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DETERMINANTS OF ENVIRONMENTAL DEGRADATION AND EMPIRICAL INVESTIGATION OF KUZNETS CURVE: A COMPARATIVE STUDY OF INDIA AND BANGLADESH

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Abstract

This paper investigates the factors responsible for Environmental degradation in terms of higher Carbon dioxide and Nitrous oxide emission over the period 1981 – 2011 for Bangladesh and India from data of World development indicator. Industrialization and greenhouse gas are major contributing factors identified for deteriorating the air quality in Bangladesh and India respectively. Concentration of population in urban areas increases carbon emission and economic globalization reduces Nitrous oxide emission in both economies. Estimation results of reduced from equation for CO_2 emission provides support in favour of inverted U and N shaped Kuznets curve for India which is robust to using dynamic specification. For Bangladesh the shape is Inverted U but this is not robust to using dynamic model. In quadratic approach to Kuznets curve energy consumption does play an important role for increased carbon emission in India but not in Bangladesh.

1. INTRODUCTION

Bangladesh and India are two emerging economies in South Asia. These two neighboring countries have experienced considerable economic growth in recent years. This paper tries to explore the nature of trade- off between macroeconomic gain in terms of High Economic growth and level of environmental pollution. In inverted U EKC trajectories, a very little is known in existing literature about the turning points of real GDP per capita after which emission of CO_2 starts falling for both economies . This paper also aims to apply the polynomial approach to EKC analysis for economy of Bangladesh. We consider two major pollutants Carbon dioxide and Nitrous Oxide. This article primarily focuses on the similarities and dissimilarities between the factors of these two developing countries responsible for higher carbon and nitrous oxide emission. Section 2 briefly discusses about review of Literature. Section 3 introduces the baseline specification and Section 4 highlights the estimation results and calculates the turning points. Section 5 identifies the contributing factors for each pollutant CO_2 and NO_2 for both countries. Section 6 illustrates the Robustness test of baseline models Section 7 suggests policy recommendations Section 8 summarizes the findings of the paper and concludes.

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2. REVIEW OF LITERATURE

2.1. Environmental Kuznets curve in Theory

Economic growth influences environmental quality through three channels, Scale effect, technological effects and composition effect (Grossman & Krueger, 1991). In the process of production, emission of byproducts deteriorates the environmental quality known as 'scale effect' in the first phase of structural change. As economy expands according to second phase of structural change from energy intensive industries to service to knowledge based technology intensive industry, so the obsolete and outdated negative externality generating production techniques are replaced as spending on R & D rises, known as technological effect of growth. This positive impact dominates the first phase of scale effect eventually the EKC bends downward.

2.2. Empirical Findings for developing economies

A large volume of literature is available for the empirical test of Environmental Kuznets Hypothesis, which is known as Environmental Kuznets Curve (EKC) (Kuznets, 1955). This hypothesis assumes that with expanding industrial sector, initially the economic growth of an emerging economy is realized at the cost of deterioration of the environmental quality as the economy is growing it attains a threshold level of Income beyond which there is no trade-off between the two, so the EKC is inverted U shaped. The comprehensive and detailed examination of EKC literature is illustrated by Dinda (2004) and Stern (2004).

In the context of developing economies most studies have focused on Asian, Latin American, African countries, as well as countries in Middle East. Results of empirical test of this hypothesis vary across countries. Narayan and Narayan (2010) tested this hypothesis for 43 developing nations from 1980 to 2004. They found for Middle Eastern panel, the countries are successful in reducing emission with higher Income per capita, as the long- run income elasticity is smaller than short run elasticity. Jaunky (2011) tested on high Income countries including MENA region over the period 1980-2005 and found emission reduces with larger level of Income in long run. Arouri *et al.* (2012) tested EKC on 12 Middle East and North African countries and found support in favour of inverted U. But they found considerably large variation in turning points and got weak evidence in support of EKC.

Comparative analysis of EKC by Jayanthakumaran *et al.* (2012) on India and China suggest CO_2 emissions are influenced by energy consumption, foreign trade and Income in China and per capita GDP causes the carbon emission in India. Song *et al.* (2007) found Inverted U EKC for China for 1985-2005 for three pollutants, waste gas, waste water and solid gas. Miah *et al.* (2011) found conventional EKC trajectory for waste emission and suspended particulate matter for Bangladesh with high turning point. According to test of EKC for Bangladesh by Islam and Shahbaz (2012), over the period 1971-2010, energy consumption is a major contributing factor for degradation of air quality in terms of increased Carbon emission and they found Pollution is negatively related to trade openness and positively related to increased urbanization. Mulali *et al.* (2015) found positive relationship between pollution and Income both in short run and long run in Vietnam over the period 1981-2011, so EKC does not exist in their sample. Saboori *et al.* (2013) found Inverted U between GDP per capita and CO_2 emission for Malaysia both in short run and in long run and found unidirectional causality from economic growth to CO_2 emission.

3. BASELINE SPECIFICATION

Widely used quadratic approximation of EKC curve is the following: Dinda (2004)

Equation in level:
$$CO_{2it} = \alpha_{it} + \beta_0 E_{it} + \beta_1 y_{it} + \beta_2 (y)_{it}^2 + \mu_{it}$$

Equation in Reduced form:

$$\ln CO_{2it} = \alpha_{it} + \beta_0 \ln E_{it} + \beta_1 (\ln y)_{it} + \beta_2 (\ln y)_{it}^2 + \mu_{it} \qquad \ldots\ldots\ldots\ldots (1)$$

Reduced form equation is obtained when the variables are expressed in natural log. Polynomial approximation of EKC is generated by adding cubic term in model (1) (Song *et al.,* 2007).

$$\ln CO_{2it} = \alpha_{it} + \beta_0 \ln E_{it} + \beta_1 (\ln y)_{it} + \beta_2 (\ln y)_{it}^2 + \beta_3 (\ln y)_{it}^3 + \mu_{it} \qquad \text{...............… (2)}$$

CO_2 = carbon dioxide emission per capita (in metric ton), extensively used proxy for environmental degradation in literature.

E and y represents energy consumption and Real GDP (per capita at constant 2005 USD) .

μ_{it} = Random error term

In model (1) if $\beta_1 > 0$ and $\beta_2 < 0$, EKC is Inverted U shaped. In model (2) if $\beta_1 > 0$ and $\beta_2 < 0$, and $\beta_3 > 0$, EKC is N shaped. There are other possibilities of the shape of EKC depending on different signs of the parameters. *i* for country and *t* for time (in year)
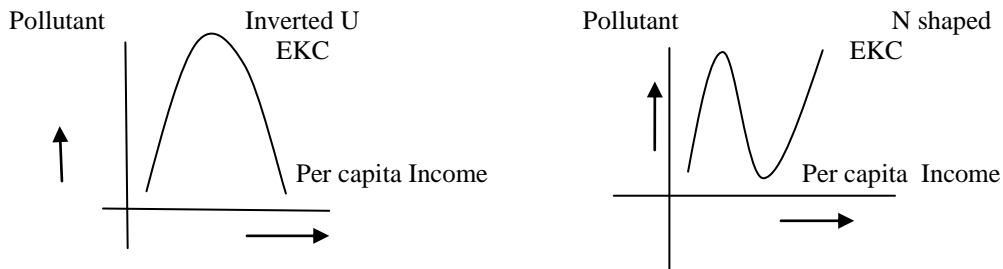
4. ESTIMATION RESULTS

Table 1: Regression results of Quadratic Model   (1981 – 2011) Estimation method (OLS)

Dependent Variable $\ln CO_{2it}$	Bangladesh	India
Regressor	Estimated coefficients	
Ln E	0.54 (1.03)	1.88*** (0.31)
Ln Y	19.9*** (5.65)	5.03*** (0.78)
(Ln Y)^2	-1.53*** (0.43)	-0.40*** (.06)
R squared	0.89	0.98
F Statistic	165.87	615.47
No of Observation	31	31

Estimation results have been obtained by applying OLS. Standard errors in parenthesis are robust standard errors. *** Significant at 1% level, ** significant at 5 % level

Table 2: Regression results of Cubic Model (1981 -2011) estimation methodology 2SLS

Dependent Variable $\ln CO_{2it}$	Bangladesh	India
Regressor	Estimated coefficients	
Ln E	-0.94(1.38)	0.67(0.55)
Ln Y	793.44*** (394.35)	99.00*** (35.00)
(Ln Y)^2	-128** (64.86)	-15.16*** (5.49)
(Ln Y)^3	6.98** (3.55)	0.77*** (0.28)
R-squared	0.91	0.98
Adjusted R squared	0.89	0.98
F-Statistic	66.77	585.83
No of Observation	31	31

Estimation results have been obtained by applying 2SLS, in parenthesis are standard errors. ***significant at 1% level,   **significant at 5 % level

4.1. Analysis of findings

In Quadratic model the EKC is inverted U shaped for Bangladesh. The elasticity of CO_2 emission with respect to per capita GDP growth is quite larger and positive. At the declining portion of the curve after reaching the threshold level of Income, emission reduces only by 1.53% for each 1% increase in per capita Income. Energy consumption has no impact on environmental degradation.

Quadratic model also explains the inverted U EKC for India. Emission rises by 5.03% for each 1% increase in per capita Income, and it reduces by 0.4% after reaching threshold level of Income along the declining portion of the curve. Energy consumption does have significant impact on emission. We observe larger difference between emission (rising and falling) for Bangladesh compare to India.

Applying instrumental variable method because of possible endogeneity problem, Polynomial model explains the N shaped EKC for both economies. The curve has two turning points. Emission rises initially with increase in per capita income, and then it reaches a threshold level of income where the degradation of air quality falls with rise in Income. EKC attains a stationary level of GDP beyond which again the deterioration of air quality starts and the curve bends upward. In cubic model the Energy consumption has no role for deteriorating the air quality. The coefficients of the regressors are mostly not precisely determined in case of Bangladesh. So our sample data adheres to inverted U shaped EKC for Bangladesh and Inverted U and N shaped EKC for India.

4.2. Finding the turning points

4.2.1. Turning point for Quadratic model

In equation (2), sample regression function is $CO_2 = f(y, E)$ We are assuming the inverted U shaped EKC is smooth and continuous, above equation is multivariable so setting the partial derivative of dependent variable with respect to Per capita real GDP equals to zero, we get the following equation:

$$\frac{\delta}{\delta y}\left(\ln CO_2\right) = 0$$

$$\Rightarrow \quad \frac{\delta}{\delta y}(\alpha) + \frac{\delta}{\delta y}(\beta_0 \ln E) + \frac{\delta}{\delta y}(\beta_1 \ln y) + \frac{\delta}{\delta y}\left(\beta_2 (\ln y)^2\right) = 0$$

$$\Rightarrow \quad \beta_1 . \frac{\delta}{\delta y}(\ln y) + \beta_2 . 2 \ln y . \frac{\delta}{\delta y}(\ln y) = 0$$

$$\Rightarrow \quad \beta_1 . \frac{1}{y} + \beta_2 . 2 . \ln y \left(\frac{1}{y}\right) = 0$$

$$\Rightarrow \quad \beta_1 . \frac{1}{y} = -2\beta_2 \ln y \frac{1}{y} \qquad \Rightarrow \beta_1 = -2\beta_2 . \ln y$$

$$\Rightarrow \quad \ln y = \frac{\beta_1}{-2\beta_2}$$

For Bangladesh we substitute the estimated coefficients in above equation and get following:

$$\Rightarrow \quad \ln y = \frac{19.9}{-2(-1.53)} \quad \Rightarrow \quad \ln y = 6.5 \quad \Rightarrow y = e^{6.5} = 665.14$$

For India, $\quad \ln y = \dfrac{5.03}{-2(-0.4)} = 6.28 \quad \Rightarrow y = 533.78$

The threshold level of per capita real GDP beyond which the Kuznets curve bends downward is 665.14 for Bangladesh and 533.78 for India.

2nd Derivative test

To be confirming we perform second derivative test .At the turning point the curve bends downward so its sign should be negative evaluated at the stationary value of GDP per capita.

$$\Rightarrow \frac{\delta}{\delta y}\ (\beta_1 . \frac{1}{y} + \beta_2 . 2. \ln y . \left(\frac{1}{y}\right))$$

$$\Rightarrow \ \beta_1 . \frac{\delta}{\delta y}\left(y^{-1}\right) + \beta_2 . 2 \frac{\delta}{\delta y}(\ln y)\left(y^{-1}\right)$$

$$\Rightarrow \ \beta_1 (-1) y^{-2} + \beta_2 . 2[(\ln y)\frac{\delta}{\delta y}\left(y^{-1}\right) + y^{-1} . \frac{\delta}{\delta y}(\ln y)$$

$$\Rightarrow \ -\frac{\beta_1}{y^2} + 2.\beta_2\left(\frac{-1}{y^2}\right) + \frac{1}{y^2} \ \ ,$$

We substitute the estimated values of β_1, β_2 and the stationary value of y in above expression for Bangladesh and India. We found that the sign of above expression is less than zero in both cases.

4.2.2. Graph of Inverted U Environmental Kuznets Curve: (1981 -2011)
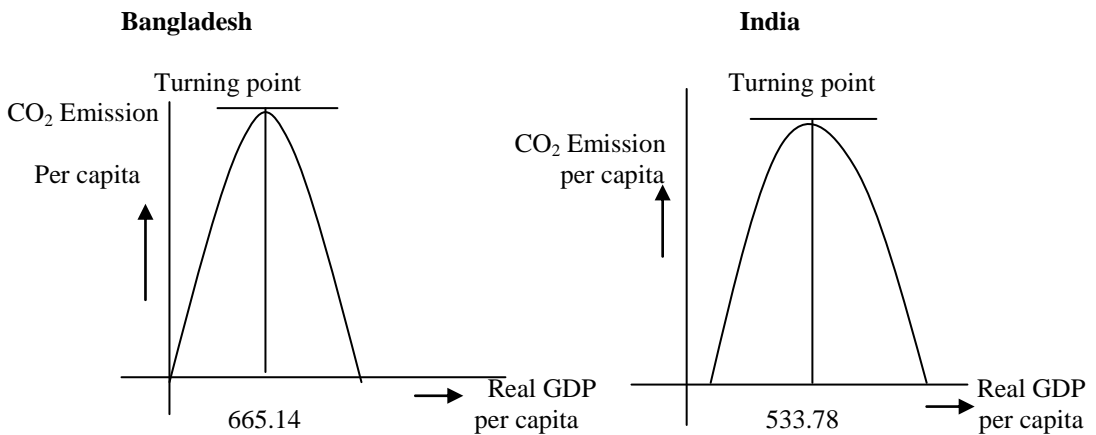
We observe that the threshold level of Income (measured in 2005 USD) at which pollution declines, is larger in Bangladesh compare to India.

4.3. Turning point for Polynomial model
We set the partial derivative of dependent variable with respect to GDP per capita equals to zero for sample regression function of model (3) and get following equation.

$$\frac{\delta}{\delta y}(\ln CO_2) = 0$$

$$\Rightarrow \ \frac{\delta}{\delta y}\left(\alpha + \beta_0 \ln E + \beta_1 \ln y + \beta_2 (\ln y)^2 + \beta_3 (\ln y)^3\right) = \ 0$$

$$\Rightarrow \ \frac{\delta}{\delta y}(\alpha) + \frac{\delta}{\delta y}(\beta_0 \ln E) + \frac{\delta}{\delta y}(\beta_1 \ln y) + \frac{\delta}{\delta y}(\beta_2 (\ln y)^2) + \frac{\delta}{\delta y}(\beta_3 (\ln y)^3) = 0$$

$$\Rightarrow \quad \beta_1 . \frac{1}{y} + \beta_2 . 2(\ln y) \ . \frac{1}{y} + \beta_3 3 . (\ln y)^2 . \frac{1}{y} + 0 = 0$$

Multiplying both sides by y

$$\Rightarrow \quad \beta_1 . + \beta_2 . 2(\ln y) \ . + \beta_3 3 . (\ln y)^2 . = 0$$

This is a quadratic equation in $\ln y$, we apply the square root formula

$\ln y = \dfrac{-2\beta_2 \pm \sqrt{(2\beta_2)^2 - 4.3.\beta_3 \beta_1}}{2.3.\beta_3}$, substituting the values of estimated coefficients in above

expression we get two turning points for India. For Bangladesh the coefficients are not precisely determined at 1% level so we calculate the threshold level of per capita GDP only for India.

$$\ln y = \frac{-2(-15.16) \pm \sqrt{.(-2.(15.16))^2 - 4.3.99.(0.77)}}{2.3.(0.77)} = 7.04, 6.08$$

$$\Rightarrow \ln y = 7.02$$
$$\Rightarrow y = e^{7.02}$$

$$y = 1141 \quad \text{and} \quad y = e^{6.101} \ , \quad y = 437.02$$

2nd derivative test

The expression for second order derivative is following:

$$\frac{\delta}{\delta y} (\beta_1 . \frac{1}{y} + \beta_2 . 2(\ln y) \ . \frac{1}{y} + \beta_3 3 . (\ln y)^2 . \frac{1}{y})$$

$$\Rightarrow \beta_1 (-1) y^{-2} + 2\beta_2 \{ \ln y (-1) y^{-2} + \frac{1}{y} . \frac{1}{y} \} + 3\beta_3 \{ (\ln y)^2 (-1) y^{-2} + 3.\beta_3 \frac{1}{y} . 2 \ln y . \frac{1}{y} \}$$

$$\Rightarrow \quad -\frac{\beta_1}{y^2} + 2\beta_2 \{ -\frac{\ln y}{y^2} + y^{-2}) - \frac{3\beta_3 (\ln y)^2}{y^2} + 2.3.\beta_3 \ln y (y^{-2)} \}$$

$$\Rightarrow \quad -\frac{\beta_1}{y^2} - \frac{2\beta_2 \ln y}{y^2} + \frac{2\beta_2}{y^2} - \frac{3\beta_3 (\ln y)^2}{y^2} + \frac{2.3\beta_3 \ln y}{y^2}$$

We substitute the estimated values of β_1 , β_2 and β_3 and each stationary value of y in above and find the expression to be At the first turning point $y = 437.02$ the sign of the second order derivative is found to be < 0.

Which is $\dfrac{-99 + 184.3 - 30.32 - 85 - 553.03}{(437.02)^2}$ = negative.

At the second turning point $y = 1141$ the sign of second order derivative is found to be > 0, which is $\dfrac{-99 + 213 - 30.32 - 114 + 32.47}{(1141)^2} = \dfrac{-243 + 245}{(1141)^2}$ = positive

So the second derivative test confirms that at $y = 1141$, the EKC bends upward again and NO_2 Emission Starts rising. We observe that for India for each 1% increase in per capita GDP the emission rises by less than 1% after the second turning point.

1st Turning Point

2nd Turning point

446.30   1141
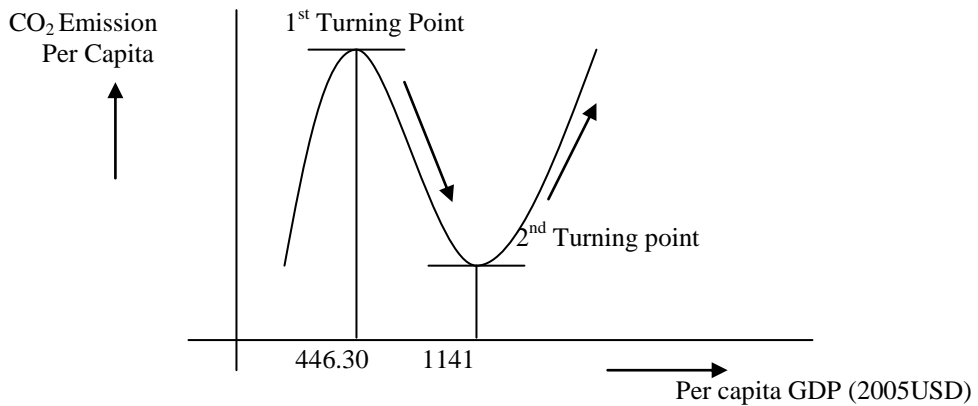
Graph of N shaped Environmental Kuznets Curve for India: (1981-2011)

5. DETERMINANTS OF ENVIRONMENTAL DEGRADATION

Our article primarily focuses on the determinants of environmental degradation. We focus on the economic variables as our regressors. We are considering two major pollutants CO_2 and NO2.

Proposed model (3) for Bangladesh and India is the following:

$$lnCo2 = \alpha + \beta \ln(indusval)_{it} + \beta_4 \ln(urban\ population)_{it} + \beta_5 \ln(trade)_{it} + \beta_6 \ln(green)_{it} + \mu_{it} \quad ……..\ (3)$$

In the above model
Indusval = industry value added (percent of GDP)
Urban population = percent of urban population (of total population)
Trade = Trade (Export plus import) as percent of GDP (Trade is the proxy for Economic globalization)
Green = Total greenhouse gas emission (kt of co2 equivalent) per capita
μ_{it} = Random Error Term

Table 3: Regression results of model (3) estimation methods (OLS)

Dependent variable $\ln CO_2$	Bangladesh	India
Regressor	Estimated Coefficients	
ln(indusval)	3.01*** (0.38)	-0.19(0.23)
ln (urban population)	1.14*** (0.38)	2.51*** (0.50)
ln(trade)	0.03(0.31)	-0.11(0.08)
ln(green)	0.28(0.26)	1.30*** (0.31)
R squared	0.94	0.97
F Statistic	187.41	376.19
No of Observation	31	31

Estimation results have been obtained by applying OLS, in parenthesis are robust standard errors. ***significant at 1% level,   **significant at 5 % level

5.1. Similarities and dissimilarities of determinants of emission between two countries
Emission rises by 1.14% and 2.51% for each 1 % rise in urban population for Bangladesh and India respectively though elasticity of CO_2 with respect to urban population is larger in India. Economic globalization has no impact on the deterioration of the air quality in both economies.

Industrialization plays a significant role for the degradation of the air quality in Bangladesh. Green house emission per capita plays a major contributing factor for emission in India. For each 1 % rise in industry value added, emission rises by 3.01% in Bangladesh. In India for each 1% rise in greenhouse gas emission per capita, CO_2 emission rises by 1.3%.

5.2. Polynomial approximation of EKC and determinants of NO_2

$$lnNO_2 = \alpha + \beta \ln (energy) + \beta_1 (lnY_i) + \beta_2 (lnY_i)^2 + \beta_3 (\ln Y_i)^3 + \mu_{it} \qquad \text{……….………} (2a)$$

Using 2SLS method we get the following estimation results[2]:

Table 4: Regression results of Polynomial model

Estimation Methodology 2SLS Dependent Variable $lnNO_2$ Regressor	Bangladesh	India
	Estimated Coefficients	
ln(energy)	0.28 (0.35)	1.05 (0.60)
lnY_i	739.78*** (102.04)	77.88*** (38.29)
$(lnY_i)^2$	-121.84*** (16.78)	-12.26***(6.01)
$(lnY_i)^3$	6.68*** (0.92)	0.63***(0.31)
R Squared	0.79	0.67
F Statistic	25.87	13.41
No. of Observation	31	31

Estimations have been obtained by applying OLS, the standard errors are robust standard errors. *** Significant at 1% , ** Significant at 1%

High R square in estimation results of Model 1, 2, 3 and 4 might generate the question of spurious regression because of the presence of the common time trend in all regressions. Longer time series data is required to check whether the EKC results are supported in long run. Our article primarily focuses on identifying the factors for environmental degradation rather than the shape of EKC in both economies.

For both economies the EKC is N shaped. NO_2 Emission initially rises but its magnitude is quite larger for Bangladesh compare to India. Then it declines with increase in income, after reaching a threshold level of Income the emission again starts increasing. The coefficients signs are precisely determined for both countries. After the second turning point for Bangladesh the NO_2 emission raises by 6.68% for each 1% rise in real GDP per capita, the corresponding number is much lower in India[3].

To find out the determining factors of Nitrous Oxide Emission we replace the dependent variable $lnCO_2$ by $lnNO_2$. We estimate the following model.

$$lnNO_2 = \alpha + \beta \ln(indusval) + \beta_4 \ln(\text{Urban Population}) + \beta_5 \ln(\text{Trade}) + \beta_6 \ln (green) + \mu_{it} \quad \text{………..……} (3a)$$

Table 5: Regression results of Model (3a)

Dependent Variable $lnNO_2$ Regressors	Bangladesh	India
		Estimated Coefficients
ln(indusval)	1.11*** (.41)	-0.15(.28)
ln (urban population)	.05 (.18)	.25(.47)
ln(Trade)	-.26***(.11)	-.33***(.07)
ln(green)	-.13 (.21)	1.12***(.25)
F Statistic	7.5	12.87
R^2	.35	.66
No of Observation	31	31

Estimations have been obtained by applying OLS. The standard errors are robust standard errors in parenthesis. *** Significant at 1% level, ** Significant at 5 % level

Industrialization and greenhouse gas play the major role for NO_2 emission in Bangladesh and India respectively. The emission reduces with Economic globalization in both economies. The model is more suitable to explain the NO_2 emission in India compare to Bangladesh because of relatively smaller R square for Bangladesh compare to India.

Elasticity of emission with respect to greenhouse gas in India and with respect to [3]We also estimated the quadratic model for both economies but did not get the predicted signs of the coefficients to trace the Inverted U shape EKC Industrialization in Bangladesh is quite similar. For each 1% rise in greenhouse gas per capita emission rises by 1.12% in India. In Bangladesh for each 1% rise in value added of the manufacturing sector emission increases by 1.11%. Urban population has no role to play for the deterioration of the air quality in both countries.

6. ROBUSTNESS CHECK OF EKC

To examine whether our estimation results of Baseline models hold using alternative specification, we introduce the first lag of the dependent variable as additional regressor in model (1) and in Model (2), and the models become following:

$$lnCO_2 = \alpha_{it} + \beta lnCO_{2, I(t-1)} + \beta_0 lnE_{it} + \beta_1 (lnY)_{it} + \beta_2 (lnY_{it})^2 + \mu_{it} \qquad \ldots\ldots\ldots\ldots\ldots (1b)$$

$$lnCO_2 = \alpha_{it} + \beta_0 ln\, CO_{2, i(t-1)} + \beta_1 ln\, E_{it} + \beta_2\, (lnY_{it}) + \beta_3\, (ln\, Y_{it})^2 + \beta_4\, (lnY_{it})^3 + \mu_{it} \qquad \ldots\ldots\ldots\ldots (2b)$$

Applying OLS in equation (1b), for Bangladesh the coefficient β is positive and precisely determined. But the signs of the other parameters are not predicted. So Inverted U is not supported by dynamic specification. Applying 2SLS for equation (2b), the parameters have their predicted signs and are precisely determined for India, but β_1 and β0 are not precisely determined in polynomial model.

In the quadratic model all the parameters have predicted signs except coefficient of first lag of dependent variable for India. Inverted U and N both shapes are supported using Dynamic specification for India, but not for Bangladesh.

For NO_2 pollutant we have got predicted signs of parameters for polynomial model except for β_1 for Bangladesh applying instrumental variable method. N shape EKC is supported for Bangladesh using dynamic specification. But none of the estimated coefficients are statistically significant for cubic model in case of India when first lag of dependent variable is introduced in the polynomial model.

7. ENVIRONMENT PROTECTION POLICY

The turning point or the level of Income beyond which emission starts declining is lower in India than Bangladesh. According to quadratic approach the emission starts declining at fairly high level of per capita GDP in Bangladesh.

There is an urgent need to replace the outdated, obsolete negative externality generating production method in manufacturing sector with cleaner, improved environment friendly technology to ensure sustainable development in Bangladesh. This might be consistent with displacement hypothesis. The developing countries are likely to be net exporter of pollution intensive goods to Developed countries with stronger environmental regulations.

In India energy consumption plays a role in degrading air quality, It should replace the existing energy base from fossil fuel to other renewable energy sources which are more environment friendly. This will also reduce the greenhouse gas emission which plays a significant role in lowering air quality. Since India has entered the second phase of structural change it should spend more on R&D to explore appropriate, cost effective source of energy consumption. Rapid urbanization deteriorates

environmental quality in both countries; appropriate policies should be implemented to reduce the traffic volumes in urban cities and unplanned internal migration from rural to urban area.

In our study we find that trade declines the level of NO_2 emission in both countries, because the elasticity of NO_2 emission with respect to trade is negative and less than unity. This might be due to technology transfer through foreign direct investment through composition effect, which reduces the emission level. An important policy implication is that both countries should continue to be integrated in Economic globalization where developing economies improve their environmental quality as investment increases Income and employment.

8. CONCLUSION

Our sample data fits with quadratic approach to Kuznets curve for Bangladesh Economy, though the result is not robust using dynamic specification. Energy Consumption has got no role to play for Increased Carbon emission. This finding contradicts with Large sample findings of Islam and Shabaz (2012) on Bangladesh as well as Findings by Alam *et al.* (2012) where they found uni- directional causality from energy consumption to CO2 emission in short run but feedback causality exists in long run and they found Carbon emission causes Economic growth in both short run and long run. In India the experience of EKC is both supported by cubic and quadratic approach which is robust and Energy consumption does play role in polluting the economy using quadratic approach.

In both economies the NO_2 emission is supported by Polynomial model and Kuznets curve is N shaped. After the second tuning point when the emission rises , for India the elasticity of emission with respect to per capita GDP is less than Unity, whereas in Bangladesh it is greater than Unity. So India is successful in reducing its emission level in recent years compare to Bangladesh. The estimation results on NO_2 pollutant qualify the robustness test for Bangladesh but not for India. We get stronger empirical evidence in support of N shaped EKC for Nitrous oxide pollutant in Bangladesh.

For carbon emission Inverted U and N shaped EKC for India qualify the robustness test. But we get stronger evidence in favour of Inverted U rather than N shape because Greenhouse gas is a major polluting factor for Carbon emission which is the result of increased use of fossil fuel energy consumption. In N shaped EKC Energy consumption is not precisely determined which is misleading.

Future Research could extend on identifying contributing factors for other pollutants like SO_2, CO etc. The measurement of environmental degradation could be manifested by pollution intensity. A comprehensive and detailed study of other forms of pollution like water pollution etc. could be examined. From our study we conclude that the shape of Kuznets curve varies with choice of pollutants. We observe that a particular pollutant may exhibit different shapes of EKC and both shapes may be robust to alternative specification. Longer time series data will help future researchers to conclude the relationship between Income and environmental degradation using Environmental Kuznets curve and explore the role of energy consumption in this framework. This would definitely help design appropriate policy directions and recommendations to achieve sustainable stable economic development for developing countries for next generation.

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