CIRJE-F-394

Globalization and Pollution Industries in East Asia

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January 2006

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January 2006

Abstract

In this paper, we investigate what the East Asian data tell us about the "pollution haven hypothesis." In the region, pollution goods are not traded so much directly, and their production is not clearly correlated with inward FDI and openness of the country in question. Although production of pollution goods is indirectly related to manufacturing exports as materials and intermediate goods, domestic consumption exerts larger impact on the production than exports. These facts imply that pollution industries are not so much influenced by the "globalization," suggesting indirectly also that a gap in environmental regulations do not lead to an increased scale of foreign trade and FDI. To the question of how FDI inflows and openness contribute to energy efficiency and labor productivity, we find a positive effect of FDI on the labor productivity in low and middle-income countries, although its effect on energy efficiency is rather vague.

Key words: trade, FDI, globalization, pollution haven hypothesis, East Asia,

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[1] This paper is one of the outcomes of projects by the Research Institute for Humanity and Nature, "Emissions of Greenhouse Gases and Aerosols, and Human Activities in East Asia," and Research Institute of Economy and International Trade, "Trade and the Environment. "The author gratefully acknowledges research assistance by Tomoko Kaino, advices on econometrics from Naoto Kunitomo and various comments from participants of the projects.

1. Introduction

Among the global environmental issues, the relationship between trade and environment has recently become a focus of extensive discussions. One of the related questions is how the trade liberalization, more generally to say, "globalization" affect the environment. The anti-globalization leaders criticize that free trade deteriorates the environment, which constitutes one of the basis of their active movements. The tendency that pollution intensive industries shift to countries with less strict environmental regulations was once called "export of pollution, " but it is recently better known as the "pollution haven hypothesis",[2] named by analogy with the concept of "tax haven". Another question is to what extent environmental regulations do affect the competitiveness of firms in the country concerned. This is also a political issue that raised hot debates on environmental and/or carbon tax. As far as environmental policies influence competitive positions of firms, the latter question is closely related to the "pollution haven" discussions.

In this paper, we deal with a question of how, and to what extent East Asian trade and foreign direct investments (FDI) affect the production of pollution industries, and thereby influence environmental degradations in the region. Pollution industries are composed of, using the International Standard Industrial Classification (ISIC) Revision 2, paper and products (341), industrial chemicals and other chemicals (351,352), petroleum refineries (353), miscellaneous petroleum and coal products (354), other non-metallic mineral products (369), iron and steel (371), and non-ferrous metals (372). [3] Those industries were not only targets of public complaints as the sources of air and water pollutions from the early 1970s, but more recently viewed also as large sources of CO_2 emissions due to the scale of their energy consumption.

East Asian countries have experienced remarkable economic development, being led and sustained by their open-door policies and manufactured exports. Although not yet having formed a legal economic integration as a whole, as seen in North America and in Western Europe, the growth in intraregional trade has been higher than in these two counterparts. In this sense, this region is a good example for testing how regional economic transactions influence the environment. The paper by Grossman and Krueger (1993) that paved the way for discussion on the Environmental Kuznets Curve (EKC) was initially motivated by a question of the environmental impacts by

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[2] Effects resulted from regulations on CO_2 emissions, in particular, are called "carbon leakage."

[3] Definition of pollution industries follows Tobey(1990), and Mani and Wheeler (1998).

forming the NAFTA.

This paper is constructed as follows. Chapter 2 reviews literature on the relationship between trade and the environment, more specifically on "the pollution haven hypothesis". Chapter 3 deals with the actual situation of East Asia using the regional data; firstly the composition of foreign trade, and secondly the production trend of the pollution industries. Whereas the East Asian trade data do not reveal that pollution goods are directly traded to a large extent, the production of those goods have been actually increased. The question of what caused the latter trend is empirically examined in the following section of Chapter 3. Chapter 4 discusses possibilities of pollution abatement; firstly effects of technology transfer by testing the influence of foreign openness and FDI on energy efficiency, then on labor productivity, and secondly potential of regional cooperation on environmental protection.

２．Pollution Haven Hypothesis

２．１　A short survey of the literature

So far, there have appeared a number of studies on the questions of how environmental regulations lead to international movement of pollution sources (or industries), and to what extent individual firms of pollution industries consider cost to observe environmental regulations in deciding location of factories.[4] Table 1 summarizes conclusions of these empirical studies, to which we add some comments.

As for the dependent variable, Tobey(1990), Busse(2004), and Grether and de Melo(2004) select trade balance, or net-export of pollution goods, while Smarzynska and Wei(2001), and Dean *et. al.* (2005) take FDI of individual firms. The former studies selecting trade data focus on the actual effects on foreign trade, while the latter analyze firms' behavior of shifting production basis on the micro-level. Grossman and Krueger (1993), though confined to the relation between USA and Mexico, choose US import ratio and production share of Mexican Maquiladora over US total, thereby in fact test both of the two aspects. Copeland and Taylor (2003), on the other hand, exceptionally take air-pollution level as a dependent variable, which in fact take into account of not only movements of pollution sources, but as well effects of environmental regulations.

[4] For influences on American manufacturing firms, in particular, see Jaffe *et al.*(1995). Copeland and Taylor (2004) review literature thereafter.

As for independent variables, not only indicators of environmental regulations, but also endowments of production factors, capital-labor ratio (capital stock per labor), economic scale, tariff rate, and geographical distance of host countries are included, because industrial structures are determined not solely by differences in environmental regulations. Needless to stress, the Heckscher-Ohlin model (HOM) tells that endowments of production factors determine comparative advantage of a country. Yet, looking at macroeconomic data alone does not fully reveal behavioral motivation of individual firms. Smarzynska and Wei(2001) and Dean *et. al.* (2005) accordingly go deeper into factors in host countries that influence multinational firms' decision whether or not to invest; such as bureaucratic corruption, infrastructure, tax rate, and quantity of laborers, and suppliers of intermediate goods.

As the right-end column of Table 1 suggests, the results of empirical studies, generally speaking, do not confirm the "pollution haven hypothesis", although with some exceptional examples. In other words, environmental regulations do not affect as much as to cause changing patterns of foreign trade, and foreign investment decisions by individual firms. However, Busse (2004) confirms partly some effects in the case of iron and steel industry, Grether and de Melo (2004) for nonferrous metals (and paper and pulp), in addition to iron and steel. These exceptional cases correspond to the conclusion of Smarzynska and Wei (2001) that admits weak evidence of environmental regulations on FDI by highly polluting industries. Dean *et. al.* (2005), analyzing joint ventures in China, confirm some influence on those in highly polluting industries, and moreover operating with Hong Kong, Taiwan, and Macao capital, while no influences is found in the joint ventures with capital from OECD countries in any industrial sectors. These results suggest some limited effects in trade and investments of firms that belong to pollution industries.

These empirical studies, however, are not free from shortcomings in their methodology and interpretation. Firstly, how to select indicators for environmental regulations is a technically difficult question. Number of international environmental treaties and protocols that a country participates in and ratifies, or the rate of penalties for pollution, for example, are selected, but they do not necessarily reflect actual state of the environmental policies. There is sometimes a wide gap between legislation and its implementation, in developing countries in particular. It is largely questionable to choose income level as representing degree of environmental regulations like Grether and de Melo (2004).

Secondly, interpretation of the empirical results is as well complicated. Bureaucratic corruption, for example, would surely retard inward foreign investments. Yet, we often find, in developing countries, corruptions coupled with loose environmental regulations. Loose regulations tend to invite FDI, on the one hand, whereas corruptions decrease attractiveness for foreign investors, on the other hand. Then, effects of environmental regulations do not appear so clearly, as Smarzynska and Wei (2001) admit.

The negative conclusion for the "pollution haven hypothesis" as a whole is consistent with following facts. The actual cost incurred by the environmental regulations (or pollution abatement cost) is reported to amount to around 2% of the total cost even in the case of heavily polluting industries.[5] In other words, the gap in monetary cost between countries with strict environmental regulations and others without any regulations does not go beyond the level of around 2% of the total. Difference in the cost of production factors, on the other hand, usually stays to a far larger extent. In particular, labor cost in Japan stays ten to twenty times more than in China. For another example, since most of pollution goods belong to intermediate goods, and tend to weigh much per value, high transportation costs hinder shifting location of production basis, as Grether and de Melo (2004) stress. Considering these factors all together, it is natural that environmental regulations do not affect trade flows and location of manufacturing factories so much as the hypothesis implies. But why do some of the empirical studies, even if partly, result in ambiguous conclusions?

To this question, we can present some probable answers. Even though the direct cost differentials in environmental regulations stand small, firms that shift their factories from other reasons, say large difference in labor costs, may take advantage of loose environmental regulations in host countries, and cause larger pollutions. Developing countries with cheap labor are usually equipped with loose environmental regulations. Even if difference in environmental policies is not the main cause for multinationals to shift their production basis, their decision may result as a matter of fact in larger pollutions.[6]

Yet, we have as well to note that the actual results depend on technical capabilities. If pollution abatement is realized with so-called "end-of–pipe" equipments such as desulfurization of waste smoke and filtering suspended particulates, then firms can avoid additional expenditure for such equipments. But if pollution abatement requires remaking of the whole production line, then environmental protection technology would remain in the same state as being operated in the developed

[5] Chemical industries (non-organic and organic) show largest proportion of 2.89%, while other industries show a little more or less than 2%. Tobey (1990), Table 1.
[6] Iwami (2004b), pp.140-41.

countries with strict regulations. In addition, multinationals facing critical eyes of the environmental NGOs cannot sacrifice reputation by making use of the loose regulations in developing countries even if it is technically feasible.[7]

２．２　Three factors that affect pollution

Open door policies to foreign economic transactions do not necessarily deteriorate the environment as leaders of anti-globalization movement often claim, because the effects of foreign trade and investments appear in complicated conjunctures. More specifically, foreign economic transactions influence the environment by way of, at least to say, three factors; 1) scale effect, 2) composition effect, and 3) technique effect.[8]

Scale effect is derived from enlarged economic scale either of industrial production, or GDP. Foreign transactions, as usually anticipated, lead to economic growth, and thereby contribute to this effect. In the debate over the globalization, mainstream economists have stressed that openness for international economic transactions is positively correlated with income level, and/or economic growth.[9] But empirical studies do not necessarily show a clear positive relationship between policies towards international trade and foreign capital, on the one hand, and growth performance, on the other. Cross-country analyses, in particular, reveal poor evidence.[10] Performance in economic growth is related not only to trade policies in a narrower sense, but also to other macroeconomic policies like stabilizing price level and choosing appropriate exchange rates, and more broadly speaking, policies of making better circumstances for investments.

Table 2 shows coefficients of correlation between the income level (GDP per capita) and openness of East Asian countries. Openness (1) stands for ratio of export plus import over GDP, while (2) for ratio of capital export and import (excluding FDI) over GDP, and (3) for capital export and import (including FDI) over GDP. Yet, the coefficients of correlation between three variables of openness show relatively high value. Rather clear difference is found between two cases, whether or not Japan that has large domestic market is included. When Japan is excluded from East Asia, coefficients of correlation are quite large. In other words, East Asian countries except

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[7] Bhagwati(2004),p.150.
[8] This taxonomy is initially adopted by Grossman and Krueger (1993), and then followed by Copeland and Taylor (2003), for example.
[9] Dollar and Kraay(2001), Bhagwati(2004).
[10] Baldwin (2004).

for Japan attain high income-levels when open policies towards international economy are employed.

When economic scale like GDP is enlarged, energy consumption and volume of wastes grow as well, thereby increasing environmental damages. However, as discussions of EKC suggest, higher income level in terms of GDP per capita may contribute to reducing impacts on the environment. With population remaining approximately stable, the influence of enlarged GDP on the environment depends on the income level of a country.

Composition effects are related to changing industrial structure induced by international trade and FDI. The "pollution haven hypothesis" suggests that pollution industries tend to concentrate in developing countries, as a result of international difference in environmental policies. The discussions of EKC are often based on the similar prepositions that lead to decreasing pollutions in high-income countries, on the one hand, and increased pollutions in low-income countries, on the other hand. Applying the HOM, however, high-income countries have comparative advantage in capital-intensive industries, because of their large capital stock. Since pollution industries are, generally speaking, capital-intensive, like iron and steel, and oil refineries, they tend to concentrate in high-income countries where capital cost is relatively low.[11] Nevertheless, it is also worth noting that capital movements across countries have recently extended to such a large scale, that difference in capital endowments tend to play rather a smaller role than former years.

Technical effects imply that new technology reduces pollution through higher energy efficiency and other abatement innovation. Since developed countries are usually in better position in utilizing these effects, the actual level of pollution can be reduced there, even if lower capital cost would invite pollution industries. When these industries are to shift to developing countries, technology transfer through FDI and imports of capital goods from developed countries would contribute to lower level of actual pollution. Through these channels, technology effects lead to less pollution worldwide, both in developed and developing countries. The critical question is to what extent innovation potential is exploited, and/or new technology is transferred. The latter aspect is naturally stimulated by increased scale of foreign trade and capital movements, an outcome of the open-door policies.

３． What do trade and production data tell?

[11] Grossman and Krueger (1993) include stock of human capital as well.

3．1 East Asian economic growth and integration

East Asian countries have attained economic development through export-led industrialization. The manufacturing share in exports has increased more rapidly than its share in GDP.[12] Moreover, the growth rates of GDP and exports stood higher than NAFTA and EU.[13] Table 3 shows that East Asian exports in 2001 stood 17.6 times as much as in 1975, while the similar figures are 6.7 times for EU（15 countries）and 8.2 times for NAFTA. The intraregional export of East Asia grew during the same time -period nearly 33 times, and its share to the world total increased from 2.4% to 10.1%; the latter figure as of 2001 reached the same level as NAFTA. Although only at a half of the EU share, the growth rate of intraregional exports has been remarkable compared with EU and even with NAFTA. Indeed, this region is lacking of the legal basis for economic integration except among ASEAN countries, but has attained a *de facto* economic integration so far through the extended scale of intraregional trade and FDI.

To examine the "pollution haven hypothesis," it is important to know what kind of trade goods have actually led a growth in exports. The intraregional exports (excluding Japan) have been sustained by machinery, more specifically machinery in general, electrical machinery, office machines, and transport equipment.[14] This pattern holds good also in exports to other regions. While the share of these goods is smaller in exports to Japan, its share stands much higher in exports from Japan to other East Asian countries (Table 4). In short, machinery and transport equipments occupy the lion's share in East Asian exports, but this feature is more evident in the case of Japan's export. Recently, a peculiar characteristic of the East Asian trade is the vertical division of labor across manufacturing process, being accelerated by Japanese FDI: Japan provides parts and equipments, while others assemble them, and then re-export.[15] This formation is one of the elements that sustain the trade pattern described above.

Another fact related to this trade pattern is worth stressing. The share of pollution

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[12] Iwami (2004b), Figure 5-1.
[13] During the period from 1965 to 1999, economic growth rates of East Asian middle-income countries stood higher than high-income countries. Iwami (2004b), Table 2-3.
[14] Table 4, and Ng and Yeats (2003), Table 11-2,12-1.
[15] Ministry of Economy, Trade and Industry (2004), p.153ff. For more details, see Ishido *et. al.* (2003).

goods in East Asian trade is small, or has become much smaller compared with former years when it stood relatively high. Let us compare export goods in Table 4 with the category of pollution goods mentioned above. "Chemicals and related products" occupies only a small share. Another pollution goods, "mineral fuels, ores and metals," recorded a share of almost a quarter in exports to both inside- and outside of the region as of 1985, but showed a sharp decline thereafter. In the case of exports to Japan, the share has been also decreasing, but the figure of 17.5% as of 2001 remains relatively high. In exports from Japan, we find the same tendency of the small chemical share, and declining share of "mineral fuels, ores, and metals". In view of these facts, we can conclude that direct transactions of pollution goods are not dominant factors in the East Asian trade.

３．２　Production trend of pollution industries

Next, we have to check the output trend of "pollution goods" in East Asia, which provides us a key to the question of to what extent foreign trade and investments have indirectly influenced the production of pollution goods, with impacts on the environment. We employ the word, "indirectly," because the share of pollution goods in the total exports is not large.

The indirect way of causality is that metals and some of the chemicals constitute inputs to manufacturing machinery. The export of automobiles, for example, increases demands for iron and steel, and rubber products, both of which belong to the category of pollution goods. According to a technology assessment in USA as of 1990, when the indirect energy use in manufacturing automobiles, such as producing parts, is included, the total use amounts to nearly six times as much as the direct one.[16] This large proportion of indirect use suggests a possibility that export of machinery "indirectly" stimulate the production of pollution goods. Another indirect causality is that increased exports lead to higher level of income, which accompanies increased consumption, thereby accelerating production of pollution goods. Demands for automobiles, for example, affect the environment in the similar way as the above explanation. However, to assess these indirect effects in detail, using input-output tables for example, requires enormous time and efforts.

Now, let us review production trend of pollution industries with Figures 1 and 2. Figure 1 illustrates the share of nominal value added in the nominal GDP. Japan,

[16] Suri and Chapman (1998), p.200.

Hong Kong, and China have decreased shares, on the one hand, while Indonesia, Malaysia, and the Philippines increased, on the other. Singapore, Korea, and Thailand reached a peak in either 1980, or 1990, and thereafter decreased. Generally speaking, there are two groups; one with increasing shares, and another with decreasing shares. Yet, these two types do not necessarily correspond to a difference in income level, and accordingly in environmental regulations. China with lower income belongs to the same group as high-income countries like Japan and Hong Kong. Moreover, this Figure does not suggest a shift of pollution industries from high-income to low-income countries. There was a remarkable gap in GDP per capita; as of 1980, for example, Japan, Singapore and Hong Kong recorded over 10 thousands US dollars, while other countries stood far below.[17]

Figure 2 illustrates real value added of pollution industries. Since price data of pollution goods are unfortunately not available, we apply, in stead, GDP deflators. Real value added increased not solely in middle-income countries such as Korea, Malaysia, and Thailand, but Japan, Hong Kong and Singapore as well, although histograms for the latter two countries are a little too short to be recognized clearly. Having said that, it is evident that stricter regulations have not decreased production of pollution goods even in high-income countries. Then, what have caused the growth of their production?

3．3 What factors actually influence production trend?

We estimated factors that may contribute to growing output of pollution goods, using the following equation.

$$PI = a + bCS + cEX + dXMN + eIMN + fOP + gFD + \varepsilon \quad \text{----------} \quad (1)$$

As a dependent variable, we selected value added of pollution goods (*PI*), whereas we put on the left-hand side as independent variables; sum of private and public consumption (*CS*), exports (*EX*), ratio of manufacturing exports to domestic production (*XMN*), and ratio of manufacturing imports to domestic production (*IMN*), openness (*OP*), and inward foreign direct investments (*FD*). ε stands for error term.

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[17] GDP per capita as of 1980 was 15,619 US dollars in Japan, 12,578 US dollars in Hong Kong, and 11,464 US dollars in Singapore, followed by Korea with 4,790 US dollars. In 2000, Japan recorded 24,675 US dollars, Hong Kong 26,669 US dollars, Singapore 24,939 US dollars (as of 1996), while Korea only 15,876 US dollars, *Penn World Table 6.1.*

Value added, consumption, exports, and foreign direct investments are all expressed in real terms, and in logarithm: FDI in million US dollars (2000 prices), and others in billion US dollars (1995 prices). For openness, we chose trade value (export plus import) over GDP, since three ratios in Table 2 show high coefficients of correlation with each other.

Data are collected from Japan, China (without Hong Kong), Hong Kong, Korea, Singapore, Malaysia, Indonesia, Thailand, and the Philippines over the period from 1980 to 2000. But this is not a uniform panel data, since data coverage is incomplete for some of the countries. In addition, East Asian countries are divided into two groups with a line of 10,000 US dollars (ppp) GDP per capita in 1980. Table 5 reports results of both ordinary least square (OLS) and fixed effect analyses, because the former assumes the constant term as uniform across countries, and therefore, its results may be disturbed by country-specific factors.

As already suggested, production of pollution goods are indirectly stimulated by exports and/or domestic consumption. We are interested in the statistical significance and size of the coefficients for exports and domestic consumption. Since these variables are expressed in logarithm, the coefficients do not reflect size of variables, but the degree of their elasticity. Yet, we have to check a possibility that these two variables, export and domestic consumption, might be inversely influenced by the production of pollution goods. Figure 1 shows, however, that pollution industries occupy at most only 10% of GDP, and for most of other cases, occupying less than that level. Table 4 also tells that the direct exports of pollution goods constitute a minor part of the total exports. From these facts seen, we conclude to put aside the inverse relationship mentioned above.

XMN and *IMN* are included, because they would suggest a possibility that manufactured trade causes changes in production of pollution goods. If *PI* increases together with *XMN*, then it implies that pollution goods are dependent on export (or export ratio)[18]. If the coefficient of *IMN* shows negative sign, it suggests that larger dependence on manufacturing imports leads to a decline in domestic production of pollution goods. In other words, manufacturing imports enable the country concerned to avoid domestic pollution. Here, we exclude the possibility that both *XMN* and *IMN* are determined by the production of pollution goods, because of the same reason mentioned above that these goods constitute only a minor part in East Asian trade.

We also add the variable of *OP*, in order to test the effects of the "globalization"

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[18] Suri and Chapman (1998) report an interesting result that energy consumption per capita positively correlates with *XMN*, and negatively with *IMN*.

from another angle. If locations of pollution industries move internationally, then, the coefficient of *OP* may show opposite signs between high-income countries, and low and middle-income countries. *FD* stands for inflows, and helps to examine the case that inward foreign investments stimulate pollution production.

The results of OLS in Table 5 tell the following,

1) The coefficient of export is statistically significant only for the low and middle-income countries, and whole East Asians, while insignificant for high-income countries. For the low and middle-income, the size of the coefficient is clearly smaller than that of domestic consumption. Namely, the larger influence on production of pollution goods comes from domestic consumption than export, which is rather unexpected. This result is not found in a case with *OP* employed for the whole East Asians.
2) Among other variables, *XMN* is significant for the whole East Asians and low and middle-income group. Yet, the sign of the coefficient is minus, which implies that, contrary to our presumption, the higher export ratio of manufactured goods is related to a decline in production of pollution goods. *IMN* is significant only for low and middle-income group, and its negative sign is consistent with the "pollution haven hypothesis". But this hypothesis usually assumes that it is high-income countries that would reduce domestic production of pollution goods. As a whole, the results of both *XMN* and *IMN* are not so favorable to the presumptions. It might be related to the East Asian characteristic of the vertical division of labor across manufacturing processes.
3) In the case of *OP*, statistical significance is found solely for the whole East Asians, and *FD* is significant for low and middle-income countries alone, but their signs are negative. In other words, there is no evidence that production of pollution goods increases in accordance with FDI inflows, nor its production is stimulated by the increased dependence on foreign trade, or "globalization." This conclusion is consistent with the above 1).

The reason why any variables other than domestic consumption and exports do not represent expected results may be due to limits of the OLS analysis. Then, we turn to the fixed effect analysis, and find the following results,

4) The basic feature that the influence of exports is smaller than that of domestic consumption holds as well. For the whole East Asians, statistical significance of the export almost disappears, while in the case of low and middle-income countries, the size of coefficients is smaller than those of domestic consumption.

5) Some of other variables show indeed different significance levels from the OLS, but most of them are only minor difference, except for the coefficient for *IMN* that turned to be significant and negative.

The most important to note is a result that production of pollution goods is not to be enlarged by the export, but by domestic consumption. This finding suggests that export-led industrialization in low and middle-income countries does not so much stimulate the pollution industries. Neither openness, nor inward FDI, nor ratios of manufacturing export and import show evidence of pollution industries shifting from the high-income to low and middle-income countries.

Even if such shifts do exist, their cause cannot be the difference in environmental regulations. Although exact data of factor prices are not available, the difference in labor cost is undoubtedly far larger. Then, critical elements in determining competitiveness in trade and FDI flows are factor prices, in particular, labor cost. As mentioned above, initial difference in capital cost tends to be reduced, due to an increased scale of international capital movements.

The real growth in output of pollution goods even in high-income countries like Japan, as Figure 2 illustrates, can be explained by a small transport cost, because of short distance to large scale consumers, manufacturing factories.[19] On the other hand, their declining share relative to GDP in high-income countries would indirectly suggest their comparative disadvantages.

4. Environmental protection in East Asia

4. 1 Effects of technology transfer

As the production of pollution goods is largely determined by the domestic consumption, efforts to reduce pollution should be taken domestically. In East Asia, policies to reduce air- and water-pollution have been indeed undertaken, but the initiative have come not so much from civil movements, except for Japan, as from governments that learned experiences of developed countries.[20] Yet, legislative actions are not necessarily accompanied by actual implementations. The

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[19] Grether and de Melo (2004) as well stress the important role of transport cost in industrial location.

[20] Iwami(2005) explains policies against air-pollution. For environmental policies in general, see also Nomura and Sakumoto (1993), (1997), and Japan Environmental Council (2003).

air-pollutants such as SOx have been successfully reduced, but CO_2 emissions have not been under regulation, since the latter does not cause immediate damages, and moreover, since East Asians except for Japan are exempted from reduction requirements by Kyoto Protocol. But East Asian countries have potential advantages in reducing CO_2 emissions as will be explained below.

The influence from developed countries take the form of technology transfer as well. As discussed with the "technology effect", open door policies accelerate transfer of environmental technology. Generally speaking, inward FDI accompanies higher energy efficiency, which indirectly results in declining emissions of SOx and CO_2. In industrializing Chinese coastal areas, for example, power stations built by foreign capital are said to record remarkably better performance in energy efficiency.[21]The similar phenomena would be also found more or less in measures for environmental protection.

We test how the openness and FDI affect environmental protection, using the following equation with energy efficiency as a dependent variable. For independent variables, we put openness, inflows of FDI, and linear and squared income, together with time trend. Linear and squared incomes are included in order to see whether the inverted U-shaped curve resembling the EKC actually exists.[22] Time trend is supposed to reflect innovations, the sign of which is expected to be positive.

$$EE = a + by + cy^2 + dOP + eFD + fT + \varepsilon \quad \text{------------} \quad (2)$$

EE : energy efficiency of industry, namely energy consumption per unit of real value added, toe (ton oil equivalent) per 1000 US dollars (ppp, benchmark 1995), *y* : income, GDP per capita (US dollars, ppp, benchmark 1995), *T* : time trend. *OP* , *FD*, data coverage, and the division between high-income, and low and middle-income countries are the same as equation (1) and Table 5. *EE*, *y*, and *FD* are expressed in logarithm.

The result of OLS in Table 6 reports,

1） In the case of all East Asia, all variables except for time trend are statistically significant, and income variables suggest an inverted U-shaped curve. In other words, energy efficiency increases along with rising income until a certain

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[21] Blachman and Wu(1999). More generally, Mielnik and Goldemberg (2002) stress a positive relationship between the FDI inflow and rise in energy efficiency.
[22] Iwami (2004) empirically confirms the EKC hypothesis for per capita emissions of CO_2 and SO_2 in East Asia

income level. Thereafter, it turns to decline. Although the sigh for openness corresponds to the expectation, the size of coefficient itself is rather small. To note also is the minus sign for FDI, contrary to our expectation, rejecting a possibility that inflow of FDI contributes to increased energy efficiency.

2） Between two country-groups, coefficients of FDI and time trend are not significant for high-income countries. For low and middle-income countries, on the other hand, openness in addition to the above two variables is also insignificant. Income variables show opposite results for the two income groups: the low and middle-income countries alone correspond to the inverted U-shaped curve. The sign of openness for high-income countries indeed corresponds to our expectation, but the size is small, similarly to the total East Asia.

Results of the fixed effect do not show much difference except for the statistical significance of time trend for all East Asia, and openness for the low and middle-income countries. The negative sign of the latter is inconsistent with our expectation, however. Thus, we have not found clear evidence that increased openness and/or inflow of FDI contribute to rising energy efficiency. The enlarged scale of foreign competition, and import of new equipments and capital goods realized through openness would, generally speaking, stimulate efforts to raise efficiency. Yet, these effects are not confirmed by the empirical tests. The reason for this unsatisfactory results might be the methodology based on macroeconomic data.

To investigate another aspect of efficiency, we put labor productivity *LE*, namely manufacturing output per labor (billion US dollars, 1995), as the dependent variable instead of energy efficiency.

$$LE = a + by + cy^2 + dOP + eFD + fT + \varepsilon \quad \text{------------} \quad (3)$$

The OLS in Table 7 reports,

1） Coefficients of income show statistical significance for both high-income, and low and middle-income countries, but their sings are opposite. High-income countries suggest an inverted U-shaped curve, while low and middle-income countries a normal U-shaped curve. In other words, labor productivity in low and middle-income decreases along with rising income until a certain income level, after which it increases. In high- income countries appears the opposite tendency.

2） Time trend is not statistically significant for all East Asia, but significant for each income group. Yet, the negative sigh of coefficient for low and middle-income countries is not consistent with our presumption.

3） As for openness and FDI, coefficient of openness is significant for all East Asia and high-income countries, but negative sighs are contrary to our expectation. Coefficient of FDI shows, on the other hand, statistical significance for low and middle-income countries, and its positive sigh is consistent to the presumption. This implies that FDI inflows to low and middle-income countries contribute to higher labor productivity.

The fixed effects show the following differences from the OLS,

4） Income variables for all East Asia become statistically significant, and their signs suggest a normal U-shaped curve, similarly to the case of low and middle-income countries. For high-income countries, on the other hand, income variables of both linear and squared lose significance.

5） Coefficients of FDI show slight significance for all East Asia, together with a positive sign as expected. Openness for high-income countries, and time trend for low and middle-income countries both turn to be with positive signs as expected, in contrast to the results of OLS.

Summarizing results of energy efficiency and labor productivity, we conclude that openness suggests only slight contribution to energy efficiency and labor productivity. The positive influence of FDI cannot be found in energy efficiency for all cases, but we notice a clear relationship between FDI inflow and labor productivity in low and middle-income countries.

Which impacts, then, would the positive effects of FDI on labor productivity cause on the environment? With higher labor productivity, the products become more price-competitive in the market, and its production may be enlarged, whereby pollution can be increased. If the positive effect are found in energy efficiency, emission intensity (emission per unit of product) of SO_2 and CO_2, for example, would be reduced. Indeed, since energy efficiency also leads to price competitiveness, the production would be as well stimulated, and total emissions could be also increased. But the possibility of more pollution would be larger in the case of higher labor productivity, since it is not accompanied by less emission intensity. Needless to say, however, if FDI leads to environmental technology transfer ("technology effect"), the final result would be different.

4. 2 Prospects for International Cooperation

In East Asia, what possibilities can we expect for the regional cooperation in environmental policies? In accordance with the fact that legal foundation for economic integration has not been realized yet, corporation in other aspects like environmental policies remain still far behind. In Europe, on the other hand, international coordination for emission reduction, like Helsinki Protocol of 1985 for SOx, and Sofiya Protocol of 1988 for NOx, have worked for almost two decades, whereas in East Asia, a monitoring network for acid rains has become only recently under discussion. There are still less common positions for CO_2 emissions, reflecting a wide gap between Japan, solely responsible for emission reduction as imposed by Kyoto Protocol, and other neighboring countries that have no obligation.

The development of regional division of labor accelerates *de facto* economic integration, but does it also contribute to regional cooperation in environmental policies? The East Asians have larger gap in economic structure and income level, compared with EU countries (more precisely, members before eastern enlargement of 2004). Does this gap hinder, or strengthen regional environmental cooperation?

It is undoubtedly easier for high-income countries to form an international cooperation against the environmental problems that civilians with higher income concern about, like air-pollution. Helsinki Protocol, although it initially aimed at preventing acid rains, is surely easier to be agreed among neighboring rich countries. Moreover, since EU countries have been for several decades striving for economic as well as political integration, environmental cooperation is easily realized as one aspect of these efforts. Yet, the common concerns about and technical capabilities against air-pollution undoubtedly constitute driving forces for such cooperation as the Helsinki Protocol. In this sense, it is understandable that this type of cooperation is more difficult in East Asia with larger income gap among them. Larger income gap in this region, on the other hand, makes CDM (Clean Development Mechanism), one of the Kyoto Mechanisms, easier to be implemented. Let us explain the reason why, using Figure 3.

Japan is obliged to reduce CO_2 emissions alone in East Asia, and let us assume that its obliged reduction corresponds to Q. Then, total reduction cost amounts to the triangle O_1CO_2, surrounded by marginal abatement cost curve, MAC_1 and both vertical CO_2 and horizontal O_1O_2. However, if Japan shares the required quantity with a country of lower income through CDM, the total cost would be cut. Because the social infrastructure is underdeveloped, fixed investments are of old vintage and inefficient in lower income countries, the cost of replacement with new infrastructure and equipments of lower emission intensity would be lower than in high-income country, in this case Japan. In other words, the marginal abatement cost is supposed to be lower.

Thus, the lower marginal abatement cost is represented by smaller steepness of the MAC_2. In Figure 3, the reduction quantity undertaken by the country 2 is shown from the right hand to the left along the horizontal axis. The sum of Japan's reduction, Q_1 and the amount undertaken by country 2, Q_2 is the same as the initial requirement, Q. The total cost of reduction will be minimum, when the reduction quantity is divided at the point, where the marginal cost of both sides stand at the same level, A. In this case, the total cost corresponds to the triangle, O_1AO_2. The cost for Japan is the triangle, O_1A B, and cost for the CDM partner, the country 2, the triangle, O_2AB. Even if Japan pays the reduction cost on the part of the partner, as determined by the CDM provision, Japan saves the total cost as much as the triangle, O_2AC.

Moreover, this effect is enhanced when undertaken with a country of lower income. As is shown in the Figure 3, the marginal abatement cost, MAC_3, of the higher income country is steeper, and the saving of cost, represented by the triangle, O_2DC, is smaller. EU has introduced the so-called "bubble" provision of dividing emission reduction among member countries, thereby cutting cost to observe obligations imposed by Kyoto Protocol. Since income gap across initial members is smaller than among East Asians, the extent of cost saving is limited. Yet, the eastward extension in 2004 enables larger cost-cut, approaching the East Asian situation.

We have to note as well some hindrance to realize CDM, however. To be acknowledged internationally as a CDM, the project should be "additional." It is naturally understandable that the emission reduction would be "additional," but developing countries demand also the "additional" money transfer, in the sense that projects undertaken within the framework of the existing ODA (Official Development Assistance) should be excluded from the CDM program. If the latter requirements are strictly applied, CDM would not be easily feasible by a country like Japan where the pressure to cut the ODA budget has gained momentum.[23]

Whereas the Kyoto Mechanism like CDM and tradable Emission Permits has merits of smaller cost in reducing CO_2 emissions, there is also a demerit of lowering incentives on the part of high income countries to generate technical innovation for emission reduction. Therefore, another provision to counterbalance this demerit is required.

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[23] For more details about CDM, see Ymaguchi (2002).

5. Concluding remarks

In conclusion, let us review what the East Asian data tell us about the "pollution haven hypothesis." In the region, pollution goods are not traded so much directly, and their production is not clearly correlated with inward FDI and openness of the country in question. Indeed, it is possible that production of pollution goods is indirectly related to manufacturing exports as materials and intermediate goods, but the real value added of pollution industries is not so clearly correlated with export- and import ratio of industrial goods. Moreover, domestic consumption affects larger impact on production of pollution goods than exports. Between the high income and low and middle-income countries, it is evident in the case of low and middle-income countries that export constitutes a smaller growth factor than domestic consumption. These facts imply that production of pollution goods is not so much influenced by the "globalization," suggesting indirectly also that a gap in environmental regulations do not lead to increased scale of foreign trade and FDI, as the "pollution haven hypothesis" stresses.

To the question of how FDI inflows and openness contribute to energy efficiency and labor productivity, we find a positive effect of FDI on labor productivity in the low and middle-income countries, although its effect on energy efficiency is rather vague. This result may be due to limits of relying on macroeconomic data. As a whole, the above empirical studies do not succeed yet in finding clear evidence of how foreign trade and investments affect pollution industries. But the fact-finding that the production of pollution industries is determined largely by the domestic consumption can be, at leas to say, an indirect evidence of rejecting the "pollution-haven hypothesis."

Lastly, as for regional environmental cooperation, East Asia is not in a favorable situation for measures against air pollution and acid rains as is found in EU. Due to larger income gap, however, the regional cooperation like CDM project is easier to be implemented.

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Table 1 Empirical Evidence of the "Pollution Haven Hypothesis"

Author (year)	Dependent variable	Independent variables	Coverage	Results (Yes or No)
Tobey (1990)	Net exports of pollution goods	environmental regulations, endowments of production factors	23countries, 5 items	No
Grossman and Krueger (1993)	US import ratio, production share of US foreign firms	Human capital, physical capital, cost of pollution abatement, tariff rate	Only between US and Mexico	No
Smarzynska and Wei (2001)	FDI of individual firms	Environmental regulations, economic size, rate of wage and tax, corruption etc of host countries	24countries, 534 firms.	NO as a whole Slight effect on pollution intensive industries
Copeland and Taylor (2003)	Air pollution	Income level, regulations on air pollution, capital-labor ratio, openness.	Cities in 43 countries.	No
Busse (2004)	Net exports of pollution goods	Environmental regulations, endowments of production factors	119 countries, 5 items	No, except for iron and steel
Grether and de Melo(2004)	Bilateral trade of pollution goods	environmental regulations, economic size, distance, infrastructure	52 countries, ,5 items	No as a whole, but yes for iron and steel, nonferrous metals (paper and pulp).
Dean *et. al.*(2005)	FDI of firms	environmental regulations, agglomeration of firms, number of laborers, suppliers of intermediate goods, infrastructure	2886 joint ventures in China	Yes only for those from Hong Kong, Taiwan, and Makao. No for others..

Table 2 Correlations between income level and openness (1980-2000)

East Asia

	income	openess (1)	openess (2)	openess (3)
income	−	0.51	0.37	0.41
openess (1)	0.51	−	0.72	0.65

East Asia excluding Japan

	income	openess (1)	openess (2)	openess (3)
income	−	0.85	0.68	0.68
openess (1)	0.85	−	0.71	0.65

Source: income level and openness (1) from *Penn World Table 6.1,* openness (2) and (3) are calculated with the capital transaction data from IMF, *International Financial Statistics.*

Note: East Asia includes China, Indonesia, Korea, Malaysia, the Philippines, Singapore, Thailand, Hong Kong, Vietnam and Japan.

Table 3 East Asian exports and world shares

	export (billions of US dollars)				world shares (%)			
	1975	1985	1995	2001	1975	1985	1995	2001
East Asia	93.6	376.5	1,315.1	1,643.0	10.9	19.0	25.6	25.7
ASEAN	22.0	72.0	307.8	403.8	2.7	3.6	6.0	6.3
EU(15)	325.3	711.6	1,893.4	2,194.8	39.2	36.0	36.9	34.3
NAFTA	148.9	351.9	922.4	1,214.7	18.0	17.8	18.0	19.0
Intraregional								
East Asia	19.7	85.3	476.7	646.4	2.4	4.3	9.2	10.1
NAFTA	55.6	159.5	396.0	646.5	6.7	8.1	7.7	10.1
EU(15)	200.2	416.9	1,168.5	1,296.6	24.1	21.1	22.7	20.2
World	829.2	1,975.9	5,137.3	6,403.1	100	100	100	100

Source: Ng and Yeats (2003), Table1.1 revised.

Note: East Asia includes Japan, China, Korea, Taiwan, Brunei, Cambodia, Hong Kong, Indonesia, Laos, Malaysia, Mongolia, the Philippines, Singapore, Thailand and Vietnam.

Table 4 Composition of East Asian export（%）

		foods, feeds, and agricultural materials	mineral fuels, ores, and metals	chemicals and related products	machinery and transport equipment	other manufactured goods	others
intra-	1985	16.3	24.1	5.2	21.0	23.5	7.9
region	1995	7.1	11.7	7.8	38.6	21.0	12.0
	2001	4.7	11.6	8.3	47.9	16.0	10.3
out of	1985	14.1	23.5	2.0	17.9	23.4	15.1
region	1995	8.5	6.8	3.1	40.6	21.2	17.6
	2001	5.0	6.8	3.3	45.9	19.4	18.5
to Japan							
	1985	19.1	63.1	2.3	2.5	8.8	2.6
	1995	16.9	21.5	3.0	23.2	22.9	10.8
	2001	11.6	17.5	3.5	32.7	21.2	11.7
Japan							
intra-	1985	2.4	17.1	7.9	52.2	11.2	7.7
region	1995	1.6	9.6	8.5	62.0	8.1	7.9
	2001	1.7	9.2	9.9	56.8	8.1	9.4
out of	1985	1.2	6.7	3.3	72.0	7.5	8.3
region	1995	0.7	3.1	5.6	74.9	5.4	8.0
	2001	1.1	2.8	6.2	72.3	4.9	9.0

Source: Ng and Yeats (2003), Table11.1 and UNCOMTRADE.

Note: East Asia excludes Japan from the countries listed in the note of Table 3. The SITC (Standard International Trade Classification) code in Revision 2 are as follows: foods, feeds, and agricultural raw materials, 0+1+2+4—27－28; mineral fuels, ores, and metals, 3+27+28+67+68; chemicals and related products, 5; machinery and transport equipment, 7; other manufactured goods, 6－67－68+84; and others, 8－84.

Table 5 Factors that affect output (real value added) of pollution industries

East Asia

	OLS			fixed effects		
C	−2.41	(−8.16)	***			
CS	0.76	(14.59)	***	0.63	(7.24)	***
EX	0.34	(5.15)	***	0.11	(1.77)	
XMN	−2.66	(−2.37)	**	−1.16	(−0.69)	
IMN	−0.74	(−0.76)		−4.46	(−3.69)	***
OP						
FD	0.54E−02	(0.17)		0.03	(1.01)	
Samples	99			99		
$\bar{R}^2$	0.94			0.99		

	OLS			fixed effects		
C	−1.80	(−4.12)	***			
CS	0.57	(4.90)	***	0.63	(7.63)	***
EX	0.54	(4.44)	***	0.14	(2.07)	*
XMN						
IMN						
OP	−0.36E−02	(−2.80)	***	0.93E−03	(0.66)	
FD	−0.04	(−1.20)		0.01	(0.47)	
Samples	99			99		
$\bar{R}^2$	0.90			0.99		

High income

	OLS			fixed effects		
C	−0.94	(−2.46)	**			
CS	0.81	(15.71)	***	0.84	(9.15)	***
EX	0.03	(0.29)		0.03	(0.30)	
XMN	−0.06	(−0.03)		2.15	(0.37)	
IMN	−2.26	(−1.17)		−1.23	(−0.57)	
OP						
FD	−0.04	(−1.53)		−0.02	(−0.89)	
Samples	32			32		
$\bar{R}^2$	0.997			0.997		

	OLS			fixed effects		
C	0.04	(0.06)				
CS	0.61	(1.52)		0.68	(6.30)	***
EX	0.25	(0.46)		0.27	(1.71)	
XMN						
IMN						
OP	−0.34E−02	(−1.09)		−0.14E−02	(−1.56)	
FD	−0.14	(−1.92)		−0.03	(−1.21)	
Samples	32			32		
$\bar{R}^2$	0.96			0.997		

Low–middle income

	OLS			fixed effects		
C	−0.57	(−1.56)				
CS	0.73	(12.48)	***	0.56	(9.23)	***
EX	0.31	(5.34)	***	0.25	(3.68)	***
XMN	−7.34	(−9.28)	***	−4.95	(−4.93)	***
IMN	−11.02	(−6.69)	***	−9.11	(−5.45)	***
OP						
FD	−0.05	(−1.51)		0.04	(0.94)	
Samples	67			67		
$\bar{R}^2$	0.96			0.98		

	OLS			fixed effects		
C	−3.68	(−6.37)	***			
CS	1.10	(7.20)	***	0.69	(5.67)	***
EX	0.56	(4.85)	***	0.43	(4.37)	***
XMN						
IMN						
OP	0.14E−02	(0.52)		0.26E−02	(1.14)	
FD	−0.19	(−3.71)	***	−0.09	(−1.55)	
Samples	67			67		
$\bar{R}^2$	0.89			0.95		

Source: Output values of pollution industries and all manufactured industries are from UNIDO (United Nations Industrial Development Organization), *Industrial Statistics Database*, CD-Rom; domestic consumption, FDI, export and import values, and price index from IMF, *International Financial Statistics*; openness from *Penn World Table 6.1*; and export and import values of manufactured products from UNCOMTRADE. Real values of domestic consumption, outputs of pollution industries and FDI are deflated with GDP deflator.

Note: t-statistics in parenthesis. Significant at ***1%, **3%, and *5%. High-income countries include Japan, Singapore and Hong Kong; low-middle income countries include China, Korea, Malaysia, Indonesia, the Philippines and Thailand.

Table 6 Factors affecting energy efficiency of industry

East Asia

	OLS		fixed effects	
C	−11.74	(−2.11) *		
y	3.80	(3.01) ***	5.87	(9.51) ***
y^2	−0.18	(−2.49) ***	−0.33	(−9.04) ***
OP	0.58E−02	(8.62) ***	−0.14E−02	(−1.64)
FD	−0.26	(−6.22) ***	−0.59	(−0.33)
T	−0.31E−02	(−0.32)	0.01	(2.21) **
Samples	155		155	
$\overline{R}^2$	0.72		0.98	

High income

	OLS		fixed effects	
C	196.75	(4.22) ***		
y	−38.03	(−3.94) ***	−55.42	(−5.67) ***
y^2	1.90	(3.79) ***	2.81	(5.54) ***
OP	0.34E−02	(13.69) ***	0.24E−02	(6.57) ***
FD	−0.87E−02	(−0.40)	0.46E−02	(−0.25)
T	0.01	(1.13)	0.35E−04	(0.32)
Samples	35		35	
$\overline{R}^2$	0.95		0.96	

Low-middle income

	OLS		fixed effects	
C	−63.01	(−10.13)		
y	16.46	(11.25) ***	8.15	(11.46) ***
y^2	−0.95	(−11.02) ***	−0.47	(−11.49) ***
OP	0.18E−02	(1.50)	−0.14E−02	(−1.96) *
FD	−0.32	(−9.72)	0.28E−02	(0.13)
T	0.04	(4.12)	1.00E−02	(1.91)
Samples	120		120	
$\overline{R}^2$	0.77		0.96	

Source: Income levels are from *Penn World Table 6.1*. Energy efficiency is based on final energy consumption from a database edited by IEE (Institute of Energy Economics, Japan). Others are the same as Table 5.

Note: t-statistics in parenthesis. Significant at ***1%, **3%, and *5%.

Table 7 Factors affecting manufacturing labor productivity

East Asia

	OLS			fixed effects		
C	14.07	(2.29)	**			
y	−1.76	(−1.28)		−13.00	(−7.10)	***
y^2	0.16	(2.08)	*	0.72	(7.03)	***
OP	−0.18E−02	(−3.74)	***	0.89E−03	(0.58)	
FD	0.04	(1.11)		0.07	(2.18)	*
T	−0.20E−02	(−0.24)		0.02	(2.06)	
Samples	112			112		
$\overline{R}^2$	0.81			0.92		

High income

	OLS			fixed effects		
C	−78.28	(−3.37)	***			
y	17.76	(3.73)	***	−1.50	(−0.44)	
y^2	−0.87	(−3.57)	***	0.10	(0.60)	
OP	−0.20E−02	(−15.53)	***	0.14E−02	(3.08)	***
FD	0.69E−02	(0.58)		0.01	(1.55)	
T	0.02	(6.32)	***	0.01	(2.52)	**
Samples	38			38		
$\overline{R}^2$	0.97			0.99		

Low-middle income

	OLS			fixed effects		
C	68.73	(5.17)	***			
y	−14.78	(−4.77)	***	−25.94	(−11.26)	***
y^2	0.93	(5.13)	***	1.43	(11.19)	***
OP	0.24E−02	(1.58)		−0.83E−03	(−0.40)	
FD	0.11	(2.22)	**	0.12	(3.18)	***
T	−0.05	(−3.62)	***	0.05	(3.68)	***
Samples	74			74		
$\overline{R}^2$	0.72			0.91		

Source: Real output per capita is calculated with UNIDO, *Database*. Others are the same as Table 6. Note: Samples are smaller than those in Table 6, since the number of employee in China and Thailand are not available; t-statistics in parenthesis. Significant at ***1%, **3%, and *5%.

Figure 1. Shares of pollution industries (value added)

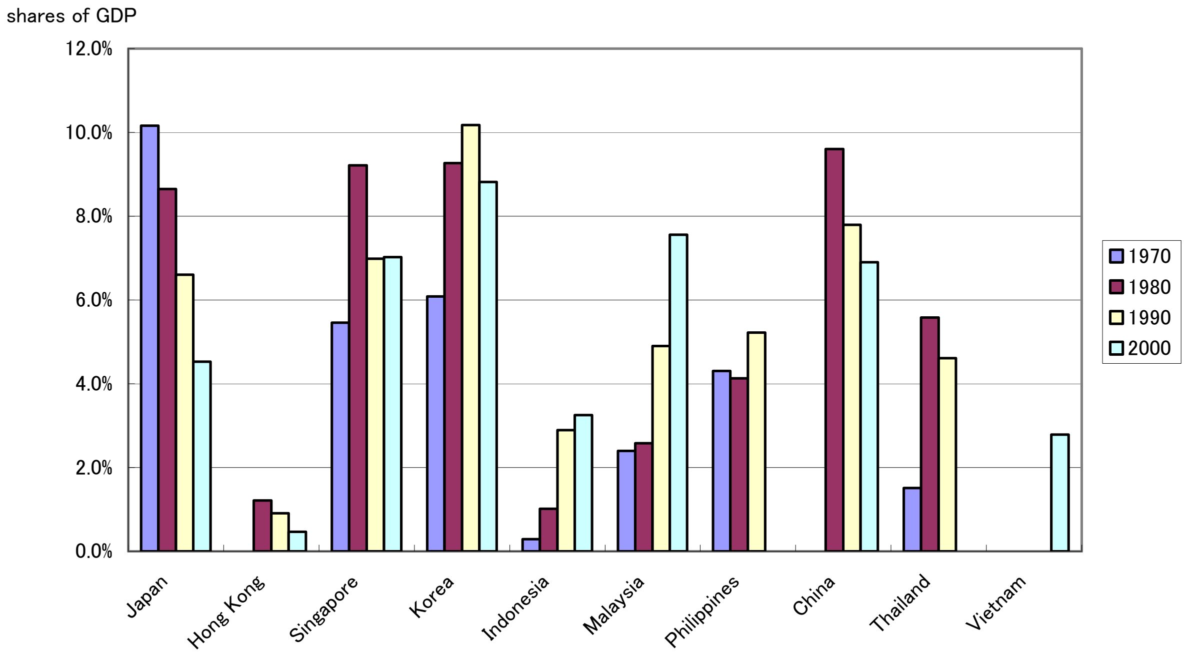
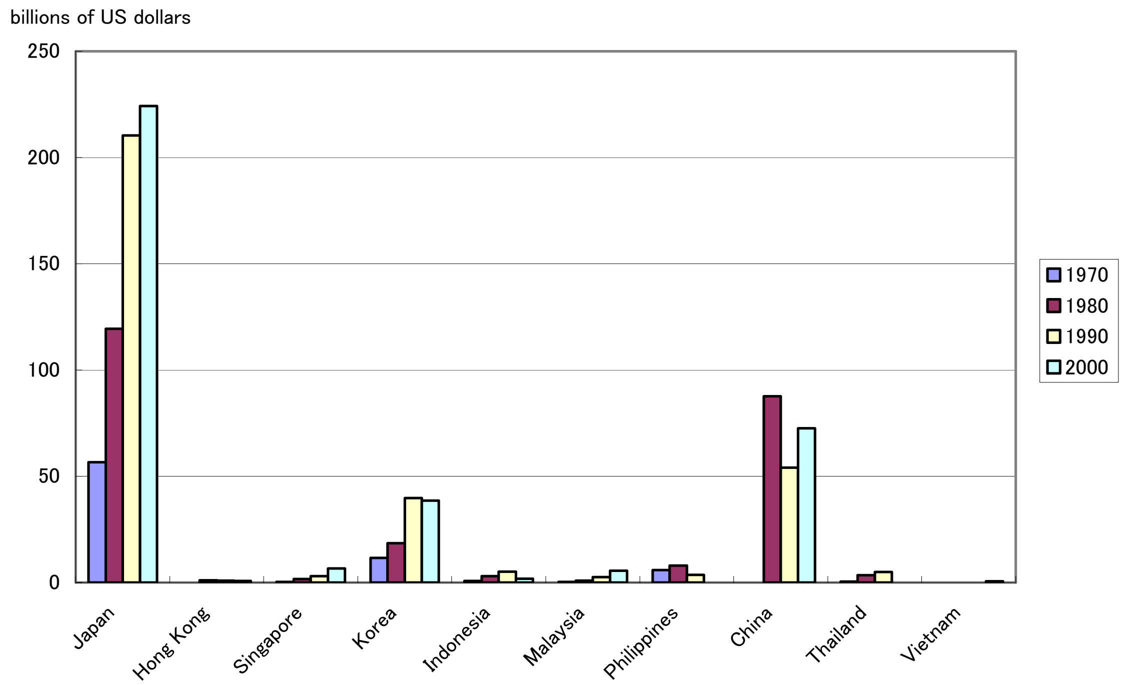


Figure 2. Real value added of pollution industries



Source: the same as Table 5.

Figure 3. Effects of CDM