find no evidence that FDI in dirtier industries is more likely to go to countries with weaker environmental regulation.

Keller and Levinson (2002) estimate effect of changing environmental standards on international investment pattern. They find modest effect of environmental standard on the capital and employment of pollution intensive multinational manufacturing firms, and on the number of planned foreign-owned manufacturing facilities.

Cole and Elliott (2005) suggest that environmental regulation does not significantly affect net export of dirty products. However, its effect is shown in some pollution intensive industries.

IV. Methodology & Data

(1) Hypothesis

As discussed above, literatures on foreign direct investment and environmental regulation are controversial, and the effect of environmental regulation is not clear yet. The Pollution Haven Hypothesis supposes that more stringent environmental regulation is harmful for the competitiveness of a firm due to higher production cost occurring from regulation. Firms will consider environmental regulation stringency of a country before investing, in addition to other determinants of FDI. Considering this background, the case of Korea will be investigated in this research. Therefore, hypothesis of this research is that stringency of environmental regulation would have a significant effect on foreign direct investment outflow of Korea's pollution intensive industry.

Hypothesis: Stringency of environmental regulation in host country will have a significant effect on outflow of FDI in Korea's pollution intensive industry.

(2-1) Issue 1

Before moving on to analysis, there are two issues that need clarification before moving further to examine the hypothesis.

First, definition of 'pollution intensive industry' is unclear. Some of the studies examined the influence of environmental regulation on the specific industry. Bartik (1985) examines whether the Pollution Haven Hypothesis is true by examining relation between environmental regulation and location decision of top 500 manufacturing firms in U.S. listed by Fortune. McConnell and Schwab (1990) examine the influence of environmental regulation on location of new automobile plants. Wheeler and Moody (1992) study how environmental regulation affects location of multinational corporate in U.S. in 1980s. However, all papers analyze the case of Pollution Haven Hypothesis with different business sectors, and no consensus is made between scholars in terms of defining pollution intensive industry (dirty industry).

To identify the term 'pollution intensive,' abatement expenditure and emission intensity of the industry per unit of production are conventionally used. Literatures using abatement cost or emission level of pollutant study the case of

developed countries, especially United States, where data is available. Robinson (1988), Tobey (1990), and Mani (1996) identify five pollution intensive sectors with abatement expenditure per unit of output in the U.S. and other OECD economies: Iron and Steel, Non-Ferrous Metals, Industrial Chemicals, Pulp and Paper, and Non-Metallic Mineral Products.

Another direct way of defining pollution intensive industry is selecting sectors which have a high level of emission intensity (emissions per unit of output). Mani and Wheeler (1998) collected air, water and heavy metal emission data of each industry by 3-digit Standard Industrial Classification (SIC) level in U.S. manufacturing. The five most pollution intensive industry ranked by the emission intensity is the same as the industries ranked by abatement cost.

Matthew A. Cole (2004) states that general consensus exists in definition of pollution intensive sector as Basic metal industries, Manufacture of wood and wood products, Manufacture of non-metallic mineral products, and Manufacture of chemicals and chemical products.

In case of Korea, data for abatement cost and emission intensity by industry are not available. Moreover, FDI data of Korea is not organized by ISIC or SITC, instead manufacturing sector is organized with 24 sub-industry. Five sectors will be used for analysis in this research referring to dirty industry defined by papers mentioned above: Basic metal industries, Manufacture of wood and wood

products, Manufacture of non-metallic mineral products, Manufacture of chemicals and chemical products and Pulp and paper.

(2-2) Issue 2

The second issue in examining the effect of environmental regulation stringency is the measurement of 'environmental regulation stringency.' There is no global data directly measuring environmental regulation stringency of each country, and proxy used for analysis differs by research.

Tobey (1990) uses environmental policy strictness data of UNCTAD survey conducted in 1976. As discussed by Walter and Ugelow (1979), UNCTAD survey measures environmental stringency in a scale of 7, answered by national governments. However, the data is too old and is available only for 23 countries which are mainly developed countries. Similarly, Dasgupta (2001) conducted a survey to 31 countries considering the state and policy performance in agriculture, manufacture, energy, transport, and the urban sector in regards of air, water, land, and living resources. Dasgupta survey is also not available in this research as the data is not available for all the countries included in this research. Another direct measurement of environmental stringency is Environmental Sustainability Index (ESI) that evaluates countries' overall progress towards environmental sustainability. One of the variables included in this evaluation is a survey result of

World Economic Forum survey on environmental governance. The survey questions address several aspects of environmental governance such as air pollution regulation, chemical waste regulation, water pollution regulation and so on. However, the data is not available in time series which is necessary in this research. Van Beers and Van den Bergh (1997) also measures environmental regulation strictness by combining seven different environmental indicators, but the data is outdated for use in this research.

One of indirect ways to measure environmental regulation stringency is estimating the pollution abatement expenditure of a state or a firm. Bartik (1988) measures government spending on air and water quality control divided by manufacturing employment. In addition, state air and water pollution compliance costs divided by expected pollution compliance costs are also measured as regulatory stringency. Friedman, Gerlowski, and Silberman (1992) measure state pollution abatement expenditure divided by state gross product originating in manufacturing industries. Gray (1997) estimates state spending per capita on programs for environmental and natural resources, and actual pollution abatement expenditure data is taken from Pollution Abatement Costs and Expenditures (PACE) Survey. Keller and Levinson (2002) also take state pollution abatement costs from PACE data set, adjusting each state's industrial composition. Levinson (2002) uses pollution abatement operating cost from PACE divided by workers in the state. List and Co (2000) measure firm level pollution operating expenditure to abate polluting air, water and waste from PACE data set.

Proxies such as GREEN index and FREE index evaluate public authorities' performance and their efforts to enforce their performance on environment. Conservation Foundation Index, Environmental Protection Index from List and d'Arge (1996) are also examples of measuring public policy regulation. Furthermore, attainment status of a county on air pollutants is also used. McConnell and Schwab (1990), Henderson (1997), List, McHone, Lee, & Soskin (1999), and Becker and Henderson (2000) use attainment status as a dichotomous variable to measure environmental regulation stringency.

Lastly, pollutant emission is used as proxy for environmental regulation since causality between stringency of regulation and emission of pollutant may exist. Among various pollutants, Shim and Jeong (2009) state that previous empirical studies in this field investigating Korea's case use CO_2 or GHG emission as a proxy. Jung and Eun (2010), and Lee and Han (2011) also estimate CO_2 emission for the case study of Korea. However, these studies do not state about the relationship between CO_2 and environmental regulation stringency.

In this research, SO_2 emission is adopted to measure environmental regulation stringency due to following reasons argued by Xing and Kolstad (1995). First, causality exists between strict environmental regulation and SO_2. When government increases stringency of environmental regulation, firms start to use abatement equipment in their production site to decrease emission of pollutants, resulting in lower emission of SO_2. As government increases the cost of using

energy, demand on sulfur fuels will decline, also resulting in lower emission of SO_2. Second, SO_2 is one of the most significant air pollutants worldwide. Third, SO_2 emission is one of the variables most commonly used to proxy for environmental quality. Fourth, SO_2 emission is highly associated with other major air pollutants such as reactive volatile organic compounds (VOCs), carbon monoxide (CO), and total suspended particulates (TSP). Correlation coefficients range from 0.846 to 0.950, showing high correlation. Xing and Kolstad (1995) also prove how environmental regulation stringency which is an unobserved variable dealing with FDI. Therefore, SO_2 emission is selected as the most appropriate proxy in this research as data is available for most countries and years compared to other proxies.

(3) Variable Definitions

Many empirical investigations addressing the effect of environmental regulation on trade flows have adopted the gravity equation model. The gravity model was first used by Tinbergen (1962), taking distance between two countries in trade as a trade barrier. In the same fashion, gravity model is also used in FDI studies. Early application of gravity model to FDI is done by Eaton and Tamura (1994), which states that FDI bilateral flows or stocks essentially depend on GDP or population of host country, and on the geographic distance between two countries. Moreover, the gravity equation has been widely used to analyze relationship between environmental regulation and trade or investment flows, especially in a research

which investigates existence of pollution haven effect. Recent examples of such analyses using gravity model are Grether and De Melo (2003), Harris, Konya, & Matyas (2002), Jug and Mirza (2005), and van Beers and van den Bergh (2003). They address the existence of pollution haven path of trade flows related to more stringent environmental regulation. In this sense, gravity model is adopted in this research in investigating the effect of environmental regulation stringency in FDI outflow of Korean dirty industry.

Determinants of FDI are first defined as follows, as the purpose of this research is to see whether environmental regulation stringency affects FDI outflow of Korea.

Distance is a critical determinant of FDI, as explained above with gravity model. Distance between the host country and the recipient country act as a trade barrier, thus further the distance between these two countries, the less FDI will outflow from Korea.

As FDI is considered to be a function of output or sales of foreign firms in the host country according to Agarwal (1980), market size of the recipient country is a critical factor that investors consider to measure potential profit they will earn. Market size of a country is captured by the level of *GDP* as in Bandera and White (1968), and it is assumed that market size and FDI value will have a positive relationship.

Labor cost is also an important determinant, especially in manufacturing sector. This relates to (vertical) efficiency seeking FDI where host country invests in a country with lower cost structure. In this research, wage in manufacturing sector of recipient countries is used since all pollution intensive industry defined in this study are sub-sector of manufacturing industry.

The *openness* of the economy which is defined as trade ratio over GDP of a country is considered to be significant in the manufacturing sector. Taylor (2000) suggests that correlation between openness and FDI turns out to be significant at only in the manufacturing sector. As this research is focused on dirty manufacturing industry, the openness of recipient country is expected to have significant relationship with FDI.

The quality of *infrastructure* in host country is expected to increase ease of business. Infrastructure availability reduces operational cost of firms, thus it is considered to hold a significant role in FDI. Erenberg (1993) argues that when infrastructure is not available to local and multinational enterprises publicly, then these enterprises would be operating with less efficiency as they would have to build their own infrastructure which results in duplication and wastage of resources.[1] In this research, telephone lines per 100 person in host country is counted as proxy for infrastructure, and it is expected to hold positive relationship with FDI.

[1] Rehman, C.A. (2011)

Finally, as discussed above in detail, SO_2 emission is measured because of its causality with strict environmental regulation, high correlation with other energy uses, and its general use in this topic. However, as *stringency of environmental regulation* assumes that government would consider welfare and environment more as their economy grows, SO_2 emission over GDP level of each country is used to measure absolute stringency of environmental regulation in a country. As condition for FDI is considered in comparison with country from origin, stringency of environmental regulation is also measured in a relative term. Host country's absolute stringency is divided by Korea's absolute stringency in Model 2, and variables in both models are expected to have positive relationship with FDI.

(4) Model

Based on previous discussion, there would appear to be six major factors determining FDI of pollution intensive industry: distance between two countries, market size, labor cost, openness, communications infrastructure and environmental regulation which is the most important variable in this research. Model 1 measures absolute stringency of regulation in the host country, and the equations can be written in the following linear form:

$$\ln(FDI_{ijt}) = \alpha_0 + \alpha_1 \ln(Distance_{ij}) + \alpha_2 \ln(GDP_{jt}) + \alpha_3 \ln(Openness_{jt})$$

$$+ \alpha_4 \ln(Wage_{jt}) + \alpha_5 \ln(Infra_{jt}) + \alpha_6 \ln(Ab\_Regulation_{jt}) + \varepsilon_{ijt} \quad (1)$$

i: Korea, j: Host country, t: Time

Model (2) measures relative stringency, and the equation can be written in the following linear form:

$$\ln(FDI_{ijt}) = \beta_0 + \beta_1 \ln(Distance_{ij}) + \beta_2 \ln(GDP_{jt}) + \beta_3 \ln(Openness_{jt})$$

$$+ \beta_4 \ln(Wage_{jt}) + \beta_5 \ln(Infra_{jt}) + \beta_6 \ln(Re\_Regulation_{jt}) + \varepsilon_{ijt} \quad (2)$$

$\ln(FDI_{ijt})$ is logged FDI from Korea(i) to the recipient country(j), in year (t). $\ln(Distance_{ij})$ is logged distance between Korea and the recipient country, $\ln(GDP_{jt})$ is logged GDP of a recipient country, $\ln(Wage_{jt})$ is logged wage in manufacturing sector of a recipient country, $\ln(Openness_{jt})$ is logged portion of trade relative to GDP of a recipient country, $\ln(Infra_{jt})$ is logged telephone lines per 100 people in a recipient country. $\ln(Ab\_Regulation_{jt})$ is logged SO_2 emission by economy size, and $\ln(Re\_Regulation_{jt})$ is logged regulation stringency of a host country divided by Korea's regulation stringency.

Table 1: Definition of Variables

Variable	Definition
$\ln(FDI_{ijt})$	Korea's Dirty industry FDI outflow
$\ln(Distance_{ij})$	Distance between two countries
$\ln(GDP_{jt})$	GDP of host country
$\ln(Openness_{jt})$	Portion of trade in GDP
$\ln(Wage_{jt})$	Wage in manufacturing sector
$\ln(Infra_{jt})$	Telephone lines per 100 people
$\ln(Ab\_Regulation_{jt})$	Sulfur Dioxide (SO2) emission per GDP
$\ln(Re\_Regulation_{jt})$	Environmental regulation stringency of host country relative to Korea

(5) Data

Each data is collected from reliable sources. Korea's FDI value is from Korea Export Import Bank. Distance is from CEPII (Centred'Etudes prospectives et d'Informations internationales), GDP is from the World Bank, Wage in manufacturing sector is from the Intenraional Labor Organization. Trade ratio in GDP representing openness of a country is from the World Bank, and telephone lines per 100 persons in a country for infrastructure is also from the World Bank.

Sulfur Dioxide (SO_2) emission data used to calculate stringency of enviornmnetal regulation is from three different sources. UNESCAP (United Nations Economic and Social Commission for Asia and the Pacific) data is used for Asian countries' emission, OLADE (Latin America Energy Organization) data is used for Latin American countries' emission, and UNEP (United Nations Environment Program) is used for the rest of the countries.

In this research, 65 countries which have hosted Korea's investment of pollution intensive industry in the past since 1990 are included. Furthermore, period from 1990 to 2008 are included in the analysis, and 1090 samples are analyzed as panel data in total.

V. Result

To study the effect of environmental regulation stringency in Korea's FDI outflow of dirty industry, the equation will be analyzed in two different methods; fixed effect and random effect.

(1) Model (1)

Table 2 shows the result of Model (1), examining the effect of absolute environmental regulation stringency with fixed and random effect model.

Cross country fixed effect model does not measure time-invariant variables, thus $\ln(Distance_{ij})$ is not measured in this model.

$\ln(GDP_{jt})$ is positive and significant, showing that Korea's pollution intensive industry FDI tends to move out to countries with higher GDP level, which represents larger market size. Coefficient of $\ln(Openness_{jt})$ is also positive and significant. Korea's dirty FDI tends to flow to countries with high portion of trade within their GDP, showing the extent of openness of a country. $\ln(Wage_{jt})$ is positive but turns out to be insignificant, and $\ln(Infra_{jt})$ is negative and significant. $\ln(Ab\_Regulation_{jt})$ is positive and significant, and this shows that Korea's dirty FDI outflows to countries with higher SO_2 emission per economy size which represents laxer environmental regulation

According to the result of random effect model, coefficient and significance level show similar result as the fixed effect model. $\ln(Distance_{ij})$ is negative and significant, consistent with the gravity model. $\ln(GDP_{jt})$ is positive and significant, and $\ln(Openness_{jt})$ is also positive and significant. $\ln(Wage_{jt})$ is positive but insignificant, however $\ln(Infra_{jt})$ is negative but significant. $\ln(Ab\_Regulation_{jt})$ is also positive and significant, which means that Korea's FDI

in pollution intensive industry outflows to countries that have lax environmental regulation.

Table 2: Empirical Results of Model (1)

Variable	Fixed Effect	Random Effect
$\ln(Distance_{ij})$	NA	-1.20 (0.01)***
$\ln(GDP_{jt})$	1.78 (0.00)***	1.39 (0.00)***
$\ln(Openness_{jt})$	1.49 (0.00)***	1.62 (0.00)***
$\ln(Wage_{jt})$	0.05 (0.35)	0.02 0.63
$\ln(Infra_{jt})$	-0.50 (0.05)**	-0.75 (0.00)***
$\ln(Ab\_Regulation_{jt})$	0.31 (0.07)*	0.24 (0.02)**
C	2.58 (0.37)	8.80 (0.04)**
Observations	1090	
R-squared	0.62	0.38

***, ** and * denote for statistical significance at 99%, 95% and 90% confidence levels, respectively.

To select the most appropriate model among fixed and random effects, Hausman test is used, and the result recommends the use of fixed effect model.

(2) Model (2)

Both Fixed and Random effect models are used also in Model (2), examining the effect of relevant environmental regulation stringency.

In fixed effect model, $\ln(GDP_{jt})$ and $\ln(Openness_{jt})$ are positive and significant, consistent with the gravity model. $\ln(Wage_{jt})$ turns out to be positive and insignificant, and $\ln(Infra_{jt})$ seems to be negative and significant. $\ln(Re\_Regulation_{jt})$ is shown to be positive, but the significance level is marginally lower than the effect of absolute stringency of environmental regulation. This shows a possibility that Korea's dirty FDI tends to outflow to countries with lower stringency of environmental regulation than Korea, however cautious interpretation is necessary due to comparatively lower significance level than Model (1).

Consistent with the result of the fixed effect model, $\ln(Distance_{ij})$ is negative and significant, and $\ln(GDP_{jt})$ is positive and significant at 1% level. $\ln(Openness_{jt})$ and $\ln(Wage_{jt})$ are also positive, but $\ln(Infra_{jt})$ is negative. $\ln(Re\_Regulation_{jt})$ is positive and significant at 1% level.

In Model (2), fixed effect model turns out to be more efficient than random effect model according to the Hausman test.

Table 3: Empirical Results of Model (2)

Variable	Fixed Effect	Random Effect
$\ln(Distance_{ij})$	NA	-1.09 (0.02)**
$\ln(GDP_{jt})$	1.48 (0.00)***	1.34 (0.00)***
$\ln(Openness_{jt})$	1.32 (0.00)***	1.42 (0.00)***
$\ln(Wage_{jt})$	0.05 (0.29)	0.03 (0.49)
$\ln(Infra_{jt})$	-0.48 (0.06)*	-0.76 (0.00)***
$\ln(Re\_Regulation_{jt})$	0.27 (0.10)	0.36 (0.00)***
C	-6.99 (0.00)***	4.02 (0.36)
Observations	1090	
R-squared	0.62	0.40

***, ** and * denote for statistical significance at 99%, 95% and 90% confidence levels, respectively.

V. Conclusion

In this paper, Pollution Haven Hypothesis was introduced and examined empirically for the case of Korea. The Pollution Haven Hypothesis predicts that environmental regulation stringency affects trade between countries, thus dirty industry tends to move to countries with laxer environmental regulation.

To investigate Korea's case, Basic metal industry, Manufacture of wood and wood products, Manufacture of pulp and paper products, Manufacture of non-metallic mineral products and Manufacture of chemicals and chemical products were defined and analyzed as pollution intensive industry. Among various proxies measuring environmental regulation stringency, SO2 emission per GDP level was used to test the effect on FDI outflow of Korea's certain industries. In addition, host country's environmental regulation stringency was divided by Korea's stringency to measure 'relative' stringency of environmental regulation.

The results showed that Pollution Haven Hypothesis applies in Korea's case, showing that Korea's pollution intensive industry tends to outflow to countries with lax environmental regulation both in absolute and relative term. However, significance level of 'relative' environmental regulation is marginally lower compared to the 'absolute' stringency. Still, it shows positive relationship with Korea's FDI outflow, meaning that Korea's pollution intensive industries are predicted to move out to countries with laxer environmental regulation than Korea. Referring to the result that effect of 'relative' environmental regulation stringency

is lower than ‘absolute’ stringency, this may imply that Korean firms are not sensitive towards Korea’s policy change in environment. In other words, firms are more concerned with host country’s regulation than Korean government’s regulation change. This may be because it is clear that Korea’s environmental regulation became stricter since 1990s, according to expenditure on environment.

Even though it is found that environmental regulation stringency affects FDI outflow of Korea, some limitations exist in this research. First, there are more external determinants that may determine FDI location but not addressed in this research. Second, although it is proved in various perspectives that SO_2 emission per GDP level represents regulation stringency in environment, it still is not a direct measurement of regulation stringency. Third, this study is restricted to Korea’s case, thus further research is necessary to generalize the effect of environmental regulation stringency in global FDI movement.

Korea has demonstrated its ambition in taking a leadership role in green growth and sustainable development. However, this research detects Korea’s inconsistent behavior and potential harm it can cause to other countries. If this analysis extends to relationship between developed and developing countries, it may accelerate discussion between the North and South in regards to the responsibility in climate change.

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Appendix

Appendix 1: List of countries included in analysis

Australia	Cote d'Ivoire	Indonesia	Nepal	Slovak Republic
Bahrain	Cyprus	Ireland	Netherlands	Solomon Islands
Bangladesh	Czech Republic	Italy	New Zealand	Spain
Barbados	El Salvador	Japan	Nicaragua	Sri Lanka
Belgium	Fiji	Kazakhstan	Pakistan	Sudan
Bolivia	Finland	Kuwait	Panama	Sweden
Brazil	France	Kyrgyz Republic	Paraguay	Switzerland
Bulgaria	Germany	Lithuania	Philippines	Thailand
Cambodia	Ghana	Luxembourg	Poland	Turkey
Canada	Guatemala	Malaysia	Romania	United Kingdom
Chile	Honduras	Malta	Russian Federation	United States
China	Hungary	Mexico	Serbia	Uruguay
Colombia	India	Mongolia	Singapore	Venezuela, RB

Appendix 2: Summary Statistics

	$\ln(FDI_{ijt})$	$\ln(Distance_{ij})$	$\ln(GDP_{jt})$	$\ln(Openness_{jt})$
Mean	3.30	8.92	4.30	3.54
Median	0.00	9.02	4.35	3.52
Maximum	13.40	9.88	9.60	5.45
Minimum	-1.27	6.86	-1.56	1.39
Std. Dev.	4.08	0.60	2.15	0.65
Sum	3595.33	9721.75	4683.38	3856.18
Sum Sq. Dev.	18086.51	397.60	5016.70	464.28
Observations	1090	1090	1090	1090

	$\ln(Wage_{jt})$	$\ln(Infra_{jt})$	$\ln(Ab\_Regulation_{jt})$	$\ln(Re\_Regulation_{jt})$
Mean	10.00	2.59	-19.86	-0.17
Median	10.15	3.02	-19.67	0.02
Maximum	20.26	4.31	-14.79	4.4
Minimum	1.65	-3.22	-26.61	-6.24
Std. Dev.	3.46	1.45	1.84	1.81
Sum	10898.46	2826.71	-21643.62	-181.66
Sum Sq. Dev.	13035.97	2295.84	3687.19	3561.93
Observations	1090	1090	1090	1090

Appendix 3: Hausman Test of Model (1)

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
	13.16	5.00	0.02
Variable	Fixed	Random	Var(Diff.)	Prob.
$\ln(GDP_{jt})$	1.78	1.39	0.07	0.16
$\ln(Openness_{jt})$	1.49	1.62	0.09	0.69
$\ln(Wage_{jt})$	0.05	0.02	0.00	0.32
$\ln(Infra_{jt})$	-0.50	-0.75	0.03	0.17
$\ln(Ab\_Regulation_{jt})$	0.31	0.24	0.02	0.59

Appendix 4: Hausman Test of Model (2)

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
	6.95	5.00	0.22
Variable	Fixed	Random	Var(Diff.)	Prob.
$\ln(GDP_{jt})$	1.48	1.34	0.036	0.44
$\ln(Openness_{jt})$	1.32	1.42	0.097	0.75
$\ln(Wage_{jt})$	0.05	0.03	0.001	0.37
$\ln(Infra_{jt})$	-0.48	-0.76	0.034	0.14
$\ln(Re\_Regulation_{jt})$	0.27	0.36	0.016	0.48

요 약

환경오염회피가설을 검증하는 기존 연구들은 환경 규제의 영향을 측정하기 위해 다양한 방법론을 활용하여 분석하였다. 그러나 대부분의 경우 선진국들의 사례를 중심으로 연구되었으며, 한국의 사례를 실증 연구한 경우에는 환경 규제의 정도를 측정하는데 한계를 보인다. 본 연구는 한국의 오염집약적 산업의 경우 환경오염회피가설이 적용되는지를 검증하기 위해 환경규제를 가장 적합하게 측정할 수 있는 지표를 사용하여 검증하였다. 분석 결과, 한국의 오염집약적 산업들이 환경규제가 약한 나라들로 해외직접투자를 많이 하며, 환경규제가 한국의 해외직접투자에 유의하게 영향을 미치는 것으로 나타났다.

주요어: 환경오염회피가설, 오염산업이전가설, 환경규제, 해외직접투자, 오염집약적 산업

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