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Governance, Pollution Control And The Environmental Kuznets Curve

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1. Introduction

Is it possible to attain economic prosperity without deterioration of environment? What kind of relation is there between environmental improvement and economic growth? And what is the major reason to make a changing pattern of environmental policies? We shall investigate an answer to them in this paper. As far as some pollutants such as SO_2, NO_2 as well as garbage in per capita term are concerned; almost economies have experienced their dramatic increase in the process of rapid industrialization. Accordingly this leads to terrible environmental issues. However, as time goes by, the government has turned its policy stance to incorporate pollution control and people try to support this policy change. This might be corresponding to a changing pattern of people's preference between income growth and environment. Then people will experience reducing economic growth but remarkable improvement in health and environment.

The main purpose of this paper is to analyze the interaction between economy and environment from both the social and political perspectives. In this paper, our focus is mainly on the econometric tests on that interaction but a theoretical foundation has already given by Yabuta (2003). Making the arguments in a nutshell leads to the following remarks. It is natural to accept that environmental situation may keep deteriorating with economic growth at low-income levels, but it will reach a turning point and then further growth leads to environmental betterment. The inverted U-shaped relationship between income and the environment is known as the 'environmental Kuznets curve' (EKC). Grossman and Krueger (1993) have found that for some air and water pollutants, EKC could be empirically observed. A large number of papers, including Cole, Rayner and Bates (1997), related to empirical studies have followed their paper. The common conclusions are that the meaningful EKC can be observed only for local pollutants like NO_2 and CO but for global pollutants like CO_2, whereas for some pollutants like CFCs no EKC relation can be confirmed. Possibly, there may be no general relation between pollutants and economic growth. On the other hand, many literatures on EKC have come from the theoretical viewpoints, including Vogel (1999), Andreoni and Levinson (2001), Levinson (2002) and Lieb (2002). Their analytical frameworks are basically static ones, which incorporate specific type of utility function and pollution abatement function. On the other side, Selden and Song (1995), Stokey (1998) and Kelly (2003) have given dynamic model frameworks for EKC. Selden and Song (1995), a revised version of Foster (1973), has shown that in an early stage of economic development, rapid increases in pollution abatement can occur due to some contributors, including technological change of abatement and consumer's tastes to pollution abatement. They have also argued that whereas capital accumulation can slow reductions in pollution, high marginal efficacy of pollution abatement can reduce pollution as a whole, leading to an inverted U-shaped EKC. Kelly (2003) has proved that in a dynamic model with pollution stock externality, the conditions an inverted U-shaped EKC can emerge require the convexity of cost function of pollution control and the normality of environmental goods. Pollution control provides benefit, but it charges additional spending to the society. It may be a consequent reasoning that an inverted U-shaped EKC occurs when marginal costs of pollution control rise by less than marginal benefits. Although the studies concerning EKC have given consistent explanations, there is no clear understanding that ties static frameworks to dynamic ones. In this paper we shall prove the determinants to fix the shape of EKC mainly from statistical and econometric viewpoints[1].

The plan of this paper is as follows. In Section 2, three phases of environmental development are proposed in a hypothesis approach. A historical investigation on the environmental development will tell us there are at least three stages to phases. In Section 3, a basic model for phase analysis is developed towards a dynamic version. In Section 4, we shall test the hypothesis framework developed in a basic model. We shall give a statistical test of the structure model with four independent variables, such as income, preference, technology and governance. In Section 5, after remarking the relationship between economic development and pollution control, the importance of the 'governance index' is examined.

2. Three Phases of Environmental Development – A Hypothesis Approach

There is no single process along which the government enforces effective and feasible programs to curb the environmental problem that people are harmed by pollution derived from specific materials. In general, it seems to be very natural to accept that there are three stages or phases along

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[1] Vogel (1999), for example, is one of the well-composed books concerning theories of EKC. His final remarks in Chapter 7 related to the views of EKC as a cure-all must be justified when he mentioned to the limitations of EKC as well. In particular, it should be notable when he wrote that 'an EKC is the more likely to occur, the less people are concerned about the pollutant in question.' (see, p.182). This is the reason why we introduce the phase analysis and we also take the people's animadverting or recognition processes of environmental issues into consideration.

which the environmental problem comes into conflict between polluters and victims and finally comes to a negotiated settlement.

The first phase is the animadverting stage upon the terrible environmental situation. Irrespective of the allocation of the property rights related to the environmental resources, people must bring an accusation against polluters as far as they are suffering from pollutions. Even if pollution provide disastrous to people's health, the local government or central government sometimes tends to hesitate to adjudge a case because of a lack of hard scientific causal relation or, possibly because it may be bribed by polluters to forget about what they have done. In almost countries where the democratic rule has been under construction, the iniquitous disregard of the fundamental human rights leads to a strangling of social anti-pollution movements. Accordingly, we find that the precondition for the society to accept the fact and to take an active interest in the environmental problem is development of the democratism. Hence, especially in many under-developing countries where democracy must be less developed, it may be observable that the government takes a negative attitude about cooperating for anti-pollution procedures.

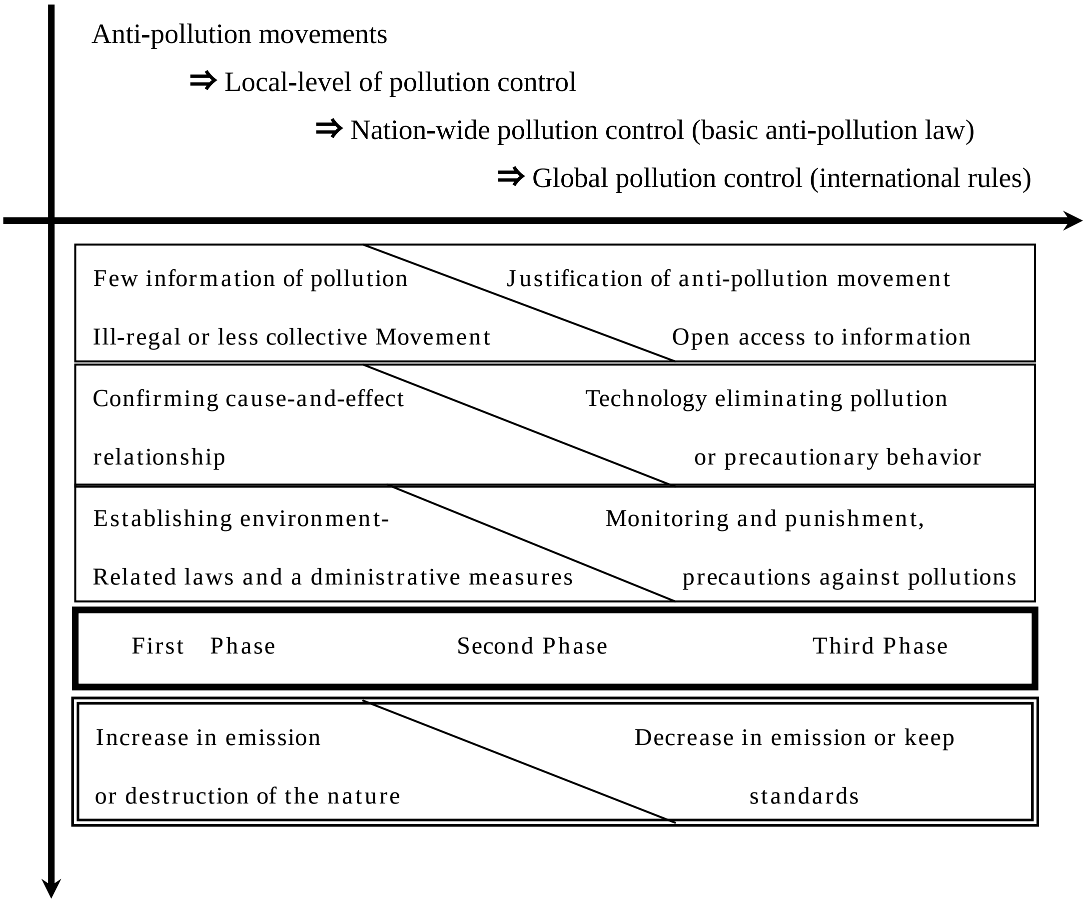
The second phase is the institutionalization stage of judicial and administrative procedures against environmental disruption. Due to a radical or socially justified movement of the people, or sometimes due to a international level of standardization for the pollution control, local and/or central governments are forced to systematize the environmental agents and to enforce the environment-related laws such as anti-air pollution law, or water conservation law. In the early stage of this period, however, it may be difficult for these systems to be sufficiently effective partly because of a lack of scientific as well as technological knowledge, but mainly because of inadequate criterions to curb pollution. If so, this phase must be an interval for adjusting the environmental standard. Although there are formally adjusted laws and agencies, this does not mean that they are truly effective against pollution control.

Actually, for an individual case of pollution dispute, various patterns of the three phases have occurred. In the case of Minamata disease, for example, the first stage was for more than twenty years period from early 1940s when the first victims emerged to 1968 when the Japanese government officially identified Minamata disease. Although Minamata disease was discovered in 1956 and reported a methyl alkyl-mercurial discharged into Minamata bay by Chisso Corporation to be the cause-substance, Chisso Corporation continued operation until 1968. It is clear that during this period an unpreventable and derelict behavior of the government led to the expansion of patients of Minamata disease. An urgent closedown of factory should have pollution abatement in Minamata Bay. During late 1950s to 1960s the Japanese economy was on the high-growth economic path and the stance of the Japanese government towards environmental issues was quite namby-pamby. However, people's antipollution movements in 1960s against local-level pollution all over industrializing regions in Japan, such as Minamata, Yokkaichi, Kitakyushu and Shizuoka, had led to changes in environmental policy towards anti-pollution initiated by local governments.

The Basic Law for Environmental Pollution Control was enacted in 1967 and the Environmental Agency, now graded up to the Ministry of the Environment, was established in 1971. As far as water pollution is concerned, the Water Pollution Control Law in 1970 containing regulations of discharge of effluent, monitoring of the conditions of water pollution, as well as promotion of measures for domestic wastewater and compensation for damages. Moreover, Environmental Quality Standards for Water Pollutants established in 1970 were target levels of water quality aim to lowering the environmental risk, protecting human health and conserving the living environment, including regulations on total mercury and alkyl-mercury compounds. By setting common national standards applicable to all public waters, civil-minimum safety from water could be maintained. The second phase is to mean the period when the central government establishes various environmental systems like anti-pollution laws and organizations.

It might be inevitable, at least in the democratic decision-making process, for the government to employ environmental policy responses against environmental issues whenever they suffer victims. In the third phase of the environmental development, the governmental activity against environmental issues would be tested how it is effective and if it takes them seriously. Monitoring to the conditions of water or air pollution, or illegal destruction of natural resources should be seriously applied. Accordingly, the government must order persons to decrease effluents into the public area or to preserve the natural environment, and take necessary measures such as punishment when they do not obey. Even if the government environmental law contains such monitoring-punishment system, it does not mean that it becomes a remedy of great efficacy. Clearly, it depends on the capability or seriousness of the government whether an effective control on the environmental condition can be attained. Successive and progressive amendments of the environmental quality standards or stepped-up monitoring and sanction must entail in the third phase of environmental development[2].

Figure 1. Three phases of environmental development



To summarize the concept of phase analysis related to environmental development, see Figure 1. As shown in Figure 1, the term “first phase” is about the period during which the specific environmental issues like air pollution or mercury pollution prevail and antipollution movements occur. Mainly local governments usually take temporal measures on a case-by-case basis. The “second phase” is corresponding to the period during which both local and central level of governments launch wide social reforms of administrative organizations and laws in the fields of environmental policy. Moreover the “third phase” is to use for identifying the stage period during

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2 Harashima and Morita (1998) also gave a useful historical perspectives related environmental policy development. From the historical and comparative viewpoints, they have mentioned six factors to make differences in the development processes of environmental policies; the role of local government, information disclosure, influence of international pressure, latecomer status, the market mechanism, and environmental issues in the policy agenda. Except for foreign factors, the domestic factors they have proposed will be incorporated in our hypothetical analysis.

which the environmental authorities broaden and strengthen the environmental quality standards and apply the monitoring and sanction rule in a strict and rigorous way. It is notable that there can be no environmental policy response against environmental issues unless people with eco-consciousness countermove against the environmental issues.

3. A Model for Phase Analysis

Models to analyze the phases of environmental development process in a nation are to identify the differences among the environmental conditions as well as institutional situations in a society. We shall incorporate model-frameworks some specific characterizations concerning the people's eco- consciousness, governmental policy stance against environmental issues and juristic and administrative institutions. Because these phases can only be identified from historical or time-horizon viewpoints, we shall compose a model that includes various variables to show a changing pattern of these institutional situations related to environmental policy.

Main task in this section is to develop a dynamic model with a common framework throughout this paper. Assume that a representative consumer faces the utility function given by

(1) $U = U(C, P)$,

where C is consumption and P is pollution. Pollution function is given by

(2) $P = P(Y, E)$, $P_Y > 0$, $P_E < 0$

where Y represents income and E shows the effort to abate pollution. We shall also assume that the price of consumption goods is unity and the abatement cost of pollution is given by e. Then we have the consumer's budget constraint with income, Y:

(3) $Y = C + e\,E$.

Consumers' income comes from production and the production function with capital stock, K, is given by

(4) $Y = Y(K, P)$, $Y_K > 0$, $Y_{KK} < 0$, $Y_P < 0$,

where it is assumed that pollution condition is also an important factor affecting production level, an environmental deterioration leading to less production.

Before composing a dynamic system of the economic as well as environmental development, it may be notable to show a static system. In a very short-run economy, assume that capital stack is constant and pollution has no effect on production. Hence, P and K can be eliminated from (4) and Y becomes constant. Then consumer behavior to maximize their welfare can be formalized as

(5) $Choose\{C,E\} = \max U(C, P(E))$, subject to $Y = C + eE$.

Consumer is assumed to be able to control both C and E. Accordingly, maximization behavior of consumer in this static framework will lead to an optimal consumption, C^* as well as an optimal effort of pollution abatement, E^* given as

(6) $(C^*,E^*) \in \{(C,E) \mid U_c = U_p P_E/e,\ Y = C + eE,\ Y \text{ is constant}\}$

The first term in the curly brackets of (6) implies that the marginal utility of consumption is equal to that of spending to abate pollution. The pollution level in equilibrium will be given by $P^*=P(Y,E^*)$.

A temporal equilibrium can be depicted as in Figure 2. Figure 2 has four dimensions: the first quadrant to show the consumer's utility function as well as budget constraint, the second quadrant to indicate the pollution function, the third one to give symmetrical relation between pollution level and the fourth quadrant to derive a development path of consumption and pollution condition. What we would like to know is just how much the environmental deterioration, or improvement, occurs in a process of economic growth usually entailing an increase in income. In Figure 2, assuming that the effect of increasing pollution on production can be neglected may lead to a conclusion that an increase in K in the process of economic growth will increase income. Accordingly, a budget line Y^1 may shift right-upwards towards Y^2. Then there are various possibilities the changing patterns of C and E will follow. These patterns are corresponding to the evolutions of C and P in the fourth quadrant in Figure 2. Among many possible development paths in the figure, the one from 1 to 2 as well as the one from 1 to 3 must be remarkable. In all quadrants of Figure 2, the path from 1 to 2 is the growth path with an increase in pollution but the growth path from 1 to 3 is the one with a decrease in pollution, although abatement costs of pollution increase in both cases.

It is easy to find that at least four factors determine the development patterns, in particular the changing patterns of economic growth against environmental conditions. They include the changing patterns of; (i) the people's preference of environment with respect to standard of living, i.e. a change in the shape of utility function, U, (ii) the progress in abatement technique to pollution control, i.e. a decrease in the marginal abatement cots, e, (iii) the end-of-pipe technology to decrease in discharge of pollution wastes into atmosphere or water, i.e. a change in the shape or magnitude of pollution function, P, and (iv) the environmental policy stance of the government against pollution, i.e. a divergence between social welfare function and people's aggregate utility function.

To give a clearer picture of the environmental development, it would be convenient to compose a specified version of the model equations. We shall assume the following equations:

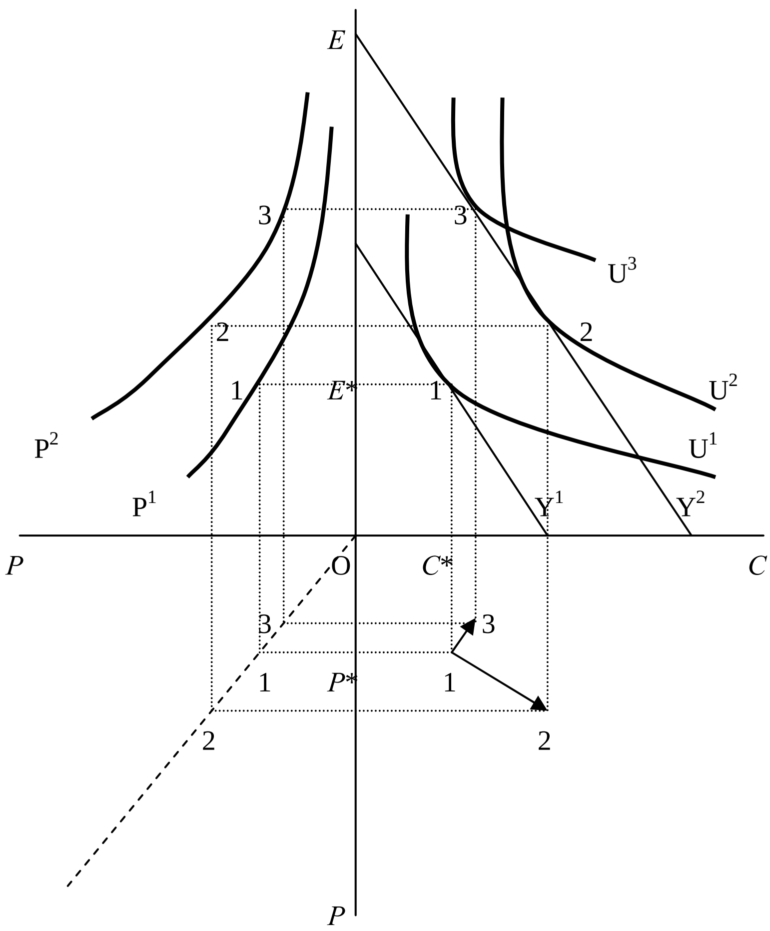
(7) $U = U_0 C^{\alpha} P^{-\beta}$,

(8) $P = P_0 Y^{\gamma} E^{-\delta}$,

where U_0,P_0 as well as α, β and γ are positive parameters. By taking the temporal equilibrium condition given by (6) into consideration, it is easy to derive the following conditions to keep the economy on the equilibrium:

(9) $P = P_0 Y^{(\gamma-\delta)} \left[\frac{(\alpha + \beta\delta)e}{\beta\delta} \right]^{\delta}$.

Figure 2. Development and Pollution



If there is a positive increment of income, i.e. dY >0, the economy grows. Then it is clear from (9), dP can be negative as far as γ is less than δ for dY >0. This case occurs whenever the effort of pollution abatement is sufficiently large and the income effect on pollution is small enough. Hence, the simple model tells us how important the technology against the pollution dispersion is. Moreover, it is clear from (9) that the changing pattern of parameters also has various effects on the pollution level. As far as the parameters in (9) are concerned, the smaller α, e and P_0 or the larger δ, β will be, the pollution condition will be improved[3]. Clearly parameters α and β are related to the people's choice behavior between consumption and pollution. Because a smaller α, or a larger β, makes the marginal rate of substitution of pollution abatement with respect to consumption smaller, it becomes more preferable for people to spend more to pollution control but less to consumption expenditure. A larger δ, or a smaller P_0, implies that pollution control will be attained more effectively then before. This is the case where a progress in end-of-pipe technology occurs. Moreover it is clear that a smaller e, i.e. a cheaper abatement cost to emission control, can be effective for reducing pollution materials.

The above-mentioned remarks show that on the economic growth process where production continues to grow, environmental conditions can be improved whereas income effect on pollution is always positive. This can be attainable by changing patterns of parameters concerning people's preference, marginal abatement cost as well as end-of-pipe technology. These changing patterns of the parameters are likely to respond to the stage of the environmental development. Hence a schematic representation concerning the phase analysis can be depicted as the bottom of the each low from (i) to (iii) in Table 1.

It still remains an unfinished work for the phase analysis of environmental development. This issue is just related to the policy stance at local as well as nation level of environmental procedures by the governments. In the first phase anti-pollution movement of the people is often identified with anti-governmental action because the governments give priority to economic growth. Accordingly, they tend to think at the initial stage of development that environmental issue follows economic

[3] This is because as for δ, we have

$$dP = P\left[\log\left(\frac{(\alpha+\beta\delta)e}{\beta\delta Y}\right) - \frac{\alpha}{\alpha+\beta\delta}\right]d\delta = P\left[-\log E - \frac{\alpha}{\alpha+\beta\delta}\right]d\delta < 0, \qquad \text{for } d\delta > 0.$$

growth as a necessity. This situation leads to a conception gap between governments and people towards environmental issues. To model this we shall introduce a new conceptual parameter determining a governmental welfare function to be optimized. The divergence of such a conception gap can be described by θ such that

(10) $W = U_0 C^{\alpha} P^{-\theta\beta}, \quad 0 < \theta \le 1,$

where W represents the welfare, which the government anticipates maximizing and θ is the parameter, which will be referred as the 'governance index'. This name comes from the fact that the government never takes people's sensitiveness towards pollution into consideration when θ is null and, for the polar case when θ is unity, the government seems to be a fair representation of the people.

Table 1. The development Phases and evolution of variables

	The First Phase	**The Second Phase**	**The Third Phase**
(i) People's Preference	Anti-pollution movement at local level	Anti-pollution movement at nation level	Think globally, Act locally Greening activity
α, β	A large α and an increasing β	Relatively small α and a large β	A small α and a large β
(ii) Abatement technique	Very high Inefficient	Gradually decreasing	Very low Efficient
e	A larger e	Decreasing	A smaller e
(iii) End-of-Pipe technology	Low and inefficient technology	Gradually improving	Eco-friendly technology
P_0, δ	A large P_0 and a small δ	Decreasing in P_0 and an increasing δ	A small P_0 and a large δ
(iv) Governance matters	Growth-oriented Neglecting people's preference	Incorporating people's welfare as well as firm's profits	Environment-oriented Firstly initiating people's preference
θ	Close to null	Increasing	Close to unity

In this case, the governance index is clearly corresponding to the governmental respondent towards people's requisition against environmental issues. We can enumerate some reasons for the difference in θ as follows: (i) a growth-myth the government believes or a faith that environmentalism will lead to reduce economic growth, (ii) the capacity or energy of the government to effectively formulate and implement environmental policies, (iii) the institutional procedures by which governments are selected, monitored and replaced, and (iv) the accountability or transparency of the environmental policies. In the very initial stage of the economic development, the institutions in a country may be still ill organized and their environmental procedures are so weak that government cannot implement the anti-pollution policies effectively. However, political maturation will lead a society whose governmental views mirror people's preference completely. Therefore, it is inevitable that the 'governance index', θ will continue to evolve from almost null towards unity while the economy is developing.

Instead of (7), the government must plan to maximize (10) subject to the social budget constraint given by (3). Therefore, the optimum process of expenditures for consumption and pollution abatement can be given by the followings:

(11) $$C = \frac{\alpha}{\alpha + \theta\beta\delta} Y,$$

(12) $$E = \frac{\theta\beta\delta}{e(\alpha + \theta\beta\delta)} Y,$$

and, for the evolution of the environmental condition, we have

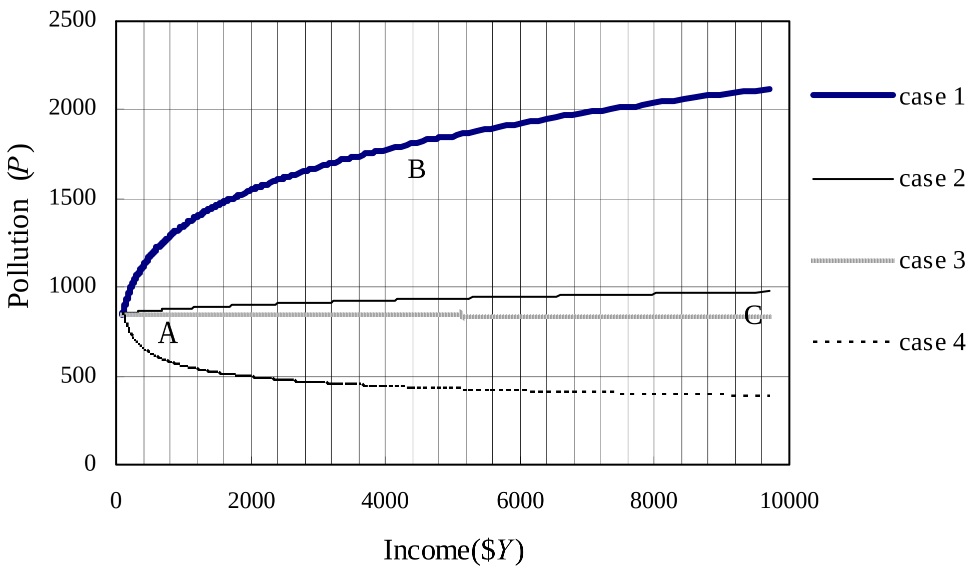
(13) $$P = P_0 Y^{(\gamma-\delta)} \left[\frac{(\alpha + \theta\beta\delta)e}{\theta\beta\delta} \right]^{\delta},$$

that is identical with (11) when θ is unity. It is clear from (13) that $\partial P / \partial \theta$ is negative, implying that an increase in θ will reduce pollution. Figure 3 shows how the pollution level changes in the economic growth process. To give a simple simulation about pollution, initial conditions concerning parameters in (13) as well as initial income are fixed in the sub-table of Figure 3. Moreover it is assumed that the economy of each case grows by 2% at annual rate.

In Figure 3, case 1 represents a reference path where no change in θ and e occurs. To compare with case 1, θ, the 'governance index', in case 2 is assumed to continue growing by 1% annual rate. Case 3 shows the environmental development path where only decreasing in e, the marginal abatement cost of pollution, by 1% annual rate occurs. Moreover, case 4 indicates how pollution can be abated when both θ and e change at a constant rate. It should be noted that in case 3 or case 4, the 'governance index' is actually very close to unity, 0.996, when per capita income is almost $10,000.

Along the economic growth path towards $10,000, case 3 shows that the institutional conditions as well as political circumstances have been adjusted towards the effective pollution controls. The tendency for reducing pollution can be strengthened by introducing more efficient abatement technology as shown by case 4. These cases are all-imaginary and far from what happens in the real world. However they tell us the possibilities of actual paths or trends that the real environmental development follows. For example, among evolution patterns of the parameters like θ and e, it is easy to choose a possible pattern where a pollution condition changes from A to C via B in Figure 3. This is the case called inverted U-shaped EKC (Environmental Kuznets Curve). As proved in this section, what kind of EKC, a relationship between income and environmental condition, emerges in the real economy is dependent on the changing patterns of many factors including technology, governance, as well as people's preference towards the good environment. Therefore, it seems impossible to give a common tendency of environmental development with respect to economic growth. EKC should be different from nation to nation.

Figure 3. Simulation paths



	Case 1	Case 2	Case 3	Case 4
$\boldsymbol{\theta}$	0.1 (constant)	Increase by 1%	0.1 (constant)	Increase by 1%
$\boldsymbol{e}$	1.0 (constant)	1.0 (constant)	Decrease by 1%	Decrease by 1%
Others	α=0.8, β=1.0,	γ=0.6, δ=0.4,	P_0=100, Y_0=100,	Growth rate=0.02

4. The Hypothesis Testing

From cross-sectional view, to follow the foregoing reasoning leads us to predict that the lower levels of 'governance index' will be associated with higher levels of pollution. Moreover, some other non-income factors, including anti-pollution technology, are proved to be important determinants of pollution level in the economy[4]. Hence the underlying structure model to be tested will be given by

(14) $ENVIRONMENT = f(INCOME, PREFERENCE, TECHNOLOGY, GOVERNANCE)$.

For explanatory variables in (14), *INCOME* means the par capita income in terms of PPP adjusted US dollars and *TECHNOLOGY* represents the levels of anti-pollution technology. Because anti-pollution technology adopted in the economy may be close to a standard in all over industries, we shall measure it in averaged points of the power of technological progress, which are reported by the Global Competitiveness Report. As far as *PREFERENCE* is concerned, we shall use the illiteracy rate and /or the rate of coverage of fixed line and mobile telephone. This is because people's environmental consciousness will be prevailed and advocated well when they have sufficiently effective means to communicate each other. Literacy is very fundamental capacity to communicate via printed media and the telephones in a society have played most popular item to communicate each other. When people can share their social issues or public nuisance among them, they will have common will, emotion and mind against such social problems, leading to regional anti-pollution movements[5].

The fourth explanatory variable in (14) is *GOVERNANCE* that shows the 'governance index' to be included to allow for 'governmental respondent' towards people's requisition against environmental issues. In the absence of direct measures for the 'governance index', we shall adopt

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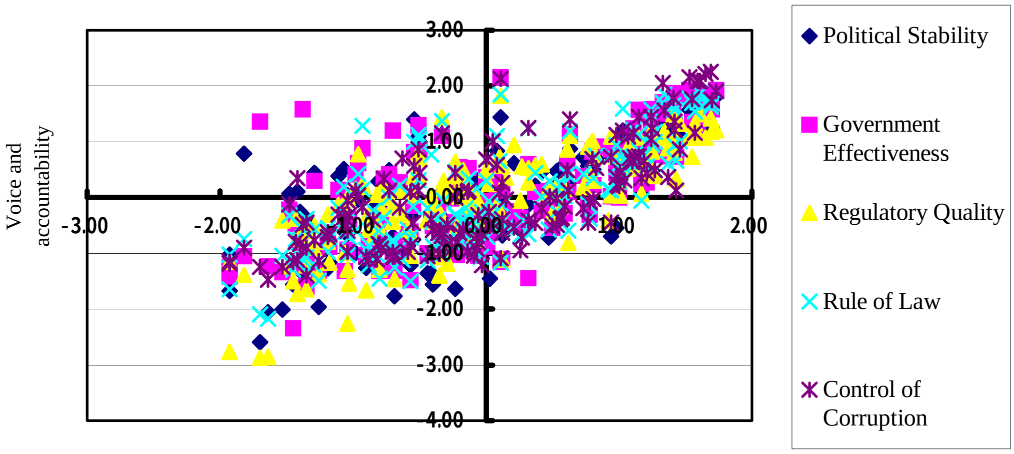
4 As Roca (2003) has mentioned, it is the real world where matters are too complicated to be predicted by only a few independent variables. In our model, we identify any reduction of environmental costs with a technological progress that will leads to more effective abatement of pollution. He stressed the importance of displacement of environmental costs among remote places or remote generations. Although we do not incorporate his arguments explicitly, it may be possible to accept that displacement can be affected through changing patterns of people's preference or governmental reaction towards environmental issues at present.

5 An interesting procedure on EKC has done by Lekakis and Kousis (2001). As for three European countries, Greece, Spain and Portugal, they have reached conclusions that rising per capita income leads to more and more frequencies of citizen's environmental actions and proved that democratic governments and open political systems may certainly enhance environmental reactions through political processes. Their argument that the outcome of EKC is dependent on an interaction of 'the demand for and supply of environmental qualities as the public goods' seems to be very close to ours, which contains an interaction between individual and public behavior towards environmental issues.

some of KKZ (Kaufmann, Kraar and Zoido) indicators[6]. The original version of KKZ indicators has developed by Kaufmann, Kraar and Zoido (1999) and latest version is published in 2002. They have composed the indices to measure the situation of governance, which is defined as the 'tradition and institution by which authority in a country is exercised'[7]. Three parts and two indices in each part compose KKZ indicators. Three parts are (i) the process by which governments are selected, monitored and placed, including 'Voice and Accountability', and 'Political Stability', (ii) the capacity of the government to effectively formulate and implement sound policies, including 'Governmental Effectiveness' and 'Regulatory Quality', and (iii) the respect of citizens and the state for the institutions that govern economic and social interactions among them, composed by 'Rule of Law' and 'Control of Corruption'[8]. KKZ indicators are depicted as in Figure 4 that shows correlations of any other indices of KKZ to 'Voice and Accountability'.

Figure 4. Governance indicators



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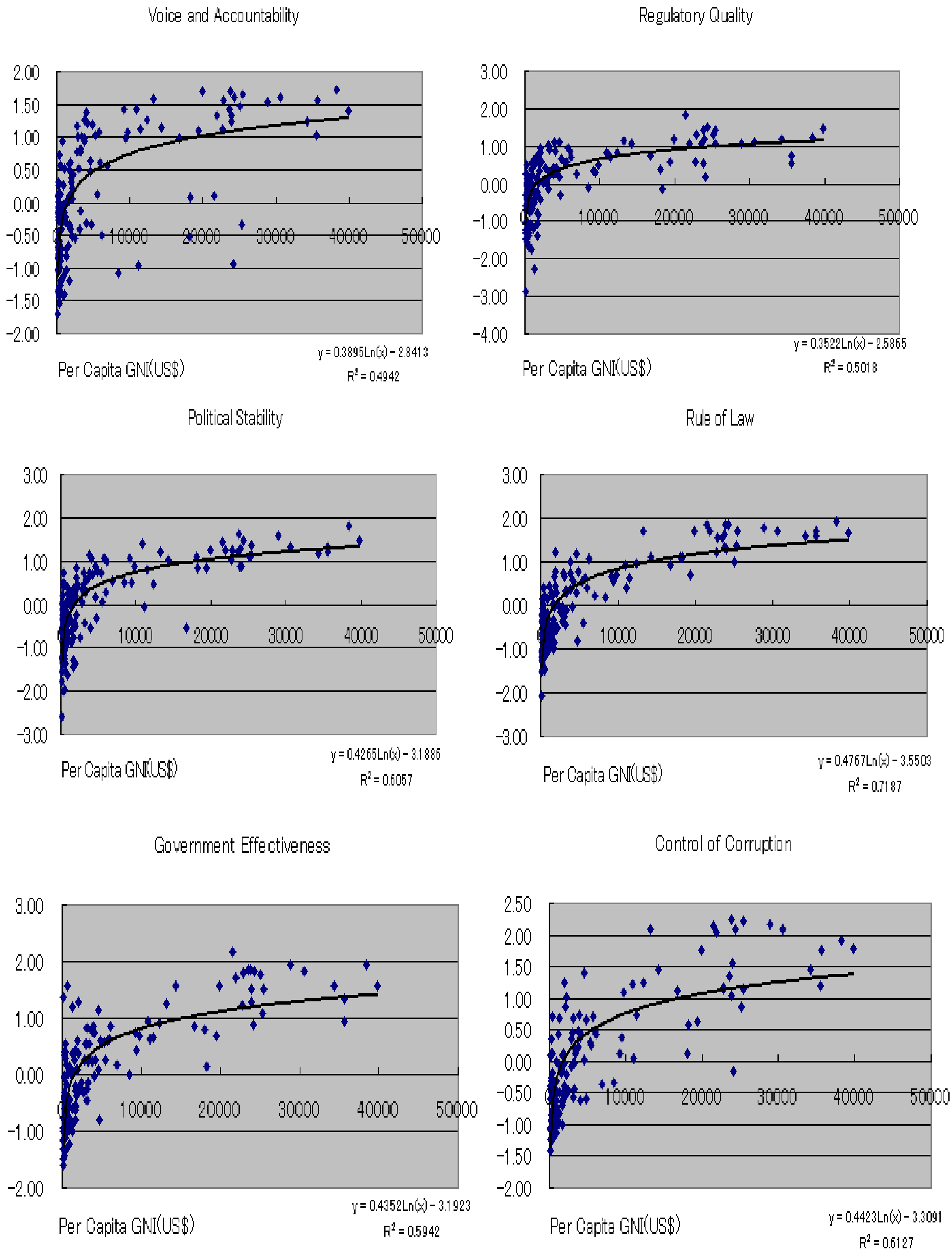
6 KKZ indicators consist of two distinguish sources; polls of experts and surveys of businesspeople or citizens. KKZ indicators are estimated by using such compound sources from 17 publications, like Country Risk Review by Standard and Poor's DRI McGraw-Hill, World Competitiveness Yearbook by Institute for Management and Development, and so on. In this connection, Ishii (2003) also gave a useful positive analysis for economic development. She has tested various patterns of explanatory variables including KKZ to get robust estimations for economic growth.

7 In this connection, see Kaufmann, Kraar and Zoido (2002), pp.4-5.

8 Our aim to incorporate '*GOVERANANCE*' into analysis is to make it clear whether the government has a sufficient qualification for representing people's attitude towards environmental issues faithfully. Although we shall focus on the aggregate effect of six KKZ indicators, each index has still its own implication and the strength of contribution to anti-pollution might be different. Damania (2002) has stressed a necessity to study the consequences of corruption on environmental outcome because almost researches concerning environmental compliance appear to have ignored this. He has proved from theoretical views that corruption is one of the major causes of environmental damage in developing countries and the judiciary is also important. Even if it is the case, it cannot be rational way to disregard other four factors that also must be causes to affect on various anti-environmental policy actions. However, it seems to be a very suggestive piece of writings that environmental policy cannot be effective without dissolving problems of

Figure 5. Six Clusters of Governance Index



corruption.

Moreover, Figure 5 shows how each cluster of governance develops with par capita income. From these graphs, it can be found that the selection, monitoring and replacing processes of the government and the implementing processes of sound policies can be enforced when the par capita income is developed.

We have estimated equation (14) for each of the environmental or pollution variables, such as the sanitation level, the accessibility to safe water, Sulfur dioxide, Nitrogen dioxide and particulate matters[9]. Before summarizing estimation results, it is notable to mention that the data-materials are from slightly different periods; for example per capita income in terms of PPP base is in the year 2001, the sanitation level, the accessibility to safe water and all variables related to ‘Governance Index’ are in the year 2000, but any other pollutants are in the year 1998-9. This is mainly because there is only a few adequate time-series data in the field of pollution materials. Moreover, the difficulties of data collection, especially about the developing countries, sometimes put limitations on econometric procedures of estimation.

4.1 Results

Table 2 shows the regression results when independent variable is sulfur dioxide, nitrogen dioxide and particulate matters sanitation level. Many authors have estimated the relation between economic growth and environmental situation and tried to prove the existence of ‘inverted U –shaped’ EKC. To accomplish this task, Boyce (2002) for example, they have included not only par capita income but also squared as well as cubed income as the explanatory variables. Because it seems to be hard to explain the justification of this assumption from theoretical viewpoints, we shall use per capita GNI only in logarithm term.

In the case of sulfur dioxide in Table 2, we obtain a plausible positive correlation between income and pollution and find an effectiveness of higher technology to reduce pollutant. As for REFERENCE, higher literacy rate, i.e. lower illiteracy rate, must lead to better environmental circumstances in urban area, though the effect of traditional telecommunication measures on decreasing SO_2 is not statistically significant. Among clusters of GOVERNANCE, two elements are

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9 As for PM, SO_2 and NO_2, we employ data by 2003 World Development Indicators, which report only some major cities in 53 countries. Among them we adopt not the capital but the city that have the largest population in the country.

statistically significant: both 'Voice and accountability' and 'Rule of Law' have desirable impact on reducing pollutant. This is acceptable result because adjusting juristic as well as administrative systems to industrializing economy, for example, will lead to a remarkable improvement to control some pollutants. Nitrogen Dioxide also improves with technical progress. The results concerning 'Voice and accountability' and ' Rule of Law' are similar to the case of SO_2. The fact that particulate matters (PM) monotonically increase with income is also similar to other two pollutants. This result is consistent with a general understanding that an industrializing economy with a rapid growth in

Table 2. The determinants of air pollution

Explanatory Variables		Sulfur Dioxide		Nitrogen Dioxide		Particulate Matter	
INCOME	Par capita GNI (LOG, PPP)	5.069	(1.773)*	18.283	(3.543)#	8.706	(2.293)**
PREFERENCE	Illiteracy rate	0.828	(2.990)#	0.007	(0.009)	2.639	(6.727)#
	Fixed Line & Mobile Telephone	0.002	(0.213)	-0.021	(-0.920)	-0.021	(-1.289)
GOVERNANCE	Voice and Accountability	-13.603	(-2.637)#	-14.289	(-1.442)	-9.876	(-1.344)
	Political Stability	17.506	(1.694)*	47.148	(2.311)**	14.652	(1.614)
	Government Effectiveness	10.747	(0.946)	16.842	(0.740)	19.059	(1.235)
	Regulatory Quality	1.977	(0.199)	-3.955	(-0.195)	-6.865	(-0.486)
	Rule of Law	-21.441	(-2.411)**	-33.941	(-1.954)*	5.700	(0.569)
	Control of Corruption	-2.923	(-0.388)	1.949	(0.137)	-16.113	(-1.551)
TECHNOLOGY	Average of GCR	-3.954	(-0.623)	-22.424	(-1.894)*	-8.677	(-1.017)
Adjusted R-squared		0.554		0.259		0.718	
Durbin-Watson		1.336		1.201		1.992	
Number of observations		39		35		42	

1) *, ** and # are statistically significant at 10%,5% and 1% level respectively.

heavy industry as well as in transportation has caused particulate matters to increase in urban area. It is notable; however, that unlike air pollutants such as SO_2 or NO_2, it seems to be much easier for people to identify how dangerous PM is for their health and for their daily life. People had no other way to breathe whereas they can drink water to buy bottled water from Switzerland instead of their own well. In fact, the Regulatory Law against Dust emitted from Factories and Business Sites in

1957 was one of the earliest national-level of anti-air-pollution laws in Japan after the World War II[10]. Moreover, a better literacy might lead to a better communication among people towards anti-pollution movements so that the government has been urgently forced to establish some institutional or legal systems. By this interaction between government and people we may find statistically significant favorable effects of higher income on emissions of PM. This is a possible explanation for the impact of literacy to be consistent. Although some clusters of GOVERNANCE have different effects, the impact of 'Voice of Accountability' is generally consistent with our hypothesis.

Our results are reported in Table 3 for the national-level variables; sanitation, safe water and

Table 3. The determinants of environmental situation (national-level)

Explanatory Variables		Access to improved sanitation		Access to improved drinking water resources		Protected area ratio to surface area 1)	
INCOME	**Par capita GNI (LOG, PPP)**	12.053	(10.454)#	7.996	(4.216)#	---	---
PREFERENCE	**Illiteracy rate**	-0.117	(-1.062)	0.326	(1.796)*	---	---
	Fixed Line & Mobile Telephone	-0.006	(-1.051)	0.007	(0.708)	---	---
GOVERNANCE	**Voice and Accountability**	-1.117	(-0.411)	3.574	(0.799)	7.012	(3.484)#
	Political Stability	-1.699	(-0.639)	0.529	(0.121)	1.130	(0.347)
	Government Effectiveness	0.524	(0.173)	6.389	(1.284)	-3.352	(-0.980)
	Regulatory Quality	3.893	(1.160)	-0.071	(-0.013)	-7.574	(-2.400)**
	Rule of Law	1.895	(0.513)	1.048	(0.172)	4.466	(1.176)
	Control of Corruption	-0.304	(-0.079)	-4.757	(-0.751)	4.513	(0.927)
TECHNOLOGY	**Average of GCR**	-3.404	(-1.285)	0.129	(0.030)	-1.233	(-0.253)
Adjusted R-squared		0.427		0.410		0.210	
Durbin-Watson		2.043		2.161		---	
Number of observations		62		62		92	

1) The model that the nations over 10,000US$ are eliminated and per capita GNI is in nominal US$ term with the constant of 34.446 (2.356) to be estimated.
2) *, ** and # are statistically significant at 10%, 5% and 1% level respectively.

10 Air pollution control law was established in 1968, more than ten years later when the Regulatory Law against Dust was established.

national protected area. To compare with individual pollutants studied above, each national-level environmental situation has lower adjusted R-squared and statistical robustness is so weak.

Moreover, we will find it inconsistent to our hypothesis that technical progress has negative impact on such environmental situations, like safe water, sound sanitation and protection of natural area, though estimation results are statistically insignificant except for sanitation.. However, it may be notable that in PREFERENCE, the literacy rate is statistically significant and consistent with our hypothesis. We do not have any statistically consistent results about protected area[11]. Some of independent variables in GOVERNANCE, such as ‘Voice and Accountability’ and ‘Rule of Law’, however, seem to have consistent impacts on protected area ratio.

4.2 Contribution by Factors: a Decomposition Procedure

Our hypothetical approach in the proceeding sections suggests that there is no logical consequence of a predictable relation between economic growth and environment, not always leading to an inverted U-shaped EKC[12]. Statistical procedures for estimating the structural model given by (14) also have proved that the hypothesis is very likely to be statistically significant, in particular for the air pollutants in Table 2. Accordingly, this allows for the possibility that the actual pollutants, such as PM, NO_2 or SO_2, in a city of the specific countries can be decomposed into four major factors; INCOME, PREFERENCE, GOVERNANCE and TECHNOLOGY. Following Table 2 that shows the estimated equation for each pollutant, we can decompose the actual pollution level into the four factors. The results are summarized by Table 4 that focuses on the different patterns of the decomposition in OECD countries to compare with those of non-OECD countries. Moreover, Figures 6 includes more detail information about pollutants emitted in related countries.

In each graph of Figure 6 concerning three different pollutants, two slightly different but

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[11] Bimonte (2002) has given the empirical tests for the percentage protected area. Its theoretical base seems to be slightly unclear but he uses some explanatory variables such as income distribution, education, information accessibility (newspaper coverage). After naming these variables ‘participation’, he has proved how important participation is to determine the environmental situation. His point must be justified because ‘participation makes social preference shift away from private towards public goods.’ (see p.154) This is also the basic recognition to approach the EKC analysis in our paper. As far as statistical procedure is concerned, however, the estimation has been done only for the EU countries.

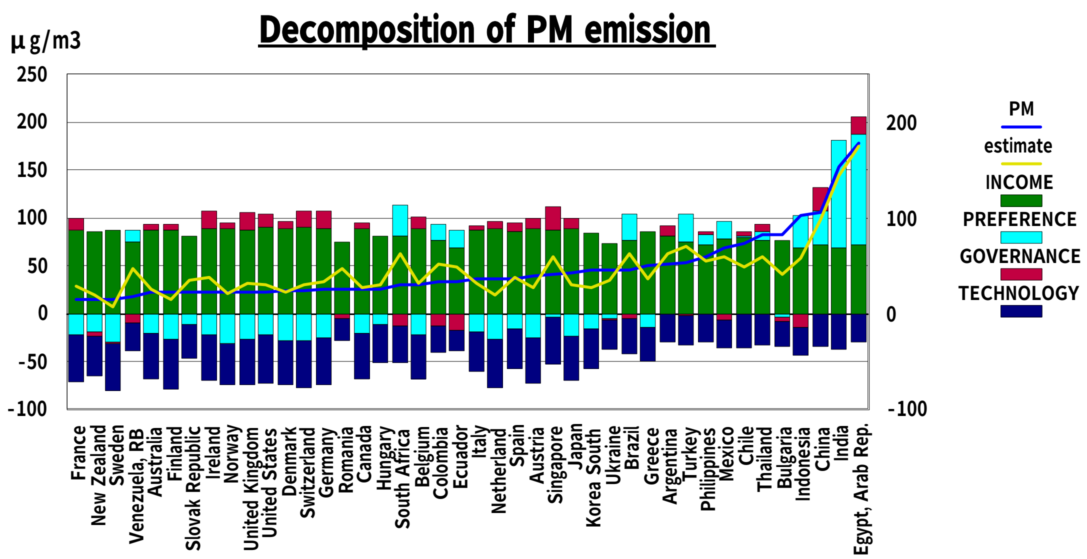
[12] The robustness of the statistical evidence for the existence of an inverted U-shaped EKC does not always supported by empirical works. Harbaugh, Levinson and Wilson (2002), for example, have proved that there is little empirical support for an inverted U-shaped relationship between several air pollutants and national income. They have also concluded that the existence of an inverted U-shaped EKC is very sensitive to data structures as well as to econometric specifications.

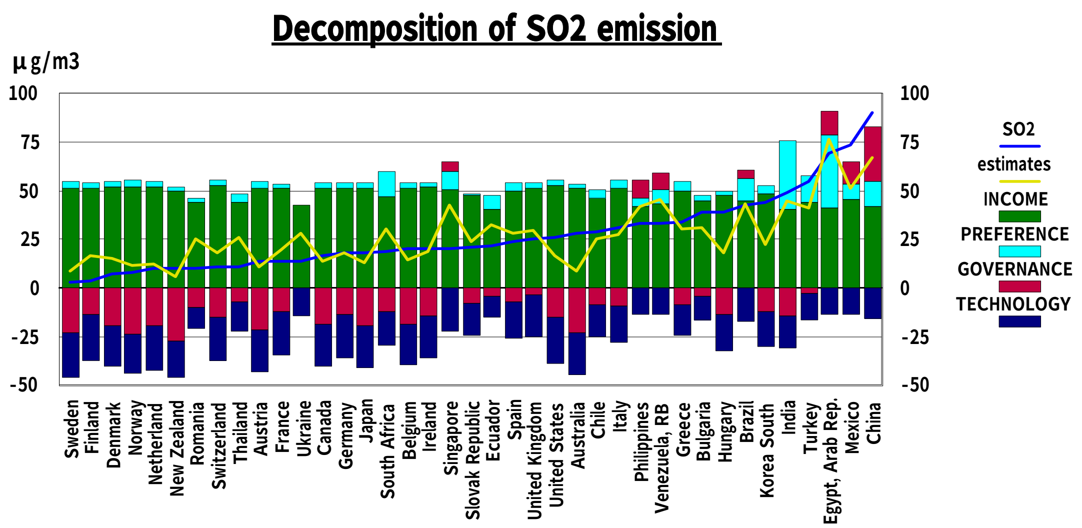
similar lines show the actual as well as predicted levels of pollutants respectively, and four cumulated bars indicate factors into which the predicted pollutant can be decomposed. Actually, countries are ranked by their environmental performance. For example, France performed best but Egypt worst as far as PM emission is concerned. A careful observation will lead us to the following points. In the case of decomposition of PM, TECHNOLOGY has positive but INCOME has negative effects on reducing emission in every countries. Although the impacts of GOVERNANCE seem to be ambiguous, greater contribution to reduce PM may be stemmed from PREFERENCE in less polluted countries. In many developing countries, like South Africa, Brazil, Indonesia, China, India and Egypt, less PREFERENCE have effect on increasing pollution, although it appears to have opposite effect with greater PREFERENCE in most developed countries. In the cases of decomposition of SO_2 and NO_2, we obtain the similar conclusions to INCOME and TECHNOLOGY that the former is positive but the latter is negative factors to increase pollution. It should be noted that GOVERNANCE must be a negative factor on emission of SO_2 in almost countries except for a few countries like Egypt, Mexico and China, and REFERENCE is still a positive factor to greater pollution. As far as NO_2 emission is concerned, PREFERENCE proves to be a negative factor for all countries and GOVERNANCE to be a small but positive factor for almost counties with a few exceptional countries such as Thailand, India, Turkey and Romania.

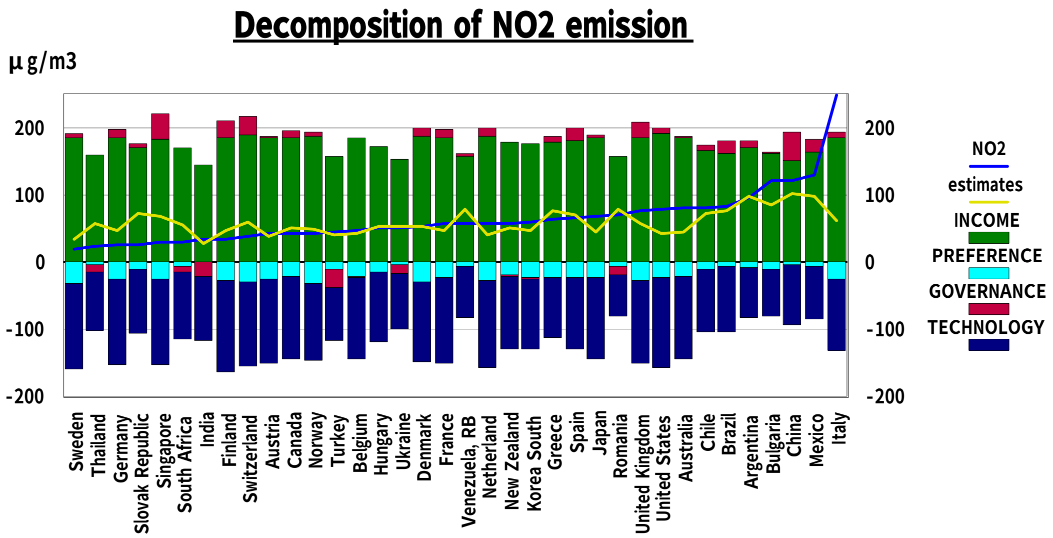
In many cases, we should be careful when we apply results of decomposition procedures of pollution to each country. This is partly because a less robustness of statistical significance but mainly because there must be any other implicit reasons, including erratum of the related data, to determine factors.

Table 4 provides the average figures of decomposition analysis. Factors of each pollutant are classified into two region categories; OECD and non-OECD countries. Table 4 proves that emission of each pollutant in an OECD country is almost a half or two-third in a non-OECD country. In the case of PM, it is clear that the difference in average emission levels between two regions mainly comes from the following reasons; in OECD countries, peoples' preference is negative factor but in non-OECD countries this is a still positive factor on pollution. This finding implies that an improvement of the communication measures among people in non-OECD countries still do not lead to a betterment of environment although it does not always mean that an advanced circumstances concerning PREFERENCE cannot be factors to reduce pollution. It might be fair to conclude that the negative role of the factors of PREFERENCE to worsen pollution will be altered into positive one when they reach to their mature level, at least the minimum of OECD countries, in the process of economic growth. Figures in Table 4 shows that if the factor of PREFERENCE in a non-OECD country could have had the same impact on pollution as that in an OECD country, emissions in both regions could be kept almost the same. Although the TECHNOLOGY factor is a negative one to pollution for the both regions, the levels of impact are different, in an OECD country the impact being almost by thirteen points less than that in a non-OECD country.

Figure 6. Decomposition of pollutant into factors: country base







As for the factor of GOVERNANCE, in an OECD country it has a larger impact on pollution by eight points than that in a non-OECD country. These findings lead to a possible explanation that non-OECD countries have emitted PM more than OECD countries because of less GOVERANCE and TECHNOLOGY. A negative effect of PREFERENCE to reduce pollution in non-OECD countries, just opposite to OECD case, must be a most striking feature, meaning that people may be still less conscious or ignore how much various environmental effects on their life are important.

As far as the emission of SO_2 is concerned, like in the case of PM and NO_2, the INCOME factor gives positive contribution to increase pollution and only a few difference in the contribution level by INCOME can be observed between OECD and non-OECD countries, only about 7 points, but 11 points for PM and 23 points for NO_2. As for the factor of TECHNOLOGY, it contributes to reducing pollution about 15% in non-OECD countries, but slightly large by 6 points in OECD countries. Most prominent features for the case of SO_2 can be found for the factors like GOVERNANCE and PREFERENCE. It is a striking distinction to the case of PM that the factor of GOVERNANCE in OECD countries tends to negatively contribute to pollution whereas it almost affects nothing on pollution in non-OECD countries. This implies that an improvement of some political process of decision making in non-OECD countries, for example, still do not lead to a betterment of environment. Like the case of PM, the factor of PREFERENCE in non-OECD countries contributes positively to pollution, almost triple to compare with that in OECD countries. This finding also leads to an implication that people in non-OCED countries may be still less conscious or ignore how much environmental effect of SO_2 emission on their life is serious.

Table 4. Decomposition of Pollutants into Four Factors

		Average emission	Factors INCOME	PREFERENCE	GOVERNANCE	TECHNOLOGY
PM μg/m3	OECD	28.35	87.96	-23.15	8.33	-46.29
			310.27%	-81.65%	29.39%	-163.28%
	Non-OECD	61.95	76.73	19.05	0.63	-33.41
			123.85%	30.75%	1.02%	-53.93%
SO_2 μg/m3	OECD	18.38	51.24	3.16	-16.08	-21.10
			278.75%	17.22%	-87.48%	-114.82%
	Non-OECD	38.82	44.43	10.34	0.17	-15.47
			114.44%	26.63%	0.43%	-39.86%
NO_2 μg/m3	OECD	63.30	184.70	-24.50	10.06	-119.59
			291.79%	-38.70%	15.89%	-188.92%
	Non-OECD	87.33	161.30	-6.44	9.09	-80.73
			184.69%	-7.37%	10.41%	-92.43%

5. Concluding Remarks

It is our main task to analyze the relationship between economic development and environmental situation. Our focus is mainly on the econometric tests on this relationship and their results are almost consistent with the hypothesis.

In order to give historical perspectives concerning environmental development in the economy, we firstly formalized a new approach termed ‘the phase analysis’, which makes it possible to classify the evolution processes of movements or policies against pollutants into three phases. A chain of events from occurrence of environmental issue to procedure of countermeasure towards environmental danger can be observed in the evolution process of every pollutant. The first phase is the period during which the specific environmental issues prevail and antipollution movements initiated. The second phase is the period during which both local and central governments launch wide social reforms of administrative organizations and laws in the fields of environmental policy while in the third phase, the environmental authorities broaden and strengthen the environmental quality standards and apply the monitoring and sanction rule in a strict and rigorous way. As Grossman and Krueger (1995) pointed out and Boyce (2002) has cited recently, people’s demand as well as ‘vigilance and advocacy’ are most critical elements that enforce the government to induce more environmental-friend policy and implement its commitment. There can be no environmental policy response against environmental issues unless people with eco-consciousness countermove against the environmental issues. In this paper we have incorporated such people's activities into the basic model. After modeling the simple relationship between income and environmental situation from our hypothetical approach, we reach our underlying structural model and test its empirical validity. Although the national-level of environment-related data is not so valid, the results concerning the city-level of pollutants like PM, SO_2 and NO_2 is statistically significant.

Our regression analysis consists of two parts. One is the ordinary regression procedure on which we introduce some independent variables concerning KKZ (Kaufmann-Kraar-Zoido) index of the 'GOVERNANCE' besides income, preference and technology. As for the general outlook of the results, the following explanations are possible. First, income effect is positive to increase pollutant. An increase in per capita income does not lead to any reduction of pollutant. Second, however, a higher rate of literacy and technology appear to put curbs on pollution. People's demand for better environmental quality can reach to government when they sufficiently communicate and discuss about the environmental issues. Third, well education and/or high literacy must lead to less pollution. Finally, among six factors in KKZ index, higher 'Voice and Accountability', more sophisticated 'Rule of Law' or more adequate 'Control of corruption' generally associates with less pollution while higher 'Political Stability' appears not to be associated with less pollution. Another procedure related to the statistical analysis is the factor-decomposition by which pollution can be decomposed into four specific factors; INCOME, PREFERENCE, GOVERNANCE and TECHNOLOGY. Major findings are as follows. First, an improvement of the communication measures among people in non-OECD countries still do not lead to a betterment of PM emission although it does not always mean that an advanced circumstances concerning PREFERENCE cannot be factors to reduce pollution. It might be predicted that the negative role of the factors of PREFERENCE to worsen pollution in non-OECD countries will be altered into positive one when they reach to their mature level. Second, the TECHNOLOGY factor plays negative role to pollution for the both regions. Third, as for the factor of GOVERNANCE, in an OECD country it has a larger impact on pollution by eight points than that in a non-OECD country. These findings lead to a possible explanation that non-OECD countries have emitted PM more than OECD countries because of less GOVERANCE and TECHNOLOGY. Fourth, as for the case of SO_2, unlike the case of PM, the factor of GOVERNANCE in OECD countries tends to negatively contribute to pollution whereas it almost affects nothing on pollution in non-OECD countries. This implies that an improvement of some political process of decision making in non-OECD countries, for example, still do not lead to a betterment of environment. Fifth, people in non-OCED countries prove to be still less conscious or ignore how seriously they are suffered from the damage of SO2 emission.

One policy implication of our findings is that although there is no direct logical relationship between income and environment, environmental situation in non-OECD countries can be accompanied by improvements in non-income factors such as PREFERENCE as well as GOVERNANCE that might be propelled by economic growth in per capita income term. Accordingly, it must be important for OECD countries to lead developing countries towards achieving improvements in those factors. Our findings also prove that prompting environmental-friendly technology in non-OECD countries possibly via foreign aids and foreign direct investment is timeworn but still important political procedure.

References

Andreoni J. and A.Levinson (2001), "The Simple Analytics of the Environmental Kuznets Curve," *Journal of Public Economics*,80(2), 269-286.

Atkinson,G.R., Dubourg,K., Hamilton,M. Munasinghe, D.Pearce and C.Young, (1997), *Measuring Sustainable Development*, Edward Elgar.

Bimonte,S. (2002), "Information access, income distribution, and the Environmental Kuznets Curve," *Ecological Economics*,41, 145-156.

Boyce,J.K. (2002), *The Political Economy of the Environment*, Edward Elgar.

Cole, M.A., Rayner, A.J. and J.M.Bates (1997), "The Environmental Kuznets curve: an empirical analysis," *Environmental and Development Economics*, 2, 401-416.

Damania,R.(2002), "Environmental controls with corrupt bureaucrats," *Environmental and Development Economics*, 7, 395-405.

Dasgupta,S., B.Laplante, H.Wang and D.Wheeler (2002), "Confronting the Environmental Kuznets Curve," *Journal of Economic Perspectives*,16,1,147-168.

Foster,B.A.(1973), "Optimal Capital Accumulation in a Polluted Environment," *Southern Economic Journal*,39,544-547.

Freeman,A.M.（2002）, "Environmental Policy Since Earth Day I: What Have We Gained?," *Journal of Economic Perspectives*,16,1,125-146.

Grossman,G.M. and A.B.Krueger, (1993), "Environmental Impacts of the North American Free Trade Agreement," in P.Garber ed., *the U.S.-Mexico Free Trade Agreement*, Cambridge MIT Press,13-56.

Grossman,G.M. and A.B.Krueger, (1995), "Economic growth and the environment," *Quarterly Journal of Economics*,112,353-377.

Hanley,N. ,Shogren,J.F. and B.White,(2001), *Introduction to Environmental Economics*, Oxford University Press.

Harashima,Y and T.Morita, (1998), "A Comparative study of environmental policy development processes in the three East Asian countries: Japan, Korea, and China," Environmental Economics and Policy Studies, 1,39-67.

Harbaugh,W.T.,A.Levinson and D.M.Wilson, "Reexamining the Empirical Evidence for an Environmental Kuznets Curve," *The Review of Economics and Statistics*,84(3), 541-551.

Ishii N.(2003), *The Positive Analysis of Long-term Economic Development* (Choki keizaihatten no Jisshou Bunseki, in Japanese), Nihon-Keizai-Shinbunsha.

Kaufmann,D. A.Kraay, and P.Zoido-Lobaton, (2002), *Governance Matters II*, Policy Research Working Paper, The World Bank, 2772 (http://www.worldbank.org/wbi/govenance/govdata 2001)

Kelly, D.L. (2003), "On environmental Kuznets curves arising from stock externalities," *Journal of*

Economic Dynamics & Control,27, 1367-1390.

Lekakis,J.N and M.Kousis, (2001), "Demand for and supply of environmental quality in the environmental Kuznets curve hypothesis," *Applied Economics Letters,* 8, 169-172.

Levinson,A.(2002), "The Ups and downs of the environmental Kuznets curve," in, List,J.A and Zeeuw,A.de ed. *Recent Advances in Environmental Economics*, Edward Elgar, 119-141.

Lieb,C.M.(2002), "The environmental Kuznets curve and satiation: a simple static model," *Environment and Development Economics*,7,429-448.

Neumayer, E.(1999), *Weak versus Strong Sustainability*, Edward Elgar.

Pashe,M. (2002), "Technical progress, structural change, and the environmental Kuznets curve," *Ecological Economics*,42,381-389.

Roca,J. (2003), "Do individual preferences explain the Environmental Kuznets Curve?," *Ecological Economics*,45,3-10.

Schwab,K, M.E.Porter, and P.K.Cornerius (2003), *The Global Competitiveness Report 2002-2003*, World Economic Forum.

Selden,T and Song D.(1994), "Environmental Quality and Development: Is there a Kuznets Curve for Air Pollution Emissions?," *Journal of Environmental Economics and Management,* 27, 142 -162.

Selden,T and Song D. (1995), "Neoclassical Growth, the J Curve for Abatement, and the Inverted U Curve for Pollution," *Journal of Environmental Economics and Management,* 29, 162-168.

Shafik,N. (1994), "Economic Development and Environmental Quality: An Econometric Analysis," *Oxford Economic Papers,*46,757-773.

Stokey,N.L. (1998), "Are there limits to growth?," *International Economic Review*,39,No.1,1-31.

Tisdell,C.(2001), "Globalization and sustainability: environmental Kuznets curve and the WTO," *Ecological Economics*,39,185-196.

Vogel,M.P.(1999), *Environmental Kuznets Curve, A Study of the Economic Theory and Political Economy of Environmental Quality Improvements in the Course of Economic Growth*, Springer-Verlag Berlin Heidelburg.

World Bank, (2003), *World Development Indicators*.

Yabuta M.(2003), *Simple Theoretical Analysis of the Environmental Kuznets Curve*, Discussion Paper Series,No.45,Chuo University.

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