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Hiroyuki Taguchi and Harutaka Murofushi

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Economic and Social Research Institute
Cabinet Office
Tokyo, Japan

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[**] Hiroyuki Taguchi : Director of Department of Administrative Affairs, Economic and Social Research Institute, Cabinet Office; E-mail: hiroyuki.taguchi@cao.go.jp

Harutaka Murofushi : Research Officer, Economic and Social Research Institute, Cabinet Office; E-mail:harutaka.murofushi@cao.go.jp

Abstract

Using the analytical framework of the environmental Kuznets curve, this study examines whether developing countries in the world enjoy the latecomer's advantage or suffer the latecomer's disadvantage in the area of environmental management and technology, with a focus on representative environmental indices of sulfur emissions and carbon emissions. The study's two main findings represent clear contrasts in panel estimation results between sulfur emissions and carbon emissions First, sulfur emissions follow the expected inverted U-shape pattern of the environmental Kuznets curve, while carbon emissions show monotonous increasing trends with per capita income in the observed range. Second, sulfur emissions represent the dominance of the latecomer's advantage while carbon emissions reveal that of the latecomer's disadvantage. The contrast in the emission-income patterns appears to come from the difference in the origin of emissions: sulfur emissions mainly from production (emissions from production are easily regulated on the local level), and carbon emissions from both production and consumption (emissions from consumption are easily externalized). In addition, the contrast in the latecomer's effects seems to be related to the degree of maturity in the know-how and technology to abate emissions: prevailing desulfurization and unrestricted "carbon leakage."

Key words: environmental Kuznets curve, latecomer's advantage, pollution heaven, carbon leakage

JEL Classification Codes: Q53, Q56

1. Introduction

At the Heiligendamm Summit in 2007, G8 leaders agreed to seriously consider reducing global greenhouse gas emissions by at least half by 2050. Such a long-term global goal can be achieved only when developing countries participate in an international framework set up to help solve environmental issues, and when environmental know-how, skills, and technology are transferred and disseminated from developed countries to developing countries. The spillover effect of environmental know-how, skills, and technology on developing countries can be shown as the "latecomer's advantage"[1] in their environmental management and technology: the availability of latecomer economies to integrate progressive know-how, skills, and technology—which have already been created by the more advanced economies—into their environmental government policies and private activities. Latecomer economies are expected not to repeat the mistakes made by developed economies, but to leapfrog over environmental difficulties by absorbing their know-how, skills, and technology. One counter-argument to this hypothesis of the latecomer's advantage is the well-known "pollution heaven" hypothesis, in which the pressure that global competition places on environmental regulations results in outsourcing or relocation of polluters from developed countries to developing countries, thereby leading to the "latecomer's disadvantage."

The purpose of this study is to examine whether developing countries in the world enjoy the latecomer's advantage or suffer the latecomer's disadvantage in the area of environmental management and technology, focusing on representative environmental indices: sulfur emissions as local air pollutants, and carbon emissions as global air pollutants. The analytical framework of the Environmental Kuznets curve (EK curve) is used to arrive at a conclusion. In the following sections, we will first review previous studies on the EK curve and clarify this article's position in the debate surrounding the EK curve (Section 2), present our own empirical study of the latecomer's advantage (Section 3), and end with concluding remarks (Section 4).

2. Previous Studies, Our Position

The EK curve postulates an inverted-U relationship between pollution and economic development; At early stages of development, environmental quality deteriorates with increases in per capita income, while at higher levels of development, environmental

[1] The hypothesis of the "latecomer's advantage" was advanced by Alexander Gerschenkron. See Gerschenkron (1962).

degradation is seen to decrease with further increases in per capita income. Kuznets's name was apparently attached to the curve by Grossman and Krueger (1993), who noted its resemblance to Kuznets inverted-U relationship between income inequality and development. Dasgupta et al. (2002) describe the process as conceived by the "conventional" explanations for the inverted-U relationship as follows: "In the first stage of industrialization, pollution … grows rapidly because people are more interested in jobs and income than clean air and water, communities are too poor to pay for abatement, and environmental regulation is correspondingly weak. The balance shifts as income rises. Leading industrial sectors become cleaner, people value the environment more highly, and regulatory institutions become more effective. Along the curve, pollution per capita levels off in the middle-income range and then falls toward pre-industrial levels in wealthy societies."

2.1 Empirical Testing of the EK Curve, Debates

The issue of the EK curve was first discussed in the World Bank's 1992 World Development Report (World Bank 1992). The report described a cross-sectional EK curve for concentrations of sulfur dioxide. Since the World Bank's report, there have been numerous empirical tests and theoretical debates on the EK curve. Empirical evidence has been accumulating, supporting the validity of the EK curve for some regions and environmental problems. Grossman and Krueger (1995) found an EK-curve relationship between the per capita GDP and urban air quality (the concentration of suspended particulate matter (SPM) and sulfur dioxide (SO_2)), while Selden and Song (1994) discovered the existence of an EK-curve relationship for the aggregate emissions of SPA, SO_2, oxides of nitrogen and carbon monoxide. Shafik (1994) had more ambiguous results, seemingly implying that the EK curve may not hold at all times and for all pollutants. The theoretical works have also shown that an environmental Kuznets curve can result if a few plausible conditions are satisfied as income increases in a society. Lopez (1994) used a fairly general theoretical model to show that if producers pay the social marginal cost of pollution, then the relationship between emissions and income depends on the properties of technology and preferences. Stokey (1998) made a theoretical contribution to the explanation of the EK curve using dynamic growth models.

Since the mid 1990s, however, the EK curve has been attacked on both empirical and methodological grounds. Empirical research has been limited to the environmental problems for which data exist, such as the concentration of pollutants in urban areas. We were not aware of any empirical analyses of the relationship between income and the degradation of key ecological services. One of the most damaging criticisms of the EK curve that advocates caution in interpreting its causes and implications is based on the linkage between the EK curve and the international trading of industrial goods. Suri and Chapman (1998) and Rothman (1998), notably, argued that the EK curve might arise due to the relocation of "dirty" industries to developing countries as a country reaches higher levels of development. Cole (2004) stated that the EK curve may thus be no more than a "historical artifact." Empirical studies of the relationship between economic growth and various indicators of environmental degradation are still ongoing, with mixed results.

2.2 Frontiers of EK-Curve Studies, Our Position

Most of the empirical studies so far have concentrated on validating the EK curve hypothesis and its requirements, using cross-sectional data. This cross-sectional approach adopted by most studies might, as Borghesi (1999) argued, be misleading, since environmental degradation is generally increasing in developing countries and decreasing in industrialized ones. Moreover, the EK curve within the cross-sectional framework might therefore reflect the mere juxtaposition of two opposite trends rather than describe the evolution of a single economy over time.

One of the frontiers of EK-curve studies, then, is to examine the EK curves of specific countries using time-series data, to compare them in terms of the height and timing of their peaks, their shapes, etc., and to investigate the causes of different EK-curve patterns. De Bruyn et al. (1998), noticing that conventional cross-section estimation techniques have generated spurious estimates of the EK curve, estimated time series models individually in four countries (the Netherlands, the UK, the US, and then-West Germany) for three types of emissions (CO_2, NO_x and SO_2) and showed that the time patterns of these emissions correlate positively with economic growth, and that emission reductions may have been achieved as a result of structural and technological changes in the economy. Irie et al. (2000) tested the empirical validity of the EK curves of individual countries for SO_2, using relevant 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 for 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: the technology available in the country, the scale of the economy, the quality of the fuel used, the leading industries, and the political system.

This time-series approach has been developed, as Dasgupta et al. (2002) argued, to examine the hypothesis that developing societies, utilizing progressive environmental management and the technologies of more advanced countries, might be able to experience an EK curve that is lower and flatter than what the conventional wisdom would suggest; they might be able to develop their economies from low levels of per capita income with little degradation in environmental quality, and then at some point experience improvements in both income and environmental quality. Concerning environmental management, Panayotou (1997)—formulating a tentative equation for a sample of 30 developed and developing countries for 1982-1994—found that effective policies and institutions can significantly reduce environmental degradation at low income levels and speed up improvements at higher income levels, thereby lowering the EK curves, at least for ambient sulfur dioxide levels. Matsuoka et al. (2000) compared the EK curves of various Asian countries and explained the differences in their height by the dissemination of environmental monitoring systems in those countries. As for environmental technology, Martin and Wheeler (1992) argued that, because increased openness to trade tends to lower the price of cleaner imported technologies while increasing the competitive pressure to adopt them, firms in relatively open developing economies adopt cleaner technologies more quickly.

One counter-argument to this hypothesis of the latecomer’s advantage is the well-known “pollution heaven” hypothesis. For example, Dasgupta et al. (2002) argues that the relatively high environmental standards in high-income economies impose high costs on polluters, and shareholders pressure the firms to relocate to low-income countries, whose people are so eager to get jobs and income that their environmental regulations are weak or nonexistent. The scenario may not shift the latecomers’ EK curves downward; on the contrary, it may even lift them.

This article, which extends the time-series approach in the EK curve studies, tries to verify the existence of the latecomer’s advantage or its disadvantage in the area of environmental management and technology in developing countries in the world. The approach is to confirm the downward or upward shift of the EK curves of the sample latecomer economies on both sulfur emissions as local air pollutants and carbon emissions as global air pollutants.

3. Empirical Studies

We now turn to the empirical studies within the analytical framework of the environmental Kuznets curve. Our analysis consists of two steps. First, we will simply overview the relationships between per capita real GDP and environmental indices of sulfur and carbon emissions. We then move to a regression analysis using panel data to examine the existence of the EK curve pattern and to see whether the latecomer's advantage or its disadvantage dominates in the environmental management of developing countries.

3.1 Data

For sulfur emissions, we will use the data estimated by Lefohn et al. (1999). This database was developed for the purpose of 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 will use the data estimated by Marland et al. (2008). The database, named "Global, Regional, and National Fossil Fuel CO_2 Emissions," covers data from 1751 to 2005. The emissions estimates are based on a specific methodology using statistics on gas fuels, liquid fuels, solid fuels, gas flaring, cement manufacturing, and estimated parameters of carbon coefficients and oxidation rates. For the population and the real GDP per capita, we will use Version 6.2 of the Penn World Tables (PWT), estimated by Heston et al. (2006). As the per capita real GDP, we will use the time-series data of "REAL GDP PER CAPITA (CONSTANT PRICE: LASPEYRES)" in 2000 US dollar prices. The database covers data from 1950 to 2004. To conduct the following panel estimation, we constructed a table of the annual environmental and economic data from the 188 economies for 1950 to 2004 (See Appendix on sample countries and data availability). As sample countries, we have two cases for estimation on each emission: Group A and Group B. Group A collects countries at maximum extent; countries that have at least one available data in both the real GDP per capita and each of sulfur or carbon emissions for a certain year. Group B targets the countries with a long range of data availability, countries that have fully available data for a certain period (from 1960 to 1990 in sulfur emissions and from 1970 to 2003 in carbon emissions).

3.2 Overview of Cross-sectional and Time-series Relationships

Next we will summarize the relationships between per capita income and environmental indices of sulfur and carbon emissions. Figure 1 indicates the cross-sectional relationships between per capita real GDP and per capita sulfur emissions in 1970 and 1990, and between per capita real GDP and per capita carbon emissions in 1970 and 2003. We found that the case of sulfur emissions does not appear to show a clear trend in the spot distribution, while the case of carbon emissions seems to reveal an increasing trend. As for the comparison of the spot locations between 1970 and a recent year, sulfur emissions indicate the downward shift of the average level of per capita emissions from 1970 to 1990, while carbon emissions show the upward shift from 1970 to 2003.

Figure 2 reports the time-series relationships between per capita real GDP and per capita emissions in main sample countries. Such developed countries as the United States, Japan, and Italy approximately create an inverted-U shape pattern in sulfur emissions, while none of countries do in carbon emissions. In addition, the downward shifts from the trajectories of developed countries to those of developing countries are clearer in sulfur emissions than in carbon emissions. China, which has the highest trajectory for both environmental indices, may be reflected its peculiar economic structure, which is characterized by a heavy dependence on coal as an energy source.

The income-emissions relationships described above may produce different implications in the shape and location of trajectories between sulfur and carbon emissions. This point will be statistically clarified through a panel estimation in the following section.

3.3 Regression Analysis Using Panel Data

We'll now move to a regression analysis using panel data to examine the existence of the EK curve pattern and to see the latecomer's advantage or its disadvantage dominates in the environmental management of developing countries.

3.3.1 Methodology

We will first clarify some methodological points related to our analysis. To study the relationship between pollution and growth, there are two possible approaches to model construction. One is to estimate a reduced-form equation that relates the level of pollution to the level of income. The other is to model the structural equations relating environmental regulations, technology, and industrial composition to GDP, and then to link the level of pollution to the regulations, technology, and industrial composition. We here take the reduced-form approach for the following reasons. First, the reduced-form estimates give us the net effect of a nation's income on pollution. If the structural equations were to be estimated first, one would need to solve back to find the net effect, and confidence in the implied estimates would depend on the precision and potential biases of the estimates at every stage. Second, the reduced-form approach spares us from having to collect data on pollution regulations and the state of the existent technology, which are not always available. Although a reduced-form relationship gives no indication of the direction of causality—namely, whether growth affects the environment or the other way around—we think that the reduced-form relationship between pollution and income is an important first step.[2]

We then specify the reduced-form equation in accordance with our analytical interests. Our specific concern regarding the EK curves for the sample economies is whether the EK-curve trajectories have shifted downward or upward, depending on the dominance of either the latecomer's advantage or its disadvantage; in other words, whether the levels of environmental pollution have been affected not only by the levels of per capita income following the EK curve, but also by the speed of development. If a sample economy later reaches a certain level of development and then lowers its environmental pollutants, we speculate that the economy does not repeat the EK-curve trajectories already experienced by the developed economies; it should leapfrog over the environmental difficulties by absorbing their know-how, skills, and technology. On the contrary, if the later development is linked with higher pollution, the sample economies may suffer from the disadvantage caused by the "pollution heaven" scenario brought about by globalization. Therefore, we will include a term representing the speed of development of the latecomers into the ordinary regression model of the EK curve, and specify the modified model as follows.

$$[\mathbf{SOP_{it}},\ \mathbf{COP_{it}},\ ] = \alpha_0 + \alpha_1 \mathbf{YRP_{it}} + \alpha_2 \mathbf{YRP^2_{it}} + \alpha_3 \mathbf{YEAR_{it}} + e_{it} \qquad (1)$$

where **i** is the country index, **t** is the time index, and ***e*** is the error term. The dependent variables **SOP** and **COP** are measures of environmental pollutions: **SOP** is for the sulfur emissions per capita, and **COP** is the carbon emissions per capita. As for the independent variables, **YRP** is the real GDP per capita, **YEAR** is the year in which the data were collected and represents the speed of development of the latecomers.

To verify the inverted U-shapes of the EK curves, the signs and magnitudes of α_1 and α_2 should be examined. Environmental pollutants can be said to exhibit a meaningful EK curve with the real GDP per capita, if $\alpha_1 > 0$ and $\alpha_2 < 0$, and if the turning point, $-\alpha_1/2\alpha_2$ is a reasonably low number. Of particular importance is the coefficient of **YEAR**, α_3, which is useful for identifying the dominance of the latecomer's advantage or its disadvantage. The negative sign of α_3, the downward shift of the trajectories, indicates that the latecomer's advantage surpass its disadvantage, while the positive sign

2 Grossman and Krueger (1995), and Selden and Son (1994), which we introduced in reviewing previous studies, also estimate a reduced-formed equation.

of α_3, the upward shift of the curve, reveals the dominance of the latecomer's disadvantage.

Apart from the real GDP per capita, the speed of development of the latecomers, there are also likely to be exogenous factors that affect emissions. For instance, climate, geography, and energy resources vary widely among countries and may well be correlated with emissions. Insofar as these factors cause the error term e to be correlated among countries for a given period, pooled cross-section estimates that ignore this correlation will be inefficient. To address this issue, we must specify an error-components model, in which:

$$e_{it} = r_i + u_{it} \qquad (2)$$

where r_i is the country effect, and u_{it} is the remaining error term. In choosing between fixed-effects and random-effects estimation, an important issue is whether the country effect is correlated with the explanatory variables. In the absence of such a correlation, random-effects estimation is consistent and efficient. In contrast, if such a correlation exists, there may be omitted-variable bias, necessitating fixed-effects estimation. According to the statistics of the Wu-Hausman test (Hausman 1978), which is used to help choose between these two approaches, we use a fixed-effects estimation on sulfur emissions for the sample countries of Group A and on carbon emissions, and use a random-effects estimation on sulfur emissions for the sample countries of Group B (see Table 1).

3.3.2 Estimation Results and Interpretations

Table 1 lists the results of the estimation of the sulfur and carbon emissions. First, we must verify the shape of the EK curve of each emission index. In the case of sulfur emissions, the estimates for the coefficients α_1 and α_2 have the signs of the inverted U-shapes, and are different from zero, as high levels of significance in both sample countries of Group A and B. The turning point in Group B case indicates a feasible number, US$17,900. The case of Group A has the turning point of $82,000, which is beyond the observed range. It may be because the distribution of the panel data is biased in recent years. The indices for the sulfur emissions can, therefore, be said to reflect a meaningful, inverted U-shaped EK curve with the real GDP per capita. On the contrary, the carbon emission cases have those coefficients α_1 and α_2, whose signs show U-shapes at high levels of significance in both cases of Group A and B. Since the turning points are negative, the observed ranges of trajectories on carbon emissions reveal monotonous increasing trends with per capita income.

Second, we must see if the trajectories show a downward shift or an upward shift, and whether the latecomer's advantage or its disadvantage dominates in the environmental management of developing countries. In the case of sulfur emissions, the estimate for the coefficients of **YEAR**, $\boldsymbol{\alpha_3}$, is negative and discernable, thereby representing the downward shift of the trajectories and the dominance of the latecomer's advantage. On the other hand, the carbon emission cases have the positive and discernable coefficient of $\boldsymbol{\alpha_3}$, showing the upward shift of the trajectories, the dominance of the latecomer's disadvantage.

The contrasting result above on the shapes of the EK curves is consistent with the findings of the exiting empirical literature on local and global air pollutants. For example, Rothman (1998) and Stern (1998) argue that the EK curve pattern is usually found to hold for pollutants with local impacts such as sulfur emissions, which cannot easily be externalized, while carbon emissions—the impacts of which are relatively easy to externalize—show no tendency to decline with increasing per capita income. Another contrasting result on the latecomer's effects is one that this study found for the first time in the literature on the EK curve.

These clear contrasts in estimation results between the case of sulfur emissions and that of carbon emissions seem to be interpreted as follows. Wealthy consumers in developed countries demand a cleaner environment and stringent environmental management, including regulations and technologies. This results in the environmental improvements of industrial production and/or the relocation of dirty industries abroad, thereby the decline in the levels of pollutants arising from production. This is nothing but the case of sulfur emissions showing the EK curve pattern, because sulfur emissions mainly come from manufacturing production activities. The verified latecomer's advantage can be interpreted in such a way that the know-how, skills, and technology to abate sulfur emissions in advanced countries' production activities are mature and feasible enough to be transferred and disseminated to developing countries[3], and that the desulfurization effects coming from technological transfer overcome the "pollution heaven" impacts coming from the relocation of sulfur polluters in developing countries.

On the other hand, the case is different in carbon emissions. Carbon emissions arise from not only production but also from consumption such as automobile use and the burning of fossil fuels for the generation of electricity, thereby being easily externalized

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3 For example, Iwami (2001) states that the remarkable improvement of sulfur emissions in Japan for the period from the beginning of 1970s to the half of 1980s comes from environmental regulations reinforced by central and local governments, and technological development for desulfurization and energy efficiency promoted by private companies. He also states that the other East Asian economies are trying to make the same kinds of efforts as Japan did.

even at the global level and thus not subject to regulation (Nahman and Antrobus 2005). That is why carbon emissions, which don't follow the EK curve pattern, continue to rise with per capital income. The latecomer's effect on carbon emissions may be explained in terms of the dominance of the "pollution heaven" impacts; the know-how and technology to mitigate carbon emissions coming from both production and consumption are too premature to be transferred and disseminated (Yaguchi et al. 2007). Thus, the effect of the relocation of pollution-intensive industries only remains in developing countries. This relocation effect may be so-called "carbon leakage": the effect that there is an increase in carbon emissions in one country as a result of an emission reduction by a second country with a strict climate policy. For example, Babiker (2005), using a multi-regional computable general equilibrium model, estimated the carbon leakage rate in case of significant relocation of energy-intensive industries from countries with carbon controls to those without them.

4. Concluding Remarks

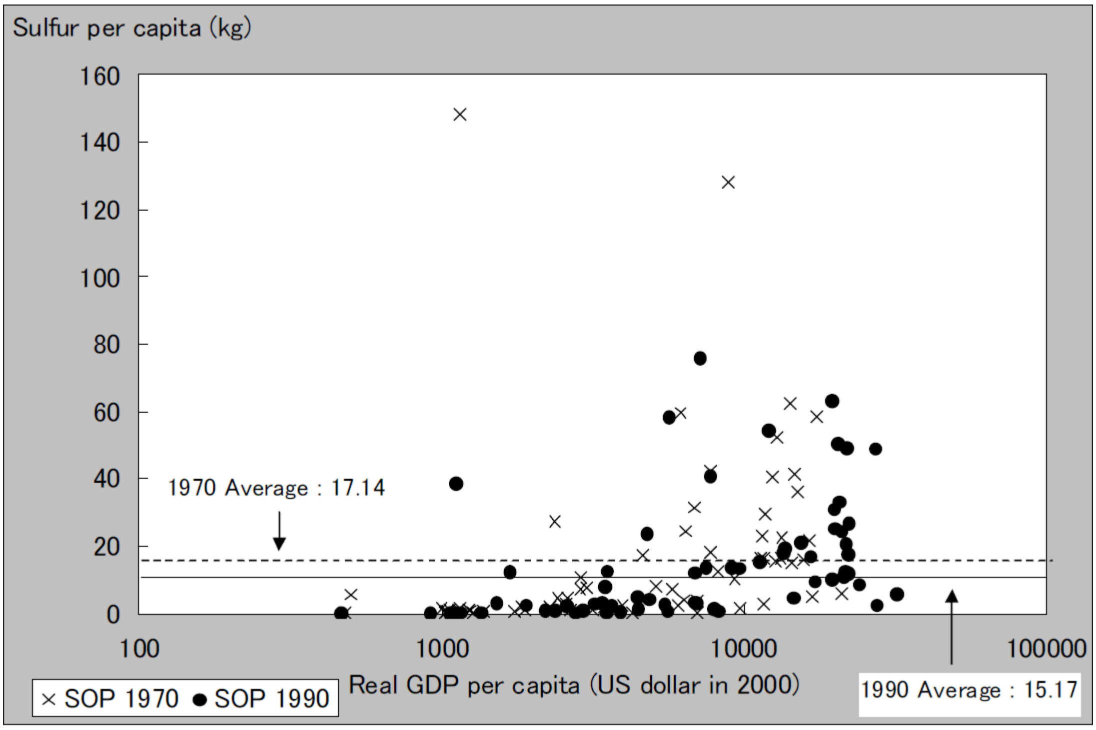
In this study, we set out to examine, using the analytical framework of the EK curve, whether developing countries in the world enjoy the latecomer's advantage or suffer the latecomer's disadvantage in the area of environmental management and technology. We focused on representative environmental indices: sulfur emissions as local air pollutants, and carbon emissions as global air pollutants. For this purpose, we carried out a regression analysis using panel data to examine the existence of the EK curve pattern and to see whether the latecomer's advantage or its disadvantage dominates in the environmental management of developing countries.

Through this analysis, we found two contrasting results between sulfur emissions and carbon emissions on the EK curve shapes and the latecomer's effects: 1) sulfur emissions follow the inverted U-shape pattern expected as the EK curves while carbon emissions show monotonous increasing trends with per capita income in the observed range, and 2) sulfur emissions represent the dominance of the latecomer's advantage while carbon emissions reveal that of the latecomer's disadvantage.

We speculate that the contraction in the shapes comes from the difference in the origin of emissions: sulfur emissions come mainly from production (emissions from production are easily regulated on the local level), and carbon emissions come from both production and consumption (emissions from consumption are easily externalized). We also presume that the contrast in the latecomer's effects lies in the degree of maturity in the know-how and technology to abate emissions: prevailing desulfurization and unrestricted "carbon leakage". The results imply the urgent necessity to facilitate the internalization of external diseconomy in carbon emissions through such methods as emissions charge and greenhouse taxes.

This study is only an initial step in the analysis of the latecomer's effects. Analytical issues still remain that need to be addressed. First, environmental degradation involves a wide variety of pollutants and ecosystems; empirical testing of emissions and factors other than sulfur and carbon is therefore needed. Second, methodological improvements for the estimation in panel data should be introduced by conducting panel unit root tests and co-integration tests. Further studies on the EK curve will provide significant information, enabling the improved planning and evaluation of global environmental policies.

Figure 1 Cross-sectional relations in sample countries



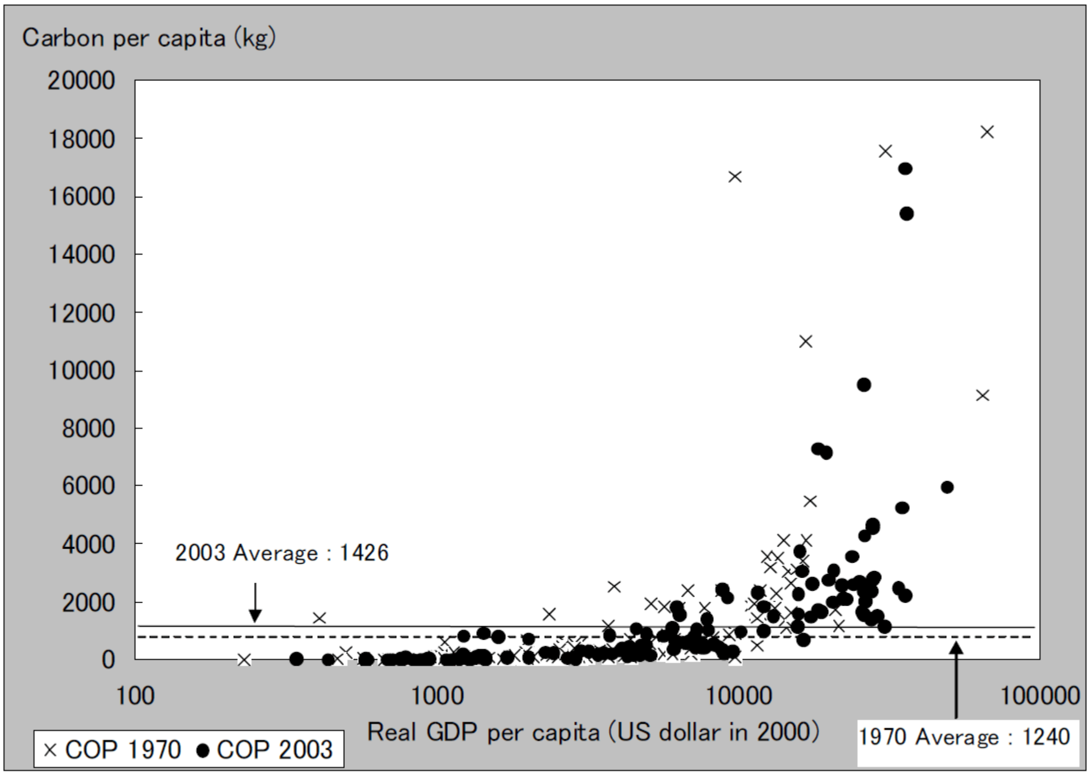
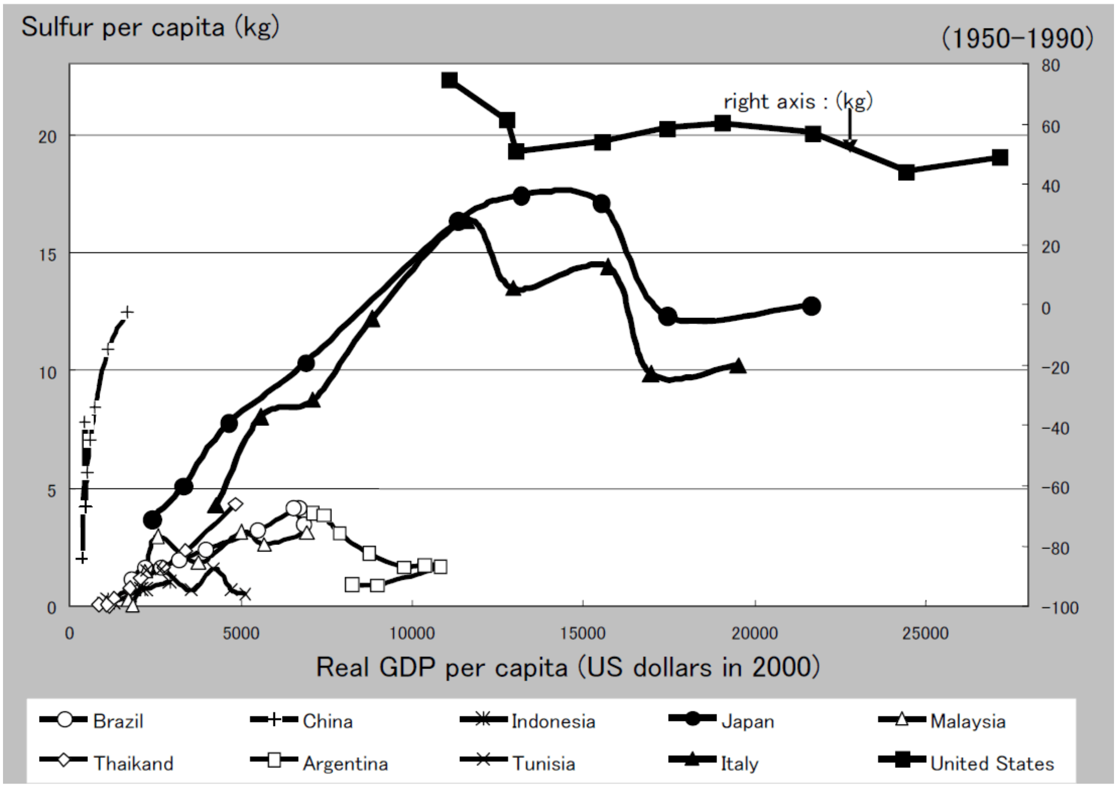


Figure 2 Time-series Relationships in Main Sample Countries



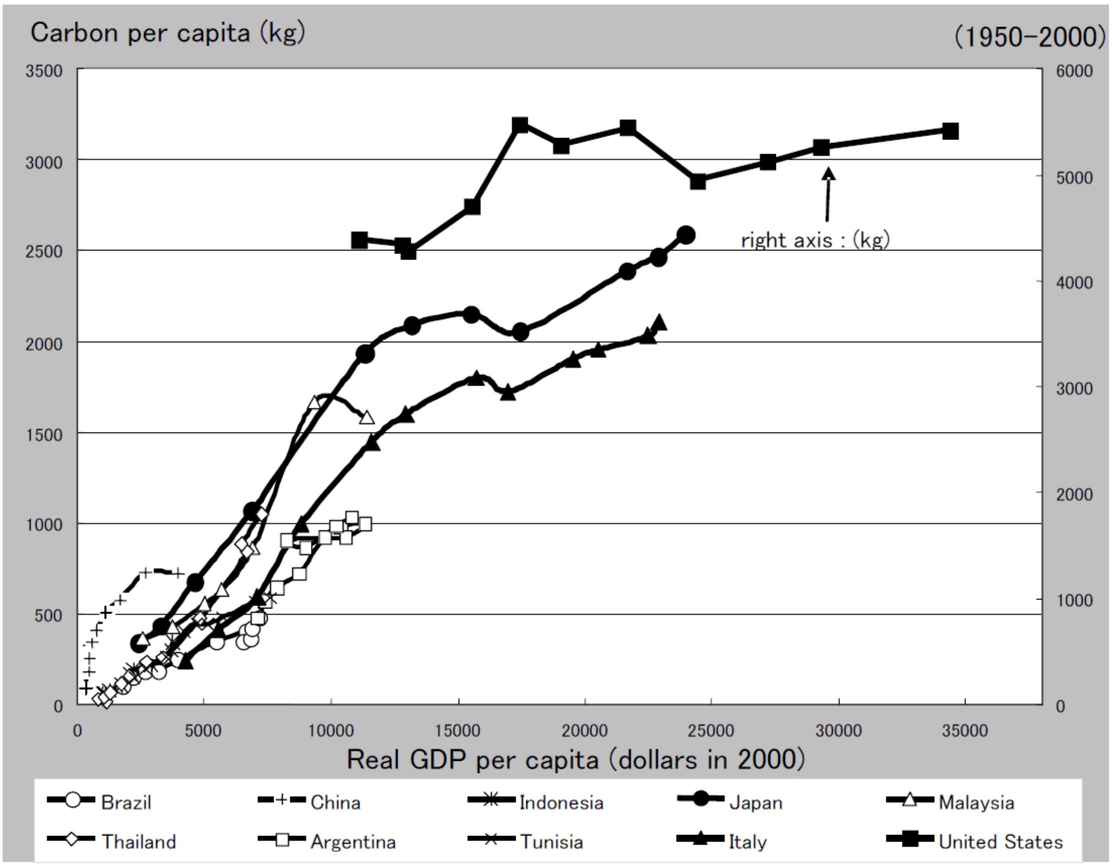


Table 1 Estimation Results for Sulfur and Carbon Emissions

Variables	$SOP*10^{6}$		$COP*10^{6}$	
	Group A	Group B	Group A	Group B
Const.	$3.25*10^{8***}$	$4.45*10^{8***}$	$-2.78*10^{9}$	$-3.00*10^{9*}$
	(5.41)	(−9.26)	(−1.61)	(−1.66)
YRP	$8.50*10^{2***}$	$3.44*10^{3***}$	$4.32*10^{4***}$	$4.23*10^{4***}$
	(5.02)	(14.9)	(7.33)	(6.87)
YRP^{2}	$-5.17*10^{-3**}$	$-9.59*10^{-2***}$	$4.92*10^{-1***}$	$5.04*10^{-1***}$
	(−2.11)	(−13.0)	(5.02)	(4.95)
YEAR	$-1.59*10^{5***}$	$-2.26*10^{5***}$	$1.79*10^{6**}$	$1.91*10^{6**}$
	(−5.16)	(−9.13)	(2.02)	(2.06)
Adj R^{**2}	0.86	0.08	0.86	0.86
Turning Point	$8.22*10^{4}$	$1.79*10^{4}$	$-4.40*10^{4}$	$-4.19*10^{4}$
<the Wu-Hausman Test>				
Chi-Sq. Statistic	32.14	0.49	324.76	303.68
Chi-Sq. d.f.	3	3	3	3
Prob.	0.00	0.92	0.00	0.00
Estimation Type	Fixed	Random	Fixed	Fixed

Note:

a) The T-value is shown in parentheses.
One, two, or three asterisks indicate that a coefficient estimate is significantly different from zero at 10, 5, or 1% percent level, respectively.

b) Constant terms for fixed-effect model indicate the mean of the estimated country effects.

Sources: Lefohn A.S., J.D.Husar, and R.B.Husar (1999)
Marland, G., T.A. Boden, and R. J. Andres (2008)
Heston Alan, Robert Summers and Bettina Aten (2006)

Appendix 1 Sample Countries and Data Avilability (SOP)

Number	Country	Sample Countries for Estimation		Data Availability	
		Group A	Group B	YRP	SOP
	Developed				
1	Australia	◎	◎	○	○
2	Austria	◎	◎	○	○
3	Belgium	◎	◎	○	○
4	Canada	◎	◎	○	○
5	Cyprus	◎	—	△	○
6	Denmark	◎	◎	○	○
7	Finland	◎	◎	○	○
8	France	◎	◎	○	○
9	Germany	◎	—	△	○
10	Greece	◎	◎	○	○
11	Iceland	◎	—	○	△
12	Ireland	◎	◎	○	○
13	Italy	◎	◎	○	○
14	Japan	◎	◎	○	○
15	Luxembourg	◎	◎	○	○
16	Malta	◎	—	△	△
17	Netherlands	◎	◎	○	○
18	New Zealand	◎	◎	○	○
19	Norway	◎	◎	○	○
20	Portugal	◎	◎	○	○
21	Slovenia	—	—	△	×
22	Spain	◎	◎	○	○
23	Sweden	◎	◎	○	○
24	Switzerland	◎	◎	○	○
25	United Kingdom	◎	◎	○	○
26	United States	◎	◎	○	○
	Developing				
27	Afghanistan	◎	—	△	○
28	Albania	◎	—	△	○
29	Algeria	◎	◎	○	○
30	Angola	—	—	△	△
31	Antigua	◎	—	△	△
32	Argentina	◎	◎	○	○
33	Armenia	—	—	△	×
34	Azerbaijan	—	—	△	×
35	Bahamas	◎	—	△	△
36	Bahrain	◎	—	△	○
37	Bangladesh	◎	—	△	△
38	Barbados	◎	◎	○	○
39	Belarus	—	—	△	×
40	Belize	—	—	△	×
41	Benin	—	—	○	×
42	Bermuda	◎	—	△	△
43	Bhutan	◎	—	△	△
44	Bolivia	◎	◎	○	○
45	Bosnia	—	—	△	×
46	Botswana	◎	—	△	△
47	Brazil	◎	◎	○	○
48	Brunei	—	—	△	×
49	Bulgaria	—	—	△	○
50	Burkina Faso	—	—	○	×
51	Burundi	—	—	○	×
52	Cambodia	◎	—	△	△
53	Cameroon	◎	—	○	△
54	Cape Verde	—	—	○	△
55	Central African Republic	—	—	△	×
56	Chad	—	—	○	×
57	Chile	◎	◎	○	○
58	China	◎	◎	○	○
59	Colombia	◎	◎	○	○
60	Comoros	—	—	○	×
61	Congo, Dem. Rep.	—	—	△	×
62	Congo, Republic	◎	—	○	△
63	Costa Rica	◎	—	○	△
64	Cote d`Ivoire	◎	—	○	△
65	Croatia	—	—	△	×

Number	Country	Sample Countries for Estimation		Data Availability	
		Group A	Group B	YRP	SOP
66	Cuba	◎	—	△	○
67	Czech Republic	—	—	△	×
68	Djibouti	—	—	△	×
69	Dominica	—	—	△	×
70	Dominican Republic	◎	—	○	△
71	Ecuador	◎	◎	○	○
72	Egypt	◎	◎	○	○
73	El Salvador	◎	—	○	△
74	Equatorial Guinea	—	—	○	△
75	Eritrea	—	—	△	×
76	Estonia	—	—	△	×
77	Ethiopia	◎	◎	○	○
78	Fiji	◎	—	△	△
79	Gabon	◎	—	○	△
80	Gambia	—	—	○	×
81	Georgia	—	—	△	×
82	Ghana	◎	◎	○	○
83	Grenada	—	—	△	×
84	Guatemala	◎	◎	○	○
85	Guinea	—	—	○	×
86	Guinea-Bissau	—	—	○	×
87	Guyana	—	—	△	△
88	Haiti	◎	—	△	△
89	Honduras	◎	◎	○	○
90	Hong Kong	◎	◎	○	○
91	Hungary	◎	—	△	○
92	India	◎	◎	○	○
93	Indonesia	◎	◎	○	○
94	Iran	◎	◎	○	○
95	Iraq	◎	—	△	○
96	Israel	◎	◎	○	○
97	Jamaica	◎	—	○	△
98	Jordan	◎	—	○	△
99	Kazakhstan	—	—	△	×
100	Kenya	◎	◎	○	○
101	Kiribati	—	—	△	×
102	Korea, Dem. Rep	◎	—	△	○
103	Korea, Republic	◎	◎	○	○
104	Kuwait	◎	—	△	○
105	Kyrgyzstan	—	—	△	×
106	Laos	—	—	△	×
107	Latvia	—	—	△	×
108	Lebanon	—	—	△	○
109	Lesotho	—	—	○	×
110	Liberia	◎	—	△	△
111	Libya	—	—	△	△
112	Lithuania	—	—	△	×
113	Macao	◎	—	△	△
114	Macedonia	—	—	△	×
115	Madagascar	◎	◎	○	○
116	Malawi	◎	—	○	△
117	Malaysia	◎	◎	○	○
118	Maldives	—	—	△	×
119	Mali	—	—	○	×
120	Mauritania	◎	—	△	△
121	Mauritius	◎	—	○	△
122	Mexico	◎	◎	○	○
123	Micronesia, Fed. Sts.	—	—	△	×
124	Moldova	—	—	△	×
125	Mongolia	◎	—	△	○
126	Morocco	◎	◎	○	○
127	Mozambique	◎	◎	○	○
128	Namibia	◎	—	△	○
129	Nepal	◎	—	○	△
130	Netherlands Antilles	◎	—	△	△
131	Nicaragua	◎	◎	○	○
132	Niger	◎	—	○	△
133	Nigeria	◎	◎	○	○
134	Oman	◎	—	△	△

Number	Country	Sample Countries for Estimation		Data Availability	
		Group A	Group B	YRP	SOP
135	Pakistan	◎	◎	○	○
136	Palau	—	—	△	×
137	Panama	◎	—	○	△
138	Papua New Guinea	◎	—	△	△
139	Paraguay	◎	—	○	△
140	Peru	◎	◎	○	○
141	Philippines	◎	◎	○	○
142	Poland	◎	—	△	○
143	Puerto Rico	◎	—	△	○
144	Qatar	◎	—	△	△
145	Romania	◎	◎	○	○
146	Russia	—	—	△	×
147	Rwanda	◎	—	○	△
148	Samoa	—	—	△	×
149	Sao Tome and Principe	—	—	△	×
150	Saudi Arabia	◎	—	△	○
151	Senegal	◎	—	○	△
152	Serbia and Montenegro	—	—	△	×
153	Seychelles	—	—	△	×
154	Sierra Leone	◎	—	△	△
155	Singapore	◎	◎	○	○
156	Slovak Republic	—	—	△	×
157	Solomon Islands	—	—	△	×
158	Somalia	◎	—	△	△
159	South Africa	◎	◎	○	○
160	Sri Lanka	◎	◎	○	○
161	St. Kitts & Nevis	—	—	△	×
162	St. Lucia	—	—	△	×
163	St.Vincent & Grenadines	—	—	△	×
164	Sudan	◎	—	△	○
165	Suriname	◎	—	△	△
166	Swaziland	◎	—	△	△
167	Syria	◎	◎	○	○
168	Taiwan	◎	◎	○	○
169	Tajikistan	—	—	△	×
170	Tanzania	◎	—	○	△
171	Thailand	◎	◎	○	○
172	Togo	◎	—	○	△
173	Tonga	—	—	△	×
174	Trinidad &Tobago	◎	◎	○	○
175	Tunisia	◎	—	△	○
176	Turkey	◎	◎	○	○
177	Turkmenistan	—	—	△	×
178	Uganda	◎	—	○	△
179	Ukraine	—	—	△	×
180	United Arab Emirates	◎	—	△	△
181	Uruguay	◎	◎	○	○
182	Uzbekistan	—	—	△	×
183	Vanuatu	—	—	△	×
184	Venezuela	◎	◎	○	○
185	Vietnam	◎	—	△	△
186	Yemen	◎	—	△	○
187	Zambia	◎	◎	○	○
188	Zimbabwe	◎	◎	○	○
	Total	127	65	—	—

Note
1. Sample Countries for Estimation
Group A : Countries that have at least some available data in both YRP and SOP for a certain year.
Group B : Countries that have fully available data in both YRP and SOP for the period from 1960 to 1990.
2. Data Availability
○ : Countries that have fully available data for the period from 1960 to 1990.
△ : Countries that have at least some available data.
× : Countries that do not have any available data.