Carbon dioxide, economic development, financial development and trade openness relationship of India: ARDL approach

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Abstract

This study investigates the long and short run relationships among carbon emissions, economic growth, financial development and trade openness in India for the year of 1971 to 2014. The autoregressive distributed lag model (ARDL) is employed for the cointegration analyses and granger causality analysis. Results had shown the empirical analysis shown presence of a cointegration among CO2, financial development and trade openness. Analysis shown long and short run relationship between CO2, financial development and trade openness and economic development did not shown any short or long run relation. Hence usage of renewable energy such as solar and hydro projects needs to consider most important.

Keywords: Carbon Emission, economic growth, financial development, trade, India, ARDL.

Introduction

Climate change is one of the most debated environmental issues worldwide in globalization era (Greta, 2019)**.** Countries are contributing maximum in raising the levels of CO_2 emissions and other greenhouse gases in the atmosphere (NASA, 2020). The Intergovernmental panel on Climate Change (IPCC) report of 2007[1] revealed that over the last three decades, GHG emissions have increased by an average of 1.6% per year with carbon dioxide (CO_2) emissions from the use of fossil fuels at a rate of 1.9% per year. Countries have also been consuming energy in large amounts for sustainable economic development and better living standards.

[1] Total GHG (Kyotogases) emissions in 2004 amounted to 49.0 Gt CO_2 -eq, which is upfrom 28.7Gt CO_2 -eq in1970 a 70% increase between 1970 and 2004. In 1990 global GHG emissions were 39.4Gt CO_2 -eq.

However, energy consumption was accompanied by pollutants that contribute to climate change (Javid A. a., 2013). The relationship between CO_2 emissions and economic growth had been proved by considerable research over the past few decades (Omri, 2014). There was direct link between economic growth and financial development (Levine, 1997) while (A.Tamazian, 2009) found that financial development lessens CO_2 emissions for the BRIC countries. The carbon emissions in a country does not necessarily depend on its income level alone; energy consumption, foreign trade (or trade openness) and financial development may be another sources as well (Acaravci I. O., 2013).

Energy sectors are in India mostly composed in the name of high economic growth. As per United Nations Framework Convention on Climate Change (UNFCCC), Rio Summit in 1992, India did not have the responsibility for reducing emission level below the current level, however it was committed to slow down the emissions growth. Literature found several research articles based on the emissions of GHGs in India, and few of them dealt with sectoral emissions in India (Subir., 1993); (Murthy NS, 1997); (Mukhopadhyay K, 2002); ((GOI), 2004); (Kapshe, 2006); (Parikh B. N., 2005); (SK Sharma, 2006). Parikh and Gokarn were tried to find the estimation level in various sectors which were considered to be essential sectors for Indian economy during the 80's. He also examined that there were difference in consumption rate in different income group and that underlying the CO_2 emission (J. Parikh, 1997). N.S. Murthy did study considering economic growth, energy demand and carbon emissions for the Indian economy by using Input–Output (IO) table for1989–90 and tried to projected emissions for 2004–05.They also estimated the trends of CO_2, SO_2 and NOx for the periods 1973–74, 1983–84, 1991–92 and 1996–97 using the IO approach (Mukhopadhyay K, 2002). Nag and Parikh provided time series estimates of indirect carbon emissions per unit of power consumption (Parikh B. N., 2005).Total greenhouse gas emissions from India for major sectors such as energy, industrial processes, agriculture activities, land use, land use change and forestry and waste management practices for 1990, 1994 and 2000 been analysed. (SK Sharma, 2006).

Energy consumption and CO_2 emissions are continuously increasing fast growing countries like India, whose emergence as global economy and dynamic policies are center of attraction. The momentum of growth of India has been upwards over the past couple of decades and that leads to increased pollutions in terms of CO_2 emission. Thus, Government adopted usage of renewable energy sources and also frame the policies to generate the sustainable energy to meet the huge demand. The Indian economy is fully dependent on energy, which is a major source of carbon emissions. The Indian government also has serious concerns about the sustainability of its economic growth and environment quality (Masih, 1996). Numerous studies have considered the relationships among CO_2 emissions, energy consumption and economic growth at the aggregated level, resulting in mixed empirical findings (Ashfaq Ahmad, 2016). Their results validated the existence of the environmental Kuznets curve (EKC), which defines the turning point of CO_2 emissions with respect to economic growth (Kuznets, 1995).

Review of Literature

Large number of researcher have explained the relationship between carbon dioxide emission, energy consumption and economic growth (Xiao-MeiCheng, 2009). Few researcher focused on EKC and its existence in the year after 20th century which were between economic growth and income inequality (Kuznets, 1995) later on his research was carried out between economic growth and environment quality, which is known as EKC.

Table 1 Literature Review

Authors	**Countries**	**Period**	**Proxies**	**Methodology**	**Result/Findings/Conclusion**
(A.Tamazian, 2009)	BRIC Countries	1992–2004	GDP, FDI, Financial liberalization, financial openness.	Standard reduced-form modeling approach.	Financial development reduces carbon emissions.
(Usama Al-mulali Sab, 2012)	African countries	1980–2008	Broad money Domestic credit to the private sector.	Cointegration and Granger causality tests.	Financial development has a positive causal relationship with CO2 emission.
(Muhammad Shahbaz S. A., 2013)	Malaysia	1971-2011	Real domestic credit to private sector per capita.	ARDL bounds testing approach to cointegration VECM Granger causality approach.	Financial development reduces carbon emissions. The non-linear relationship between financial development and CO2 emissions is U-shaped but it is statistically insignificant.
(Acaravci I. o., 2013)	Turkey	1960-2007	Domestic credit to private sector to GDP.	Bounds F-test, Error correction based Granger causality models.	Financial development has no significant effect on carbon emissions.
(Muhammad Shahbaz Q. M., 2013)	Indonesia	1975–2011	Real domestic credit to private sector per capita.	Zivot Andrews's unit root test ARDL bounds testing approach VECM Granger causality Technique.	Financial development decrease carbon emissions. Presence of inverted U shaped relationship between financial development and carbon emissions.
(Boutabba, 2014)	India	1971–2008	Domestic credit to private sector to GDP.	ARDL bounds testing procedure.	Financial development has positive effect on carbon emissions.

(Muhammad Shahbaz H. M., 2015)	India	1970–2012	Domestic credit to private sector per capita.	Cointegration approach ARDL.	Financial development has positive effect on carbon emissions.
(Javid K. A., 2013)	Saudi Arabia	1980-2011	Economic growth, carbon emissions and energy consumption.	ARDL bounds testing procedure.	Carbon emissions increase with the increase in per capita income.
(Masih, 1996)	Ind, Pak, Mal, Sing, Indo, & Phili.		Energy consumption, real income and temporal causality.	Cointegration ,Granger causality.	Indian economy is dependent on energy, which is a major source of carbon emissions.
(Mohammad Jahangir Alam, 2011)	India	1971-2006	Energy consumption, CO2 emissions and economic growth.	Error Correction Model.	There is no causality relationship between energy consumption and income in any direction in the long-run implying.
(Md. Mahmudul Alama, 2016)	Brazil, China, India and Indonesia	1970-2012	Carbon emissions, economic growth, energy consumption &population growth.	ARDL	CO2 emissions have increased statistically significantly with increases in income and energy consumption.
(Ghosh, 2002)	India	1950-51 to 1996-97	Electricity consumption and economic growth.	VAR	Absence of long-run equilibrium relationship among the variables but there exists unidirectional Granger causality running from economic growth to electricity consumption without any feedback effect.
(YingLiu, 2012)	China & India	1971–2007	CO2 emissions, energy consumption, trade and income.	ARDL bounds testing procedure.	Causal connection cannot be established for India with regard to structural changes and CO2 emissions.
(Jena, 2008)	India	1991–2003	Environmental productivity and EKC	GMM	Overall environmental productivities decrease over time in India.

(YemaneWolde-Rufael, 2010)	Chin, Ind, Jap, Kor.,SA. And USA	1965-2005	Coal consumption and real GDP.	VAR	Unidirectional causality running from coal consumption to economic growth in India and Japan while the opposite causality running from economic growth to coal consumption was found in China and South Korea.
(VGRC Govindaraju, 2013)	India & China	1965-2009	CO2 emissions, economic growth and coal consumption	Cointegration ,Granger causality	The results indicated the presence of cointegration in China, but not in India. In China, unidirectional causality runs from economic growth to CO2 emissions. In the case of India, only a short-run causality is detected.
(Muhammad Arshad Khan, 2005)	Pakistan	1971-2004	Financial Development and Economic Growth	ARDL	In the long run financial depth and real interest exerted positive impact on economic growth.

Methodology and Data

Study analyse the relationship among the carbon dioxide, Economic growth, trade openness and financial development. Annual data of India for the year 1971 to 2014 been used. We consider all variables in logarithmic form to address the issue of heteroskedasticity. Study applied following model for empirical analysis:

Table 2 Basic Models

$$LNCO2_t = \alpha_0 + \beta_1 LNFD_t + \beta_2 LNGDP_t + \beta_3 LNOP_t + e_t \quad (1)$$

$$LNGDP_t = \alpha_0 + \beta_1 LNCO2_t + \beta_2 LNFD_t + \beta_3 LNOP_t + e_t \quad (2)$$

$$LNFD_t = \alpha_0 + \beta_1 LNCO2_t + \beta_2 LNGDP_t + \beta_3 LNOP_t + e_t \quad (3)$$

$$LNOP_t = \alpha_0 + \beta_1 LNCO2_t + \beta_2 LNGDP_t + \beta_3 LNFD_t + e_t \quad (4)$$

Where LCO2 represents the natural logarithm of carbon dioxide emission per capita, ED denotes natural logarithm of real GDP per capita, OP indicates the natural logarithm of total trade per GDP and FD indicates the natural logarithm of Domestic credit to private sector percentage of GDP. In addition, α_0 is a constant and e_t is error term.

Study summarized in the following steps:

1. Run Unrestricted VAR model and select the lag for each dependent and independent variables.
2. After lag selection, check the stationarity of the variables. Study test whether variables are characterized by the presence or not of unit root. For this end, Study used standard unit root test such as the ADF test of Dickey and Fuller.
3. In the third step, study run the ARDL model with automatic selection criterion in the E views.
4. Fourth step is to check the long term and short term association. For that study calculated the long run association and bound test.
5. In the fifth step, run the Error correction model.
6. Granger causality diagnostics to check the causal relationship between the variables.
7. Last step was diagnostics checking of the model which comprises :
    1. Residual Diagnostics
        1.Heteroscedesticity
        2. Serial Correlation
        3. Normality Checking
    2. Stability Diagnostics
        1.Recursive Estimation
            1. CUSUM Test
            2. CUSUM of square test

Econometrics Estimation

The autoregressive distributed lag (ARDL) methodology developed by Pesaran and Shirin to examine the cointegration relation between dependent and independent variable (M. Hashem Pesaran, 2001). Here ARDL applied to examine the cointegration relationships among the carbon Emission, Energy consumption, financial development and trade openness. Many cointegration testing approaches have been used in the literature, such as those used by Phillips and Hansen (1990); Johansen and Juselius (1990); Engle and Granger (1987) (Hansen, 1990) **;** (Juselius, 1990)**;** (Granger, 1987)**.** However the above methods are useful and also mentioned in the literature but as far as ARDL is concern it can best cointergration equation estimation for the small data set. ARDL test is that it is more robust and performs better for small sample size of data which suitable for this research (Razdi, 2015)**.** Study can use the ARDL approach when the variables are stationary at I(1) or I(0) or I(1)/I(0); however, ARDL bound testing is not applicable when the variable is stationary at I(2) (Ouattara, 2004)**.**Such methodology provides unbiased results of long run relationships (Narayan, 2005) and is more appropriate for small sample sizes (Haug, 2002). The ARDL model has the proper specification to resolve the problem of endogeneity and residual serial correlation simultaneously (M. Hashem Pesaran, 2001). The unrestricted error correction model is presented for long and short run relationships as follows:

Table 3 Error correction model

$$\Delta LNCO2_t = \alpha_0 + \sum_{i=1}^{p} \beta_{1i}\,\Delta LNCO2_{t-r} + \sum_{i=1}^{p} \beta_{2i}\,\Delta LNFD_{t-r} + \sum_{i=1}^{p} \beta_{3i}\,\Delta LNGDP_{t-r} + \sum_{i=1}^{p} \beta_{4i}\,\Delta LNOP_{t-r} + \gamma_5 LNCO2_{t-i} + \gamma_6 LNFD_{t-i} + \gamma_7 LNGDP_{t-i} + \gamma_8 LNOP_{t-i} + e_t \quad (5)$$

$$\Delta LNGDP_t = \alpha_0 + \sum_{i=1}^{p} \beta_{1i}\,\Delta LNGDP_{t-r} + \sum_{i=1}^{p} \beta_{2i}\,\Delta LNCO2_{t-r} + \sum_{i=1}^{p} \beta_{3i}\,\Delta LNFD_{t-r} + \sum_{i=1}^{p} \beta_{4i}\,\Delta LNOP_{t-r} + \gamma_5 LNGDP_{t-i} + \gamma_6 LNCO2_{t-i} + \gamma_7 LNFD_{t-i} + \gamma_8 LNOP_{t-i} + e_t \quad (6)$$

$$\Delta LNFD_t = \alpha_0 + \sum_{i=1}^{p} \beta_{1i}\,\Delta LNGDP_{t-r} + \sum_{i=1}^{p} \beta_{2i}\,\Delta LNCO2_{t-r} + \sum_{i=1}^{p} \beta_{3i}\,\Delta LNFD_{t-r} + \sum_{i=1}^{p} \beta_{4i}\,\Delta LNOP_{t-r} + \gamma_5 LNGDP_{t-i} + \gamma_6 LNCO2_{t-i} + \gamma_7 LNFD_{t-i} + \gamma_8 LNOP_{t-i} + e_t \quad (7)$$

$$\Delta LNOP_t = \alpha_0 + \sum_{i=1}^{p} \beta_{1i}\, \Delta LNGDP_{t-r} + \sum_{i=1}^{p} \beta_{2i}\, \Delta LNCO2_{t-r} + \sum_{i=1}^{p} \beta_{3i}\, \Delta LNFD_{t-r} + \sum_{i=1}^{p} \beta_{4i}\, \Delta LNOP_{t-r} + \gamma_5 LNGDP_{t-i} + \gamma_6 LNCO2_{t-i} + \gamma_7 LNFD_{t-i} + \gamma_8 LNOP_{t-i} + e_t \quad (8)$$

Before applying ARDL, study needs to check the characteristics of the data, that is, whether they fulfill the required assumptions or not. Accordingly, we first apply different types of unit root tests to examine the stationary level of all the series because the bound testing approach requires that none of the series is stationary at I (2). Thus, if any series found stationary at second difference, then the generated results of ARDLF-statistic would be unsound (Ouattara, 2004)**.**Different unit root tests are available, such as PP (Phillips-Perron) unit root test by Phillips and Perron (1988), ADF (Augmented Dickey-Fuller) unit root test by Dickey and Fuller (1979), and KPSS by Kwiatkowski. (1992) (Peter c. B. Phillips, 1988); (Fuller, 1979); (Denis Kwiatkowski, 1992). Study used the all of three to check the unit root checking.

Once all the series are confirmed to be stationary at I(1) or I(0) or mixed, and none of the series is stationary at I(2), then study can go for the ARDL bound test methodology. The next step will be running the bound test to determine the existence of long run relationships between the variables by computing the ARDL F-statistic for the joint significance of lag level variables. We derived two hypotheses from Eq. (5,6,7 and 8) for the long run relationship. The first is null hypothesis, i.e. $\gamma_5 = \gamma_6 = \gamma_7 = \gamma_8 = 0$ while alternative is $\gamma_5 \neq \gamma_6 \neq \gamma_7 \neq \gamma_8 \neq 0$.

After that study will compare the ARDL F-statistic with the critical values (upper bound and lower bound) generated by Pesaran and Narayan (M. Hashem Pesaran, 2001)**;** (Narayan, 2005). If the ARDL F-statistic lies before the lower critical bound, then no cointegration exists; if the ARDL F-statistic crosses the upper critical bound, then a cointegration is present. If the ARDL F-statistic falls between the lower and upper critical bounds, then the results are inconclusive (Javid A. a., 2013).If all related variable series are integrated at I(1),then, assessment regarding cointegration is based on the upper critical bound; otherwise, we follow the lower critical bound if all the series of related variables are integrated at I(0). After confirming the existence of a cointegration between the variables, we move to the second step of examining the long and short run relationships, expressed as follows:

Table 4 Long and Short run relationships

Short Run Equations

$$\Delta LNCO2_t = \alpha_0 + \sum_{i=1}^{p} \beta_{1i}\, \Delta LNCO2_{t-r} + \sum_{i=1}^{p} \beta_{2i}\, \Delta LNFD_{t-r} + \sum_{i=1}^{p} \beta_{3i}\, \Delta LNGDP_{t-r} + \sum_{i=1}^{p} \beta_{4i}\, \Delta LNOP_{t-r} + e_t \quad (9)$$

$$\Delta LNGDP_t = \alpha_0 + \sum_{i=1}^{p} \beta_{1i}\, \Delta LNGDP_{t-r} + \sum_{i=1}^{p} \beta_{2i}\, \Delta LNCO2_{t-r} + \sum_{i=1}^{p} \beta_{3i}\, \Delta LNFD_{t-r} + \sum_{i=1}^{p} \beta_{4i}\, \Delta LNOP_{t-r} + e_t \quad (10)$$

$$\Delta LNFD_t = \alpha_0 + \sum_{i=1}^{p} \beta_{1i}\, \Delta LNGDP_{t-r} + \sum_{i=1}^{p} \beta_{2i}\, \Delta LNCO2_{t-r} + \sum_{i=1}^{p} \beta_{3i}\, \Delta LNFD_{t-r} + \sum_{i=1}^{p} \beta_{4i}\, \Delta LNOP_{t-r} + e_t \quad (11)$$

$$\Delta LNOP_t = \alpha_0 + \sum_{i=1}^{p} \beta_{1i}\, \Delta LNGDP_{t-r} + \sum_{i=1}^{p} \beta_{2i}\, \Delta LNCO2_{t-r} + \sum_{i=1}^{p} \beta_{3i}\, \Delta LNFD_{t-r} + \sum_{i=1}^{p} \beta_{4i}\, \Delta LNOP_{t-r} + e_t \quad (12)$$

Long Run Equations

$$LNCO2_t = \delta_0 + \gamma_6 LNCO2_{t-i} + \gamma_7 LNFD_{t-i} + \gamma_8 LNGDP_{t-i} + \gamma_9 LNOP_{t-i} + \varphi ECT_{t-1} + e_t \quad (13)$$

$$LNGDP_t = \delta_0 + \gamma_6 LNGDP_{t-i} + \gamma_7 LNCO2_{t-i} + \gamma_8 LNFD_{t-i} + \gamma_9 LNOP_{t-i} + \varphi ECT_{t-1} + e_t \quad (14)$$

$$LNFD_t = \delta_0 + \gamma_6 LNGDP_{t-i} + \gamma_7 LNCO2_{t-i} + \gamma_8 LNFD_{t-i} + \gamma_9 LNOP_{t-i} + \varphi ECT_{t-1} + e_t \quad (15)$$

$$LNOP_t = \delta_0 + \gamma_6 LNGDP_{t-i} + \gamma_7 LNCO2_{t-i} + \gamma_8 LNFD_{t-i} + \gamma_9 LNOP_{t-i} + \varphi ECT_{t-1} + e_t \quad (16)$$

ECT = Error Correction Term

The Granger causality classifies the directions of causality into long and short run. The statistical significance of $ECT_{t-1}$with a negative sign proves that a long run causality exists among the variables. To determine short run causality, study apples the Wald test on variables. Similarly, the significance of the joint causalities (long and short run causality) is also checked using the Wald test.

Data sources

Study uses annual time-series data covering the 1971 to 2014 time period for carbon emissions, financial development and economic growth of India. The data Trade openness per GDP, Financial development, Domestic credit to private sector (% of GDP), and CO2 emission are obtained from the World Development Indicators of World Bank.

Interpretation and Analysis

Firstly, study select the appropriate lag for each of variable for further analysis with ARDL and VAR in Table 1. After that study checks the stationary level or the unit root properties of all the series. Study apply PP (Phillips and Perron) and ADF unit root tests, and the test results are shown in Table 2. Table 2 shows that all the variables are non-stationary at level but after taking their first differences, all the variables show the same level of integration i.e. I(1). Thus, all the series are found to be stationary at I(1).

Table 5 Lag Selection

VAR Lag Order Selection Criteria

Variable	**Lag Selected**
CO2	1st Lag
FD	1st Lag
GDP	1st Lag
OP	1st Lag
CO2 FD GDP OP (Joint effect)	2nd Lag

Table 6 Results of unit root analysis

Variable	**ADF unit root test**		**PP unit root test**		**Decision**
	Level	**First difference**	**Level**	**First difference**	
LNCO2	0.9966	0.0000	0.9963	0.0000	**I(1)**
LNFD	0.7911	0.0217	0.7781	0.0000	**I(1)**
LNGDP	0.9718	0.0000	0.9670	0.0000	**I(1)**
LNOP	0.7582	0.0001	0.7591	0.0001	**I(1)**

The same order of integration of the variables leads to apply the Johansen cointegration test to examine the cointegration relationships among the variables. The results are reported in Table 3. Study finds the presence of a cointegrating vector via the trace test and maximum eigen test value test. As a result, the null hypothesis is rejected. At this point, we may conclude that cointegration is present among carbon emissions, economic growth, financial development and trade openness of India. The Lon run and bound test statistics proved that there is short rum relation between CO2, and trade openness while other variables such as while financial development have long run relationship. The analysis is not in statistically significant for economic development with other variables as far as India as a country is concerned. The table 4 suggests that study can go for Long run and short run relation analysis with CO2, financial development and Trade openness while economic development is inconclusive for the said time period.

Table 7 Johansen Cointegraton Test

Hypothesis	**Trace Test**	**Prob.**	**Hypothesis**	**Max. Eigen Test**	**Prob.**
None*	57.6758	0.004	None*	27.5617	0.0503
At most 1*	30.1141	0.0460	At most 1	19.2848	0.0889
At most 2	10.8293	0.2222	At most 2	10.8291	0.1630
At most 3	0.00021	0.9900	At most 3	0.00021	0.9900

* denotes rejection of the hypothesis at the 0.06 level

Table 8 Bound Test Result

Equation	**F statistics**	**I(0) at 5%**	**I(1) at 5%**	**Results Remarks**	**Decision**
CO2	1.8168	3.23	4.35	F statistics < I(0) & I(1)	ARDL Short Run
FD	4.5211	3.23	4.35	F statistics > I(1)	ECM Long Run
GDP	4.2982	3.23	4.35	F statistics > I(0) & F statistics <I(1)	Inconclusive
OP	1.3785	3.23	4.35	F statistics < I(0) & I(1)	ARDL Short Run

The long and short run analysis and ECM also proves that there is short run and long run relationship exist between the CO2, OP and FD. The granger causality also proves the one directional causality from openness to CO2. India's trade had positive impact on CO2 emission.

Table 9 Results of long run and short run analysis

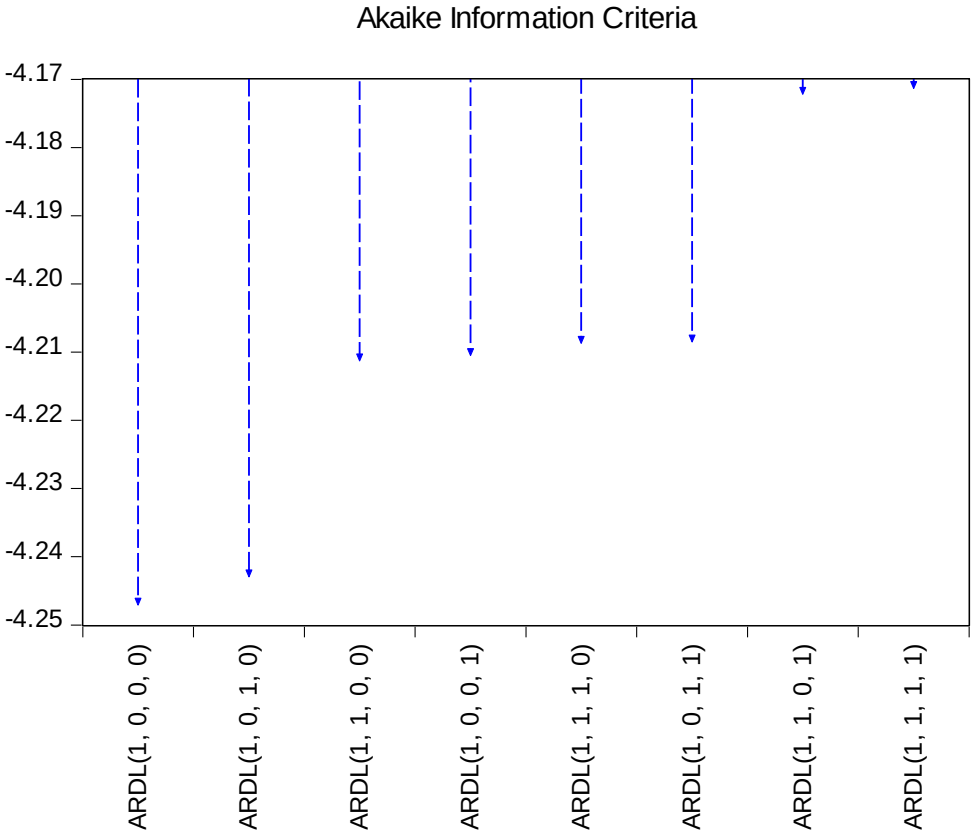
	Variable	**Coefficient**	**Std. Error**	**t- Statistics**	**Probability**
Long Run					
FD	Constant	-0.222517	0.25146	-0.884899	0.3818
	LNCO2	-0.133449	0.06493	-2.055050	0.0468
	LNFD	0.791192	0.09573	8.264573	0.0000
	LNGDP	0.071139	0.07612	0.934486	0.3560
	LNOP	0.155497	0.05350	2.906360	0.0061
Short Run					
CO2	Constant	0.002833	0.00919	3.081735	0.0003
	ΔLNCO2	0.048132	0.16232	0.296525	0.7685
	ΔLNFD	-0.052445	0.08355	-0.627649	0.5341
	ΔLNGDP	0.032253	0.57818	0.578182	0.5666
	ΔLNOP	0.13405	0.06124	2.188952	0.0350
OP	Constant	0.042439	0.022398	1.850134	0.0723
	ΔLNCO2	-0.582239	0.405001	-1.437625	0.1589
	ΔLNFD	-0.276638	0.208482	-1.326919	0.1927
	ΔLNGDP	0.409944	0.139184	2.945331	0.0056
	ΔLNOP	0.150071	0.152805	0.982109	0.3324
ECT					
	LNFD	-0.108801	0.024631	-4.417274	0.0000

Table 10 Granger Causality

	CO2	**FD**	**GDP**	**OP**
CO2	-	CO2≠FD	CO2≠GDP	CO2≠OP
FD	FD≠CO2	-	FD→GDP	FD≠OP
GDP	GDP≠CO2	GDP≠FD	-	GDP→OP
OP	OP→CO2	OP≠FD	OP≠GDP	-

Diagnostics analysis

Figure 1 Model Selection Summary (AIC Criterion)

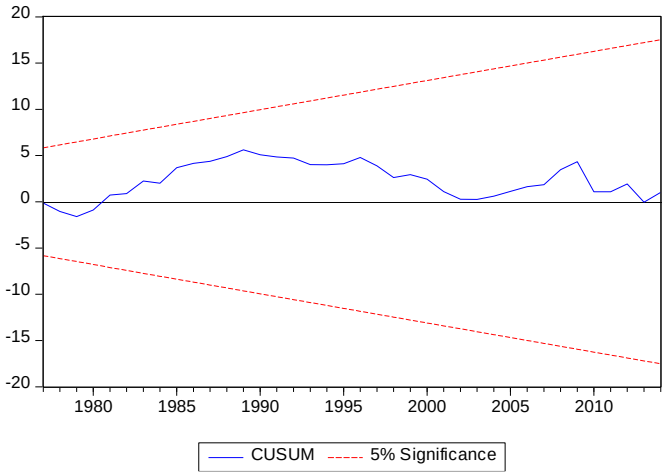


Study perform diagnostic tests of the model and found absence of

Table 11 Diagnostic Tests

Test	**F statistics**	**P value**	**Result**
Hetroscedesticity	1.64480	0.1832	Rejection
Serial Correlation	0.710016	0.4049	Rejection
Normality test	4.930600(Jarque – Bera test)	0.08	Residuals are normally distributed
CUSUM Test	-	-	Stable

Figure 2 CUSUM Test Result



Conclusion

The main objective of the research study is to find the relationship between, carbon dioxide and financial development, economic growth and trade openness of India during 1971–2014 by applying the short and long run analysis on Indian economy. The cointegration among variables was examined by applying the ARDL approach. The VECM Granger causality test was applied to check the causal relationships among carbon emissions with economic growth, financial development and trade openness. The empirical analysis shown presence of a cointegration among CO2, financial development and trade openness. Analysis shown long and short run relationship between CO2, financial development and trade openness and economic development did not shown any short or long run relation. Indian economy is growing rapidly as a result India is investing huge in production and manufacturing industries which resulted in high requirement of energy. Which makes India as one of the CO2 gas emitting county of the world after USA and China. This is the time when Indian government need to think about renewable energy sources such as solar energy and Hydro power plant as country had good amount of inland waters such as number of rivers. Currently Indian government is investing and motivating household to use the solar energy.

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