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Article

Do Developing Countries Enjoy Latecomers' Advantages in Environmental Management and Technology?—Analysis of the Environmental Kuznets Curve

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Developing countries are under pressure to deal with a variety of environmental problems, such as industrial pollution, urban environmental issues, the deterioration of ecosystems, and global warming, while they are expected to simultaneously achieve high economic growth. In this context, they urgently need to leapfrog over environmental difficulties through progressive environmental management and technology by utilizing their "latecomers' advantages" to the maximum extent possible. By utilizing the analytical framework of the environmental Kuznets curve (EK curve), this study examines whether or not developing countries actually enjoy latecomers' advantages in environmental management and technology, depending on their stages of development. The study's main findings are as follows: (1) regional analysis focusing on selected East Asian countries shows that both the EK curve trajectories and observed facts are generally consistent with the hypothesis that developing countries do enjoy latecomers' advantages; and (2) a regression analysis using cross-sectional data provides significant confirmation of the existence of latecomers' advantages for addressing the well known environmental problem of sulfur emissions.

Keywords: Environmental Kuznets curve, Latecomers' advantages in environmental management and technology, Economic development and environmental conservation, Leapfrog environmental difficulties, Technology transfers to developing countries.

1. Introduction

Developing countries presently face two kinds of policy challenges: economic development and environmental conservation. In particular, developing countries in the process of industrializing are under pressure to deal simultaneously with a variety of environmental problems, including industrial pollution, urban environmental issues, the deterioration of ecosystems, and global warming, while at the same time they are expected to achieve further economic development. In this context, developing countries urgently need to leapfrog over environmental difficulties with progressive environmental management and technology by utilizing their "latecomers' advantages" – developing countries'

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availability of the capital, skills, and technology of more advanced countries, to the maximum extent possible.

This study is aimed at examining whether or not developing countries actually do enjoy latecomers' advantages (depending on their stages of development) in environmental management and technology by utilizing the analytical framework of the environmental Kuznets curve. The strategic implications of our findings are significant, in terms of international assistance in environmental technology and management areas, to help developing countries benefit from latecomers' advantages. In the following sections, we will first outline the hypothesis behind the environmental Kuznets curve (Section 2), review previous studies on that topic (Section 3), conduct our own empirical study of latecomers' advantages (Section 4), and then end with concluding remarks (Section 5).

2. EK curve hypothesis

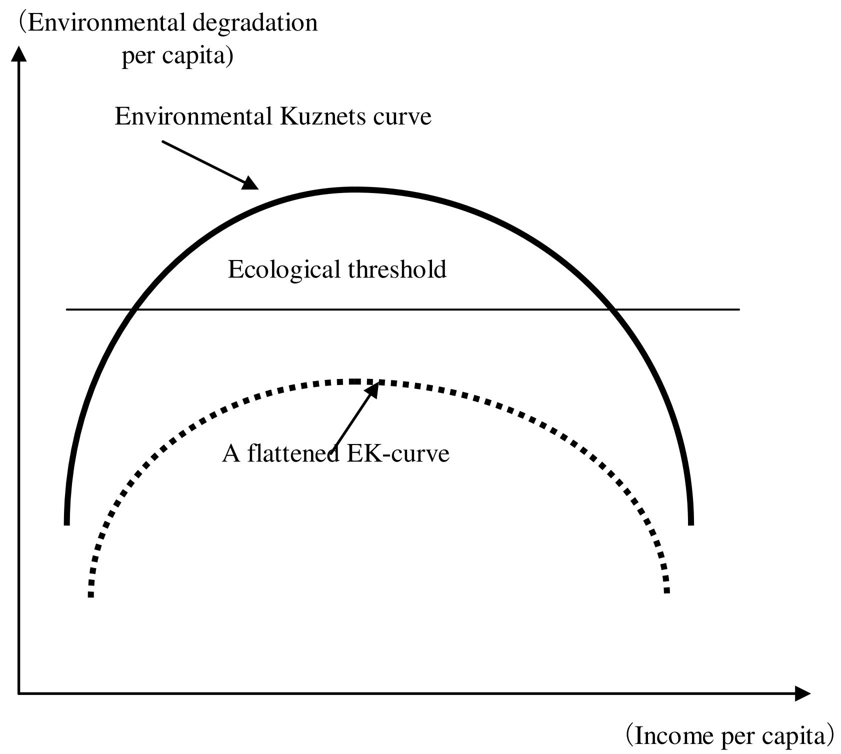
The environmental Kuznets curve (EK curve) provides an analytical framework to examine how developing countries deal with environmental issues. The EK curve hypothesis suggests that in the course of economic development, the environment gets worse before it gets better. Its origin comes from the intriguing hypothesis advanced by Simon Kuznets in 1955 that in the course of economic development income disparities rise at first and then begin to fall. This relationship, which when graphed appears in the shape of an inverted U, came to be known as the Kuznets curve. The environmental Kuznets curve will thus be applied to the relationship between the rate of environmental degradation and the level of economic development (see Figure 1.). In this section, we outline the theoretical background for the EK curve, then show its policy implications, including those for developing countries, by summarizing the explanations of Panayotou (1995).

2.1 Theoretical background

We first concentrate on the reason why environmental degradation rises at first and then falls in the course of economic development.

First, the state of natural resources and the environment in a country depends on the structure of its economy. There are fairly close relationships between the level of development, the share of the industrial sector in GDP, and the structure of industry. In the low-income stage, the share of industry in GDP is small (less than that of agriculture)—dominated by agroprocessing and light manufacturing. In the middle-income stage, industry's share approaches or exceeds one-third of GDP, and the sector is dominated by heavy steel, pulp and paper, cement, and chemical industries; the relationships, however, are not linear ones. In the higher-income stage, the share of industry stabilizes or declines somewhat, dominated by

Figure 1. Environmetal Kuznets curve



Sources: Panayotou (1995)

more sophisticated technology industries, such as electrical machinery and electronics. Industrial emissions vary with the size of industrial sector and the share of chemical and heavy industries. In the later development stage, the share of the industrial sector within the total GDP (and within industry, the share of chemicals and heavy industries) levels off and begins to decline gradually. These structural changes alone may explain the inverted relationship between emissions and the level of economic development.

Second, as incomes grow, people can afford to become more environmentally-conscious; environmental regulations are tightened and more strictly enforced. Environmental quality is an income-elastic "commodity" that does not constitute a significant part of the consumer's budget until fairly high levels of income have been attained. As the development process takes off, resource depletion accelerates and environmental pollution begins to accumulate at an increasing rate. In contrast, environment protection expenditures grow only slowly, because of lags in environmental awareness and in the change of preferences with rising incomes. Only after the higher levels of income and wealth are consolidated economically does the demand for environmental quality (being income-elastic) rise. As a result, economic, social, and political pressures are built up to institute and enforce environmental regulations and to increase budgetary allocations for environmental protection. These pressures are exerted through a number of channels, including by people joining the environmental movement, voting for “green” or pro-environmental parties, boycotting polluting industries, and expressing a preference for “green” products. Thus, in the later stages of development, environmental quality improves.

2.2. Policy implications of the EK curve hypothesis

The EK curve hypothesis has important policy implications. First, it implies a certain inevitability of environmental degradation along a country’s development path. Second, it suggests that as the development process picks up, when a certain level of income per capita is reached, economic growth turns from an enemy of the environment into an ally. This would tend to suggest that the environment needs only limited attention at the early stage of economic development; resources can best be focused on achieving rapid economic growth to move quickly through the environmentally-unfavorable stage to the environmentally-favorable range of the EK curve.

However, there are several reasons why this growth-oriented policy may not be optimal. First, the positively-sloping part of the curve, where growth worsens the environment, may take several decades to peak, in which case the present value of higher future growth and a cleaner future environment may be more than offset by high current rates of environmental damage. Second, it may be less costly today than in the future to prevent or abate certain forms of environmental degradation, such as with the problem of hazardous waste. Third, certain types of environmental degradation may be physically irreversible. Tropical deforestation and the loss of biological diversity, for example, are either physically irreversible or prohibitively costly to reverse. The fourth reason, more important in economic terms, is that certain forms of environmental degradation—such as soil erosion, watershed destruction, and damage to human health and productivity—constrain economic growth. Therefore, environmental degradation may need to be addressed directly through environmental policies and investments. To sum up, the policy implication is that in the presence of ecological thresholds, a sharply rising EK curve (implying high rates of resource depletion) should be flattened out through better management.

2.3. Implications for developing countries

Developing countries often appear on the positively-sloping part of their EK curve, and some of them may reach ecological thresholds beyond which environmental damage may be irreversible. Since environmental resources are valuable for high-income countries today and for developing countries in the future, a case could be made for providing assistance to developing countries to help them to flatten their EK curve so as to avoid, or at least to limit, irreversible environmental damage. In addition, the idea of assistance derives from the observation that production technologies in developed countries are cleaner than those in developing countries, and that a wide range of pollution abatement technologies are available in developed countries. Since most developing countries lack the financial resources to import these technologies at commercially-viable costs, the case has been made that developed countries should transfer these technologies to developing countries on concessionary terms. At any rate, developing countries are expected not to repeat the mistakes of the past that occurred in developed countries, and to leapfrog over environmental difficulties by absorbing their know-how and skills—in other words, by utilizing their latecomers' advantages.

3. Previous studies

Next is a summary of previous studies on the EK curve, first with the World Bank Report in 1992, followed by a discussion on the frontiers of studies on the topic.

3.1. World Bank Report in 1992

The issue of the EK curve was first discussed in the World Bank's 1992 World Development Report (World Bank 1992). The report showed that in industrial countries economic growth is being "de-linked" from pollution as environmentally non-damaging practices are incorporated into the capital stock. This de-linking is observed in the levels of emissions, such as lead, particulates, and sulfur oxides. It also stated that past patterns of environmental degradation are not inevitable; individual countries can choose policies that lead to much better (or worse) environmental conditions than those in other countries at similar income levels. In addition, technological change is enabling countries to grow more rapidly with less negative environmental impacts than was possible earlier. In this context, the report illustrates the downward shift of the cross-sectional EK curve, which shows that concentrations of sulfur dioxide are lower today than in the past; so that a person living in a country with a per capita income level of U.S.$500 is more likely to breathe cleaner air than in previous decades.

3.2. Previous empirical studies

Since the World Bank's report, there have been numerous theoretical debates and empirical tests on the EK curve. Empirical evidence has grown supporting the EK curve for some regions and some environmental problems.[1] Grossman and Krueger (1995) found an EK curve relationship between per capita GDP and urban sulfur dioxide (SO_2) concentrations. A similar relationship was found for air particulates in cities, and fecal coliform and arsenic in rivers (Islam 1996). The concentrations of these pollutants begin to fall when incomes reach $5,000–$7,000 (on a purchasing power parity basis). A similar relationship has been identified for tropical deforestation (Panayotou 1995). The turning point, however, was at a much lower level of annual income per person—approximately $1,000.

Despite these results, it is prudent to resist the temptation to elevate the EK curve hypothesis to a universal law of development (Cleveland and Ruth 1997). First, there is a substantial body of empirical work that rejects the EK curve hypothesis. For example, the income-pollution relationship varies widely across Asian countries (Islam 1996, Vincent 1997). In addition, the validity of the results from empirical EK curve analyses hinges on, among other things, the use of appropriate statistical techniques. One re-examination of the EK curve for income and SO_2 concentrations actually found the opposite result, namely, that the two showed a U-shaped pattern rather than the expected inverted U-shape (Kaufmann et al. 1998). Key to this finding was the inclusion of critical variables, such as the density of economic activity. Second, research is limited to the class of environmental problems for which data exist, such as

1 The descriptions in this section mostly refer to the Asian Development Bank (1997) and (2000).

the concentration of pollutants in urban areas. We are not aware of empirical analyses of the relationship between income and the degradation of key ecological services. Third, many of the important environmental gains in developed countries were achieved by the effective enforcement of environmental legislation. Income per capita was not the principal driving force, although income is related to the adoption of environmental legislation.

3.3. Frontiers of EK curve studies

Most of the empirical studies so far have concentrated on validating the EK curve hypothesis and its requirements by using cross-sectional data from developed countries. Other issues that have not been addressed as much include comparing the EK curves of specific countries in terms of the height and timing of their peaks, shapes, and so on; and investigating the causes of different patterns of EK curves, especially external impacts, such as policy changes and technological innovation and transfer. To address these issues, the EK curve should be validated in specific countries with the use of time-series data.

Irie (2000) tested the empirical proof on the EK curves of individual countries for SO_2 by using time-series data from 30 developed countries (OECD countries and the former Soviet Union). The main findings were that (1) the EK curves were verified on SO_2 emissions in 17 countries; (2) the EK curves varied in the shape of their trajectories and the height and timing of their peaks; and (3) the differences in the height can be explained by five factors (a country's available technology, scale of economy, fuel quality, leading industries, and political system). Irie (2000) also conducted a simulation and showed that enhancing environmental consciousness as well as technological innovation and transfers are highly effective measures for flattening the EK curve. Matusoka et al. (2000) compared the EK curves of Asian countries and explained the differences in the height of the EK curves by the latecomers' advantages as arising from the dissemination of environmental monitoring systems in Asian countries.

4. Empirical studies

Now, by utilizing the analytical framework of the environmental Kuznets curve, we examine whether developing countries enjoy latecomers' advantages in environmental management and technology. We first focus on East Asian countries and analyze their latecomers' advantages by examining the differences in the trajectory of the EK curve of each country over time. It seems significant to target East Asian countries, which are at different stages of development, because they face environmental policy challenges in the process of industrialization. In addition to the observation of the EK curves, we examine actual examples of latecomers' advantages in East Asian countries. We next carry out a regression analysis to identify the latecomers' advantage by using cross-sectional data from selected countries in the world with a per capita GDP of \$2,000. Throughout these analyses we focus on sulfur and carbon emissions as indexes of the environment, because they are often used to represent environmental quality, and data are generally available.

4.1. Analysis of the EK curves of East Asian countries

We next examine the time-series EK curves of the second half of the past century (1950–1990) for each of the selected East Asian countries: China, Indonesia, Japan, Korea, Malaysia, the Philippines, Taiwan, and Thailand.[2] We use per capita sulfur and carbon emissions as indexes of environment and per capita real GDP as an index of income.

4.1.a. Data

For sulfur emissions, we use the data estimated by Center for Air Pollution Impact and Trend Analysis (CAPITA) from Washington University in St. Louis, Missouri (ASL & Associates 1996). This database was developed for estimating the global emissions of sulfur from 1850 to 1990, with a common methodology applied across all years and countries. In all cases, the emissions estimates for each country are based on the production, percent sulfur, and sulfur retention information associated with that country's activities.

For carbon emissions, we use the data estimated by Carbon Dioxide Information Analysis Center (CDIAC) at the Oak Ridge National Laboratory of the U.S. Department of Energy (Marland et al. 2000). The database, named "Global, Regional, and National Fossil Fuel CO_2 Emissions," covers data from 1751 to 1997. The emissions estimates are based on a specific methodology using statistics on gas fuels, liquid fuels, solid fuels, gas flaring, cement manufacturing, estimated parameters of carbon coefficients and oxidation rates.

For population figures and per capita real GDP, we use Version 5.6 of the Penn World Tables (Heston and Summers 1995). As per capita real GDP, we use the time-series data of "Real GDP per capita" (Laspeyres Index) in 1985 international prices.

4.1.b. Main findings

Figure 2 and Table 1 describe the relationships between per capita sulfur and carbon emissions and per capita real GDP in eight countries for 1950–1990.

It is only in the case of sulfur emissions in Japan that the inverted U-shape in the EK curve is identified. Other instances, including the case of CO_2 emissions in Japan, suggest that the economy has reached the positively-sloping part of the EK curve. Korea and Malaysia, however, have recently begun to show flatter slopes for sulfur emissions.

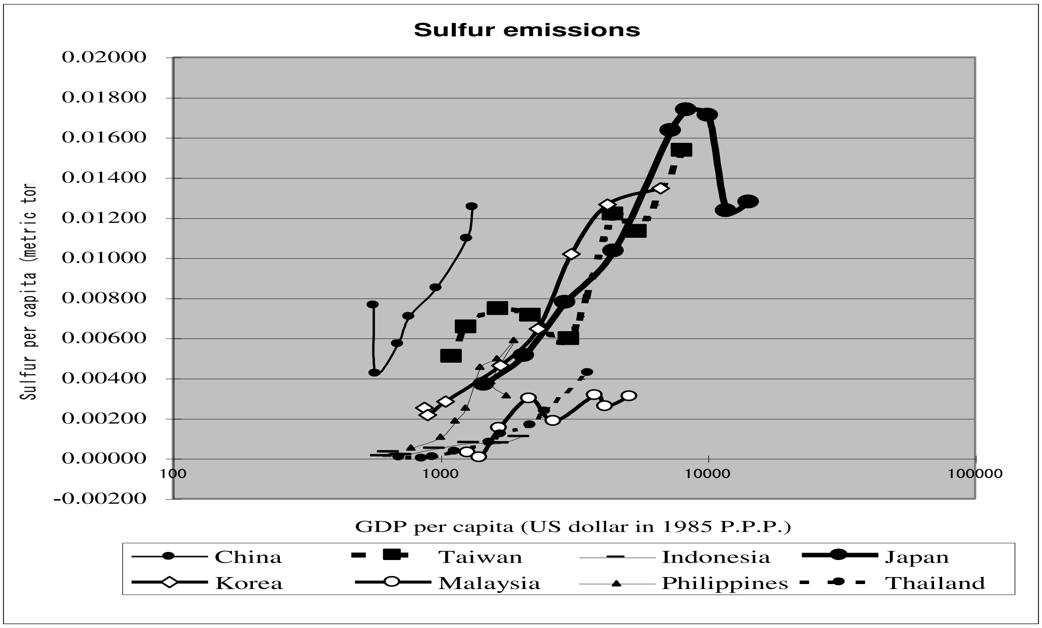
Korea and Taiwan, the newly industrializing economies (NIES) in Asia, indicate almost the same trajectories as the positively-sloping part of Japan's curve. Their latest per capita sulfur and carbon emissions, however, are lower than that of Japan at the same level of per capita real GDP.

The ASEAN countries of Indonesia, Malaysia, Thailand, and some parts of the Philippines have positively-sloping but lower trajectories than those of Japan, Korea, and Taiwan. Malaysia, in particular, shows a flatter slope than other countries in sulfur emissions. It shows that ASEAN sample countries employed better environmental technology and management, compared with similar earlier stages of

2 Hong Kong and Singapore were excluded because in the context of this study they behave more like big cities, and also because of the difficulty in comparing them with other countries in terms of per capita environmental pollution. Taiwan was excluded in the case of carbon emissions because of data constraints.

industrial development in Japan, Korea, and Taiwan. We can therefore speculate on the existence of the effects of the latecomers' advantages.

China has the highest and steepest trajectories of all other sample countries in both sulfur and carbon emissions. The trajectory may reflect China's own structure, including a heavy dependence on coal as an energy source. (The factor of energy source will be analyzed later in Section 4.)



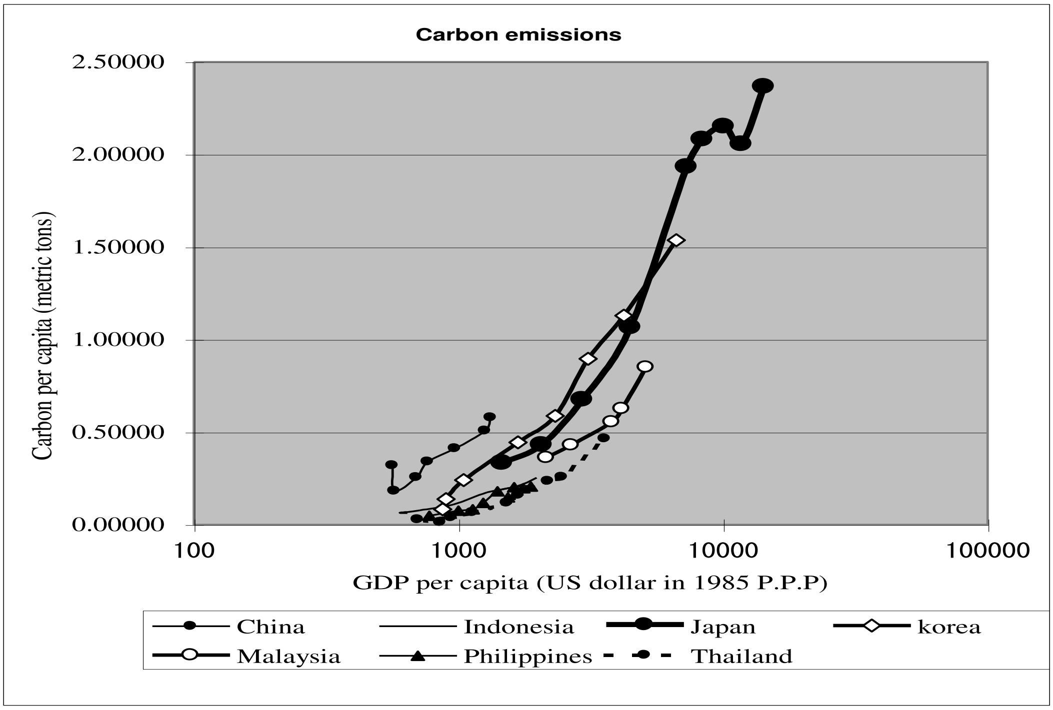


Figure 2. Income-environment relationships in selected East Asia countries (a. sulfur per capita, b. carbon per capita)

Table 1. Income-environment relationships in selected East Asian countries

Sulfur emissions per capita (metric tons)

Year	China	Taiwan	Indonesia	Japan	Korea	Malaysia	Philippines	Thailand
1950	n.a.	n.a.	n.a.	0.0037	n.a.	n.a.	0.0005	0.0000
1955	n.a.	0.0051	n.a.	0.0051	0.0025	0.0003	0.0011	0.0001
1960	0.0076	0.0065	0.0003	0.0078	0.0022	0.0001	0.0019	0.0001
1965	0.0042	0.0075	0.0001	0.0103	0.0028	0.0015	0.0025	0.0004
1970	0.0057	0.0071	0.0002	0.0163	0.0046	0.0030	0.0046	0.0008
1975	0.0071	0.0060	0.0005	0.0174	0.0065	0.0019	0.0050	0.0012
1980	0.0085	0.0122	0.0008	0.0171	0.0102	0.0031	0.0059	0.0017
1985	0.0110	0.0113	0.0008	0.0123	0.0126	0.0026	0.0039	0.0024
1990	0.0125	0.0153	0.0011	0.0128	0.0135	0.0031	0.0031	0.0043

Carbon emissions per capita (metric tons)

Year	China	Taiwan	Indonesia	Japan	Korea	Malaysia	Philippines	Thailand
1950	n.a.	n.a.	n.a.	0.3347	n.a.	n.a.	0.0478	0.0126
1955	n.a.	n.a.	n.a.	0.4312	0.0829	n.a.	0.0746	0.0277
1960	0.3192	n.a.	0.0624	0.6746	0.1382	n.a.	0.0825	0.0384
1965	0.1815	n.a.	0.0635	1.0669	0.2399	n.a.	0.1184	0.0662
1970	0.2560	n.a.	0.0770	1.9333	0.4434	0.3625	0.1793	0.1173
1975	0.3398	n.a.	0.1083	2.0816	0.5870	0.4291	0.2024	0.1605
1980	0.4108	n.a.	0.1741	2.1510	0.8959	0.5547	0.2063	0.2340
1985	0.5058	n.a.	0.2058	2.0550	1.1293	0.6259	0.1467	0.2568
1990	0.5782	n.a.	0.2530	2.3654	1.5355	0.8493	0.1967	0.4641

Real GDP per capita (US dollars in 1985 base)

Year	China	Taiwan	Indonesia	Japan	Korea	Malaysia	Philippines	Thailand
1950	n.a.	n.a.	n.a.	1465	n.a.	n.a.	776	854
1955	n.a.	1108	n.a.	2066	873	1272	1000	704
1960	564	1255	641	2943	898	1409	1133	940
1965	573	1651	603	4464	1046	1665	1243	1134
1970	695	2185	715	7304	1677	2154	1404	1528
1975	766	3044	955	8376	2321	2668	1625	1686
1980	971	4458	1282	10068	3093	3805	1882	2180
1985	1262	5449	1651	11771	4217	4146	1542	2463
1990	1324	8067	1973	14317	6665	5117	1761	3570

Sources: ASL & Associates (1996); Marland, G., T. A. Boden and R. J. Andres (2000); Heston, A. and R. Summers (1995).

4.2. Examples of latecomers' advantages

We next show several factual examples of the latecomers' advantages in the East Asian countries. Developing nations, such as ASEAN countries, have incorporated environmental considerations into their development strategies in their earlier development stages by learning from the lessons acquired in developed countries.

From the late 1970s to the early 1980s, Indonesia, Malaysia, the Philippines, and Thailand moved forward with establishing fundamental frameworks for environmental protection, such as laws, standards, and institutions. Indonesia and the Philippines specified items for environmental protection in their constitutions (Japanese Environment Agency 1998); and each developed their own environment impact assessment system (Indonesia in 1978, the Philippines in 1993)—earlier than Japan did in 1997. In addition to legal and institutional frameworks, they have introduced advanced environmental technologies at various levels of central and local governments and private companies. For example, in the field of environmental monitoring technology, Matusoka et al. (2000) showed that Malaysia, Thailand, and Indonesia simultaneously introduced automatic air-monitoring facilities, such as telemeter systems (remote data reporting), during the 1980s and 1990s by learning from the experiences of industrialized countries.

However, the efforts of ASEAN countries have not always led to successful performances in environmental management, because they have often lacked the capacity to enforce environmental laws and standards, and to disseminate new technologies nationwide. Developed countries, therefore, have focused their assistance since the 1980s on capacity building in environmental management. As a typical example, the Japanese government has provided official development assistance (ODA) to establish and manage environmental management centers, with functions such as environmental monitoring, training, and research (Ministry of the Environment 2001)—in Thailand, the Environmental Research and Training Center opened in March 1992; and in Indonesia, the Environmental Management Center opened in August 1993. The Japanese government has promoted technical cooperation with these centers, involving a systematic and comprehensive combination of dispatching experts, providing equipment and offering training programs.[3]

4.2.a. Regression analysis of latecomers' advantages

Now we conduct a regression analysis to identify the latecomers' advantage. We have already recognized the possibility of the existence of the latecomers' advantage by showing the differences in the trajectory of the EK curves over time in East Asian countries in Section 4.1. It seems, however, that the differences in each country's EK curve may be produced by other factors, like industrial structure and the structure of energy sources, rather than the latecomers' advantage. Therefore, the comprehensive relationships must be analyzed between the differences in EK curves and related factors, and then the significance of the latecomers' advantage can be validated.

Parameters of the analysis

We first focus on the countries in the world that have attained $2,000 of real GDP per capita (1985 international prices) since 1950. The reason we chose the level of $2,000 is that the data could cover a wide range of countries—from early-comers like Spain in 1950 and Japan in 1955, to latecomers like Indonesia in 1990—so that we could get 35 sets of cross-sectional data.

We now specify the modality of regression. We use ordinary least squares, a technique for calculating the regression equation that minimizes the sum of the squares of the error terms (that is, the differences

3. During the 1990s, the Japanese government provided assistance for establishing and managing environmental management centers in China, Chile, Mexico, and Egypt, as well as Thailand and Indonesia.

between the observed values for the dependent variable and the predicted values for the dependent variable). The dependent variables are sulfur and carbon emissions per capita (SO_2 and CO_2). The independent variables are as follows: the year when a sample country attained $2,000 of real GDP per capita (YEAR); the share of coal as a source for electricity production in a sample country in the YEAR (COAL); and the share of "industry" value-added in GDP of a given country in that YEAR (INDS). "Industry" comprises mining, manufacturing, construction, electricity, water, and gas. The data on SO_2, CO_2, real GDP, and population come from the same sources as those in Section 4.1.a. The data on COAL and INDS come from World Bank (2000). All the sample data are shown in the Appendix.

The crucial variable for this study is the YEAR: If the coefficient of the YEAR is significantly negative, we can assume the existence of latecomers' advantages. This is because a negative YEAR coefficient means that the later a sample country attained $2,000 of real GDP per capita, the lower are that country's sulfur and carbon emissions per capita. Table 2 reports the results of the regressions.

Main findings

In the regressions for SO_2, both equations *a* and *b* showYEARs registering significantly negative. INDS in equation *a*, and COAL and INDS in equation *b*, are significantly positive.

In the regressions for CO_2, neither equations *c* nor *d* perform well in terms of adjusted R-squared values.[4] It is notable that YEARs in both equations are negative, although not to a significant degree.

From the above observations, we have confirmed the existence of latecomers' advantages for sulfur emissions. We speculate that the reason for this is that developed countries were early to address the problem of sulfur emissions, which directly affects human health. To respond, they regulated sulfur emissions strictly and developed desulfurization technologies. This argument is consistent with the fact that many developed countries, including Japan, show the inverted U-shape relationship in their EK curves for sulfur emissions. One could conclude that developing countries seem to be in the position in which they can benefit from the transfer of environmental know-how and technologies from the developed countries that already possess them.

On the other hand, our analysis was not able to verify the existence of latecomers' advantages for carbon emissions. Perhaps this is because many countries—developed countries included (many of which are still on the positively-slope of their EK curve for carbon emissions)— has just begun to address the issue of carbon emissions, which is related to global warming. As a result, it may be difficult for developing countries to benefit from latecomers' advantages on this more recent environmental issue.

4 In regression analysis, the adjusted R-squared is the fraction of variation in the dependent variable explained by variation in the independent variable or variables.

Table 2. Results of regressions on sulfur and carbon emissions in countries with GDP per capita of U.S.$2,000

	Equation	YEAR	COAL	INDS	R**2
SO2	*a*	-0.012***		1.074***	0.322
	b	-0.010**	0.294**	0.785***	0.410
CO2	*c*	-0.092		17.301***	0.175
	d	-0.058	3.661	13.707**	0.188

Notes: 1. *, **, *** indicate coefficient is significant at 10, 5, and 1 percent levels, respectively.
2. Data are shown in the Appendix.

5. Concluding remarks

In this study we set out to examine, using empirical studies (Section 4), whether or not developing countries enjoy latecomers' advantages in environmental management and technology.

First, we concentrated on a regional survey focusing on East Asian countries. We found that the differences in the trajectories over time of their EK curves for sulfur and carbon emissions are mostly consistent with the hypothesis that developing countries benefit from latecomers' advantages in environmental management and technology. Information collected about the situations in countries also support the findings. Nevertheless, the survey cannot be considered a direct proof of the existence of latecomers' advantages. Therefore, as a second step we carried out a regression analysis to identify the latecomers' advantages by using cross-sectional data on selected countries in the world. Through this analysis, we verified the existence of latecomers' advantages on the well known environmental issue of sulfur emissions.

However, these studies may only be initial steps for analyzing the latecomers' advantages in developing countries. Analytical issues still remain that need to be addressed. First, environmental degradation involves a wide variety of pollutants and ecosystems; therefore, empirical tests are needed on emissions and factors other than sulfur and carbon. Second, the analytical method for identifying the existence of latecomers' advantages needs to be developed further. For example, this paper narrows the focus considerably by selecting countries with a per capita GDP of $2,000. Therefore, the regression analysis needs to made broader and more robust. Third, we can enrich the corroborative information on latecomers' advantages by showing how and in what fields the transfers in technology and know-how to developing countries have been carried out. Further studies on the environmental Kuznets curve will provide significant information to enable improved planning and evaluation of environmental assistance to developing countries.

Appendix: Data for regressions in Table 2

	YEAR	SO2	CO2	COAL		INDS	
Algeria	1972	0.31	529.74	0.0		44.2	
Bolivia	1978	2.70	258.73	0.0		51.9	(1986)
Brazil	1967	2.11	203.41	3.8	(1971)	37.1	
Colombia	1968	2.54	360.28	7.7	(1971)	22.7	
Cyprus	1955	40.51	233.96	0.0	(1971)	25.2	(1975)
Czechoslovakia	1966	98.01	76.15	84.8	(1971)	62.7	(1980)
Dominican Rep.	1974	5.40	355.55	14.3	(1985)	28.5	
Ecuador	1972	1.22	189.65	0.0		27.9	
Egypt	1985	3.76	372.28	0.0		28.6	
El Salvador	1974	0.92	132.61	0.0		25.1	
Gabon	1961	0.22	96.98	0.0	(1971)	31.6	
Greece	1958	2.90	248.69	53.4	(1960)	20.7	(1960)
Guatemala	1970	0.88	117.80	0.0	(1971)	18.7	
Indonesia	1990	1.09	252.98	29.4		39.1	
Jamaica	1964	4.26	646.27	0.0	(1971)	37.1	
Japan	1955	5.12	431.24	32.2	(1960)	44.2	(1960)
Jordan	1971	2.16	272.55	0.0		17.6	
Korea, Rep.	1973	5.39	559.69	9.0		32.1	
Malaysia	1970	2.99	362.48	1.5	(1988)	25.2	
Malta	1968	0.12	545.45	5.4	(1982)	30.9	
Morocco	1985	3.04	220.84	15.6		33.4	
Nicaragua	1963	3.94	133.41	0.0	(1971)	23.7	(1965)
Panama	1965	12.28	314.24	0.0	(1971)	21.0	(1980)
Paraguay	1978	0.62	135.39	0.0		23.8	
Peru	1960	22.40	223.53	0.0	(1971)	31.5	
Portugal	1961	2.92	277.50	1.9		37.5	(1986)
Romania	1986	59.83	2354.98	31.5		57.2	(1987)
Singapore	1966	12.43	94.57	0.0	(1971)	23.7	
South Africa	1953	17.70	1320.84	99.8	(1971)	37.7	(1960)
Spain	1950	4.11	323.63	12.9	(1960)	37.3	(1985)
Sri Lanka	1985	0.47	67.94	0.0		26.2	
Syria	1964	1.48	230.68	0.0	(1971)	21.8	(1965)
Thailand	1978	1.28	214.32	3.9		29.6	
Tunisia	1975	0.70	261.99	0.0		25.9	
Turkey	1967	8.38	279.09	34.2		20.4	(1968)

Notes:

YEAR: Year when a country attains U.S.$2,000 of GDP per capita

SO2: Sulfur emissions per capita of a country in the YEAR (kg)

CO2: Carbon emissions per capita of a country in the YEAR (kg)

COAL: Electricity production from coal sources of a country in the YEAR (% of total). (When the data is not available in the YEAR, the alternative data in the nearest year is used. The year of the alternative data is shown in parentheses.)

INDS: Industry, value added of a country in the YEAR (% of GDP). ("Industry" comprises value added in mining, manufacturing, construction, electricity, water, and gas [ISIC divisions 10-45]. When the data is not available for the YEAR, alternative data for the nearest year is used. The year of the alternative data is shown in parentheses.)

Sources: ASL & Associates (1996); Marland, G., T. A. Boden and R. J. Andres (2000); Heston, A. and R. Summers (1995); World Bank (2000).

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