Policy Implication of Economic-Environmental Linkage in Korea

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Abstract: While the rapid growth of the Korean economy has been extensively researched, relatively little attention has been paid the environmental consequences. The first part of the paper reviewed the evidence on the relationship between economic growth and the state of the environment within the context of the interdependence between the three economic spheres. The latter part of paper identified the environmental implications of economic growth for Korea. Based on the Environmental Kuznet's Curve (EKC) test, Korean economy during the past decades appears to be broadly consistent with a positive pattern of interaction between economic growth, industrialization and the environment. Even if economic growth in Korea contributes to slightly positive structural and technological effects that offset the negative scale effects of local air pollutants, economic growth does not address the cumulative effects of pollution. In this context, Korea needs a policy for structural and technological changes that "dematerialization" and "depollute" economic activities. Such a policy will induce profound changes in the energy intensity industrial structure.

INTRODUCTION

After the Rio Summit in 1992 Countries around the world began to ask. "What is the relationship between economic growth and environment?" and "Is economic growth a threat to the environment?" The common notion behind these questions is that, on a global scale, there is serious doubt that continuing growth and a sustainable environment are compatible objectives. In this paper, "economic growth" is defined as the quantitative increase in the scale of the physical dimensions of economy; for example, the flow rate of matter and energy through the economy from the environment as raw material and back to the environment as waste (Daly 1987). One thesis about the relationship between economic growth and the environment is that economic growth and industrialization should lead to an improved environmental quality. According to Stern (1996), the Environmental Kuznet's Curve, which claims that there is a relationship between development and environmental degradation, suggests that the long-term effect of economic growth is an improved environmental quality. In contrast, there is considerable evidence that economic growth and industrialization are associated with the dramatic declines in environmental quality. It is now widely recognized that pollution and resource depletion are critical issues associated with the dark side of economic growth. This is, particularly, true in the developing countries where this situation creates contradictory conditions.

Thus, to have a clear understanding of the relationship between economic growth and the environment, one must view those problems within the context of a global framework. This paper analyses some different aspects of the linkages between the environment and economic growth in economies at different stages of development. The paper's main concern lies with the emerging economies known as the Newly Industrialized Countries (NICs), particularly South Korea. In this context, the debates about the relationship between

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economic growth and environment can be clearly examined by analyzing the course of South Korea's development. Korea serves as an appropriate case for this study because Korea has been transformed itself from a survival economy to an NIC in just one generation.

This paper is organized into four sections. Section II will address the positive and negative linkages of economic growth to the environment. Section III will address the mechanisms that cause economic growth to have an impact of on the environment and will include scale, structure and technological effects. Section IV will outline contemporary the international difference with respect to economy-environmental linkages in terms of system-wide perspectives such as the framework of a political economic approach. For purpose of analysis, and bearings in mind the ever-increasing divergences among developing countries, the countries are divided into core, semi-peripheral and peripheral groups. On addition, the environmental implications of NICs within the context of a new international division of labor (NIDL) are reviewed. The final Section will analyze the environmental implications of economic growth for Korea. This analysis for Korea will test the Environmental Kuznet's Curve (EKC) for Korean data.

THEORETICAL OVERVIEW OF THE ECONOMIC-ENVIRONMENTAL LINKAGE

Positive Linkages of Economic Growth to the Environment

There is an arguments is that economic growth and industrialization will lead to an improved environmental quality. Proponents of this argument view economic growth as a panacea for environmental problems. For example, at a UN conference in Stockholm in 1972, the slogan "pollution of poverty" implied that environmental quality improved as societies became wealthier (Adams 1990: 36). This belief is supported by the Environmental Kuznet's Curves (EKC) hypothesis, which holds that there is an inverted U-shaped relationship between environmental degradation and per capita income and consequently implies that economic growth reduces the environmental impact of economic activity. Therefore, rather than being a threat to the environment as argued in, for example, *The Limits to Growth*, economic growth is the means to environmental improvement (Stern 1996). According to Panayotou (1993), the mechanism of the environmental Kuznet's curve is as follows:

- Initially, a growing economy consumes larger quantities of energy, raw materials and generates increasing volumes of waste.
- At higher levels of development, structural and technological change, coupled with increased public's environmental awareness and ability to pay for a cleaner environment and government response to environmental policy such as by requiring stricter regulations and investments in environmental infrastructure, result in a gradual reduction of environmental degradation.

After comparing the empirical evidence on the relationship between air and water quality indicators and the scale of economic activities, Grossman (1995) pointed out that economic growth does not always contribute to environmental degradation. In a certain income ranges, economic growth will lead to a short term worsening of environmental features; however in the medium to longer term, there will be a positive relationship between income levels and a clean environment.

According to the World Resource Institute (1990), higher incomes tend to be associated with a higher proportion of the population having access to safe drinking water. The improvements associated with higher per capita income are primarily attributable to an increased investment in sewage and industrial wastewater treatment although stricter effluent standards also play a role. The situation is similar concerning in air pollution tendencies.

By the end of the 1960s, the majority of developed countries had reached a higher level of economic growth, which in turn brought about environment improvements such as cleaner air and safer water. As Berckerman (1992) and Panayotou pointed (1997), this improvement was partly due to the environmentalist movement and the socio-economic structural changes that resulted from increased enforcement of environmental regulations and clean technology. Therefore, it shows that there is a positive correlation between income growth and improved environmental conditions. Thus, it appears that the best way to improve the environment is to foster economic growth.

Negative Linkage of Economic Growth to Environment

Since the early 19th century, the conflict between economic growth and environmental protection has been discussed in terms of resource constraints. There are growing concerns that continued expansion of the global economy will cause irreparable damage to the environment and result in global warming and a reduced quality of life for future generations. This pessimistic perspective is based on following the beliefs:

- More output requires more input, and so the natural resources will inevitably be depleted from the continued growth of production and consumption.
- More output means more emissions and wastes.

Accordingly two major reasons for unsustainable economic growth are the exhaustion of natural resources and the global scale of environmental pollution with its associated threat of climatic changes in particular. These serious concerns indicate that economic activity will eventually exceed the 'carrying capacity' of the biosphere (Daly, 1987). A report by the Club of Rome, entitled *The Limits to Growth,* predicted that the world's natural reserves would soon be exhausted. In particular, Meadows *et al.* (1972) suggested that within 50 to 100 years, there would be a global disaster resulting in the collapse of the industrial economy. Moreover, it has recently been recognized that economic growth leads to a greatly increased concentration of carbon dioxide in the atmosphere, which will have a significant impact on the global climate particularly by causing global warming associated with the greenhouse effect. In addition, population growth and rapid industrial development are pushing forests, soils, water, and fisheries beyond their limits. Consequently, a pessimistic viewpoint is that economic growth and environmental protection are incompatible. Those who hold this view argue that to avoid such a tragic outcome, global economic expansion must cease and there must be the transition to a steady-state economy, which means zero economic growth, zero population growth and zero increase in the scale of the economy (Daly 1987).

Mechanisms for the Impact of Economic Growth on the Environment

As Daly (1987) points out, the benefits of continued economic growth that will eventually exceed the carrying capacity of the biosphere, and there will be a trade-off relationship with environment concerns in terms of the inevitable negative effects on environment. On the contrary, the World Bank (1992) and Grossman (1995) have noted that the composition of economic output and the technology have an important role in determining the depletion rate of natural resources. In this context, a number of different economic growth channels that include preferences, technology and economic structure affect the level of environmental quality (Sharfik 1994). Following Grossman (1995), Shafik (1994), O'Connor (1994) and the World Development Report (World Bank, 1992), the different effects of economic growth on the environment can be categorized into four types: scale effects, composition effects on industrial structure, and technology effects, and income effects.

Scale effects refers to the notion that continued economic growth will generate significant pressure on the environment by the expansion of production and consumption, and contribute to a greater use of natural resources and pollutant greater emissions. Barry Commoner (1971) observed that the total environmental burden **(EB)** created by human activity is a function of three factors: population **(P)**, affluence **(A :** a proxy for production and consumption, in other words, economic growth), and technology **(T)**, and this is how the pattern of production and consumption is created. This so-called Commoner equation is expressed as **EB= P X A X T.** According to this formula, increasing the human population, expanding the level of economic activities or changing the technological pattern to create affluence will increase the burden on the environment. This suggests that scale effect is related to the notion, that an increase in output means an increase in pollution. In this context, Commoner equation can be first interpreted as the scale effect of economic growth and then transformed to a simple decomposition as follows suggested by Grossman (1995:19):

The total emissions of some pollutant at time t are expressed by

$$Ey =_{i} a_{it} s_{it} Y_{t}$$

Y_t : the scale of economic activity (i.e. GDP) at time t

a_{it} : the amount of waste generated per unit of output in sector i

s_{it} : the share of output deriving from sector i

Structural change effects or composition effects are associated with the structural change caused by economic growth (Grossman 1995). It is generally stated that, economic growth has both positive and negative structural effects in allocating economic activity in accordance with the environmental capacities and conditions of different countries and the promotion of the efficient use of resources (O' Connor 1994: 14).

$$E' = Y' + \sum_i ⊕_i s_i + \sum_i ⊕_i a_i'$$

$⊕_i$: the share of the total amount of emissions of the pollutant generated by economic activity sector

a_i' : a rate of change in the amount of waste generated per unit of output in sector i

Y' : a rate of change in the scale of economic activity(i.e. GDP)

E' : a rate of change in total emission of the pollutant

s_I : the share of output deriving from sector i

As per capita income increase, there is a change in the social preference toward a more environmentally friendly industrial structure, goods and services and composition of industrial structure, which are more environmentally friendly (Grossman and Kruger 1996). As Syrquin (1989) pointed out, the structural transformations that accompany growth can have beneficial side effects on the environment. The pattern of development entails an initial shift of resources from agriculture to industry, and a subsequent shift from industry to services that do the least damage to the environment. As within the industry sector, there is strong tendency toward increasing portions of high-tech industries that entail a less intensive use of energy, natural resources and less emission of pollutants.

Technology effects are associated with the relationship between the flow of emissions and the stock of the pollutant in the biosphere that hinges on the regenerative capacity of the environment.

$$P_{t-1} = P_{t-1} + E_t + N + \delta\ (P_t^* - P_{t-1})$$

E_t : emission of pollutant at time t

P_t : the stock of the pollutant at time t

N : baseline emissions per unit time from non-anthropogenic sources

P* : the amount of the pollutant to which the stock would tend to converge in the absence of any new emissions

δ : The speed of convergence to the natural level

According to Grossman (1995:20), P_t approaches a constant as long as E_t does. However, environmental degradation may continue for a while even after emissions have levelled off. As technology progresses, market-induced substitution is beneficial only because substituting its less-polluting technologies are less expensive, or because government regulations cause less-polluting technologies to replace dirtier ones. At that point, the rate of emissions may fall over time (Grossman 1995).

Income effects refer to tendency of citizens, as per capita incomes rises, to express a greater social preference for a cleaner environment, which in turn creates a demand for tougher environmental regulations to which government may have to respond. Accordingly, there is an income induced pollution abatement effect. Economic growth then originates from the increasing social pressures for higher environmental quality by the government, NGOs and consumers (Grossman 1995, Lucas *et al.* 1992). The increase in per capita income not only induces a demand for more stringent environmental regulations, but it also induces more investment to develop cleaner technologies (Shafik 1994, Grossman and Kruger 1993, Lucas *et al.* 1992). According to Komen *et al.* (1997), there are positive linkages between income elasticity, public research and development funding for cleaner technology. Increase in per capita income provides a greater interest in and more funds to spend on environmental protection.

GLOBAL PERSPECTIVES ON ECONOMIC-ENVIRONMENTAL LINKAGES

In accordance with the linkages between growth and environment, it is necessary to consider the global dimension and its dynamics. Political economy and a universal approach may be relevant for analyzing the dynamic interaction between growth and the environment, especially when focusing on the problems between developed countries and developing countries. As Wallerstein (1976: Cited in Roberts and Grimes 1992) points out, the three structures of the global economic core, peripheral and semi-peripheral- are based on the international division of labor, which is directly linked to environmental degradation. Redclift (1984:1) argues that from the outset, the environment can only be understood "within the framework of global economic relations." These patterns of interaction[1] between economic growth and the environment appear to be interpreted along economic hierarchies ranging from the local to national to global and from developing countries to developed countries. In particular, global economy can be seen as three different, overlapping economies: [2]the core (developed economy), the semi-

1) An important aspect related to the linkage is that the generic problem of economic growth and ecological degradation seems to have a close relationship with the the New World manufacturing order' and its specific link to pollution. New World Manufacturing theory focuses on the cost of labor as the main determinant of industrial locations.

2) The terms were adopted from Vandana Shiva, Ecology

peripheral (emerging economy) and survival economy (the peripheral).

Survival Economy Perspective - the Peripheral

According to the Hart (1997), the survival economy exits primarily in Africa, India, and China, and is the traditional village way of life of rural areas, which are subsistence oriented and obtain their basic needs directly from nature. Clearly, the critical environmental issues facing these countries are poverty-related, and resolving the issue is imperative to meet the basic needs for food, water and sanitation (Beckman 1992). The crucial elements of the interaction between environment and economic growth in survival are the increasing population growth, and poverty associated with the marginalizaiton of labor (Perrings, 1991; Dasgupta 1990). For example, Perrings (1991) maintained that there was a close connection between environmental degradation and poverty by examining empirical studies on aid to the dry land agricultural areas of Sub-Saharan Africa.

Second, some developing countries produce goods that pollute excessively during their manufacture, and these countries also serve as the recipients of direct shipments of industrial hazardous wastes from the core nations. This scheme has been nicknamed "*trash for cash*" scheme (Smith and White 1992). The interdependency of the global economy allows survival economies to become dumping grounds for toxic wastes and the movement of dirty manufacturing from advanced core states.

Emerging Economy Perspective -the Semi-peripheral

According to Frobel (1980), the emerging economies or the semi-peripheral countries resulted from the rise of the New International Division of Labor (NIDL). This phenomenon is a consequence of globalisation, namely, global capital markets, regional trading blocks, and declining transportation costs. In fact, while NIDL theory focuses on the cost of labor as the major determinant of industrial location, it is clear that environmentally related costs could also make the Third World attractive to industrial firms and potential investors. Cheap and plentiful resources, low cost energy, and minimal or non-existent pollution abatement standards can also enhance economic competitiveness. In a sense, a number of emerging economies in Asia and Latin America have oppressive levels of pollution, because industrialization in those semi-peripheral countries initially focused initially on commodities and heavy manufacturing. As Beckerman (1992) noted, air pollutants such as sulphur dioxide (SO_2) and suspended particulate matter (SPM) is a serious environmental problem in peripheral regions. This is because emerging economies specialize in the production of commodities that are labor intensive and consume natural resources, whereas developed countries specialize in capital and technologically intensive activities. If pollution-intensive industries shift from rich countries to semi-peripheral countries, then certain heavily polluting industries, including intermediates such as ferrous and non-ferrous metals, petrochemicals and cement, have great significance to emerging economies.

Developed Economy Perspective -the Core

The developed countries of the Northern Hemisphere account for about 20% of the world's population consumes the bulk of the world's energy and resources and generate the most pollution, in both in absolute and in relative terms. Thus, in order to meet consumer needs, the core economies create a large global environmental burden. Despite such an intense use of energy and materials, the

and the Politics of Survival(New Delhi: United Nations University Press, 1991) pollution levels are relatively low in developed economies (Hart 1997). In this regard, it should be emphasized that to some extent the clean environment of the developed countries is at the expense of the environments in developing countries. For example, pollution has increased in developing countries because of the import of the commodities from emerging economies and the import of natural resources from survival economies. Moreover, the presence of the downward sloping and the inverted-U relationships in developed countries is reflected in a reduction in emission in rich countries, and an increase in emissions in poor countries (Arrow *et al.*, 1995).

ECONOMIC GROWTH-ENVIRONMENT LINKAGES IN KOREA

The framework developed in Section III for linking economic growth to its consequences for the environment help in the analysis of the environmental implications of Korea's economic growth. In this connection, the Environmental Kuznet's Curve and the mechanisms for the impact of economic growth on the environment can be used to explain the environmental consequences of Korean economic growth. In principle, economic growth need does not necessarily bring about environmental degradation. The Environmental Kuznet's curve (EKC) hypothesis maintains that there is an 'inverted - U' relationship between various indicators of environmental degradation and levels of per capita income (Stern *et al.*, 1990). The relationship between economic growth and environmental degradation, such as the link between economic growth and income inequality posited by economist Simon Kuznet, is curvilinear. That is, in the early phases of economic growth, economic growth itself is the primary cause of environmental degradation, industrialization and an improved environmental quality at a higher income level. This suggests that there is positive pollution emissions elasticity (or 'marginal propensity to emit') at a low-income level, which gradually inverts to negative emissions elasticity as incomes rise above some transition value (Moomaw and Unruh, 1997). Many empirical studies have estimated the EKCs from cross-country panel data sets that can be categorized into two types. One is relates to emissions per capita (Selden and Song, 1994; Holtx-Eakin and Selden, 1995), and the other is related to concentration of pollutants to per capita income (Grossman and Krueger 1993, 1995; Shafik, 1994). The estimated per capita income of the turning points for SO_2, SPM and CO are at around \$4000-\$5000 and \$3000-\$4000(Grossman and Krueger 1993; Shafik and Bandyopadhyay 1992). On the other hand, Selden and Song (1992) estimated turning points with an income SO_2 of \$8,709, SPM of \$10,289 and CO of \$5,963 are considerably higher in relation to other studies.

First, the data from Korea concerning the different profiles of local air pollutants such as particulate matter, SO_2 and CO relation to the scale of economic activities from 1985～1997 appear to be broadly consistent with the implications proposed by Shafik and Bandyopadhyay (1992). As they indicated in Table 1, the levels of particulate matter generally begin to decline in 1985 at a per capita income of \$2,311, which is lower than sulphur dioxide in 1988 of at \$4295.

Secondly, the turning points of the per capita emissions are: the emission of SO_2 reaches at a level of \$5,917, which is higher than the urban concentration at \$4,330; suspended particulate matter at \$6,799 is higher than the urban concentration at \$2,311; CO, at \$6,799 is higher than the urban concentration at \$5,233. On the other hand, emissions per capita of particulate matter begin to decline in 1991 at income capita of \$6,799, which is higher than sulfur dioxide in 1990 at \$ 5,917. Thus, the estimated turning point for per capita emissions of the four air pollutants appears

Table 1. Estimated EKC Turning Points

	[1]*EKC literature*				*The case of Korea*[3)]	
	Urban concentration		*Emissions per capita*		*Urban concentration*	*Emissions per capita*
Environmental indicator	[2]G& K	Shafik	S & S	Cole	Author	Author
SO_2	$4,053	$3,670	$8,916	$5,700	$4,330	$5,917
SPM	$6,151	$3,280	$9,811	$9,400	$2,311	$6,799
CO	-	-	$6,241	$1,100	$5,233	$5,917
NO_2	-	-	$12,041	$15,100	N/A	N/A
CO_2	-	-	$35,428	-	N/A	N/A

Source:
[1]EKC literature refers to M.A, Cole *et al.* (1997) Environment and Development Economics 2, p407.
[2]G& K refers to Grossman and Krueger (1995), Shafik refers to Shafik (1994) and S&S refers to Selden and Song (1994) and Cole refer to Cole *et al.*(1997)

to be high in relation to other estimations: SO_2, $8,709: NO_x, $11,217; SPM, $10,289; and CO, $5,963.

As Selden and Song (1994) explain, this is because ambient pollution levels are likely to decline before aggregate emissions. This indicates that the concentration of pollution sources is then likely to undergo a similar process, and consequently, the trends of declining ambient concentration do not necessarily mean that total emissions are declining.

Thirdly, it is necessary to note that the relationship between per capita income growth and pollutants such as such as the CO_2 emissions per capita that have the long-term, system-wide consequences, are less likely to conform to the EKC hypothesis (World Bank, 1992; Shafik, 1994; Moomaw and Unruh 1997). The World Bank (1992) and Shafik (1994) find that carbon dioxide emissions monotonically increase with income growth, and little confidence can be held in the estimated turning points. On the other hand, Holtz-Eakin and Selden (1995) examined on per capita emissions of CO_2 from fossil fuel consumption. They estimated a turning point of $35,428 per capita and pointed out that significant economic growth would be necessary to reach the turning points of CO_2 emissions. According to Moomaw and Unruh (1997), three countriesCanada, Luxembourg and the United States are exceptional for having an 'N shaped correlation between per capita CO_2 emission and GDP.

Positive Interaction Between Economic Growth and Environment

Based on the EKC test, Korean economy during the past decades appears to be broadly consistent with a positive pattern of interaction between economic growth, industrialization and the environment, as suggested by Grossman (1995) and Shafik (1994). As Arrow *et al.* (1995) noted, economic growth is never significant enough to become an environmental panacea, but on the other hand, the environmental effects of growth cannot be neglected. Of particular importance is that the Korean economic growth can be explained by the possible mechanisms linking economic growth to

3) Primary data were drawn from the OECD Environmental data 1997, 1999 and the Environmental Statistics Yearbook from Ministry of Environment. Income data in terms of GDP per capita at current prices and current exchange rates are drawn from the national accounts of OECD (1999)

the environment. The structural shift towards the service sector and technological changes via induced through economic growth, may compensate for the negative scale effects of industrialization in some cases, by utilizing Korea's advantages as "a late industrializer" or "from environmental leap-frogging" (O' Connor 1994: 32).

As O'Connor (1994) has noted, the latecomer status of NICs within the global economy is an important context for policy responses with respect to technology, allows Korea to have access to an array of environmentally advanced technologies that were developed in the advanced countries. NICs such as Korea may be able to avoid the transitional technological solution and directly adopt the latest available technologies in the form of clean technology. Moreover, the advantage of later industrialization has implications in terms of the relationship between per capita income and a society's environmental choices. It is clear that for a given level of per capita income, latecomer countries will be able to afford a higher level of pollution abatement than earlier-industrialized countries. As Grossman (1995) has noted, growth in middle-income countries often involves the replacement of old capital equipment with new and the replacement of older technologies with newer ones. Thus, socio-technical structural change such as a qualitative improvement in the structure, design and composition of physical stocks and flows may result in the reduction of environmental degradation. As can be seen in Figure 1, Korean economic growth may contribute to positive structural effects that offset the negative scale effects of local air pollutants such as SO_x and Total Suspended Particulate (TSP). Thus far, the experiences of the Korean economy during the past decades appear to be broadly consistent with a positive pattern of interaction between economic growth, industrialization and the environment as discussed in the literature of the Environmental Kuznet's Curve literature. From 1985 to 1997, the

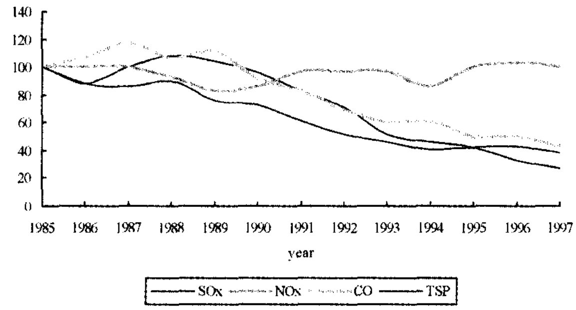

Figure 1. Trends in air quality, 1985 base referenc = 100, 1985 ~ 1997.

Sources: OECD (1999); MoE (1998)
Note: Concentration index 1985=100, Units of concentration measurement: ppm

annual concentration level of Total Suspended Particulate (TSP) in Korea has decreased by over 60 per cent and the annual average concentration levels of SO_2 and CO fell by 73% and 57% respectively over the same period. NO_2 levels, however, remained virtually unchanged.

Negative Interaction Economic Growth and Environment: Emission Stock

As Arrow *et al.* (1995) points out, there is a positive impact of income growth on the environment for local air pollutants, such as SO_2 particularly and CO that involve a short-term abatement cost. In contrast, there is a notoriously negative environment-economic linkage for indicators, particularly CO_2 and NO_2. which have a global and indirect effect. Table 2 and Figure 2 show the estimates for five air pollutants from 1985 to 1999 of the total emission and per capita emission in kilograms per capita. Per capita SO_2 emissions in Korea showed a substantial decrease of 25.3% from 1985 to 1999. TSP also declined by 10% between 1991 and 1995. On the other hand, per capita NO_2 emissions increased by 57% from 1985 to 1999, and not surprisingly, CO_2 emissions leapt by 189% during the same period.

Table 2. Trends in Air pollutant Emission, 1985～1999 (unit: 1000 tons)

	1985	1990	1995	1999	Change '85～'90	Change '90～'95	Change since 85
SOx	1,352	1,611	1,532	951	19%	-5%	-29.6%
(Kg/cap.)	(33.1 kg)	(37.6 kg)	(34.0 kg)	(24.7 kg)	(13%)	(-9.5%)	(-25.3%)
CO	1362	1,991	1,109	1,036	46%	-44%	-24%
(Kg/cap.)	(33.3 kg)	(46.4 kg)	(24.5 kg)	(23.2 kg)	(39%)	(-47%)	(-30%)
Particulate	342	431	406	440	26%	-5.8%	28.6%
(Kg/cap.)	(8.3 kg)	(10.0 kg)	(9.0 kg)	(9.8 kg)	(20%)	(-10%)	(18%)
NOx	723	926	1,152	1,135	28%	24%	57%
(Kg/cap.)	(17.7 kg)	(21.5)	(25.5 kg)	(23.3 kg)			(31%)
CO_2 (TOE)	158	232	362	456	47%	56%	189%
Ton/capita	(3.9)	(5.5)	(8.2 kg)	(9.5 kg)			(144%)
Economic Indicators							
GDP	$2,311	$5,917	$10,120	$8,660	60%	84%	194%
US$/capita		($6,799)*					
GDP ($PPP)	$4,238	$7,787	$12,648	-	60%	84%	194%
US$/capita		($8,440)*					

Sources: OECD (1998); National Statistical Office (1998, 1999), MoE (1999, 2000)

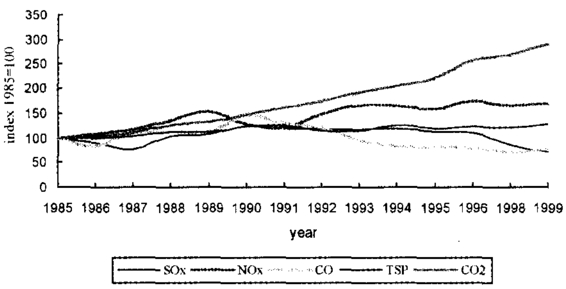

Figure 2. Emissions of air pollutants 1985～1997 (1985 base reference = 100).

Note: 1985 base reference (index 1985=100)
Sources: OECD (1999), MoE (1998, 2002)

CONCLUSION AND POLICY SUGGESTIONS

While the rapid growth of the Korean economy has been extensively researched, relatively little attention has been paid the environmental consequences. The first part of the paper reviewed the evidence on the relationship between economic growth and the state of the environment within the context of the interdependence between the three economic spheres. The latter part of paper identified the environmental implications of economic growth for Korea.

Environmental consequences are generated from the economic growth induced-scale, technology and structural effects, in the context of the interdependence between the three economic spheres. In particular, Korea appears to support the notion by Beckerman (1992:491) that: the surest way to improve your environment is to become rich. Korea has successfully decoupled the emissions of most traditional air pollutants from economic growth. However, the positive co-relationship between GDP and the reduction of pollutants exist only for local air pollutants such as SO_2, NO_2 and Particulate. Greenhouse gas emissions, however, have not been decoupled from economic growth. Indicators that have a global effect, particularly CO_2 have notoriously negative environment-economic linkages. Even if economic growth contributes to slightly positive structural and technological effects that offset the negative scale effects of local air pollutants, economic growth does not address the cumulative effects of pollution. That explains why the negative scale effects of, for example, cumulative CO_2 emissions, may outweigh any positive technological and structural effects.

Another important implication is that positive linkages of economic growth to the environment appears to be in air concentration levels of local pollutants, rather than at 'resource stock' levels. Given this analysis, one of the most important recommendations is that Korea needs to make a greater effort to find methods that alleviate the trade-off between CO_2 emissions and the continued economic growth. In this policy sphere, the energy efficiency, policy must promote a shift from an economy of energy-intensive industries to one with a dematerialized economic structure. Because it is difficult to change the levels of production and consumption, it is essential to change methods of production. These policies must be designed in a way to reduce green house gases and not conflict with the national goals of achieving economic development. Kaya (1989), following the suggestions of Commoner (1971) indicates that CO_2 emissions are created by four factors: the carbon intensity in energy consumption (T1), energy intensity (T2), per capita income (A) and population (P)(**EB=P X A X T;** See Section ?).

Some of policy suggestions can be made following Kaya's analytical factors. First, much more attention needs to be paid to the introduction of cleaner technologies and energy efficiency improvements in order to reduce energy intensity, which will decrease CO_2 emissions at little or no cost. Accordingly, maximum CO_2 emission reductions will be beneficial to the economic growth. Second, the structural change towards less carbon-intensive economic growth strategies is a solution that stems from the aggregate limit of CO_2 emissions. In this regard, Korea needs a policy for structural and technological changes that "dematerialization" and "depollute" economic activities. Such a policy will induce profound changes in the energy intensity industrial structure. The proper environmental and economic policy, harmonized with industrial and technology policies is critical to a cost effective reduction of the pollution, energy and materials intensity. That means, each unit of GDP must be produced with less environmental resources ("dematerialization"). Pollution per unit of GDP must also be reduced, and that pollution must be decoupled from economic production ("depollution").

Bibliography

Adams, W. M. 1990. *Green Development: Environment and Sustainability in the Third World,* New York: Routledge.

Arrow, K *et al.* 1995. Economic Growth, Carrying Capacity, and The Environment, *Science* 268, p. 520~521.

Beckerman, W. 1992. "Economic Growth and the Environment: Whose Growth? Whose Environment?" *World Development*, Vol.20, No.4, pp.481~492, 1992. Printed in Great Britain.

Cole, M. A., Rayner. A. J., and Bates J. M. 1997. The Environmental Kuznet Curve: An Empirical Analysis, *Environment and Development Economics* 2, p.401~416

Commoner. B. 1971. *The Closing Circle*, New York, NY: Knopf

Daly, H. E. 1987. "The Economic Growth Debate: what some economist have learned and others had not." *Journal of Environmental Economics and Management:* 14, 1987: 323~336.

Dasgupta, P. 1990. "The Environment as a Commodity" in *Oxford Review of Economic Policy, Vol6*, No1.55~66.

Frobel et. al. 1980. *The New International Division of Labour*. London, Cambridge University Press.

Grossman, G. M. 1995. Pollution and Growth: What Do We Know? *The economics of* *sustainable development,* Goldin I. and L. A. (eds.). Cambridge Univ. Press.

Grossman, G. M. and Krueger, A. B. 1995. "Economic Growth and the Environment," *The Quarterly Journal of Economics*, May 1995:353～377.

Grossman, G. M. and A. B. Krueger, 1996. "The inverted-U: what does it mean?" *Environment and Development Economics*1, 1996, p.119～122.

Hart, S. 1997. "Strategies for a Sustainable World" *Harvard Business Review*, January-February, pp.67～76. 1997.

Holtz-Eakin, D. and Selden, T. M. 1995. "Stoking the Fire? CO_2 emissions and Economic Growth," *Journal of Public Economics*, Vol. 57: 85～101.

Kaya, Y. 1989. "Impact of Carbon Dioxide Emission Control on GNP Growth: Interpretation of Proposed Scenarios" *IPCC Response Strategies Working Group*, Geneva, May 1989.

Komen, M. H. C. *et al.* 1997. Income and environmental R&D: empirical evidence form OECD countries, *Environment and Development Economics*, Vol2 (4): 505～515.

Lucas, R. E. B., Wheeler, D., and Hettige, H. 1992. Economic Development, Environmental Regulation and the International Migration of Toxic Industrial Pollution: 1960～1988, in Low, P. (ed.), *International Trade and the Environment*, Washington, D.C.: World Bank Discussion Papers159: 67～88.

Meadows *et al.* 1972. *The Limits to growth*, New York: Universe Books.

MoE (1998), *Environmental Protection in Korea: 1997,* MoE, Korea.

Moomaw, W. R. and G. U. Unruh. 1997. "Are environmental Kuznet curves misleading us? The case of CO_2 emissions," *Environment and Development Economics2 (4),* p.451～463, Cambridge University Press.

O'Connor, D. 1994. *Managing the Environment with rapid industrialisation: Lessons from the East Asian experience*, OECD, Paris.

OECD 1998. *Towards sustainable development: OECD Environmental indicators 1998,* OECD, Paris.

OECD 1999. *National Accounts, volume 1,* OECD, Paris.

Panayotou, T. 1997. "Demystifying the environmental Kuznet's curve: turning a black box into a policy tool, Special Issue on Environmental Kuznet's Curves for air pollution emissions?" *Environment and Development Economics 2(4):* 465～484.

Perrings, C. 1991. "Incentives for the ecologically sustainable use of human and natural resources in the dry lands of sub-Saharan Africa: A review," *World Employment Programme Research Working Paper,* ILO, 1991.

Redclift, M. 1984. *Development and Environment Crisis: Red or Green Alternatives,* Methuen, London, 1984.

Roberts, J. T. and P. Grimes. 1992. "*Social Roots of Environmental Damage: A World-System Analysis of Global Warming and Deforestation*" the National Science Foundation of United States, August 1992.

Shafik, N. and Bandyopadhyay 1992. "Economic Growth and Environmental Quality: Time Series and Cross Section Evidence." *Working Papers for World Development Report 1992.* Washington, D.C.: 147～162.

Shafik, N. 1994. Economic Development and Environmental Quality: An Econometric Analysis, *Oxford Economic Papers,* Vol.46: 757～773.

Selden, T. M. and D. Song 1994. Environmental Quality and Development: Is There a Kuznets Curve for Air Pollution Emission? *Journal of Environmental Economics and Management* 27:147～162.

Syrquin, M. 1989. "Patterns of structural change," in H. Chenery and T. N. Srinivasan (eds), *Handbook of Development Economics*, vol.1, Amsterdam: North-Holland.

Stern, D. I., Common, M. S, and Barbier, E. B. 1996. Economic growth and Environmental Degradation: The Environmental Kuznets Curve and Sustainable Development, *World Development*, Vol, 24, No.7: 1151～1160.

Smith, D and White D. 1992. "Structure and Dynamics of the Global Economy : Network Analysis of International Trade" *Social Forces 70(4)* : 857～893

World Bank 1992. *World Development Report 1992: Development and the Environment*, Oxford University Press: New York.

World Resource Institution (1990), *World Resources 1990-91,* Oxford University.