Duo Analysis of Openness and Gas Emission: An Econometric Analysis with Reference to India

SHAHIN KHAN[1], SHILPI GUPTA[2]

Research Scholar, Manipal University Jaipur, INDIA

Associate Professor, Manipal University Jaipur, INDIA

Abstract: Some economist believe that relatively lax environmental standards give developing countries a comparative advantage in pollution -intensive goods. This paper brings together the literature on openness and growth and on EKC curve, to demonstrate that the opposite may be true. The present study deals with the estimation of Environmental Kuznets Curve in India by using Co-Integration Analysis for the period 1985-2018. This study uses secondary data on GDP per capita, trade intensity and N_2Oemission from world data indicator of world bank. The empirical finding supports the existence of Inverted ‘U’ shaped relationship between environmental degradation and growth of GDP. The inclusion of trade intensity suggest that freer trade aggravates environmental damage via terms of trade, but mitigate it via income growth.

Key-Words: EKC, N_2O emission, Environmental degradation, Trade.

1. Introduction

One of the most widely debated aspects of globalization has been the environmental consequences of trade liberalization. This research work investigates how “openness” to international markets affects pollution levels. The decomposition of trade’s impact on pollution into scale, technique, and composition effects and examine this theory using data on N2O from the World data indicator.

EKC is a well-known hypothesis in the literature of Environmental Economics. “Environmental Impact of North American Free Trade Agreement” by Gene Grossman & Alan Krueger concludes that urban air concentration of SO_2 along with two types of Suspended Particulate Matter (SPM) exhibit an inverted U-shaped relationship with national income level. At low income level, environmental quality deteriorates with economic growth but above a certain threshold level of approximately $ 4000 to $5000 per capita per year air quality improves with economic growth. This inverted U relationship has been termed the EKC after 1995 paper by Simon Kuznets hypothesizing a link between economic growth and income distribution (Kuznets, 1995).

Hereafter different studies have been published considering various elements such as countries, time, economic indicators & pollutants which resulted into different shapes of EKC. These different shape of EKC whether increasing, U Shape, inverted-U shape, N shape, inverted N shape are sensitive to the choice of context, model specification, explanatory variables, turnaround points, time-period, location etc. either supporting or disapproving this hypothesis.

The first step towards analysing the effect of economic growth on environment is through understanding the income-environment relationship. In this research work, attempt is made to incorporate explicit trade consideration for the better understanding of income environment relationship. Effect of trade on environment can be via income channel and non-income channel (Frankel & Rose, 2002). The premise EKC is based on the interaction between economic growth and environmental degradation. According to Grossman (1995) the amount of environmental damage in a country at any point of time is endogenous and depends upon the income level of country. (Grossman and Kruger, 1995; Selden and Song 1994). This effect can take place by the means of three channel namely scale, composition and technique effect.

Scale effect measures the increase in pollution that would be generated if the economies were simply scaled up, holding constant the mix of goods produced and production technique. In order to fuel growth, the demand for natural resources rises consequently the direct and indirect consumption of natural resources are transformed into production process which generates industrial waste. This by-product of economic growth poses serious threat to environment. Now with the increase in level of income, industrial structure of an economy undergoes a transformation along with the change in composition of an economy. Composition effect is captured by change in the share of dirty goods in national income, keeping constant the scale of economy and emission intensities. During this time the secondary sector start maturing and economy shifts towards cleaner technologies. In this way economic growth exerts technique effect on environment during which the economy starts turning out knowledge intensive rather than capital intensive.

2. Review of Lierature

Antweiler, Copeland, and Taylor (1998) develop a theoretical model to decompose the effect of income growth on emissions into scale and composition, and technique effects. They then estimate changes in SO_2 emissions using a single equation reduced-form model and pooled cross-country time series data. The authors acknowledge that such estimation will not distinguish the extent to which trade policy has affected emissions, since trade policy itself will generate the three effects above. From separate estimates, they find that trade liberalization does shift the composition of output towards dirty goods for low income countries. However, the magnitude of this effect is small. In addition, when compositions effects are added to indirect calculations of the impact of trade liberalization on scale and technique, the authors find that trade liberalization appears to be good for the environment.

Hu Xiqim, Zeng Hai, Yang li (2013) supports sustainable trade as a solution to find a way to strike a balance between international trade and environment in “Resolving trade and environment conflicts: A focus on sustainable trade in china”.

Judith M. Dean, (2002) in “Does Trade Liberalization Harm the Environment?” used regression analysis to examine the impact of trade liberalization on environment and results shows trade liberalization have multiple effects on environment. It has negative effect on pollution emission causing environmental degradation but simultaneously it reduces the emission growth of pollutants through income effect and hence having positive effect on environment.

P. Ekins, 1997 “The Kuznets Curve for the Environment & Economic Growth: Examining the evidence” studied on the evidence for an EKC relationship by using regression analysis and found that most of the world population is still on increasing part of the curve. The inverted-U hypothesis is correct (Grossman and Krueger 1995; Selden and Song 1994); however, the amount of environmental damage in a country at any point in time is endogenous and depends upon the income level of the country. According to this literature, and income growth has three effects on the existing amount of pollution emissions. First, greater economic activity raises demand for all inputs, increasing emissions (the 'scale effect'). Second, higher income causes people to increase their demand for a clean environment (a normal good) and to tolerate higher levels of pollution only if effluent charges are higher. This encourages firms to shift towards cleaner production processes, reducing emissions (the 'technique effect'). Third, income growth increases demand for relatively cleaner goods. This causes the share of pollution-intensive goods in output to fall, reducing emissions (the 'composition effect'). The inverted-U hypothesis states that at low levels of income, the scale effect outweighs the composition and technique effects. Thus, as a poor country begins to grow, it sees a net increase in environmental damage. Over time, income reaches some critical level, and the latter two effects outweigh the former. Growth then leads to a net reduction in environmental damage.

Shafik and Bandyopadhyay, (1992) in “Economic Growth and Environmental Quality: Time series and Cross-Country Evidence” used panel data regression in context of 149 countries for 30 years (1960-1990) and found out monotonically increasing EKC with no turnaround point. Holtz-Eakin and Selden, (1995) in “Stoking the fires? CO_2 emissions and economic growth” used quadratic power of income on panel data and found inverted U-shaped EKC at turnaround point 35,428.

Muhamad Shahbaz and Avik Sinha, (2019) in “Environmental Kuznets curve for CO_2 emissions: a literature survey” provide a survey of the empirical literature on environmental Kuznets curve (EKC) estimation of carbon dioxide ($CO_{2)}$ emission over the period of 1991-2017 on the basis of power of income in empirical model of EKC and the results are inconclusive in nature due to the attribution of choice of context, time period, explanatory variables, and methodological adaption.

Hill and Magnani, (2002) in “An exploration of the conceptual and empirical basis of the environmental Kuznets curve” used panel data and cubic power of income on 156 countries (1970-1990) and found N-shaped EKC with first turnaround point at 3,007.01 and second point at 721,919.40.Day and Grafton, (2003) in “Growth and the Environment in Canada: an empirical analysis” used time series data for Canada (1958-1995) and gave N-shaped EKC by using OLS method at two turn around points 19,133.10 and 20,760.86 respectively.

Lantz and Feng, (2006) in “Assessing income, population, and technology impacts on CO_2 emission in Canada: where’s the EKC?”, also done their study on Canada, using time series data and quadratic power of income and GLS method which resulted into monotonically increasing shape of EKC. Ang, (2007) “CO_2 emission, energy consumption, and output in France”, Energy Policy, used ARDL bounds on quadratic power of income and found out inverted U-shaped EKC curve at 11,096.35 turnaround point. Akbostanci et al., (2009) conducted study on Turkey (1968-2003) in “The relationship between income and environment in Turkey: is there an environmental Kuznets curve?” on time series data with cubic specification using cointegration technique and found out N-shaped EKC with turnaround point 1437.8.

Halicioglu, (2009) in “An econometric study of CO_2 emission, energy consumption, income and foreign trade in Turkey” also used time series data and ARDL bounds model which resultant in inverted U-shaped EKC with 1661.81 turnaround points. Jalil and Mahmud, (2009) “Environment Kuznets curve for CO_2 emission: a cointegration analysis for China” in “Environmental Kuznets Curve for CO Emission: A Cointegration Analysis for China” used 30 years (1975-2005) data on China and found Inverted U shaped EKC by using ARDL at 12,992 turnaround point.

Bello and Abimbola, (2010) in “Does the Level of Economic Growth Influence Environmental Quality in Nigeria: A Test of Environmental Kuznets Curve (EKC) Hypothesis” used FMOLS and found no evidence of EKC for Nigeria. He and Richard, (2010) examined time series data for Canada from 1948-2002 and found no evidence of EKC using cubic power of income in “Environmental Kuznets curve for CO_2 in Canada”. Iwata et al., (2010) in “Empirical study on environment Kuznets curve for CO_2 in France: the role of nuclear energy” used quadratic power of income using ARDL bounds for France from 1960-2003 and found inverted U-shaped EKC with turnaround points 21,187.96, 20,620.03 and 21,097.22 respectively for three different models.

Pao and Tsai, (2010) in “CO_2 emission, energy consumption and economic growth in BRIC countries” used panel cointegration for time series data from 1971-2005 on BRIC countries and found no evidence of EKC for brazil, U-shaped EKC for Russia, Inverted U-shaped for India, china and BRIC. Guangyue and Deyong, (2011) in "An empirical study on the environmental Kuznets curve for China's carbon emissions: based on provincial panel data" studied 27 Chinese provinces using cointegration method and found inverted U-shaped EKC for Eastern and central provinces while U- shaped for Western provinces.

Jalil and Feridun, (2011) "The impact of growth, energy and financial development on the environment in China: a cointegration analysis" used panel regression and ARDL bounds for time series data of linear and quadratic power of income respectively on China from 1953 to 2006 and found inverted U-shaped and monotonically increasing EKC. Nasir and Rehman, (2011) in "Environmentally Kuznets Curves for carbon Emission in Pakistan: An Empirical Investigation" used cointegration and found inverted U-shaped EKC for the time period of 36 years from 1972 to 20008.

Fosten et al, (2012) in "Dynamic misspecification in the environment Kuznets curve: evidence from CO_2 and SO_2 emission in the United Kingdom", examined time series data on cubic specification of power on UK from 1830 to 2003 using OLS and found N-shaped EKC with 9,565.58, 18943.66 turnaround point without energy price and 13,678.16, 23,124.25 turnaround points with energy price. Jayantha Kumaran et al. (2012) in "CO_2 emission, energy consumption, trade and income: a comparative analysis of China and India", used ARDL bounds on time series data of India and China and found inverted U shaped EKC at turnaround point of 417.06 and 367.05 for China and India respectively.

Saboori et al, (2012a) in "Economic growth and CO_2 emission in Malaysia: a cointegration analysis of the environmental Kuznets curve" used cointegration on time series data of Malaysia (1980-2009) which shows existence of inverted U-shaped EKC at turned around point 4,789.70.Saboori et al, (2012b) in "An empirical analysis of the environmental Kuznets curve for CO_2 emission in Indonesia: the role of energy consumption and foreign trade", used ARDL bounds on time series data of Indonesia from 1971 to 2007 on quadratic power of income and found U-shaped EKC at 774.89 turnaround point.

Shahbaz et al., (2012) in "Environmental Kuznets curve hypothesis in Pakistan: cointegration and Granger causality" used ARDL bounds time series data and found inverted U-shaped EKC for Pakistan from 1971 to 2009.

Chandran and tang, (2013) in "The impact of transport energy consumption, foreign direct investment and income on CO_2 emission in ASEAN-5 economies" applied Johansen cointegration on time series data of 5 ASEAN countries and found monotonically increasing EKC for Indonesia, U shaped for Malaysia, No EKC for Singapore and Philippines and U-shaped EKC for Thailand.

Kanjilal and Gosh, (2013) in "Environmental Kuznets's curve for India: evidence from tests for cointegration with unknown structural breaks" threshold cointegration on Time series data of India from 1971 to 2008 and found U shaped EKC. Shahbaz, (2013) in "Does financial instability increases environmental degradation? Fresh evidence from Pakistan" used ARDL bounds method on time series data for linear power of income for Pakistan (1971-2009) and found no EKC. Shahbaz, Tiwari and Nasir, (2013) used ARDL bounds on time series data for linear power of income and found Monotonically increasing EKC in "The effects of financial development, economic growth, coal consumption and trade openness on CO_2 emission in South Africa".

Sulaiman et al. (2013) in "The potential of renewable energy: using the environmental Kuznets curve model" used ARDL bounds on time series data for Malaysia (1980-2009) and found inverted U-shaped EKC. Boutabba, (2014) in "The impact of financial development, income, energy and trade on carbon emissions: evidence from the Indian economy" used ARDL bounds method on time series of India from (1971- 2008) and found inverted U-shaped EKC at 19,370.36 turnaround point. Farhani, Chaibi and Rault,

(2014) "CO_2 emissions, output, energy consumption, and trade in Tunisia" used ARDL bounds time series data on quadratic power of income for Tunisia (1971-2008) and found inverted U-shaped EKC at turnaround point 4,377.35.Fahani, Marizak, Chaibi and Rault, (2014) in "The environmental Kuznets curve and sustainability: a panel data analysis" used FMOLS and DOLS on 10 MENA countries (1990-2010) on panel data and found inverted U- shaped EKC at turnaround point of 31, 929.55 and 33, 024.34.

Lau et al., (2014) in "Investigation of the environmental Kuznets curve for carbon emission in Malaysia: do foreign direct investment and trade matter?" used ARDL bounds on time series data on quadratic power of income for Malaysia (1970-2008) and found inverted U- shaped EKC at turnaround point 11,018.40.

Shahbaz, Khraief, Uddin and Ozturk, (2014) in "Environmental Kuznets curve in an open economy: a bounds testing and causality analysis for Tunisia" used ARDL bounds on time series data and found inverted U-shaped EKC for Tunisia at 1,740.56 turnaround point. Shahbaz, Shahbaz, Sbia, Hamdi and Ozturk, (2014) in "Economic growth, electricity consumption, urbanization and environmental degradation relationship in United Arab Emirates" used ARDL bounds on time series data of UAE (1975-2011) and found inverted U-shaped EKC at turn around point of 262,158.14.

Yavuz, (2014) in "CO_2 emission, energy consumption, and economic growth for Turkey: evidence from a cointegration test with a structural break" used FMOLS as well as OLS on time series data of Turkey (1960-2007) and found inverted U-shaped EKC at turnaround point of 2, 547.64 (1960-1978), 3,849.94 (1979-2007 and turnaround point of 2,453.24 (1960-1978) respectively.

Farhani and Ozturk (2015) "Casual relationship between CO2 emission, real GDP, energy consumption, financial development, trade openness, and urbanisation in Tunisia" used ARDL bound on time series data for Tunisia (1971-2012) and found monotonically increasing EKC. Dogan and Turkekul, (2016) in "CO_2 emission, real output, energy consumption, trade, urbanization and financial development: testing the EKC hypothesis for the USA", used ARDL bounds on time series data for quadratic power of income and found U-shaped EKC at turnaround point of 126.58 for USA (1960-2010).

Ertugrul et al.,(2016) in "The impact of trade openness on global carbon dioxide emission: evidence from the top ten emitters among developing countries" used ARDL bounds on time series data of 10 developing countries (1971-2011) and found no EKC for Malaysia, Thailand, Brazil, South Africa, Mexico, inverted U-shaped EKC for China (2,527.41), India (313.98), Turkey (6,863.63) and monotonically increasing EKC for Indonesia. Alvarez- Herranz et al., (2017) in "Energy innovations- GHG emissions nexus: fresh empirical evidence from OECD countries" used Panel regression on panel data for 28 OECD countries (1990-2014) on cubic power of income and found N-shaped EKC at turnaround point 20,885.38 and 67,309.06.

Pal and Mitra, (2017) in "The Environmental Kuznets curve for carbon dioxide in India and China: growth and pollution at crossroad", used ARDL bounds on time series data of India and China (1971-2012) and found no existence of EKC.

Copeland and Taylor, 2004 also support that rising income (Economic Growth) affects environmental quality in a positive way. When we assess the effect of growth and trade, we can't simply associate increasing economic activity with increasing environmental damage & hence environmental policy should not be overly constrained by trade agreements. Mauyad Alsamara & Shaif Hezam Jarallah, 2016 "The impact of economic development on environmental degradation in Qatar" in find out that EKC is not valid for Qatar. Regarding environmental regulation and FDI, the study by Xing and Kolstad (1997) deserve mention. They submitted that the dirty industries relocate to countries with lax environmental regulation. (Supporting PHH)

Juan S. Blyde, 2010 “Does international trade hurt the environment? Old theory, New Development” used Ricardian model to find out the effectiveness of using trade restriction (trade policy) to improve the environmental condition of developing counties & find out that dirty goods producing country doesn’t necessarily become dirtier. (Rejecting PHH)

Ernst- Detlef Schulze & others, 2013 “Making deforestation pay under Kyoto protocol” found that under the clean development mechanism due to extension in the time limit for reforestation Kyoto protocol is paradoxical in some countries. Andrew J. Weaver, 2011 have done a descriptive study to find out the need of modification in the Kyoto protocol before entering into second commitment period & find out that separate steps should be taken to reduce the emission of short lived GHGs.

Existing studies on this aspect of trade, growth & environmental quality for India have typically been descriptive. Theoretical study had been done by R.S. Pathak, 1994 in “International Trade and Environmental Development: A view from India” to find out the environmental law in India and it suggests that inequitable pricing is the reason of over exploitation of natural resource of developing countries. Kakali Mukhopadhyay & Debesh Chakroborty, 2006 used Input – Output technique to evaluate the impact of trade on environment in India & find out that there is evidence of environmental gain due to trade. Jha & Rabindra using regression analysis, to examine the inflow of FDI into pollution intensive sector in post liberalization period & to examine the impact of trade liberalization on the composition of manufacturing export study found out that there is a greater flow of FDI in pollution intensive sector and air and water pollution intensive export have increased in post liberalization period.

3. Methodology

In the literature of EKC, three types of EKC specification models i.e. linear, quadratic and cubic were use. Linear specification model only explained the relationship of any variable using the time series data and the constraint of this model is, it can’t explain the shape of EKC. (Brown and McDonough, 2016). Quadratic specification of EKC generally gives U-shape or inverted U-shape EKC curve which provide present and immediate futuristic information regarding the relationship between economic growth and environmental degradation whereas cubic specification of EKC derive N- shape and inverted N -shape EKC curve which provides more futuristic information regarding environmental quality and growth of an economy. To check the shape of EKC provided by the specification model, have to be passed validation condition, as per the validation condition and noncompliance of those validation condition lead to failure of model. In the case of quadratic specification of model there is no applicability of validation criteria since the first order condition is linear. Therefore, the validation of model can be performed by looking at the sign of coefficient of squared term of income as the maxima and minima value depends on explanatory variable (income or GDP).

To analyse the EKC curve for N_2O relation, the study uses quadratic specification of EKC model considering the above-mentioned points. Researcher designed its own model. The model is as follow-

$N_2O = b_0 + b_1 GDP + b_2\ GDP^2 + b_3\ T + \varepsilon$……………………………… (1.1)

First order conditions

1. If $b_1 = b_2 = b_3 = 0$ indicates no growth-pollution association.
2. If $b_1 > 0$, $b_2 = b_3 = 0$ indicates linearly increasing growth- pollution association.
3. If $b_1 < 0$, $b_2 = b_3 = 0$ indicates linearly decreasing growth- pollution association.
4. If $b_1 > 0$, $b_2 < 0$, $b_3 = 0$ indicates inverted U- shaped growth- pollution association.
5. If $b_1 < 0$, $b_2 > 0$, $b_3 = 0$ indicates U-shaped growth- pollution association.

To find out the long run relationship between trade openness and environmental variables this study used Johansen cointegration technique. Prior to apply cointegration it checked the stationarity of individual time series for which we have use 2 tests.

1. ADF- Augmented Dickey Fuller test
2. KPSS test – Kwiatkowski-Phillips-Schmidt-Shin test

Also, we have made the correlogram of the time series for the better understanding of time series data with diagrammatic presentation.

3.1 Analysis of Unit Root Test: -

Following are the hypothesis for stationarity test of series.

H_0 : series is stationary or trend stationary, there is no unit root. / [H_0: I (0)].

H_1 : series is non- stationary, there is unit root. / [H_1: I (1)].

For ADF-

H_0 : $|\phi| < 1$; $\delta < 1 \Rightarrow Yt \sim I(0)$; series is stationary OR there is no unit root.

H_1 : $\phi = 1$; $\delta = 0 \Rightarrow Yt \sim I(1)$; series is non-stationary OR there is unit root.

For KPSS

H_0 : $\sigma_\varepsilon^2 = 0$; I (0); series is stationary OR there is no unit root.

H_1 : $\sigma_\varepsilon^2 > 0$; I (1); series is non-stationary OR there is unit root.

Table-3.1 Condition for the acceptance and rejection of null hypothesis under ADF & KPSS Test

Test	Condition	Result
ADF	If calculated value > Critical value	Rejection of H_0
KPSS	If P- value < 5%	Acceptance the H_0

Table 3.2 -Output table of ADF & KPSS for different variables

Variables	Test	Stat	P-Value	C.V.	Stationary?
Trade	No Const	10.2	99.9%	-2.0	False
	Const-Only	-1.5	54.9%	-3.2	False
	Const+Trend	-3.3	0.1%	-1.6	True
	Const+Trend+Trend^2	-3.2	0.1%	-1.6	True
GDP	No Const	-0.5	49.9%	-2.0	False
	Const-Only	-1.6	49.4%	-3.2	False
	Const+Trend	-1.1	13.1%	-1.6	False
	Const+Trend+Trend^2	-2.3	1.2%	-1,6	True
N_2O	No Const	0.1	69.8%	-2.0	False
	Const-Only	-2.0	34.4%	-3.2	False
	Const+Trend	-2.8	0.3%	-1.6	True
	Const+Trend+Trend^2	-3.6	0.0%	-1.6	True

*all values are at 5% level of significance.

Interpretation –

In the output table of ADF and KPSS test, we are examining the stationarity assumption under different scenarios.

No constant
⇒ time series has zero mean.
Constant only ⇒
time series has non-zero mean.
Constant + Trend
⇒ time series has a deterministic trend.

Constant+ Trend+ Trend^2 ⇒ time series has a quadratic trend curve over time.

So, from above result and while considering both the test we can conclude *that all-time series data are having unit root* in at least one of the scenarios which is No constant. While some of them are non-stationary under all the four assumptions. This mean that our time series for all of these variables will use be non-stationary. Apart from GDP time series data shows a random walk under "constant only" assumption also.

3.2 Analysis of Johansen's Cointegration Test

All series are non-stationary in nature and having unit roots so we can apply Johannsen test.

Following are the hypothesis for cointegration test of series.

For Trace test-

H_0: $K = K_0$; $K_0 = 0$,There is no cointegration between the series. (r=0)

H_1: $K > K_0$; $K_0 \neq 0$,There is cointegration between the series. (r>0)

For Maximum Eigen Test-

H_0: $K = k_0$; $K_0 = 0$, there is only one possible combination of non-stationary variables to yield stationary series.

H_1: $K = k_0+1$; $K_0 \neq 0$, there is more than one possible combination of non-stationary variables to yield a stationary process.

Table 3.3 - Condition for the acceptance and rejection of null hypothesis under Trace test and Maximum Eigen Test

Test	**Condition**	**Result**
Trace test	If calculated value > Critical value	Rejection of H_0
Maximum Eigen Test	If calculated value < Critical value	Rejection of H_0

Results

Table 3.4 - Cointegration for Model 1.1

Test	**Stat**	**C.V.**	**Passed?**
Trace test (r = 0)	**0**		**r >0**
No Const	65.2	40.2	True
Const-Only	93.2	47.9	True
Const+Trend	107.7	55.2	True
Maximum Eigenvalue test (r=3)	**3**		**r = 3**
No Const	1.4	4.1	False

Const-Only	1.1	3.8	False
Const+Trend	1.1	3.8	False

Interpretation: -

In trace test we asked whether there is at least one possible linear combination for the input variables to yield a stationary process. We examine this under different assumptions for the input variables i.e. no constant, constant only and constant+trend and they all passed. Thus, we conclude that the variables are cointegrated.

In maximum eigen value test we want to be sure that the number of linear combinations doesn't equal to the number of input variables. Why? because if they do, the input variables are stationary to start with and cointegration is not relevant. We carry this test under different assumption and they all failed we would state that the input variables are cointegrated.

Table-4.8 shows that the calculated values for trace test under different condition i.e. no constant, constant-only and constant+trend. We can conclude from above two tables that all the variable is cointegrated in long run. Now we will try to find out that relationship.

Second order condition

To check the validity of model Eq 1.1 must be differentiated to the first order. First order differentiation is given by-

$d(N_2O)/d(GDP) = b_1 + 2b_2GDP$…… (1.2)

The second order condition derived from (1.2), takes the following form:

$d^2(N_2O)/d(GDP)^2 = 2b_2$…… (1.3)

The validity of second order condition is also provided by Eq 1.3

First order condition is linear. In this case the validation of the model requires the sign of coefficient of squared GDP or any other indicator of economic growth.

In this case

$b_2 < 0$ implies the presence of local maxima therefore indicating the inverted U-shaped EKC.

$b_2 > 0$ implies the presence of local minima, therefore indicating the U-shaped EKC.

As a result, there is long run relationship among economic growth, trade intensity and N_2O emission, now this study investigates the shape of quadratic relationship among them.

Table 3: Parameters estimates of difference equation for N_2O emission in India

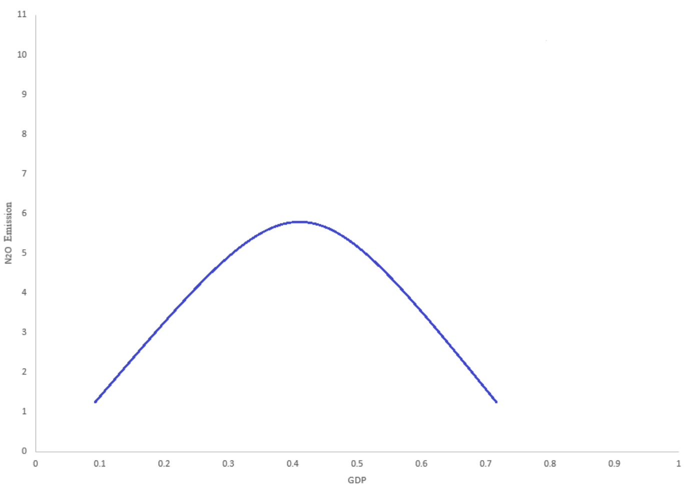

FIG.1.1 - Quadratic specification of environmental Kuznets curve.

4. Conclusion

As evident from the study, trade liberalization is associated with increase in N_2O emission in India. The presence of Inverted U shaped EKC is optimistic and efforts should be done in future so that turning point can be earlier. Efforts should be made to make trade composition cleaner with adoption of strict environmental norms and better enforcement of laws. India need to follow a two-way strategy with one aim of raising income level so that composition and technique effect can outweighs the scale effect and other at controlling environmental regulation.

References

[1]. Andrew J. Weaver (2011). Towards the Second Commitment Period of the Kyoto Protocol. *Science New Series*, 332,795-796.

[2]. Antweiler W., Copland, B.R. & M.S. Taylor, (2004). Trade, Growth and the environment. *National Bureau of Economic Research*.

[3]. Antweiler, W., Copland, B.R. & M.S. Taylor, (2001). Is Free Trade Good for the Environment? *American Economic Review,* 91, 269-286.

[4]. Akbostanci, E., Turut-Asik, S., & Tunc, G. I, (2009). The relation-ship between income and environment in turkey: IS there an environmental Kuznets curve? *Energy policy*, 37(3), 867-867.

[5]. Alvarez – Herranz, A., Balsalobre, D., Cantos, J. M. & Shahbaz, M. (2017). Energy innovations- GHG emissions nexus: fresh empirical evidence from OECD countries. *Energy Policy*, 101, 90-100.

[6]. Ang, J.B. (2007). CO_2 emission, energy consumption, and output in France. *Energy Policy*, 35(10), 4772-4778.

[7]. Apra Sinha, & M.Y. Bhatt (2017). EKC for CO2 and NO_x Emissions: A Case Study of India. *European journal of Sustainable Development*, 6(1), 267-276.

[8]. Bello, A.K. & Abimbola, O.M. (2010). Does the level of economics growth influence environmental quality in Nigeria: a test of environment Kuznets curve (EKC) hypothesis? *Pakistan Journal of Social Sciences*, 7(4), 325-329.

[9]. Boutabba, M.A., (2014). The impact of financial development, income, energy and trade on carbon emissions: evidence from the Indian economy. *Economic Modelling*, 4 (1), 33-41.

[10]. Balibey, M. (2015). Relationships among CO_2 emissions, eco- nomic growth and foreign and direct investment and the EKG hypothesis in Turkey. *International Journal of Energy*

Economics and Policy, 5(4), 1042-1049.

[11]. CM Lakshama (2015). Demographic change & the Environment. *Economic & Political weekly*, 45, 56-57.

[12]. Commoner, B. (1972). The Environmental Cost of Economic Development in Population. *Resources and the Environment*, 4, 339-363.

[13]. Copeland, B.R. & M.S. Taylor, (2003). Trade and the Environment: Theory and Evidence. *Princeton University Press*.

[14]. Chandran, V.G.R. & Tang, C.F. (2013). The impact of transport energy consumption, foreign direct investment and income on CO_2 Emission in ASEAN-5 Economies. *Renewable and Sustainable Energy Reviews*, 24, 445-453.

[15]. Cole, M. A., Rayner, A. J., & Bates, J. M. (1997). The Environmental Kuznets curve: An empirical analysis. *Environment and Development Economics*, 2(4), 401-416.

[16]. C.-H. Cho, Y-. P. Chu & H.Y. Yang (2014). An environmental Kuznets Curve for GHG emission: A Panel Cointegration Analysis. *Energy Source Part B: Economics, Planning, and policy*. 9(2), 120-129.

[17]. Dogan, E. & Turkekul, B. (2016). CO_2 Emission, Real Output, Energy Consumption, Trade, Urbanization and Financial Development: Testing the EKC Hypothesis for the USA. *Environmental Science and Pollution Research*, 23 (2), 1203-1213.

[18]. Dickey, D. A. & W. A. Fuller (1979). Distribution of the estimators for Autoregressive Time Series with a unit root. *Journal of the American Statistical Association*, 74(366), 427-431.

[19]. Dickey, D. A. & W. Fuller (1981). Likelihood Ratio statistics for autoregressive Time Series with a Unit Root. *Econometrica*, 49(4), 1057-1072.

[20]. Deininger, K., & Squire, L. (1998). New ways of looking at old issues: Inequality and growth. *Journal of Development Economics*, 57, 259-287.

[21]. Dasgupta, S., Laplant, B., Wang, H., & Wheeler, D. (2002). Confronting the Environmental Kuznets Curve. *The Journal of Economic Perspectives*, 16(1), 147-168.

[22]. Day, K.M., & Grafton, R.Q. (2003). Growth and the Environment in Canada: an empirical analysis. *Canadian Journal of Agricultural Economics*, 51(2), 197-216.

[23]. Ernst-Detlef Schulze, Danilo Mollicano, Frederic Achard, & Hugh. Eva (2013). Making Deforestation Pay under the Kyoto Protocol. *Science, New Series*, 299, 1669.

[24]. Esty, Daniel, & Damien Girardin (1998). Environmental Protection and International Competitiveness: A Conceptual Framework. *Journal of World Trade* 32(3), 5-46.

[25]. Ertugrul, H.M., Cetin, M., Seker, F. & Dogan, E. (2016). The Impact of Trade Openness on Global Carbon Dioxide Emission: Evidence from The Top Ten Emitters Among Developing Countries. *Ecological Indicators*, 7, 543-555.

[26]. Fosten, J., Morley, B. & Taylor, T. (2012). Dynamic misspecification in the environment Kuznets curve: evidence from CO_2 and SO_2 emission in the United Kingdom, *Ecological Economics*, Vol. 76, pp. 25-33.

[27]. Farhani, S. and Ozturk, I. (2015). Causal relationship between CO_2 emission, Real GDP, Energy Consumption, Financial Development, Trade Openness, and Urbanisation in Tunisia. *Environmental Science and Pollution Research*, 22(20), 15663-15676.

[28]. Farhani, S., Marizak, S., Chaibi, A. & Rault, C. (2014). The environmental Kuznets curve and sustainability: A Panel Data Analysis. *Energy Policy*, 71(1), 189-198.

[29]. Feizpour, M.A., & Shahmohammadi Mehrjardi, A. (2014). Comparative Advantages and Sustainable Development in Iranian Manufacturing Industries. *Iranian Economic Review*, 18(1), 33-52.

[30]. Farhani, S., Chaibi, A. & Rault, C. (2014). CO_2 emissions, output, energy consumption, and trade in Tunisia. Economic Modelling.38(1), 426-434.

[31]. Guangyue, X. & Deyong, S. (2011). An empirical study on the environmental Kuznets curve for China's Carbon Emissions: Based on Provincial Panel Data. *Chinese Journal of Population Resources and Environment*, 9(3), 66-76.

[32]. Gradus, R., & Smulders, S. (1993). The trade-off between Environmental Care and Long-term Growth Pollution in three Prototype Growth Models. *Journal of Economics*, 58(1), 25-51.

[33]. Hu Xiquim, Zeng H., & Yang Li (2013). Resolving trade and Environment Conflicts: A Focus on Sustainable Trade in China. *Chinese Journal of Population Resources and Environment*, 4(2), 55-60.

[34]. Holtz-Eakin, D. & Selden, T.M., (1995). Stoking the fires? CO_2 emissions and economic growth. *Journal of Public Economics*, 57(1), 85-101.