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ABSTRACT

Do Environmental Regulations Effect FDI Decisions? The Pollution Haven Hypothesis Revisited*

In an attempt to verify the pollution haven hypothesis, this study investigates the impact of environmental regulations on foreign direct investment (FDI). We use Korean outward FDI data covering the manufacturing sector for 2009-15. The study not only considers the stringency but also the enforcement of environmental regulations when measuring the degree of the host country's environmental regulations. Since the pollution haven's effects indicate moving the polluting production stages from the home country to other (host) countries, we distinguish between investments in the 'production' part from that in the non-production part using location information about the host country. The main results of the estimation of a FDI model show that the stricter the regulations in host countries in Asia the lower the FDI both intensively and extensively to those countries. This supports the prevalence of the effects of pollution havens. However, before we separate the FDI into the production part, the effect of environmental regulations on FDI is hindered by the FDI in the non-production part. The results indicate that environmental regulations are determinants of FDI in the production part, while environmental regulations do not have a significant effect on FDI decisions when the entire FDI is considered.

JEL Classification: F23, K32, L51, Q56

Keywords: pollution haven hypothesis, environmental regulation, foreign direct investment

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NON-TECHNICAL SUMMARY

This study is an attempt to verify the pollution haven hypothesis. It investigates the impact of environmental regulations on foreign direct investment (FDI). We use Korean outward FDI data covering the manufacturing sector for 2009-15. The study not only considers the stringency but also the enforcement of environmental regulations when measuring the degree of the host country's environmental regulations. Since the pollution haven's effects indicate moving the polluting production stages from the home country to other (host) countries, we distinguish between investments in the 'production' part from that in the non-production part using location information about the host country. The main results of the estimation of a FDI model show that the stricter the regulations in host countries in Asia the lower the FDI both intensively and extensively to those countries. This supports the prevalence of the effects of pollution havens.

1. Introduction

Do environmental regulations effect foreign direct investment (FDI) decisions? This question is related to the pollution haven hypothesis and the role of environmental regulations as determinants of FDI. The pollution haven hypothesis means that FDI seeks locations with weak regulations for manufacturing polluting products. Many studies have investigated the impact of environmental regulations on a firm's decision about a production location. The findings from these studies are mixed. Eskeland and Harrison (2003) found that foreign investment did not flow disproportionately into highly emitting industries. Neumayer (2001) argues that the evidence for pollution havens is relatively weak at best and inconclusive or even negative at worst. However, Chung (2014) found strong evidence that polluting industries tended to be invested more in countries with laxer environmental regulations. In his study investment patterns were in terms of both the amount of investments and the number of new foreign affiliates from South Korean data over 2000-07. Further, Henna (2010) found that amendments to the US Clean Air Act led US multinational firms to increase their foreign asset holdings and foreign produced outputs. The author argues that environmental regulations contributed to the departure of manufacturing firms; this supports the pollution haven hypothesis.

Generally FDI strategies related to the pollution haven hypothesis include the motivation for moving the production part to another country and not necessarily moving the non-production part to the same place. Some firms build foreign affiliates to approach local markets, get access to natural resources and better extraction and production technology and so on. When we examine the effect of the pollution haven hypothesis, we have to limit our focus on FDI mainly invested for establishing production stages in foreign countries. If a firm builds a research institution in Sweden, the degree of environmental regulations might not affect its FDI decision. Instead human capital and skill requirements will be the key determinants. Regulations might possibly have some positive effect on building a research institution since stringency of environmental regulations in general is positively related to the degree of development or technology in a country. Even when firms build affiliates in the same industry, their main FDI strategies can be different. Hence, it is hard to accurately distinguish different investment objectives without a firm's cooperation in providing the required information.

Our study investigates the impact of environmental regulations on FDI, with the objective of verifying the pollution haven hypothesis. The term 'Factory Asia' gives a hint about how to distinguish production and non-production foreign investment activities. As is commonly known many manufacturing plants are concentrated in Asia and this phenomenon is accelerated by FDI flows. So we can infer that outward FDI to Asian countries has the primary objective of building affiliates for manufacturing products. Ramondo (2016) called for a reallocation of the whole production process from developed to Asian countries as factory-less FDI, since the developed economies hold non-production processes such as marketing, design and R&D in their home countries. They move the production parts to Asian countries. Therefore, the destination country's characteristics such as whether it is located on the Asian continent, could represent the main objective of FDI -- for production and/or non-production purposes. In this study, investments in Asian countries except in Japan are viewed as a relocation of production, while investments in non-Asian countries are seen as establishing affiliates which focus relatively less on production and more on non-production activities such as research.

With Korean outward FDI data for 2009, 2011, 2013 and 2015, this paper found evidence that supports the pollution haven hypothesis. Our estimation results show that weak environmental regulations in host countries attract FDI for the production part of a manufacturing process. This effect vanishes if we do not control for investments in moving out non-production parts with an Asia dummy. This result indicates that capturing the environmental regulation effect on establishing the production part in a foreign country might be hindered by the non-production part if we do not distinguish between the two. Weak environmental regulations are found to have a positive effect on FDI both intensively and extensively. Further, we not only consider the stringency but also the enforcement of the index of environmental regulations. Since large heterogeneity might exist among non-Asian countries we used a non-developed country dummy instead of the Asia dummy to be inclusive.

The rest of this paper is organized as follows. Section 2 reviews previous literature on determinants of FDI and the pollution haven effect. Section 3 describes patterns of Korean FDI and environmental regulations and Section 4 introduces the data. Section 5 presents an estimation of the model and the main empirical results. Section 6 further exploits the impact of environmental regulations on FDI decisions with several indices and a non-developed country dummy variable as a complement to the regression analysis. Section 7 gives a conclusion.

2. Literature Review

With a surge in FDI, several streams of researches about the determinant of FDI have been conducted. The first stream focuses on the cost of production (Caves, 1982; Helpman and Krugman, 1985; Slaughter, 2003) which argues that the difference in factor costs across countries is a key determinant of FDI decisions. The second stream highlights the demand side because even if a firm manufactures products at a low cost and does not manage to sell its products then its profits may not be realized (Dunning, 1993; Shatz and Venables, 2000; Woodward, 1992). The third stream accentuates firm heterogeneity. Melitz (2003) and Hemplman et al., (2004) show that the most productive firms establish affiliates in foreign countries. The last and current controversial stream is about environmental regulations related to the pollution haven hypothesis. The pollution haven hypothesis means that multinational firms search for countries with lax environmental regulations to escape strict regulations in their home countries.[1] According to this view, a country with weak environmental regulations may attract foreign investors. Many papers have tried to verify the pollution haven hypothesis but their findings do not match their predictions.

Several papers have argued that environmental regulations do not effect FDI decisions. Using Japanese data from 1960 to 1995, Muthukumara and David (1998) maintain that there was no active displacement of polluting production to developing countries. They define a set of polluting industries based on the level of emission intensity (emissions per unit of output) of

[1] The pollution haven hypothesis is perhaps best seen as a corollary to the theory of comparative advantage: as costs for pollution control begin to matter for some industries in some countries, other countries should gain comparative advantage in those industries if pollution control costs are lower there (for whatever reason): provided by Eskeland and Harrison (1997: 4).

the industry at the 3-digit Standard Industrial Classification (SIC) level of US manufacturing and find patterns in favor of the hypothesis; the output of polluting sectors decreased in OECD countries but it increased in developing countries. However, they do not see this pattern as consistent with the pollution haven hypothesis based on evidence including: (i) the ratio of consumption to production in the polluting sectors in developing countries took a value close to 1, (ii) polluting products were concentrated in basic sectors and the developing countries have a highly income-elastic demand for these products, and (iii) not weak regulations but low energy prices and abundant energy subsidies attracted OECD countries' foreign investments. Evidence which did not support the pollution haven hypothesis was also found in US establishment-level data from 1982 to 1987. Levinson (1996) argues that the strict state environmental regulations did not deter the entry of new plants in the US. He argues that since compliance costs for environment are too small or the cost for establishing plants in new locations is too large, state environmental regulations do not significantly effect a firm's investment location decision. Eskeland and Harrison (2003) examined the FDI pattern using 4-digit industry level data from four developing countries[2] after controlling country-specific factors (openness, market concentration, market size, wage, etc.). In order to see if the costs from environmental regulations led firms to move theirs plants abroad, they used pollution abatement costs. Even if foreign investors were skewed towards polluting sectors, the evidence was too weak.

Other studies have found evidence which supports the pollution haven hypothesis. Using inward FDI data for the US List and Co (2000) examined whether FDI was sensitive to differences in environmental regulations across different states. They found that stricter regulations discouraged the entry of new firms which means decisions about FDI's location were affected by the degree of environmental regulations. Using firm-level data from 1966 to 1999, Hanna (2010) investigated whether the Clean Air Act Amendments (CAAA) effected multinationals' foreign investment decisions. Hanna's paper argues that regulations on pollution (CAAA), led multinational corporations to actively substitute foreign production locations for domestic locations.

While most of the studies focus on developed countries, Chung (2014) examines patterns of Korean outward FDI from 2000 to 2007. The author tests the pollution haven hypothesis with the host country's stringent environmental regulations and the industry pollution intensity of Korean data. Different from previous studies whose main findings are whether weak environmental regulations attract FDI or not, Chung investigates which industry should move where in terms of the industry's pollution intensity and environmental regulation variables. He found that Korean multinational firms tended to invest more in polluting industries located in countries having less stringent environmental regulations.

Our paper also uses Korean outward FDI data, yet there are several differences between Chung (2014) and our study. First, we use data covering the period 2009-15. With China's growth after 2000, the amount of Korean outward FDI has consistently and rapidly increased (Figure 1). However, the number of new established foreign affiliates suddenly dropped in 2008, the year

[2] The four developing countries are Cote d'Ivoire (1977-1987), Mexico (1984-1990), Morocco (1985-1990) and Venezuela (1983-1988).

of the global financial crisis and Korea has been getting the shrunk amount after the crisis year. This pattern of Korean outward FDI shows that before the global economic shock, FDI might have been subjected to bubbles. Hence, using the time after 2009 is a better way of investigating the effect of environmental regulations on FDI. Second, we disentangle foreign production investments using the Asia dummy variable. To verify the pollution haven hypothesis, we have to investigate FDI whose main objective is production because comparative advantage or cost issues matter only when multinational firms actually 'produce' goods. If all FDI is considered, the other motives like research may hinder what we want to investigate. Last, the index of environmental regulation used in our paper considers not only the stringency but also the enforcement of the environmental regulations. Even if a country has tight regulations on environment, if it does not enforce the regulations strongly then the degree of the regulations may not be stringent in reality. Therefore, considering both the indices – stringency and enforcement of environment regulations – matter for the results and analysis.

3. Characteristics of Korean FDI and Regulations

Figure 1 shows the trend of Korean outward FDI as recorded by the Export-Import Bank of Korea from 1980 to 2016. The statistics show negligible amount of outward FDI flows before 1990. In the mid-1990s there was a rapid increase in the level of outward FDI flows from Korea and after 2005 the amount of outward FDI became much larger. Growth after 2005 came because of economic growth in China and the opening of its market after it became a member of the World Trade Organization (WTO). Asian countries took quite a large portion of Korean global FDI in all these periods. However, there was a sudden decrease such as in 1997, 1998 and 2009. This is attributed to macroeconomic shocks of the Asian financial crisis and the global economic crisis. But besides these years, the amount of Korean outward FDI increased consistently.

[Insert Figure 1]

When it comes to the locations of Korean outward FDI, the number of new foreign affiliates is highly skewed in favor of locations in Asian economies (Figure 2). In contrast to a consistent trend of FDI amounts, new FDI amounts do not show consistent positive trends in 1980-2016. Despite the fact that the number of new established foreign affiliates decreased in 1998, the overall trend from 1980 to 2007 was upward. There was a sudden drop in 2008 but the amount remained constant after 2008, accounting for almost half of the value in the middle of 2000. This pattern indicates that because of growth and a positive demand shock from China, many Korean firms entered the Chinese market through FDI. But after the 2008 global financial crisis, the bubble that influenced a positive demand shock from China vanished. Going by Figures 1 2, it can be predicted that Korean outward FDI stabilized after 2008. Therefore, we chose our sample to include the post-2008 period as this period allows us to investigate the pollution haven hypothesis by utilizing more stabilized FDI samples after their investment patterns had settled down.

[Insert Figure 2]

In 2009 the Korean government declared that it would reduce greenhouse gases by 30 per cent calculated based on business as usual (BAU) by 2020. In 2008 the President of the Republic of

Korea, Myun-bak Lee had proposed low-carbon green growth as Korea's new vision. In an attempt to achieve green growth the government launched the Global Green Growth Institute (3GI) in 2010. In parallel the European Union's environmental policy also enacted several legislations for the environment[3] which meant that public interest in environment grew globally at that time.

4. Data and Variables

We use the Export-Import Bank of Korea's statistics covering South Korean manufacturing outward FDI data from 2009 to 2015. The bank records all Korean firms' outward FDI. FDI is categorized under 24 manufacturing sectors and 75 host countries. Table 1 shows the summary statistics of Korean outward FDI in 2009, 2011, 2013 and 2015. We divided the FDI into two groups: FDI to Asian countries and FDI to non-Asian countries. Another grouping is by the level of development in the developed and not-developed host countries. We used industry and country level data and at 642, the observations of FDI to Asian destinations are smaller than that to non-Asian country destinations (764 observations). From every aspect, the mean value of FDI to Asian countries was larger than that to other countries. The mean amount of FDI to Asian countries was about $ 274 million, while that to non-Asia country destinations was $ 159 million. The average number of new foreign affiliates in the Asian country group was 3.92 while the corresponding figure for the non-Asian country group was 1.42.

[Insert Table 1]

Table 2 gives the mean value of Korean outward FDI's variables by industry. As can be seen from the table there were differences in FDI patterns across industries. The most active industry was Electronics and Communication equipment with the highest observations and the number of newly established foreign affiliates in our sample, while the Tobacco industry was the least active in FDI. Industries related to basic metals, electronics and transport had larger FDI amounts.

[Insert Table 2]

According to previous literature (Chen and Moore, 2010; Dunning, 1993; Hyun and Hur, 2013; Yeaple, 2009), host country characteristics effect the location decisions for FDI. Hence, we added host country characteristics as control variables. We used real GDP and GDP per capita data from OECD.[4] The GDP is proxy for the foreign market size and the GDP per capita represents the country's labor costs. Both the variables are transformed to logarithmic forms in our estimation. Summary statistics of host country characteristics are described in Table 1. On

[3] The European Commission's Restriction of Hazardous Substances Directive (RoHS) come into force in 2006 and Registration, Evaluation, Authorisation & Restriction of Chemicals (REACH) came into force in 2007. In 2009, the European Chemicals Agency declared seven products as 'Substance of Very Concern' in its efforts to restrict these chemical substances.

[4] Even other host characteristics such as degree of corruption and rule of law are additionally included in the estimation. The results were not statistically different from our main estimation results including only GDP and GDP per capita variables.

average both the market size and the factor cost of Asian countries were smaller than those of non-Asian countries. The largest GDP level was about $ 1,860 billion, while the smallest was $ 1.70 billion. The highest GDP per capita was $ 106,000 while the lowest was $370.

We used environmental regulation data for the environment index from the Travel & Tourism Competitiveness Report (TTCR) which is a comprehensive report series published by the World Economic Forum. The World Economic Forum has measured and analyzed national competitiveness in many fields. It tries to provide benchmarking tools or indices which enable countries to measure and understand their economic competitiveness around the world. Starting from 2007, seven reports had been published till 2017 and we used four of the published reports (2009, 2011, 2013 and 2015). TTCR provides several indices for about 140 sample countries measuring their competitiveness in the sustainable development of the travel and tourism sector.[5] To measure the degree of environmental regulations we used one index – measuring environmental sustainability. Among several indices on environmental sustainability, we chose two indices related to environmental regulations.

The first index is the stringency of environmental regulations. This index is measured using the question: 'How would you assess the stringency of your country's environmental regulations?' The index takes a value between 1 and 7 with two periods' weighted average. The country's index takes the value of 1 if its environmental regulations are very lax and 7 if the regulations are the most stringent in the world. We used this first index in our main estimation step. But even if a country is highly regulated, if it does not implement the regulations properly and does not monitor their implementation, the regulations may not be strict in reality. So enforcement of regulations has to be considered when computing the index to measure the degree of environmental regulations. In Section 6, we conduct a robustness check with the index considering the enforcement of environmental regulations. The question is stated as 'How would you assess the enforcement of environmental regulations in your country?' with index value ranging between 1 and 7, that is, the same as in the first index on the stringency of environmental regulations. Additionally, we sum the first and second indices by considering both the degree and the enforcement of environmental regulations.

Based on the 2015 report, Denmark was ranked the highest with a stringency index of 6.3 and Yemen the lowest at 1.8. For the enforcement index, the Finland ranked at the top with a 6.3 index value while Yemen was the last with an index value of 1.7. Korea ranked 59th on the stringency index and 53th on the enforcement index among the 141 sample countries with 4.3 and 4.1 index values respectively.

Figure 3 shows the rank of FDI host countries measured in terms of stringency and enforcement of environmental regulations according to the Travel & Tourism Competitiveness Report (TTCR, 2015). The country ranks of the two indices shown in the figure are not the same. The two indices are highly correlated, but in several cases there are also some differences between

[5] The Travel & Tourism Competitiveness Index is constructed by aggregating 14 indicator categories including business environment, safety and security, health and hygiene, human resources and labor market, ICT readiness, prioritization of travel and tourism, international openness, price competitiveness, environmental sustainability, air transport infrastructure, ground and port infrastructure, tourist service infrastructure, natural resources and cultural resources and business travel.

them. Since Korean firms do not send FDI to all the countries, their range of target countries at 66 is smaller. In our sample, Egypt had the lowest rank in both the stringency and enforcement indices. As in the 2015 report, even in our indices Denmark and Finland had the tightest stringency and enforcement of environmental regulations respectively.

[Insert Figure 3]

Summary statistics of the two key environmental regulation indices and their aggregation are given in Table 1. All indices of environmental regulations are higher in non-Asian countries, indicating that Asian countries have weaker environmental regulations. The stringency of environmental regulation index takes a value between 1.50 and 6.60 and its average value is 3.80 and 4.83 for Asian and non-Asian country groups respectively. The enforcement index's maximum value is 6.40 while its minimum value is 1.40 and the mean value of Asian and non-Asian country groups is 3.72 and 4.61 respectively. The degree of environmental regulations in Korea is close to the world average. The correlation between the stringency and enforcement indices is 0.95 which indicates that a country with stricter environmental regulations tended to enforce the regulations more seriously.

5. Model Specification and Results

We used a non-linear model specification to investigate whether environmental regulations effected decisions about FDI and its location. This was motivated by the fact that after some specific degree of regulations, the growth in regulation effects would either slow down or intensify. The amount of FDI and the number of new FDI of Korean multinational firms are used as dependent variables, exploiting both the intensive and extensive sides of the environmental stringency effects. The model is specified as:

$$FDI_{ict} = a_0 + a_1 ER_{ct} + a_2 ER_{ct}^2 + a_3 Asia_c + a_4 ER_{ct} Asia_c + X'_{ct}\beta + Industry_i * Time_t + e_{ict}$$

$$where\ X'_{ct}\beta = \beta_1 GDP_{ct} + \beta_2 GDPP_{ct}$$

where FDI_{ict} is the amount of outward FDI (or alternatively the number of new foreign affiliates) of Korean multinationals in industry *i* to host country *c* at year t. ER_{ct} is the index of the degree of environmental regulations in host country *c* at year *t*. The larger the ER variable the stricter the country's environmental regulations. $Asia_c$ is a dummy variable which takes a value of 1 if FDI is sent to Asian country c, otherwise it takes the value of 0. We do not include Japan in the Asian country group because heterogeneity in development and environment exists between Japan and the other Asian countries. X'_{ct} is a vector of host country c's characteristics at year t. It includes aggregate real GDP and GDP per capita in a logarithmic form. GDP captures the size of the economy and the market, while GDP per capita gives the productivity of labor, level of development and well-being in the host country. $Industry_i$ is the industry dummy (24 sectors for manufacturing) and $Time_t$ is year dummy variables (2009, 2011, 2013 and 2015). The industry- and time-specific fixed effects are used to control unobservable effects of industry and time to FDI. $\alpha_1, \alpha_2, \alpha_3, \alpha_4\, \beta_1,\ and\ \beta_2$ are

unknown parameters to be estimated and e_{ict} is the standard random error term clustered by industry.

The estimation results with the amount of investment as the dependent variable are shown in Table 3.A. The sign of the environmental regulation (ER) coefficients is neither consistent with expected effects nor statistically significant in any of the model specifications. The model specifications differ by non-linearity in the ER effect and the Asian destination and its interactions with ER. With the results of environmental regulation variables, one may conjecture that environmental regulations do not effect FDI decisions. This result is in agreement with that of Eskeland and Harrison (2003) who found that the pollution haven effect exists but is too weak and insignificant. They used US industry-level data after controlling other factors which are known to have significant effects on FDI.

[Insert Table 3.A]

In order to verify the pollution haven hypothesis we have to only consider FDI whose main objective is establishing the production stage. This is because FDI for high technology and knowledge intensive activities which are not necessarily related to environment strictness may hinder the impact of environment restrictions on FDI. While the objective of the investment is not classified in our data, we can predict that FDI aimed at production is concentrated in Asian host countries. Hence, we added the Asia dummy variable and the interaction term of Asia and the environmental regulation variable to see if there was any evidence of the pollution haven effect on FDI in Asian countries. The coefficient of the Asia dummy is positive which means that Korean multinational firms tended to invest in Asian countries more than in other countries. The coefficient of our key variable, Asia and ER interaction term is negative and statistically significant at the 1 per cent level (column (3) of Table 3.A). This result indicates that environmental regulations matter when Korean multinational firms invest in Asian countries. In other words, the pollution haven effect exists, but it does not seem to support the hypothesis when the analysis is not limited to FDI in the production stage.

Since host country characteristics effect decisions about foreign investments (Dunning, 1993; Cheng and Kwan, 2000), we attempt to control them with real aggregate GDP and GDP per capita. The GDP variable in determining FDI is found to be positive and statistically significant in all columns of Table 3.A, meaning that the larger the country's market size the larger the multinational investments. The coefficients of the GDP per capita variables are negative and statistically significant, except in column (3) of Table 3.A. The results show that firms tended to invest more in countries whose factor costs were lower. Our results after including control variables are almost the same as those found in literature (for example, Chen and Moore, 2010).

In order to investigate how environmental regulations effect the number of new foreign investment avenues' extensive margins, we use the number of new foreign affiliates as dependent variables in Table 3.B. Again the model specifications differ as they assume non-linearity in ER effects on FDI and Asia destination and its interactions with ER. Since the dependent variable, the number of newly established foreign affiliates, is count data, the distribution may be skewed toward zero. So we use the zero inflated discrete count data model which follows a Poisson distribution.

When we consider FDI to Asian countries, the coefficient of environmental regulations still

holds at negative and statistically significant in column (3) of Table 3.B. The interaction term of Asia and the regulation variables have statistically significant and negative coefficients, meaning that the effects of the regulations are more intensive on new foreign affiliates in Asian countries. The estimation results of control variables do not differ from the results based on amount of FDI in Table 3.A as market size has a positive effect and factor costs have a negative effect on the number of new foreign investments.

[Insert Table 3.B]

The estimated coefficients of environmental regulations in Table 3.B are negative and statistically significant at the 10 per cent level, meaning that Korean multinationals tended to establish new affiliates in foreign countries where environmental regulations were lax. If the index of environmental regulation decreases one unit in a country, about 0.527 affiliates would be newly established in that country based on column (1) of Table 3.B. The corresponding decline in establishment of new affiliates calculated as a derivative of FDI with respect to ER are -0.648 and -0.650 based on columns (2) and (3) of Table 3.B. Likelihood ration tests of functional form suggest the general model in column (3) as the accepted model specification. This result shows that even if we do not restrict FDI to investment aimed at establishing production plants in foreign host countries, environmental regulations have extensive effects on FDI. This result is in agreement with that of Chung (2014) who found that environmental regulations effected extensive margins of FDI in Korean outward FDI data from 2000 to 2007.

6. Robustness Check

As mentioned earlier there are two indices which measure the host country's environmental regulations – the stringency of the regulations and their enforcement. In the main estimation, we used the index capturing the stringency of regulations. But the enforcement index also needs to be considered when measuring the degree of environmental regulations. We conducted additional robustness checks with other indices of environmental regulations – the enforcement index and the sum of stringency and enforcement indices with the same weights. Our estimation results based on the accepted model specifications incorporating squared ER, Asia dummy and its interactions with ER as well as control variables corresponding to column (3) of Table 3.B are reported in Table 4.

[Insert Table 4]

With the stringency and enforcement of regulation indices as well as the sum of the two indices in columns (1), (2) and (3) respectively, the amount of outward FDI is used as a dependent variable in Table 4. The main results in column (1) based on stringency of regulations are compared with the enforcement of regulations and the combined indices. All index variables have positive first order effects on FDI but the coefficients are not statistically significant, except the index measuring the enforcement of regulations. The coefficient of the squared ER index in different models is negative but insignificant. The coefficients of the interaction term of Asia and environmental regulation variables are consistently negative and statistically significant at the 1 per cent level even with other indices of the regulations. In this additional specification test, the results in the main estimation qualitatively and quantitatively remain the same as before.

Estimation results of the number of new FDI using the Poisson regression method with different indices and their combinations are presented in columns (4)-(6) of Table 4. The coefficients of the regulations are negative when the enforcement of the regulations is considered but they are insignificant. The coefficients of the key variable, the interaction term in columns (5) and (6) considering the enforcement index, are still negative and statistically significant at the 1 per cent level. This was also the case while using only the stringency index in column (4).

There might be large heterogeneity among non-Asian countries as receivers of FDI. If Korean multinational firms establish R&D centers, it is very likely that they send FDI to Europe or America but not to Africa. So for the robustness check instead of the $Asia_c$ variable, we use the development of country as a criterion for classification. $NDev_c$ is the dummy variable which takes the value 1 if FDI sent to host country c which is not developed and is located in Africa, Asia (except Japan) and South America, otherwise it takes the value 0. The estimation results for the non-developed country dummy are described in Table 5.

[Insert Table 5]

In columns (1)-(3) of Table 5 the amount of FDI is used as a dependent variable, while the number of new FDI is given in columns (4)-(6). We also consider all the indices for environmental regulations. In the first row, there are no negative and statistically significant coefficients of the ER indices, indicating that there is no pollution haven effect when it comes to decisions about new FDI. However, the interaction term of the non-developed country dummy variable and environmental regulations has negative and statistically significant coefficients in all columns, except in column (1). The results using the degree of development of the country as the criterion of classification consistently show that weak regulations on environment attract FDI in production. It should be noted that the total effect of ER is the effect of interest. Due to insignificant individual coefficients the total effect of changes in ER on amount and the number of new FDI reflect the true effect.

7. Conclusion

A number of researches have studied the impact of environmental regulations on FDI flows verifying the pollution haven hypothesis. But due to mixed results this issue is being debated. A weakness of previous studies is that they did not pay attention to the separation of foreign direct investment for the purposes of production and non-production activities overseas. A pollution haven means that multinational firms try to produce their polluting products in other countries through the relocation of their production processes to host countries with lax environmental regulations. Earlier researches only pay attention to polluting products and they do not consider whether the firms move their ‘production’ or ‘non-production’ parts to other countries. Neglecting these two may result in biased and confounded effects and inferences about the pollution haven hypothesis. Our paper tested the pollution haven hypothesis with production/non-production aspects of FDI in focus. Since our data does not include the objective of foreign investments or the type of foreign affiliates, we assume FDI to Asian countries as foreign investments aimed at relocation of production, while investments in non-Asian countries as being aimed at non-production activities. This classification of countries captures FDI’s environmental and cost considerations.

Using Korean outward FDI data we found that environmental regulations did not affect the whole FDI but it only effected FDI to Asian countries. This indicates a trade-off effect of the two confounded effects in which one is positive and the other is negative. If FDI for production is not classified and separated, the two effects are confounded and as such neutralize each other with an insignificant effect. In such a situation one may erroneously conclude that environmental regulations do not have any effect on FDI. Differentiating foreign investments in the production stage from that in the other stages with the Asia country dummy, we found that Korean multinational firms tended to make production investments in countries whose environmental regulations were lax. Environmental regulations influenced FDI decisions both intensively and extensively. The results provide evidence which supports the pollution haven hypothesis.

Our main findings are robust with other indices which consider enforcement of regulations and the classification of production and non-production parts based on sample countries' development levels. The results are almost the same as those using only the regulation stringency index. Nonetheless, this research can be generalized in a number of ways. First, we assume foreign affiliates in Asian countries as production plants. We could not use precise data of foreign affiliates because data for type of foreign affiliates is not available. Second, our research uses industry-level FDI data, but firm heterogeneous characteristics may have considerable effects on FDI decisions. If firm-level data becomes available in the future, the effect of the stringency and enforcement of environmental regulations on firms' FDI decisions can be investigated more intensively.

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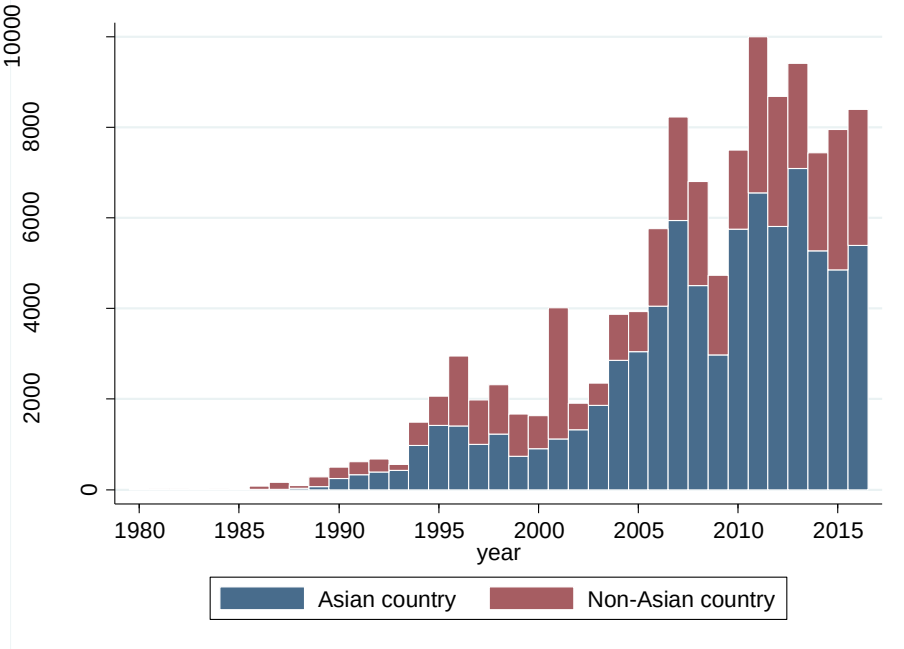
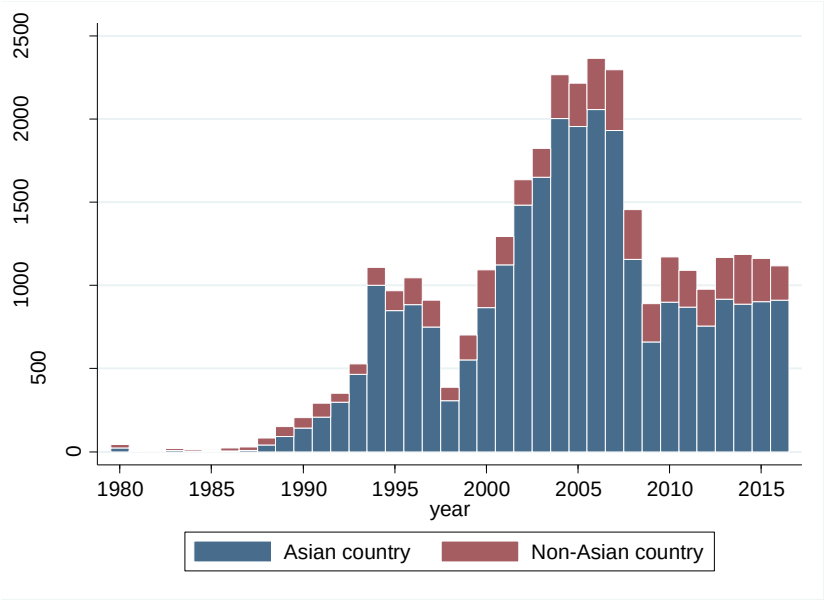
Figure 1: Development and decomposition of Korean Outward FDI, 1980-2016



Source: The Export-Import Bank of Korea.

Figure 2: Number of newly established foreign affiliates by Korean multinationals, 1980-2016



Source: The Export-Import Bank of Korea.

Table 1: Summary statistic of FDI, host country characteristics and indices of environmental regulations

Asian country (642 obs)	Mean	Std. Dev.	Min	Max
Amount of FDI	274.77	1340.91	0.00	31575.03
Number of new FDI	3.92	9.33	0.00	94.00
GDP	284.81	487.10	1.97	1860.98
GDP per capita	100.81	137.59	7.28	746.87
Stringency of environmental regulations	3.80	0.79	1.90	5.80
Enforcement of environmental regulations	3.72	0.78	1.90	5.70
Sum of stringency and enforcement indices	7.53	1.55	4.00	11.50
Non-Asian country (764 obs)	Mean	Std. Dev.	Min	Max
Amount of FDI	159.07	567.65	0.00	8032.30
Number of new FDI	1.42	2.66	0.00	23.00
GDP	367.88	500.05	1.70	1694.01
GDP per capita	301.45	201.76	3.70	1064.09
Stringency of environmental regulations	4.83	1.03	1.50	6.60
Enforcement of environmental regulations	4.61	1.10	1.40	6.40
Sum of stringency and enforcement indices	9.44	2.09	2.90	13.00
Not developed country; NDev (471 obs)	Mean	Std. Dev.	Min	Max
Amount of FDI	255.88	1256.87	0.00	31575.03
Number of new FDI	3.37	8.54	0.00	94.00
GDP	254.59	447.48	4.30	1694.01
GDP per capita	94.97	126.52	3.70	746.87
Stringency of environmental regulations	3.81	0.80	1.50	5.80
Enforcement of environmental regulations	3.68	0.76	1.40	5.70
Sum of stringency and enforcement indices	7.49	1.52	2.90	11.50
Developed country; Dev (935 obs)	Mean	Std. Dev.	Min	Max
Amount of FDI	154.56	476.66	0.00	6875.00
Number of new FDI	1.61	2.92	0.00	23.00
GDP	458.04	553.01	1.70	1860.98
GDP per capita	385.90	167.07	53.11	1064.09
Stringency of environmental regulations	5.18	0.84	2.90	6.60
Enforcement of environmental regulations	5.02	0.93	2.80	6.40
Sum of stringency and enforcement indices	10.21	1.74	5.70	13.00

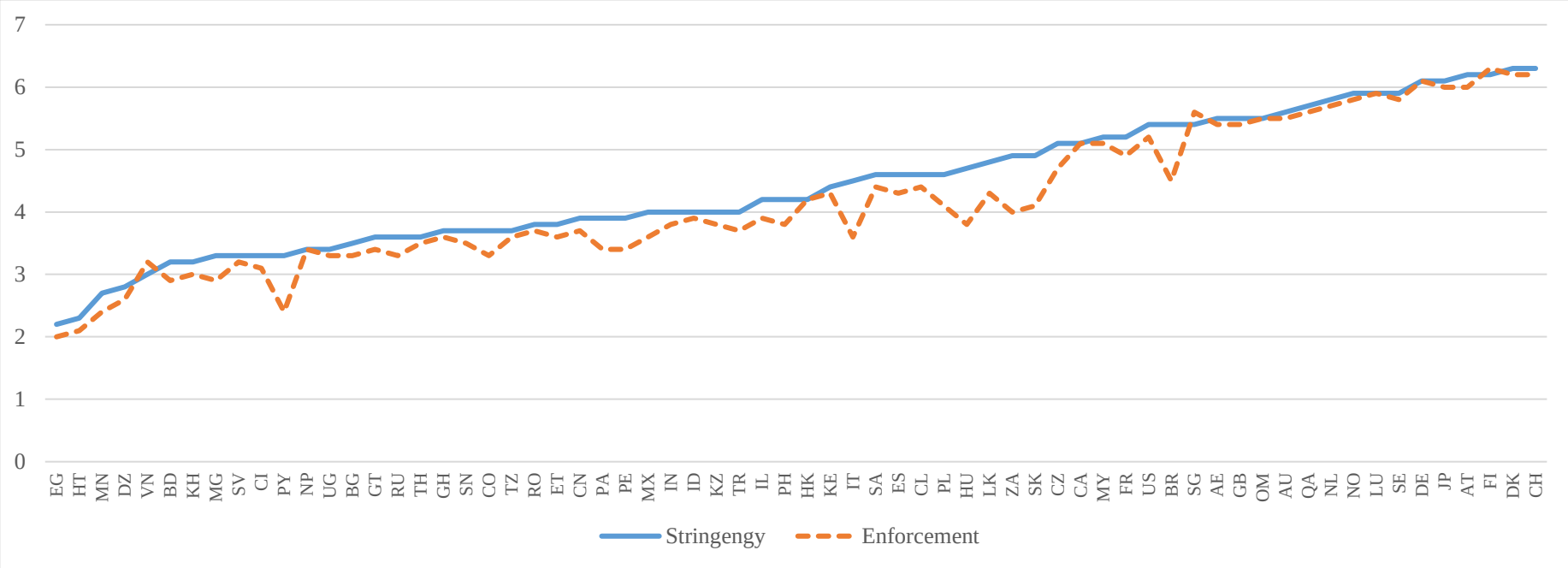
Notes: 2009, 2011, 2013 and 2015 data are used in the table. The unit of amount of FDI is $ 100 million. Unit of amount of GDP is $ 10 billion. Unit of GDP per capita is $ 100.

Table 2: Summary statistics of Korean outward FDI across industries

Industry	Observation	Amount of FDI	Number of new FDI
Food	63	168.80	2.13
Beverages	18	110.47	0.56
Tobacco	5	326.31	0.20
Textiles	53	103.00	2.66
Apparel	61	182.30	4.48
Leather and Luggage	45	103.16	2.04
Wood	36	31.51	0.89
Pulp and Papers	32	35.03	1.00
Printing	24	6.63	0.96
Refined petroleum	39	69.24	0.62
Chemical	99	203.98	2.65
Pharmaceuticals	56	58.62	1.18
Rubber and Plastic	78	163.57	2.82
Non-metal	35	119.81	1.69
Basic metals	69	507.32	1.58
Fabricated metals	86	85.44	2.31
Electronics and Communication equipment	102	776.91	6.55
Precision and optical instruments	84	38.85	2.19
Electrics	97	164.84	2.79
Other electrical equipment	97	200.25	5.10
Vehicles	96	525.62	3.43
Other Transportation equipment	39	329.26	1.31
Furniture	25	27.78	1.64
Other manufacturing	67	100.97	2.87
Total manufacturing	1,406	221.94	2.78

Notes: 2009, 2011, 2013 and 2015 data are used in the table. Unit of amount of FDI is $ 100 million.

Figure 3: Index of stringency and enforcement of environmental regulations across countries, 2015



Notes: Countries are ranked by level of stringency of environmental regulations.

Table 3.A: Effect of environmental regulations' stringency on amount of FDI

Ln(Amount of investment)	(1)	(2)	(3)
ER	-0.196	-0.619	0.195
	(0.144)	(0.592)	(0.758)
ER^2		0.0485	-0.00777
		(0.0724)	(0.0832)
Asia			3.685***
			(0.851)
Asia*ER			-0.635***
			(0.184)
lnGDP	0.674***	0.684***	0.661***
	(0.0607)	(0.0607)	(0.0627)
lnGDPP	-0.252**	-0.255**	-0.0836
	(0.119)	(0.121)	(0.120)
Constant	-8.306***	-7.676***	-11.71***
	(1.763)	(2.122)	(2.422)
Observations	1,406	1,406	1,406
R-squared	0.244	0.245	0.274
Total ER effect (δFDI/δER)	-0.196	-0.250	-0.154

Notes: Pooled least squares estimation model is employed with industry-year fixed effects. The environmental regulation (ER) variable is defined as stringency of environmental regulations. F-value tested between models in columns (1) and (2) 0.64. F-value tested between model in columns (2) and (3) 27.87. Numbers in parentheses are standard errors clustered by 2 digit level industry. ***, **, * indicate significance at the 1%, 5% and 10% levels of significance.

Table 3.B: Effect of environmental regulations' stringency on number of new FDI

Number of new FDI	(1)	(2)	(3)
ER	-0.527***	-1.849***	-0.745*
	(0.0332)	(0.164)	(0.394)
ER^2		0.158***	0.0711*
		(0.0183)	(0.0400)
Asia			5.162***
			(1.079)
Asia*ER			-0.975***
			(0.242)
lnGDP	0.663***	0.712***	0.692***
	(0.0440)	(0.0443)	(0.0408)
lnGDPP	-0.187***	-0.235***	0.107*
	(0.0299)	(0.0353)	(0.0573)
Constant	-14.54***	-12.94***	-19.48***
	(1.354)	(1.343)	(2.041)
Observations	1,406	1,406	1,406
R-squared	0.411	0.417	0.472
Total ER effect (δFDI/δER)	-0.527	-0.648	-0.650

Notes: The Poisson regression model is employed with industry-year fixed effects. The environmental regulation (ER) variable is defined as stringency of environmental regulations. Likelihood-ratio chi-square value in test between models in columns (1) and (2) is 80.21 and that between models in columns (2) and (3) is 682.22. Numbers in parentheses are standard errors clustered by 2 digit level industry. ***, **, * indicate significance at the 1%, 5% and 10% levels of significance.

Table 4: Effect of environmental regulations on amount and number of FDI, using different indices

Variable	Ln(Amount of investment)			Number of new FDI		
	Stringency of Regulations	Enforcement of Regulations	Sum of Stringency and Enforcement	Stringency of Regulations	Enforcement of Regulations	Sum of Stringency and Enforcement
	(1)	(2)	(3)	(4)	(5)	(6)
ER	0.195	1.243*	0.373	-0.745*	0.356	-0.260
	(0.758)	(0.716)	(0.391)	(0.394)	(0.340)	(0.171)
ER^2	-0.008	-0.126	-0.0172	0.071*	-0.030	0.014
	(0.083)	(0.081)	(0.022)	(0.040)	(0.034)	(0.009)
Asia	3.685***	3.288***	3.604***	5.162***	4.696***	5.040***
	(0.851)	(0.853)	(0.874)	(1.079)	(0.915)	(1.010)
Asia*ER	-0.635***	-0.570***	-0.315***	-0.975***	-0.896***	-0.479***
	(0.184)	(0.195)	(0.098)	(0.242)	(0.206)	(0.114)
lnGDP	0.661***	0.627***	0.643***	0.692***	0.599***	0.653***
	(0.063)	(0.063)	(0.063)	(0.041)	(0.045)	(0.042)
lnGDPP	-0.084	-0.120	-0.099	0.107*	-0.019	0.059
	(0.120)	(0.109)	(0.114)	(0.057)	(0.056)	(0.056)
Constant	-11.710***	-12.530***	-12.220***	-19.480***	-18.050***	-18.430***
	(2.422)	(2.321)	(2.420)	(2.041)	(1.612)	(1.823)
Observations	1,406	1,406	1,406	1,406	1,406	1,406
R-squared	0.274	0.271	0.272	0.472	0.441	0.457
Total ER effect (δFDI/δER)	-0.156	-0.235	-0.030	-0.651	-0.343	-0.268

Notes: The pooled least squares estimation model is employed with industry-year fixed effects in column (1)-(3). The Poisson regression model is employed with industry-year fixed effects in column (4)-(6). The environmental regulation (ER) variable is defined as stringency of environmental regulations in columns (1) and (4), as enforcement of environmental regulations in columns (2) and (5), and as sum of stringency and enforcement of environmental regulations in columns (3) and (6). Numbers in parentheses are standard errors clustered by 2 digit level industry. ***, **, * indicate significance at the 1%, 5% and 10% levels of significance.

Table 5: Effect of environmental regulations on amount and number of FDI, using different classification criteria

Variable	Ln(Amount of investment)			Number of new FDI		
	Stringency of Regulations	Enforcement of Regulations	Sum of Stringency and Enforcement	Stringency of Regulations	Enforcement of Regulations	Sum of Stringency and Enforcement
	(1)	(2)	(3)	(4)	(5)	(6)
ER	-0.085	1.660**	0.433	0.843	1.665***	0.629*
	(0.689)	(0.739)	(0.369)	(0.673)	(0.569)	(0.333)
ER^2	0.031	-0.154*	-0.017	-0.069	-0.150***	-0.027
	(0.069)	(0.078)	(0.019)	(0.066)	(0.057)	(0.017)
NDev	3.166*	3.483**	3.567**	6.515***	5.390***	6.401***
	(1.530)	(1.278)	(1.441)	(1.053)	(0.854)	(1.039)
NDev*ER	-0.483	-0.602**	-0.297*	-1.306***	-1.115***	-0.659***
	(0.308)	(0.281)	(0.151)	(0.262)	(0.219)	(0.131)
lnGDP	0.707***	0.655***	0.681***	0.697***	0.620***	0.664***
	(0.062)	(0.063)	(0.062)	(0.044)	(0.046)	(0.045)
lnGDPP	-0.090	-0.151	-0.116	-0.019	-0.177***	-0.079*
	(0.133)	(0.116)	(0.124)	(0.043)	(0.044)	(0.044)
Constant	-12.650***	-14.440***	-13.860***	-22.680***	-20.490***	-21.990***
	(2.478)	(2.212)	(2.323)	(2.048)	(1.657)	(1.975)
Observations	1,406	1,406	1,406	1,406	1,406	1,406
R-squared	0.259	0.259	0.258	0.446	0.415	0.430
Total ER effect (δFDI/δER)	-0.188	0.641	0.169	-0.016	0.431	0.125

Notes: The pooled least squares estimation model is employed with industry-year fixed effects in columns (1)-(3). The Poisson regression model is employed with industry-year fixed effects in columns (4)-(6). The environmental regulation (ER) variable is defined as stringency of environmental regulations in columns (1) and (4), as enforcement of environmental regulations in columns (2) and (5), and as sum of stringency and enforcement of environmental regulations in columns (3) and (6). Numbers in parentheses are standard errors clustered by 2 digit level industry. ***, **, * indicate significance at the 1%, 5% and 10% levels of significance.