ISSN (Online): 2230-7893
www.IJCEM.org

# Estimation of Environmental Kuznets Curve and Kyoto Parties: A Panel Data Analysis

**Surender Mor[1] and Shivani Jindal[2]**
**[1]Assistant Professor, Department of Business Administration,**
**Chaudhary Devi Lal University, Sirsa Haryana 125 055 India**
**Surender_mor71@rediffmail.com**

**[2]Research Scholar, Department of Economics,**
**Chaudhary Devi Lal University, Sirsa Haryana 125 055 India**
**Shivani_83Jindal@yahoo.com**

**Abstract**

The present study investigates the relationship between economic growth and environment quality using panel data on 39 countries which includes Annex 1 and Non-Annex 1 parties under the Kyoto Protocol. The study employs least squares method for testing the Environmental Kuznets Curve hypothesis using secondary data on GDP per capita and $CO_2$ emissions. The Environmental Kuznets Curve hypothesis postulates an inverted 'U' shape relationship between income and environmental quality. The empirical findings of the study support the EKC hypothesis and found inverted 'U' shape relationship between income and environment with turning point at a level 30088 US $ PPP. Similarly Non-EIT parties and Non-Annex1 parties are also support the EKC hypothesis with turning point levels 37500 US $ and 48125 US $ PPP respectively. However in case on EIT parties there found a 'U' shape relationship between income and environment with turning point at a level 29000 US $ PPP. For Indian economy the study reveal a inverted U shape relationship between $CO_2$ emission and growth of per capita GDP with turning point occurring at 49003 US $ PPP. The study reveals that the growth of per capita tends to improve the environmental quality. The study suggests that at a broad level of development per capita emission of $CO_2$ begin to decline. The acceptance of EKC implies that there is an inevitable level of environmental damage that follows up due to economic development of a country at early stages but with significant improvement at later stage of development. This means that nations can opt for present value of higher future growth and cleaner future environment at the cost of current rate if environmental damage.

Keywords: Global Warming, Kayoto Protocol, Environmental Kuznets Curve, Turning Point

## 1. Introduction

Global warming is a growing concern over the world. The increasing CO2 in the atmosphere gave rise to warmer global temperature (IPCC, 1995). The main source of $CO_2$ emissions is human activities such as industrial process; fossil fuel combustion and deforestation of the earth are responsible for increasing the greenhouse gases in the atmosphere. The mean global temperature could increase by 1.0–3.5 degrees Celsius and the global sea level could rise by 15–95 centimetres if current trends in greenhouse gas emissions continue by 2100 AD (IPCC, 1995). Temperature increase of the earth has created various environmental problems including global environmental problems such as global climate change and ozone layer depletion; pollution; waste problems; deforestation; desertification; depletion of exhaustible resources; destruction of ecosystems; and loss of biodiversity. Responding to concerns that human activities are increasing concentrations of "greenhouse gases" (such as carbon dioxide and methane) in the atmosphere, most nations of the world joined together in 1992 to sign the United Nations Framework Convention on Climate Change (UNFCCC) at the Earth Summit in Rio, which was signed by more than 150 countries. The objective of the UNFCCC is to stabilize concentrations of green house gases in the atmosphere at levels that would prevent "dangerous" human interference with the climate.The Kyoto protocol was signed in 1997 in Kyoto, Japan, where industrialised nations committed themselves to mitigate overall GHG's emission by 5.2 per cent by 2008-2012 compared to 1990 base year.

The EKC takes after the name Simon Kuznets who had famously hypothesized an inverted 'U' income-inequality relationship (Kuznets, 1955) and was introduced by Grossman and Krueger's work (1991), Shafik and Bandyopadhyay's (World Development Report, 1992) and Panayotou (1993). These studies support the existence of an inverted U-shaped relationship between several pollutants and per capita income. The Environmental Kuznets Curve (EKC) hypothesis posits that there is an

inverted U-shaped relation among various indicators of environmental degradation and *per capita* income. It suggested for this hypothesis is that economic growth gives rise to changes in economic structure and technology, as well as to improvements in regulation and an enhanced environmental awareness that offset the impact of growth on the environment

Holtz-Eakin and Selden (1995) have done most likely the first study on EKC for CO2 and found a monotonous straight line. They used a quadratic model for data estimation. They estimated data for a panel of 130 countries (with complete data of 108 countries) from 1951-1986 and obtained some support for an EKC of CO2. However, their estimated turning point occurs at a very high level of per capita income ($35,428 in per capita 1986 dollars) for the 1995 study. Moomaw and Unruch (1997) use a sample of 16 developed OECD countries for the period 1950-1992. The relationship between carbon dioxide emissions and GDP is examined in the panel data framework and with help of so called structural transition model. The results confirmed the EKC hypothesis for the period under examination but with inverted-V shape and not inverted-U shaped curve. Turning points for each country varies from $ 8,884 to $ 15,425. Agras and Chapman (1999) found a surprisingly low amount of income per capita for turning point of CO2 (only $13630). Heil and Selden (2001) used a second order polynomial in income per capita with several specification tests to study a panel data from 135 countries over the period 1951-1992 and reported a monotonous increasing relationship between CO2 emissions and income per capita. Martinez-Zarzoso and Bengochea-Morancho (2004) examine the relationships between carbon dioxide emissions and GDP in panel data analysis by using 22 OECD countries for the period from 1975 to 1998.

In this background the present study intends to investigate and test the EKC for selected parties of Kyoto protocol. The remainder of this paper as follows. Section 2 highlights the data and methodology employed in the study while Section 3 devoted to the results and discussion. Conclusion and suggestions are made in section 4.

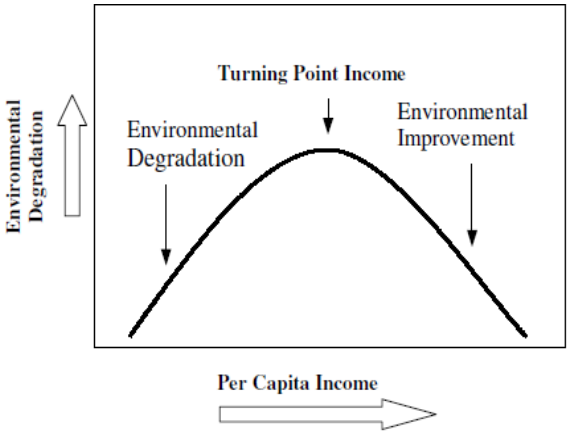
## 2. Data and Methodology

The present study is an attempt to investigate the relationship between economic growth and environmental quality on selected Kyoto parties. The study uses method of least squares for panel data (1997-2008) for 39 countries.

**2.1 Data:** This study contains 39 countries which include 35 Annex 1 countries (22 Non-EIT and 13 EIT parties) and 4 Non-Annex 1 countries including India.The study uses panel data for the period 1997-2008 on variables Per Capita Gross Domestic Product, Per capita $CO_2$ emission. The data on per capita GDP US$ PPP at current prices taken from Penn World Tables and per capita CO2 emission data taken from World Development indicators.

### 2.2 Genesis of EKC

The EKC takes after the name Simon Kuznets who had famously hypothesized an inverted 'U' income-inequality relationship (Kuznets, 1955). The Environmental Kuznets Curve (EKC) hypothesis posits that there is an inverted U-shaped relation among various indicators of environmental degradation and *per capita* income. Among the interpretations suggested for this hypothesis is that economic growth gives rise to changes in economic structure and technology, as well as to improvements in regulation and an enhanced environmental awareness that offset the impact of growth on the environment. The Environmental Kuznets Curve hypothesis was introduced by Grossman and Krueger's work (1991), Shafik and Bandyopadhyay's background study for the World Development Report in 1992 and Panayotou (1993). These studies support the existence of an inverted U-shaped relationship between several pollutants and per capita income.




### 2.3 Model Specification

In order to investigate the relationship between environmental degradation and economic growth, the following model is used:

$$E_{it} = \beta_0 + \beta_1 Y_{it} + \beta_2 Y^2_{it} + E_{it} \quad (1)$$

$E_{it}$, as dependent variable, represents the environment quality while $Y_{it}$ is the independent variable representing the income per capita. T time index, I country, ε normally distributed error Term, $\beta_0$, $\beta_1$, $\beta_2$ elasticity coefficients to be estimated.

In equation (1) if $\beta_1 > 1$ and $\beta_2 < 1$ then the estimated curve has a turning point per capita income level calculated as

$$Y^* = (-\beta_1 / 2\beta_2) \text{ and } Y^* = (-\beta_1 / 2\beta_3)$$

The relationship between $CO_2$ emission and per capita GDP is examined for 39 countries that have ratified Kyoto

Protocol including Annex1 and Non-Annex1. Annex1 countries includes Non-EIT (22 Countries) and EIT (13 countries) and remaining 4 countries from the list of Non-Annex 1 countries as well as for India. The following model is estimated

$E_{it} = \beta_0 + \beta_1 Y_{it} + \beta_2 Y^2_{it} + E_{it}$ (2)

Where

E= $CO_2$ Emission (per capita)

Y= per capita GDP

$Y^2$ = per capita square GDP

i=Country

t= Time index

β's= parameters to estimated.

The method of least squares is applied to equation (2) using data on $CO_2$ and per capita GDP for 39 countries.

## 3. Results and Discussion

The parameter estimates of least squares for all 39 sampled countries are reported in table1 and found statistically significant at 5 per cent level of significance. The table1 support the existence of EKC hypothesis, i.e, inverted U shape relationship between environmental degradation and GDP growth per capita with a turning point at income level 30088 US $. Further the relationship between environmental degradations and growth of GDP turned out to be N shape when cubic of GDP is introduced in the function.

The Table 2 presents the parameter estimates of least squares for 22 Non-EIT Parties. The table supports the existence of inverted U shape relationship between carbon dioxide emission and income per capita with turning point occurring at income level 37500 US $ PPP. Further the relationship between environmental degradations and growth of GDP turned out to be N shape when cubic of GDP is introduced in the function. The table 4 reveals that turning point occur at income level 48125 US $ for all 4 selected Non-Annex 1 countries supporting the existence of inverted U shape relationship and N shape relationship when the cubic term is introduced in the function(though statistically non-significant). The findings are also supported by the studies of Holtz-Eakin & Selden (1992), Moomaw and Unhruh (1997), Cole et al. (1997), Agras and Chapman (1999), Dijkgraaf and Vollebergh (2001) also support the Environment Kuznets curve. Table 5 presents the relationship of $CO_2$ emissions and growth of per capita GDP in India and suggest that there exist an inverted U shape relationship with turning point occurring at 49003 US $ PPP. This relationship turns out to be N shape with the inclusion of cubic term in the function.

The Table 3, on the contrary, indicates a U shape relationship (though statistically non-significant) between $CO_2$ emissions and growth of per capita GDP in EIT countries just rejecting the Environmental Kuznets Hypothesis with a turning point at 29000 US$ PPP at Minimum level. Further with the inclusion of cubic income term in the function the relationship turn out to be opposite N shape. The findings are also supported by the studies of Antle and Heidebrink (1995), and Martinez-Zarzoso and Bengochea-Morancho (2004).

## 4. Conclusions

This study investigated and tested the relationship between $CO_2$ emissions per capita and per capita income with a panel data with 39 countries over the period 1997-2008. The empirical findings of the study support the EKC hypothesis and found inverted 'U' shape relationship between income and environment with turning point at a level 30088 US $. Similarly Non-EIT parties and Non-Annex1 parties and India are also found supporting the EKC hypothesis with turning point levels 37500 US $ PPP, 48125 US $ PPP and 49003 US $ PPP respectively. However in case of EIT parties there found a U shape relationship between emission of $CO_2$ and per capita GDP. Further when the cubic term in per capita GDP is included in the function there found N shaped EKC for All 39 countries, Non-EIT, Non-Annex 1 and India while opposite N shapes for EIT parties. The findings of the study reveals that the growth tends to improve the environmental quality. But growth does not reduce pollution automatically, rather it can facilitate to make legislation for control of emission and promote investment in adoption of environmental cleaner technologies. The findings of the study at a broad level of development per capita emission of $CO_2$ begin to decline. The acceptance of EKC implies that there is an inevitable level of environmental damage that follows up due to economic development of a country at early stages but with significant improvement at later stage of development. This means that nations can opt for present value of higher future growth and cleaner future environment at the cost of current rate if environmental damage.

## References:


- Agras, J.; Chaman, D. A dynamic approach to the Environmental Kuznets Curve hypothesis. Ecological Economics, New York, vol. 28, p. 267-277, 1999.
- Dijkgraaf, E.; Vollebergh, H. R. J. A Note on Testing for Environmental Kuznets Curves. Environmental Policy, OCFEB Research Memorandum 0103, mai. de 2001
- Grossman, G., and Kreuger, A., Economic Growth and the Environment, *Quarterly Journal of Economics* 110 (2), 353-377 (1995).

- Heil, Mark T. & Selden, Thomas M., 2001. "Carbon emissions and economic development: future trajectories based on historical experience," Environment and Development Economics, Cambridge University Press, vol. 6(01), pages 63-83, February
- Holtz-Eaken, D.; Seldon, T. M. Stocking the fire? CO2 emissions and economic growth. Journal of Public Economics, vol. 57, p. 85-101, 1995.
- IPCC (Intergovernmental Panel on Climate Change), (2005).
- Kuznets, Simon (1955): "Economic Growth and income inequality", *American Economic Review* 45, 1 - 28.
- Martinez-Zarzoso,& Bengochea-Morancho, Aurelia, 2004. "Pooled mean group estimation of an environmental Kuznets curve for CO2," Economics Letters, Elsevier, vol. 82(1), pages 121-126, January
- Moomaw, W.R., and Unruh, G.C. An Alternative analysis of apparent EKC-type transitions. Ecological Economics **25**, 221-229 (1997).
- Panaytou, T. Empirical tests and policy analysis of environmental degradation at different stages of economic development, Working Paper WP238, Technology and Employment Programme (Geneva: International Labour Office), 1993
- Shafik, N., Bandyopadhyay, S., 1992. Economic Growth and Environmental Quality: Time Series and Cross-Country Evidence. Background Paper for the World Development Report. The World Bank, Washington, DC
- Summers, R. and A. Heston (1994): "Penn World Table (Version 7.0): An Expanded Set of International Comparisons: 1950–2008", NBER, PWT 7.0.
- World Bank (2010): *World Development Report2010*, Oxford University Press New York.


Table 1: EKC Parameter Estimation for All (39) Countries Kyoto Parties

| Coefficients | Coefficient | t-Statistic |
|---|---|---|
| $\beta_0$ | 5.507991 | 17.58422 |
| $\beta_1$ | 0.000275 | 5.917602* |
| $\beta_2$ | -4.57E-09 | -2.798716* |
| $\beta_3$ | 1.37E-14 | 1.16003 |
| $R^2$ | 0.216763 | |
| F-Statistics | 42.80439 | |
| EKC Shape | Inverted U-shape (with Y and $Y^2$) | |
| | N shape (with Y and $Y^3$) | |
| Turning point | PPP $ US 30088 | |

Table 2: EKC Parameter Estimation for Non-EIT Kyoto Parties

| Coefficients | Coefficient | t-Statistic |
|---|---|---|
| $\beta_0$ | 8.291737 | 14.92731 |
| $\beta_1$ | 0.000102 | 2.760128* |
| $\beta_2$ | -1.36E-09 | -1.929356* |
| $\beta_3$ | 2.88E-13 | 1.09016 |
| $R^2$ | 0.038109 | |
| F-Statistics | 3.433602 | |
| EKC Shape | Inverted U-shape (with Y and $Y^2$) | |
| | N shape (with Y and $Y^3$) | |
| Turning point | PPP $ US 37500 | |

Table 3: EKC Parameter Estimation for EIT Kyoto Parties

| Coefficients | Coefficient | t-Statistic |
|---|---|---|
| $\beta_0$ | 9.9251 | 7.69545 |
| $\beta_1$ | -1.16E-04 | -0.05898 |
| $\beta_2$ | 2.01E-09 | 0.12312 |
| $\beta_3$ | -1.80E-14 | 0.1837 |
| $R^2$ | 0.456 | |
| F-Statistics | 12.36 | |
| EKC Shape | U-shape (with Y and $Y^2$) | |
| | Opposite N shape (with Y and $Y^3$) | |
| Turning point | PPP $ US 29000 Minimum | |

Table 4: EKC Parameter Estimation for Non-Annex 1 Kyoto Parties

| Coefficients | Coefficient | t-Statistic |
|---|---|---|
| $\beta_0$ | 6.019523 | 7.762545 |
| $\beta_1$ | 0.000385 | 0.595375 |
| $\beta_2$ | -4.07E-09 | -0.003387 |
| $\beta_3$ | 1.41E-13 | 0.94774 |
| $R^2$ | 0.038 | |
| F-Statistics | 13.433 | |
| EKC Shape | Inverted U-shape (with Y and $Y^2$) | |
| | N shape (with Y and $Y^3$) | |
| Turning point | PPP $ US 48125 | |

Table 5: EKC Parameter Estimation for India

| Coefficients | Coefficient | t-Statistic |
|---|---|---|
| $\beta_0$ | 0.587875 | 1.060642 |
| $\beta_1$ | 0.000295 | 3.025317* |
| $\beta_2$ | -0.301E-09 | -2.500965* |
| $\beta_3$ | 0.895E-15 | 1.98.236 |
| $R^2$ | 0.322701 | |
| F-Statistics | 6.987967 | |
| EKC Shape | Inverted U-shape (with Y and $Y^2$) | |
| | N shape (with Y and $Y^3$) | |
| Turning point | PPP $ US 49003 | |

## Appendix

### EKC Turning Points of Annex-1 Non-EIT Parties

| Sr. No | Name of the country | EKC shape with Y and $Y^2$ | EKC shape with Y and $Y^3$ | Turning point PPP $ US |
|---|---|---|---|---|
| 1 | Australia | U-shape | Opposite N shape | 15527.5 Minimum |
| 2 | Austria | U-shape | Opposite N shape | 14501.1 Minimum |
| 3 | Belgium | U-shape | Opposite N shape | 14745.9 Minimum |
| 4 | Canada | Inverted U-shape | N shape | 20126.05 |
| 5 | Denmark | U-shape | Opposite N shape | 15343.3 Minimum |
| 6 | Finland | U-shape | Opposite N shape | 13035.9 Minimum |
| 7 | France | U-shape | Opposite N shape | 14058 Minimum |
| 8 | Germany | U-shape | Opposite N shaped | 14770.6 Minimum |
| 9 | Greece | Inverted U-shape | Monotonic Decreasing | 31294.1 |
| 10 | Iceland | Inverted U-shape | N shape | 19385.27 |
| 11 | Ireland | Inverted U-shape | N shape | 16081.77 |
| 12 | Italy | U-shape | Opposite N shape | 12136.5 Minimum |
| 13 | Japan | U-shape | Opposite N shape | 13756 Minimum |
| 14 | Netherlands | U-shape | Opposite N shape | 15585.2 Minimum |
| 15 | New Zealand | Inverted U-shape | N shaped | 10810.63 |
| 16 | Norway | Inverted U-shape | N shaped | 27491.16 |
| 17 | Portugal | Inverted U-shape | N shaped | 9797.037 |
| 18 | Spain | U-shape | Opposite N shape | 9485.06 Minimum |
| 19 | Sweden | U-shape | Opposite N shape | 12315.9 Minimum |
| 20 | Switzerland | U-shape | Opposite N shape | 17745.1 Minimum |
| 21 | UK | U-shape | Opposite N shape | 13868.8 Minimum |
| 22 | USA | Inverted U-shape | Monotonic Decreasing | 54615.56 |

### EKC Turning Points of Annex-1 EIT Parties

| Sr. No | Name of the country | EKC shape with Y and $Y^2$ | EKC shape with Y and $Y^3$ | Turning point PPP $ US |
|---|---|---|---|---|
| 1 | Belarus | Inverted U-shape | N shaped | 8760.28 Minimum |
| 2 | Bulgarian | U-shape | Opposite N shape | 4036.25 Minimum |
| 3 | Croatia | U-shape | Opposite N shape | 3454.54 Minimum |
| 4 | Czech Republic | U-shape | Opposite N shape | 7058.82 Minimum |
| 5 | Estonia | U-shape | Opposite N shape | 5984.38 Minimum |
| 6 | Hungary | U-shape | Opposite N shape | 6875.98 Minimum |
| 7 | Lativa | U-shape | Opposite N shape | 5722.23 Minimum |
| 8 | Lithuania | U-shape | Opposite N shape | 6264.70 Minimum |
| 9 | Poland | U-shape | Opposite N shape | 6518.51 Minimum |
| 10 | Romania | U-shape | Opposite N shape | 4497.22 Minimum |
| 11 | Russian Federation | Inverted U-shape | N shaped | 10000 |
| 12 | Slovenia | Inverted U-shape | N shaped | 4821.43 |
| 13 | Ukraine | U-shape | Opposite N shape | 2429.48 Minimum |

### EKC Turning Points of Non-Annex-1 Parties

| Sr. No | Name of the country | EKC shape with Y and $Y^2$ | EKC shape with Y and $Y^3$ | Turning point PPP $ US |
|---|---|---|---|---|
| 1 | India | Inverted U-shape | N shaped | 49003 |
| 2 | Brazil | Inverted U-shape | N shaped | 35008.16 |
| 3 | China | Inverted U-shape | N shaped | 43572.28 |
| 4 | Argentina | Inverted U-shape | N shaped | 39573.26 |