



Investigating the Environmental Kuznets Curve for India

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Abstract

In recent years various empirical studies have investigated and quantified the causal relationship between economic growth and environmental degradation through an empirical model so-called Environmental Kuznets Curve (EKC), currently applied to a range of pollutants. The inverted U-shaped Environmental Kuznets curve (EKC) demonstrates that initially the pollution and environmental degradation surpass the level of income per capita; however this trend reverses since at the higher income levels, economic growth initiates environmental upgrading. It's distinguishing aspect in the initial stage of development exhibits negative relationship between the environmental quality and per capita income increased and positive relationship between improving environmental condition at the higher level of development. The developing countries find Kuznets verdict indubitably tedious between economic growth and environmental development. Unresponsive regarding environmental protection and endeavor to speed up economic growth had not only kept environmental considerations as secondary objectives in policy making in these countries but also threatened their sustainable future. The paper overviews the EKC literature, background history, policy conceptual insights, and the conceptual and methodological critique. It also underlines other econometric problems with estimates of the EKC. Based on secondary data with reference to India for EKC, this paper analyzes the relationship between Carbon Emission CO₂ (per capita metric tons) and GDP (real net per capita in Rs). Using Kuznets original model we conclude that in India after 1990 CO₂ emission growth rate is lower than GDP (real net per capita in Rs) growth rate (Implying India follows EKC).

Keywords: Environmental Kuznets Curve (EKC), Economic growth, Environmental degradation, CO₂emission, GDP per capita, India.

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1. Introduction

The increasing pace of growth and extreme pressure of population has led to an increase threat of global warming and climate change. The carbon dioxide (CO₂) emission is considered as the main cause to the Green House Gases (GHGs). It is responsible for at least 60% to the cause of global warming. Since 1990, the linkage between emissions and economic growth has been studied extensively as global warming is raising the concern of environmental degradation. In order to reduce the emission of GHGs, there have been several international attempts of which the Kyoto protocol agreement is the most notable one. The Kyoto Protocol, signed in 1997, is a protocol to the United Nations Framework Convention on Climate Change (UNFCCC) and the important feature of this protocol is to reduce the collective emissions of GHGs of 39 industrialized countries and European Union by 5.2 percent from 1990 level during the period of 2008-2012. In 2015, the historic United Nations Climate Change Conference (UNCCC) was held in Paris. It was an opportunity to put the world on course to meet the climate change challenge and to construct a new model of growth that is safe, durable and beneficial to all. The reconciliation of economic growth with environmental sustainability is a major concern in the environment economy debate because the growth theory has majorly ignored environment. On the other hand it was also argued that growth is also a precondition for environmental improvement (Bhagwati, 1993). According to Beckerman (1992) "the strong correlation between incomes and extent to which environmental protection measures are adopted demonstrates that, in the longer run, the surest way to improve your environment is to become rich". Studies by Georgescu-Roegen (1971) have claimed that there exists a trade-off between economic growth and environmental sustainability. In this context, there have been a lot of empirical studies regarding the trade-off that exists between environmental degradation and economic growth. Studies have put forth the hypothesis that there exist an inverted-U-shaped relationship between per capita income and indicators of environmental degradation. According to this inverted U shape relationship between different pollutants and per capita income in different countries which is also called the "Environmental Kuznets Curve" (EKC), environmental degradation first increases with the per capita income and then after a turning point it decreases as per capita income increases. There are few explanations for the inverted U shape of EKC;

a). Composition Effect: Economies move from subsistence to more material and intensive patterns of agriculture towards industrialization and then to service sector. This development path is the result of capital accumulation and knowledge based economies. Study by Ekins (1997) suggests that the i) composition effect adds to the scale effect that is it leads to environmental damage at a faster rate than income ii) the composition effect acts against but does not fully counteract the scale effect.

b). Displacement Effect: Economies undergo displacement effect in which there is an increased demand of environmental quality as a result of increased income.

Against this backdrop, the objective of the present study is to analyze the relationship between Carbon Emission CO₂ (per capita metric tons) and GDP (real net per capita in Rs) for India from the period 1970 to 2010. The paper reviews EKC literature, background history, conceptual insights, and the conceptual and methodological assessment. It also underlines other econometric problems with estimates of the EKC, and re-evaluates several empirical studies.

2. Origin of Environmental Kuznets Curve

In the sixty seventh annual meeting of American Economic Association in December 1954, Simon Kuznets delivered presidential address entitled "Economic Growth and Income Inequality". He suggested that as per capita income increases, income inequality also increases at first and then after some turning point starts declining. This relationship between per capita income and income inequality can be represented by bell shaped curve known as Kuznets Curve.

In 1990's Kuznets curve took a new form of relationship. The study of Grossman and Krueger (1991) for per capita income and environmental degradation shows the same inverted U shape relationship as original Kuznets curve. Latter, this inverted U shaped relationship was supported by studies of World Bank 1992 Development Report (Shafik and Bandyopadhyay, 1992) and ILO discussion paper (Panayotou, 1993). Now Kuznets curve has become a vehicle for describing the relationship between income and environmental quality (Dinda, 2004).

3. Environmental Kuznets Curve: A Debate

The study by Grossman and Krueger (1991) emphasizes the various sources of environmental impact from a greater openness to trade namely the scale effect, composition effect and technique effect. According to his study the scale effect refers to the impact of economic growth on the environment. The major finding of the study was that the level of pollutants were rising with per capita income at low levels of income, as expected, but to fall with per capita income giving rise to an inverted U shaped relationship between economic growth and environmental degradation. Studies by Selden and Song (1994) and Grossman and Krueger (1995) found similar findings that there exists an inverted U-shaped relationship between economic growth and indicators of environmental degradation. Stokey (1998) explains the EKC phenomenon in terms of changes in the marginal utility of consumption at different levels of per capita income. Dasgupta *et al.* (2002) gives conventional explanation of EKC: "In the first stage of industrialization, pollution grows rapidly because people are more interested in jobs and income than clean air and water, communities are too poor to pay for abatement and environmental regulation is correspondingly weak. The balance shifts as income rises, leading industrial sectors become cleaner, people value the environment more highly, and regulatory institutions become more effective. Along the curve, pollution levels off in the middle income range and then falls toward pre industrial levels in wealthy societies".

However some studies had more ambiguous results, implying that EKC may not hold at all times and for all pollutants (Shafik, 1994). It has been observed that EKC has been attacked on both empirical and methodological grounds e.g. (Stern and Common, 2001; Dasgupta *et al.*, 2002; Perman and Stern 2003). There were four types of contributions to the EKC literature between 1991 and 1998: estimation of the basic EKCs, studies of the theoretical determinants of the EKC, studies of the empirical determinants and critique of EKCs" (Stern, 1998).

Estimation of basic EKC refer to “studies whose main aim is to estimate the relationship between environmental indicators and growth rate” (Stern, 1998). Concluding studies have shown that EKC does not necessarily apply to all indicators of environmental degradation. Studies of the theoretical determinants of the EKC “have built on the heuristic theory of the EKC to mathematically relate plausible assumptions about technology and preferences to the shape of the time path of environmental impacts” (Stern, 1998). These include studies of Lopez (1994); Selden and Song (1995); John and Pecchenno (1994); John *et al.* (1995); Mcconneli (1997) and Stokey (1998). Studies of the empirical determinants of the EKC have focused on examining possible determinants of the EKC relationship (Stern, 1998). Conditioning variables include trade (e.g. (Rock, 1996; Rothman, 1998)); political freedom (e.g. Torras and Boyce (1998)) density of economic activity (e.g. Kaufmann *et al.* (1998)) and economic structure (e.g. (Rock, 1996; Suri and Chapman, 1998)). Stern (1998) identified some major critiques related to EKC namely the assumption that changes in trade relationships associated with development have no effect on environmental quality ,econometric problems ,ambient concentrations versus emissions ;asymptotic behavior etc.

Some of the recent studies include the empirical analysis of the relationship between income and pollution by assuming a common structure of all countries by Eugenio Figueroa B and Roberto Pasten C. The study uses the Random Coefficient Model proposed by Swamy and Mehta (1975) and empirically estimates EKCs for sulphur dioxide with specific turning points from a sample of 73 high and low income countries. The study suggests that regulatory processes resembling market mechanisms could induce the empirical emergence of EKCs. A Bayesian estimator is used in order to test the EKC hypothesis country by country. In order to check for a heterogeneous rather than a common structure, the study tested for variable slopes instead of constant slopes to analyze the EKC for SO₂ emissions. Results show that for some countries the EKC hypothesis is robust but for other countries it is not. For homogenous developed countries, there is strong evidence of an overall EKC. At country level, for most of the OECD members and for most of the members of the developed world the EKC hypothesis is robust. However a few members of the OECD and a few members of the developed world do not display an EKC. At country-specific level, 17 out of 28 countries strongly support the EKC hypothesis, and 11 out of 28 countries do not support the EKC hypothesis.

With reference to India the study by Pradyut (2009) analyzed the determinants of environmental productivities and finds Environmental Kuznets Curve type relationship existence between environmental productivity and income. The study relies on state-level industry data of sulphur dioxide, nitrogen dioxide, and suspended particular matter over the period 1991–2003 in the analysis of environmental management because it influences the cost of alternative production and pollution abatement technologies. The production function analysis is used to measure productivity change in a joint production model, with the help of a vector of market and nonmarket outputs (see Kumar (2006) for the literature). This approach uses the Luenberger productivity index, which is the dual to the profit function and does not require the choice of an input–output orientation (Chambers *et al.*, 1996). This study uses two datasets, viz, market input/output, TFP_{Market} , and environmental input/output, TFP_{Joint} , considering the maximum expansion of good outputs and contraction of bad outputs. The total factor productivity (TFP) associated with environmental outputs, TFP_{Env} or environmental productivity, is then calculated as:

$$TFP_{Env} = TFP_{Joint} - TFP_{Market}$$

Where TFP is Luenberger indices, which gives the difference of the two models. The TFP indicates not only the change in technology, but also the effect of management-level changes in institutions, including environmental regulations. Results of the study shows that overall environmental productivities decrease over time, the existing environmental management is not sufficient to bring sustainable development in the country. The environmental productivities, in general, decline more in high-income states in comparison to the low-income states. Panel analysis results show that a combined effect of income on environmental productivity is negative which removes the confusion why productivity has declined faster in developed states than their underdeveloped counterparts. The study therefore, concludes that the ongoing pace of industrialization should be met with an effective environmental management to free from untoward consequences in India.

4. Data and EKC Model

The period of the study is from 1960 2010. All the data has been taken from World Bank database of country level indicators. After checking for the stationary of the time series data using unit root test (both data sets are integrated of order one ,I(1), i.e. are non- stationary and hence were made stationary by first differencing) we conducted linear, quadratic and cubic regression to construct an EKC equation thereafter..

The linear equation of the EKC is given by:

$$Y_t = \beta_0 + \beta_1 X_t + U_t \dots\dots\dots (1)$$

Where Y_t = CO₂ emission per capita, β_0 = country specific intercept, X_t = real GDP per capita, U_t = an error term, t = time period (1960.....2010). If $\beta_1 > 0$, the relationship between GDP and CO₂ emissions is linearly increasing .Any increase in income results in a proportional increase in CO₂ emissions: the CO₂ emissions may worsen as per capita income increases. The relationship will be monotonically decreasing if $\beta_1 < 0$. In both the cases, the link between environment and income only exists when the β_1 is significant.

The quadratic form is the traditional one used in most EKC studies, defined as:

$$Y_t = \beta_0 + \beta_1 X_t + \beta_2 X_t^2 + U_t \dots\dots\dots (2)$$

The EKC hypothesis holds if $\beta_1 > 0$ and $\beta_2 < 0$, and both are statistically significant. Therefore a turning point and an inverse U –shaped relation could exist. With these observations, there exist a linkage between CO₂ emissions and GDP. The turning point where the EKC changes its curvature is estimated by taking out the first derivative and equating the same to zero.

Mathematically it is given by

$$Y^* = - \beta_1 / 2 \beta_2 \dots\dots\dots (3)$$

In this case, environmental pressure increases at initial growth stages but at a decelerating rate, up to a threshold. However, after this phase, growth allows improvements in the environmental state. If $\beta_1 < 0$ and $\beta_2 > 0$, a U shaped pattern is observed, which is particularly bad for sustainable development assumptions. The cubic form of EKC is given by:

$$Y_t = \beta_0 + \beta_1 X_t + \beta_2 X_t^2 + \beta_3 X_t^3 + Ut \dots \dots \dots (4)$$

The equation describes a relationship with two potential turning points. Indeed if $\beta_1 > 0$, $\beta_2 < 0$ and $\beta_3 > 0$, we have an N-shaped function. After an initial EKC like phase, environmental pressure begins to rise again thereafter. But only one inflection point could exist (an increasing or decreasing relationship). The inflection point is found in the same way by putting second derivative equal to zero and is solved for income i.e.

$$Y^0 = -\beta_2 / 3 \beta_3 \dots \dots \dots (5)$$

5. Econometric Specifications and Results

We have tested the null hypothesis that EKC does not holds in case of India against the alternative that the relationship does hold in the country .After running the cubic regression in EVIEWS software we obtained U shaped relationship between GDP and CO2 emissions in the initial phase, the results of which are shown below. The study runs the cubic regression because it was originally used by Grossman and Krueger (1994) in their path breaking study. This section shows the model results and briefly summarizes the major findings

5.1. Augmented Dickey Fuller Test Results for CO2

Null Hypothesis: D (CO2) has a unit root
 Exogenous: Constant, Linear Trend
 Lag Length: 0 (Automatic- based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.740520	0.0000
Test critical values:	1% level	-4.152511	
	5% level	-3.502373	
	10% level	-3.180699	

*MacKinnon (1996) one- sided p-values.

5.2. Augmented Dickey Fuller Test Results for GDP

Null Hypothesis: D (GDP) has a unit root
 Exogenous: Constant, Linear Trend
 Lag Length: 0 (Automatic- based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.004709	0.0000
Test critical values:	1% level	-4.152511	
	5% level	-3.502373	
	10% level	-3.180699	

*MacKinnon (1996) one- sided p-values.

5.3. Cubic Model for CO2

Dependent Variable: CO2
 Method: Least Squares
 Date: 10/15/16 Time: 15:16
 Sample (adjusted): 1960 2011
 Included observation: 52 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.405960	0.024982	16.25012	0.0000
GDAP	5.36E-07	5.25E-08	10.20918	0.0000
GDAP^2	-1.00E-13	1.81E-14	-5.510450	0.0000
GDAP^3	6.42E-21	1.52E-21	4.211233	0.0001
R-squared	0.912244	Mean dependent var		0.749812
Adjusted R-squared	0.906759	S.D. dependent var		0.403332
S.E. of regression	0.123159	Akaike info criterion		-1.276879
Sum squared resid	0.728069	Schwarz criterion		-1.126784
Log likelihood	37.19886	Hannan- Quinn criter.		-1.219336
F- statistic	166.3232	Durbin- Watson stat		1.312553
Prob (F-statistic)	0.000000			

As it can be clearly seen from the above tables, the Augmented Dickey Fuller test clearly states that all the variables are integrated of order one i.e all the series taken up in the analysis is I(1).The p-value is less than .05 which clearly states that we do not reject the null hypothesis and conclude that the series is stationary on first difference. Also since the series is integrated of order one we can conclude that there exists a long term relationship between GDP and CO2. We now conduct simple cubic OLS since the quadratic model proved to be inconclusive regarding the shape of EKC since the betas were insignificant. The descriptive statistics ,the long run as well as short run cointegration have been shown in the appendix

The results clearly show that there is existence of an N-shaped EKC for CO2 since $\beta_1 > 0$, $\beta_2 < 0$ and $\beta_3 > 0$ and all are statistically significant. In the table.5.3 the value of $\beta_1 = 5.36$ $\beta_2 = -1.000$ while the value of $\beta_3 = 6.42E$ the t

values of all variable including intercept are greater than 2 (absolute term), which means we reject the null hypothesis that GDP has no impact on CO₂. In an alternate way probability of all variable including intercept are less than 0.05 that means we reject the null hypothesis at 5% level of significance. Thus, for India there exists an inverse N shaped relationship between GDP and CO₂ emission. R² value of about 91% that shows a good fit and states that 91% of the variation in CO₂ emission is explained by GDP. From these results we can say that as GDP increase CO₂ emission also increase but as the economy grows further CO₂ emissions fall and then increases further. Hence an inverted U - shape exists and CO₂ emissions rise again.

6. Conclusions

The study clearly shows that there is existence of an N shaped EKC for CO₂ emissions. For a developing nation, GDP growth is enabled by electricity consumption. After the Bhopal Gas disaster in 1984, regulatory frameworks relating to environmental protection experienced an unprecedented shock. At that time, India started to take environmental protection policies more seriously. The shift from traditional production technologies to green technologies over the period of time, improved efficiency of coal fired power plants in reducing carbon intensity and CO₂ emissions has resulted in better performance for India. However, given the fact that as GDP is increasing further this decline in the emission level is not sustained. The economy witnesses a further increase in these emission levels and the tunneling through the inverted U shaped EKC for a developing country like India is only temporary. This study demands more stringent environment policies like carbon tax, command and control measures etc.

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Appendix: The descriptive statistic of the variables and long run relationship between GDP and CO2 emissions are given below respectively

Descriptives:

	CO2	GDP
Mean	0.846341	629.3341
Median	0.8	473
Maximum	1.7	1726.7
Minimum	0.4	221.1
Std. Dev.	0.37623	415.9639
Skewness	0.545504	1.083491
Kurtosis	2.375253	3.160497
Jarque-Bera	2.700203	8.066022
Probability	0.259214	0.017721
Sum	34.7	25802.7
Sum Sq. Dev.	5.661951	6921039
Observations	41	41

Long run Cointegration

Sample (adjusted): 1972 2010				
Included observations: 39 after adjustments				
Trend assumption: Linear deterministic trend				
Series: CO2 GDP				
Lags interval (in first differences): 1 to 1				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.585075	36.31810	15.49471	0.0000
At most 1	0.050268	2.011460	3.841466	0.1561
Trace test indicates 1 cointegratingeqn (s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon <i>et al.</i> (1999) p-values				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.585075	34.30664	14.26460	0.0000
At most 1	0.050268	2.011460	3.841466	0.1561
Max-eigenvalue test indicates 1 cointegratingeqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon <i>et al.</i> (1999) p-values				
Unrestricted Cointegrating Coefficients (normalized by b'S11*b=I):				
CO2	GDP			
1.661885	-0.006126			
11.82679	-0.010159			
Unrestricted Adjustment Coefficients (alpha):				
D(CO2)	-0.026387	-0.008305		
D(GDP)	-23.75644	2.085250		
1 Cointegrating Equation(s):		Log likelihood	-108.5844	
Normalized cointegrating coefficients (standard error in parentheses)				
CO2	GDP			
1.000000	-0.003686			
	(0.00040)			
Adjustment coefficients (standard error in parentheses)				
D(CO2)	-0.043852			
	(0.01213)			
D(GDP)	-39.48047			
	(6.19749)			