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Original Article

Causal Relationship between the Economic Growth and CO_2 Emissions Level in Bihar, India: An EKC Approach

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Abstract *- The main purpose of this paper is to examine the long run causal relationship between the economic development and carbon emissions level and to examine the existence of EKC hypothesis in Bihar, India. The time series analysis is done for the period 1971-1999, covering a time span of 29 years and the variable selected for analysis are CO_2 emissions level and real per capita Gross State Domestic Product of Bihar, India. The time series data was collected from different sources. To investigate the short and long run relationship between these two variables, the ARDL co-integration test was performed and to test the causal relationship between the variables, Granger Causality test was applied. Finally, to test the EKC hypothesis, OLS (Ordinary Least Square) regression was performed. The results of ARDL co-integration test suggests that there is a long run relationship or co-integration among the variables CO_2 emissions and real per capita GSDP. The Granger Causality test results points to unidirectional relationship between CO_2 emissions and real per capita GSDP, i.e., real per capita GSDP does Granger cause CO_2 emissions. The results of quadratic form of EKC model indicates that there is evidence of EKC hypothesis and the results of cubic form of EKC model shows that the inverted U-shaped curve does not exist, it would be N-shaped curve in Bihar, India.*

Keywords *- ARDL, CO_2 emissions, EKC hypothesis, Granger Causality and per capita GSDP.*

1. Introduction

As the economy progresses on the path of development, the environment deteriorates at an increasing rate. Due to increasing economic growth there is a fear of a deteriorating environment and global warming. Greenhouse gas emissions, especially CO_2 is the main cause of global warming. Human activities have clearly caused global warming mainly through the emissions of greenhouse gases, with the global surface temperature rising 1.1° C above 1850-1900 in 2011-2020. With large increases over land 1.59 [1.34 to 1.83]$^{\circ}$C than over the ocean 0.88 [0.68 to 1.01]$^{\circ}$C. Globel surface temperature in the first two decades of the 21st century (2001-2020) was 0.99 [0.84 to 1.10]$^{\circ}$C higher than 1850-1900. IPCC Reports suggest that global surface temperature has increased faster since 1970 than in any other 50-years period over at least the last 200 years. Continued greenhouse gas emissions will lead to increasing global warming, with the best estimates of reaching 1.5° in the near term [1].

Whenever we need to establish a strong link between economic growth and environmental degradation, the main purpose is to test Environmental Kuznets Curve hypothesis which shows that in the early stage of economic development leads to increase the level of environmental degradation, but after a certain level of economic development the trend between these two component reverses, so that high level of economic development implies that improvement of environmental degradation. Many studies have focused on analysing the relationship between economic growth and environmental degradation. In China, Zang & Cheng (2009) investigated the energy consumption, carbon emissions and economic growth relationship and found a unidirectional Granger Causality running from GDP to energy consumption. Moreover, the study reported that a unidirectional Granger Causality was observed from energy consumption to carbon dioxide emissions in the long run [2]. A study done by Shikwambana et al. found that emissions level is generally correlated with economic growth in South Africa between 1994 and 2019 [3]. In another study done by Saboori et al. to determine the relationship between economic growth and CO_2 emissions level, the result indicates that using disaggregated energy data, there is evidence of EKC hypothesis and there is bi-directional causality between economic growth and carbon emissions, with coal, gas, electricity, and oil consumption [4]. A study over some selected South Asian countries by Ahmed et al. found that there is a bi-directional causality between energy consumption and trade openness and unidirectional causality running from energy consumption, trade openness and population to CO_2 emissions [5]. A study over some selected African countries by Esso et al. shows that there is bi-directional causality between economic growth and CO_2 emissions in short run for Nigeria and in the long run for Congo and Goban and in the long run energy consumption and economic growth cause CO_2 emissions in

Benin, Cote d' lvoire, Nigeria, Senegal, south Africa, and Togo [6]. In United States, Soytas et al. investigated the effect of energy consumption and output on carbon emissions. They found that income does not Granger cause carbon emissions in the US in the long run, but energy use does [7]. In Pakistan, Shahbaz et al. investigated the relationship between CO_2 emissions, energy consumption, economic growth, and trade openness over the period of 1971-2009 and found there is a long run relationship among the selected variables and the EKC hypothesis is supported and unidirectional causality between economic growth to CO_2 emissions. Energy consumption increases CO_2 emissions both in the short and long run. Trade openness reduces CO_2 emissions in the long run but it is insignificant in the short run [8]. In India, Ghosh investigated the nexus between electricity supply, employment and real GDP and found long- and short-run Granger causality running from real GDP and electricity supply to employment. Thus, growth in real GDP and electricity supply were found to be responsible for the high level of employment in India [9]. In India, Misra investigates the relationship between economic growth and carbon emissions for the period 1970-2012 and found that there exists a long run relationship between the selected variables whereas in the short run, there is no relationship between the selected variables [10]. Further the study done by Makarabbi et al. in India shows that the bi-directional causality between CO_2 emissions per capita and FDI, CO_2 emissions per capita and energy consumption, but unidirectional Granger causality running from GDP per capita to CO_2 emissions per capita. Also, there is no evidence of EKC hypothesis [11]. Alam investigated the impact of economic development on quality of environment in India and found there is a long run relationship among CO_2 emissions, GDP per capita and industrial value added. GDP per capita is found to be negatively related with carbon emissions in India, but with no change in GDP per capita, carbon emission rise with rise in industrial value added [12]. A study done by Ghoshal et al. found that coal is the most important source of CO_2 in all the states. The relationship between per capita gross state domestic product and CO_2 follows an inverted U-shape [13]. In this paper we specially focus on the relationship between the economic growth and environmental degradation.

The rest of this paper is organised as follows. In section 2 description of the study area is provided. In section 3 discussion on methodology and data collection is given. In section 4 presentation of empirical results of the analysis is provided. And the last section states the conclusion of this study.

2. Study Area

Bihar is a state of India which is in the eastern part of the country and covers an area of 94,163 square kilometers. Its geographical location is $21^\circ 58' 10'' \mathrm{N}$ to $27^\circ 31' 15'' \mathrm{N}$ latitude and between $82^\circ 19' 50'' \mathrm{E}$ to $88^\circ 19' 50'' \mathrm{E}$ longitude. Its average elevation above sea level is 173 feet. In the south lies the Chota Nagpur plateau, which was once a part of Bihar. Southern part of the Bihar state was bifurcated to form a new state of Jharkhand on 15th November 2000. Bihar has 38 districts and the capital of Bihar is Patna. The Gross Domestic Product for the FY 2022-23 is around Rs. 8.59 lakh crore and the per capita income is Rs. 75135. Bihar has the fastest growing state economy in terms of GSDP. As per census 2011, the population of Bihar is 10,40,99,452 in which the contribution of urban area is 11.29% and the remaining 88.71% contribution comes from the rural areas.

3. Data and Methodology

In this study, the following variables have been selected to establish the relationship between the economic development and carbon emissions in Bihar, India: per capita GSDP (in Rs) and CO_2 emissions (in metric tons). Gross State Domestic Product (GSDP) represents the economic development of Bihar, India. The period of this time series data analysis is 1971 to 1999. This period is selected based on availability of the data for all the variables. The data are collected from different sources. The data of GSDP, Bihar has been taken from the Ministry of Statistics and Programme Implementation, the data is in the constant prices of 1980-81. And the data of carbon emissions has been reported by Tapas Ghosal and Ranajoy Bhattacharyya [13]. The data of population has been taken from Census 2011, Bihar [14]. In this paper we specially examine the nature of the relationships between the above-mentioned variables, which means that we investigate the long run relationship among these variables and if the long run relationship exists, then we find the speed of adjustment toward the long-term equilibrium.

In order to test the long-run relationship or co-integration and the causal effect between these two variables we followed the following three steps: first we examine the selected variables are stationary or not. There are many methods available to examine the time series data is stationary, but mostly Augmented Dickey Fuller (ADF) is used for checking the series is stationary. In this test, we have three options: stationary without intercept and trend, stationary with intercept and with intercept and trend also. Augmented Dickey Fuller test also tells us about order of integration which means that if the time series data is stationary at raw data or level data that implies to us the series is stationary at level or integration of order 0, i.e., I (0) and if the time series data is stationary at 1st difference of the raw data that implies to us the series is stationary at 1st difference or integration of order (1), i.e., I (1).

To apply the unit root test in the time series y_t, the ADF equation is given below

$$\Delta y_t = \beta_0 + \beta_1 t + \varphi_1 y_{t-1} + \sum_{i=1}^{p-1} \gamma_i \Delta y_t + e_t \qquad (1)$$

where β_0 represents the intercept, β_1 represents the trend and y_t is the time series data. Here, if $\varphi_1 > 1$, then the time series is explosive. Again, if $\varphi_1 < 1$, then the series is stationary because there is no trend in the time series. Also, if $\varphi_1 = 1$, then the series is non-stationary which means that the series has unit root.

Once we know that the series is stationary at level or at 1st difference, we proceed to the second step which is to examine the co-integration or long run relationship between these two variables by using Autoregressive Distributed Lag (ARDL) bound test method. In the case of ARDL, the selected variable can be of the order I (0), I (1) or a fraction of the order.

Now if the ARDL bound test confirms that the series are co-integrated to each other that means there exists a long-run relationship or co-integration exists. Thirdly, we need to examine the causal relationship between them by using Granger Causality test. This test tells us short and long run causal effect among the variables. Finally, we will do some residual tests and stability test in the model, so we can say that the existing model is good enough.

The Autoregressive Distributed Lag model equation is given below

$$(\ln CO_2)_t = \alpha_0 + \sum_{i=1}^{p} \delta_i (\ln CO_2)_{t-i} + \sum_{j=1}^{q} \theta_j \ln GSDP_{t-j} + e_t \quad (2)$$

Where $\ln CO_2$ is the natural log form of the carbon emission level, lnGSDP is the natural log form of the GSDP and e_t is the error term.

In ARDL bound test, first we estimate equation by using ARDL at different lag length. After this, we will perform long run form and bound test to examine the existence of log run relationship or co-integration. If the test value of F statistics is greater than the upper bound which means that there is co-integration. If the test value of F statistics is less than the lower bound which means that there is no co-integration. And if the test value of F statistics lies between the lower and upper bound which shows that the result is inconclusive. Once this is confirmed that there is a long run relationship among the variables.

Then there is a possibility of causal relation between these two variables at least in one direction. To find causal relation between the variable we will perform Granger Causality test whose null hypothesis is there is no causal relation between the variables.

The environmental Kuznets curve represents a relationship between environmental degradation and Gross State Domestic Product. It tells us carbon emissions level increases in the early stage of economic growth due to high level of emissions, but after some turning point the economic growth leads to low carbon emissions level. It means that carbon emissions level is an inverted U-shaped function of GSDP. To test the EKC hypothesis, we use regression analysis of the EKC model.

The quadratic form of the EKC model is given below

$$Y_t = \beta_0 + \beta_1 X_t + \beta_2 X_t^2 + e_t; \ Y = CO_2 \text{ emissions } \& \ X = GSDP \quad (3)$$

The EKC model holds that if $\beta_1 > 0$ &$\beta_2 < 0$, and both are statistically significant. Then there is a turning point and an inversed U-shaped curve exists.

Also, the cubic form of the EKC model is given below

$$Y_t = \beta_0 + \beta_1 X_t + \beta_2 X_t^2 + \beta_3 X_t^3 + e_t; \ Y = CO_2 \text{ emissions } \& \ X = GSDP \quad (4)$$

If $\beta_1 > 0, \beta_2 < 0$and $\beta_3 > 0$, then there is a N-shaped curve exists which indicates that the carbon emissions level starts increasing again after a reduction to a specific level.

3. Result and Discussion

The relationship between economic growth and carbon emissions in Bihar is tested on the value of variable per capita real gross state domestic product (GSDP (in Rs.)) and absolute value of the variable carbon emissions(CO_2) (in Metric tonnes).

The data analysis is done for the period 1971-1999, covering three decades. The variable taken for analysis is first converted into their natural logs. This is done because the time series data has exponential growth factor due to time factor. The data analysis begins by plotting raw data first (See figure 1).

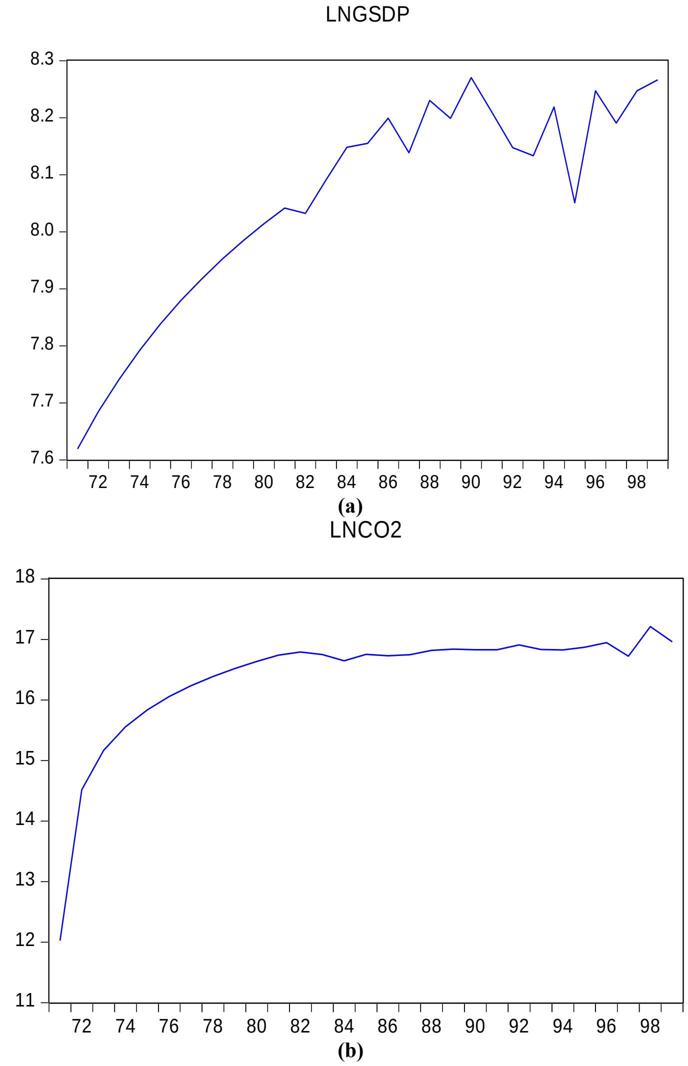

Fig. 1 plotting the raw data (a) graph of log of per capita GSDP & (b) graph of log of CO_2 emissions level

The selected data for analysis has time series properties. Since, the variable taken for analysis are time series as shown in graph, running directly multiple regression involving these two variables may lead to spurious regression if these are not all stationary which means that model is overfitted. Thus, it is important to check whether the series is stationary or not. To do so we will use ADF Unit Root Test. The Augmented Dickey Fuller test has been applied to check for the presence of unit root in the selected variables. Following are the results of the Unit Root Test (Table 1).

Table 1. Result of unit root test

Variables	**Null Hypothesis**	**At Level *i.e.* I(0)**	**ADF t-stats**	**Test critical values at 1%**	**Test critical values at 5%**	**Test critical values at 10%**	**Prob. Value**
LNCO2	The Series has a unit root.	C	-13.60	-3.69	-2.97	-2.63	**0***
		C & T	-4.94	-4.34	-3.59	-3.23	**0.003***
LNGSDP	The Series has a unit root.	C	-3.07	-3.7	-2.98	-2.63	**0.04***
		C & T	-2.04	-4.34	-3.59	-3.23	0.56
Variables	**Null Hypothesis**	**At 1st Diff. *i.e.* I(1)**	**ADF test-statistics**	**Test critical values at 1%**	**Test critical values at 5%**	**Test critical values at 10%**	**prob. Value**
LNCO2	The Series has a unit root.	C	NA	NA	NA	NA	NA
		C & T	NA	NA	NA	NA	NA
LNGSDP	The Series has a unit root.	C	-9.67	-3.7	-2.98	-2.63	**0***
		C & T	-10.64	-4.34	-3.59	-3.23	**0***

Table 2. AIC, SC & HQ for optimal lag length in standard VAR

Lag Length	0	1	2
Akaike Information Criteria	-1.204283	-4.140864	-4.755239*
Schwarz Information Criteria	-1.108295	-3.8529	-4.275300*
Hannan- Quinn Information Criteria	-1.175741	-4.055237	-4.612528*

Table 3. ARDL bound test result

ARDL bound test:				
Equation: LNCO2|CONSTANT_LNGSDP				
Test Statistic	**Value**	**Significance Level**	**I(0) bound**	**I(1) bound**
F-statistic	26.95522	10%	3.02	3.51
		5%	3.62	4.16
		2.50%	4.18	4.79
		1%	4.94	5.58

Based on the results of ADF test, the series LNCO2 is stationary at level (*i.e.,* integrated of order zero) with constant and trend and the series LNGSDP is stationary at 1st difference (*i.e.,* integrated of order one) with constant and trend. Thus, it can be concluded that the selected variables are stationary at $I(0)$& $I(1)$ (Table 1). Once the selected data is confirmed with stationary property, co-integrating or long run relationship was tested by using ARDL (Auto Regressive Distributed Lag) model. For this, we must select the optimal lag length by using lag-length criteria on vector autoregressive (VAR) model including both the variables as endogenous variables before applying ARDL model.

Based on Akaike Information Criteria 2 lags was selected as optimal lag length for further consideration (Table 2) and the results of lag length structure are presented in the figure-2. Next, in order to search for the possibility of a co-integration or long-run relationship between these two variables (LNCO2 & LNGSDP), and we will perform the ARDL bound test to get the result (Table 3).

In our case, the estimated F– statistics value was found to be 26.96, when log of carbon emissions was dependent variable (Table 3). And, the computed F-statistics value was found to be greater than $I(1)$ upper bound critical value at the1,2.5, 5 and 10% level of significance.

Thus, we conclude that there is long run relationship and co-integration exists between the variables LNCO2 and LNGSDP.

Also, the prob-value of the coefficient of LNGSDP was found to be 0.0906 which is significant at 10% level of significance. So, the coefficient of LNGSDP has long run effect on LNCO2 at 10% level of significance. And, this is the way a long run causal effect is calculated

$$\mathrm{EC} = \mathrm{lNCO_2} - (1.0550 * \mathrm{LNGSDP} + 8.3074) \qquad (5)$$

EC is the Error Correction Term and it is the residual from long run equation (Table 4).

Table 4. Residual from long-run equation

Levels Equation				
Case 2: Restricted Constant and No Trend				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LNGSDP	1.05496	0.596049	1.769922	**0.0906**
C	8.307395	4.872012	1.705126	0.1023
EC = LNCO2 – (1.0550*LNGSDP + 8.3074)				

Table 5. Error correction model result

ECM Regression				
Case 2: Restricted Constant and No Trend				
Variable	**Coeff.**	**Std. Error**	**t-Stats**	**Prob.**
D(LNGSDP)	-0.29	0.3368	-0.87	0.39
D (LNGSDP (-1))	-1.16	0.3467	-3.34	0.003
CointEq (-1) *	-0.40	0.0428	-9.39	0
R-squared	0.78	Mean dep var	0.09	
Adjusted R-squared	0.76	S.D. dep var	0.19	
S.E. of regression	0.10	AIC	-1.76	
Sum squared resid	0.22	SC	-1.62	
Log likelihood	27	Hannan-Quinn criter.	-1.72	
Durbin-Watson stat	2.1			

Now the error correction term is used as an explanatory variable in the existing model to check the speed of adjustment towards the long run equilibrium. The term CointEq (-1) means the error correction coefficient. In our case, CointEq (-1) is found to be -0.401846 and it is significant at 5% level of significance which means that there is presence of long run causality. Also, the CointEq (-1) tells us speed of adjustment of any equilibrium towards long run equilibrium state. So, in this case, the speed of adjustment is 0.40*100= 40% which means that the speed of adjustment is quite enough (Table 5). The co-integration graph represented in figure-3.

After identification of long run relationship there must be existence of causal relationship among the variables at least in one direction. For this, the Granger Causality test was applied to check for the existence of causal relationship between the variables. Following are the results of the same (Table 6). Here, the null hypothesis tested in the Granger Causality test is that there is no causal relationship exists between the variables. And, based on the probability values from the causality analysis, there is a causal relation from GSDP to CO_2 . So, the unidirectional causality between GSDP and CO_2 emissions which means that when Gross State Domestic Product increases the Carbon dioxide emissions is also increases.

Table 6. Granger causality test

S.No.	Direction of causality	Prob.	Existence of causality
1	GSDP to CO2	0.0051	yes
2	CO2 to GSDP	0.419	No

The short run causality analysis was performed by Wald test and it reveals that there is presence of short run causality among the variables. Here, the null hypothesis tested in Wald test there is no short run causal effect between the variables. As the probability value of chi-square is less than 5%, we reject the null hypothesis which means that there is short run causality exists between the variables (Table 7).

Table 7. Wald test result

Wald Test:			
Test Statistic	**Value**	**df**	**Probability**
F-statistic	132.7455	(4, 22)	0
Chi-square	530.982	4	0

We further go ahead and check for normality, serial corelation and heteroskedasticity of the residual and check the stability of the model. As per the result of the normality test, the residuals are not normally distributed in the model (See figure 4). The serial correlation LM test is applied for the testing of serial correlation of residual. In this test the null hypothesis is there is no serial correlation, as per the result we see that the p-value of chi-square is far away from the value 0.05 which means that we accept the null hypothesis. So, the residuals are not serially correlated in this model (Table 8).

Finally, the heteroskedasticity test is used for checking the residuals are heteroskedastic or homoscedastic in the model. As per result of this test, residuals are homoscedastic in the model (Table 9). The CUSUM test is used for checking the stability of the model. As per the CUSUM test, the model is found to be stable as 5% level of significance (See figure 5).

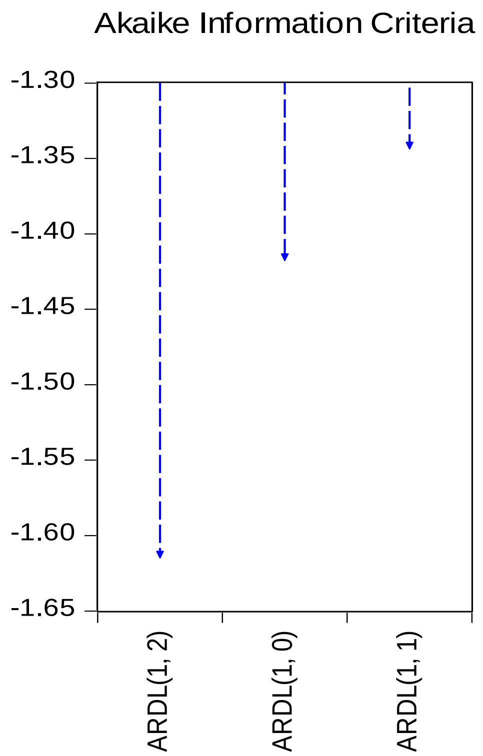

Fig. 2 AIC for model selection

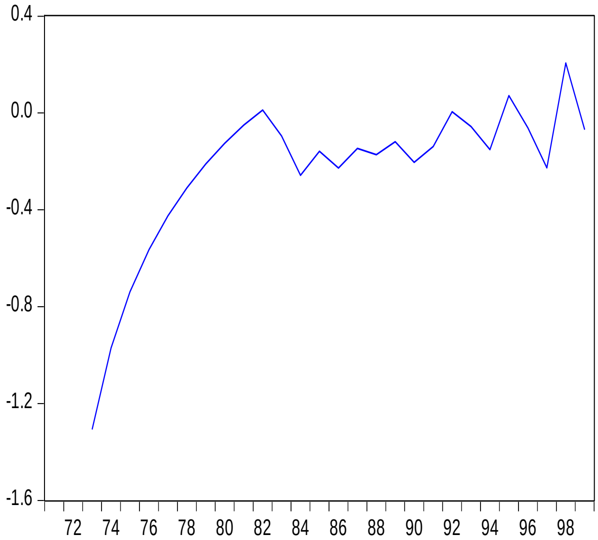

Fig. 3 Co-integration graph

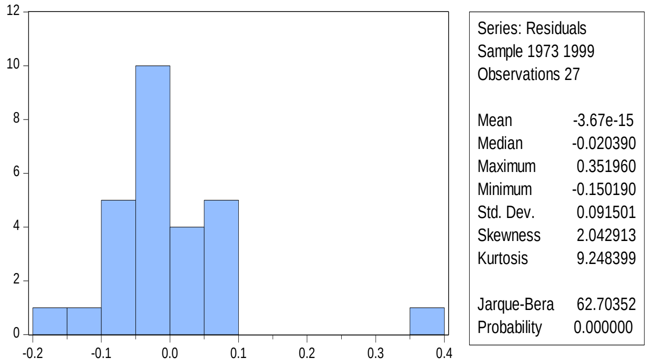

Fig. 4 Histogram of residual normality test

Table 8. Serial correlation LM Test Result

Breusch-Godfrey Serial Correlation LM Test			
F-statistic	0.112159	Prob. F(2,20)	0.8945
Obs*R-squared	0.299471	Prob. Chi-Square(2)	0.8609

Table 9. Heteroskedasticity Tests: No Cross Terms

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	1.013055	Prob. F(4,22)	0.4222
Obs*R-squared	4.19964	Prob. Chi-Square(4)	0.3797
Scaled explained SS	11.49925	Prob. Chi-Square(4)	0.0215

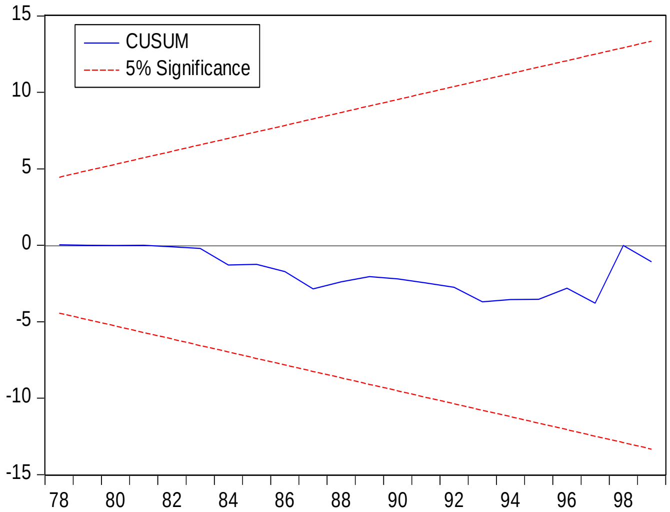

Fig. 5 stability analysis-CUSUM Test

Table 10. Quadratic environmental kuznets curve regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GSDP	31.8899	4.791763	6.65515	0
SQ_GSDP	-5.87E-06	1.29E-06	-4.532681	0.0001
C	-20766442	4114210	-5.047492	0
R-squared	0.901363			
F-statistic	118.7966			
Prob(F-statistic)	0			

Table 11. Cubic Environmental Kuznets Curve Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GSDP	97.0482	18.42252	5.26791	0
Square of GSDP	-4.33E-05	1.04E-05	-4.167146	0.0003
Cubic of GSDP	6.70E-12	1.85E-12	3.621434	0.0013
Constant	-55484598	10171250	-5.455042	0
R-squared	0.935303			
F-statistic	120.4718			
Prob(F-statistic)	0			

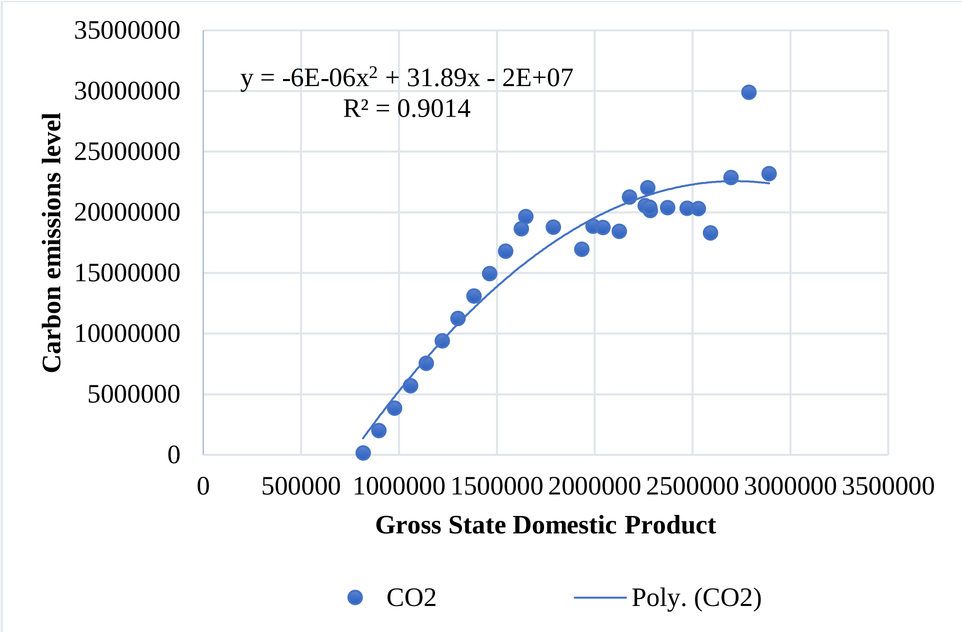

Fig. 6 Quadratic EKC model

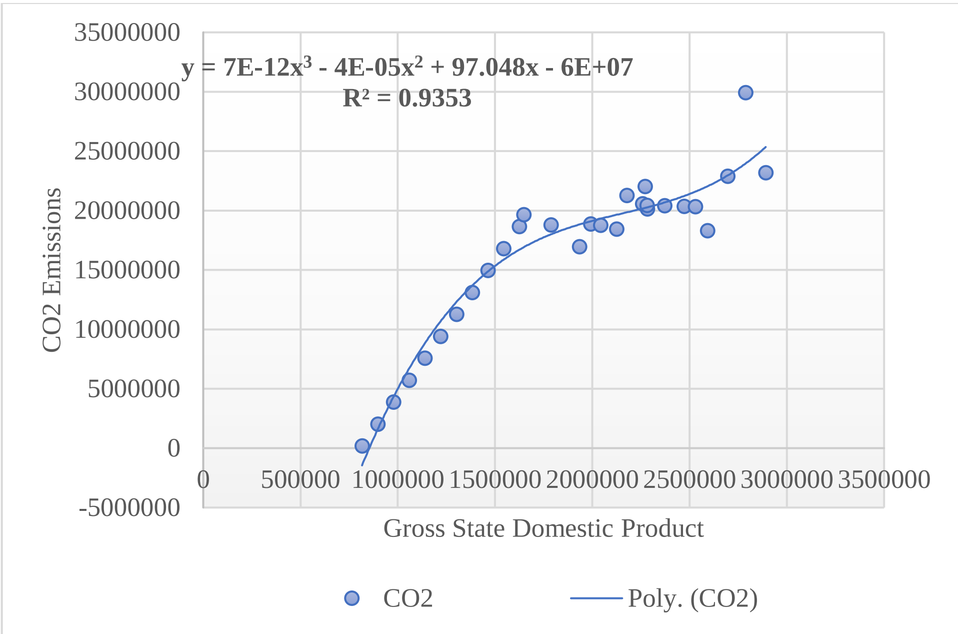

Fig. 7 Cubic EKC model

Lastly, the carbon dioxide (CO_2) was regressed on the explanatory variable Gross State Domestic product (GSDP). The results of quadratic form of EKC model indicates that all the co-efficient are significant at 1% level of significance. And the test value of $R^2 = 0.90$ which shows that 90% of the variation in the dependent variable can be affected by explanatory variables (Table 10). The expected sign of the square of the GSDP was found to be negative and the sign of GSDP was found to be positive that means this is the evidence of inverted U-shaped EKC. The regression line represented in the chart with regression equation and their co-efficient values (See figure 6). And the results of cubic form of EKC model indicates that all the co-efficient in the cubic regression are significant at 1% level of significance (Table 11). Also, the value of $R^2 = 0.94$ implies that 94% of the variation in the dependent variable CO_2emissions is affected by the independent variable GSDP in this present regression model. The remaining 6% of the variation are due to constant term. The expected sign for the real GSDP was positive. It concludes that the early stage of economic growth in the state leads to increase in the CO_2 emissions level. And the co-efficient of square of real GSDP was negative and co-efficient of the cubic of real GSDP was positive. It follows that there is no existence of EKC which means that no inverted U-shaped curve in the state. It would be N-shaped curve in this context. The regression line represented in the chart with regression equation and their co-efficient values (See figure 7).

4. Estimate Equations in this Model

The ARDL model is presented below in equation (6)

$$(\ln CO_2)_t = C(1)\,(\ln CO_2)_{t-1} + C(2)\ln GSDP + C(3)\ln GSDP_{t-1} + C(4)\ln GSDP_{t-2} + C(5) \quad (6)$$

After substituting the co-efficient values in equation (6), we have

$$(\ln CO_2)_t = 0.59\,(\ln CO_2)_{t-1} + 0.29\ln GSDP + 0.44\ln GSDP_{t-1} + 1.16\ln GSDP_{t-2} + 3.34 \quad (7)$$

The above equation (7) shows that when the real per capita GSDP increased by 1% then CO2 emissions level increased by 29%.

And the co-integrating equation is given below in equation (8)

$$\Delta\,(\ln CO_2)_t = 3.34 - 0.40\,(\ln CO_2)_{t-1} + 0.42\ln GSDP_{t-1} - 0.29(\ln CO_2 - (1.05\ln GSDP_{t-1} + 8.31) - 1.16\nabla\ln GSDP_{t-1}) \quad (8)$$

5. Finding and Conclusion

In this paper the analysis is done for finding the long run and causal relationship between the carbon emissions level and per capita real GSDP based on the available data for the period 1971-1999. First, the ARDL model was conducted to verify that there is a long run relationship or co-integration between the variablesCO_2 and per capita GSDP. And then Granger Causality test was applied to examine the causal relationship between the variables CO_2 and per capita GSDP at least in one direction. Lastly, to test the existence of EKC we will perform the regression analysis between the variable CO_2 and real GSDP not on the per capita. Based on ARDL co-integration or bond test confirms that there is a strong long run relationship between CO_2 and Per capita GSDP. Also, the ECT co-efficient was found to -0.4 which indicates that there is presence of long run causality. And the speed of adjustment towards long run equilibrium is 40 percent. As per result of Wald test, there is presence of short run causal effect between the variables. And the Granger Causality test implies that there is causal relation from per capita GSDP to Carbon emissions level which means that there is a unidirectional relationship between the variables per capita GSDP and CO_2 emissions. Also, by some residual test the residuals are not normally distributed, residuals are not serial correlated and the residual series is homoscedastic. Based on CUSUM test model is stable at 5% level of significance. Lastly, by the regression analysis the quadratic form EKC model indicates that there is evidence of inverted U-shaped curve in Bihar context which is statistically significant at 5% level of significance. And the cubic regression of EKC model implies that there may be N-shape curve in Bihar, India. So, it is important to take necessary decisions in helping the state move towards energy efficiency in order to reduce the carbon emissions level.

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