Is India tunnelling through Environmental Kuznets Curve? An Empirical Analysis

Apra Sinha
Research Scholar,
Department of Economics, Jamia Millia Islamia,
New Delhi-110025..

Received: March 07, 2018 Accepted: April 09, 2018

ABSTRACT *Various econometric studies have examined and modelled the causal relationship between economic growth and environmental degradation through so-called Environmental Kuznets Curve (EKC). The inverted U-shaped Environmental Kuznets curve (EKC) elucidates (pollution-income relationship) that initially the pollution and environmental degradationsurpass the level of income per capita; however this reverses since at the higher income levels, economic growth initiates environmental upgrading. Unresponsive regarding environmental protection and endeavour 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, policyconceptual insightsand methodological critique. It also underlines other econometric problems with estimates of the EKC, and re-evaluates several empirical studies. 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).*

Keywords: *Environmental Kuznets curve (EKC); Economic growth; Environmental degradation; CO2emission; GDP per-capita; India.*

1. Introduction

The increasing rate of growthand extreme pressure of population has led to an increase threat of global warming and climate change .The carbon dioxide (CO_2) emission is considered as the main cause to the Green House Gases (GHGs).It is responsible for least 60% to the cause of global warming. Since 1990, the linkage between emission and economic growth has been studied extensively as global warming is an important concern . 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,was 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 decrease 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 was held in Paris. The trade offof economic growth withenvironmental 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".According toGeorgescu-Roegen (1971) that there exists a trade-off between economic growth and environmental sustainability.Studies have put forth the hypothesis that there exist an inverted–U-shaped relationship between per capita income and indicators of environmental degradation. There are few explanations forthe inverted U shape of EKC; namely the a). CompositionEffect: Economies move from subsistence to more material and intensive patterns of agriculture towards industrialization and then to service sector. According to (Ekins 1997) 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. The second effect is Displacementeffect: Economies undergo displacement effect in which there is anincreased demand of environmental quality as a result of increased income.

The objective of the present study is to analyzethe relationship between Carbon Emission CO_2 (per capita metric tons) and GDP (real net per capita in Rs) for India from the period 1960to 2011. The paper reviews EKC literature, background history, conceptual insights, andmethodological assessment. The main aim of the paper is to path a way forward for further research in Environmental Kuznets Curve by taking Deforestation and Biodiversity loss as indicators of environmental variables and then figuring out its relation with increase in income per capita.

In1990's Kuznets curve took a new form of relationship. The study of Grossman and Krueger's in 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).

2. Environmental KuznetsCurve : A Brief Literature Review

The study by Grossman and Krueger(1991) focussed on 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 (1995) found similar findings that there exists an inverted U-shaped relationship between economic growth and indicators of environmental degradation. Stokey (1995) 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 ambiguousresults, implying that EKC may not hold at all times and for all pollutants (e.g. 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 basicEKCs,studies of the theoretical determinants of the EKC,studies of the empirical determinants and critique of EKCs" (Stern 1998)

Estimation of basic EKCs 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).This line of thought includes studies of Lopez (1994), Selden and Song (1995),John and Pecchenino(1994), John et al. (1995),McConnell (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. Kaufman et al 1998) and economic structure (e.g.Suri and Chapman ,1998;Rock 1996). Stern study (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 behaviour etc.

3. Objectives of the Study:

To estimate shape of EKC for India for the time period 1970 to 2010

To estimate the extended EKC Model for India overcoming the problem of omitted variable bias

We have taken time period from 1970 - 2010as it denotes twenty years before liberalisation and roughly twenty years after liberalization.

4. Data and EKC Model

We use data for both GDP and CO2 from secondary sources, starting from 1970-71 to 2010(41 observations), and collect GDP data from Economic Survey of India 2014-2015 (real GDP per capita based on 2004 – 2005. All database collected from World bank. 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) we conducted linear, quadratic and cubic regression to construct an EKC equations thereafter.. We have also framed an extended EKC Model with variables exhibiting liberalisation.

5. Econometric Specifications and Results

According to the EKC hypothesis, the long-run relationship between economic growth and environmental degradation can be expressed as a logarithmic cubic function of the income, given by

$lnP_t= \alpha_0+\alpha_1 \log Y_t+\alpha_2 \log Y_t^2+\alpha_3 \log Y_t^3+\xi_t$……………………………………(1)

This equation allows us to test the various forms of environmental economic relationships;

$\alpha_1>0,\alpha_2<0,\alpha_3>0$ reveals an N-shaped relationship;

$\alpha_1<0,\alpha_2>0,\alpha_3<0$ reveals an inverse N-shaped relationship;

$\alpha_1<0,\alpha_2>0,\alpha_3=0$ reveals a U-shaped relationship;

$\alpha_1>0,\alpha_2<0,\alpha_3=0$ reveals an inverse U-shaped relationship, representing the EKC hypothesis, the turning point of the EKC is computed by =

$\alpha_1>0,\alpha_2=0,\alpha_3=0$ reveals a monotonically increasing linear relationship;

$\alpha_1<0,\alpha_2=0,\alpha_3=0$ reveals a monotonically decreasing linear relationship.

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.

6. Econometric Results

Regression Model results are given below:

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.183921	0.046099	-3.989720	0.0003
GDP	0.002983	0.000214	13.96137	0.0000
GDP2	-2.33E-06	2.71E-07	-8.591081	0.0000
GDP3	7.28E-10	9.94E-11	7.320065	0.0000
R-squared	0.988483	Mean dependent var		0.846341
Adjusted R-squared	0.987549	S.D. dependent var		0.376230
S.E. of regression	0.041982	Akaike info criterion		-3.410702
Sum squared resid	0.065211	Schwarz criterion		-3.243524
Log likelihood	73.91939	Hannan-Quinn criter.		-3.349825
F-statistic	1058.512	Durbin-Watson stat		1.840720
Prob(F-statistic)	0.000000			

**at 5 % and 1% level of significance*
*** results as per* EVIEWS

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. Also in the above results $\beta_1>0$(0.002983) , $\beta_2<0$ (-2.33E-.06)and $\beta_3>0$ (7.28E-10)which clearly justifies the econometrical foundation of the N shaped Environmental Kuznets Curve .Thus ,for India during the initial phase there exists an inverse U shaped relationship between GDP and CO2 emission but later as the economy grows the environmental pressure increases. R^2 value of about 0.99 that shows a good fit and states that 99% of the variation in CO2 emission is explained by GDP. From these results we can say that as GDP increase CO2emission also increase .

7. Extended EKC Model

The data utilized in the current study ratio of net foreign assets to GDP and domestic credit to private sector (denoted by FINDEV), trade ratio (denoted by TROP) over the period from 1971 to 2011. All of the variables were obtained from the World Development Indicators (WDI) database of the World Bank. TROP is the total value of exports and imports as a share of GDP, and it is added to the models to see whether there is a causal relation between openness and energy consumption.We have included two indicators of Financial Development - Net foreign assets and domestic credit to private sector denoted by FD and FD1 respectively

Independent variable	Dependent variable Carbon emissions
Energy Usage	10.58540[a]
GDP	27.81276[a]
GDP^2	-2.450248[a]
Financial Deve	0.004857
Trade openess	-0.211749
FinanDevelop1	0.559855[a]
Cons.	-132.0910[a]
R^2	0.994731
Adj. R^2	0.993578

a Value at 1% significance level

b Value at 5% significance level

c Value at 10% significance level

Since the sign of GDP, GDP square are positive and negative respectively, we see an existence of inverted U shaped extended EKC model. The sign of energy usage is positive implying a one percent increase in energy usage will increase carbon emissions by 10.58 percentage. The sign of financial development is positive, implying a one percent increase in financial development (here NFA) increase carbon emissions by 0.004857 percentage. Similiarly a one percent increase in net domestic credit to private sector increases carbon emissions by 0.55 percentage. A one percent increase in trade openness decreases carbon emissions by 0.211 percentage.Some of the recent literature exhibiting the impact of financial development on energy consumption are (Tamazian et al. 2009); (Jalil and Feridun 2011); (Sadorsky 2010); (Sadorsky 2011)]. Financial Development leads to increase in growth rate thereby increasing reliance on energy consumption. According to (Beck 2006) Financial development affects saving rates, investment decisions, technologicaldevelopments, long-run growth rates and hence energy consumption. As per Jensen(1996) financial development will lead to more industrial and consumptionactivities that result in greater pollution. Frankel and Romer (1999) stated that, financialliberalization and development will lead foreign direct investment (FDI) and research anddevelopment (R&D) investments which, in turn, promote economic growth and affectdynamics of environmental performance.Study of Jalil and Feridun (2011) was one of the first study to investigate the long-run equilibria between financial developmentand environmental pollution in China. The study used autoregressive distributed lag(ARDL) bounds testing procedure for the period 1953–2006 for China .The finding of the positive effect of energyconsumption is in line with Ang (2009), Jalil and Feridun (2011) and Pao and Tsai (2010),Alper and Onur (2016). The sign of trade openness*pro*vides support to Grossman and Krueger (1995), who indicated that developing countries tend to have dirty industries with a heavy share of pollutants (Jalil and Feridun, 2011).

8. Short –run Relationship between GDP and CO2

We also used Granger casualty test in order to check the short run relationship between GDP and CO_2

Sample: 1970 2010

Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
GDP does not Granger Cause CO2	39	4.29530	0.0217
CO2 does not Granger Cause GDP		0.34738	0.7090

Here, F statistics is 4.29530 implyingGDP causes CO_2 to rise. Alternatively, the probability of null hypothesis is 0.0217 which is less than 0.05; hence GDP causes CO_2 to rise (5% level of significance).The lag length is 2 in this case..The results clearly shows that in the long run as growth rate increases further the rate of growth of CO2 emissions decline (the economy becomes environmentally sensitive due to availability of low carbon technologies options , levy carbon tax etc.)

9. Environmental Kuznets Curve: A New Paradigm

Studies have used a wealth of indicators for finding whether there exists an inverted U shape Environmental Kuznets curve. Some of studies have analyzed a wide variety of environmental variables including water pollution (Grossman and Krueger 1995, Shafik 1994), deforestation (Cropper and Griffiths 1994, Koop and Tole 1999), municipal solid waste etc.Deforestation is one of the serious environmental problems now-a-days being faced by India and other countries. It has become an issue of global concern because of the role of forests in biodiversity conservation and reducing greenhouse effect. The macroeconomic growth theory has neglected this problem Deforestation affects economic activity and also affects life of people dependent on forests. The theoretical exploration for Deforestation Kuznets curve is provided by Lopez (1994).Study clearly reveals that if stock effects of forest resource on agricultural production are internalized then economic growth leads to less of deforestation.

Deacon (1994) relates deforestation to insecure property rights for 120 countries. The study found that there exists a close association between deforestation and government instability variables.

However the most important global environmental quantities biodiversity has been rarely looked upon.One of the major studies by Simon Dietz (2009) shows that there does not exist any EKC for Biodiversity loss. The main reason behind is that the theoretical dynamics of species diversity cannot predict a Kuznetian type development with income .The most distinguishing characteristic of biodiversity loss data is that direct species count exist. The most important result that EKC does not exist for biodiversity loss is due to lack of clarity regarding the correct type of curve. A non-parametric function test, in which the shape of curve is plotted against the calculation based, can give light to the issue.

In the Indian context no study has been done on Biodiversity Loss Kuznets curve and Deforestation Kuznets curve. This research paper can path the way forward for future research areas for the above untouched environmental indicators and can contribute towards the achievement of a sustainable path.

References

1. A, Feridun M (2011) The impact of growth, energy and financial development on the environment in China: a cointegration analysis. Energy Econ 33(2):284–291
2. Alper , , Onur (2016) Envirinmental Kuznets Curve hypothesis for the subelements of carbon emissions in China
3. Beck T (2006) Creating an efficient financial system: challenges in a global economy. The World Bank policy research working paper 3856: Feb 2006
4. Beckerman, W; (1992).Economic growth and the environment: whose growth? Whose environment? *World Development*. 20(4):481-496
5. Bhagawati, J; (1993). The case for free trade. *Scientific American:* 42 – 49.
6. Chambers, R.G., Färe, R., Grosskopf, S; (1996). Productivity Growth in APEC Countries. *Pacific*. *Economic Review,* 1(1): 181–190.
7. Dasgupta, S., Laplante, B., Wang, H., Wheeler, D; (2002). Confronting the Environmental Kuznets Curve. *Journal of Economic Perspectives* 16 (1): 147 – 168.
8. Dinda, S; (2004). Environmental Kuznets Curve hypothesis: a survey. *Ecological Economics,* vol. 49(1): 431-455.
9. Ekins, P; (1997). The Kuznets Curve for the environment and economic growth: examining the e evidence. *Environment and Planning* A (29): 805 – 830.
10. Frankel Jeffrey A, Romer D (1999) Does trade cause growth? Am Econ Rev 89(3):379–399\
11. Georgescu-Roegen, N; (1971). The Entropy Law and the Economic Process *Cambridge, Harvard University Press*
12. Grossman, G.M., Krueger, A.B;(1991). Environmental impacts of the North American Free Trade Agreement. *NBER. Working paper* 3914
13. Grossman G, Krueger A; (1994). "Economic growth and the environment", WP-4634, *National Bureau of Economic Research*, Cambridge, MA, February
14. Grossman, G.M., Krueger, A.B;(1995). Economic growth and the environment. *Quarterly Journal of Economics* 110 (2): 353 – 377
15. Jansen, V., 1996. The pollution haven hypothesis and the industrial flight hypothesis: some perspectives on theory and empirics. Working Paper 1996.5, Centre for Development and the Environment, University of Oslo
16. John, A.andPecchenno, R.; (1994).An overlapping generation's model of growth and environment. *Economic Journal.*104(427) :1393-1410
17. John, A; Pecchenino, R ;Schmmelpfennig,D and Schreft, S; (1995). Short –lived agents and the long lived environment. *Journal of Public Economics*.5(1): 12-20
18. Kaufmann,R.K,David,Garnham,S.andPauly,P;(1998)The determinants of atmospheric SO2 concentrationsreconsidering the environmental Kuznets curve. *Ecological Economics*,25(2):209-220

19. Kumar,S; (2006). Environmentally sensitive productivity growth: A global analysis using Malmquist–Luenberger. *Ecological Economics*,56(2):280-293
20. Lopez, R; (1994).The environment as a factor of production: the effects of economic growth and trade liberalization. *Journal of Environmental Economics and Management*, 27(2):163-184
21. MacKinnon, J. G; (1996), Numerical distribution functions for unit root and cointegration tests. *J. Appl. Econ*., 11: 601–618.
22. MacKinnon, J. G., Haug, A. A. and Michelis, L; (1999), Numerical distribution functions of likelihood ratio tests for cointegration. *J. Appl. Econ*., 14: 563–577.
23. Mcconneli, K.E; (1997).Income and the demand for environmental quality. *Environment and Development Economics,*2(4):383-399
24. Panayotou, T;(1993). Empirical tests and policy analysis of environmental degradation at different stages of economic development, *ILO, Technology and Employment Programme, Geneva*
25. Perman,R. and Stern ,D.I;(2003).Evidence from panel unit root and cointegration tests that the environmental Kuznets curve does not exist .*Australian Journal of Agricultural and Resource Economics.*47(3):325-348
26. Pradyut Ranjan Jena (2009). "Estimating environmental efficiency and Kuznets curve for India". *Institute of environmental economics and world trade. Leibniz Universität Hannover, Paper prepared for presentation at the International Association of Agricultural Economists Conference, Beijing, China*, 16-22.
27. Rock, M.T; (1996).Pollution intensity of GDP and trade policy :can the World Bank be wrong? *World Development*. 24(3):471-479
28. Rothman, D.S ;(1998).Environmental Kuznets curves-real progress or passing the buck? A case for consumption-based approaches. *Ecological Economics*. 25(2):177-194
29. Selden, T.M., D. Song; (1994). Environmental quality and development: is there a Kuznets Curve for air pollution emissions? *Journal of Environmental Economics and Management,* 27(2):147-162.
30. Selden, T., Song, D.,(1995). Neoclassical growth, the J Curve for abatement,and the inverted-U Curve for pollution. *Journal of Environmental Economics and management* 29: 162 – 168
31. 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*
32. Shafik, N;(1994). Economic development and environmental quality: an econometric analysis. *Oxford Economic Papers* 46, 757 – 773
33. Stern, D.I; (1998). Progress on the environmental Kuznets curve? *Environment and Development Economics* 3: 175 – 198
34. Stern, D.I., Common, M.S,(2001). Is there an environmental Kuznets curve for sulfur? *Journal of Environmental Economics and Management* 41 (2): 162 – 178.
35. Stokey,N.I;(1998). Are there limits to growth? *International Economic Review*.39 (1):1-31.
36. Suri, V., Chapman, D;(1998). "Economic growth, trade and the environment: implications for the environmental Kuznets curve", *Ecological Economics* 25(1): 195– 208.
37. Swamy, R and Mehta J.S; (1975). "Bayesian and Non-Bayesian Analysis of Switching Regressions and of Random Coefficient Regression Models", *Journal of the American Statistical Association,* 70: 593-602
38. Torras, M., Boyce, J.K; (1998). Income, inequality and pollution :a reassessment of the environmental Kuznets curve. *Ecological Economics.*25(2):147-160
39. Tamazian A, Chousa JP, Vadlamannati C (2009) Does higher economic and financial development lead to environmental degradation: evidence from the BRIC countries. Energy Policy 37(1):246–253.

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