Comparative Studies on Social Capability for Environmental Management in East Asia

Shunji MATSUOKA, Reishi MATSUMOTO*,*
*Ikuho KOCHI**, Makoto IWASE**
**Graduate School for International Development and Cooperation (IDEC), Hiroshima University*
***IDEC, Hiroshima University / Nicholas School of the Environment, Duke University*

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Shunji MATSUOKA*, Reishi MATSUMOTO*, Ikuho KOCHI, Makoto IWASE***

*Graduate School for International Development and Cooperation (IDEC), Hiroshima University

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Foreword

Shinichi ICHIMURA
Director, The International Centre for the Study of East Asian Development

At the occasion of the Economic and Social Commission for Asia and the Pacific (ESCAP) Ministerial Meeting on Environment in Kitakyushu on August 31 to September 5, 2000 we have decided to report on our recent studies on environmental problems in Japan and other East Asian countries by publishing a special issue of our quarterly journal, *Higashi Asia heno Shiten* (*Views on East Asia*). It includes the following two articles. This working paper is the English summary of some parts of the second article by Matsuoka group.

1. Hidefumi Imura *et al*, "Urbanization in East Asia and the Environmental Problems–the Applicability and the Effectiveness of the Kitakyushu Model,"
2. Shunji Matsuoka *et al*, "Comparative Studies on Social Capability for Environmental Management in East Asia."

These two studies have been undertaken as our commissioned research projects for several years and just completed. It is our great pleasure that we can present the reports to the world experts and officials at this precious occasion.

Our Center ICSEAD, being located in the city which was honored with two prizes from the United Nations in 1990 and 1992, has been seriously engaged in the studies of environmental issues in Kitakyushu and East Asian countries. An early study of our group was published as a monograph:

Imura, Hidefumi and Katsuhara, Takeshi (eds.), *The Environmental Problems in China* (Chugoku no Kankyo Mondai), Toyokeizai Shimpo Sha, Tokyo, 1995.

The Imura group's report is a study of this city's grapple with the environmental problems and summarizes its achievement as the Kitakyushu Model. The first half of the study report is already out in the spring special issue of our same journal in 1999, and this is the second and final part of the Imura report. Dr. Imura is a professor of environmental engineering and the head of the Kitakyushu branch of the Institute of Global Environmental Strategies (IGES).

The Matsuoka group's report is based on their field works in East Asia visiting many cities and interviewing the officials in those cities. Dr. Matsuoka is also a professor of environmental engineering at Hiroshima University. His group's complete report is published in Japanese as mentioned above. Its contents are as follows:

Chapter 1 Economic growth of developing economies and environmental problems: is the Kuznets curve established?

Chapter 2 Social capacity building for environment management in East Asia

Chapter 3 Country reports

1. Indonesia
   1.1 Overview
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Chapter 9 Economic growth of East Asian economies and the changes in the CO_2 emission structure: manufacturing and electric power industries.

This working paper is a summary of the main parts of Chapter 1, Chapter 2 and Chapter 8. We plan to translate the summary of other chapters and publish them in our biannual English journal, *East Asian Economic Perspectives* later. I sincerely hope that even with these reports the reader in other Asian countries and areas will understand what we are trying to achieve in this research field.

I would like to draw your attention to another field of research among others that we have been pursuing for a number of years. That is the regional study of the Yellow Sea basin economies in East Asia and the cargo transportation between Kyushu and the East China Sea basin economies. We will continue to publish the findings of our research in these fields in our journals and working papers. We will always make them available both electronically and as working papers.

Chapter 1

Economic growth and Environmental Quality in Developing Countries: A Verification of "Environmental Kuznets Curve"

Shunji MATSUOKA*・Reishi MATSUMOTO*・Ikuho KOCHI**

*Graduate School for International Development and Cooperation (IDEC), Hiroshima University

**IDEC, Hiroshima University / Nicholas School of the Environment, Duke University

1. Introduction

The World Development Report 1992 reports that environmental degradation and increase of per capita income have an inverted U-shaped relation trend. This means that environmental damage increases at early stages of development, then declines when the economic level reaches a certain point (World Bank, 1992). This inverted U-shaped relation is the so called "Environmental Kuznets Curve" (hereafter EKC), named after Kuznets who hypothesized an inverted U pattern in the relation between inequality of income distribution and a nation's economic level. Nowadays, EKC is the leading hypothesis concerning economic growth and environmental quality.

Figure 1-1 illustrates EKC. This hypothesis indicates the following 4 points.

First, environmental degradation is an inevitable outcome of economic growth because there is a trade-off between economic growth and environmental degradation until a turning point is reached.

Second, environmental degradation is restrained as the economy grows, because environmental resources become more scarce. Investment into pollution removal devices also increases. Consequently, economic growth and environmental preservation may occur at the same time.

Third, developing countries have late-comer advantages such as access to, and opportunity to use cheaper and more efficient pollution removal devices introduced through technical innovation, and economic development with comparatively low polluting industrial activities. Therefore, EKC shifts towards the origin (left and down).

Finally, environmental policy in developing countries is not always effective, and must be compatible with their economic level. Furthermore, technical transfer by Official Development Assistance (ODA) or Foreign Direct Investment (FDI) from developed countries could be much more effective.

The EKC hypothesis can be used to rationalize the position that "pollution can not be avoided during economic growth". This "Polluted and Clean" hypothesis can cause irreversible environmental destruction.

To begin with, we must mention that EKC is still an open question. Thus, in this paper, we empirically examine the concepts of EKC. We verify EKC with per capita emission of SOx, NOx and CO_2, which is based on per capita Gross Domestic Product (GDP) and purchasing power parity (PPP), ratio of population with access to safe water and urban sanitation, and deforestation, by elasticity and regression analysis with cross-country data. In addition, adding the social factor of population growth as an explanatory, we determine the relation between economic growth and environmental degradation in a more structured manner. Finally, we conclude that EKC should not be widely assumed and that it is necessary to refer to various and more flexible considerations. In other words, not only economic factors but also social and natural ones should be taken into account.

2. Review of empirical studies of the EKC hypothesis

As mentioned above, the World Bank's World Development Report 1992 (World Bank, 1992), subtitled "Development and the Environment" and presented at Earth Summit 1992, was a leading paper which discussed the concept of the EKC. This report asserted that there were three types of cases related to environmental degradation and economic growth.

Type 1 is the case in which, while income increases, some environmental conditions, such as the ratio of population without access to safe water, and urban population without access to adequate sanitation, declines. This occurs because increases in income improves access to public services such as sanitation and rural electricity.

Type 2 is the case where pollution is initially worsened but then improves as income increases. Such examples are air pollution such as SOx and suspended particular matter (SPM), water pollution and some types of deforestation. Thus, environmental preservation can be achieved only when countries deliberately introduce policies to ensure that additional resources are devoted to dealing with environmental problems as income increases.

Type 3 is the case where income growth worsens some aspects of the environment such as the emission of CO_2, NOx and municipal waste. In this case, it is difficult to reduce emissions because abatement is more expensive than the social cost produced by emission.

Type 2 has become the main hypothesis for explaining the relation between environment and development in developing countries, probably because this idea has been easier to adapt by economists.

Shafik(1994) is one of the leading researchers, who developed the background report of the World Bank Report 1992. Also, previous studies by Grossman (Grossman & Kruger 1995, Grossman 1995), Selden & Song (1994) and Hayami (1995) are important.

The environmental indicators used in previous studies are shown in Table 1-1. Shafik analyzed indicators such as, air and water pollution, deforestation, municipal waste, lack of access to safe water, lack of access to urban sanitation, and emission of carbon dioxide. Grossman & Kruger analyzed two groups, air pollutants (SOx, SPM, and dark matter (fine smoke)) and water pollutants in detail. Also Selden & Song analyzed 4 air pollutants in their study, and Hayami analyzed CO_2 in his research.

It is important to determine which kind of indicator is to be chosen for analysis, because it directly relates to the treatment of environmental problems. Most previous studies used air and water pollution indicators taken from the Global Environmental Monitoring System (GEMS).(1) This data is limited to urban areas for air pollution and rivers for water quality. Even though the data can not show the full picture of a country's environmental state, it is a crucial environmental indicator when dealing with pollution concentration.

Some previous studies do not use GEMS data, but instead use indicators such as "amount of emission per capita" or "amount of emission per GDP" (only Hayami uses the latter). This "amount of emission per capita" is not appropriate for estimating EKC because it indicates energy efficiency rather than environmental damage.

As shown in Table 1-2, all previous studies used cross country data and dummy variables. Their analysis show that the reverse U shape can be seen if analysis is based on SOx, SPM, biological oxygen demand (BOD) and chemical oxygen demand (COD)(see Table 1-3).

Originally, the Kuznets Curve was to be analyzed using time series data for each country. Unfortunately, it is difficult to acquire environmental data in time series especially in developing countries. Thus, we can not help but use cross country data to analyze EKC as has been done in previous studies. A problem of previous studies was that they used each country’s dummy variables to conduct regression analysis. But this can be misleading in terms of the actual trend because it may lead to the assumption that there are environmental data for 3 points in time and each data set in the time series worsens. But if the data from a country with a higher average income is relatively less than data from a lower average income country, then an ostensibly inverted U or steadily decreasing function form would be realized from regression analysis using dummy variables.

3. Estimation Result

The flow-chart of our study is shown in Figure 1-2, and data sources are shown in Table 1-4. Country names and nominal and PPP・GDP are shown in Table 1-5.

The environmental indicators we examined are SOx, NOx, CO_2, ratio of population with access to safe water, the ratio of population with access to urban sanitation, and deforestation in 1980 and 1990. The SOx, NOx and CO_2 measures are based on aggregate emission per capita but we also analyzed aggregate emission per GDP.

As mentioned above, in order to treat a variety of countries data as one country data, we must examine the data trend for each country. Therefore, we applied elasticity analysis, which is a regression analysis with the rate of change of environmental indicators divided by per capita GDP growth rate in 1980 and 1990 as the objective variable, and per capita GDP in 1980 as the explanatory variable. This elasticity analysis makes it possible to determine the function form based on the actual trend of each country.

3.1 Elasticity analysis and Regression analysis

The elasticity analysis result is shown in Table 1-6. In the case of using nominal GDP, the equation concerning only deforestation has little explanatory meaning (R^2=0.382). In the case where PPP・GDP is used, the equations about NOx, ratio of population with access to urban sanitation, and deforestation, also have little explanatory meaning.

The indicators that have sufficient explanatory meaning due to elasticity analysis are further analyzed, and the trend of each country's data near the X segment will determine the function form. In the case where the regression curve has the X segment, thereafter, that indicator will be applied to quadratic form. In the case where the regression curve does not have the X segment, thereafter, the indicator will be applied to linear form. The X segment which has sufficient explanatory meaning indicates whether the trend of environmental indicators change from increasing to decreasing at some GDP level or not. For example, SOx has enough data to exceed the value on the X segment (US$4,421 in nominal GDP, US$3,412 in PPP・GDP) with a 95% confidence interval (see Figure 1-3, Figure 1-4). This means regression has explanatory meaning for the X segment, thus it is proper to regress this indicator to quadratic form.

But, NOx, CO_2, ratio of population with access to safe water and ratio of population with access to sanitation equipment are properly regressed to linear form because their values of the X segment are so large and the trend of each county's data near the X segment is diverse. For example, in the case of NOx, there are few data that exceed the value on the X segment (US$11,431) with a 95% confidence interval. This means regression has little explanatory meaning for the X segment (shown in Figure 1-5).

The regression result based on Table 1-6 is shown in Table 1-7. The environmental indicator, log scale per capita SOx in both nominal GDP and PPP・GDP has sufficient explanatory meaning to be regressed to quadratic form. This form, an inverted U shaped curve, suggests that EKC can be explained in the case of SOx. The value of per capita GDP at the peak of SOx emission is US$8,747 in nominal GDP (shown in Figure 1-6) and US$17,359 in PPP・GDP. However, the peak value derived from elasticity analysis, US$4,421 in nominal GDP and US$3,412 in PPP・GDP, is more important. NOx, CO_2, ratio of population with access to safe water and ratio of population with access to urban sanitation have sufficient explanatory meaning to regress by linear form, which means these indicators increase steadily with economic growth (shown in Figure 1-7).

3.2 Additional examination : the case of environmental indicators per GDP

The above analysis uses per capita emission of SOx, NOx and CO_2. Furthermore, we conducted the same analysis using different indicators; the amount of emission of SOx, NOx and CO_2 per GDP. The results are shown in Table 1-8 and Table 1-9. With nominal GDP, log scale NOx and CO_2 have inverted U curves but there is little explanatory meaning with PPP･GDP. NOx and CO_2, in the nominal GDP case do not have enough explanatory meaning because R^2 is rather smaller than that of per capita NOx and CO_2. As we mentioned already, indicators such as the amount of NOx emission per GDP or the amount of CO_2 emission per GDP are similar to energy consumption per GDP. Thus, it should be discussed as an indicator of energy efficiency (inverse) not an indicator of the environment, and we can not claim the EKC with per capita indicators .

3.3 Deforestation ratio, economic growth and population growth

Since the deforestation ratio could not be explained only by economic indicators (per capita GDP), we add population growth as an explanatory value. The result in Table 1-10 shows population growth's contribution to deforestation ratio. That is, there is no relation between the rate of deforestation and the degree of economic growth.

4. Concluding Remarks

Our findings strongly suggest that it is not appropriate to generalize the emergence of EKC for all sources of environmental destruction.

First, among the following environmental indicators, SOx, NOx, CO_2, ratio of population with access to safe water, and the ratio of population with access to urban sanitation, it is only SOx that forms EKC based on cross country data. This result is examined by an original method using elasticity analysis that can reflect the trend of environmental indicators in each country. Therefore, this result has high reliability.

But as we already mentioned, EKC should be considered as being based on time series data in one country. Therefore, we proceed to the analysis of Tokyo and Yokohama based on 1960's time series data. Figure 1-8 and Figure 1-9 show the realization of EKC, both of which have a turning point in around the mid-1960s. As far as the amount of SOx emission in the case of Japan as a whole is concerned, the curve is at its peak in the mid-1960s and then the figures are flat. After the mid-1970s, the curve shows a drastic decline. This sudden change was the result of efforts mainly by local residents, the local government, and private companies. In large cities, anti-pollution agreements had been concluded between local government or local residents, and private companies since early 1960. To reduce SOx emissions, private companies took measures such as heavy oil desulfurization and the selective use of fossil fuels low in sulfur content. Thereafter, the amount of SOx emission was abruptly reduced by the oil crisis and the spread of fuel-gas desulfurization technology.

Second, social factors, such as population growth, could have more of an explanatory meaning than economic factors such as deforestation.

We believe that to hold that there is a relation between economic growth and environmental degradation, we must explain the mechanisms of environmental problems. These mechanisms are not only economic factors but also social, natural, and physiographical factors as well as mechanisms of environmental restriction developed by local resident's environmental activities, freedom of information and environmental education.

Acknowledgement

This article is a revision of our published paper "Shunji Matsuoka, Reishi Matsumoto and Ikuho Kochi (1998), Economic Growth and Environmental Quality in Developing Countries: A Verification of Environmental Kuznets Curve, Environmental Science, 11(4), 349-362". Original paper was written by Japanese and published in November 1998 by the Society of Environmental Science, Japan.

Note

(1) Global Environmental Monitoring System (GEMS) is a project to collect worldwide environmental data conducted by WHO and UNEP. Air quality data (GEMS /AIR) has been collected since 1975 and Water quality data since 1976. Air quality data contains ambient air quality in urban areas and water quality data contains river quality data. This database includes data from 20 to 60 countries.

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Figure 1-1　Environmental Kuznets Curve (EKC)

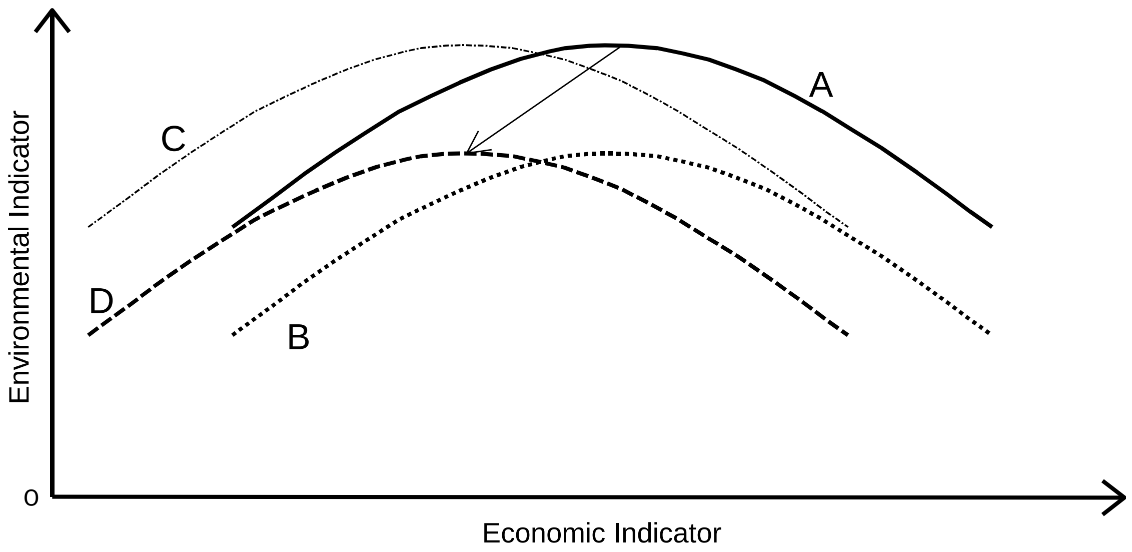


Table 1-1　Environmental Indicators in previous studies

	SOx	NOx	CO_2	safe water	sanitation	deforestation	SPM	smoke	DO	BOD	COD	Coliform	heavy metal	municipal waste	CO
Shafik(1994)	a	—	b	d	d	e	a	—	a	—	—	a	—	b	—
Grossman and Krueger(1995)	a	—	—	—	—	—	a	a	a	a	a	a	a	—	—
Selden and Song(1994)	b	b	—	—	—	—	b	—	—	—	—	—	—	—	b
Hayami (1995)	—	—	c	—	—	—	—	—	—	—	—	—	—	—	—

Note: Marks in the table are the denomination of each environmental indicator. a: concentration, b: per capita, c: per GDP, d: Maintaining ratio to population, e: Deforestation ratio. Heavy metals in Grossman and Krueger (1995) are Lead, Cadmium, Arsenic, Mercury and Nickel in rivers.

Table 1-2　Analysis Method in previous studies

	Function form			Explaining variables				Dummy variable
	liner	quadratic	cubic	GDP/capita	log(GDP/capita)	log(PPP·GDP/capita)	GDP/capita term average	
Shafik (1994)	Y	Y	Y	—	—	Y	—	Y
Grossman and Krueger(1995)	—	—	Y	Y	—	—	Y	Y
Selden and Song(1994)	—	Y	Y	—	Y	—	—	Y
Hayami (1995)	—	Y	—	—	Y	—	—	Y

Note: Y means that the method was applied in each study.

Table 1-3　Analysis Result of previous studies

	SOx	NOx	CO_2	Safe water	sanitation	deforestation	SPM	smoke	DO	BOD	COD	Coliform	heavy metal	municipal waste	CO
Shafik (1994)	Y	—	N	N	N	Y	Y	—	N	—	—	Y	—	N	—
Grossman and Krueger(1995)	Y	—	—	—	—	—	Y	N	Y	Y	Y	Y	Y	—	—
Selden and Song(1994)	Y	Y	—	—	—	—	Y	—	—	—	—	—	—	—	Y
Hayami (1995)	—	—	Y	—	—	—	—	—	—	—	—	—	—	—	—

Note: Y：It has a Peak N：It has no Peak

Figure 1-2 Research Flow Chart

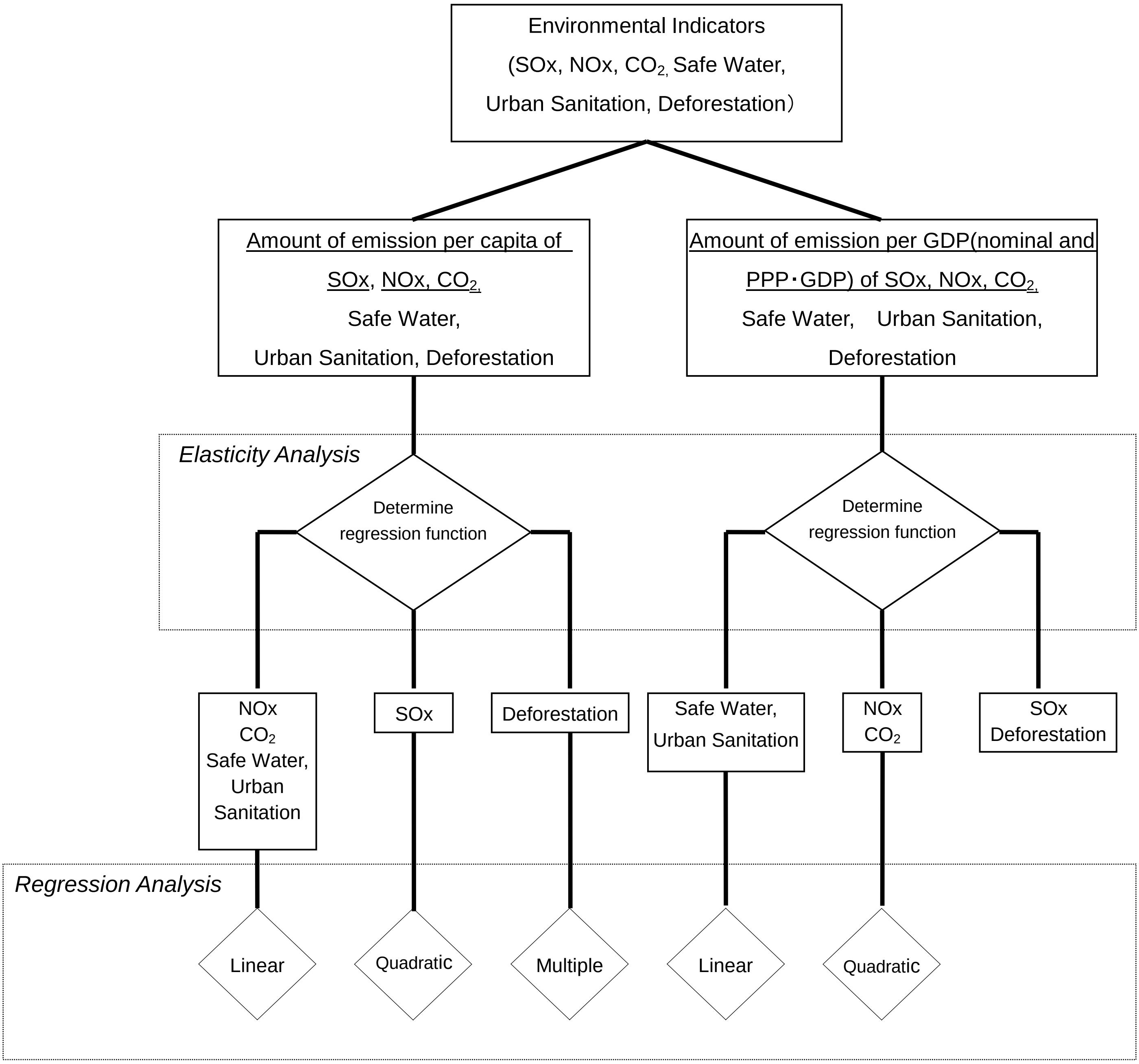


Table 1-4 Data Source

	1970' Data	1980' Data	1990' Data
Population	United Nations(1976) Statistical Yearbook 1975. United Nations	United Nations(1986) Statistical Yearbook 1983/84. United Nations	United Nations(1995) Statistical Yearbook 1993. United Nations
Nominal GDP		World Bank(1982) World Development Report 1982. Oxford U. P.	World Bank(1992) World Development Report 1992. Oxford U. P.
PPP・GDP		PWT(Penn-World Tables)(1997) http://www.nber.org/pwt56.html	PWT(Penn-World Tables)(1997) http://www.nber.org/pwt56.html
SOx emission (kg)		STA(1993), Energy Use in Asia and Environmental Forecasting WRI(World Resources Institute) (1994) World Resources 1994-1995. World Resources Institute	STA(1993), Energy Use in Asia and Environmental Forecasting WRI(World Resources Institute) (1994) World Resources 1994-1995. World Resources Institute
NOx emission (kg)		STA(1993), Energy Use in Asia and Environmental Forecasting WRI(World Resources Institute) (1994) World Resources 1994-1995. World Resources Institute	STA(1993), Energy Use in Asia and Environmental Forecasting WRI(World Resources Institute) (1994) World Resources 1994-1995. World Resources Institute
CO_2 emission(t)		World Bank(1996). World Development Report 1996. Oxford U. P.	World Bank(1996). World Development Report 1996. Oxford U. P.
Safe water accessible rate (%)		World Bank(1994) World Development Report 1994. Oxford U. P.	World Bank(1994) World Development Report 1994. Oxford U. P.
Urban sanitation accessible rate (%)		World Bank(1994) World Development Report 1994. Oxford U. P.	World Bank(1994) World Development Report 1994. Oxford U. P.
Deforestation rate (%)		World Bank(1996). World Development Report 1996. Oxford U. P.	

Notes:

1.Taiwan's population and GDP data is from N. Kobayashi(1995), Introduction to Taiwan's Economy (Japanese).

2.Indonesia's 1970 population data is from United Nations(1972) Statistical Yearbook 1971. United Nations.

3.SOx data of 14 Asian countries are from STA(1993) and we used 1975 data for 1980 and 1987 data for 1990. SOx data of 15 European and North America countries are from WRI(1994) 1980 and 1990. The definition of SOx in STA(1993) is as follows: SOx emissions caused by primary energy consumption, and refinery of nonmetal materials. Please refer to the definition of SOx in WRI(1994).

5. NOx data of 14 Asian countries are from STA(1993) and we used 1975 data for 1980 and 1987 data for 1990. SOx data of 15 European and North America countries are from WRI(1994) and we used 1980 and 1990 data. Spain's data in 1990 is unexplained. The definition of NOx in STA(1993) is as follows: NOx emissions caused primarily by energy consumption. Please refer to the definition of SOx in WRI(1994).

6. CO_2 emission is defined as emissions by primary energy consumption. Taiwan's data was unobtainable.

7. Safe water access rate indicates the rate of those people who have access to safe water to the entire population. Safe water is defined as treated water or nonpolluted water.

8. Urban sanitation access rate indicates the rate of those people who have access to urban sanitation to the entire population. Urban sanitation is infrastructure such as sewers.

9. Deforestation rate (%) is the average rate from 1981 to 1990.

Table 1-5 GDP per Capita

	Nominal GDP per capita(US$)		PPP・GDP per capita(US$)	
	1980	1990	1980	1990
1 Bangladesh	126	212	1,085	1,390
2 China	252	316	972	1,324
3 India	214	308	882	1,264
4 Indonesia	477	597	1,281	1,974
5 Japan	8,903	23,822	10,072	14,331
6 Korea, Rep.	1,528	5,514	3,093	6,673
7 Malaysia	1,702	2,387	3,799	5,124
8 Pakistan	260	317	1,110	1,394
9 Philippines	738	713	1,879	1,763
10 Singapore	4,341	12,791	7,053	11,710
11 Sri Lanka	255	427	1,635	2,096
12 Thailand	720	1,430	2,178	3,580
13 Hong Kong	4,015	10,459	8,719	14,849
14 Taiwan	2,323	7,906	4,459	8,063
15 Belgium	11,829	19,303	11,109	13,232
16 Denmark	12,957	25,479	11,342	13,909
17 Finland	10,439	27,527	10,851	14,059
18 France	12,136	20,988	11,756	13,904
19 Ireland	5,234	12,132	6,823	9,274
20 Italy	6,983	18,917	10,323	12,488
21 Netherlands	11,852	18,670	11,284	13,029
22 Norway	14,004	24,954	12,141	14,902
23 Portugal	2,215	5,758	4,982	7,478
24 Spain	5,298	12,609	7,390	9,583
25 Sweden	14,771	26,651	12,456	14,762
26 Switzerland	15,892	33,500	14,301	16,505
27 United Kingdom	9,346	16,941	10,167	13,217
28 Canada	10,537	21,447	14,133	17,173
29 United States	11,360	21,575	15,295	18,054

Sources: UN 1986&1996, World Bank 1982&1992, Penn-World Tables 1997

Table 1-6　Elasticity Analysis:
GDP and Environmental Indicators per Capita

In Nominal GDP

Environmental Indicators	Regression Result	Adjusted R^2	Intercept (GDP*US$)	Explanatory meaning	Assumable Function	Number of observations
SOx emission per capita	E=5.048-0.601ln(GDP*) t= (-5.264)	0.497	4,421	Y	quadratic	28
NOx emission per capita	E=3.895-0.417ln(GDP*) t= (-5.315)	0.512	11,431	Y	linear	27
CO_2 emission per capita	E=4.504-0.490ln(GDP*) t= (-6.659)	0.625	9,899	Y	linear	27
Safe water accessible rate	E=3.869-0.421ln(GDP*) t= (-7.277)	0.712	9,771	Y	linear	22
Urban sanitation accessible rate	E=6.521-0.697ln(GDP*) t= (-4.914)	0.563	11,609	Y	linear	19
Deforestation rate	E=14.897-1.655ln(GDP*) t= (-3.899)	0.382	8,104	N	—	24

*GDP per capita

In PPP・GDP

Environmental Indicators	Regression Result	Adjusted R^2	Intercept (GDP*US$)	Explanatory meaning	Assumable Function	Number of observations
SOx emission per capita	E=13.353-1.641ln(GDP*) t= (-7.101)	0.647	3,412	Y	quadratic	28
NOx emission per capita	E=7.099-0.749ln(GDP*) t= (-3.848)	0.347	13,122	Y	—	27
CO_2 emission per capita	E=9.002-0.979ln(GDP*) t= (-5.510)	0.530	9,891	Y	linear	27
Safe water accessible rate	E=7.883-0.828ln(GDP*) t= (-4.364)	0.462	13,699	Y	linear	22
Urban sanitation accessible rate	E=13.108-1.368ln(GDP*) t= (-2.743)	0.266	14,451	N	—	19
Deforestation rate	E=32.461-3.593ln(GDP*) t= (-4.211)	0.421	8,385	N	—	24

*GDP per capita

Notes: 1. Rate of Environmental Indicators elasticity - GDP effect is the rate of change of environmental indicators divided by per capita GDP growth rate from 1980 to 1990.
2. Deforestation is the rate of forest degradation ratio from 1981 to 1990 divided by per capita GDP growth rate from 1980 to 1990.
3. The Philippines is excluded because of it's minus growth rate of GDP per capita.

Figure 1-3 Elasticity Analysis: SOx Emisson and Nominal GDP

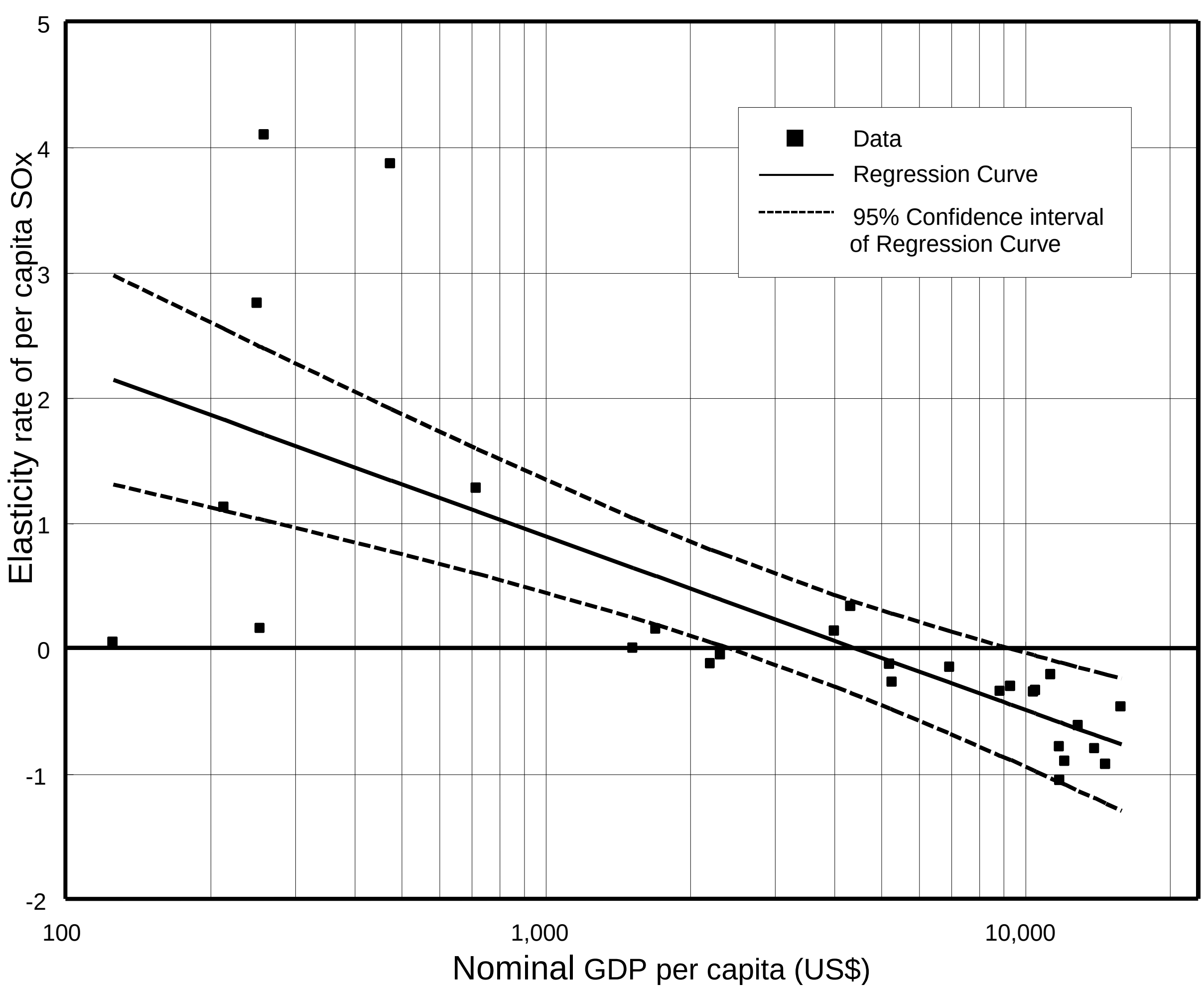


Figure 1-4　Elasticity Analysis: SOx Emission and PPP・GDP

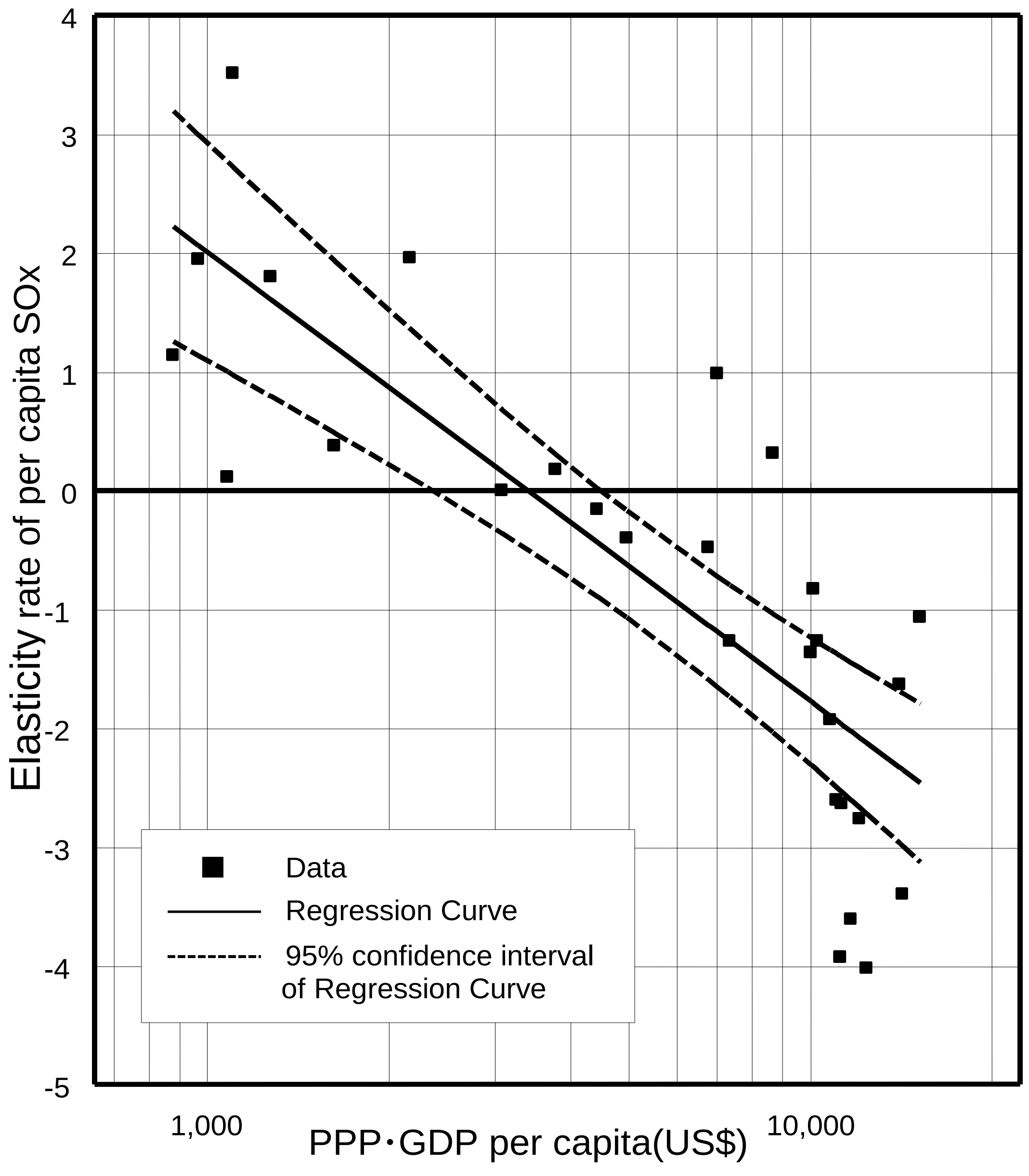


Figure 1-5　Elasticity Analysis: NOx Emission and Nominal GDP

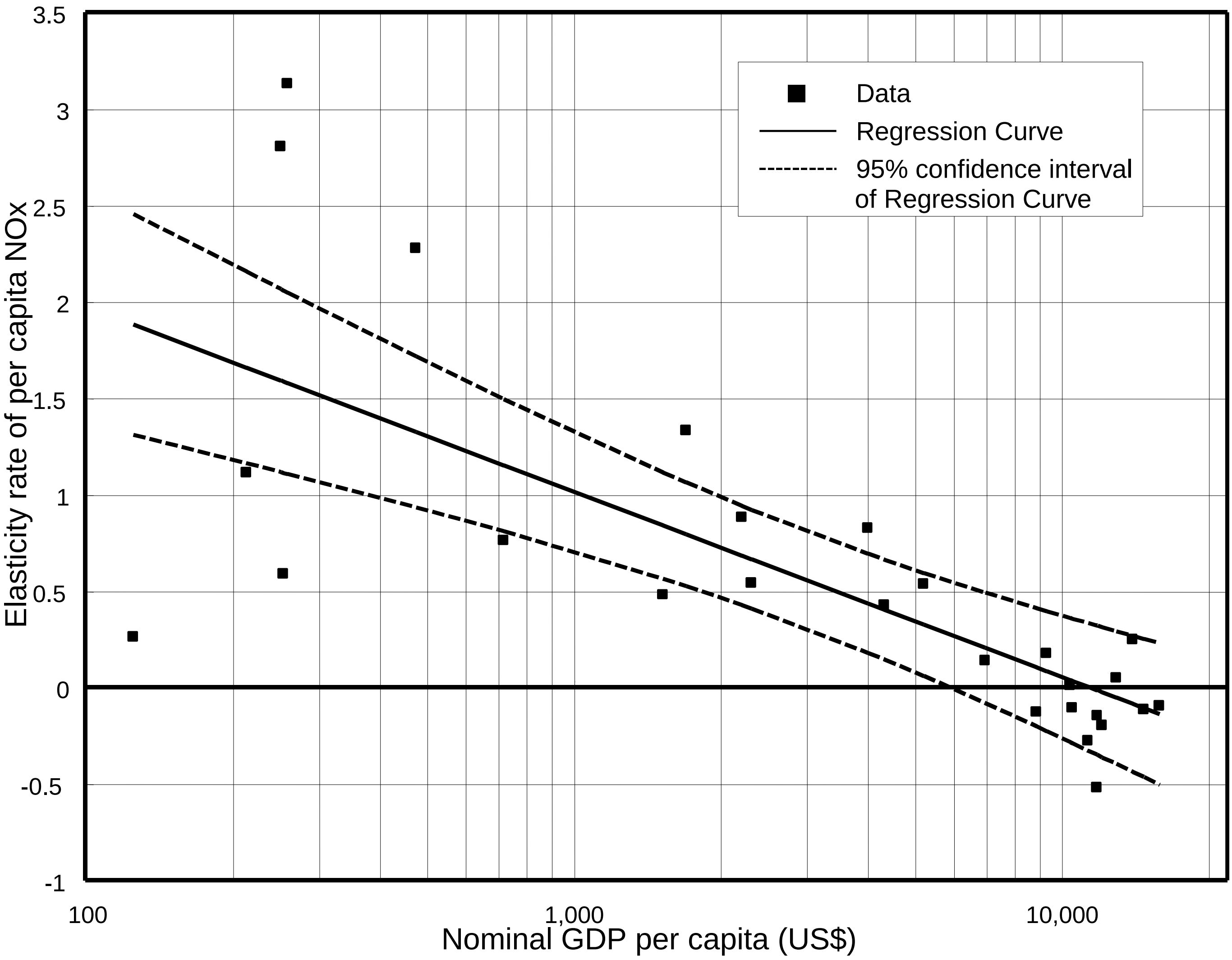


Table 1-7　Regression Results: Environmental Indicators per capita and GDP

In Nominal GDP

Dependent Variables	Regression formula	Adjusted R^2	Number of observations
SOx emission per capita	y=-236.716+59.407ln(GDP/人)-3.056ln(GDP*)^2 t= (1.796) (-1.442)	0.266	58
log-scale SOx emission per capita	y=-17.050+4.592ln(GDP*)-0.253ln(GDP*)^2 t= (5.981) (-5.143)	0.713	58
NOx emission per capita	y=-62.598+10.790ln(GDP*) t= (8.429)	0.556	57
log-scale NOx emission per capita	y=-3.565+0.752ln(GDP*) t= (19.450)	0.871	57
CO_2 emission per capita	y=-13.741+2.470ln(GDP*) t= (8.808)	0.582	56
log-scale CO_2 emission per capita	y=-4.746+0.733ln(GDP*) t= (16.387)	0.829	56
Safe water accessible rate	y=-13.856+11.625ln(GDP*) t= (11.511)	0.725	51
Urban sanitation accessible rate	y=-50.829+15.417ln(GDP*) t= (11.675)	0.750	46

In PPP・GDP

Dependent Variables	Regression formula	Adjusted R^2	Number of observations
SOx emission per capita	y=6.987-17.620ln(GDP/人)+2.401ln(GDP/人)^2 t= (-0.152) (0.346)	0.292	58
log-scale SOx emission per capita	y=-35.449+8.038ln(GDP/人)-0.412ln(GDP/人)^2 t= (2.549) (-2.184)	0.620	58
CO_2 emission per capita	y=-31.826+4.435ln(GDP/人) t= (9.524)	0.620	56
log-scale CO_2 emission per capita	y=-9.654+1.263ln(GDP/人) t= (15.467)	0.812	56
Safe water accessible rate	y=-98.228+20.798ln(GDP/人) t= (12.233)	0.748	51

*GDP per capita

Figure 1-6 Economic Growth and SOx Emission：Nominal GDP

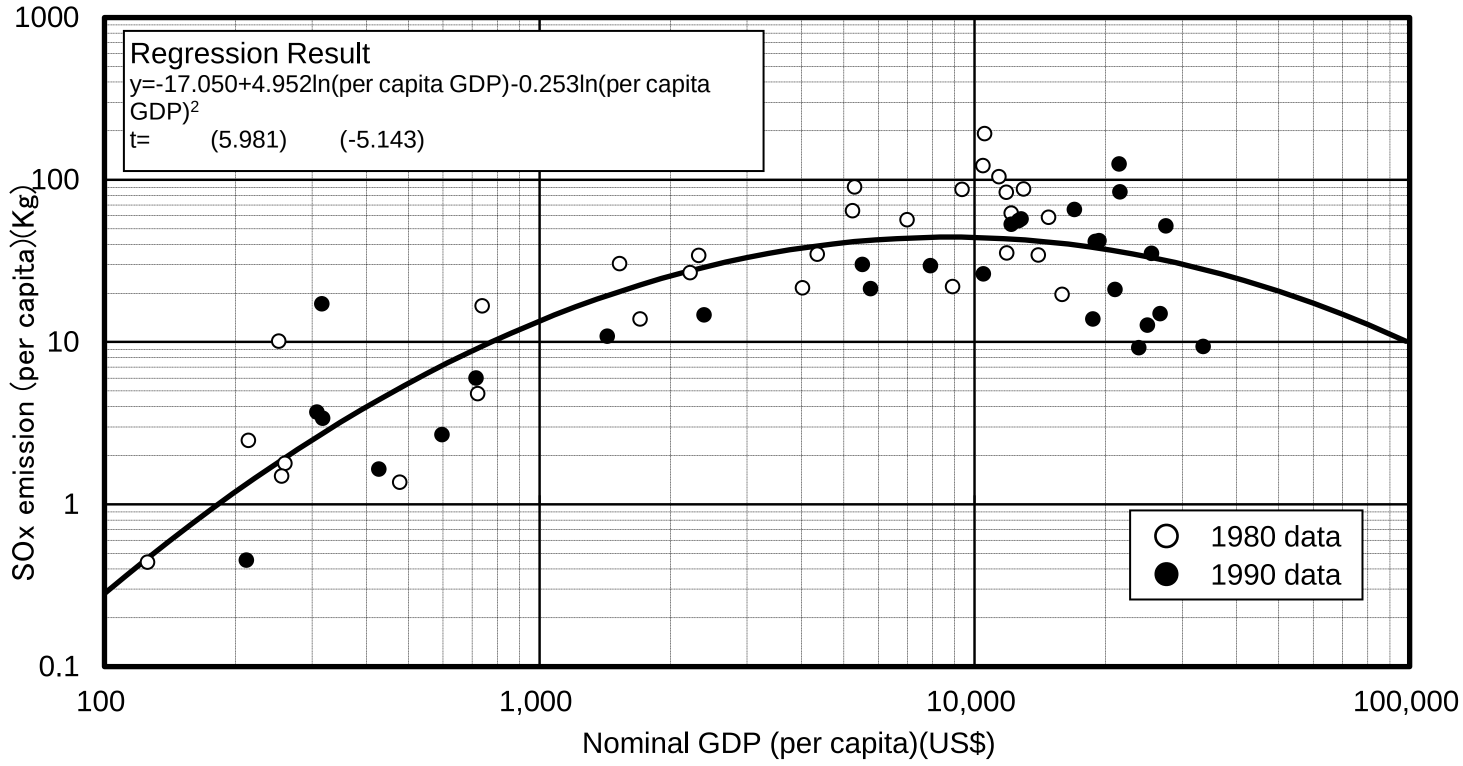


Figure 1-7 Economic Growth and CO_2 Emission

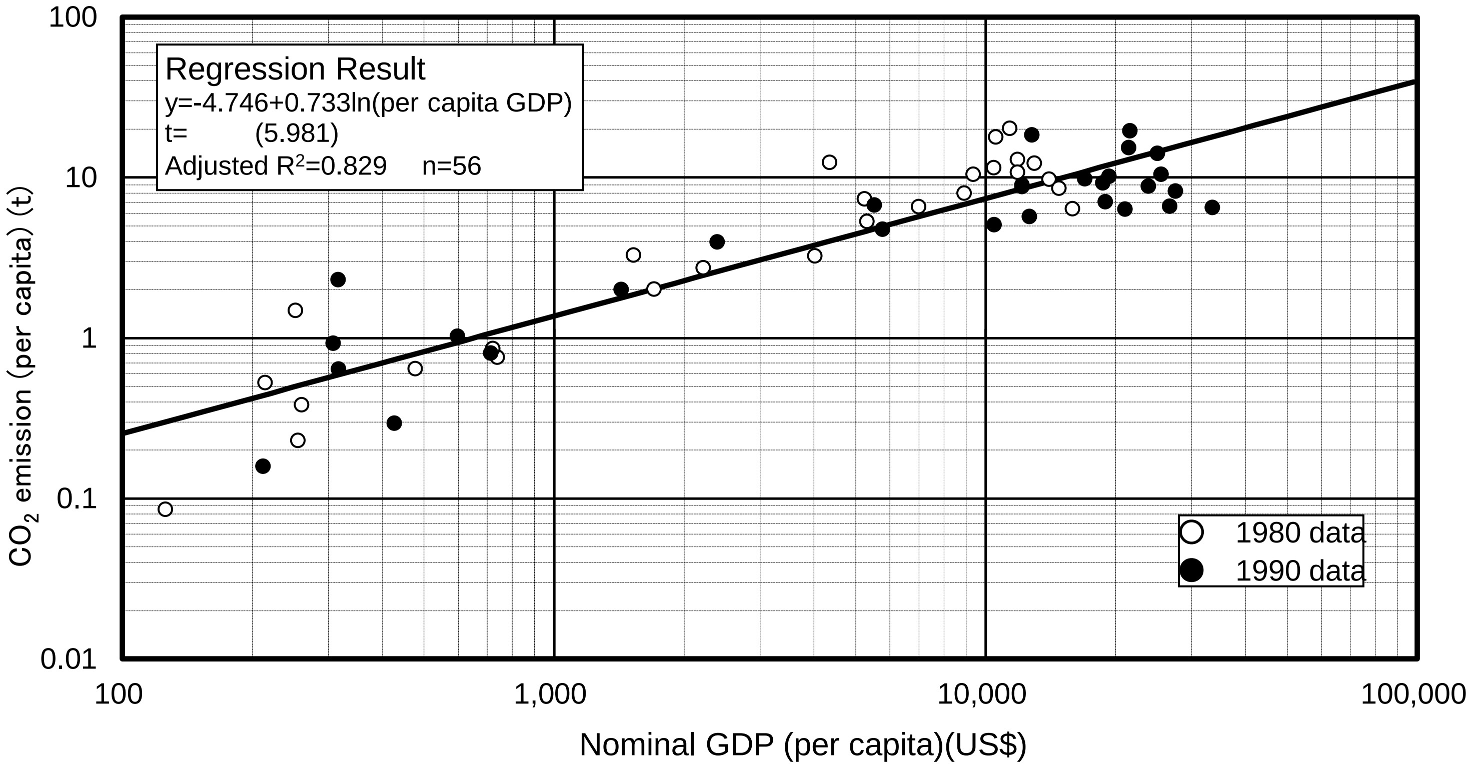


Table 1-8 Elasticity Analysis: GDP and Environmental Indicators per GDP

In Nominal GDP

Environmental Indicators	Regression Result	Adjusted R^2	Intercept (GDP*US$)	Explanatory meaning	Assumable Function	Number of observations
SOx emission per GDP	E=1.218-0.208ln(GDP/人) t= (-2.798)	0.196	349	N	-	29
NOx emission per GDP	E=1.123-0.169ln(GDP/人) t= (-4.986)	0.469	759	Y	linear	28
CO_2 emission per GDP	E=1.519-0.214ln(GDP/人) t= (-7.349)	0.663	1,216	Y	linear	28

In PPP･GDP

Environmental Indicators	Regression Result	Adjusted R^2	Intercept (GDP*US$)	Explanatory meaning	Assumable Function	Number of observations
SOx emission per GDP	E=6.366-0.888ln(GDP*) t= (-4.781)	0.438	1,296	N	-	29
NOx emission per GDP	E=3.087-0.393ln(GDP*) t= (-3.318)	0.270	2,583	N	-	28
CO_2 emission per GDP	E=4.298-0.539ln(GDP*) t= (-5.090)	0.480	2,886	Y	linear	28

*GDP per capita

Notes: Rate of Environmental Indicators elasticity - GDP effect is the rate of change of environmental indicators divided by per capita GDP growth rate from 1980 to 1990.

Table 1-9 Regression Results: Environmental Indicators(per GDP) and GDP

In Nominal GDP

Dependent Variables	Regression formula	Adjusted R^2	Number of observations
NOx emission per GDP	y=0.013-0.001ln(GDP*)-0.000ln(GDP*)^2 t= (-0.289) (-0.120)	0.306	57
log-scale NOx emission per GDP	y=-7.385+0.785ln(GDP*)-0.066ln(GDP*)^2 t= (1.663) (-2.194)	0.454	57
CO_2 emission GDP per GDP	y=0.002+0.000ln(GDP*)-0.000ln(GDP*)^2 t= (0.241) (-0.587)	0.249	56
log-scale CO_2 emission GDP per GDP	y=-11.993+1.696ln(GDP*)-0.126ln(GDP*)^2 t= (3.270) (-3.797)	0.509	56

In PPP･GDP

Dependent Variables	Regression formula	Adjusted R^2	Number of observation
CO_2 emission GDP per GDP	y=-0.001+0.000ln(GDP/人)-0.000ln(GDP*)^2 t= (0.183) (-0.115)	0.024	56
log-scale CO_2 emission GDP per GDP	y=-14.596+1.463ln(GDP/人)-0.072ln(GDP*)^2 t= (0.663) (-0.543)	0.135	56

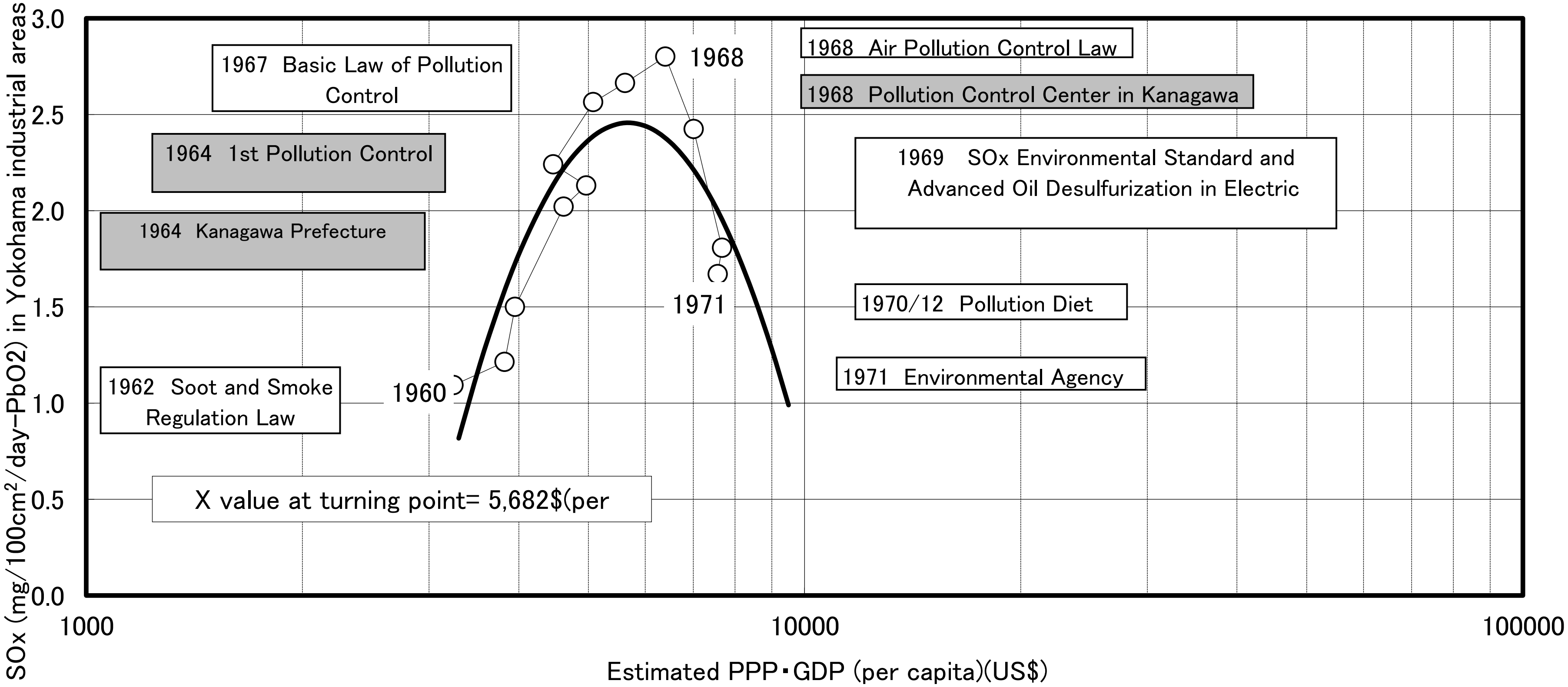
*GDP per capita

Table 1-10 Deforestation Ratio and Multiple Regression Results

Dependent Variables	Regression formula	Adjusted R^2	Number of observations
Growth rate of GDP(nominal) per capita and Population	y=-7.522-0.005(GDP)+1.452(Population) SC= (-0.017) (0.742) t= (-0.121) (5.198)	0.524	28
Growth rate of GDP(PPP) per capita and Population	y=-5.574-0.085(GDP)+1.521(Population) SC= (-0.110) (0.776) t= (-0.807) (5.720)	0.536	28
Population growth rate	y=-8.753+1.561(Population) t= (6.430)	0.590	29

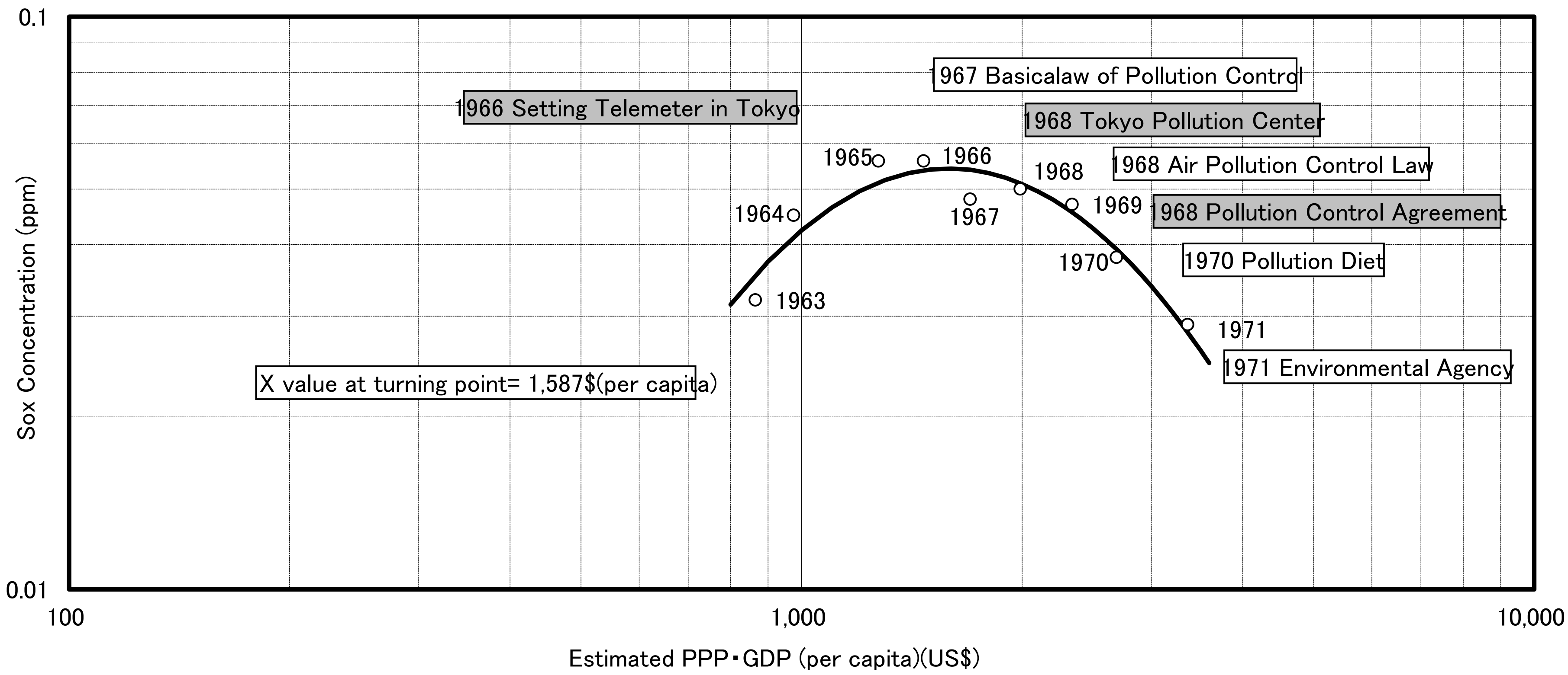
Notes: 1. The Philippines is excluded because of its negative growth rate of GDP per capita.
2. SC is Standardized regression coefficient.

Figure 1-9 Economic Growth and SOx Concentration in YOKOHAMA (Industrial Area)



SOURCE: Pollution Control Center In Yokohama(1970), Report of Air Pollution in Yokohama City
Economic Planning Agency In Japan(1974), Provincial Income Stastics, Shiseidou

Figure 1-8 Economic Growth and SOx Concentration in Tokyo



SOURCE: Hanya・Matsuda(1977), Introduction to Urban Environment, Tokai University (Japanese)
Economic Planning Agency In Japan(1974), Provincial Income Stastics, Shiseidou

Chapter 2
Economic Growth and Social Capability Building for Environmental Management in Southeast Asia

Shunji MATSUOKA*, Reishi MATSUMOTO*, Ikuho KOCHI**, Makoto IWASE*
*Graduate School for International Development and Cooperation (IDEC), Hiroshima University
**IDEC, Hiroshima University / Nicholas School of the Environment, Duke University

1. Introduction

1.1 . Background and Purpose of Research

The previous studies focusing environmental management capability building can be classified into two main schools. The first classification is based on the institutional approach. The emphasis is on 'how to establish environmental law system and environmental management administration.' The second classification is based on 'Environmental Kuznets Curve' (EKC). The emphasis are have laid on the fact-finding or collection of the data regarding economic growth and environmental quality to draw EKC and then to build the social capacity for meeting the environmental targets.

Among the institutional approach, the studies by O'Connor (1994) and Harashima and Morita (1995) are the main achievements. O'Connor's study for OECD discusses the turning point at a certain time period for establishment of environmental management for various Southeast Asian countries. He indicated that turning point for Japan in 1979, Korea, Taiwan, and China in 1980, and Thailand and Indonesia in 1988. However, that study does not indicate the facts, which can be testified for the proposed capability to establish environmental institutions. Similarly, the study by Harashima and Morita also discusses institutional building process during the environmental policy making period for countries like Japan in 1965, Korea in 1980, and China in 1987. However, their relationship between the proposed policy making period and environmental management capability is not very clear.

The fact-finding studies based on EKC are mainly supported by World Development Report 1992 of the World Bank. Figure 2-1 shows EKC based on economic growth as 'X-axis' and degraded environmental quality (pollution) as 'Y-axis.' The relationship between those two indicators is shown by curve 'A' as a development pattern followed by the developed countries. A shift from curve 'A' to curve 'B' indicates the shift towards lower level for the turning point in the environmental pollution levels. Similarly, a shift from curve 'A' to curve 'C' indicates the shift towards lower level for the turning point in economic growth level. Therefore, curve 'D' is a combination of curves 'B' and 'C' and indicates the shift in both the environment levels and the economic growth level. Hence, in the case of developing countries if they take advantage of backwardness or late-comers, then they can follow the development path similar to curve 'D'.

We have already analyzed the possibility of EKC hypothesis based on original elasticity between economic growth and environmental pollution (Matsuoka and et al. 1998). In that study we focused on the volume of emissions of SOx per capita, NOx per capita, and CO_2 per capita. We also focused on coverage ratio of safe water supply, urban sanitation, and forest area. All these environmental indicators were compared with GDP per capita as an economic growth indicator. Our results suggested that the only relationship that follows EKC is between the volume of emissions of SOx per capita and GDP per capita. In that study the turning point is maintained at GDP per capita of US$4,421 and PPP (purchasing price parity) of GDP per capita of US$3,412. Hence, the conclusion of that study suggested that when the countries can reach that level of economic growth, they can build their environmental capability for effective implementation of SOx reduction policy. However, that study can not provide an analytical framework for the research on 'how to make the process for building environmental management capability clear.'

In this study, taking into consideration the limitations of previous studies on both institutional approach and EKC approach, we add the third factor of environmental capability to analyze its dynamic relationship with the other two factors viz.: economic growth and environmental quality. However, the building process for the holistic environmental capabilities is very complex and it can not be directly analyzed in a single framework. Therefore, we analyze the environmental monitoring capability that is assumed as the basic capability for the environment management. Among this environmental monitoring we focus on air pollution monitoring system with an especial focus on SOx emissions, as it is the only pollutant that follows EKC. We initially analyze Japan's case and then take it as a reference point to analyze the Southeast Asian countries' case with regard to SOx emissions.

1.2. Framework for Research

The framework of our previous study (Matsuoka et al. 1998) as shown in Figure 2-2 is the basis for developing the analytical framework for this study. The present study framework has been set-up on social environmental system as shown in Figure 2-3. This system is divided into three sub-systems. The first sub-system is based on actors, institutions and behaviors. The second sub-system is based on socio-economic patterns, which are heavily dependent on economic growth. The third sub-system is of environmental quality. In the first sub-system of social environmental management, the behavior of actors is influenced by the institutions and that behavior effects the environmental quality in question. Moreover, the environmental quality has influence over the awareness/behavior of the actors and as per that awareness the actors try to build or constitute new institutions. Furthermore, institutions, actors' behavior, and environmental quality have a strong relationship with economic growth as has already been discussed. Hence, social environmental system consists of various actors, institutions, and behaviors. However, among these factors the most important one is environmental monitoring system. Therefore, this study focuses on the capability building for environmental monitoring system.

2. Factors and Indicators in Environmental Management System

2.1. Factors and Indicators

At first we set-up the factors and indicators for the environmental monitoring system. There are many important previous studies including Kazi et al. (1997), Davos et al. (1991a, 1991b, 1991c, & 1993), Simpson (1988), Tamori (1995), Imura et al. (1999), and UNEP and WHO (1996). Among these the study carried out jointly by UNEP and WHO under GEMS (Global Environmental Monitoring System) project is the most important one. This study covers environmental monitoring system in 20 major cities and most of these cities are located in the developing countries. We have quoted this study in our research as GEMS report.

The factors and indicators for our study are taken from GEMS report after a critical analysis of each factor and indicator. Figure 2-4 shows the factors of environmental monitoring system quoted from GEMS report. This report is mainly focused on air quality management and it divides air monitoring management capability into four factors viz.: measurement of air quality, assessment and disclosure of the data, estimation of emissions, and enable management. There are several indicators for each factor and each indicator should be scored in a range from 0.5 to 4.0 points. Each of the four factors discussed can achieve the highest score of 25 points, which combines to make 100 points for the whole system. The score of 25 points for each sector has been distributed to different indicators at different weights. For example, in the fist factor for measurement of air quality, 13 points go to the indicator for implementation of air quality measurement/recording system. This includes number of air quality polluters measured, consistency and number of readings per day/hour, and the length of available data for up to 5 years. Under the same factor, 5 points are kept for the number of monitoring staff and so on. Table 2-1 shows all the indicators with their maximum points. According to GEMS report, an equal weight of 25 points had been given to each of the four factors. However, a critical analysis of those factors suggests that there is a hierarchical structure among those factors. For example measurement of air quality is the basic and first step to build the whole system.

2.2. Economic Growth and Environmental Monitoring System

GEMS report has built a relationship between environmental monitoring and GDP per capita as shown in Figure 2-5 The report suggests that the factors like assessment and disclosure of the data, estimation of emissions, and enable management, also increase if economic growth increases. However, as per assessment of available data, this relationship does not follow the suggested pattern after a certain level of economic growth. The factor of assessment and disclosure of data is highly dependent of political and institutional set-up of the country. Hence, our research indicates that GEMS report is not very clear. Therefore, we use the composition analysis using the score of four major factors of GEMS report. Figure 2-6 shows the result of our composition analysis. We have analyzed that the factor of estimation of emissions is different from the three other factors; although, GEMS report suggests that assessment and disclosure of the data is a different factor. We assume that the emissions inventory factor is relatively a high technology level, while the rest of the factors are basic without an essential requirement of high-tech.

According to our research results, we define measurement of air quality, assessment and disclosure of data, and enable management as the primary or basic functions as these can even be implemented with the help of low level technology. Among these three factors, measurement of air quality is the very basic function as the lack of correct data or information regarding the environmental quality will make is impossible to produce a good analysis of the environmental quality and to formulate and implement right policies to enable management. On the other hand, the factor of inventory of environmental emissions is a higher function that can be effectively implemented only with the help of high level technology.

Therefore, we take into consideration the number of environmental monitoring stations in each country as representative indicators for assessing the capability of environmental management. We take the case of Japan as a reference point to assess our three dimensional system of economic growth, environmental quality, and social capability building.

3. Air Quality Monitoring System, Economic Growth, and Environmental Quality in Japan

3.1. Air Quality Monitoring System in Japan

When we conduct a quantitative analysis of air quality monitoring data, the basic shortcoming in the previous studies is the unavailability of the appropriate time-series data for each country. The GEMS report or EKC studies commonly used cross-country data or the data from different country in different situation and assumed it as the data for the county in question. Hence, they have failed to generate reliable results. However, in Japan during 1999, we can use numerical data available on CD-ROM format. This data along with time-series data helps us to analyze the number of monitoring stations, economic growth, and environmental quality.

The first factor for measurement of air quality includes number of continuous monitoring stations with effective maintenance and operation, and also the availability of measurement technology to collect the pollution data at the required time intervals. Figure 2-7 shows the number of continuous air pollution monitoring stations, number of municipalities with at least single air pollution monitoring stations, and municipalities with multiple pollution monitoring stations in Japan. Analyzing that data, it reveals that monitoring stations were started from 1963 in Japan and their number almost came to steady state in 1980 in case of single station municipalities and in 1978 in case of multiple station municipalities. This shows that urban areas with multiple stations achieved the steady patterns two years earlier then the general trends in Japan.

As far as the essential number and optimal location for monitoring stations is concerned, UNEPA studies and GEMS report for 20 major cities suggest that at least one station each in residential, commercial, and industrial area is required. Thus, the minimum number should be three for urban cities, if the zoning is properly enforced.

3.2. Establishment of Monitoring System and its Relationship with Economic Growth and Environmental Quality

We analyze the impact on the environmental capability with each additional monitoring station. The impact is higher for the additional monitoring station if the existing number of the stations is less. In other words we can say that the impact of setting-up an additional monitoring station in the earlier period for environmental capability is higher than the impact in the later period, when there are more stations in operation. Hence, we take the number of monitoring stations in log scale to evenly assess their impact on the environmental quality. Figure 2-8 shows the concentration of SOx emissions and the number of monitoring stations in Japan. The total number of continuous and long-term stations is 14 as five are located in Tokyo, four in Yokohama, three in Kawasaki, and one each in Yokkaichi and Sakai. Average peak of SOx concentrations was during 1967 and the number of stations during that time was 94 with a log value of 1.973. As per least square (regression) method, the number of monitoring stations required for those peak SOx concentration calculated as 71.4 with a log value of 1.854. The number of monitoring stations in 1996 was 1730 with a log value of 3.238. A comparative analysis of the number of monitoring stations in log terms with the peak SOx concentrations in 1996 shows that the turning point of SOx is at 60% of the log value for the existing stations during 1996.

Figure 2-9 shows SOx concentrations and the number of monitoring stations in five major cities of Japan. Looking at the trends of SOx concentrations and the number of monitoring stations in those five major cities, we realize that the statistical analysis indicates that an essential number for monitoring stations to be 19.4 or 1.288 in log terms to achieve the turning point. However, the actual number of monitoring stations in those five cities is 75 with a log value of 1.875. This shows that the turning point is at 70% of the log value for the number of existing stations. Based on this analysis, we can highlight two points. Firstly, in case of Japan, if the number of monitoring stations is taken as an indicator for environmental management capability, then the turning point for environmental quality is at about 60% to 70% of the existing number of the stations. Secondly, at the turning point, annual SOx concentrations would be 0.060 ppm and PPP-GDP per capita would be US$5,032.

Based on the above assessments and taking into consideration about the advantage of late comers or backwardness as per EKC, we can predict the shifting of income, pollution, and number of the stations towards original point. In case of Southeast Asian countries, we can assume PPP-GDP per capita at US$5,000 as an essential level for economic growth to reach the turning point. The turning point for continuous and reliable monitoring stations would be in a range of few tens (for example, in between 40 to 60). According to USEPA (United States Environmental Protection Agency) standard guidelines the necessary number of stations for a city of 1 million people should be 15 and for a city of 10 million people should be 35.

4. Economic Growth and Air Quality Monitoring System in Southeast Asia

4.1. Trends for Air Quality Monitoring Stations

In this section, based on the Japanese experience, we analyze the relationship among three factors: economic growth, environmental quality, and the process for environmental monitoring capability. At first we touch on the development of air quality monitoring system. This system can be divided into two main stages as per level of technological involvement. The first stage includes sample collection at a fix location, transportation of that sample to the laboratory, and finally analyzing the sample. This stage is called manual analysis stage. The second stage is the continuous measurement with automatic process for analysis. The first stage 'manual analysis stage' can be further divided into two sub-stages depending on the automatic sample collection or the manual sample collection process. The second stage can also be divided into two sub-stages depending whether the continuous analysis is being done with the help of telemeter or without telemeter. Hence, automatic sample collection with continuous telemeter readings is the highest stage. Table 2-2 shows the ambient air quality in Southeast Asian countries. In case of SOx, NOx, CO, and O_3 hourly value is set and data should be monitored after every hour. Therefore, in that case it is essential to connect all the monitoring stations with telemeter system.

Table 2-3 shows the number of air quality monitoring stations in Southeast Asia. In

Singapore, manual analysis system was started during early 1970s and the system was completely converted to automatic monitoring and analysis system by using telemeter and networking in 1994. Hence, Singapore built its capability for air quality monitoring in that year. In case of Malaysia, manual monitoring and analysis system was started from late 1970s at nation-wide level. In 1992 automatic telemeter system was introduced and it is planned that by the year 2000, Malaysia will have a completely automatic system with a network of 50 monitoring stations across the country. Thailand introduced manual analysis system in late 1970s and the automatic system was introduced during 1980s. However, the automatic telemeter system was started in 1992 and completed in 1997. As a matter of fact, due to financial crisis, the telemeter system is not being working effectively as the monitoring data is collected only once a day. As far Indonesia, manual analysis system was adopted in late 1970s and only during 1990s, when Jakarta Metropolitan Area had set-up automatic system, that in other major cities the same system is being set-up with the support of Austria and Japan. However, telemeter system has not yet been installed. Finally, in Philippines' case, they also started their manual system from early 1970s just like Singapore. Though, they also managed to set-up an automatic system during 1990s in Metro Manila, but those instruments could not be used on sustainable basis due to lack of maintenance. In 1990s ADB (Asian Development Bank) also gave the donation to set-up the monitoring equipment, but again the lack of maintenance made it difficult to use that instrument effectively. At present, there are 10 monitoring stations in Metro Manila, but the total staff in Environmental Management Bureau and that for air quality monitoring is only five. Hence, they can not manage the monitoring stations effectively and the data collection activity remains at once a week. Therefore, for Philippines, the first priority should be the of setting-up of effective monitoring system, at least in Metro Manila and then to set-up the same system across the country.

4.2. Economic Growth and Building of Air Quality Monitoring System in Southeast Asia

As we have already discussed in section 1.1 about our previous study on EKC. We used data of 1980 from 29 countries to analyze the elasticity between GDP per capita and SOx emissions per capita. The regression line had shown the statistically significant crossing point at X-axis. Based on that reason, we made clear the possibility of EKC in case of SOx emissions. Figure 2-11 shows results of our study and also indicates those points for Japan and as well as for Southeast Asian countries. With the help of this figure, as per parallel to the regression line, we establish the present position for each country. Figure 2-12 shows the results of our calculations. Based on Figure 2-12, it is evident that Singapore has already reached the turning point during early 1990s. Malaysia also achieved the turning point during mid 1990s. Thailand will reach at the turning point by end of 1990s or early 2000. Indonesia will take a little more time as it may arrive at the turning point by

2010. However, for Philippines, we cannot estimate the exact time required for achieving the turning point due to unavailability of the essential data.

Comparing with the situation of air quality monitoring system in Southeast Asia, as discussed in the previous section 4.1, we can get the similar results for EKC and also for the environmental monitoring capability in each country. Therefore, with the exception of Philippines, Singapore, Malaysia, Thailand, and Indonesia have already set-up the automatic monitoring stations expeditiously after 1980s as per their rapid economic growth. Moreover, telemeter system has already been installed in those countries except Indonesia, where telemeter system is under installation. Furthermore, those Southeast Asian countries completed the setting-up of nation-wide automatic system prior to their respective turning points, and this is a different trend from the Japan. Therefore, Southeast Asian countries very expeditiously built the air quality monitoring capability on nation-wide basis. However, this rapidness also caused some technological problems and only Singapore is different as it has a long and sustainable history for manual analysis system.

5. Conclusion

In this research, which is primarily based on EKC to draw a trend between economic growth and environmental quality, we have added the third dimension as air monitoring system for environmental management capability. We have taken the case of Japan as a reference point and analyzed the case of five Southeast Asian countries. Similar to Japan's trends, those five countries have also got a very strong relationship among all the three dimensions. However, the major difference for those countries is evident from the pace of setting-up nation-wide automatic monitoring system. We also made clear the effectiveness of our research framework to analyze the social capability building process for environmental management. However, this study is mainly focused on SOx as a typical pollutant. Therefore, for NOx, CO, and PM10 we will make other efforts to analyze those pollutants as they also cause a very serious non-point source pollution problems in the developing countries.

Acknowledgement

We undertook a field study in August and September 1999 for collection of data to analyze EMS (environmental management systems) in Southeast Asia. Therefore, we express our deep gratitude and thanks to the following institutions and their officials: Singapore: Ministry of Environment, Malaysia: Ministry of Science, Technology, and Environment (MOSTE), Department of Environment, Thailand: MOSTE, Pollution Control Department, Indonesia: JICA/BAPEDEL Environmental Management Center, BAPEDEL, Philippines: DENAR, Environmental Management Bureau.

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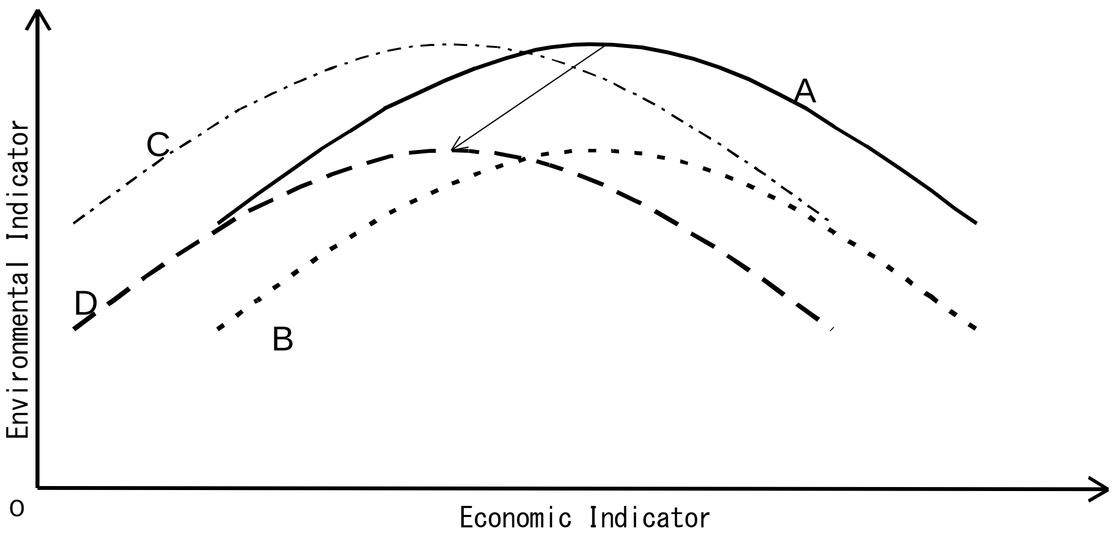
18) UNEP and WHO (1996), *Air Quality Management and Assessment Capabilities in 20 Major Cities*, MARC (Monitoring and Assessment Research Center, London)

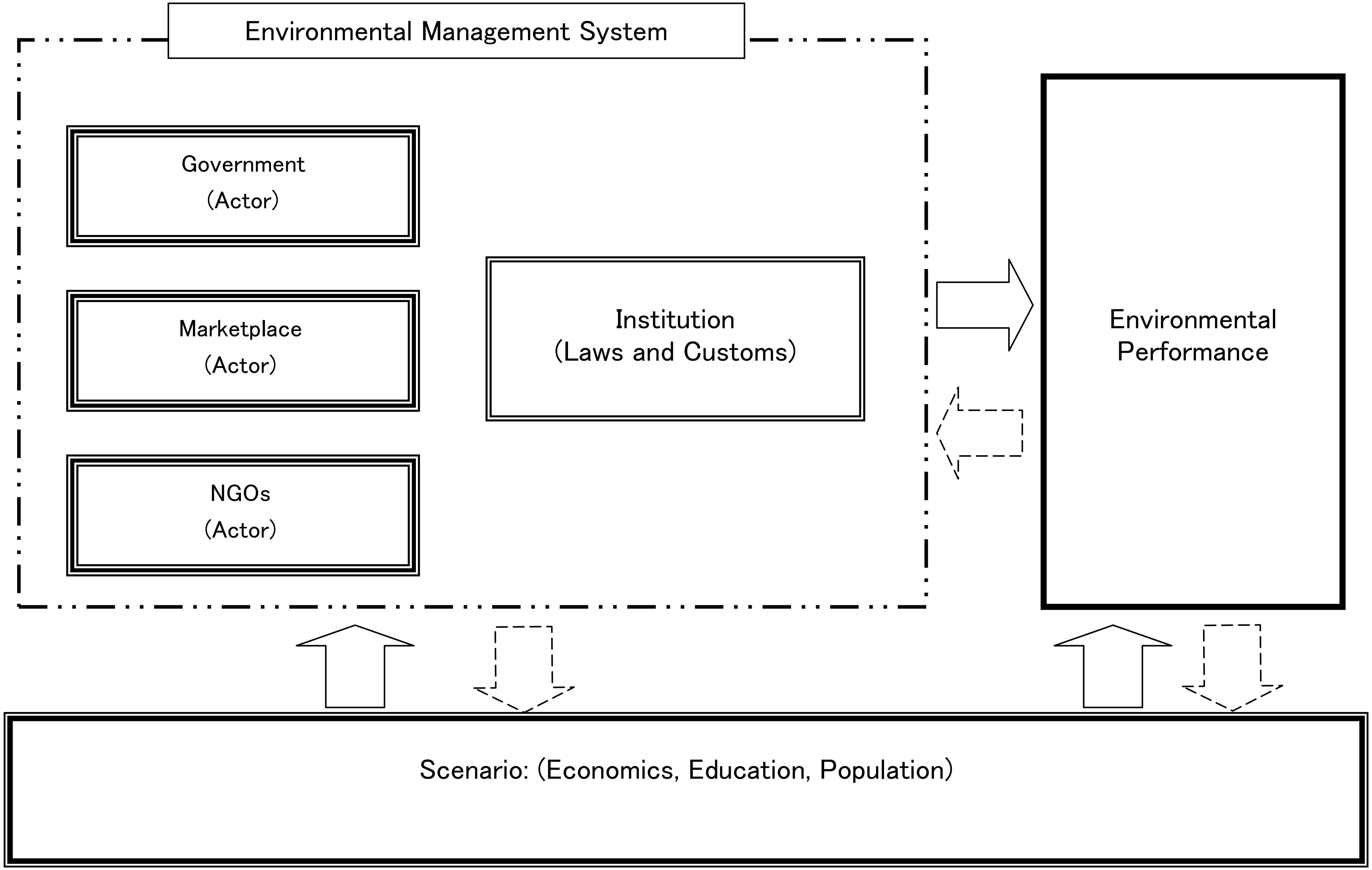
19) World Bank (1992), *World Development Report 1992*, Oxford U.P.

Figure 2-1 Environmental Kuznets Curve



Source: Matsuoka, S., Matsumoto, R. and Kochi, I. (1998) Economic Growth and Environmental Problem in Developing Countries: The Environmental Kuznets Curve Do Exist? (in Japanese), *Environmental Science*, 11(4), 349-362

Figure 2-2 Structure of Environmental Management System



Source: Matsuoka, S., Kochi, I. and Shirakawa, H. (1999) Social Evaluation on International Environmental Cooperation: a Case of Japan's Environmental Project in Thailand, *Journal of International Development and Cooperation*, 5(1), 11-22

Figure 2-3 Social Environmental Management System

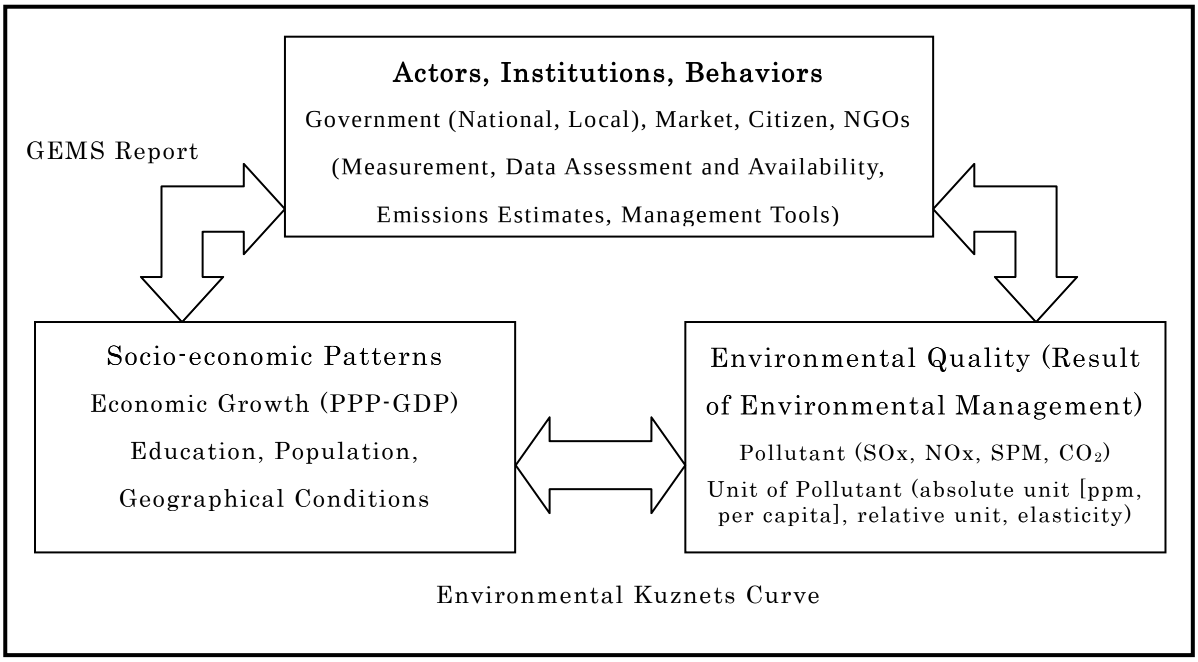
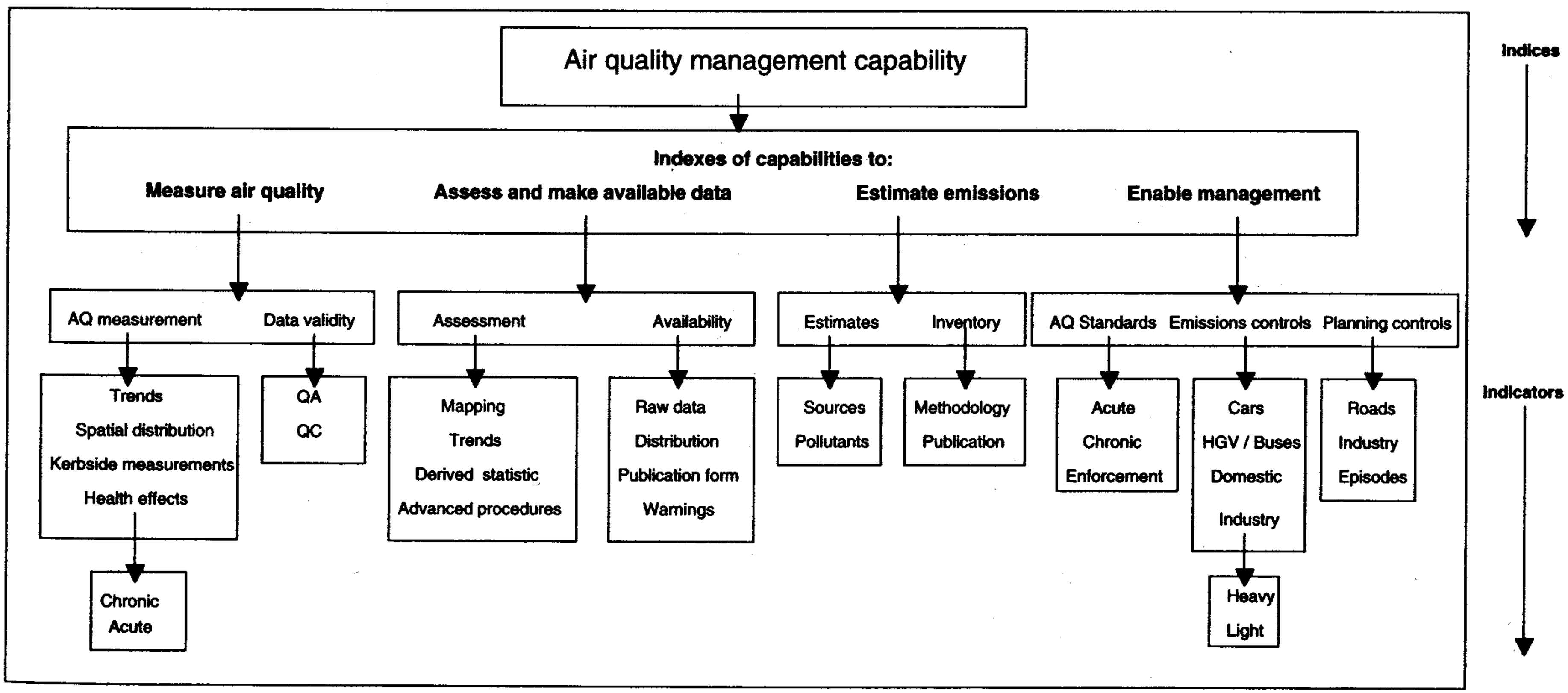


Figure 2-4 Factors of Environmental Monitoring System (GEMS Report Model)



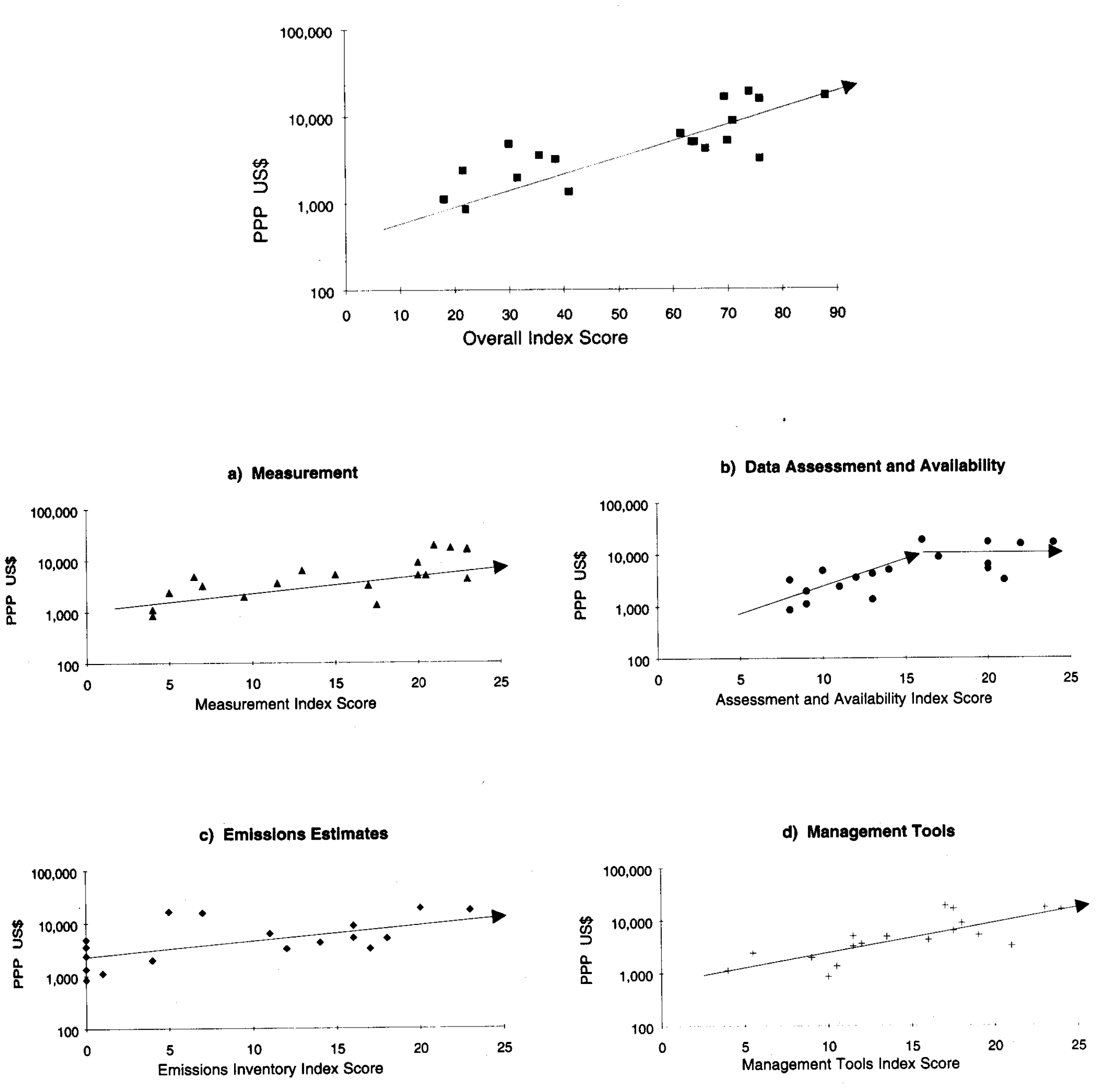
Source: UNEP&WHO (1996), *Air Quality Management and Assessment Capabilities in 20 Major Cities*, MARC (Monitoring and Assessment Research Center, London)

Table 2-1 Indicators of Environmental Management (in GEMS Report)

Indicator of Air Quality Measurement Capacity (Total: 25 points)	Monitoring at least one site in a residential area with a frequency of greater than one day (more than 1 years) (each pollutant: 0.5 point)	NO_2, SO_2, Particulate matter, CO, Pb, O_3
	Monitoring at least one site in a residential area and provides daily or hourly mean values day (more than 1 years) (each pollutant: 0.5 point)	NO_2, SO_2, Particulate matter, CO, O_3
	Measure trends (more than 5 years) (each pollutant: 0.5 point)	NO_2, SO_2, Particulate matter, CO, Pb, O_3
	Measure spatial distribution (more than 3 stations) (each pollutant: 0.5 point)	NO_2, SO_2, Particulate matter, CO, Pb, O_3
	Measure road side concentrations day (more than 1 years) (each pollutant: 0.5 point)	NO_2, SO_2, Particulate matter, CO, Pb
	Data quality (sub total 12 points)	Calibrations, Site audits, Auditing by independent body, Inter-comparison
Data Assessment and Availability (Total: 25 points)	Indicators of the capacity to analyze data (sub total 14 points)	Statistical analyze (mean, percentiles, trends, mapping), Computer use
	Indicators of data dissemination (sub total 11 points)	Newspaper, Television, Published reports, Air quality warnings
Emissions Estimates (Total: 25 points)	Source emission estimates (each source: 1 point)	Domestic, Commercial, Power-generating, Industry, Cars, Motorcycles, Others, HGV/buses
	Pollutant emissions estimates (each pollutant: 1 point)	NOx, SO_2, Particulate matter, CO, Pb, Hydrocarbons
	Accuracy of emissions estimates (sub total 9 points)	Estimates from actual measurements, Estimates from fuel consumption, Include non-combustion process, Cross check, Future inventory plan
	Availability of the emissions estimates (sub total 2 points)	Published in full: 2points, Partially available: 1 point
Management Capability Assessment Tools (Total: 25 points)	Capacity to assess air quality acceptability (sub total 8 points)	Air quality standards, Regulations, Local standards, Future plan
	Capacity to use air quality information (sub total 17 points)	Emissions controls, Penalties, EIA in new development area, Unleaded petrol, Additional emission controls among the warning

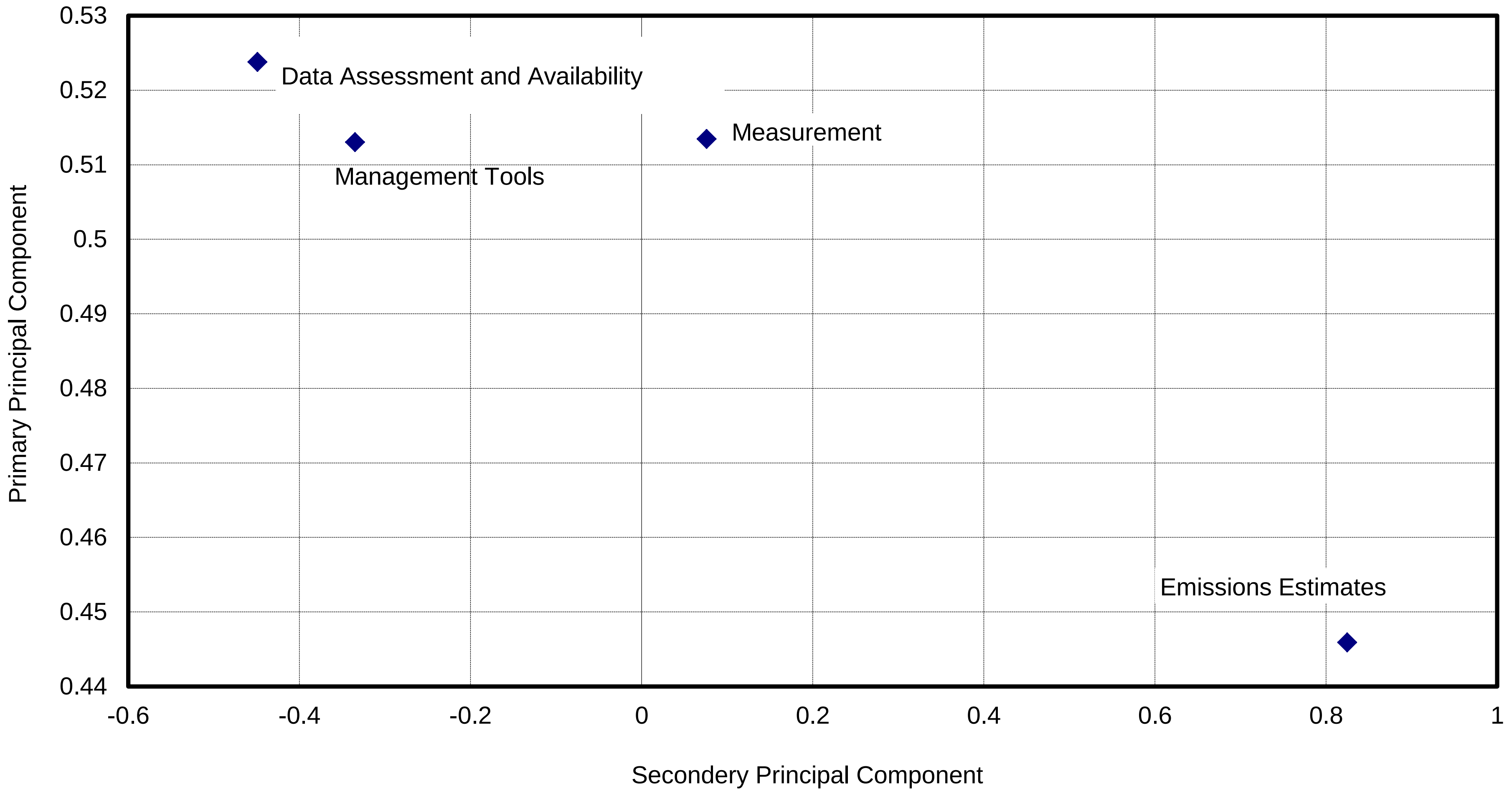
Source: UNEP&WHO (1996), *Air Quality Management and Assessment Capabilities in 20 Major Cities*, MARC (the Monitoring and Assessment Research Center, London)

Figure 2-5 Relationship between Environmental Monitoring and GDP per capita



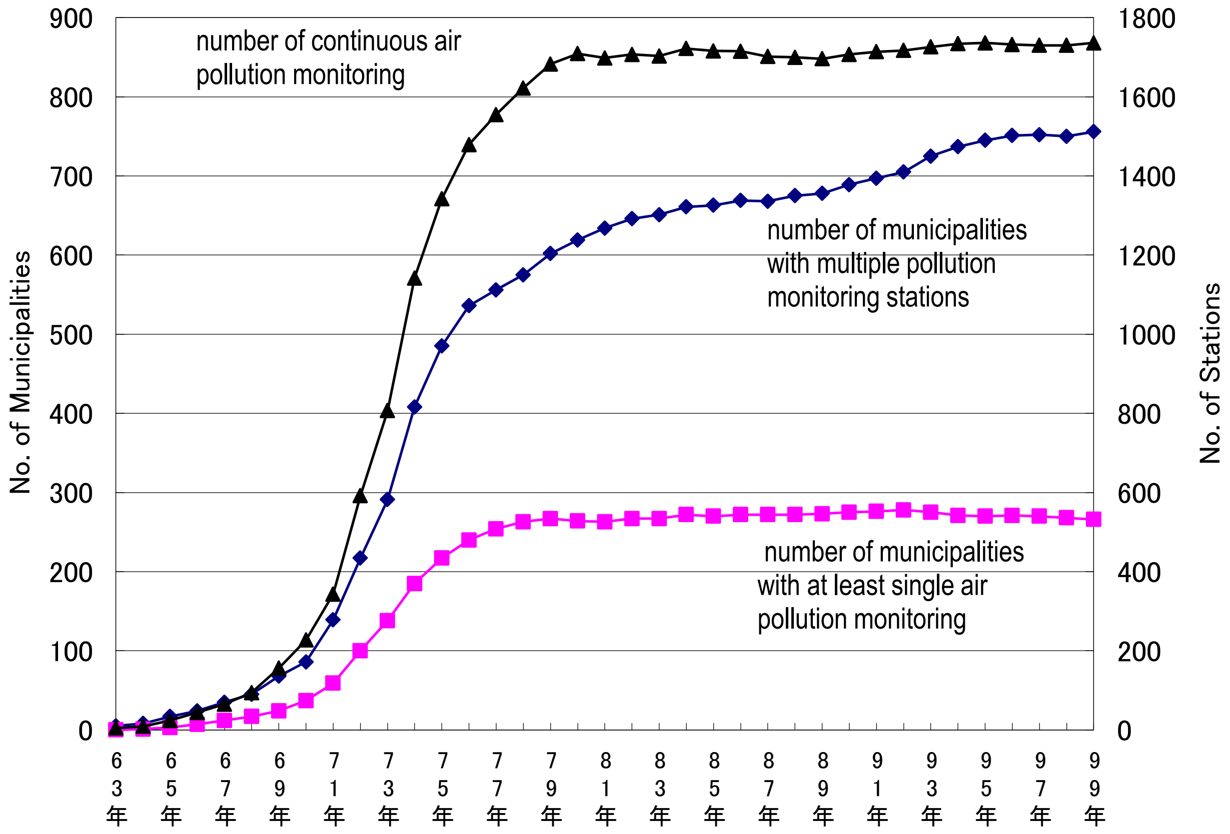
Source: UNEP&WHO (1996), *Air Quality Management and Assessment Capabilities in 20 Major Cities*, MARC (Monitoring and Assessment Research Center, London)

Figure 2-6 PCM of GEMS Data



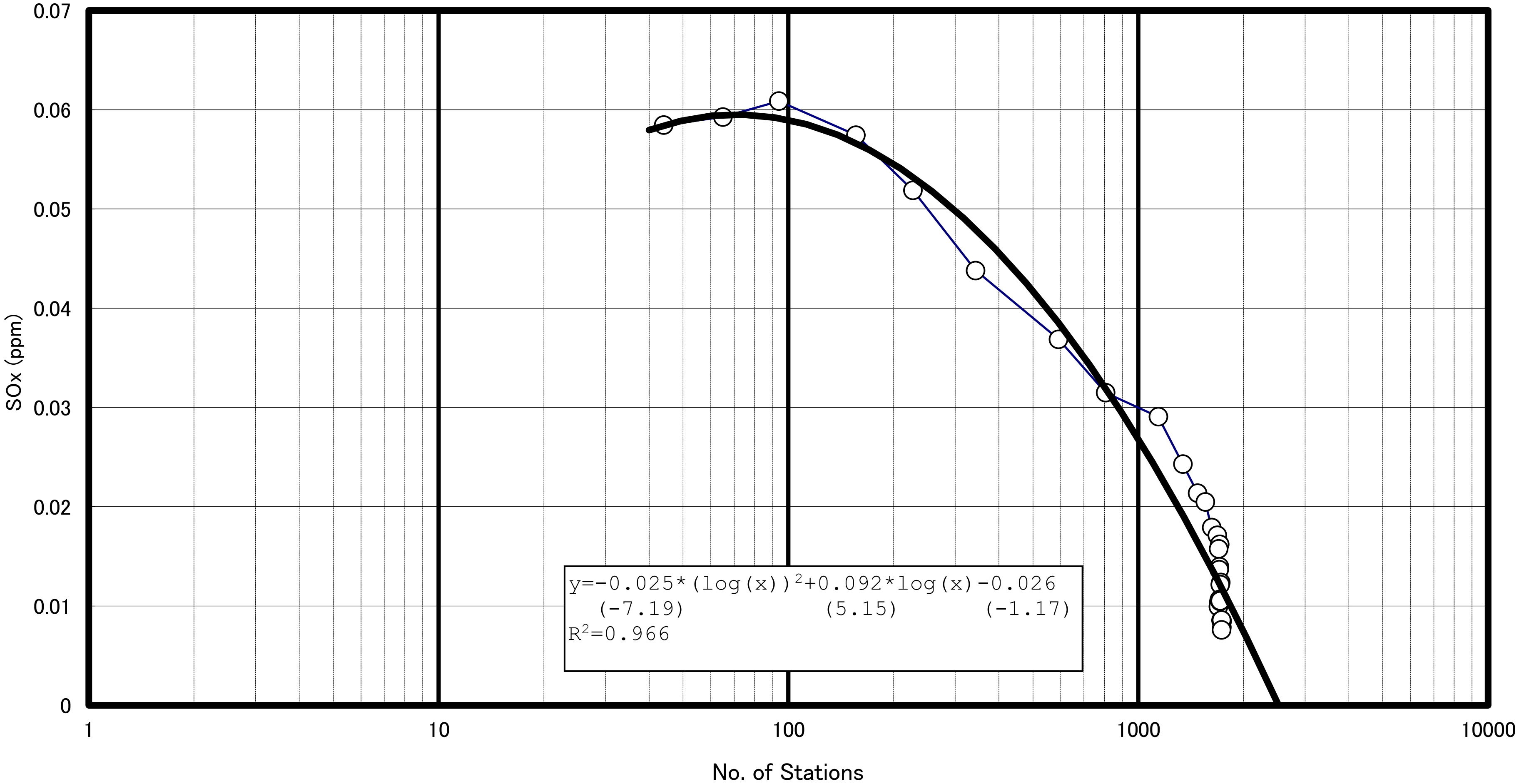
Source: UNEP and WHO (1996), *Air Quality Management and Assessment Capabilities in 20 Major Cities*, MARC (Monitoring and Assessment Research Center, London)

Figure 2-7 Number of Stations and Municipalities



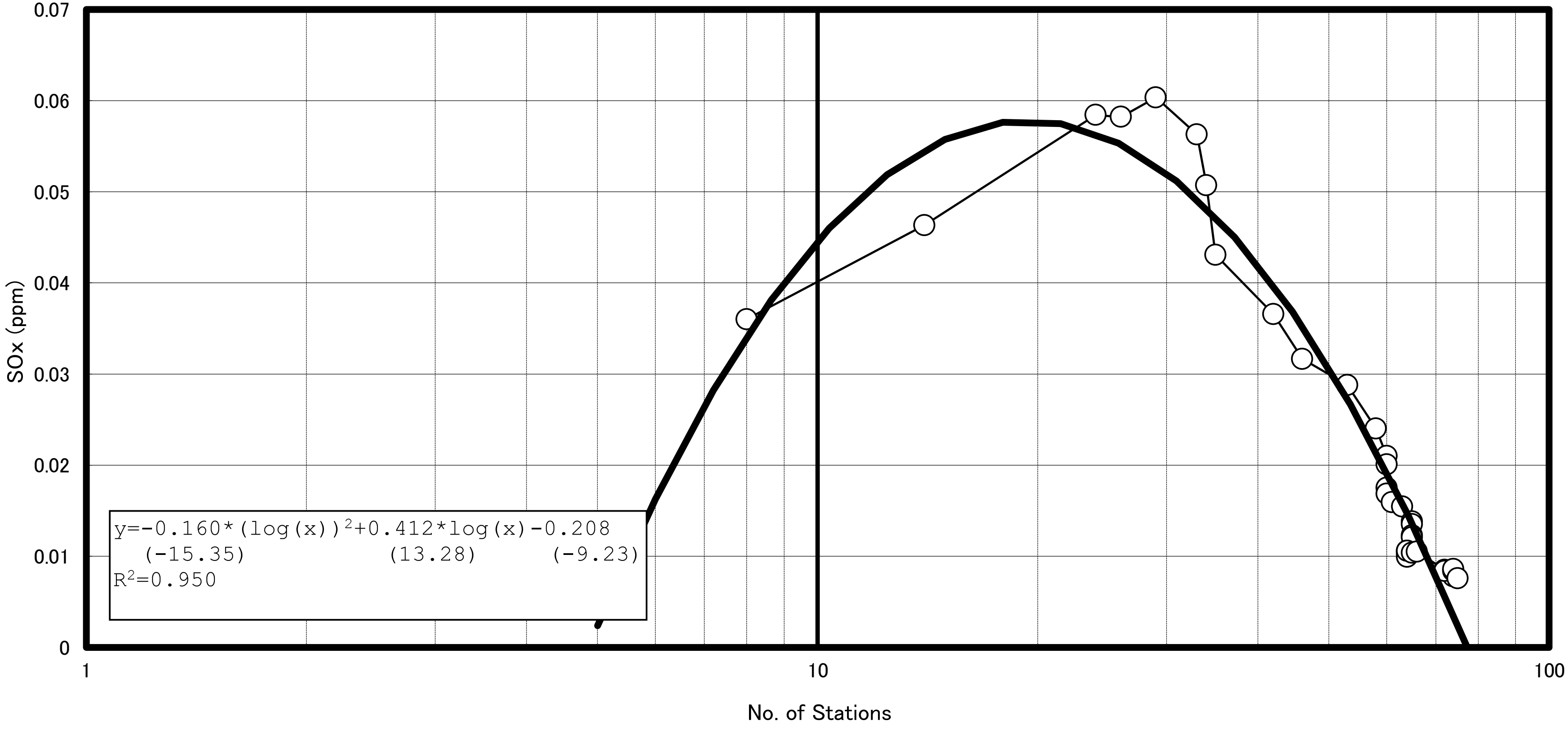
Source: EPA(Environmental Protection Agency in Japan), Taiki Jyoji Kanshi Kenkyukai (ed.) (1999) Heisei 9 nen Ippan kankyo Taiki Sokuteikyoku Kekka Houkoku (CD-ROM edition,Gyousei

Figure 2-8 SOx Concentrations and Number of Monitoring Stations in Japan



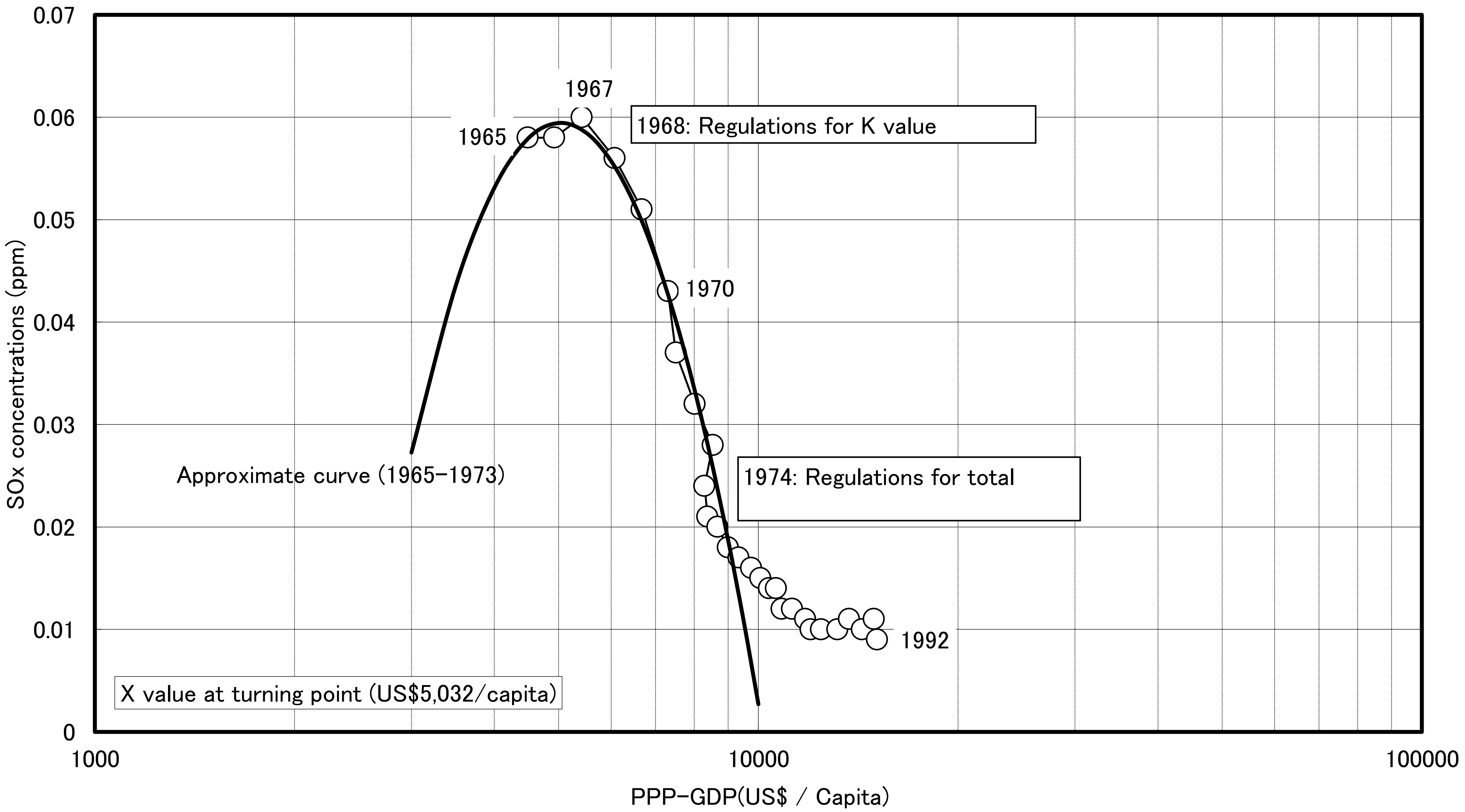
Source: EPA(Environmental Protection Agency in Japan), Taiki Jyoji Kanshi Kenkyukai (ed.)(1999)Heisei 9 nen Ippan kankyo Taiki Sokuteikyoku Kekka Houkoku (CD-ROM edition), Gyousei

Figure 2-9 SOx Concentrations and Number of Monitoring Stations in Five Major Cities of Japan



Source: EPA(Environmental Protection Agency in Japan), Taiki Jyoji Kanshi Kenkyukai (ed.)(1999)Heisei 9 nen Ippan kankyo Taiki Sokuteikyoku Kekka Houkoku (CD-ROM edition), Gyousei

Figure 2-10 Economic Growth and SOx Concentrations in Japan



Note: The value of SOx concentrations is taken as average of the value measured at 14 long term monitoring stations
Source: Envrionmental Agency (1999),
The present situation of Air Pollution in Japan adopted from Gyosei, PWT (1998): PWT(Penn-World Tables, http://www.nber.org/pwt56.html

Table 2-2 Number of Monitoring Stations in Asian Countries

	Singapore		Malaysia		Thailand		Indonesia		Philippines		Japan(SOx)
	Manual	Automatic	Manual	Automatic	Manual	Automatic	Manual	Automatic	Manual	Automatic	Automatic
1970											390
1971	21								6		599
1972	(n.a.)								6		791
1973	17								6		1,071
1974	12								4	6	1,257
1975	15								4	6	1,359
1976	17						1		(n.a.)	6	1,426
1977	17		9		3		1			6	1,488
1978	18		25		4		1			6	1,535
1979	19		147				3			6	1,587
1980	14		197				8			6	1,611
1981	14		316				9			6	1,622
1982	14		343				9			6	1,626
1983	14		(n.a.)			8(n.a.)	17			6	1,648
1984	14		(n.a.)				17			3	1,647
1985	14		(n.a.)				17			0	1,638
1986	15		241				16		8		1,625
1987	11		(n.a.)			13(n.a.)	16		(n.a.)		1,625
1988	12		(n.a.)				11				1,623
1989	12		224				11				1,622
1990	12		219				11				1,620
1991			217			17(n.a.)	17		2	5	1,621
1992				3			19	1	5	5	1,618
1993				3			19	4			1,610
1994		15		3			19	4			1,616
1995		15		3	14	23(14)	19	4			1,618
1996		15		13			19	4			1,605
1997		15		29			19	7			
1998		15		39							
1999		15		39	20	54(37)		[27(20)]			
2000				[50]				[66(59)]			
2001 after								[79(72)]			

Note: [ ] is future plan number of monitoring stations.
( ) is number of monitoring stations in rural area.

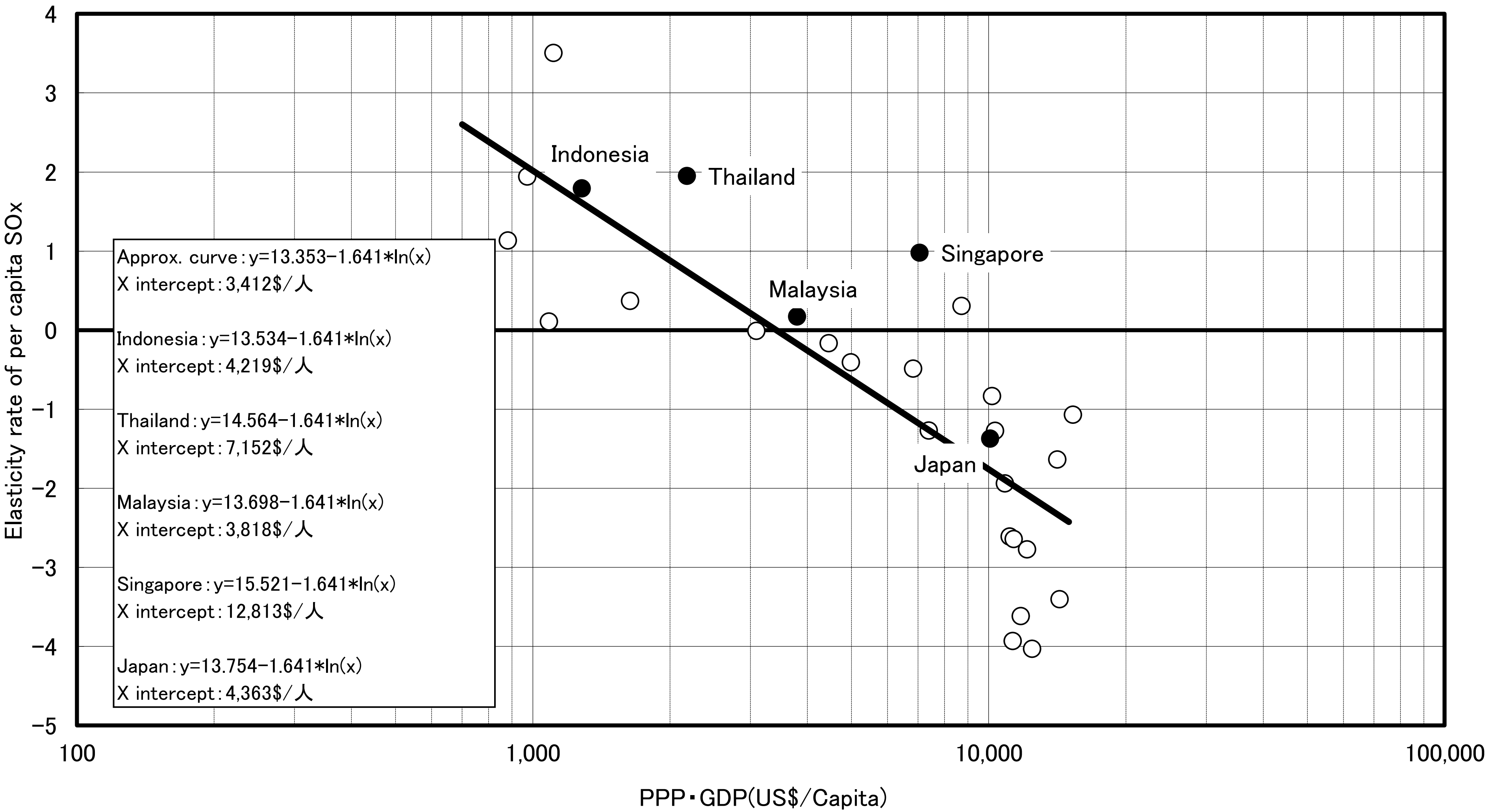
Source: Pollution Control Department, ENV, Singapore, Pollution Control Report: 1987-1997
Prime Ministers Office, Singapore, Anti Pollution Unit: Annual Report: 1970-1986
DOE, MOSTE, Malaysia, Environmental Quality Report：1990-1997
MOSTE, PCD, Thailand (1996) Pollution Thailand 1995
World Bank (1997) Urban Air Quality Management Strastegy in Asia: Jalarta Report
World Bank (1997) Urban Air Quality Management Strastegy in Asia: Metro Manila Report
Taiki Jyoji Kanshi Kenkyukai, EPA, Japan, (1999) Heisei 10 nenban Nihon no Taiki Osen Jokyo

Table 2-3 Air Quality Standard in Asian Countries

	Unit Time	Japan	Singapore	Malaysia	Thailand	Indonesia	Philippine
TSP ($\mu g/m^3$)	1 hour	200[SPM]				90	
	8-h mean						
	24-h mean	100[SPM]	(PM10 150)	260(PM10 150)	330(PM10 120)	230(PM10 150)	230(PM10 150)
	Annual mean		(PM10 50)	90(PM10 50)	100(PM10 50)		90(PM10 60)
SO_2 ($\mu g/m^3$)	10 minutes			500(0.19ppm)			
	1 hour	(0.1ppm)		350(0.13ppm)	780(0.30ppm) (local: 1300)	900	
	24-h mean	(0.04ppm)	365(0.14ppm)	105(0.04ppm)		365	180(0.07ppm)
	Annual mean		80(0.03ppm)			60	80(0.03ppm)
CO (mg/m^3)	1 hour		40(35ppm)	35(30ppm)	34.2(30ppm)	30	30
	8-h mean	(20ppm)	10(9ppm)	10(9ppm)	10.26(9ppm)		10(9ppm)
	24-h mean	(10ppm)				10	
NO_2 ($\mu g/m^3$)	1 hour			320(0.17ppm)	320(0.17ppm)	400	
	24-h mean	(0.04-0.06ppm)		(0.04ppm)		150	150(0.08ppm)
	Annual mean		100(0.053ppm)			100	
HC ($\mu g/m^3$)	3-h mean					160	
O_3 ($\mu g/m^3$)	1 hour	(0.06ppm)	235(0.12ppm)	200(0.10ppm)		235	
	8-h mean			120(0.06ppm)			60(0.03ppm)
	1 year					50	
Pb ($\mu g/m^3$)	24-h mean					2.0	
	1 Month mean				1.5	1.0	
	3 Month mean		1.5	1.5			1.5
	Annual mean						1.0

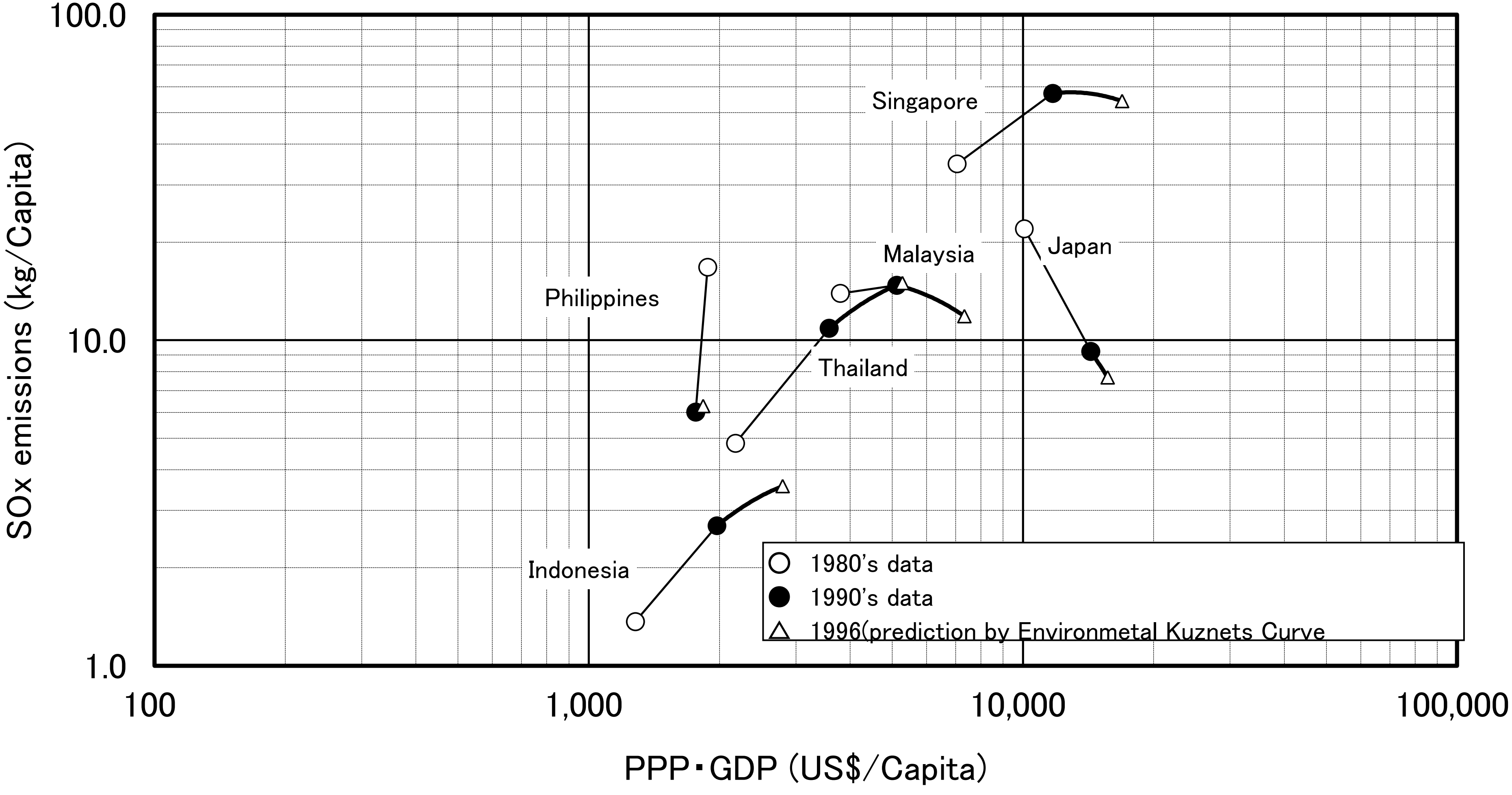
Source: EPA(Environmental Protection Agency in Japan), Taiki Jyoji Kanshi Kenkyukai (ed.)（1999）*Heisei 10 nenban Nihon no Taiki Osen Jokyo*, Gyousei, Ministry of Environment,Singapore(1998)Annual Report ’97, MOSTE･DOE(1998)Malaysia Environmental Quality Report 1997, MOSTE･PCD(1996)Pollution Thailand 1995, BAPEDAL(1999)Peraturan Pemerintah Republik Indonesia Nomor 41 Tahun 1999, Philippine(1999)Philippines Clean Air Act of 1999

Figure 2-11 Elasticity Analysis for SOx Emissions and PPP.GDP



Note: Assume latecomer advantage as per EKC for developing countries, they can achieve turning point at lower level of income per capita in comparision to developed countries. However, the turing points of PPP.GDP per capita for Singapore and Thailand are higher than Japan. The reasons may be: possibility of overestimation of PPP.GDP, choice for

Figure 2-12 Environmental Kuznets Curve for Souteast Asian Countries



Chapter 3
Cost Benefit Analysis of the Sulfur Dioxide Emission Control Policy in Japan

Ikuho KOCHI
Nicholas School of the Environment, Duke University /
Graduate School for International Development and Cooperation, Hiroshima University

1. Introduction

Cost Benefit Analysis (CBA) is a technique intended to evaluate the economic efficiency of public policy, using as a metric a monetary measure of the policy cost and benefit. Although there are many criticisms of CBA when applied to environmental decision-making , CBA, when properly applied, has concrete advantages including 1) improving the transparency of government action, 2) raising environmental knowledge and 3) enabling the comparison of alternative policies (Kopp et al, 1997). Moreover, the recent General Accounting Office and Morgenstern studies suggest that CBA has some impacts on regulatory development (GAO 1998, Morgenstern 1997).

For example, in the United States, this policy decision tool has been authorized by Executive Order 12291 in 1981 and Executive Order 12866 in 1993, which required all major federal regulations to pass a cost benefit test before implementation. The field of air quality management is also required to conduct CBA based on the Clean Air Act Amendments of 1990, section 812.

Japan, by contrast, does not have any systematic analysis of the costs involved, or any CBA (OECD 1994). However, the economic evaluation could make environmental policy efficiently meet the current diversified environmental problems, such as global warming, and improve the quality of that policy. In this report, a retrospective analysis on air quality management in Japan is conducted using sulfur dioxide (SO_2) emission control policy as an example to examine the efficiency of Japan's environmental policy.

2. SO_2 emission control policy in Japan

Post-1967 data from nation-wide monitoring stations indicate that average annual concentrations of atmospheric SO_2 experienced a downward trend following their peak of 0.04 ppm in 1967 (Figure 3-1). This could be the result of the introduction of emission controls called "K-value control " in 1968. Then, the SO_2 measure was reinforced in 1974 by introducing the "Total Emission Control" for the areas where the regular emission standards were insufficient to meet the SO_2 ambient standard .

With these new measures, the private sector also promoted various measures such as installation of tall chimneys, fuel desulfurization, fuel conversion to LNG (liquefied natural gas), and installation of fuel-gas desulfurization facilities (CJEBAP 1997). As a result, SO_2 concentration dramatically dropped and the environmental standard was attained at every monitoring station in 1983. The concentration level continued to decline after attainment of the environmental standard, because both K-value Controls and Total Emission Controls strictly regulated new pollutant emission facilities.

This paper divides SO_2 emission control policy into three stages based on history, and conducts CBA in each stage to determine the changes in efficiency of the policy. The first stage is from 1968 to 1973, when K-value Control played a prominent role. The second stage is from 1974 to 1983, when Total Emission Control was the main control strategy. The third stage is from 1984 to 1993, when the new source regulation became effective.

3. Method

3.1 Cost and Benefit items

The first step of a CBA is to determine the policy's costs and benefits. Table 3-1 summarizes the cost and benefit items of previous CBA studies for air pollution control policy conducted by the USEPA and OECD.

The USEPA study performed a CBA of the entire Clean Air Act (CAA) from 1970 to 1990, and assessed the benefits and costs related to all air pollutants. The direct benefits included reduced incidence of a number of adverse health effects (hereafter health benefits), improvements in visibility, and avoided damages to soil and agricultural crops. The direct costs of implementing policy included annual compliance expenditures in the private sector and program implementation costs in the public sector. The study suggested that there are indirect costs not readily quantified, such as the possible adverse effects of CAA implementation on capital formation and technological innovation. (USEPA 1997).

The OECD study conducted a CBA of SO_2 emission control in Europe. The direct benefits included avoided damage to materials, crops and aquatic ecosystems, and health benefits. The direct costs included capital investment for pollution control devices and operating costs of those devices in the private sector (OECD 1981).

To summarize these studies, the benefits of air control policy could be health benefits, avoided damages to materials, crops and ecosystems, and improvement of visibility. The costs associated with implementing environmental policies include costs in three social sectors: private, government and society.

Conceptually, the analysis should include all benefits and costs related to the policy at issue, but there is an inevitable data limitation. Moreover, the essence of CBA is covering large proportion of costs and benefits of that policy (OECD 1981). Thus, this analysis applies to health benefit; especially chronic bronchitis, a primary concern of SO_2 pollution control policy in Japan as a policy benefit. The cost for pollution control by the private sector is applied as a policy cost, because the proportion of the private sector's investment in air pollution measures is large.

3.2 Discount Rate (SDR)

Taking into account the argument that 'environmental' projects should be subjected to a lower discount rate (Winpenny 1991), SDR is set at 0%. 2.5% and 9% SDR are also set referred to extreme ranges of commercial interest between 1970 and 1990 in Japan. In the analysis, r stands for SDR and is applied for both cost and benefit estimations.

4. Benefit Analysis

This section first introduces the method for economic valuations of human health, focused on morbidity. Then, the model of valuating human benefit developed from previous studies is determined. Finally, results of the economic benefits analysis are presented. All Japanese yen values are rounded and are in 1993 yen.

The procedure used in this analysis for estimating health benefit is based on Freeman, and it involves three steps (Freeman 1982). These steps are 1) Determine the relationship between exposures to different levels of air quality and human health as measured by morbidity rates, 2) Use this relationship to predict the changes in morbidity associated with some specified change in air quality and exposure to pollutants and 3) Use monetary measures of willingness to pay to assign values to the predicted changes in morbidity. In the following section, these steps are applied to the Japan's SO_2 emission control respectively.

4.1 Relationship between SO_2 concentration and Chronic Bronchitis

There are several approaches to getting better information on the relationship between air quality and human health, including microepidemiology studies and laboratory studies of animals and of clinical effects on humans. The most common are macroepidemiology studies. Macroepidemiology studies typically use data for morbidity rates for population groups aggregated by country or city, and use multivariate statistical techniques to test whether there is a positive association between air pollution and morbidity (Freeman 1982).

In Japan, the EPA conducted a macroepidemiology study from 1980 to 1985. This study examined the relationship between the rate of major respiratory illness for population groups aggregated by 51 cities, a sample of 98,695 children and 167,165 adults, and the concentration of criteria air pollutants including SO_2. Unfortunately, there is no study about the relationship between chronic bronchitis and SO_2 concentrations. So this paper assumes substitutes asthma for chronic bronchitis. Children are better subjects than adults for measuring pollution effects because they have fewer confounding variables such as smoking habits. Therefore this analysis uses the dose-response function between SO_2 and morbidity of girls' asthma to estimate the policy benefit of reducing the morbidity of chronic bronchitis. Figure 3-2 shows this dose-response function as statistically significant ($p<0.05$) (EPA 1986).

4.2 Changes in morbidity associated with SO_2 concentration

The nation-wide annual average SO_2 concentration is available from Japan's national air monitoring record (EPA 1998). Although nation-wide annual average concentrations may not relate to real health damage, they serve to evaluate the macro trend of policy impacts. Thus, these data are applied, and the concentration changes in each policy stage are as follows:

Stage 1 (1968-1973)	0.0385ppm→0.0185ppm
Stage 2 (1974-1983)	0.0185ppm→0.0070ppm
Stage 3 (1984-1993)	0.0070ppm→0.0050ppm

From the concentration change data and dose-response function mentioned above, morbidity changes are calculated as follows.

Stage 1 (1968-1973)	4.918%→3.492%
Stage 2 (1974-1983)	3.478%→2.650%
Stage 3 (1984-1993)	2.650%→2.506%

4.3 Monetary measures of willingness to pay

What is now known is that the reduction in air pollutant concentrations resulted in a reduction in morbidity risk. It is this reduction in morbidity risk that is valued in a monetized benefit analysis. Individuals willingness to pay (WTP) for small reductions in morbidity are summed over enough individuals to infer the value of a statistical health problem avoided. This is different from the value of a particular, identified health saved (USEPA 1997).

There are two major approaches to measure the WTP for statistical health problem avoided. One is to observe actual behavior and choices where individuals actually exchange or trade off changes in their risk levels for other things that have a monetary value such as a wage. The other approach is to conduct surveys, asking individuals a series of questions about hypothetical situations involving safety-money trade-offs (Freeman 1982). However, both of them require large sample surveys, which are difficult to find in Japan. Thus, in this analysis, WTP is estimated by using the cost of illness approach (COI).

COI estimates include all out-of-pocket costs of the illness including the present discounted value of the stream of medical expenditures related to the illness, as well as the present discounted value of the stream of lost earnings related to the illness. These COI estimates are likely to substantially understate total WTP to avoid an illness, because of the insufficient information, and the lack of important value components such as avoiding the pain and suffering associated with the illness (USEPA 1997). Cropper et al. reported WTP estimates were from 3.4 times to 6.3 times the full COI estimates (Cropper et al. 1990), but this paper does not modify the results of COI estimation because of the high uncertainty of the relationship between WTP estimates and COI estimates in Japan.

Chronic bronchitis is one of the only morbidity endpoints that may be expected to last from the initial onset of the illness throughout the rest of the individual's life. The full COI could be estimated using the average annual lost earnings and the average annual medical expenditures with the assumption that 1) lost earnings continue until age 65, 2) medical expenditures are incurred until death, and 3) life expectancy is unchanged by chronic bronchitis (Cropper et al. 1990).

Values derived from these assumptions depend crucially on the age of the population at risk. Cropper et al. presented values for age populations of 30, 40, 50 and 60 years old (Cropper et al 1990). Euisoon Shin et al. used the average age for the population as a whole (Euisoon Shin et al. 1997). In this analysis, the population at risk assumes the average age for the population as a whole at each policy-starting year.

Equation 1 shows the above benefit estimation model (see Box 1). Benefit is the sum of social medical expenses (BMt) during the eth year and the social labor losses (BLt) during the lth year, where e is remaining lifetime, and l is years in labor force remaining. Table 3-2 shows e and l data in each policy stage.

Medical expenses and labor losses in tth year can be calculated as follows (refer to equations (2) and (3) in Box 1). BMt is derived by multiplying the reduction in the expected numbers of respiratory patients and annual medical expenses for the respiratory illness (Mf). The expected numbers of respiratory patients reduced by SO_2 emission control policy are determined by multiplying these morbidity changes by population ((Ds-Df)*Pf). From the morbidity change data found above and the population in the policy end year, these numbers are found to be dropping, with

1571 thousand, 990 thousand and 180 thousand at the first, second and third stages respectively. Data on annual medical expenses for respiratory illness are obtained from medical statistics in Japan (MOW 1993) and shown in Table 3-3.

Values of labor losses (BLt) consider only the population who are working. BLt should be divided into two parts: hospital visits and hospital admissions. Values of each case are derived by multiplying the reduction in number of workers due to morbidity, the daily average wage, and the days of work lost because of the illness.

The analysis assumes that 83% (A) of all respiratory patients are hospital outpatients, and the rest, of 17 % (E) are admitted into the hospital. The reduction in number of workers due to morbidity is a proportion both of above 15 years (Wf), and productive workers, which is 44% of all hospital visit (B) and 31% of all hospital admission (G) in the expected numbers of respiratory patients. Duration of hospital visit is assumed to be 52 days (c) per year and duration of hospital admission is assumed to be 15 days (H) per year. These assumptions are based on the medical statistics of respiratory illness patients in 1993 (MOW 1993). Workers are assumed to lose the whole daily wage during the hospital stay (Ff) and half of the daily wage per hospital visit (Euisoon Shin et al. 1997).

The portion of the whole population that is above 15 years old (Wf) and the average income per day (Ff) in each policy stage are shown also in Table 3-3. As a result, the policy benefit in each policy stage is determined (Table 3-4). It appeares that, where the discounting rate is 2.5%, the policy benefit of stage 1 is 35,137.4 billion yen; at stage 2, it is 34,457.2 billion yen and at stage 3, it dramatically falls to 8,120.9 billion yen.

5. Cost Analysis

Box 2 shows the Cost Estimation Model. To balance the cost cycle with the benefit cycle, it is hypothesized that the cost rose during the eth year continuously. This cost cycle is shown in Figure 3-3, and consists of fuel conversion costs, capital investment costs, and running costs. Fuel conversion costs and running costs are assumed to rise constantly during the eth year, and all capital investment during the policy period are assumed to arise at the end of the policy period, and would rise again 14 years later along with renewal of the facilities.

Table 3-5 shows the calculation methods and data sources of each cost. Fuel conversion includes changing to low-sulfur crude oil, low-sulfur heavy oil, and LNG. Those costs are calculated by multiplying a price difference between high-sulfur fuel, which had been used until the policy implementation, and low-sulfur fuel. Capital investments are calculated based on the production record of tall chimneys, fuel-gas desulfurization facilities and fuel desulfurization facilities. Because of data limitations, running cost is calculated only for fuel-gas desulfurization facilities. The results of are shown in Table 3-6.

Table 3-7 shows the following cost estimate results. Where SDR is 2.5%, the policy cost is 6,565.4 billion yen in stage 1, it increases to 16,385.8 billion yen at stage 2, and in stage 3 falls to 8,494.1 billion yen.

Table 3-8 summarizes the above cost and benefit estimation results and the cost benefit ratio. Where the SDR is 2.5%, the cost benefit ratio is 5.35 at stage 1. It dramatically decreases to 2.10 at stage 2, then further drops to below 1.0; 0.96 at stage 3.

6. Conclusions

This report presents a Cost Benefit Analysis of SO_2 emission control policy in Japan. The policy is divided into three stages by epochal policy reinforcement, and conducts CBA in each stage to figure out the change in policy efficiency. Health benefits are interpreted policy benefits and costs in the private sector are interpreted as policy costs.

As a result, the cost benefit ratio in each stage is clear. Where the SDR is 2.5%, the cost benefit ratio is 5.35 in stage 1(1968-1973), 2.10 in stage 2 (1974-1983) and 0.96 in stage 3 (1984-1993). The OECD conducted a CBA of sulfur oxide control in Europe, and reported cost benefit ratios between 0.6 and 5.8 (OECD 1981). Thus the result of this analysis is reasonable in light of CBAs for SOx emission control policy. This analysis yields the following conclusions:

1) The economic effectiveness of SO_2 emission control policy in Japan has decreased as air quality improved.

2) New pollution sources regulations lose their validity from the economic perspective because the cost benefit ratio is below 1.0 at stage 3.

Further examination is needed to affirm the second conclusion, since the benefits could be underestimated as a result of using the COI. However it can be assumed that Japan needs to reconsider its SO_2 emission control policy from the economic perspective.

Currently Japan faces a variety of environmental problems not only in air quality but also in water quality and waste management. There is an urgent need to take measures to address these problems efficiently. This report suggests that Japan’s environmental policy tends to lose its efficiency when environmental quality is improved, and needs to take into account economic perspectives in its decision making process.

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Box 1 Benefit Estimation Model

Benefit＝

$$\sum_{t=0}^{e} BMt/(1+r)^{t} + \sum_{t=0}^{l} BLt/(1+r)^{t} \qquad (1)$$

BMt: social medical expense in year t
BLt: social labor loss in year t
e: remaining life time (life expectancy at average age of population)
l: years in labor force remaining (65-average age of population)

and

BMt＝(Ds－Df)･Pf･Mf (2)
BLt＝ Hospital visit[A･(Ds－Df)･Pf･Wf･B･Ff／2･C] +
Hospital admission[E･(Ds－Df)･Pf･Wf･G･Ff･H] (3)

where;

Ds: morbidity at policy starting year
Df: morbidity at the end of policy period
Pf: population at the end of policy period
Mf: average per capita medical expenses for respiratory illness at the end of policy period
Wf: working ratio above 15 years old at the end of policy period
Ff: average income/day at the end of policy period
A=0.83: hospital visit ratio in all respiratory patients
B=0.44: product population ratio in the hospital visit respiratory patients
C=52: annual average hospital visit days of respiratory illness patients
E=0.17: hospital admission ratio in all respiratory patients
G=0.31: product population ratio in the hospital admission respiratory patients
H=15: annual average hospital admission days of respiratory illness patients

Source) Cropper et al. (1990), MOW (1993).

Box 2　Cost Estimation Model

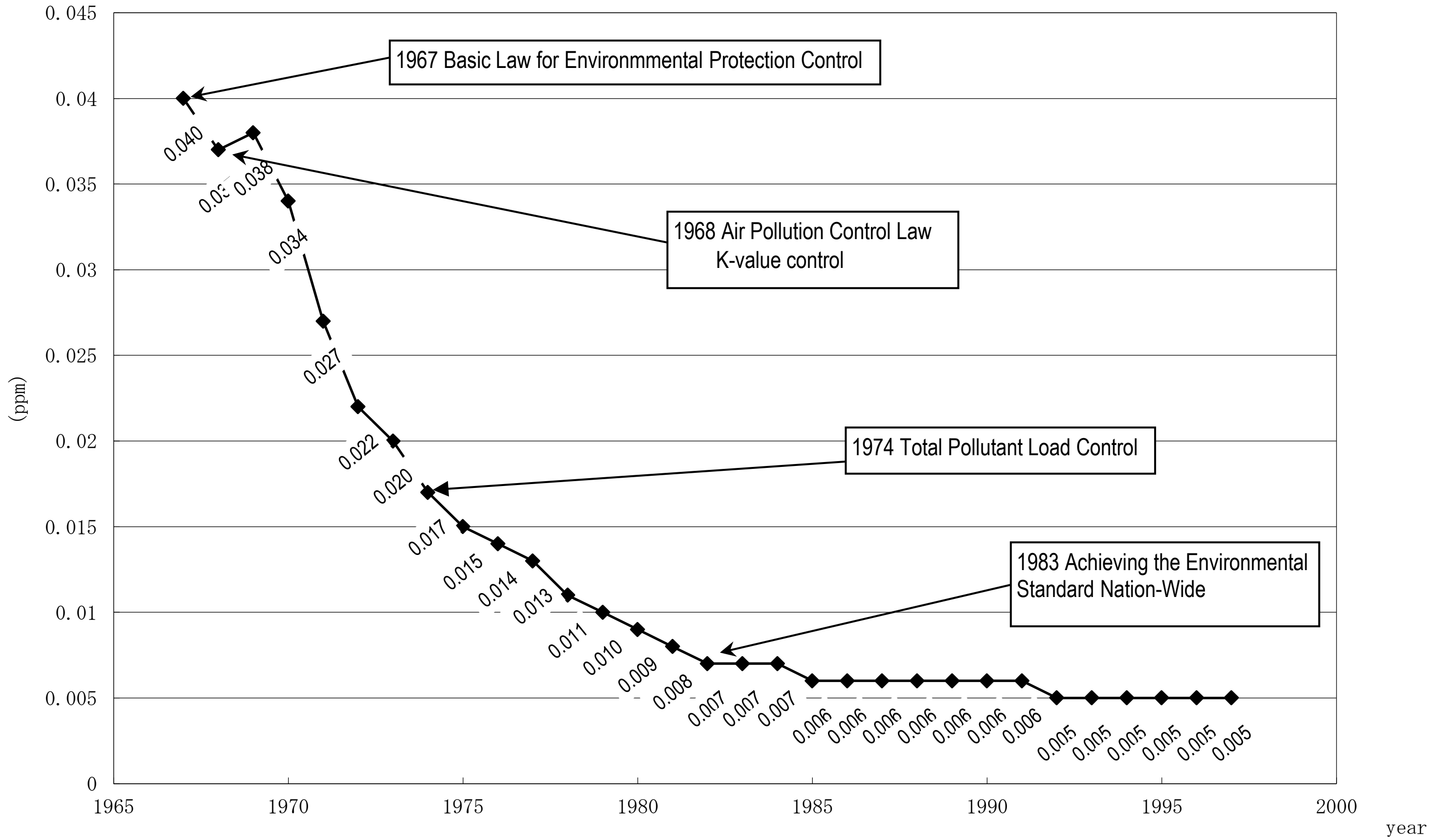
Cost＝

$$\sum_{t=0}^{e} Ct/(1+r)^{t} \qquad (4)$$

Ct： cost at t[th] year

e：remaining life time (from benefit estimation)

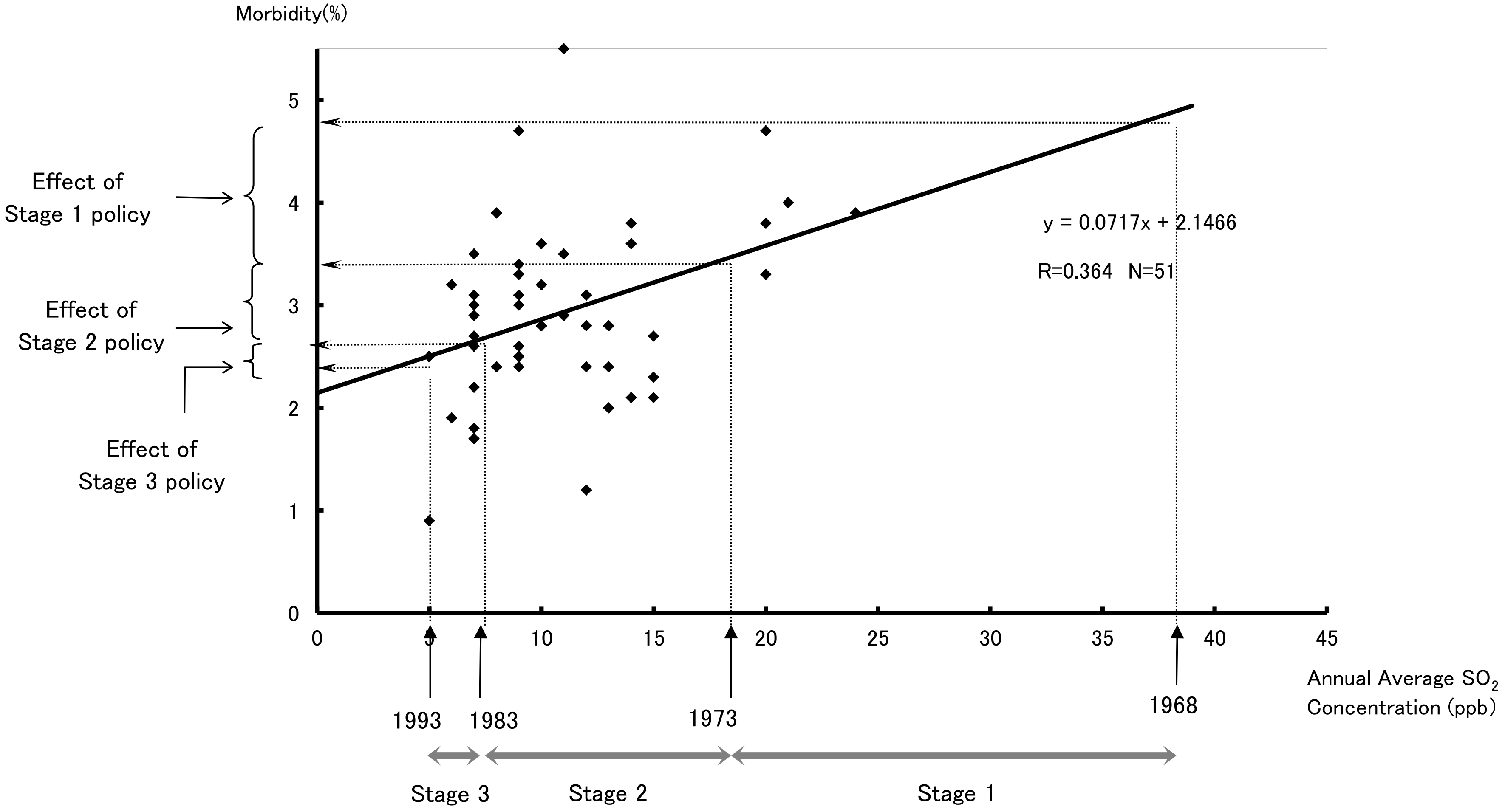
Figure 3-1 Change in Average Annual SO_2 Concentration and SO_2 Emission Control Policy in Japan (1967-1997)



Note) The concentration data is average from nation-wide environment monitoring stations. The number of station increased from 113 to 1375 through 1967 to 1997.

Source) Government of Japan (1971), EPA (1998).

Figure 3-2 Does-Response Relationship between SO_2 and Morbidity of Girl's Asthma and Policy Effect



Source) EPA (1986).

Table 3-1 Benefits Items and Cost Items of Air Quality Management

		EPA (1997)	OECD (1981)
Control policy Objective		All Air pollutant	SO_2
Benefits	Human Health		
	Mortality	√	
	Morbidity	√	√
	Materials		√
	Agriculture	√ (Including Soil)	√
	Ecosystem		√ (Only Aquatic)
	Visibility	√	
Costs	Private	√	√
	Government	√	
	Society	(√)	

Source) USEPA (1997), OECD (1981).

Table 3-2 The Period of Benefit Arising in Each Policy Stage

	Stage 1	Stage 2	Stage 3
Policy starting year	1968	1974	1983
Average Age	32	34	38
Life expectancy at Average Age (*e*)	44	44	41
65 years old – Average Age (*l*)	33	31	27

Source) Management Coordination Agency (1973, 1983 and 1993).

Table 3-3 Basic Data for Benefit Estimation

	Stage 1	Stage 2	Stage 3
Policy End Year	1973	1983	1993
Wf: Working Ratio of Avobe 15 Years Old	65	64	64
Ff: Average Income /Day (yen:1993 year price)	8,451	11,645	13,107
Mf: Annual Average Medical Expense for Respiratory Illness/ capita (yen 1993 year price)	765,308	1,203,355	1,641,174

Source)Management Cordination Agency in Japan (1973,1983,1993,1997), MOW (1993).

Table 3-4 Benefit Estimation Results

(unit:billion yen (1993 year price))

SDR=0%

	Stage 1	Stage 2	Stage 3
Medical Expenses	54,106.8	53,596.4	12,383.9
Labor Losses	3,018.0	2,428.0	434.1
Total	57,124.8	56,024.3	12,817.9

SDR=2.5%

	Stage 1	Stage 2	Stage 3
Medical Expenses	33,069.9	32,757.9	7,803.6
Labor Losses	2,067.5	1,699.2	317.2
Total	35,137.4	34,457.2	8,120.9

SDR=9%

	Stage 1	Stage 2	Stage 3
Medical Expense	14,260.8	14,126.2	3,475.3
Labor Loss	1,017.6	860.6	170.9
Total	15,278.4	14,986.8	3,646.2

Figure 3-3 Benefit Cycle & Cost

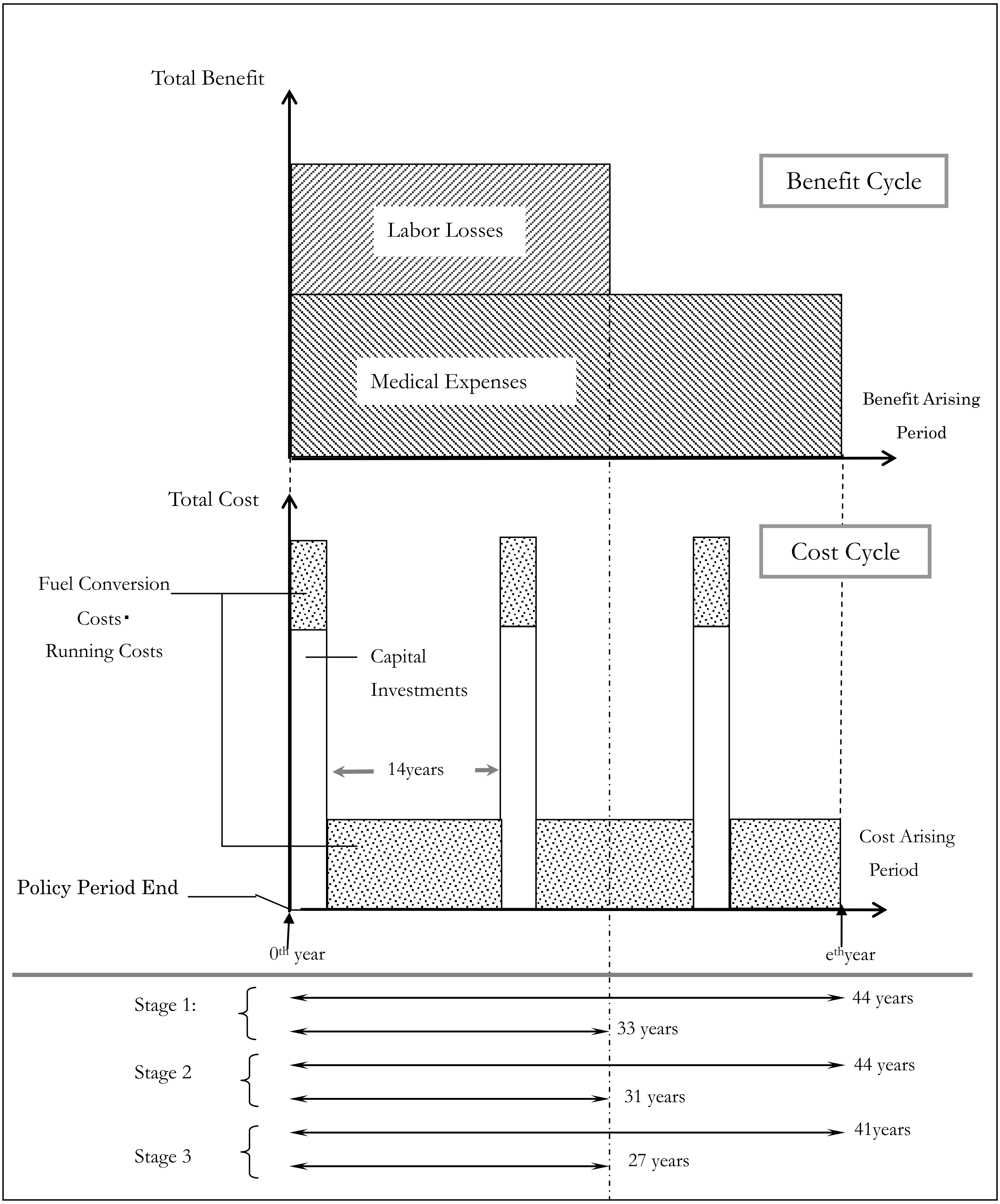


Table 3-5 Cost Calculation way and Data Source

Cost Item		Calculation Way	Data Source
Fuel Conversion	Low-Sulfur Crude Oil	(Low-sulfur Crude Oil Price－High-sulfur Crude Oil Price)× Amount of Low-sulfur Crude Oil Import	Oil Association (1985、1992)
	LNG	(LNG price- Heavy Oil Price)× Amount of LNG Import	EDMC(1997)
	Low-Sulfur Heavy Oil	(Low-sulfur Heavy Oil Price- High-sulfur Heavy Oil Price)× Amount of Low-sulfur Heavy Oil Production	*Sekitsuu*(1984、1994)
Capital Investment	Tall Chimney	Production Record	Japan Society of Industrial Machinery Manufactures, "Kankyo Sochi no Seisan Jisseki (Annual Report)
	Fuel-gas Desulfurization facility		
	Fuel Desulfurization facility		
Running Cost	Fuel-gas Desulfurization facility	Running Cost(hundred million yen)＝0.3136×Capacity of Dealing with Fuel Gas(10000Nm3/h)+0.4	Japan Society of Industrial Machinery Manufactures, (1986)

Table 3-6 Basic Data for Cost Estimation

（unit：billion yen(1993 year price)）

Capital Cost

	Total 1968-1973	Total 1974-1983	Total 1984-1993
Fuel-gas desulfurization facility	153.9	826.3	363.2
Fuel desulfurization facility	326.9	291.7	191.4
Tall Chimney	210.3	103.7	83.2
Total	691.1	1,221.6	637.8

Fuel Conversion and Running Cost

	Average 1968-1973	Average 1974-1983	Average 1984-1993
Low-sulfur Crude Oil	0.2	0.2	0.1
LNG	0	117.4	131.4
Low-sulfur Heavy Oil	121.2	315.8	107.5
Runnning Cost for Fuel-gas de	52.9	48.5	28.7
Total	174.3	481.9	267.7

Table 3-7 Cost Estimation Results

（unit：billion yen (1993 year price)）

	Stage 1	Stage 2	Stage 3
SDR=0%	10,608.1	26,572.9	13,157.6
SDR=2.5%	6,565.4	16,385.8	8,494.1
SDR=9.0%	3,045.7	7,445.2	4,041.3

Table 3-8 Cost benefit ratio

	Stage 1	Stage 2	Stage 3
SDR =0%	5.39	2.11	0.97
SDR =2.5%	5.35	2.10	0.96
SDR =9.0%	5.02	2.01	0.90