Environment Pollution Control: Advantage or Disadvantage
for Latecomer's Economies in East Asia?
— GMM Estimation on Environmental Kuznets Curve —

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Abstract

Using the analytical framework of the environmental Kuznets curve, this study examines whether the latecomer's economies in East Asia enjoy technological spillover effects (latecomer's advantage) or suffer pollution haven damages (latecomer's disadvantage) in their environmental pollution management. We carried out dynamic panel estimation by Generalized Method of Moments (GMM) using the panel data with 18 economies for the period from 1990 to 2007. We found two contrasting results among the environmental indices. First, per capita consumption of ozone-depleting substances (ODS) and industrial organic water pollutant emissions (BOD) indicate monotonic decreasing trends with per capita real GDP while per capita carbon dioxide emissions (CDE) show monotonic increasing trend. Second, the ODS and BOD represent the dominance of the latecomer's advantage while the CDE reveals that of the latecomer's disadvantage. We speculate that the contrast in the trends comes from the difference in the origin of emissions: the ODS and BOD come mainly from production (easily regulated on the local level), and the CDE come from both production and consumption (easily externalized and not easily subject to regulation). We also presume that the contrast in the latecomer's effects lies in the degree of maturity in regulatory framework and technology that offset pollution haven effect: good governance for controlling the ODS and BOD, versus unrestricted "carbon leakage" for latecomer's economies.

Key words: environmental Kuznets curve, latecomer's advantage and Disadvantage, pollution haven, spillover effect

JEL Classification Codes: Q53, Q56

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1. Introduction

Environmental issues have come to be addressed toward setting a long-tem goal at the global level. At the United Nations Summit on Climate Change dated September 22, 2009, for instance, the Secretary-General stated that world leaders acknowledged the scientific imperative to cut global greenhouse gas emissions by at least 50% below 1990 levels by 2050 to meet the goal to keep the global temperature increase to a safe level. 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"[2] 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 haven" 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. The "pollution haven" can, therefore, bring about "latecomer's disadvantage" for developing countries with immature environmental management.

East Asian economies are composed of a variety of countries with different stages of development: high-income countries like Japan and Korea, middle-income ones like Malaysia and Thailand, low-income ones such as Cambodia and Myanmar.[3] In addition, East Asia has created a continuous trend of growing economic integration in terms of trade and investment flows. Kawai (2009) indicates, for example, that the ratio of intra-regional trade relative to world trade in East Asia has gone up from 35 percent in 1980 towards 56 percent in 2004. The diversification and integration characterized by East Asian economies make East Asia a typical area with provability of technology spillover or pollution haven.

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[2] The hypothesis of the "latecomer's advantage" was advanced by Alexander Gerschenkron. See Gerschenkron (1962).
[3] The classification depends on World Band (2009).

The purpose of this study is to examine whether the latecomer's economies in East Asia enjoy technological spillover effects or suffer pollution haven damages in their environmental pollution management: in other words, which of latecomer's advantage or latecomer's disadvantage dominates for pollution control in East Asian economies. We focus on environmental indices with data availability: carbon dioxide emissions, consumption of ozone-depleting substances and industrial organic water pollutant (BOD) emissions. 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 effects (Section 3), and end with concluding remarks (Section 4).

2. Previous Studies, Our Position

The environmental Kuznets curve (EK curve) provides an analytical framework to examine how economies deal with environmental issues. 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 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.

2.1 The EK Curve Concept and Its Policy Implications

Dasgupta et al. (2002) described 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 in clean air and water, communities are too poor to pay for abatement, and environmental regulation is correspondingly weak. Along the curve, pollution per capita levels off in the middle-income range and then falls toward pre-industrial levels in wealthy societies. It is because leading industrial sectors become cleaner, people value the environment more highly, and regulatory institutions become more effective.

The EK curve hypothesis has important policy implications. 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 to an ally for the environment. This would tend to suggest that 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, Panayotou (1995) pointed out the following 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 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, 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 such environmental management as government policies, social institution, and the completeness and functioning markets other than income growth. Dasgupta et al. (2002) picked up the following factors that make the EK curve lower and flatter: environmental regulation, economic liberalization, pervasive informal regulation, pressures from market agents and better information. When it comes to the case of developing countries, where the lack of capacity to enforce environmental laws and standards often deteriorates the policy performance, capacity building may be inevitable for securing the effectiveness of environmental policies.

2.2 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). Since this 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. 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. At the first stage, Grossman and Krueger (1991) argued that economic growth affects the quality of environment in three different channels; scale effects, technological effects, and composition effects. 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 questioned on empirical, methodological, and interpretative grounds. From an empirical aspect, Shafik (1994) presented more ambiguous results, seemingly implying that the EK curve may not hold at all times and for all pollutants. Furthermore, empirical research has been limited to the environmental problems for which data exist, such as the concentration of pollutants in urban areas. It has also methodologically been shown that the very existence of an EK curve is questionable; the EK curve may well arise as a "methodological artifact" (Nahman and Antrobus 2005). The methodological problem of cross-sectional approach will be discussed in the next section. 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. Nahman and Antrobus (2005) stated that the EK curve may thus be no more than a "historical artifact." This criticism toward the EK curve will be further discussed in the context of "pollution haven" hypothesis in the next section.

2.3 Frontiers of EK-Curve Studies

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 be misleading, as Borghesi (1999) argued, since environmental degradation is generally increasing in developing countries and decreasing in industrialized ones; the EK curve within the cross-sectional framework might 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, thus, 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. Noticing that conventional cross-section estimation techniques have generated spurious estimates of the EK curve, De Bruyn et al. (1998) 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 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, by 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 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 the period from 1982 to 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 haven" 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 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 up.

The two contrasting hypotheses above – the downward shift of the latecomer's EK curve reflecting technological spillover or the upward shift of the curve due to pollution haven effect – tempt us to put the hypotheses into the empirical tests. Taguchi (2009), by using the EK curve framework, examined whether developing countries enjoy the latecomer's *advantage* or suffer the latecomer's *disadvantage* in the environment management, focusing on sulfur emissions as local air pollutants and carbon emissions as global air pollutants. It found contrasting result between sulfur and carbon emissions on the latecomer's effects; sulfur emissions represent the dominance of the latecomer's advantage (the EK curve's downward shift), while carbon emissions reveal that of the latecomer's disadvantage (the EK curve's upward shift). It interpreted this contrast as the difference of maturity level in the know-how and technology to abate emissions: prevailing desulfurization technology and unrestricted "carbon leakage" (a kind of pollution haven in carbon emissions).

2.4 Our Position and Contributions

This article aims at testing the two contrasting hypothesis above in East Asia, – the existence of the latecomer's advantage (technological spillover) or the latecomer's disadvantage (technological spillover). The main contribution of this study is to extend the existing literature, mainly of Taguchi (2009), to the following directions. First, our study concentrates on the East Asian economies (18 economies). The intra-area of East Asia with the characteristic of economic diversification and integration, as stated in Introduction, can be an experimental area suitable enough to put the hypotheses of technological spillover and technological spillover into empirical tests. In addition, the evidence on the latecomer's effects in East Asia has been extremely limited in the existing literature.[4] Second, our analysis uses the latest data of the period for 1990-2007 on carbon dioxide emissions, consumption of ozone-depleting substances and industrial

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[4] To our knowledge, the papers that dealt with the East Asian EK curve is Taguchi (2001), in which a regression analysis using cross-sectional data of selected East Asian countries provided significant confirmation of the existence of latecomers' advantages for controlling sulfur emissions.

organic water pollutant (BOD) emissions. The usage of the latest data enables us to make the EK curve estimation reflect the recent trends of technological progress and policy responses to address environmental issues as well as growing economic interaction of East Asia. Third, our estimation for the EK curve adopts a dynamic panel model by a system of Generalized Method of Moments (GMM). It appears to take some periods for the current level of emissions to adjust toward their equilibrium level – a kind of inertia in the emission level. Most of previous studies for the EK curve have adopted a static panel model in terms of ordinary fixed or random estimations. When there is evidence of dynamics in the data, however, the validity of applying a static model might be questioned as being dynamically miss-specified. To our knowledge, it is only Halkos (2003) that constructed a dynamic panel model for the EK curve estimation. This paper adopts the method of Halkos (2003), which allows dynamic adjustments in the level of emissions.

3. Empirical Studies

We now turn to the empirical studies within the analytical framework of the EK curve. Our analysis consists of two steps. First, we will simply overview the relationships between per capita real income and environmental indices. We then move to a dynamic panel analysis using cross-country panel data to examine the EK curve pattern and to see whether the latecomer's advantage or its disadvantage dominates in the environmental management in East Asian economies.

3.1 Data

We collect the data for three environmental indices per capita –carbon dioxide emissions, consumption of ozone-depleting substances and industrial organic water pollutant emissions– and real GDP per capita. All the data come from the Annual Core indicators online database developed by the Statistics Division of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP).[5] The database covers data from 1990 to 2007, all of which we use as sample periods. The sample economies are the following 18 ones in East Asia: Brunei Darussalam, Cambodia, China, DPR Korea, Hong Kong, Indonesia, Japan, Lao PDR, Macao, Malaysia, Mongolia, Myanmar, Republic of Korea, Singapore, Thailand, the Philippines, Timor-Leste and Viet Nam.

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[5] See the website of http://www.unescap.org/stat/data/syb2008/syb2008_web/index.asp.

The indicator of "carbon dioxide emissions per capita" that we can obtain from the online database is defined as the quantity of estimated carbon dioxide emissions (tons of carbon dioxide) divided by total population, whose data sources are the United Nations Millennium Development Goals Indicators and the World Population Prospects: the 2006 Revision Population Database. The indicator of "consumption of ozone-depleting substances per capita" is defined as the sum of the national annual consumption in weighted tons of individual substances in the group of ozone-depleting substances multiplied by their ozone-depleting potential (Ozone-depleting substances are any substance containing chlorine or bromine that destroys the stratospheric ozone layer), expressed as ODP kilograms per 1,000 population. Its data sources are the same as those of carbon dioxide emissions per capita. The indicator of "industrial organic water pollutant emissions" is defined as the biochemical oxygen demand, which refers to the amount of oxygen that bacteria in water will consume in breaking down waste, expressed as kilograms per day. Its data source is the United Nations Environment Program, Emission Database for Global Atmospheric Research (EDGAR 3.2). This indicator shows total amount, thereby being divided by population. We can find the other emissions indicators in the online database: nitrous oxide emissions, sulfur dioxide emissions and PM10 concentration in urban area, but do not adopt them for the dynamic estimation later since their data cover only every five years. For the real GDP per capita, the indicator of "GDP per capita on 1990 US dollars base" is obtained from the online database.

To sum up, for conducting the dynamic panel estimation later on, we constructed a panel table of the annual data of the 18 economies from 1990 to 2007 on each of per capita environmental indices of carbon dioxide emissions, consumption of ozone-depleting substances and industrial organic water pollutant emissions.

3.2 Overview of the EK Curves in Sample Economies in East Asia

Figure 1 indicates the time-series relationships between per capita real GDP and three kinds of environmental indices per capita in main samples of East Asian economies. The rough findings are as follows. First, there appears to be no cases where the assembly of the economy's trajectories clearly produces inverted-U shape patterns. The trajectories of carbon dioxide emissions represent an increasing trend whereas their slope seems to be flattened with higher real GDP per capita. The lines of consumption of ozone-depleting substances roughly represent declining slope. The cases of industrial organic water pollutant emissions have no clear trend of trajectories. We might

speculate that the carbon dioxide emissions stay at the positively-sloping part of the EK curve, while the consumption of ozone-depleting substances stays at its negatively-sloping part. Second, the locations of the economy's trajectories represent a clear contrast; the upward shifts of trajectories for latecomer's economies are observed in the case of carbon dioxide emissions, while downward shifts are seen in the cases of consumption of ozone-depleting substances. The cases of industrial organic water pollutant emissions have no clear shift of trajectories. The GDP-emissions relationships described above may produce different implications among environmental indices. This point will be statistically tested through dynamic panel estimations in the following section.

3.3 Dynamic Panel Analysis

We'll now move to a dynamic panel analysis using cross-country panel data to examine the EK curve pattern and to see whether the latecomer's advantage or its disadvantage dominates in the environmental management in East Asian economies.

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 backward to find the net effect. Moreover, 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. Thus, we think that the reduced-form relationship between pollution and income is an important first step.

We then specify the reduced-form equation by basically following the traditions of the literatures like Grossman and Krueger (1995) and Selden and Son (1994), and adding appropriate variables in accordance with our analytical interests. Our specific

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concern regarding the EK curve for the sample economies in East Asia is to see whether the EK-curve trajectories for the latecomer's economies have shifted downward or upward, depending on the dominance of either the latecomer's advantage or its disadvantage[6]; in other words, the levels of environmental pollution per capita have been affected not only by the level of per capita income following the EK curve, but also by the later degree of development among the economies. If a sample economy with later degree of development among the samples enjoys the lower level of environmental pollution (traces the downward course of the EK curve), we speculate that the economy, not repeating the EK-curve trajectories already experienced by the developed economies, should enjoy the latecomer's advantage by absorbing the progress in environmental know-how, skills, and technology i.e. technological spillover. On the contrary, if the later development in a sample economy is linked with higher pollution, the economy may suffer from the latecomer's disadvantage caused by the "pollution haven" scenario (see Diagram). Therefore, we will include a term representing the later degree of development among the economies into the equation for the EK curve. The later degree of development of a sample economy in a certain year is specified as the ratio of the GDP per capita of that economy relative to the maximum GDP per capita among sample economies (equivalent to the GDP per capita of Japan) in that year.

Another methodological innovation in this study is to adopt a dynamic panel model. Halkos (2003) pointed out that a static model is justified either if adjustment processes are really very fast or if the static equation represents an equilibrium relationship, argued that since the assumption that the data are stationary is incorrect, and we are not expecting a very fast adjustment for estimating the EK curve, a statistically sound approach requires estimating a dynamic model. Following the argument of Halkos (2003), we construct a dynamic panel model by inserting a lagged dependent variable as a regressor into the EK curve equation for materializing a partial adjustment toward equilibrium emissions level.

Based on analytical interests mentioned above, we specify the modified EK curve model as follows:

$$\text{EMS}_{it} = \alpha_0 + \alpha_1 \text{GDP}_{it} + \alpha_2 \text{GDP}^2_{it} + \alpha_3 \text{LAC}_{it} + \alpha_4 \text{EMS}_{it-1} + \alpha_5 f_i + e_{it} \quad (1)$$

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[6] As Dasgupta et al. (2002) showed the revised EK curve that is actually dropping and *shifting to the left* as growth generates less pollution in the early stages of industrialization and pollution begins falling at lower income levels, the latecomer's effects may not always be tantamount to a simple up- and downward shifts of the EK curve. However, we here simplify the analysis by focusing on up- and downward shift of the EK curve.

where **i** is the economy's index (country or area), **t** is the time index, and *e* is the error term. The dependent variables **EMS** is measure of the per capita emissions: carbon dioxide emissions (CDE), consumption of ozone-depleting substances (ODS) and industrial organic water pollutant emissions (BOD). As for the independent variables, **GDP** is the real GDP per capita. **LAC** represents the later degree of development, specifically the ratio of the real GDP per capita of a certain economy relative to the maximum real GDP per capita among economies in a certain year (i.e. real GDP per capita of Japan) – the lower **LAC** means the later development of the economy. f_i denotes exogenously economy-specific factors that affect emissions; climate, geography, energy resources, etc. The equation does not include period dummy, because its inclusion was rejected significantly by statistical tests in the equation estimate.

To verify the inverted-U shapes of the EK curves, the signs and magnitudes of α_1 and α_2 should be examined. Environmental emissions per capita 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 **LAC**, α_3, which is useful for identifying the dominance of the latecomer's advantage or its disadvantage. The positive sign of α_3, the lower pollution with the later development of the economy that creates the downward shift of the latecomers' trajectories, indicates that the latecomer's advantage surpasses its disadvantage. On the other hand, the negative sign of α_3, the higher pollution with the later development of the economy equivalent to the upward shift of the latecomers' curve, reveals the dominance of the latecomer's disadvantage.

Equation (2) contains the lagged dependent variable among the explanatory variables, thereby the ordinary OLS estimator being biased and inconsistent. Obtaining unbiased and consistent estimates requires the application of an instrumental variables estimator or Generalized Method of Moments (GMM). We here adopt the GMM estimator developed by Arellano and Bond (1991) who argues that additional instruments can be obtained in a dynamic model from panel data if we utilize the orthogonality conditions between lagged values of the dependent and the disturbances. The GMM estimator eliminates country effects by first-differencing as well as controls for possible endogeneity of explanatory variables. The first-differenced endogenous variables of **EMS** with two lagged periods can be valid instruments provided there is no second-order autocorrelation in the idiosyncratic error terms. We also use the first differenced explanatory variables of **GDP** with one lagged period as an instrumental variable since **GDP** can possibly be correlated with the error term in case that

environmental pollution might aggravates economic growth. We then conduct two step GMM iterations with updating weights once, and adopt White period as GMM weighting matrix. We present the tests for autocorrelations and the Sargan test of over-identifying restrictions in the table that follow.

3.3.2 Estimation Results and Interpretations

Table 1 lists the results of the GMM estimation per capita on carbon dioxide emissions (CDE), consumption of ozone-depleting substances (ODS) and industrial organic water pollutant emissions (BOD). All the cases indicate that the inclusion of the lagged dependent variable of the emissions per capita proved to be positively discernable, thus imply inertia in the level of the emissions and justify forming the dynamic panel model. The Sargan tests do not suggest rejection of the instrumental validity at conventional levels for any cases estimated. As for the test results for autocorrelations, all the AR(2) test statistics reveal absence of second-order serial correlation in the first-differenced errors and thus that the instruments are valid.

We first verify the shape of the EK curve of each emission index. There are no cases that reveal the meaningful EK curve with the inverted-U shape. The linear CDE estimation indicates upward sloping with real GDP per capita at significant level. The quadratic CDE estimation has the significant coefficients, α_1 and α_2 with correct signs of the inverted-U shape. Its turning point of 26,800 US dollars is, however, falling into the edge of the samples, i.e. only within the sample of Japan with the highest real GDP per capita. Almost all of the trajectories are within the monotonic increasing trend, i.e. the positively-sloping part of the EK curve. The ODS estimation indicates that the trajectories are in the monotonic decreasing trend regardless of the linear or quadratic equation forms. Although the quadratic estimation's coefficients, α_1 and α_2, suggest not inverted-U but *U* shape, the turning point of 116,000 US dollars is far higher from the range of the samples. The BOD represents only monotonic downward sloping in its estimation, since the coefficient of the square of GDP, α_2, is insignificant. We speculate that it is due to the shortage of sample data backward from 1990 that the ODS and BOD do not prove to form the inverted-U shape curve in their estimation.

We next see if the latecomer's EK trajectories show a downward shift or an upward shift, namely whether the latecomer's advantage or its disadvantage dominate in the environmental management of latecomer's economies. The CDE estimate has significantly negative α_3, coefficient of LAC, thereby representing the upward shift of the latecomer's trajectories and the dominance of the latecomer's disadvantage. On the

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other hand, the ODS and BOD estimates have significantly positive α_3, showing the downward shift of the latecomer's trajectories, the dominance of the latecomer's advantage.

There seem to be some contrasts of estimation results in terms of both the trajectory's shape and location between CDE and the other indices of ODS and BOD. These contrasts appear to be interpreted as follows. The first contrast is concerned with the shape of the EK trajectories. The ODS and BOD mainly come from manufacturing production activities, thereby being subject to regulation due to their localized impact. In fact, the pollution controls on the ODS and BOD have intensively been promoted by East Asian countries. The ozone-depleting substances have been strictly regulated since the 1987's signature of the Montreal Protocol, i.e. an international treaty designed to protect the ozone layer by phasing out the production of a number of substances believed to be responsible for ozone depletion. All of East Asian countries have had a commitment to the treaty or its amendments in terms of ratification, accession or acceptance. The issues of water pollution as well as air pollution have also been addressed with technological progress over a broad area of East Asia since the 1970-80s, when ASEAN countries formulated comprehensive environmental protection laws (the Philippines in 1977, Malaysia in 1974, Thailand in 1975, and Indonesia in 1982). These factual backgrounds seem to make the EK trajectories of ODS and BOD slope downward i.e. create downward sloping part of the inverted-U shaped EK curve. On the other hands, the CDE is producing an opposite pattern of its trajectories, a positively-sloping part of the EK curve. It seems to be because carbon dioxide 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 and thus not subject to regulation. The reality is that it is only after the Kyoto Protocol was approved in 1997 that regulatory frameworks on Greenhouse Gas have come to be set about domestically and internationally. The contrasting outcomes on the shape of the EK trajectories in this study appear to be consistent with those of previous works, which Nahman and Antrobus (2005) summarize by stating that the levels of the pollutants with local impacts fall with per capita income whilst the levels of easily externalized pollutants continue to rise with per capita income.

The second contrast – downward shift of the latecomer's trajectories on the ODS and BOD versus upward shift on the CDE – can be explained by the degree of maturity in the know-how and technology to abate those emissions in East Asia. More or less, the concentration of manufacturing industrial activities have tended to shift from advanced economies to developing economies since wealthy consumers in advanced economies

demand a cleaner environment and stringent environmental regulations. Thus, the pollution haven effects can not help being avoided for latecomer's economies. The question is, then, whether the technological spillover effects overcome the pollution haven effects for latecomer's economies i.e. the dominance of latecomer's advantage or disadvantage. The cases with downward shift of the latecomer's trajectories on ODS and BOD can be interpreted in such a way that the policy efforts, know-how and technology to abate those emissions are mature and feasible enough to be transferred to latecomer's economies and to exceed their suffering pollution haven effects in the area of East Asia. Especially, as Kofi Annan, the Former Secretary General of the United Nations, stated "perhaps the single most successful international agreement to date has been the Montreal Protocol",[7] the widespread adoption and implementation of the international framework to protect the ozone layer seems to be effective enough for developing economies in East Asia to enjoy the latecomer's advantage. On the contrary, the case with upward shift of the latecomer's trajectories on CDE may be explained in such a way that the regulatory framework and technology to mitigate the emissions coming from both production and consumption are too immature to be transferred and disseminated to latecomer's economies (Yaguchi et al. 2007). Thus, only the pollution haven effect seems to remain for latecomer's economies. This phenomenon on carbon dioxide emissions might be regarded as what we call "carbon leakage" in the context of the Greenhouse Gas reduction at global level: 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.

4. Concluding Remarks

In this study, we set out to examine, using the analytical framework of the environmental Kuznets curve, whether the latecomer's economies in East Asia enjoy technological spillover effects or suffer pollution haven damages in their environmental pollution management, in other words, which of latecomer's advantage or latecomer's disadvantage for pollution control dominates in East Asian economies. For this purpose, we carried out dynamic panel estimation by a system of Generalized Method of Moments (GMM), using the panel data with 18 economies for the period from 1990 to 2007 on environmental indices of carbon dioxide emissions, consumption of ozone-depleting substances and industrial organic water pollutant emissions.

Through this analysis, we found two contrasting results among the environmental
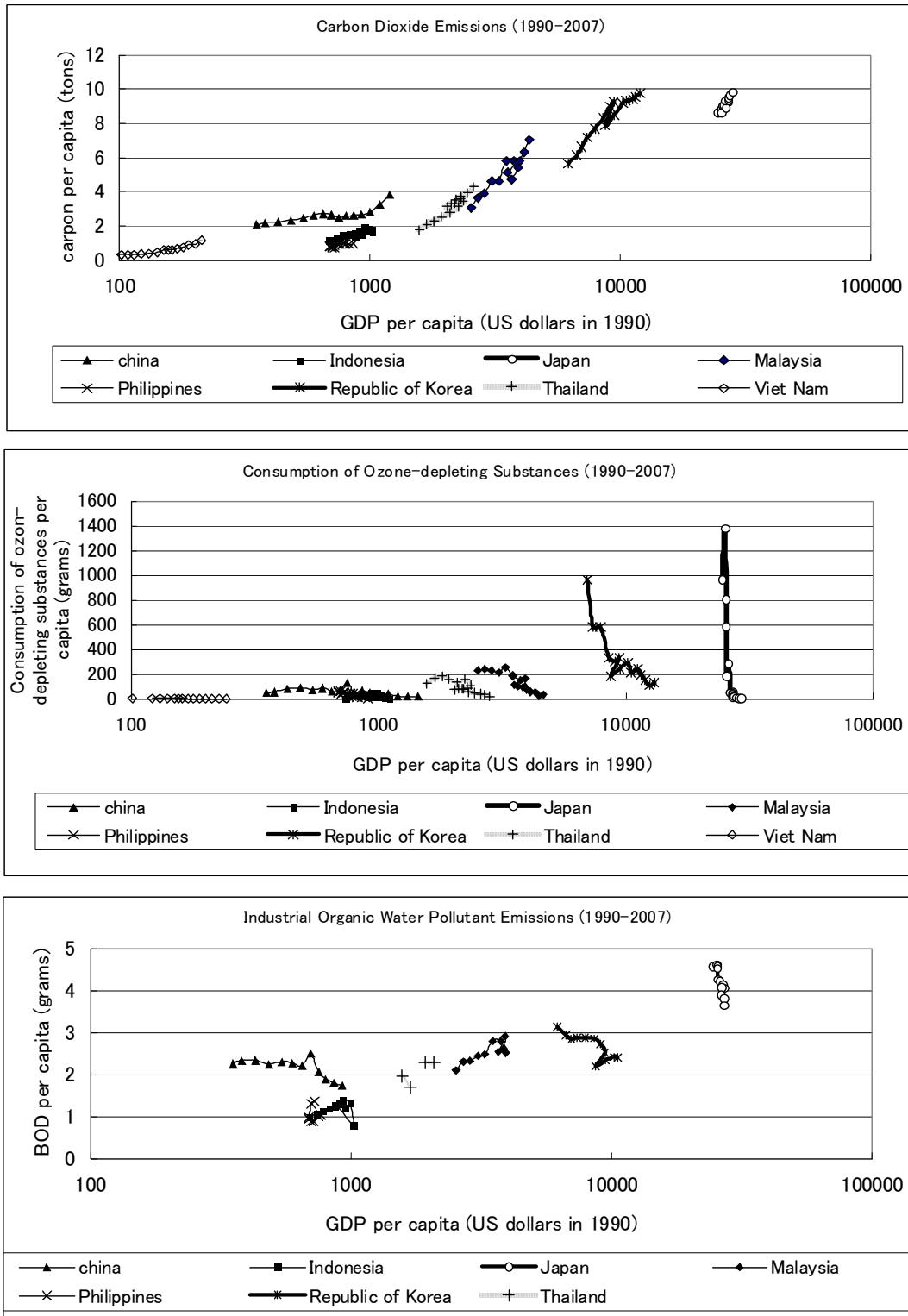

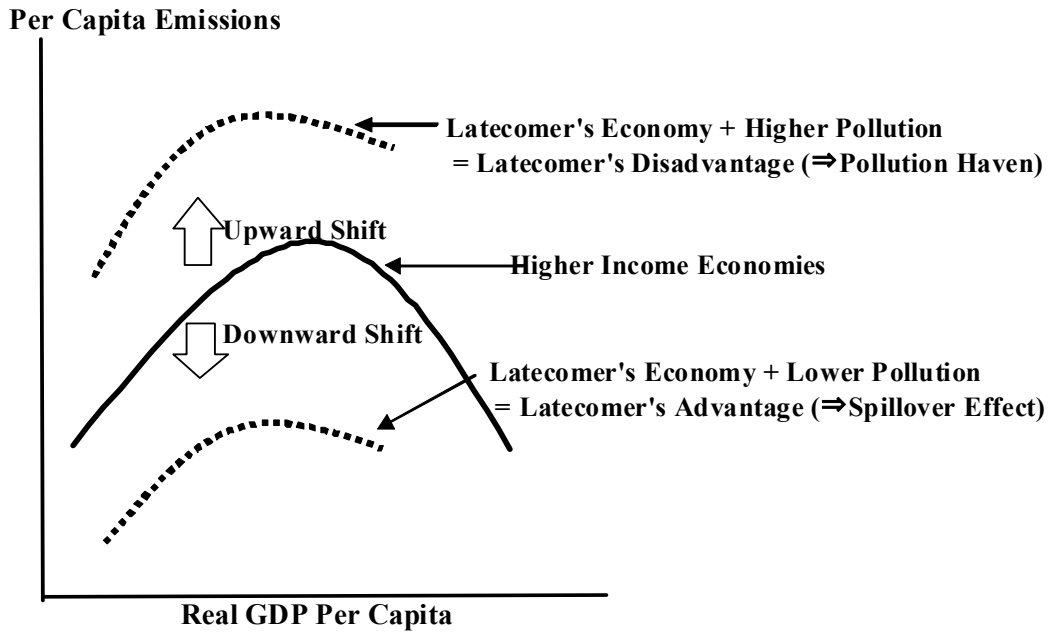[7] See the website: http://www.theozonehole.com/montreal.htm.

indices: 1) per capita consumption of ozone-depleting substances and industrial organic water pollutant emissions indicate monotonic decreasing trends with per capita real GDP while per capita carbon dioxide emissions show monotonic increasing trend, and 2) consumption of ozone-depleting substances and industrial organic water pollutant emissions represent the dominance of the latecomer's advantage while carbon dioxide emissions reveal that of the latecomer's disadvantage. We speculate that the contrast in the trends comes from the difference in the origin of emissions: consumption of ozone-depleting substances and industrial organic water pollutant emissions come mainly from production (easily regulated on the local level), and carbon dioxide emissions come from both production and consumption (easily externalized and not easily subject to regulation). We also presume that the contrast in the latecomer's effects lies in the degree of maturity in regulatory framework and technology that offset pollution haven effect: good governance for controlling ozone-depleting substances and water pollutants, versus unrestricted "carbon leakage" for latecomer's economies.

The result implying "carbon leakage", suggests the urgent necessity to facilitate the technological progress such as the development of technology on carbon dioxide capture and storage, and the internalization of external diseconomy through such methods as emissions charge and greenhouse taxes. For latecomer's economies in East Asia, which appear to face a trade-off between environmental quality and productive activities, it can be expected that the spillover effects from technological progress and the consolidated regulatory framework should overcome "carbon leakage".

Figure 1. Overview of the EK Curves in Sample Economies

Carbon Dioxide Emissions (1990-2007)

Consumption of Ozone-depleting Substances (1990-2007)

Industrial Organic Water Pollutant Emissions (1990-2007)

Diagram   EK Curve and Latecomer's Effects

Per Capita Emissions

Latecomer's Economy + Higher Pollution
= Latecomer's Disadvantage ($\Rightarrow$ Pollution Haven)

Upward Shift

Higher Income Economies

Downward Shift

Latecomer's Economy + Lower Pollution
= Latecomer's Advantage ($\Rightarrow$ Spillover Effect)

Real GDP Per Capita

Table 1. Results of Dynamic Panel Estimation by GMM

	CDE		ODS		BOD	
GDP	$4.43*10^{-4}$ ***	$2.57*10^{-3}$ ***	$-2.33*10^{-2}$ ***	$-2.98*10^{-2}$ ***	$-1.38*10^{-4}$ ***	$-3.41*10^{-4}$ **
	(978.87)	(33.96)	(-68204.89)	(-6078.09)	(-6.97)	(-2.25)
GDP^2		$-4.78*10^{-8}$ ***		$1.28*10^{7}$ ***		$3.53*10^{-9}$
		(-21.42)		(1150.38)		(1.25)
LAC	$-2.21*10$ ***	$-5.18*10$ ***	$1.56*10^{2}$ ***	$2.39*10^{2}$ ***	1.22 *	4.61 **
	(-2980.99)	(-291.37)	(14700.19)	(3125.34)	(1.72)	(2.12)
(EMS)$_{t-1}$	$4.96*10^{-1}$ ***	$4.53*10^{-1}$ ***	$5.66*10^{-1}$ ***	$5.65*10^{-1}$ ***	$6.11*10^{-1}$ ***	$5.76*10^{-1}$ ***
	(11958.02)	(106.46)	(517030.9)	(171680.4)	(19.48)	(10.00)
Tuning Point		$2.68*10^{4}$		$1.16*10^{5}$		$4.83*10^{4}$
Sargan test	0.60	0.85	0.71	0.75	0.88	0.91
AR(1)	0.00	0.01	0.07	0.07	0.01	0.01
AR(2)	0.21	0.24	0.74	0.75	0.86	0.81
No. of obs.	222	222	192	192	93	93

(Notes)

i) The t-value are in parentheses. ***, **, and * indicate rejection at the 1 percent, 5 percent, and 10 percent significance levels.

ii) "Sargan test" denotes the p-value of a Sargan-Hansen test of overidentifying restrictions.

iii) AR(k) is the p-value of a test that the average autocovariance in residuals of order k is zero.

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