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Long- And Short-Run Causal Relationship Between The Economic Growth And Carbon Emissions Level In Ranchi, Jharkhand

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Abstract:

The main purpose of this paper is to examine the long- and short-run causal relationship between the economic development and carbon emissions level and to examine the existence of EKC hypothesis in Ranchi, Jharkhand. The data analysis is done for the period 2001-2020, which covers 20 years and the variable selected for analysis are CO_2 emissions level and real per capita Gross District Domestic Product of Ranchi, Jharkhand. The 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 implies that there is a long- and short-run relationship or co-integration among the variables CO_2 emissions and real per capita GDDP. The Granger Causality test results implies that there is unidirectional relationship between LNCO2 and LNPCGDDP, i.e., Carbon emissions does Granger cause per capita real GDDP. The results of quadratic form of EKC model shows that there is evidence of inverted U-shaped curve and the result of cubic form of EKC model indicates that there is an inverted N-shaped curve in Ranchi, Jharkhand.

Keywords:

ARDL model, CO_2 Emissions, GDDP per capita, EKC hypothesis and Granger Causality

Introduction:

Economic growth can endanger the environment and contribute to global warming. Greenhouse gas emissions, especially CO_2 is the main factor of the 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 then 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. Global surface temperature has increased faster since 1970 than in any other 50-years period over at least the last 200 years (IPCC). Continued greenhouse gas emissions will lead to increasing global warming, with the best estimates of reaching 1.5° in the near term [1].

If we want to determine the linkage between economic growth and environmental degradation. The main purpose is to focus on Environmental Kuznets Curve hypothesis which shows that in 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. A study conducted by Zang and Cheng in Chaina that implies us there is a unidirectional Granger causality running from GDP to energy consumption. Moreover, the study also reported that a unidirectional Granger Causality was observed from energy consumption to carbon dioxide emissions in the long run [2]. 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 [3]. A study is done by Shikwambana et al found to be emissions level are generally correlated with economic growth in South Affrica between 1994 and 2019 [4]. A study is done by Saboori et al to establish the relationship between economic growth and CO_2 emissions level which results 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 [5]. 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 [6]. In Pakistan, Shahbaz et al investigates 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 [7]. 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 are responsible for the high level of employment in India [8]. 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 [9]. And the study done by Makarabbi et al in India implies 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. And there is no evidence of EKC hypothesis [10]. Alam investigates 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 [11]. A study is 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 [12]. A study presented by Sinha et al in Indian cities context found that non-rejection of EKC hypothesis reemphasized the impact of growth catalysing economy policy decision on environment [13,14]. In this paper we specially focus on the relationship between the economic growth and environmental degradation.

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

Study area:

Ranchi is a capital of Jharkhand which is a state of India and it covers an area of 175 square kilometres. And its geographical location is 23°22′N 85°20′E. Its average elevation above sea level is 2,136 feet. Ranchi is in the Southern part of the Chota Nagpur plateau. And the area comes under humid subtropical climate. As per census 2011, the population of Ranchi is 1,073,427 in which the contribution of urban area is 14,56,528. Ranchi has 18 blocks, 1,311 villages and 45 police station. Ranchi is one of the major industrial cities of Eastern India. Ranchi is rapidly growing its economy. Also, it is known City of waterfalls. The location map of Ranchi is shown in figure 1.

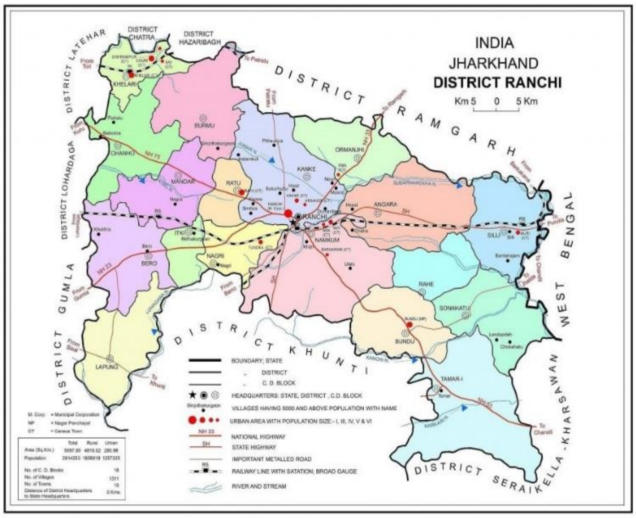


Figure 1: Location map of Ranchi, Jharkhand

Data and methodology:

In this paper, the following variables has been selected to determine the relationship between the economic development and carbon emissions in Ranchi, Jharkhand: per capita GSDP (in Rs) and CO_2 emissions (in metric tons). Gross District Domestic Product (GDDP) indicates that the economic development in Ranchi, Jharkhand. The period of this data analysis is 2001-2020 which cover 20 years. This period is selected based on the availability of the data for all the variables. The data are collected from different sources. The data of GDDP, Ranchi has been taken from the Directorate of Economics & Statistics, Government of Jharkhand and http://data.icrisat.org/dld/src/gdp.html, the data is in the constant prices of 1999-2000. And the data of carbon emissions has been reported by Amit Kumar and Ashwani Kumar [15]. And the data of population has been taken from Census 2011, Ranchi. In this study, we specially examine the nature of the relationship between the above-mentioned variables, which means that we investigate the long- and short-run causal relationships among these variables and if the long run relationship exists, then, we must find the dynamic 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 need to perform some well-known tests: like ADF test is used to check the series is stationary or not, Auto-regressive distributed Lag bound test is applied to examine there is a long-run relationship or Co-integration exists among these variables, Granger Causality test to check the causal effect between these variables and lastly, do some coefficient diagnostics, residual and stability tests.

Let
$$y_t = \alpha + \beta y_{t-1} + \varepsilon_t \quad (1)$$

It can be interpreted as if $\beta > 1$, then the series y_t is explosive because, if $\beta < 1$, then the trend in the series y_t die out, the series is stationary and if $\beta = 1$, then trend exist in series.

Again let
$$y_t = \beta y_{t-1} + \varepsilon_t \quad (2)$$

Now by subtracting y_{t-1} on the both side of the above equation, we have

$$y_t - y_{t-1} = \beta y_{t-1} + \varepsilon_t - y_{t-1}$$

$$\text{i.e., } \Delta y_t = (\beta - 1) y_{t-1} + \varepsilon_t$$

$$\text{i.e., } \Delta y_t = \gamma y_{t-1} + \varepsilon_t \text{ ; } \gamma = (\beta - 1) \quad (3)$$

In general, the unit root test in the time series y_t, the ADF equation is given below is given below

$$\Delta y_t = \alpha + \varphi t + \gamma y_{t-1} + \sum_{i=1}^{p-1} \delta_i \Delta y_t + \varepsilon_t \quad (4)$$

Where α represents the intercept & β represents the trend. Here, if $\gamma > 0$, then the time series is explosive. Again, if $\gamma < 0$, then the series is stationary because there is no trend in the time series. Also, if $\gamma = 0$ $(\text{i.e.}, \beta = 1)$, then the series is non-stationary which means that the series has unit root.

In unit root test for time series y_t, there are three basic series assumptions are as follows

a) The series is stationary without intercept and trend, *i.e.,* $\Delta y_t = \gamma y_{t-1} + \varepsilon_t$.
b) The series is stationary with intercept and no trend, *i.e.,* $\Delta y_t = \alpha + \gamma y_{t-1} + \varepsilon_t$.
c) And the series is stationary with intercept and trend, *i.e.,* $\Delta y_t = \alpha + \varphi t + \gamma y_{t-1} + \varepsilon_t$.

Unit root test also tells us order of integration of the time series date. if the time series data is stationary at raw data which indicates that the order of integration of the series, is I (0) and the time series data is stationary at 1st difference which indicates that implies the series is of order I (1).

Once this confirms that the series is stationary at level or at 1st difference. We proceed to the next 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 ARDL model, series 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 which means that there exists a long-run relationship or co-integration exists. Now, we need to apply the Granger Causality test to confirmed that there is a long- and short-run causal effect among these variables at least in one direction. Finally, we perform some residual tests and stability test in the model, so we say that existing model is good enough.

The Autoregressive Distributed Lag model equation is given below

$$(\ln CO_2)_t = \alpha_0 + \sum_{i=1}^{p} \delta_i \, (\ln CO_2)_{t-i} + \sum_{j=1}^{q} \theta_j \ln GSDP_{t-i} + \varepsilon_t \qquad (5)$$

Where $lnCO_2$ 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 Co-integration test, we estimate equation by using ARDL model 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 long- and short-run causal effect between these two variables. 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 District 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 GDDP. To test the EKC hypothesis, we use regression analysis of the EKC model.

The quadratic form of the EKC model is given below

$$Y_t = \beta_0 + \beta_1 X_t + \beta_2 {X_t}^2 + \varepsilon_t; \; Y = CO_2 \text{ emissions}, \; X = \text{GDDP} \,\&\, t = \text{time factor} \qquad (6)$$

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

$$Y_t = \beta_0 + \beta_1 X_t + \beta_2 {X_t}^2 + \beta_3 {X_t}^3 + \varepsilon_t; \; Y = CO_2 \text{ emissions}, \; X = \text{GDDP} \,\&\, t = \text{time factor} \; (7)$$

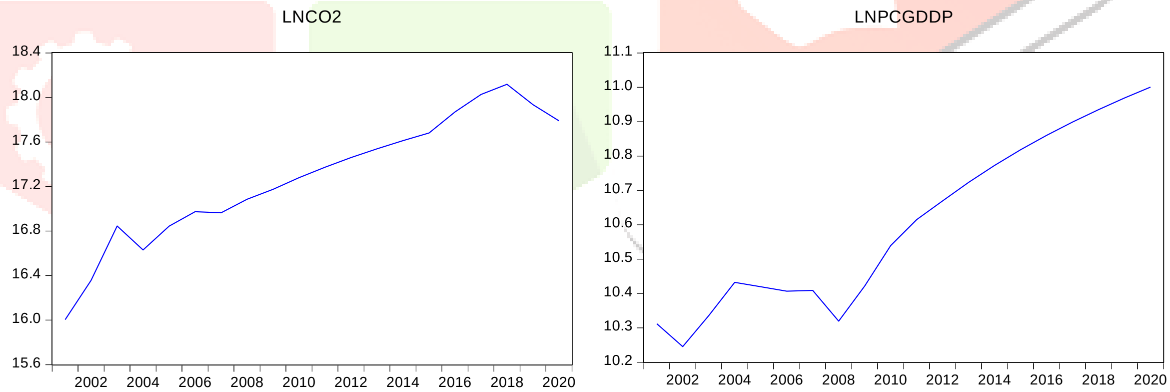
If $\beta_1 < 0, \beta_2 > 0$ and $\beta_3 < 0$, then, there is an inverted N-shaped curve.

Table 1: Summary statistics of the variables

	CO2 (in Mtons)	GDDP (in Lakhs)
Mean	36717351	1231940
Median	33525092	1133490
Maximum	73853093	2049450
Minimum	8930782	677624
Std. Dev.	18739496	449329.8
Skewness	0.435802	0.443235
Kurtosis	2.138901	1.795061
Sum	7.34E+08	24638809
Sum Sq. Dev.	6.67E+15	3.84E+12

Results and Discussion:

The relationship between economic growth and carbon emissions in Ranchi is tested on the value of variable per capita real gross district domestic product (GDDP (in Rs.)) and absolute value of the variable carbon emissions (CO_2) (in Metric tonnes). The data analysis is done for the period 2001-2020, covering two decades. The variable taken for analysis is first converted into their natural logs. This is done because time series data has exponential growth factor due to time factor. The data analysis begins by plotting raw data first (figure 2).



(a) (b)

Figure 2: plotting of raw data (a) graph of log (CO_2) and (b) graph of log (pcgddp)

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 perform Unit Root Test by using ADF 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 2).

Table 2: Unit Root Test Results

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	-2.810539	-3.831511	-3.02997	-2.655194	0.0755
		C & T	-3.461115	-4.571559	-3.69081	-3.286909	0.0746
LNPCGDDP	The Series has a unit root.	C	0.189943	-3.831511	-3.02997	-2.655194	0.9642
		C & T	-2.238272	-4.532598	-3.673616	-3.277364	0.4440
Variables	**Null Hypothesis**	**At 1st Diff. *i.e.* I(1)**	**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	-3.905943	-3.857386	-3.040391	-2.660551	**0.0091**
		C & T	-4.942915	-4.616209	-3.710482	-3.297799	**0.0056**
LNPCGDDP	The Series has a unit root.	C	-4.117385	-3.857386	-3.040391	-2.660551	**0.0059**
		C & T	-3.887304	-4.571559	-3.690814	-3.286909	**0.0352**

Based on the results of ADF test, the series LNCO2 is stationary at 1st difference (*i.e.,* integrated of order one) with constant and trend and the series LNPCGDDP is stationary at 1st difference (*i.e.,* integrated of order one) with constant and trend. Thus, it was concluded that the selected variables are both stationary at I(1) (Table 2). 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 all the two variables as endogenous variables before applying ARDL model.

Table 3: AIC& SIC for Optimal Lag Length in Standard VAR

Lag Length	0	1	2
Akaike Inf. Criteria	-0.795644	**-4.012872***	-3.913769
Schwarz Inf. Criteria	-0.696714	**-3.716082***	-3.419118

Based on Akaike Information Criteria 1 lag is selected as optimal lag length for further consideration (Table 3) and the results of lag length structure were presented in the figure-3. Next, in order to search for the possibility of a co-integration or long-run relationship between these two variables (LNCO2 & LNPCGSDP), and we will perform the ARDL bound test to get the results (Table 4).

Table 4: ARDL bound test Results

ARDL bound test:				
Equation: LNCO2|CONSTANT_LNPCGDDP				
Test Statistic	**Value**	**Significance Level**	**I (0) bound**	**I (1) bound**
F-statistic	**6.49832**	10%	3.02	**3.51**
		5%	3.62	**4.16**
		2.50%	4.18	**4.79**
		1%	4.94	**5.58**

Here, the estimated F-statistics value was found to be 6.5, when log of carbon emissions was dependent variable (Table 4). And, the computed F-statistics value was found to be greater than I(1) upper bound critical value at the 1, 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 LNGDDP.

Also, the prob-value of the coefficient of LNGDDP was found to be 0.0057 which is significant at 10% level of significance. So, the coefficient of LNGDDP has long run effect on LNCO2 at 10% level of significance. And, this is the way a long run causal effect is calculated

$$EC = LNCO_2 - (1.4586 * LNPCGDDP + 1.9936) \quad (8)$$

EC is the Error Correction Term and it is the residual from long run equation (Table 5).

Table 5: Residual from Long-run Equation

Levels Equation				
Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNPCGDDP	1.458648	0.457509	3.188236	**0.0057**
C	1.993622	4.932367	0.404192	0.6914
$EC = LNCO_2$ - (1.4586*LNPCGDDP + 1.9936)				

Now the error correction term is used as an explanatory in the existing model to check the speed of adjustment towards the long run equilibrium. The term CointEq (-1) means the error correction coefficient. Here, CointEq (-1) is found to be -0.401525 and it is significant at 10% level of significance which means that there is presence of long- and short-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 0.401525*100= 40% which means that the speed of adjustment is quite enough (Table 6). The co-integration graph represented in figure-4.

Table 6: Error correction Model Result

Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
CointEq (-1) *	**-0.401525**	**0.085738**	**-4.683143**	**0.0002**
R-squared	0.395542	Mean dependent var	0.093965	
Adjusted R-squared	0.395542	S.D. dependent var	0.165334	
S.E. of regression	0.128542	Akaike info criterion	-1.21393	
Sum squared resid	0.297414	Schwarz criterion	-1.164223	
Log likelihood	12.53233	Hannan-Quinn criter.	-1.205517	
Durbin-Watson stat	2.073999			

After identification of long- and short-run relationship there must be existence of causal relationship among the variables. 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 7). 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 at 10% level, there is a causal relation from LNCO2 to LNPCGDDP. So, the unidirectional causality between LNCO2 and LNPCGDDP which means that when the carbon emissions level increases the gross district domestic product increases.

Table 7: Granger Causality Test Results

S.No.	Direction of causality	Prob.	Existence of causality
1	PCGDDP to CO2	0.3079	No
2	**CO2 to PCGDDP**	**0.0994**	**Yes**

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 8).

Table 8: Wald Test Results

Wald Test:			
Test Statistic	Value	df	Probability
F-statistic	112.774	(2, 16)	0
Chi-square	**225.548**	**2**	**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 (figure 5). 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 9). 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 10). 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 (figure 6).

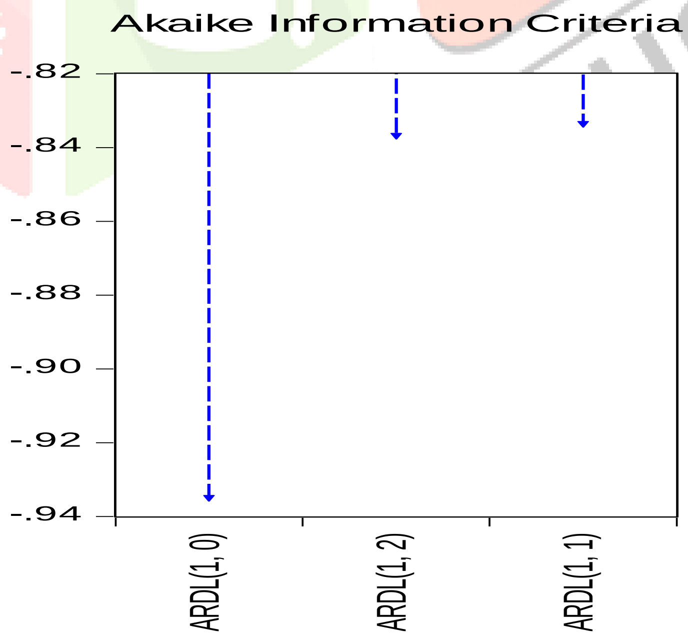


Figure 3: AIC for model selection

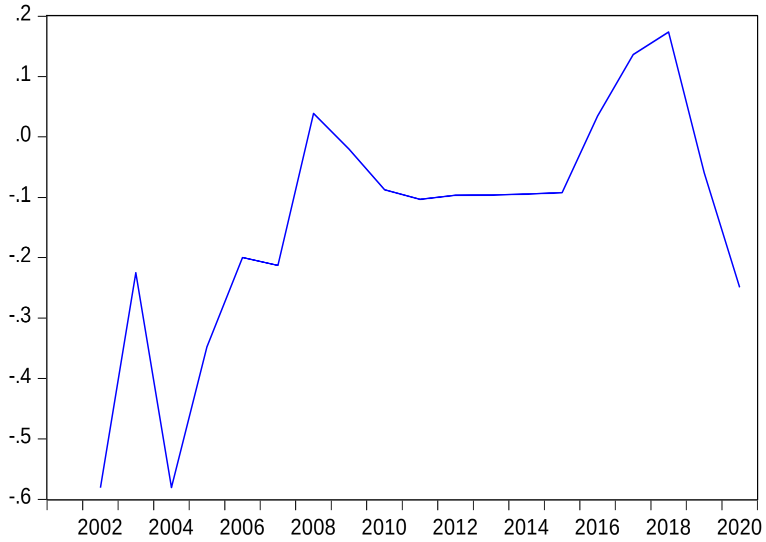


Figure 4: Co-integrating graph

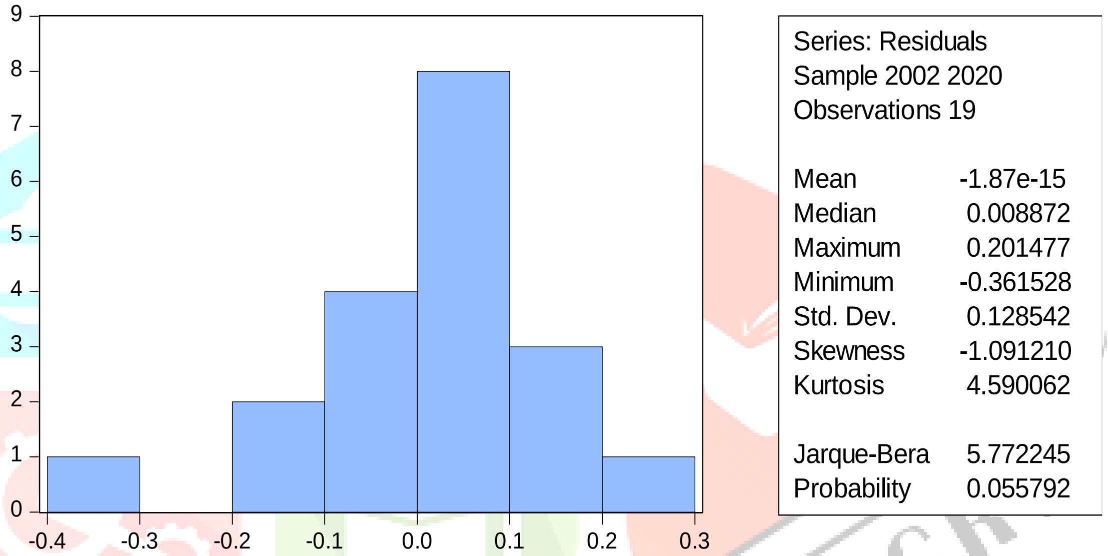


Figure 5: histogram of residual normality test

Table 9: Serial correlation LM Test Result

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.1937	Prob. F (2,14)	0.8261
Obs*R-squared	0.51159	Prob. Chi-Square (2)	**0.7743**

Table 10: Heteroskedasticity Tests: No Cross Terms

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	0.079227	Prob. F (2,16)	0.9242
Obs*R-squared	0.186319	Prob. Chi-Square (2)	**0.911**
Scaled explained SS	0.237172	Prob. Chi-Square (2)	0.8882

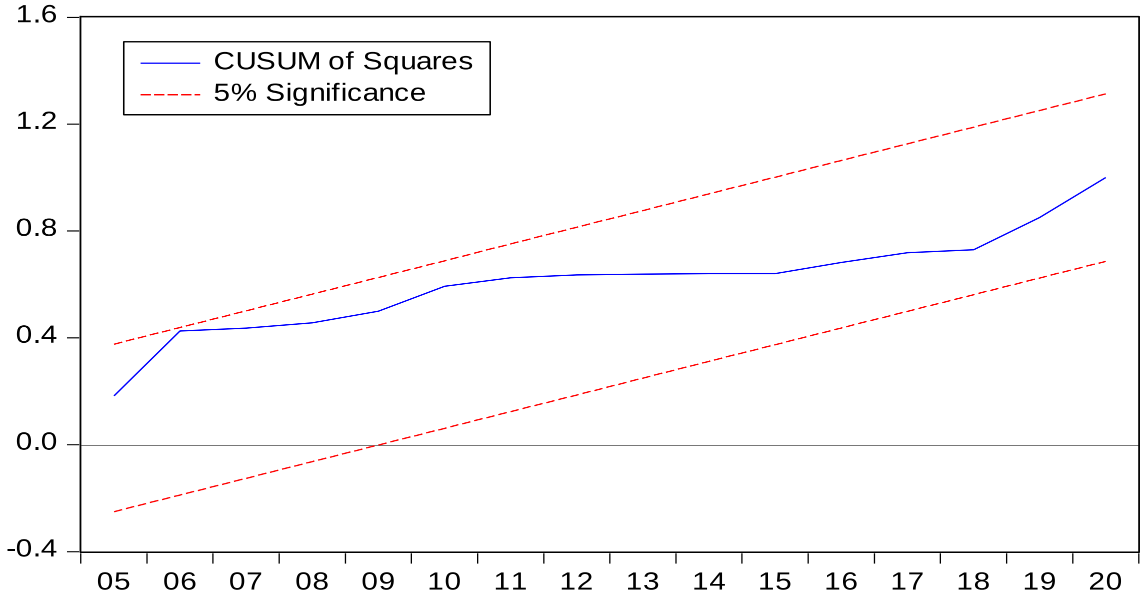


Figure 6: stability analysis-CUSUM of square test

Table 11: Quadratic Environmental Kuznets Curve Regression

Dependent Variable: CO2				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDDP	**76.4931**	**23.75881**	**3.219568**	**0.005**
SQ_GDDP	**-1.39E-05**	**8.87E-06**	**-1.567775**	**0.1354**
C	**-33753716**	**14422046**	**-2.340425**	**0.0317**
R-squared	**0.911774**			
F-statistic	**87.8436**			
Prob(F-statistic)	**0**			

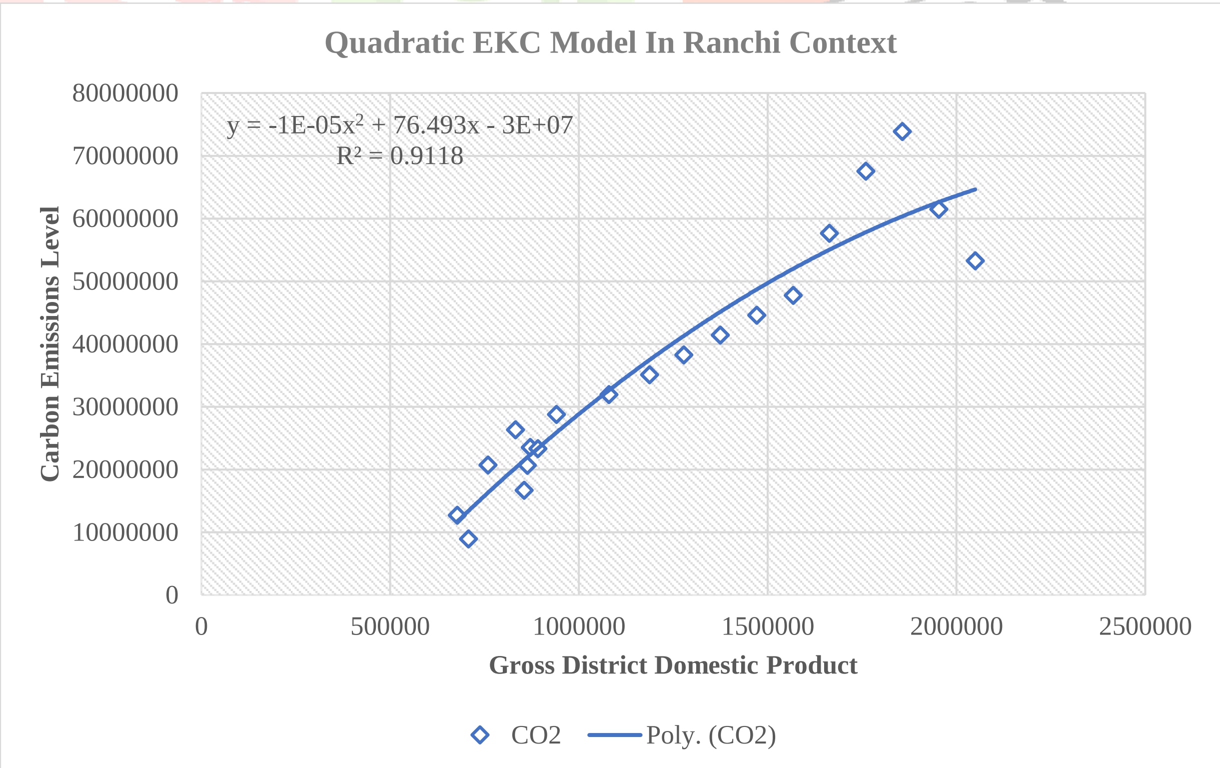


Figure 7: quadratic EKC model

Table 12: Environmental Kuznets Curve Regression

Dependent Variable: CO2				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDDP	**-108.6769**	**122.6431**	**-0.886123**	**0.3887**
SQ_GDDP	**0.000131**	**9.47E-05**	**1.383683**	**0.1855**
CUBIC_GDDP	**-3.56E-11**	**2.32E-11**	**-1.536762**	**0.1439**
C	**39821893**	**49847598**	**0.798873**	**0.4361**
R-squared	**0.923122**			
F-statistic	**64.04024**			
Prob(F-statistic)	**0**			

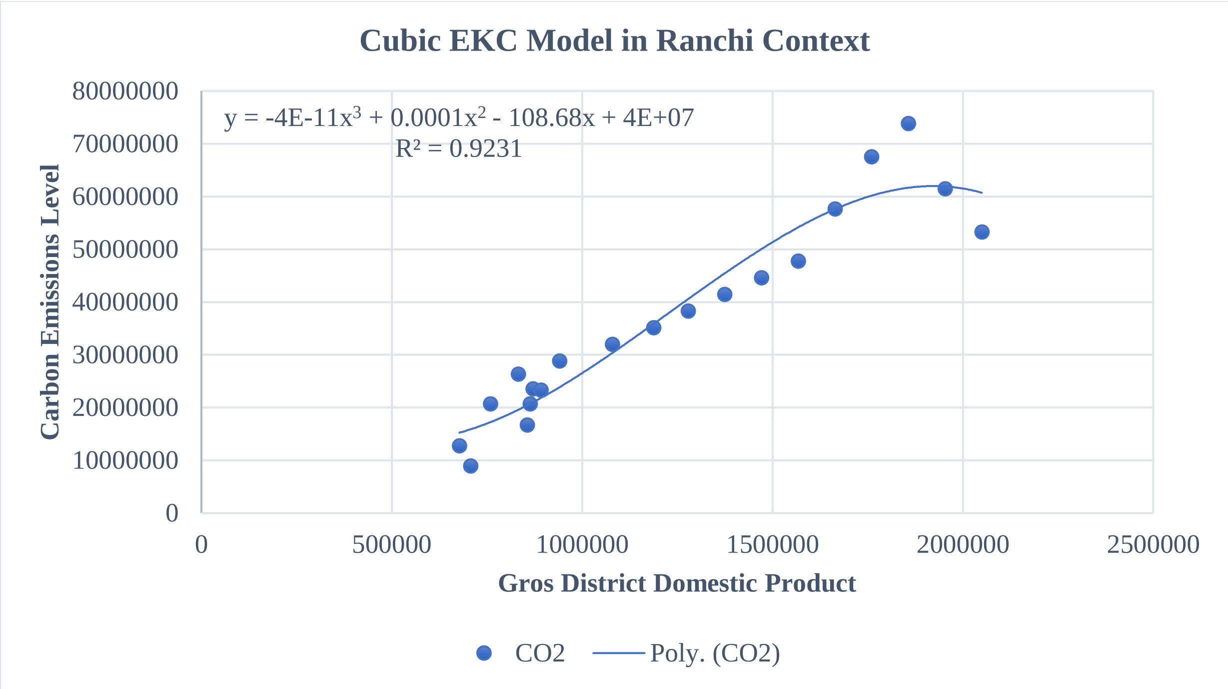


Figure 8: cubic EKC model

Lastly, the carbon dioxide (CO2) was regressed on the explanatory variable Gross District Domestic product (GDDP). The results of quadratic form of EKC model indicates that all the co-efficient are insignificant at 5% level of significance but the expected sign of the square of the GDDP was found to be negative and the sign of GDDP was found to be positive that means this is the evidence of inverted U-shaped EKC (Table 11). The regression line represented in the chart with regression equation and their co-efficient values (figure 7). And the results of cubic form of EKC model indicates that all the co-efficient in the cubic regression are insignificant at 5% level of significance. The expected sign for the real GDDP was negative, the co-efficient of square of real GDDP was positive and co-efficient of the cubic of real GSDP was negative. It follows that there is no existence of EKC rather then, there is an inverted-N shaped curve in the Ranchi context (Table 12). The regression line represented in the chart with regression equation and their co-efficient values (figure 8).

Estimate Equations in this Model:

The ARDL model is presented below in the equation (9)

$$(\ln \mathrm{CO_2})_t = C(1)\,(\ln \mathrm{CO_2})_{t-1} + C(2)\ln \mathrm{PCGSDP} + C(3) \qquad (9)$$

After substituting the co-efficient values in equation (9), we have

$$(\ln CO_2)_t = 0.5985\,(\ln CO_2)_{t-1} + 0.5857 \ln PCGSDP + 0.8005 \qquad (10)$$

The above equation (10) shows that when the real GSDP increased by 1% then CO2 emissions level increased by 59%.

And the co-integrating equation is given below in equation (11)

$$\Delta\,(\ln CO_2)_t = 0.8005 - 0.4015\,(\ln CO_2)_{t-1} - 0.29(\ln CO_2 - (1.4586 \ln PCGSDP_{t-1} + 1.9936) + 0.5857 \ln PCGSDP) \qquad (11)$$

Finding and Conclusion:

In this paper the analysis is done for finding the long- and short-run causal relationship between the carbon emissions level and per capita real GDDP based on the available data for the period 2001-2020, it covers 20 years. First, the ARDL model was performed to verify that there is a long- and short-run relationship or co-integration exist between the variables CO_2 and per capita real GDDP. And then Granger Causality test is applied to examine the causal relationship between the variables CO_2 and per capita real GDDP. Lastly, to test the existence of EKC we perform the regression analysis between the variable CO_2 and real GDDP not on the per capita. Based on ARDL co-integration or bound test which confirms that there is a both long-run and short-run relationship between CO_2 and Per capita real GDDP. Also, the ECT co-efficient was found to -0.4 which indicates that there is presence of long- and short- run causality. And the speed of adjustment towards long run equilibrium is 40%. 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 LNCO2 to LNPCGDDP which means that there is a unidirectional relationship between the variable's causal relation from LNCO2 to LNPCGDDP at 10% level of significance. 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 of Square 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 Ranchi, Jharkhand. And the cubic regression of EKC model implies that there may be inverted N-shaped curve in Ranchi, Jharkhand. But both models are statistically insignificant. So, it is important to take necessary decisions in helping the district move towards energy efficiency in order to reduce the carbon emissions level.

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