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Article

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Verifying the Environmental Kuznets Curve Hypothesis in the Case of India

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ABSTRACT

Growth with sustainability has nowadays become an important thrust area of world economy. The present paper has tried to examine the pollution-income relationship to verify the phenomenon of EKC hypothesis in the case of India for the period of 1978-2014. The application of Johansen cointegration method reveals that there is long run cointegration relationship between the two in the case of India. The study also validates the EKC hypothesis thus giving signal that India should pursue the strategy of "grow now and clean later," a policy usually adopted by most of the rich countries of the world.

Keywords: Environmental Kuznets Curve, Johansen cointegration, India
JEL Classifications: Q56, O53

1. INTRODUCTION

The debate over relationship between economic growth and environmental quality is not new but started since 1970s. Many physical and social scientists of the period tried to enquire about whether there is tradeoff between economic progress and environmental purity. For example, Georgescu-Roegen (1971), Meadows et al. (1972) were of the opinion that economic activity requires more of energy and other materials and consequently would cause more amount of waste products to sink. Gradually it becomes difficult for the biosphere to absorb larger amount of accumulated wastes and pollutants when larger amount of natural resources is extracted in pursuit of achieving higher level of economic activities (Daly, 1991). The debate over the issue continued during the 1980s also facing the challenge of depleting biodiversity, weakening of ozone layer and global warming. Following Brudtland's report, the discourse of sustainable development now shifted towards achieving high rate of growth as a strategy to deal with poverty, social deprivation and environmental degradation particularly for developing countries (WCED, 1987).

The 1990s witnessed the discussion over association between economic activity and environmental quality on different path. Many started arguing that environmental quality can be improved in faster way by accelerating economic growth. At somewhat higher level of income, people demand more of goods which are less material intensive and would also demand better environment which would force the government to adopt measures to protect environment and develop environment friendly technologies. Beckerman (1992) argued that surest way to improve environment is to become rich. Bartlett (1994) was of the opinion that restricting economic growth in pursuit of maintaining environmental quality in fact ends up in deteriorating environmental quality.

With publication of work of Grossman and Kruegar (1991) on potential environmental impact of NAFTA in which they found Kuznets curve pattern of relationship between economic growth and environmental quality, enquiry about the association between economic growth and environmental degradation suddenly took a different turn. They observed that as the economy grows, initially, the environmental pollution increases with increase in per capita income, then, after reaching a certain level of income (known as turning point) the trend is reversed and pollution declines. The observed relationship between income per capita and environment quality when represented graphically form U-shape curve. This curve is popularly called as Environmental Kuznets curve (EKC), named after Kuznets (Kuznets, 1955) who found similar inverted U-shaped relationship between per capita income level and inequality. The concept then becomes more popular after publication of World Bank Report (1992).

With these publications, the empirical investigation about the association between economic growth and the quality of environment suddenly exploded and lots of empirical studies started testing the validity of Environmental Kuznets curve (EKC) hypothesis (Stern, 2003; 2004; Cole and Neumeyer, 2005).

Despite the fact that number of studies has been done to empirically investigate the relationship between economic activity and environmental quality, there is lack of empirical study enquiring the same in the case of India. Thus, the objective of present study is to examine the association between economic activity and quality of the environment in the case of India. Further, the study would try to verify whether the EKC hypothesis is also valid in the case of India. The findings would be important from the point of view of India's future policy with regard to economic activity.

The paper is organized as follows. In next section, theoretical and empirical literature discussing the relationship between economic activity and environmental pollution. This is followed by description of data and econometric methodology to examine the relationship. Then, the empirical results will be analysed. Lastly, conclusion and policy implications will be presented.

2. THEORETICAL AND EMPIRICAL LITERATURE

The EKC hypothesis implies that in the short run, the economic growth adversely affects the environment quality. However, in the long run, once the specific level of income is reached, further growth in income will reduce the environmental degradation. Several explanations have been to justify this relationship. One of arguments given in support of this hypothesis is that environment is a normal good with positive income elasticity of demand. As a result, as income rises, people's concern about environment increases, sometimes by more than proportionately (Beckerman, 1992; World Bank, 1992). Further, rich countries can handle the environmental situation in better way through their better environmental institution (Neumayer, 2003b). Second, Grossman and Kruegar (1995) argue that with economic growth, introduction of modern and less pollution emitting technology is possible. However, Lopez (1992) said that even in such cases pollution per capita may reduce but not in absolute amount. Third, change in sectoral composition of country's economic activities may be another reason for decrease in environmental degradation with economic progress. With economic progress, the relative share of service sector goes up which is less polluting sector as compared to industrial sector. However, it is also said that the developed countries shift the production of resource and pollution intensive products in less developed countries and import these products from there that may give impression that environmental degradation declines with economic progress. Despite some recent evidences, the empirical record of such argument remains inconclusive (Neumayer, 2001). Another argument put forth in support of the hypothesis is that with economic progress, the growth rate of population and hence of environmental degradation declines. UNDP (1999) report reveals that higher population emits more and vice versa. Still there are some like (Neumayer, 2001) who argue that economic progress is not the only determinant of population growth. Hence, the relationship between economic growth and environmental degradation remains inconclusive from theoretical perspective.

The empirical literature also gives mixed evidence of the relationship between growth and environmental quality. Saidi and Hammami (2017) while analyzing the causal relationship between growth, transport and environment found bidirectional relationship between the growth and environmental degradation in the case of high-income countries but unidirectional effect from growth and transport to environment in the case of other countries. Omri et al. (2015) also analysed the association between finance, environment, trade and growth in the case of MENA countries and found bidirectional relationship between income and environmental quality and have also confirmed environmental Kuznetss curve. A causality link between environmental quality, FDI and economic growth for Middle East and North African (MENA) countries has been examined by Abdouli and Hammami (2017) using simultaneous equations model estimated by vector autoregressive model (VAR) and found bidirectional relationship between economic growth and CO_2 emissions as well as between FDI and CO_2 emissions. Onafowora and Owoye (2014), using bound testing approach to investigate the relationship between economic growth, energy consumption, population density, trade openness and CO_2 in of eight countries (Brazil, China, Egypt, Japan, Mexico, Nigeria, South Korea and South Africa) based on EKC hypothesis. The study has found U shape relationship in the case of Japan and South Korea. For the rest of the countries, long run relationship between economic growth and environmental degradation follows N shaped path and not of inverted U shaped. Further, the estimated turning points are much higher than the sample mean.

Mahmood and Alkhateeb (2017) have also found the inverted U shape relationship between income and environmental quality in the case of Saudi Arabia. Similar result was also found by Mahmood and Alkhateeb (2019) In the case of Egypt when they included other variables like FDI, energy consumption and trade GDP ratio. Ben et al. (2015) in the case of Sub Saharan African countries has not found inverted U-shape pattern of relationship between growth and carbon emission in the long run. Armeanu et al. (2018) also examined the EKC hypothesis in the case of 28 European Union (EU) countries and found the evidence of EKC in the case of discharge of Sulphur oxide, release of non-methane volatile organic compound and ejection of ammonia. Further, the fixed effect regression with Driscoll-Kraay standard errors back the EKC hypothesis for greenhouse gas emissions, greenhouse gas discharge intensity of energy consumption, release of nitrogen oxide, discharge of non-methane volatile organic compound and ejection of ammonia. Taguchi (2012) examined the case of EKC hypothesis for 7 Asian countries and found the EKC pattern in the case of Sulphur emission specially in economically advanced countries like Japan, South Korea, Taiwan province of China, but not so in the case of carbon where turning point is expected at about \$50,000, a level beyond the observed level. In the case of carbon, increasing trend has been observed with increasing per capita income i.e. manifest early stage of EKC. In the case of Eastern European and Central Asian emerging economies, Kolio (2019) has found evidence of EKC pattern of development. Though, all the countries have not achieved the turning point level of income.

Though there are number of studies on developed countries examining the EKC hypothesis, the investigation of similar studies on India is very scarce. Only few studies have been done so far. For example, Usman et al. (2019) examined the EKC hypothesis in the case of India by incorporating additional variable like energy consumption and democratic environment and found EKC pattern of development. Kanjilal and Ghosh (2013) in their study also confirm EKC hypothesis in the case of India while examining the cointegration relationship between carbon discharge, energy consumption, economic activity and trade openness for India using threshold cointegration tests. Rudra and Chattopadhyay (2018) tried to examine EKC hypothesis of different states and found that Kerela and Punjab follow the inverted U shape pattern of relationship between income and pollution while states like Bihar, West Bengal, Maharashtra will take a long time to lessen toxins.

Thus, the present study intends to examine whether environmental pollution in India follow inverted U-shape pattern (EKC) with growth of the economy or show a rising trend.

3. ECONOMETRIC METHODOLOGY

To examine the EKC phenomenon, a quadratic model using environmental quality as a function of per capita income was used by earlier studies. Some has also applied cubic model to examine the impact of economic activity on environmental quality. The present paper has used a simple quadratic model to examine the association between per capita income and pollutant discharge per capita of the following form.

$$Co_t = \alpha_0 + \alpha_1 PCI_t + \alpha_2 PCISQ_t + \varepsilon_t \qquad (1)$$

Where,
CO is carbon discharge per capita
PCI is per capita income, and
t refers to time period

The variables have been expressed in natural log form.

In the above model, if α_1 is positive and significant and α_2 is statistically insignificant, then we will have unidirectional positive relationship between pollutants discharge and growth of per capita income. In such case, we will have clear sign of deterioration in environmental quality. If α_1 is negative and statistically significant while α_2 is statistically insignificant, it would show continuous improvement in the quality of the environment. However, if the α_1 is positive and significant, and α_2 is negative and significant, we will have inverted U-shape pattern of relationship between carbon discharge and economic growth measured in terms of per capita income that will verify the EKC hypothesis. Though, some have also tested environmental quality as cubic function of per capita income hypothesizing N-pattern of the relationship. But the objective of the present paper is to test the EKC hypothesis in the case of India for which quadratic model has been used.

To examine the EKC hypothesis, the data on carbon emission per capita and per capita income has been taken from World Development Indicator (WDI) for the period 1978 to 2014. The EKC may be verified by estimating the long run cointegration relationship and then by normalizing the cointegration equation as per above model. For the purpose, the present study has applied Johansen Cointegration method. As the first degree of integration of the included variables in the model is the prerequisite of application of this method, augmented Dickey-Fuller (ADF) and Phillips-Perron method will be applied to establish order of integration of the variables. Having fulfilled the requirement of order of integration, the Johansen technique will be applied to estimate the long run association between carbon emission per capita and per capita income and examine the sign and statistical significance of the coefficients of per capita income and square of per capita income. This would verify EKC hypothesis in the case of India. The short run relationship can be examined through vector error correction model (VECM). Various diagnostic tests would validate our results.

4. DATA ANALYSIS

As is revealed from Table 1a and b, both the variables used in the model have unit root at level as the t-statistics of ADF statistics is more than the Mc Kinnon critical value. Hence, we reject the

Table 1a: Results of ADF test for unit root

Variables		Level		First difference		Inferences
		C	C and T	C	C and T	
COt		0.303390	−1.523634	−5.747985*	−5.674995*	I(1)
PCIt		−1.074316	−2.556959	−4.169695*	−4.225752**	I(1)
PCISQt		0.986329	Level	−3.660975	−3.779338	I(1)
Mc Kinnon critical values	1%	C	C and T			
	5%	−2.945842	−3.540328			
	10%	−2.611531	−3.202445			

*Shows significant at 1%. Schwarz information based lag order. ADF: augmented Dickey-Fuller null hypothesis that the variables (carbon emission and per capita income) are stationary at level. But the t-statistics for ADF statistics of both the variables are less than the Mc Kinnon critical value when we test the variables at first difference. Hence, the ADF test confirms that both the variables are integrated of first order. Similar result is obtained when we apply PP test to know the stationarity of the variables. Thus, both the tests confirm that carbon emission and per capita income are integrated of first order, a pre-condition to apply Johansen cointegration method.

We may now proceed to apply cointegration method to estimate long run association between carbon discharge and per capita income after verifying the pre-requisite of the Johansen method. As the number of lags significantly affects the result of our study, choice of suitable lag period is crucial to get prudent result. Table 2 reveals the different statistics for selection of lag period. All the criteria except SC criterion suggest 2 period lags would be appropriate for the model. Hence, lag of 2 period has been selected to estimate the cointegration between per capita income and carbon emission.

Following (Tables 3a and b) display the results of Johansen cointegration. The trace statistics for null hypothesis of no cointegration (33.19971) is more than the critical value (24.27596), thus, rejecting the null hypothesis of no cointegration at 5 percent significance level, and conclude that the variables have atleast one cointegration relationship between themselves. The trace statistics for null hypothesis that the variables have at most one cointegration is 15.79075 which is again more than the critical value of 12.32090 implying that there is at least two cointegration relationship between environmental quality and per capita income. But the null hypothesis that they have at most two cointegration can be accepted as the trace statistics is less than the critical value at 5 percent significance level. Hence, we may conclude on the basis of trace statistics that there is at most two cointegration relationship between carbon emission and per capita income. The result of maximum Eigen value statistics (Table 3b) also confirms at most two cointegration relationship between the variables included in the study as the test statistics is greater than the value at 10 percent for no cointegration and at 5 per cent for at least one cointegration but less than the critical value for at least two cointegration. Thus, on the basis of both the statistics, it may be concluded that environmental quality and economic activity have long run association.

$$Co_t = 0.43PCI_t - 0.046PCISQ_t + \varepsilon_t \quad (2)$$

t-values (2.41896) (2.50647)

Table 1b: Results of PP test for unit root

Variables		Level		First difference		Inferences
		C	C and T	C	C and T	
COt		0.269875	−1.832664	−5.788786*	−5.719913*	I(1)
PCIt		−0.508221	−2.073004	−4.342461*	−4.394680*	I(1)
PCISQt		1.911817	−1.586560	−3.754640**	−3.921874**	
Mc Kinnon critical values	1%	−3.626784	−4.234972			
	5%	−2.945842	−3.540328			
	10%	−2.611531	−3.202445			

*Shows significant at 1%. Number of truncation lags is based on Newey-West criterion

Table 2: Lag selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	−40.15676	NA	0.002542	2.538633	2.673312	2.584562
1	211.4822	444.0688	1.61e-09	−11.73425	−11.19553*	−11.55053
2	225.3867	22.08366*	1.23e-09*	−12.02275*	−11.08000	−11.70124*
3	233.2991	11.17034	1.36e-09	−11.95877	−10.61198	−11.49948

*Indicates lag order selected by the criterion. LR: Sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion. VAR lag order selection criteria, Endogenous variables: lCO, lPCI, (lPCI)2, Exogenous variables: C

Table 3a: Unrestricted cointegration rank test (Trace)#

Hypothesized No. of CE(s)	Eigen value	Trace statistics	0.05 Critical value	Prob.**
None*	0.400721	33.19971	24.27596	0.0029
At most 1*	0.315358	15.79075	12.32090	0.0126
At most 2	0.082015	2.909516	4.129906	0.1042

2 cointegrating eqn(s) according to Trace test at the 0.5% significance level

Table 3b: Unrestricted cointegration rank test (Maximum Eigen value)#

Hypothesized No. of CE(s)	Eigen value	Max-eigen statistic	0.05 Critical value	Prob.#
None**	0.400721	17.40896	17.79730	0.0571
At most 1*	0.315358	12.88123	11.22480	0.0254
At most 2	0.082015	2.909516	4.129906	0.1042

2 cointegrating eqn(s) according to Maximum eigen value at 0.5% level of significance. *Indicates rejection of the hypothesis at the 0.05 level, and ** shows rejection of hypothesis at 0.1 level. #MacKinnon-Haug-Michelis (1999) P-values.

Table 4: Granger causality based on VECM: carbon emission Per capita (CO_t) as dependent variable

Independent variable	ΔPCI_t	$\Delta PCISQ_t$	ECT_{t-1}	Diagnostic tests (P-value)
Chi-square (P-value) [t-value]	(0.1317)	(0.0709)	−0.122802 [−2.44746]	LM Serial Correlation: 0.7639 Jarque-Bera Normality Test: 0.8829 Heteroskedasticity: 0.4096

The normalization of cointegration equation reveals that the coefficients of per capita income and square of per capita income are statistically significant. The coefficient of per capita income is positive and that of square of per capita income is negative. Thus, the relationship between economic activity and environmental quality will manifest an inverted U-shape pattern of curve. This implies that the environmental pollution curve will initially rise with increase in per capita income but after reaching a point will start falling. The turning point in the case of India is estimated to have been achieved at about 51000 rupees in 2009. This implies that until 2009, the environmental quality worsens with economic growth until 2009 after that it improves in per capita sense if not in absolute sense. This confirms the EKC hypothesis in the case of India. There can be many reasons for observation of such pattern of income-pollution relationship. This may be because of growing concern of the people for better environment and the demand elasticity for better environment may be positive. This may also be because of use of better technology causing less emission of pollutants per unit of output (Grossman and Krueger, 1995). This may also reflect India's commitment to Kyoto protocol which was signed in 2002 and again in Paris conference in 2016 to control emission of pollutants. Another likely reason may be change in sectoral composition of output as the share of service sector which is relatively less polluting than the industrial sector and its share in GDP is rising over the period of time (e.g. Jänicke et al., 1997). The share of service sector has risen to about 54% of GDP. The share of industry in GDP has started declining since 2008 and may have led to less emission of pollutant per capita.

Since the variables are cointegrated, we estimate vector error correction model to do the Granger causality test between the variables. The result is presented in Table 4. The VECM reveals two sources of causality. Short run causality is known from lagged difference terms and long run causality is expressed by lagged error correction (ECTt-1) term. The table shows that in the short run, per capita income does not Granger cause environmental degradation but in the long run it does as is revealed from the fact that the error correction term is negative and significant. However, the coefficient of error correction term is small showing slow rate of adjustment.

5. CONCLUSION

The objective of the paper is to verify the EKC hypothesis in the case of India and also to examine the causal relationship between carbon emission and economic growth in India. Applying Johansen's method of cointegration on the data from 1978 to 2014 obtained from world Development Indicator, we find that environmental degradation measured in terms of carbon emission per capita and economic growth measured by per capita income have long run cointegration relations. The normalization of cointegration equation reveals that the coefficient of per capita income is positive and statistically significant and the coefficient of square of per capita income is negative and statistically significant. The sign and statistical significance of these coefficients confirm the EKC hypothesis in the case of India and the turning point for India is 2009 at per capita income of about 51000 rupees.

The fall in the income pollution relationship curve after rising or EKC pattern of relationship may imply that India should go ahead with pursuit of higher rate of economic growth of course with better and less polluting technology and the encouraging more environment friendly sector in order to keep the growth sustainable.

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