# ECONOMIC DEVELOPMENT AND ENVIRONMENTAL QUALITY: AN ENVIRONMENTAL KUZNETS CURVE (EKC) INVESTIGATION USING CROSS-COUNTRIES DATA

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**ABSTRACT**

*This paper tests a relationship between economic development, measured by per capita income, and environmental quality, particularly investigates an existence of Environmental Kuznets Curve (EKC) using cross-countries data. Sampled data consists of 124 countries divided by low-income countries, middle-income countries, and high-income countries. It is different from previous studies; environmental quality is measured by index named Environmental Performance Index (EPI). Statistical test suggests that for all countries (full-sample data), the relationship follows a smooth N-shaped. There is no relationship for low-income countries; linear function for high-income countries; and quadratic function for middle-income countries. Thus, the existence of the EKC is not found in this study.*

Keywords: *Environmental Kuznets Curve, Environmental Performance Index, Environmental Quality.*

## 1. INTRODUCTION

Environmental problem is very complex because of many affecting factors considered. Lim (1997) mentions five determinants of environmental quality: (1) per capita income (e.g. per capita GDP); (2) population density; (3) technologies; (4) the level of environmental policies; and (5) endowments such as climate, geography and resource endowments. Meanwhile, Dietz and Rosa (1997) recognize anthropogenic factors, often called ‘‘driving forces’’, of environmental change: (1) population, (2) economic activity, (3) technology, (4) political and economic institutions, and (5) attitudes and beliefs.

Of factors affecting environmental problems, economic development has been a central issue related to environmental quality, especially in sustainable development framework. Some economists consider economic development and environmental quality are “trade-off” relationship. This means that the effort to boost the economic growth will be followed by environmental damage because of natural resources depletion and environmental degradation. In such condition, a country must limit the economic growth to keep a certain level of the environmental quality.

The idea refers to “the limit to growth” developed by Meadow et al. (1972) with two reasons: (1) the limited capacity of natural environments to receive the waste generated by the economic system; and (2) the finite nature of exhaustible resources (Turner et al., 1994). The critics against the limit to growth point to number of reasons: (1) positive and increasing income elasticity for environmental quality; (2) changes in the composition of production and consumption; (3) increasing levels of education and environmental awareness; (4) technological progress; and (5) more open political systems. The critics imply that the economic growth trajectory for environmental problem is likely to depend upon both market forces and changes in environmental policies and regulations (Lim, 1997).

The economic growth and environmental quality relationship has been widely debated inside academic circles. Some scholars believe that the causal relationship may be bi-directional or feedback effect. In addition to the effect of economic growth on the environmental quality, environmental degradation may have harmful effects on production possibilities (Pearson, 1994; Stern et al., 1994). The others find that the causal relationship between the economic growth and the environmental quality is unidirectional from the latter to the former, but not *vice versa* (Coondo and Dinda, 2002; Liu, 2006).

Most of studies in the relationship field are related to investigate the existence of an "Environmental Kuznets Curve (EKC)" hypothesis. The EKC hypothesis postulates that environmental degradation follows an inverted U-shaped curve relative to income. This means that the environmental degradation initially increases with the level of income, reaches a turning point or threshold, and then declines with further increases in income. On the other word, the environmental quality decrease with rising income but after a certain income level has been reached, it begin to increase. Scholars in this field define this relationship Environmental Kuznets Curve, in accordance with the Simon Kuznets (1955) original hypothesis on the existence of a relationship between income level and income distribution (Bimonte, 2001).

This paper addresses to test the relationship between economic development, measured by per capita income, and environmental quality, an existence of the EKC, using cross-countries data. The reminder of this paper is organized as a follows. Section 2 summarizes literature overview of the EKC hypothesis. Section 3 proposes methodology including analytical model, variable measurement and sampled data. Section 4 shows the results consisting of descriptive result and empirical result of the EKC. Finally, Section 5 presents conclusion of this study.

## 2. ENVIRONMENTAL KUZNETS CURVE (EKC) HYPOTHESIS: AN OVERVIEW

The Environmental Kuznets Curve (EKC) is a famous tool for analyzing a pattern of income and environmental quality relationship. The EKC implicitly assume that there is no feedback effect from the environment to income or the relationship is unidirectional (Liu, 2006). Most of the EKC studies apply reduced-form equation with or without additional explanatory variables as control variables. The quadratic or cubic form of polynomial function is widely used in a model to capture the future behavior of the income and the environmental quality relationship, particularly the inverted U-shaped relationship.

Since the early 1990's a number of authors have estimated the EKC for various indicators of environmental degradation. Most of the studies construct econometrics techniques. Panel data is widely used rather than time-series or cross-section data. Basic models used by those studies define a pollutant as a function of per capita income. The following discussion presents several studies dealing with investigation of the EKC.

Shafik and Bandyopadhyay (1992) estimate the EKC for ten different environmental indicators from 1961 until 1986. The study finds different results of income and environmental degradation relationship. Lack of clean water and lack of urban sanitation decline uniformly with increasing income. Two measures of deforestation (change in the forest area and the annual rate of deforestation) do not depend on income. River quality (dissolved oxygen (DO), faecal coliforms, and municipal waste) tends to worsen with increasing income. Two of air pollutants (suspended particulate matter (SPM) and sulfur dioxide ($SO_2$)) conform to the EKC hypothesis, but carbon dioxides ($CO_2$) emissions increase with rising income.

Panayotou (1993) investigates the EKC for $SO_2$, nitrogen oxide ($NO_x$), SPM, and deforestation. The three pollutants are measured in term of emission per capita and deforestation is measured as the mean annual rate of deforestation. The analysis shows that the EKC is found for all the environmental indicators. Selden and Song (1995) test the EKC focusing on emissions of four important air pollutants (SPM, $SO_2$, $N_20$, and carbon monoxide (CO)). The study confirms to Panayotou's finding that the EKC is found for all four air pollutants.

Grossman and Krueger (1994) explore some of the empirical evidence of the EKC. By using cross-country panel data of the Global Environmental Monitoring System (GEMS), the study finds that level of $SO_2$ and dark matter suspended in the air increase with income at low levels of national income, but decrease with income at higher levels of income. This means that inverted U-shape relationship or the EKC is found for the two indicators. For the mass of suspended particles, the relationship between income and the pollutant is found to be monotonically decreasing.

The research wave of the EKC hypothesis has been still going on until now. However, empirical evidence does not support the EKC hypothesis in a general way. Egli (2004) reported that empirical results and conclusions are "ambiguous".

> …some authors find evidence of the EKC for different air and water pollutants and other measurements of environmental degradation (e.g. Grossman and Krueger 1995, Selden and Song 1994, Cole et al. 1997). Others, on the other hand, report either monotonically increasing or decreasing relationships between pollution and per capita income, or even find no such relationship (e.g. Torras and Boyce 1998 and partly Shafik 1994)…

Ultimately, the results of the studies are strongly dependent on many factors, i.e. the indicators of environment degradation; the functional form, methods and explanatory variables included in analytical model, the data and countries characteristics considered in the sample (Martinez-Zarzoso, 2003).

The EKC implies that the magnitude of environmental degradation of economic growth will fall as income rises above some turning point or threshold level. This idea is based on the argument as follows (Panayotou, 1993):

> At low level of development both quantity and intensity of environmental degradation is limited to the impact of subsistence economic activity on the resource base and to limited quantities of biodegradable wastes. As economic development accelerates with the intensification of agriculture and other resource extraction and the takeoff industrialization, the rates of resources depletion began to exceed the rates of resource regeneration, and waste generation increases in quantity and toxicity. At higher level of development, structural changes towards information-intensive industries and services, coupled with increased environmental awareness, enforcement of environmental regulation, better technology and higher environmental expenditures, result in leveling off and gradual decline of environmental degradation.

The validity of the EKC hypothesis is very important for policy implications. If the hypothesis held generally, it would imply that economics growth is the means to environmental improvement. That is, as countries develop economically, moving from lower to higher levels of income, overall levels of environmental degradation will eventually fall. Therefore, it would be seem that there is no need to curtail growth in the world of economy in order to protect the global environment. However, if the hypothesis proposition does not hold, public intervention would be necessary to curb the environmental degradation and make sustainable development a reality (Perman, et al., 2003; Martinez-Zarzoso, 2003).

## 3. METHODOLOGY

Basically, a common analytical model used by previous studies to capture an inverted-U shaped relationship between income level and environmental quality, the EKC, is polynomial equation with quadratic or cubic function. Some authors include control variables, such as population density (Selden and Song, 1995; Lim, 1997), industry share of GDP (Egli, 2004), etc. The others adopt reduced-form equation without the control variables (Shafik and Bandyopadhyay, 1992; Grossman and Krueger, 1994; Day and Grafton, 2002). There are two main advantages of the reduced-form: (1) its estimates give the net effect of income on the environment;

(2) it spares from having to collect data on environmental regulation and state of technology, in which are not readily available are of questionable validity. The limitation of the reduced-form approach, however, it is unclear why the estimated relationship exists (Grossman and Krueger, 1994).

A model applied in this study adopts a cubic function of polynomial equation without control variables. The using of cubic function is proposed to capture another form of relationship, besides inverted U-shaped. The relationship between income and environmental quality in this study is expressed as follows:

$$I_i = b_o + b_1Y_i + b_2Y_i^2 + b_3Y_i^3 + e_i \quad (3)$$

where: *I* is environmental quality; *Y* is income level; *e* is error or residual term; $b_0$, $b_1$, $b_2$, $b_3$, are regression parameters; and *i* denotes country. Since environmental indicators is measured by environmental quality rather than environmental degradation, then the EKC exists if $b_1<0$, $b_2>0$ and $b_3=0$ or graphically a curve follows U-shaped. However, other the relationships may occur. If $b_1>0$, $b_2<0$ and $b_3=0$, then inverted U-shaped is found. If $b_1<0$, $b_2=0$ and $b_3=0$, then the curve form is monotonically decreasing, whereas if $b_1>0$, $b_2=0$ and $b_3=0$, then the curve form is monotonically increasing. The others may also occur. If $b_1<0$, $b_2>0$ and $b_3<0$, the curve follows an inverted N-shaped whereas $b_1>0$, $b_2<0$ and $b_3>0$, the curve follows N-shaped.

The environmental quality is measured by index, Environmental Performance Index (EPI). The EPI published by Yale University and Columbia University in 2006 as a pilot of the environment quality performance is developed by six policy categories including sixteen indicators of environmental performances. (The EPI framework present in figure 1). Income is measured by per capita GNI (Gross National Income) of 2006 calculated using Atlas Method by World Bank (2008).

Besides all countries (full sample) including 124 countries, the sampled countries are divided into three categories based on income level. Those are low-income countries (42 countries), middle-income countries including lower-middle income and upper-middle income (53 countries), and high-income countries (29 countries). (The country classification is presented in Table 1). The classification refers to World Bank (2008) which classifies countries into income level as follows: low income ($905 or less), lower middle income ($906-$3,595), upper middle income ($3,596-$11,115), and high income ($11,116 or more).

## 4. RESULTS

### 4.1. Descriptive Result

The environmental quality in 2006, measured by EPI score, presents a good performance in overall. Data shows that a mean of the score of 128 sampled countries is 64.4, greater than a half in index score range. However, the variation of the score among countries is high enough. The highest score in EPI is 88.0 (New Zealand), 3.5 folds better compared with the lowest one is 25.7 (Niger).

Income level is one of the main factors affecting on the environmental change. It is hypothesized that the higher income, the higher score. Data shows that high-income countries have the highest EPI score, 80.8 on average, much greater than 64.4 of overall mean. In contrast, the score mean of low-income countries is 49.6, less than the overall mean. In addition, the high-income countries perform much less variation than the low-income countries and middle-income countries. Statistically, there is a significant difference of environmental quality among various levels of income (Table 2).

The income level is sometimes referred to a level of development. Comparing countries that are at a similar level of development provides a starting point for comparative analysis. High achievers are able to adequately benchmark themselves against other countries facing the challenges inherent in developed nations. The top five countries in EPI (New Zealand, Sweden, Finland, the Czech Republic, and the United Kingdom) are

OECD (Organization for Economics Co-operation and Development) member countries. Twenty-one of the OECD countries rank within the top 25 countries overall, and all OECD countries rank in the top half of the EPI rankings. The countries are representatives of developed economies indicated by high income with high capacity for sophisticated environmental protection and energy efficiency. On the other hand, the lowest-five-ranked countries (Ethiopia, Mali, Mauritania, Chad, and Niger) are member of LDCs (Least Developed Countries). Overall, the LDCs rank within the bottom half of the EPI, and make up eight of the ten lowest scoring countries. Limited financial resources of these countries severely constrain the ability to meet environmental quality.

### 4.2. Empirical Result for The EKC Hypothesis

A linear function firstly is applied as a basic model to investigate the effects income on environmental quality. Statistical result for all-countries data shows that the income has a significant effect on the environmental quality. A positive relationship between the income and the environmental quality is found; a one dollar increase in the income will rise EPI score by 0.0006. Overall the model is fit enough, indicated by 0.42 of adjusted $R^2$, in explaining the environmental quality behavior (Table 3).

Due to an existence of the EKC investigation, the linear function is changed into quadratic function with adding a squared term of income in the model. The model estimation presents a significant positive sign of income and significant negative sign of squared income. The signs mean that the environmental quality initially rises with the income and then it eventually falls in a higher income level. The result does not support the EKC hypothesis because this study uses environmental quality rather than environmental degradation as environmental indicator. Based on assessment of fit criteria, the quadratic function of income is better than the linear one referred to 0.55 of adjusted $R^2$ is greater than 0.42.

A cubic function of polynomial equation is applied for further analyze of pattern of income and environmental quality relationship. In similar way to the quadratic function, a cubic term of income is added to the model. The rising of adjusted $R^2$ becomes 0.63 suggests that a recent model is more robust than the two previous models. The model estimation shows a significant positively of income, significant negatively of squared income, and significant positively of cubic income. The result suggests that there is "N-shaped" relationship between the income and the environmental quality. However, the estimated turning point occurs at a very out-of-sample high income level, about $37,667 (Figure 2), so that within the sample data only a monotonically upward trend in environmental quality with increasing income level is discovered.

Estimation of income and environmental quality relationship for various levels of income yield different results. For lower-income countries, statistically income does not have a significant effect on environmental quality. A significant of intercept suggests that the environmental quality in the countries is determined by other factors besides income. In fact, environmental problem is a complex issue. Besides income, there are many factors affecting it such as population, technology, environmental policy and regulation, beliefs and attitude, and endowment factors. Data shows that more than 60% of the low-income countries are dominated by Sub-Sahara Africa countries. In general, the countries are indicated by very low income level and geographically poor of natural resources and vulnerable of natural disaster. The low-income countries do not have budget enough to improve technology, spend to environmental regulation, and enhance education and environmental awareness. In such conditions, the income level is not sufficient enough to be a driver for improving the environmental quality.

For middle income, statistically income level has a significant positive effect and squared income has a significant negative effect on environmental quality. The signs suggest that the relationship follows "inverted U-shaped". It means that the environmental quality rise with income increase; however after reaching a certain income level, it decreases in a higher level of income. The estimated turning point occurs at $8,329 (Figure 3). More detailed analysis is needed to explain the environmental quality behavior along income level, particularly the turning point. Generally, the middle-income countries are indicated by high enough of income as a result from high economic growth and large number of population with its high growth. The two characteristics can be used as a clue for discussing the phenomena. First, some studies (Dietz and Rosa, 1997; Shi, 2001, Rosa and York, 2002, and Neumayer, 2004) prove that the population pressure affects adversely on the environment and the pressure is more pronounced in developing countries. Second, the countries with higher income level have a high demand for energy. Because of energy resource scarcity, particularly exhaustible resource, a high economic density will utilize lower quality energy resource with high pollution level.

Statistical test for high-income countries show a significant effect of income on environmental quality, even though at 10% level of significance, for linear function but not for both quadratic and cubic function. It indicates that the relationship is monotonically increasing; the environmental quality always increases following income level increases. The result is conformed to Panayotou's (1993) arguments that the countries with high income level have opportunities to improve the environmental quality by structural changes towards information-intensive industries and services, coupled with increased environmental awarness, enforcement of environmental regulation, better technology and higher environmental expenditures. The countries have a positive and increasing income elasticity for the environmental quality and do not experience with population pressure because of small population size and high educated and environmental awareness.

## 5. CONCLUSION

This study using 124 of cross-countries data conclude that there is no evidence to support the Environmental Kuznets Curve (EKC) for both full sample and various levels of income data. Model estimation and statistical test show that for all countries, income and environmental quality behave "N-shaped" relationship. There is no relationship for low-income countries, linier function for high-income countries, and "inverted U-shaped" for middle-income countries. This study recommends income as one way to improve the environmental quality. However, it alone can not create automatically environmental quality because the environmental problems are very complex and associating with many factors affected. Government intervention is still needed toward a sustainable environmental quality.

Finally, there are two caveats representing some limitations proposed to the study. First, according to Egli (2004), the study in the EKC using cross-countries data simply reflect the juxtaposition of all countries with different income levels and other characteristics, so that only single-country studies could shed light on the validity of the EKC hypothesis. Second, the environmental quality indicator used in the study is index number, EPI, developed by six categories including sixteen indicators of environmental performance. Thus, EPI is so wide in which there are some possible conflicting relationship between income and various environmental performance indicators within EPI. Ignorance to the limitations, the study provides a different view in filed of the relationship between income and environmental quality studies. While most of the EKC studies apply one environmental degradation indicators or many separated indicators, this study introduces wider environmental indicators including all of environmental performance indicators in one package.

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**Figure 1. The EPI (Environmental Performance Index) Framework**

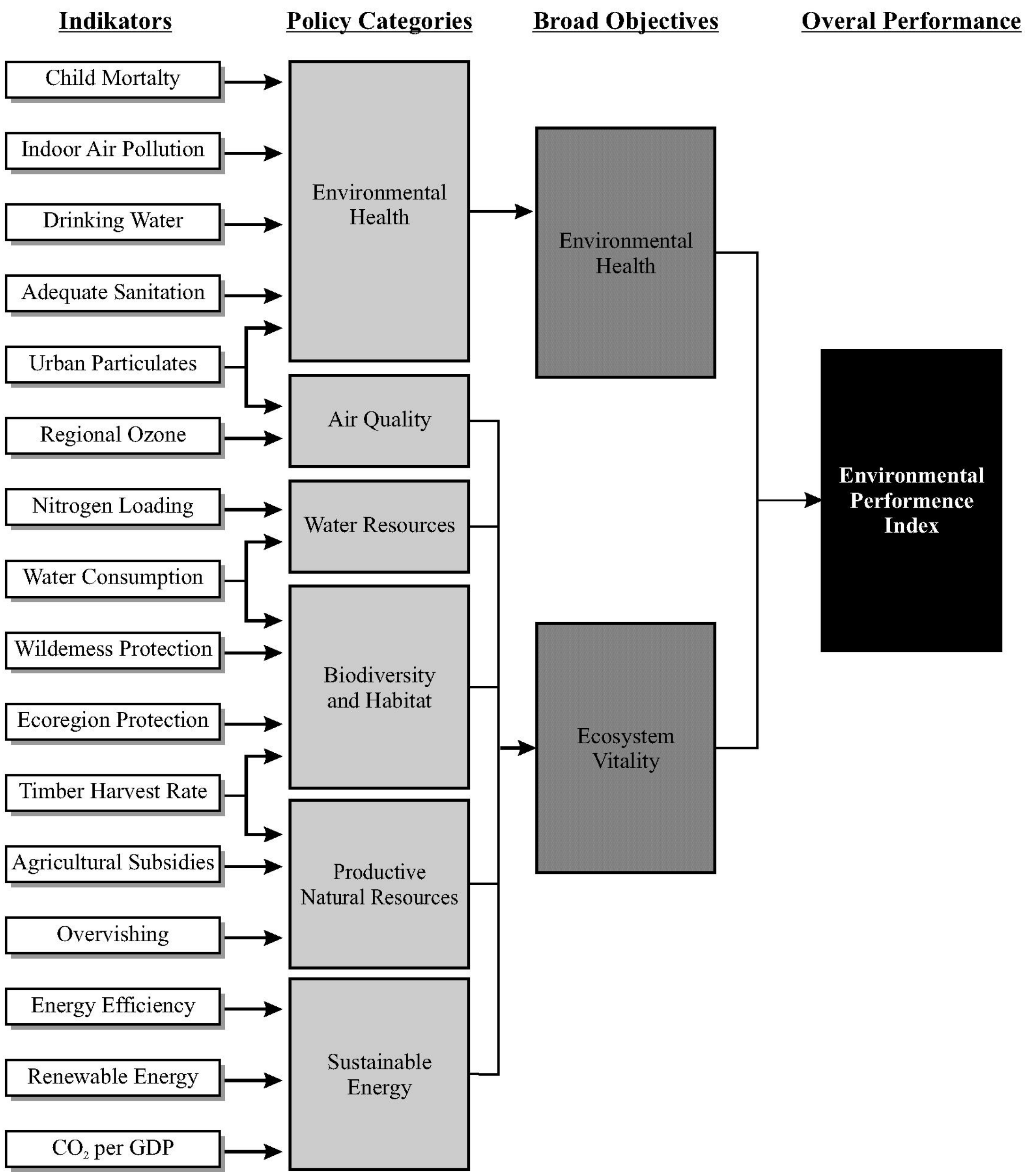

**Table 1. List of Sampled Countries (124 countries)**

| | Low-Income Countries | | Middle-Income Countries | | High-Income Countries |
|---|---|---|---|---|---|
| 1 | Burundi | 1 | Congo | 1 | Saudi Arabia |
| 2 | Dem. Rep. Congo | 2 | Nicaragua | 2 | Czech Rep. |
| 3 | Malawi | 3 | Cameroon | 3 | Trinidad & Tobago |
| 4 | Ethiopia | 4 | Bolivia | 4 | Taiwan |
| 5 | Guinea-Bissau | 5 | Moldova | 5 | Portugal |
| 6 | Sierra Leone | 6 | Honduras | 6 | Slovenia |
| 7 | Rwanda | 7 | Sri Lanka | 7 | Israel |
| 8 | Niger | 8 | Egypt | 8 | Greece |
| 9 | Madagascar | 9 | Paraguay | 9 | United Arab Emirates |
| 10 | Nepal | 10 | Indonesia | 10 | New Zealand |
| 11 | Uganda | 11 | Philippines | 11 | Spain |
| 12 | Zimbabwe | 12 | Georgia | 12 | Italy |
| 13 | Mozambique | 13 | Syria | 13 | Australia |
| 14 | Tanzania | 14 | Azerbaijan | 14 | Canada |
| 15 | Togo | 15 | Morocco | 15 | France |
| 16 | Central African Republic | 16 | Armenia | 16 | Germany |
| 17 | Tajikistan | 17 | Ukraine | 17 | Japan |
| 18 | Guinea | 18 | Angola | 18 | Belgium |
| 19 | Mali | 19 | China | 19 | Austria |
| 20 | Burkina Faso | 20 | Swaziland | 20 | United Kingdom |
| 21 | Bangladesh | 21 | El Salvador | 21 | Finland |
| 22 | Cambodia | 22 | Guatemala | 22 | Netherlands |
| 23 | Chad | 23 | Jordan | 23 | Sweden |
| 24 | Haiti | 24 | Colombia | 24 | United States |
| 25 | Kyrgyzstan | 25 | Ecuador | 25 | Ireland |
| 26 | Laos | 26 | Dominican Rep. | 26 | Iceland |
| 27 | Ghana | 27 | Peru | 27 | Denmark |
| 28 | Benin | 28 | Albania | 28 | Switzerland |
| 29 | Kenya | 29 | Tunisia | 29 | Norway |
| 30 | Uzbekistan | 30 | Thailand | | |
| 31 | Zambia | 31 | Iran | | |
| 32 | Nigeria | 32 | Namibia | | |
| 33 | Viet Nam | 33 | Jamaica | | |
| 34 | Mauritania | 34 | Kazakhstan | | |
| 35 | Senegal | 35 | Bulgaria | | |
| 36 | Yemen | 36 | Brazil | | |
| 37 | Pakistan | 37 | Romania | | |
| 38 | Papua New Guinea | 38 | Panama | | |
| 39 | Sudan | 39 | Costa Rica | | |
| 40 | India | 40 | Gabon | | |
| 41 | Côte d'Ivoire | 41 | Argentina | | |
| 42 | Mongolia | 42 | South Africa | | |
| | | 43 | Turkey | | |
| | | 44 | Lebanon | | |
| | | 45 | Malaysia | | |
| | | 46 | Russia | | |
| | | 47 | Venezuela | | |
| | | 48 | Chile | | |
| | | 49 | Mexico | | |
| | | 50 | Poland | | |
| | | 51 | Oman | | |
| | | 52 | Slovakia | | |
| | | 53 | Hungary | | |

**Table 2. EPI (Environmental Performance Index) among Various Level of Income**

| No. | Country | Obs. | Min. | Max. | Mean | SD | F-test |
|---|---|---|---|---|---|---|---|
| **1** | **All** | **124** | **25.7** | **88.0** | **64.4** | **14.4** | 129.83*** |
| 2 | Low-Income | 42 | 25.7 | 63.1 | 49.6 | 8.8 | |
| 3 | Middle-income | 53 | 39.3 | 83.3 | 68.5 | 9.3 | |
| 4 | High-Income | 29 | 68.3 | 88.0 | 80.8 | 4.6 | |

***significance at 0.01

**Table 3. Estimation Results for the EKC Hypothesis**

| Country | Variable | 1 (linear) | 2 (quadratic) | 3 (cubic) |
|---|---|---|---|---|
| **All** | Intercept | 58.4404*** | 55.3399*** | 52.4100*** |
| | Y (Income) | 0.0006*** | 0.0017*** | 0.0034*** |
| | $Y^2$ (Income^2) | | -2.3929E-08*** | -1.0350E-07*** |
| | $Y^3$ (income^3) | | | 9.1589E-13*** |
| | Adjusted $R^2$ | 0.4246 | 0.5539 | 0.6295 |
| **Low-Income** | Intercept | 50.2966*** | 47.1108*** | 41.1555*** |
| | Y (Income) | -0.0014 | 0.0143 | 0.0650 |
| | $Y^2$ (Income^2) | | -1.56845E-05 | -0.0001 |
| | $Y^3$ (income^3) | | | 8.11541E-08 |
| | Adjusted $R^2$ | -0.0238 | -0.0430 | -0.0627 |
| **Middle-Income** | Intercept | 60.0051*** | 54.5523*** | 54.3232*** |
| | Y (Income) | 0.0020*** | 0.0051*** | 0.0053 |
| | $Y^2$ (Income^2) | | -3.06013E-07** | -3.52673E-07 |
| | $Y^3$ (income^3) | | | 2.83756E-12 |
| | Adjusted $R^2$ | 0.2726 | 0.3188 | 0.3050 |
| **High-Income** | Intercept | 76.8006*** | 71.7869*** | 76.2547*** |
| | Y (Income) | 0.0001* | 0.0004* | -1.0955E-05 |
| | $Y^2$ (Income^2) | | -4.70923E-09 | 8.6925E-09 |
| | $Y^3$ (income^3) | | | -1.15808E-13 |
| | Adjusted $R^2$ | 0.0926 | 0.1178 | 0.0899 |

***significance at 0.01
**significance at 0.05
*significance at 0.1

**Figure 2. Estimation Curve of Income and Environmental Quality Relationship (All Countries)**

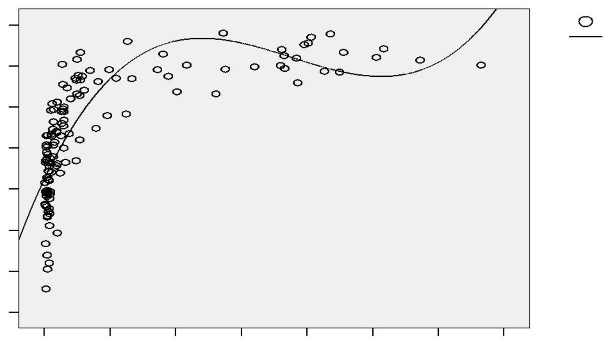

**Figure 3. Estimation Curve of Income and Environmental Quality Relationship (Middle-Income Countries)**

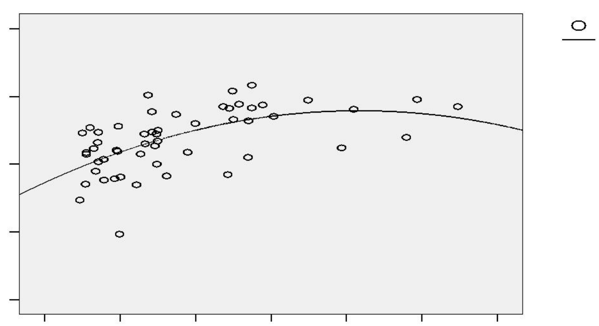

**Figure 4. Estimation Curve of Income and Environmental Quality Relationship (High-Income Countries)**