Trade and the Environment in East Asia: Examining the Linkages with Japan and the USA[1]

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Abstract

This paper investigates how the environmental pollution in East Asian countries can be affected by trade of 'dirty' goods with Japan and the USA. By controlling for trade openness, the share of manufacturing in GDP, and the trade of pollution-intensive products with Japan and the USA, CO_2 emissions are estimated for ten East Asian countries between 1988 and 2000. Our results show that increasing exports in 'dirty' industries to Japan and domestic industrialization in East Asia tend to raise CO_2 emissions in East Asian countries, while 'dirty' trade with the USA is not related to the EKCs in the area. We also find that estimated peak turning points in the models that include 'dirty' goods trade with Japan are higher than those in models that do not.

JEL classification: F18; O13; L60; Q56
Keywords: Trade; Pollution; Environmental Kuznets curves; East Asia

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1. Introduction

The purpose of this paper is to investigate how the environmental pollution in East Asian countries can be affected by trade of 'dirty' goods with Japan and the USA. The linkage between trade and environment arose from Grossman and Krueger's (1991) path-breaking study on the environmental Kuznets curve (EKC). The EKC is an inverted U-shaped relationship between pollution and per capita income. This hypothesis has attracted the attention of many researchers since the early 1990s, despite considerable criticism of early studies on the EKC on both theoretical and empirical grounds.[4]

One important criticism of the EKC is that it does not take changes of trade patterns into account. Several economists argue that developing countries have a comparative advantage in pollution-intensive industries, since they set less stringent environmental regulations than advanced countries.[5] If this is the case, 'dirty' industries are likely to migrate from high-income countries to low-income countries. This may generate a reduction in pollution in high-income countries and increase imports of 'dirty' products from low-income countries. Such reallocation of 'dirty' industries from high-income countries to low-income countries can generate the downward sloping portion of the EKC of high-income countries. Thus, the EKC may reflect a transfer of pollution from high-income countries to low-income countries, but the decrease shown by the downward slope may not contribute to a net reduction in pollution in the whole world.

The effect of trade composition on pollution has been the focus of a number of recent studies (Suri and Chapman, 1988; Antweiler et al., 2001; Cole and Elliot, 2003; Cole, 2004). In particular, Cole (2004) showed the effect of 'dirty' trade on the EKC of OECD countries, by estimating ten air and water pollutants, including as independent variables trade of pollution-intensive industries between OECD and non-OECD countries. Contrary to Cole (2004), this paper examines how the migration of pollution-intensive industries affects the EKCs of developing countries. Analyses on developing countries are particularly important, since they are not compelled to reduce CO_2 emissions under the Kyoto Protocol and are likely to be the key countries to solve the global warming problem. For example, according to the Carbon Dioxide Information Analysis Center (CDIAC), total CO_2 emissions of China ranked second in 2000, and those of Korea ranked tenth.

In this paper, the CO_2 emissions of ten East Asian countries between 1988 and 2000 were estimated by using trade intensity, the share of manufacturing in GDP, and 'dirty' trade with Japan and the USA as independent variables. Our results show that increasing 'dirty' industry exports to Japan and domestic industrialization in East Asia tended to raise CO_2 emissions in East Asian countries, while 'dirty' trade with the USA

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[4] For surveys on the EKC, see Dasgupta, S. et al. (2002), Cole (2003), Yandle et al. (2004), and Stern, D. I. (2004).

[5] Antweiler et al. (2001) and Copeland and Taylor (2004) argue that there is another competing theory to determine comparative advantage. So-called factor endowments hypothesis assumes that capital-abundant countries (advanced countries) export the capital-intensive (dirty) goods to developing countries.

was not related to the EKCs in the area. We also found that an increase in the share of manufacturing in GDP raises CO_2 emissions. Finally, the estimated peak turning points in the models that include 'dirty' goods trade with Japan are higher than those in models that do not.

The rest of the paper is organized as follows: Section 2 reviews the linkages between trade and the environment and examines trends in foreign direct investments and in trade of pollution-intensive products between East Asian countries and Japan. Section 3 explains the estimation method used and the data, and Section 4 discusses the results. Concluding remarks are provided in Section 5.

2. Trade and the Environment: Migration of Dirty Industries to East Asia

In the area of trade and the environment, many researchers have investigated the potential linkages between trade liberalization and pollution.[6] A seminal paper of Grossman and Krueger (1991) presents a systematic analysis of the connections between trade and the environment by classifying the effect of trade on the environment into three categories. The first category is the scale effect, which refers to the situation in which growing market access increases economic growth and the resulting pollution. The second category is the technique effect, which refers to the likely improvement of production techniques caused by trade liberalization, and which reduces pollution. The third category is the composition effect, which refers to the change in composition of an economy after trade liberalization, as countries increasingly specialize in the industries in which they enjoy a comparative advantage.

The last composition effect is the most relevant to our analysis of the EKC. Specifically, how the composition effect affects pollution depends on whether a country has a comparative advantage in pollution-intensive industries. In general, developing countries, which are abundant in natural resources, land and labor, attempt to promote heavy industries, which usually are pollution-intensive, by accepting foreign direct investment of developed countries. In contrast, developed countries shift from heavy industries to service- and information-intensive industries, which are environmentally cleaner.

In order to examine the effect of such migration of pollution-intensive industries on the trade patterns of East Asian countries, we first look at the trends of the foreign direct investments of Japan, which is the major investor in the region. Figure 1 shows cases of Japan's foreign direct investment in East Asian countries. After the 1970s, Asian NIEs (Korea, Taiwan, Hong Kong, and Singapore) became the first major recipient countries of Japanese investment. However, as production costs, which included wages, land prices, and exchange rates, rose in these countries, ASEAN 4 countries (Malaysia, Indonesia, the Philippines, and Thailand) emerged as major recipients in the 1980s. Since the 1990s, China and Vietnam, former socialist countries, have attracted investors.

Figure 2 presents the value of foreign direct investments of Japanese pollution-intensive industries in East Asian countries. Pollution-intensive industries here refer to the metal and chemical industries. Investments in Asian NIEs have been relatively

[6] For example, Copeland and Taylor (2003) survey both recent theoretical and empirical studies of trade and the environment.

small throughout the 1990s, except for those made in Korea in the fiscal years 1999 and 2000. In contrast, ASEAN countries, especially Indonesia and Thailand, received a large amount of investment in the 1990s. China also enjoyed a fair amount of investment after the latter half of the 1990s.

Then we calculate the specialization index of pollution-intensive industries between East Asian countries and Japan (Figure 3). Pollution-intensive industries here include iron and steel, chemicals and chemical products, and non-metallic mineral products, which are the main sources of CO_2 emissions. The specialization index of trade of industry k between Japan and country i in year t is expressed in equation 1 below. If the index has a positive value, this means that Japan is a net exporter of that industry, while if it has a negative value, Japan is a net importer. In other words, Japan has a comparative advantage in pollution-intensive industries when the sign is positive, whereas the negative sign means the reverse.

$$\text{Specialization index} = \frac{X_{kt}^{i} - M_{kt}^{i}}{X_{kt}^{i} + M_{kt}^{i}} \tag{1}$$

From Figure 3 we can interpret the specialization index of pollution-intensive industries between 1988 and 2000 as in Figure 4. For Vietnam, which has the lowest per capita GDP in the region, and the Philippines, Japan has been a net exporter of dirty goods. In cases of ASEAN countries including Indonesia, Malaysia, and Thailand, Japan was a net exporter of dirty goods until the mid-1990s, while it turned out to be a net importer after that. This is because these countries proceeded in industrialization by receiving foreign direct investments and then became exporters of dirty goods to Japan. In the next developmental stage, Japan has been a net importer of Korean dirty goods over the sample period. In the final stage, for other Asian NIEs – Singapore, Hong Kong, and Taiwan - Japan has again been a net exporter of dirty goods, since these countries were more advanced and focused more on service- and information-intensive industries. In the case of China, Japan has been a net importer of dirty goods, as has Korea, over the sample period. This seems to be an exceptional case, considering the fact that China's per capita GDP was close to Indonesia's. However, since in cities like Beijing and Shanghai, per capita GDP has been three or four times of the national average, China's level of industrialization seemed to catch up with Korea's.

As discussed in this section, Japanese data on foreign direct investments and trade indicate that the migration of Japanese pollution-intensive industries affected the trade structure of East Asian countries. In the following section, we will analyze the effect of the change in trade structure on pollution by including dirty trade between East Asian countries and Japan in the estimation of the EKC.

3. Estimation method

The EKCs of CO_2 emissions were estimated for ten East Asian countries (China, Hong Kong, Indonesia, Korea, Malaysia, the Philippines, Singapore, Taiwan, Thailand, and Vietnam) between 1988 and 2000. Specifically, we estimated the following timedemeaned equation, using unbalanced panel data. Since heteroscedasticity is present, the model uses White's heteroscedasticity-adjusted standard errors.[7]

$$\widetilde{E}_{it} = K_t + \beta_1 \widetilde{Y}_{it} + \beta_2 \widetilde{Y}^2_{it} + \beta_3 \widetilde{Y}^3_{it} + \delta \tilde{I}_{it} + \gamma \widetilde{M}_{it} + \eta_1 \widetilde{JDX}_{it} + \eta_2 \widetilde{JDM}_{it}$$
$$+ \lambda_1 \widetilde{USDX}_{it} + \lambda_2 \widetilde{USDM}_{it} + \tilde{\varepsilon}_{it}$$

where $\widetilde{E}_{it} = \ln E_{it} - \sum_{t=1}^{T} \ln E_{it} \Big/ T$, $\widetilde{Y}_{it} = \ln Y_{it} - \sum_{t=1}^{T} \ln Y_{it} \Big/ T$,
$\widetilde{Y}^2_{it} = \left(\ln Y_{it}\right)^2 - \sum_{t=1}^{T} \left(\ln Y_{it}\right)^2 \Big/ T$, $\widetilde{Y}^3_{it} = \left(\ln Y_{it}\right)^3 - \sum_{t=1}^{T} \left(\ln Y_{it}\right)^3 \Big/ T$,
$\tilde{I}_{it} = \ln I_{it} - \sum_{t=1}^{T} \ln I_{it} \Big/ T$, $\widetilde{M}_{it} = \ln M_{it} - \sum_{t=1}^{T} \ln M_{it} \Big/ T$,
$\widetilde{JDX}_{it} = \ln JDX_{it} - \sum_{t=1}^{T} \ln JDX_{it} \Big/ T$, $\widetilde{JDM}_{it} = \ln JDM_{it} - \sum_{t=1}^{T} \ln JDM_{it} \Big/ T$,
$\widetilde{USDX}_{it} = \ln USDX_{it} - \sum_{t=1}^{T} \ln USDX_{it} \Big/ T$, $\widetilde{USDM}_{it} = \ln USDM_{it} - \sum_{t=1}^{T} \ln USDM_{it} \Big/ T$,
and $\tilde{\varepsilon}_{it} = \ln \varepsilon_{it} - \sum_{t=1}^{T} \ln \varepsilon_{it} \Big/ T$.

E is per capita CO_2 emission, K refers to year-specific effects, Y is per capita real GDP based on either a market exchange rate or a purchasing power parity (PPP) exchange rate. By including a cubic income term, our estimation allowed for the possibility of pollution beginning to rise again, as in an N-shaped curve, at the high-income level. I represents trade intensity, and M is the share of manufacturing in GDP. JDX refers to 'dirty' exports share of the total exports from Japan to the East Asian country in question, while JDM is 'dirty' imports share of the total imports of Japan from an East Asian country. Likewise, USDX refers to 'dirty' exports share of the total exports from the USA to the East Asian country in question, while USDM is 'dirty' imports share of the total imports of the USA from an East Asian country. Subscripts i and t represent country and year, respectively.

The trade intensity I is the ratio of the sum of exports and imports (excluding re-exports for Hong Kong and Singapore) to GDP. K is included to represent effects like technological progress, which change over time but are common to all countries. JDX and JDM are included to analyze the effects of dirty trade between Japan and East Asian countries. For comparison, USDX and USDM are also included to examine the effects of dirty trade between the USA and East Asian countries. Dirty goods here include iron and steel, chemicals and chemical products, non-metallic mineral products, and paper-pulp, which are the top four industries in terms of CO_2 emission.

Sources of data and their descriptive statistics are presented in Table 1 and Table 2, respectively. Figure 5 and Figure 6 show the relationship between E and Y. Figure 5 is drawn by using per capita real GDP based on market exchange rates, while Figure 6 is based on PPP exchange rates. In both graphs, per capita CO_2 emissions stop rising in high-income countries. These graphs indicate the possibility of the existence of the EKC in East Asian countries.

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[7] We test the non-stationarity of our data by employing the procedure of Levin, Lin and Chu (2002). For all variables a null hypothesis of integration of order 0 can be rejected. In addition, we do not find autocorrelation in the model. The strict exogeneity for all the independent variables is supported.

We next considered the relationship of pollution to ‘dirty’ trade. An increase in ‘dirty’ imports from East Asian countries indicates growing production of ‘dirty’ goods in East Asian countries. In contrast, an increase in ‘dirty’ exports to East Asian countries suggests that exports of ‘dirty’ goods are substituted for production of these goods in the East Asian countries. Thus, we would expect to estimate a positive relationship between JDM/USDM and E, but a negative relationship between JDX/USDX and E.

4. Results

Table 3 and Table 4 present estimation results. Real GDP per capita is based on market exchange rates in Table 3, while it is based on PPP exchange rates in Table 4. Model 1 picks up the relationship among pollution (E), income (Y) , trade intensity (I), and the share of manufacturing in GDP (M), whereas Model 2 adds ‘dirty’ trade (JDX, JDM, USDX, and USDM) as independent variables. Considering the possibility of multicollinearity between ‘dirty’ trade with Japan (JDX and JDM) and that with the USA (USDX and USDM), we separately estimate the effect of ‘dirty’ trade with these countries in Model 3 and Model 4.

For all regressions, the income-cubed term is statistically significant, providing two turning points in the relationship between income and pollution. In other words, CO_2 emissions are estimated to fall at very low-income levels before exhibiting an inverted U-shaped curve for most of the income range within the sample, drawing an inverted N-shaped curve on the whole, as shown in Figure 7.

The estimated income level at which the emission peaks (Peak turning point) and the estimated income level at which the emission bottoms out (Bottom turning point) are within the income range of the sample for all types of estimation used. In our sample, only Singapore and Hong Kong have already peaked out. As discussed in Section 2, these two countries mainly import ‘dirty’ goods from Japan rather than export them. We also find that higher turning points are obtained for regressions using PPP exchange rates relative to regressions using market exchange rates.

The share of manufacturing in GDP (M) has a significantly positive relationship with CO_2 emissions (E) for all regressions. That is, domestic industrialization is an important factor in the rise of CO_2 emissions. By contrast, the coefficients of USDX and USDM are not statistically significant for three of the four regressions. This indicates that ‘dirty’ trade with the USA (USDX and USDM) does not seem to affect CO_2 emissions.

With regard to ‘dirty’ trade between Japan and East Asian countries, Model 3 shows that ‘dirty’ imports share of total imports (JDM) has a significantly positive relationship with CO_2 emissions (E). That is, an increase in exports of ‘dirty’ goods to Japan raises the production of dirty goods and CO_2 emissions in East Asian countries. In contrast, the coefficients of ‘dirty’ exports share of total exports (JDX) are not statistically significant. This result indicates that imports of dirty goods from Japan neither substitute for domestic production, nor reduce CO_2 emissions in East Asian countries.

Our mixed evidence is consistent with the findings of Cole (2004), which shows that imports in the South have a positive impact on CO_2 emissions in the North, while exports in the South do not seem to be related to CO_2 emissions in the North.

Combining both 'dirty' imports share of total imports (JDM) and the share of manufacturing in GDP (M), an increase in Japanese imports from East Asian countries was caused mainly by domestic industrialization in East Asia rather than by the migration of dirty industries from Japan and the USA.

If 'dirty' trade with Japan contributes to the inverted U relationship, estimated turning points from simpler models, which do not include JDX and JDM (Models 1 and 4), are expected to differ from those that include them (Model 3). The estimated peak turning point in Model 3 is higher than those in Model 1 and Model 4. This is consistent with Cole (2004) and suggests that the EKC models that exclude 'dirty' trade variables may underestimate the turning point compared to models that include it.

Our results also provide controversial evidence of a positive relationship between trade intensity and CO_2 emissions. That is, trade liberalization tends to increase CO_2 emission in East Asian countries. This indicates that trade liberalization facilitates international reallocation of industries according to comparative advantages, which are determined by environmental regulation as well as factor endowments. In an extreme case, trade openness can be said to result in a so-called "race to the bottom," as East Asian countries, which face intense international competition, may ease their environmental regulation to attract foreign funds.

Finally, Figure 8 shows that estimated coefficients of year dummies in Model 3 increase over time. This finding contradicts the results of Cole and Elliott (2003) and Taguchi (2004), in which the coefficients of time trends are negatively related to pollutants, possibly because of the improvement of technology. Our result suggests that the EKC tends to become higher over time in East Asian countries during the sample period, since most of the countries still proceed in industrialization.

5. Concluding remarks

This paper investigated how the EKC inverted-U relationship in East Asian countries can be affected by trade of 'dirty' goods with Japan and the USA. By controlling for trade openness and the trade of pollution-intensive products with Japan and the USA, CO_2 emissions were estimated for ten East Asian countries between 1988 and 2000. Our results showed that increasing exports in 'dirty' industries to Japan and domestic industrialization in East Asia tended to raise CO_2 emissions in East Asian countries, while 'dirty' trade with the USA did not seem to affect CO_2 emissions in the area. We also found that the estimated peak turning points in the models that include 'dirty' goods trade with Japan are higher than those in models that do not.

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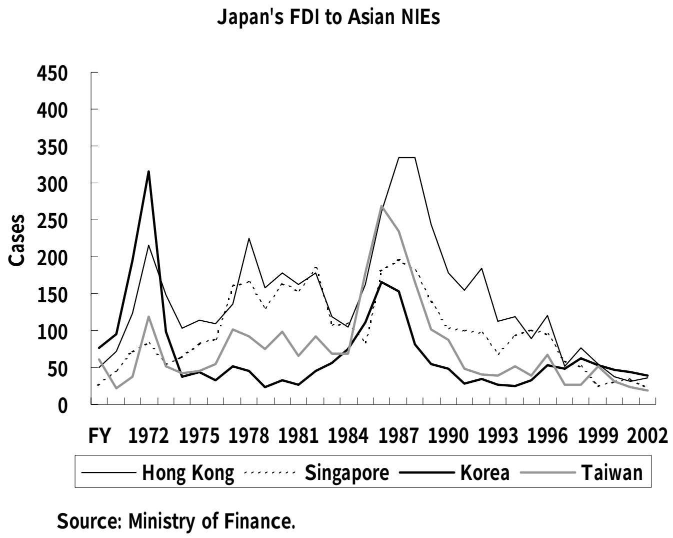
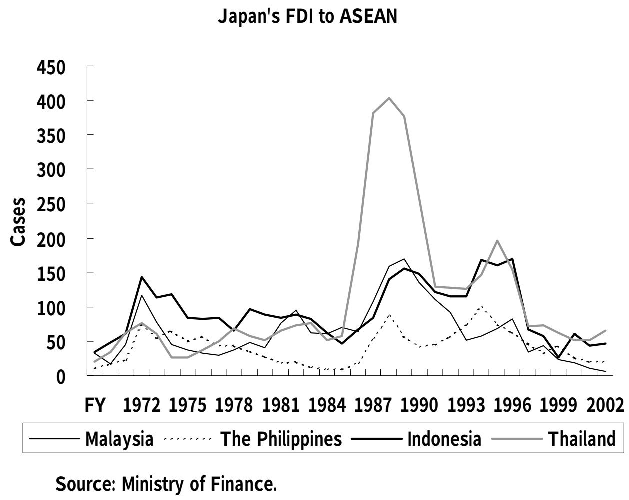
Figure 1. Japan’s FDI to East Asia





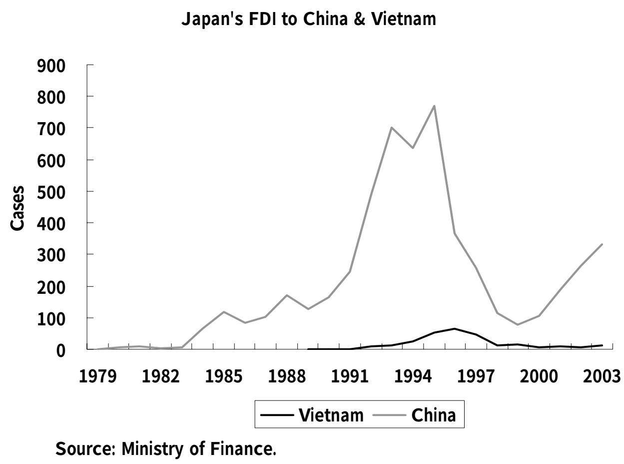
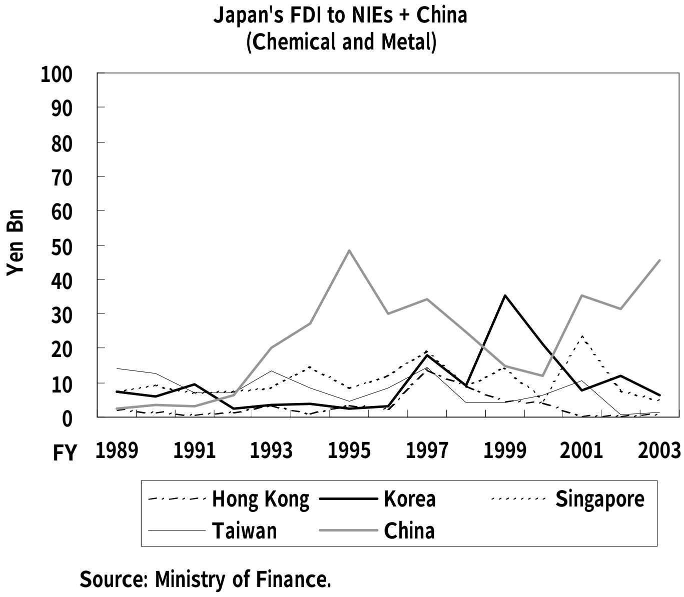


Figure 2. Japan’s FDI to East Asia (Chemical and Metal)



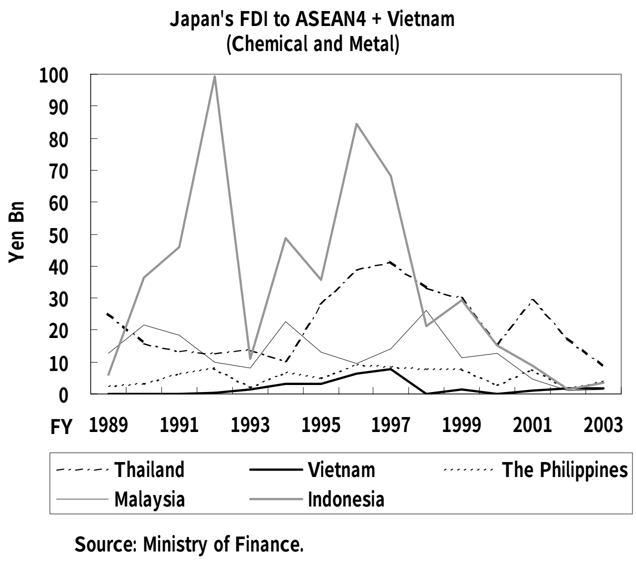


Figure 3. Specialization patterns for pollution-intensive industries in East Asia

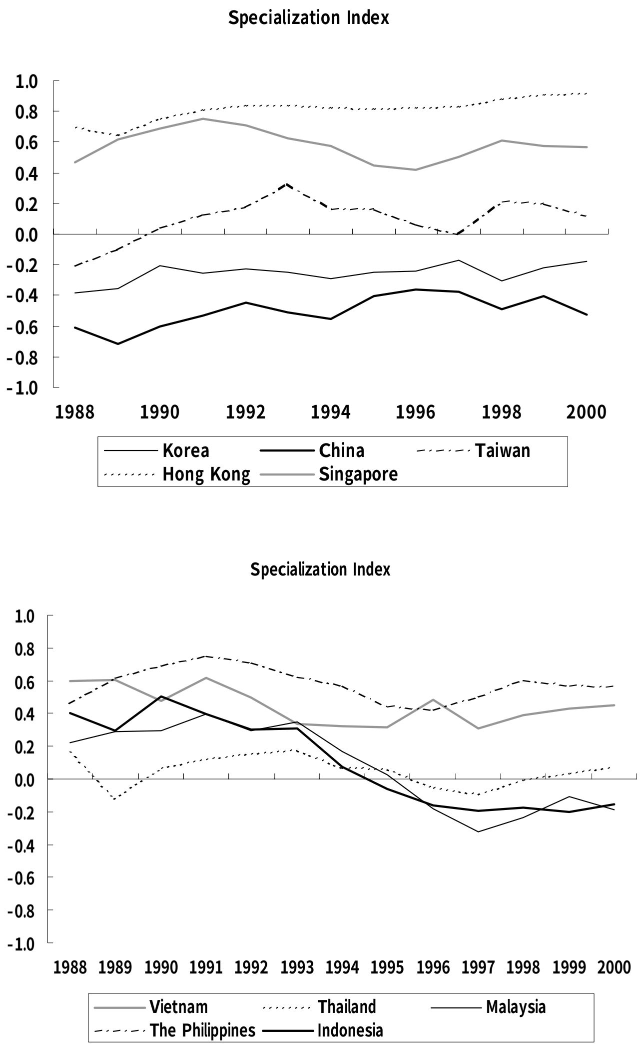


Figure 4. Specialization patterns and development in East Asia

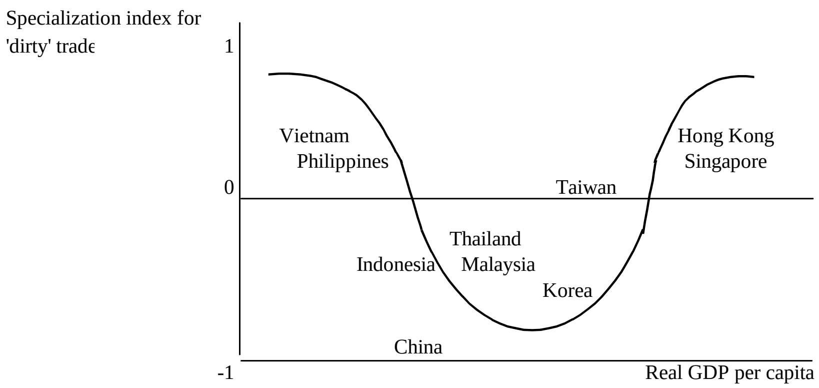


Figure 5. Relationship between real GDP per capita and CO_2 emission based on market exchange rates

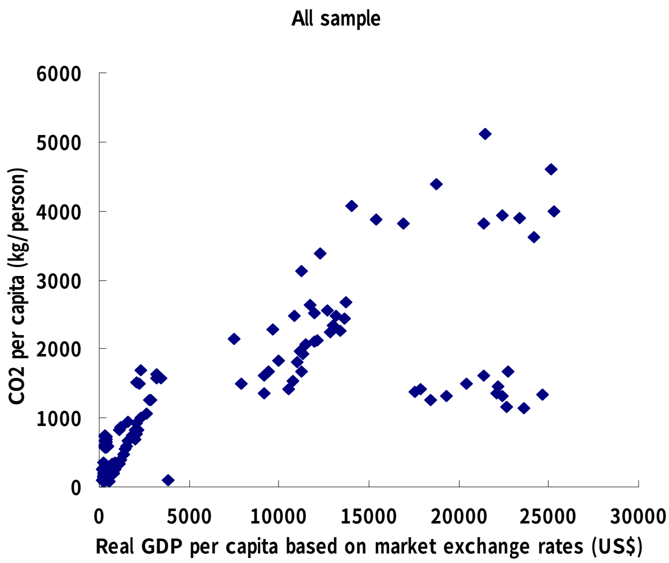


Figure 6. Relationship between real GDP per capita and CO_2 emission based on PPP

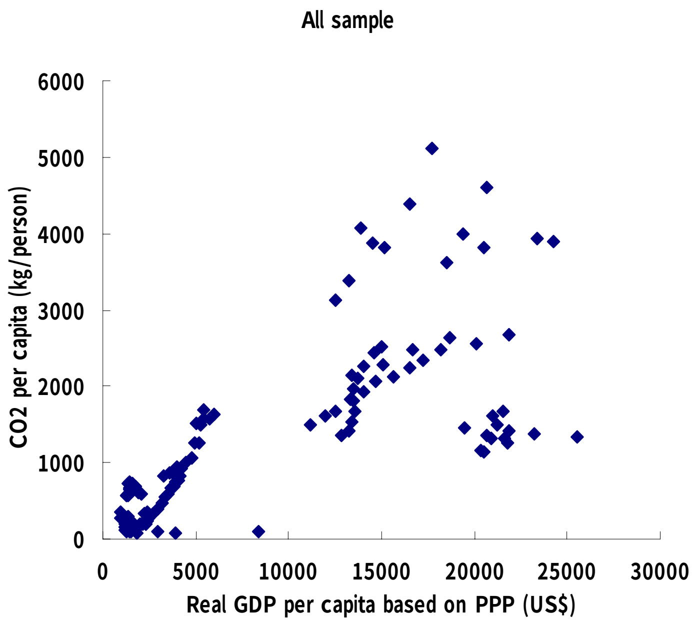


Figure 7. Environmental Kuznets curve

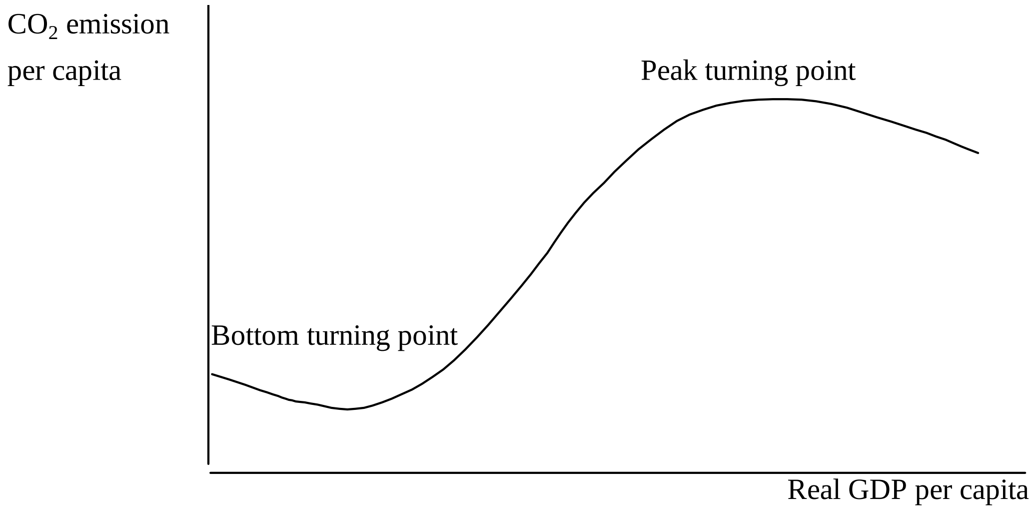


Figure 8: Coefficients of year dummies

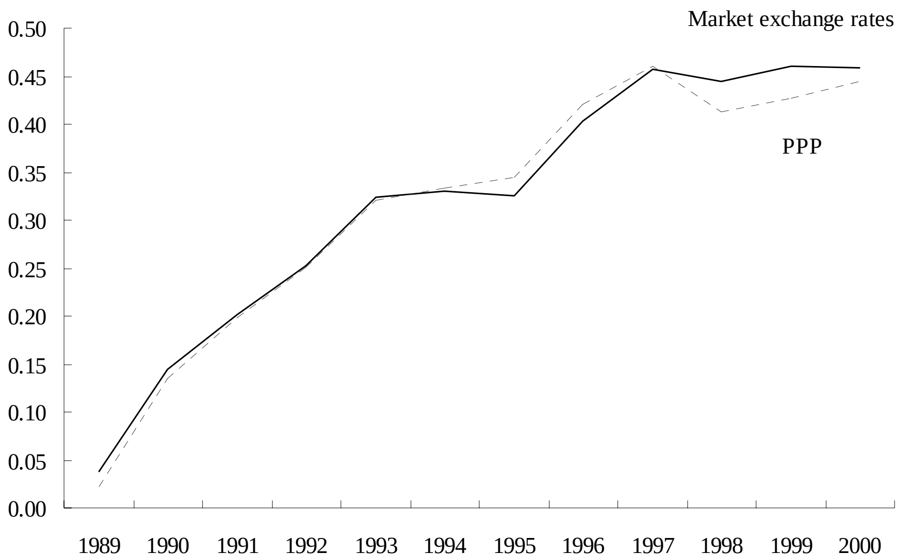


Table 1. Data information

Variable	Source
CO_2 emission	Marland, G., T. A. Boden, and R. J. Andres (2003).
Real GDP per capita	IMF (2004).
Trade as % of GDP	IMF (2004), and trade statistics of each country.
Manufacturing as % of GDP	World Bank (2003), National Statistics of Taiwan (2004), and Asian Development Bank (2004).
Share of Japanese 'dirty' imports and exports in total imports and exports	Calculated using trade statistics from Ministry of Finance Japan (2004). Chemincals / chemical products, iron and steel, and non-metallic mineral products are classed as 'dirty' sectors.
Share of US dirty imports and exports in total imports and exports	Calculated using ITCS International Trade Data, OECD. Chemincals and related products (5), iron and steel (67), non-metallic mineral manufactures (66), and paper, paperboard, articles of paper, paper-pulp/board (64) are classed as 'dirty' sectors.

Table 2. Descriptive statistics

	Real GDP per capita Constant price (US$)	Real GDP per capita PPP (2000 $)	CO_2 emission (kg/person)	I (%)	M (%)	JDX (%)	JDM (%)	USDX (%)	USDM (%)
Mean	6,906.6	8,493.1	1,268.8	94.4	24.8	3.8	3.6	14.5	3.4
Median	2,060.4	4,118.0	870.0	72.7	26.1	2.6	2.2	14.1	3.4
Maximum	25,260.4	25,492.7	5,120.0	268.9	37.1	18.2	17.8	53.9	9.3
Minimum	183.9	937.7	70.0	16.3	5.8	0.4	0.1	0.0	0.5
Std. Dev.	8,046.1	7,680.2	1,163.8	61.5	7.1	3.2	3.6	6.8	1.7
Skewness	0.9	0.6	1.3	1.2	-0.8	1.6	1.6	1.6	0.5
Kurtosis	-0.5	-1.2	1.0	0.4	0.3	2.6	2.4	8.3	0.1
Observation	130	130	130	130	130	130	130	130	124

Table 3. Estimation results for CO_2 emissions based on market exchange rates

	Model 1		Model 2		Model 3		Model 4	
$\tilde{Y}$	-4.406	(1.60) ***	-7.934	(2.25) ***	-3.752	(1.61) **	-8.248	(2.20) ***
$\tilde{Y}^2$	0.634	(0.21) ***	1.118	(0.30) ***	0.548	(0.22) **	1.159	(0.30) ***
$\tilde{Y}^3$	-0.028	(0.01) ***	-0.049	(0.30) ***	-0.024	(0.01) **	-0.051	(0.01) ***
$\tilde{I}$	0.345	(0.11) ***	0.226	(0.14)	0.368	(0.11) ***	0.237	(0.14) *
$\tilde{M}$	0.282	(0.07) ***	0.244	(0.08) ***	0.208	(0.08) ***	0.260	(0.07) ***
$\widetilde{JDX}$			-0.041	(0.05)	-0.017	(0.04)		
$\widetilde{JDM}$			0.025	(0.04)	0.070	(0.03) **		
$\widetilde{USDX}$			0.121	(0.08)			0.124	(0.08)
$\widetilde{USDM}$			-0.056	(0.06)			-0.053	(0.05)
Peak turning point	15,308.2		13,675.3		19,329.6		14,311.2	
Bottom turning point	228.2		285.9		188.2		287.4	
Adjusted R^2	0.989		0.989		0.989		0.989	
S.E.	0.114		0.107		0.113		0.107	
Hauman test of H0: RE vs. FE	Chisq(5)=24.6 ***		Chisq(10)=29.4 ***		Chisq(8)=32.1 ***		Chisq(9)=27.8 ***	
n	130		124		130		124	

Notes 1: Standard errors are in parenthesis.
2. ***, ** and * denote statistical significance at 99%, 95% and 90% confidence levels, respectively.

Table 4. Estimation results for CO_2 emissions based on PPP

	Model 1		Model 2		Model 3		Model 4	
$\tilde{Y}_{ppp}$	-20.386	(6.18) ***	-55.356	(10.27) ***	-17.698	(6.35) ***	-57.956	(9.93) ***
$\tilde{Y}^2_{ppp}$	2.435	(0.73) ***	6.625	(1.22) ***	2.117	(0.75) ***	6.926	(1.18) ***
$\tilde{Y}^3_{ppp}$	-0.095	(0.03) ***	-0.259	(0.05) ***	-0.082	(0.03) ***	-0.270	(0.05) ***
$\tilde{I}$	0.171	(0.10) *	0.057	(0.12)	0.212	(0.10) **	0.040	(0.12)
$\tilde{M}$	0.310	(0.07) ***	0.254	(0.09) ***	0.221	(0.10) **	0.262	(0.07) ***
$\widetilde{JDX}$			-0.042	(0.04)	-0.034	(0.05)		
$\widetilde{JDM}$			0.021	(0.04)	0.075	(0.04) *		
$\widetilde{USDX}$			0.022	(0.08)			0.023	(0.08)
$\widetilde{USDM}$			-0.079	(0.05)			-0.085	(0.05) *
Peak turning point	16,553.6		16,974.6		19,586.1		17,107.4	
Bottom turning point	1,566.3		1,505.4		1,396.3		1,526.9	
Adjusted R^2	0.988		0.989		0.988		0.990	
S.E.	0.122		0.103		0.121		0.103	
Hauman test of H0: RE vs. FE	Chisq(6)=29.0 ***		Chisq(9)=24.1 ***		Chisq(7)=28.7 ***		Chisq(8)=246 ***	
n	130		124		130		124	

Notes 1: Standard errors are in parenthesis.
2. ***, ** and * denote statistical significance at 99%, 95% and 90% confidence levels, respectively.