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WILL CONTINUED ECONOMIC GROWTH BRING EVER GREATER HARM TO THE EARTH'S ENVIRONMENT?: A THEORETICAL FRAMEWORK AND EMPIRICAL EVIDENCE

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ABSTRAK

Pertumbuhan ekonomi telah lama menjadi orientasi dominan dalam pelaksanaan pembangunan di hampir seluruh negara di bumi raya ini. Namun demikian, orang tidak dapat mengingkari bahwa kian hari, kian lama, udara yang mereka hirup semakin tak segar, suhu bumi makin tak menentu, dan makin berkurang kekayaan sumber daya alam sebagai sarana produksi. Kesadaran ini akhirnya melahirkan kepedulian akan pembangunan yang memperhatikan lingkungan hidup sekitar. Seiring dengan peningkatan kepedulian orang akan kualitas lingkungan hidup, para ekonom mulai merancang dan merumuskan konsep, teori maupun model, yang menjelaskan hubungan antara kualitas lingkungan hidup dan pembangunan ekonomi.

Tulisan ini menjelaskan dampak pembangunan ekonomi terhadap kualitas lingkungan hidup. Hipotesis Kuznets mengatakan bahwa pada pada awal upaya pertumbuhan ekonomi, kualitas lingkungan hidup akan menurun tetapi lambat laun akan meningkat seiring dengan peningkatan aktivitas ekonomi. Persoalannya adakah dukungan empiris atas hipotesis tersebut? Selain memaparkan tentang perdebatan teori di kalangan ekonom mengenai keterkaitan antara pertumbuhan ekonomi dan kualitas lingkungan hidup, tulisan ini menampilkan pula studi-studi empiris di beberapa negara yang menguji hipotesis Kuznet tersebut.

Keywords: *Kuznets Curve, Pollutants, Economic growth, Environmental quality.*

INTRODUCTION

Substantial empirical evidence now suggests that the relationships between many forms of pollution and national income follow an inverse-U-shaped pattern, rising initially, peaking, and then declining. Empirical studies (Hettige, et.al. (1992), Shafik (1994), Seldon and Song (1994) and Grossman and Krueger (1995) have searched for systematic relationships by regressing cross country measures of ambient air and water quality on various polynomial specifications of income per capita. This extensive body of work has been motivated by several related questions: Does pollution follow a Kuznets' curve, first rising and then falling as income increases? At what income level does the turnaround occur? Do all pollutants follow the same trajectory? Is pollution reduction in developed economies due primarily to structural change, or to regulation?

Nevertheless, all empirical studies carefully avoid making structural interpretations of their results. With no theory to explain the observed pattern of environmental quality, the door is left open for divergent conclusions. Particularly worrisome are suggestions that environmental improvement is a naturally occurring process, and that economic growth by itself will be a panacea for environmental degradation. Beckerman (1992) writes that "in the longer run, the surest way to improve your environment is to become rich." Even more disturbing are claims that "existing environmental regulation, by reducing economic growth, may actually be reducing environmental quality" (Bartlett, 1994).

Thus, in this situation, the question emerges how do economists explain theoretically the way economic growth affects natural environment? How do they say about the relationship between economic development and natural environment? Despite the importance of these questions, it is surprisingly difficult to find clear answer to them. This study attempts to address the questions by constituting what economists say about the relationship between environmental quality and economic development. Firstly, it will be presented the way economists explain theoretically about that relationship. This consists of the general theory and the formulation of natural environment-economic model. Next, to add what the basic theory states, some empirical evidence will follow. Mostly, economists refer to the empirical evidence to bring them to develop an appropriate theoretical foundation.

DOES POLLUTION FOLLOW A KUZNETS' CURVE, FIRST RISING AND THEN FALLING AS INCOME INCREASES?

1. General framework

Perman, *et.al.* (1996) conclude that there are no fixed coefficient relationships between the level of economic activity and the level of materials used or discharges of potentially damaging pollutants. It is because the economic growth process is characterised by qualitative changes and substitution effects as well as by quantitative changes. Growth is measured by increases in the value of output, and higher value may not necessarily require higher quantities of inputs. Moreover, as relative resource scarcities change, to the extent that these changing scarcities are reflected in changing prices, substitution effects will take place on both the demand and supply side of economic activity (Perman, *et.al.*(1996)).

The theoretical work has shown that a Kuznets, or inverted-U, relationship can result if a few plausible conditions are satisfied as income increases. These condition are constant or falling marginal utility of consumption; rising marginal disutility of pollution; constant or rising marginal pollution damage; and rising marginal abatement cost. Because the pattern resembles the time series of income inequality described by Kuznets, the environmental pattern has been labeled the "environmental Kuznets curve." Selden and Song (1994) say, that is, while industrialisation and agricultural modernisation may initially lead to increased pollution, other factors may cause an eventual downturn, at least for some pollutants. Among these factors are: (1) positive income elasticities for environmental quality; (2) changes in the composition of production and consumption; (3) increasing levels of education and environmental awareness; and (4) more open political systems. That is, the development trajectory for pollution is likely to reflect both market forces and changes in government regulation. As a result, it is reasonable to expect that economies would pass through "stages of development," in which at least some aspects of environmental quality first deteriorate and then improve. (Selden and Song (1994).

Hilton and Levinson (1998) constitute two alternative theories that may explain the observed inverse-U relationship between many pollutants and income. Firstly, it could be that the natural pattern of economic development involves a transition from subsistence agriculture, which is not pollution intensive, to the more polluting early stages of manufacturing, to less polluting service industries. This is sometimes called the "composition effect ." In part, the transition away from polluting industries could be the result of wealthy countries shifting pollution-intensive manufacturing processes to less developed countries. If so, then it will not be possible for all nations to experience improving environmental quality, as the poorest nations will never have poorer ones on which they can dump polluting processes.

Alternatively, it may be that the environmental Kuznets curve is based on two entirely separate relationships. First, many economic activities pollute the environment, and wealthy countries (with more polluting activity) generate more pollution. This has sometimes been called the “scale effect.” Second, environmental quality is a normal good, and wealthier countries’citizens demand more of it in the form of regulations requiring reductions in the amount of pollution per unit of activity (pollution intensity). This has sometimes been called the “technique effect.” Overall pollution is the product of polluting activity and pollution intensity, and consequently the pollution income relationship has a theoretically ambiguous shape.

Furthermore, Common (1995) examines the implications of the EKC (Environmental Kuznets Curve) hypothesis for the long-run relationship between environmental impact and income. To do this, he examines two special cases of the EKC. In one case -- what we shall call case **a** - environmental impacts per unit of income eventually fall to zero as the level of income rises. Case **b** is characterised by environmental impacts per unit income falling to some minimum level, *k*, at a high level of income, and thereafter remaining constant at that level as income continues to increase.

Suppose that the world consists of two countries’ the *developed* and *developing*, which are growing at the same constant rate of growth. Suppose that the growth process began at an earlier date in the developed country and so, at any point in time, its per capita income level is higher than in the developing country.

Common (1995) concludes that in case **a**, for some period of time, income levels in the two countries will be such that the developed country is on the downward-sloping portion of its EKC whilst the developing country is still on the upward sloping part of its EKC. However as time passes and growth continues, both countries will be at income levels where the EKC curves have a negative slope; together with the assumption in case **a** that impacts per unit income fall to zero, this implies that the total level of impacts will itself converge to zero as time becomes increasingly large.

Conversely, in case **b**, no matter how large income becomes, the ratio of environmental impacts to income can never fall below some fixed level, *k*. Of course *k* may be large or small, but this is not critical to the argument at this point; what matters is that *k* is some constant positive number. As time passes, and both countries reach high income levels, the average of the impacts to income ratio for the two countries must converge on that constant value, k. Since it is assumed that each country is growing at a fixed rate g, the total level of impacts (as opposed to impacts per unit income) must itself be increasing over time at the rate g, going eventually to infinity.

We obtain two paths of environmental impacts over time which are entirely different from one another in qualitative terms for very small differences in initial assumptions. Which of these two possibilities –case **a** or case **b** – is the more plausible? Common (1995) argues that the laws of thermodynamics imply that *k* must be greater than zero. If so, the long-run relationship between total environmental impacts and that level of world income would be of the linear form. Any attempt to infer from the inverted U shape of the EKC that growth will reduce environmental damage in the long run would be incorrect.

2. The environment-economic model

Beside constituting the theory that explain the observed inverse-U relationship between economic activity and environmental quality, some economists also have formulated the model that can show such relationship. The most famous model is the model that is constructed by R.C. d’Arge (1972) called as *the materials-balance view of a ‘semirealistic’* *resource system*. In this model, d'Arge (1972) assumes that an economy is not static so he models the environment in some semi-realistic and manageable way. This section will include what d'Arge has discussed.

A basic identity derivable from the principle of conservation of matter-energy is:

$$R = W_i + W_f = W \text{ , with } Z_i, Z_f = 0;$$
$$F = W_f, \qquad (1)$$

where R, F, Z, and W denote material extraction and fixation, final consumption, recycled materials, and total waste flows, respectively. W_i and W_f are the amounts of waste flow originating in, and Z_i and Z_f the amounts of recycled residuals returning to, the production and consumption sectors.

Basically, it is assumed that there are only two types of consumer goods, one containing material and the other purely nonmaterial:

$$P_f . F + P_s . S = Y . N, \qquad (2)$$

where P_f and P_s denote unit prices of F and S, and Y and N denote money income per capita and population. For this discussion, assume that P_s . S equals zero and money income is only counted in units of material.

Then

$$P_f . F = Y . N$$

and (3)

$$F = y . N,$$

where y is per capita income in units of material flow per capita. Finally, let it be assumed that total waste flows are proportional to final product in each period t:

$$W_t = g F_t, \qquad (4)$$

Then, by assuming that each variable previously defined refers to one time interval, t, waste flows are linearly related to total income measured in material units:

$$W_t = g . y_t . N_t \qquad (5)$$

Thus a relation is obtained between **waste flows and output per capita**. By definitions, $W_t = R_t$, so $W_t = g . y_t . N_t$ yields $y_t = (1/g)(R_t / N_t)$. Thus, in this most simple case, production results only from the magnitude of raw materials and there is, by implication, no substitution between labor and raw materials in the production process.

Then, environmental pollution, at least in its quantitative dimensions, is usually expressed in terms of concentrations –i.e., parts per million of dissolved solids or DDT, parts per million (suitably indexed) of carbon monoxide or reactive hydrocarbon concentrations in air, or tons per cubic acre of solid wastes.

Let D_t denote waste density at the beginning of time interval t and V denote total environmental waste holding capacity. Thus, in effect the closed resource system has been identified by a simple fixed volumetric magnitude, V. Then

$$D_t . V = \Sigma_{j=0} W_j + VD_0, \qquad (6)$$

since by definition waste divided by volume equals average waste density. By substitution of (5) into (6),

$$D_t = g/V \ \Sigma_{j=0} y_j.N_j + D_0 \qquad (7)$$

given exogenously determined percentage rates of growth in population (θ - 1)100 and material flow per capita (β - 1)100 such that

$$y_j = \beta.y_{j-1} \qquad \beta \geq 1 \qquad (8.1)$$

and

$$N_j = \theta \ N_{j-1} \qquad \theta \geq 1 \qquad (8.2)$$

Waste density can be related easily to initial levels of population and material flow per capita

$$D_t = g/V \ y_0 \ N_0 \ . \ (\beta\theta^{\ t} - 1)/(\beta\theta - 1) + D_0 \ , \qquad . . . . (9)$$

Thus, the impact of population and material flow per capita on waste densities is obtained. That is, if population and material flow per capita rise, the waste densities must be increasing even more rapidly. Aggregate damages are measured in terms of some common unit such as dollars or utils when it is assumed that the natural environment is small and the waste flows affect to the people's health. In this case, for each individual a monotonic, continuous increasing function relating per capita damages and waste densities could be presumed.

$$\mu_{it} = \mu_D (D_t) \qquad i = 1, \ldots, N; \qquad (10)$$

where μ_{it} equals damages to the ith individual during period t.

Then, if the preferences and incomes of all individuals are identical and the locations of waste densities are not varied, the total waste damage costs equal:

$$\mu_t = N_t \, . \, \mu_D (D_t) \qquad (11)$$

By substitution of (9) into (11):

$$\mu_t = N_t \, . \, \mu_D [g/V \, y_0 \, N_0 \, . \, (\beta\theta^{\,t} - 1)/(\beta\theta - 1) + D_0] \qquad (12)$$

As mentioned before, the increase of waste density must be more rapidly compared with either population or material flow per capita, in turn; it leads to an increase of damage costs per capita. The rate of damage costs per capita would be increasing at the similar rate to the rate of waste density if there were a linear and positive (the magnitude of μ_D) correlation between density and damage costs. By definition, multiplying population to damage costs per capita is equal to total damage cost, as a result, total damage costs associated with waste accumulation must be increasing at an even faster rate than damage costs per capita. Hence, when both population and material flow per capita are increasing, a spiralling rise in damage costs due to waste accumulation is obtained. Each individual's waste from production and consumption activities effects a toll of damages on himself and all other individuals, including future generations.

EMPIRICAL EVIDENCE

Substantial empirical evidence suggests the existence of the hypothesis of Kuznets curve on the relationships between national income and pollution (Hettige, Mani, and Wheeler, 1997). That is, such relationship follows an inverse-U shaped pattern, rising initially, peaking and then declining. The pattern has been labelled the "environmental Kuznets curve" since it is similar to the time series of income inequality described by Kuznets (1995). (Selden and Song, 1994). **Table I** summarizes some studies that would be explained below.

Because the empirical evidence relies on reduced-from regressions of environmental quality on income and other covariates, most researchers avoid interpreting those result structurally, leaving open the question of why pollution follow this inverse-U pattern. A number of plausible explanations exist for the observed inverse-U relationship. First, it could be that the pattern reflects the natural progression of economic development, from clean agrarian economies to polluting industrial economies to clean services economies (Arrow, *et al.*, 1995). This mechanism may be facilitated by advance economies exporting their pollution—intensive production processes to less-developed countries (Suri and Chapman, 1998). If the downward sloping portion of the pollution-income relationship is due to this type of pollution exporting, then the process of environmental improvement will not be indefinitely replicable, as the world's poorest countries will never have poorer countries to which they can export their pollution.

An alternative explanation suggested that pollution stops increasing and begins decreasing with income because, with economic growth, some constraint becomes non-binding. Some of the researchers support this conclusion. Stokey (1998) stated that below the threshold level of economic activity, only dirtiest technology could be used. When the threshold is passed cleaner technologies can be used. This relationship followed the inverse-U pattern.

Table 1. Existing Evidence on the Income-Pollution Relationship

	Dependent variable		Countries	Years	Specification	Other Independent variables	Turning point ($1985)	The relationship between economic development and environmental quality
	Pollutants	Units						
Grossman and Kruger	SPM, SO2, water quality	Ambient concentrations	42 (SO2), 29 (SPM)	1977 - 1988	Cubic in levels	Time trend, population density, geography	< $ 8,000	EKC
Shafik and Bandyopadhayay	SPM, SO2, water quality, CO emissions	Ambient concentrations for SPM, SO2	149	1972 – 1988 for SPM, SO2	Quadratic in logs	Investment, growth, energy subsidies, trade openness, debt, civil and political liberties	$ 3,670 (SO) $ 3,280 (SPM)	EKC
Selden and Song	SPM, SO2, NOx, CO	Emissions	30	1973 - 84	Quadratic in levels	none	$ 9,000 - $ 10,000 (SPM, SO2) $ 12, 000 - 22,000 (NOx, CO)	EKC
Holtz-Eakin and Selden	CO	Emissions	130	1951 - 1986	Quadratic in levels and logs	none	> $ 8 million	no EKC
Hilton and Levinson	Gasoline	Emissions	48	1972 - 1992	Quadratic in levels and logs	Population density, year	$ 1,500	EKC

Note : SPM = suspended particulate matter; SO2 = sulfur dioxide; NOx = nitrogen oxides; CO = carbon; EKC = Environmental Kuznet Curve
Source : Hilton, et.al. (1997).

The strongest evidence for the U-shaped pollution income relationship comes from some studies that used international panel data to regress environmental quality on a polynomial function of per capita income and other covariates. Almost all studies find the existence of Kuznets hypothesis on the relationship between pollution and income for some various pollutants.

For example, Shafik and Bandyopadhyay (1992) regress the level of various pollutants on a polynomial in the logarithm of GDP. The U-shaped relationships exist for the case of deforestation and urban air pollution in terms of their correlations with GDP. On the other hand, for other cases, such as drinking water quality, urban sanitation, or river water quality, they do not find evidence of Kuznets curve hypothesis. Similarly, Grossman and Kruger (1995) examine the relationship between GDP, the level of ambient concentrations of urban air, water pollution, and other covariates (lagged values of the GDP polynomial, a time trend, population density, and indicators for the nature of the surrounding area (coastal, residential, etc.)). They find the evidence of U-shaped relationships for urban air and water pollution, rising initially, peaking, and then declining after the per capita income reaches above \$ 8000 (in 1985 dollars). Of the 14 pollutants studied. 13 have peaks between \$ 1887 and \$ 11, 632 GDP per capita, and the other (large airborne particulates) declines monotonically

By focussing on emissions of common local air pollutants, Selden and Song (1994) summarize that below \$10,000 of GDP per capita, the levels of GDP peaks for particulate and sulfur emissions. Meanwhile, for nitrogen and carbon emissions, it peaks about \$ 10,000 of per capita GDP. Notice that both peaks are high enough above the per capita incomes of most countries that global emissions of these pollutants will continue to increase for the foreseable future. Holtz-Eakin and Selden (1995) examine carbon monoxide emissions using quadratic equations in levels and logs of GDP. Unlike the other environmental problems studied in the other studies, carbon emissions constitute an international externality. Each country's emissions affect the entire planet, and emissions reduction has the nature of a global public good. Countries are unlikely to impose unilateral carbon regulations, given the incentives to free ride on other countries' efforts. Perhaps for this reason, Holtz-Eakin and Selden find that carbon emissions increase monotonically, only peaking far out of sample at per capita GDP above \$ 8 million.

Hettige, Mani, and Wheeler (1997) attempt to advance the state of the art, using new data on industrial water emissions in developed and developing countries. They measure the effect of income growth on three proximate determinants of pollution: the share of manufacturing in total output; the sectoral composition of manufacturing; and the intensity (per unit of output) of industrial pollution at the end-of-pipe. They find that the manufacturing share of output follows a Kuznets-type trajectory, but the other two determinants do not. Sectoral composition gets 'cleaner' through middle-income status and then stabilizes. At the end of pipe, pollution intensity declines strongly with income.

They attribute part of this to stricter regulation as income increases, and part to pollution-labour complementarities in production. When they combine the three relationships, they do not find a Kuznets story. Instead, total industrial water pollution rises rapidly through middle-income status and remains approximately constant thereafter. To explore the implications of their findings, they simulate recent trends in industrial water pollution for industrial economies in the OECD, the NIC's, Asian LDC's and the ex-COMECON economies. They find approximately stable emissions in the OECD and ex-COMECON, moderate increases in the NIC's and rapidly growing pollution in the Asian LDC's. During the 1980's, their estimates suggest that the latter group displaced the OECD economies as the world's largest generator of industrial water pollution. Overall, however, the negative feedback from economic development to pollution intensity was sufficient to hold total world pollution growth to around 15 % during a twelve-year sample period.

Andreoni and Levinson provide a simple analytics of the environmental Kuznets curve (Andreoni and Levinson, 1998). By contrast to the other researchers' approach, they build a simple and straight –forward static model of the micro foundation of the pollution-income relationship. They also state that the observed inverse-U pattern does not require dynamics, predetermined patterns of economic growth, multiple equilibria, released constraints, political institutions, or even externalities. Rather, an environmental Kuznets curve can be derived directly from the technological link between consumption of desired good and abatement of its undesirable by product.

Their model has several notable implications. First, it suggests that the observed income-environment relationship is perfectly reasonable. Second, the inverse-U shaped pollution-income curve does not depend on externalities. This is reassuring since several recent empirical studies (Kahn, 1998) find that household-level pollution also follow an inverse-U, consistent with their results. A third implication of these findings is that the environmental Kuznets curve may depend more on technology than on environmental externalities inherent in growth.

The final implication show that the model does not support the argument that observed inverse-U-shaped pollution paths justify laissez-faire attitudes towards pollution, or that economic growth alone will solve pollution problems. They also state that absent environmental regulations, the pollution-income path may well have an inverse-U shape, but the amount of pollution at every income will still be inefficiently high.

Finally, Hilton and Levinson (1998) provide new evidence of the existence of an environmental Kuznets curve for the case of airborne lead pollution, using a data set of 48 countries over a 20-year period. They find three main findings. First, it adds automotive lead emissions to the list of pollutants shown to follow an inverse-U with respect to national income. Second, it shows that the location of the peak of this curve is sensitive to both the functional form and the time period chosen to estimate the curve. Third, automotive lead pollution is the product of two separate factors: lead per gallon of gasoline (pollution intensity), and gasoline consumption (polluting activity).

By separately estimating the relationship of these two factors to national income, they take one step beyond the typical aggregate estimates of environmental Kuznets curves and shows that the declining portion of the curve depends critically on reductions in gasoline lead content, not gasoline consumption. In other words, the improvement in environmental quality that accompanies income growth depends on the types of regulations and developments that reduce pollution intensity rather than reducing polluting activity.

CONCLUSION

This study has tried to constitute what economists formulate about the relationship between economic development and environmental quality. Several points need to be emphasized concerning the interpretation of what this study presents. First, even for those dimensions of environmental quality where growth seems to have been associated with improving conditions, there is no reason to believe that the process has been an automatic one. In principle, environmental quality might improve automatically when countries develop if they substitute cleaner technologies for dirtier ones, or if there is a very pronounced effect on pollution of the typical patterns of structural transformation.

Second, it is possible that downward sloping and inverted U-shaped patterns might arise because, as countries develop, they cease to produce certain pollution-intensive goods, and begin instead to import these products from other countries with less restrictive environmental protection laws. If this is the main explanation for the (eventual) inverse relationship between a country's income and pollution, then future development patterns could not mimic those of the past. Developing countries will not always be able to find still poorer countries to serve as havens for the production of pollution intensive goods. However, the available evidence does not support the hypothesis that cross-country differences in environmental standards are an important determinant of the global pattern of international trade.

Finally, it should be stressed that there is nothing at all inevitable about the relationships that have been observed in the past. These patterns reflected the technological, political, and economic conditions that existed at the time. The low-income countries of today have a unique opportunity to learn from this history and thereby avoid some of the mistakes of earlier growth experiences. With the increased awareness of environmental hazards and the development in recent years of new technologies that are cleaner than ever before, we might hope to see the low-income countries turn their attention to preservation of the environment at earlier stages of development than has previously been the case.

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