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## Article

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## Is India Financing Its Emissions Through External Debt?

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### ABSTRACT

The main aim of this study is to analyze the effect of external debt on different types of emissions in India as carbon dioxide emissions, methane emissions, emissions from liquid fuel consumption, emissions from solid fuel consumption, and emissions from gaseous fuel consumption. India has a fast growing in external debt especially after 2008 world financial crisis. India has a similar situation to China and Turkey which also started to increase external debt significantly after 2008 world crisis. This study aims to fill the gap in the literature by analyzing the effect of external debt on emissions. This study is the first study in the literature for India. The second aim of the study is to investigate whether inverted U relationship exists between economic development, and carbon oxide emissions, methane emissions, methane emissions, emissions from liquid fuel consumption, emissions from solid fuel consumption, and emissions from gaseous fuel consumption. This study confirmed inverted-U relationship between methane gas emissions and economic development, and emissions from gaseous fuel consumption and economic development. The positive and significant effect of external debt on carbon dioxide emissions, methane emissions, emissions from gaseous fuel consumption and emissions from solid fuel consumption is confirmed by this study. The analysis is important since after 2008 crisis many countries such as China and Turkey besides India started to borrow external debt heavily to create government investments to boost employment market which collapsed due to global economic crisis. This study carries importance since global greenhouse gas emissions may be financed through external debt in India. Since sustainability is the main issue in current world and reduction of emissions is one of the highest priorities of humanity, necessary measures should be taken into account to reduce financing of emissions through external debt in India. This study recommends further analysis to be done with updated intervals.

**Keywords:** External Debt, India, ARDL Model, Emissions, Economic Growth

**JEL Classifications:** Q01, Q56, C01

### 1. INTRODUCTION

This study investigated the effect of external debt (EX) on greenhouse gas emissions which are carbon dioxide emissions (CE), methane emissions (MN), emissions from solid fuel consumption (SFCO), emissions from gaseous fuel consumption (GFCO), and emissions from liquid fuel consumption (LFCO) for India for the period 1971 to 2012. This is the first study in the literature that investigates the effect of external debt on greenhouse gas emissions for India. In this study, CE, MN, EX, GFCO, SFCO and LFCO are chosen to be investigated by Autoregressive Distributed Lag Model by Pesaran et al. (2001). World Bank website is used to gather the data analyzed in this study.

Data used in this study are gathered from World Bank database. CE are emissions from manufacturing of cement and burning of fossil fuels. CE are in kilo tons term. MTHN are emissions from industrial methane production and agriculture. MN are in kilo tons of CE equivalent. SFCO are in kilo tons term. SOFC are emissions from mainly of coal use as energy source. LFCO are in kilo tons term. LFCO are emissions from mainly of petroleum derived fuels as energy source. GFCO are in kilo tons term. GFCO are emissions from mainly of natural gas use as energy source. EX is in current US dollars term. EX is the total external debt which includes long-term debt and short-term debt. Economic development (GD) which is gross domestic per capita are in terms of constant 2010 US\$. GD2 is the square of GD. Energy consumption (ECM) is in terms of kg of oil equivalent per capita. Time period of this

study is between 1971 and 2012 which chosen according to the availability of data in data sources.

CE increased by 8.7 times between 1971 and 2012. MN increased by 0.58 times in the same period. SFCO increased by 8.7 times between 1971 and 2012 (Figure 1). GD increased by 2.7 times and ECM increase 1.2 times (Figure 2). EX increased by 41 times and EX increase rapidly after 2008 (Figure 3). GFCO increased 71 times and LFOC increased by 6.84 times between 1971 and 2012 (Figure 1). All the variables used in this study are in increasing trend in India for the period 1971-2012.

The main aim of this study is to investigate the effect of EX on emissions so to answer the question whether India is financing its emissions through EX. Although the main of the study is to investigate the effect of EX on emissions, the Kuznets curve

relationship is also investigated as second aim of this study in India. There is a gap in the literature for the investigation of the effect of external debt on emissions for India. This study aims to fill this gap by performing this study.

H<sub>1</sub>: EX has a significant impact on CE in India for the period 1971-2012.

H<sub>2</sub>: There is inverted U relationship between CE and GD in India for the period 1971-2012.

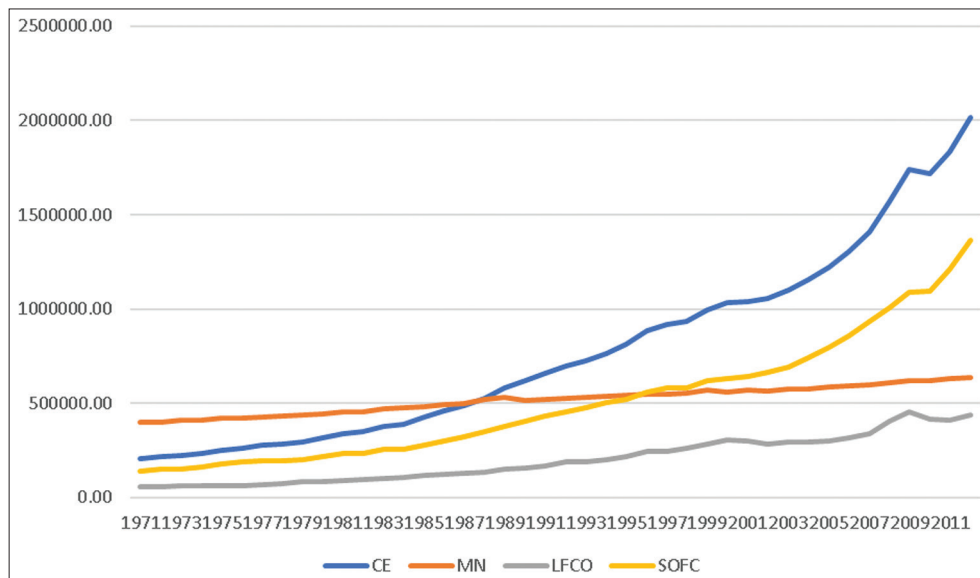
H<sub>3</sub>: EX has a significant impact on MN in India for the period 1971-2012.

H<sub>4</sub>: There is inverted U relationship between MN and GD in India for the period 1971-2012.

H<sub>5</sub>: EX has a significant impact on SFCO in India for the period 1971-2012.

H<sub>6</sub>: There is inverted U relationship between SFCO and GD in India for the period 1971-2012.

**Figure 1:** CE, MN, LFCO and SOFC



**Figure 2:** GD and ECM

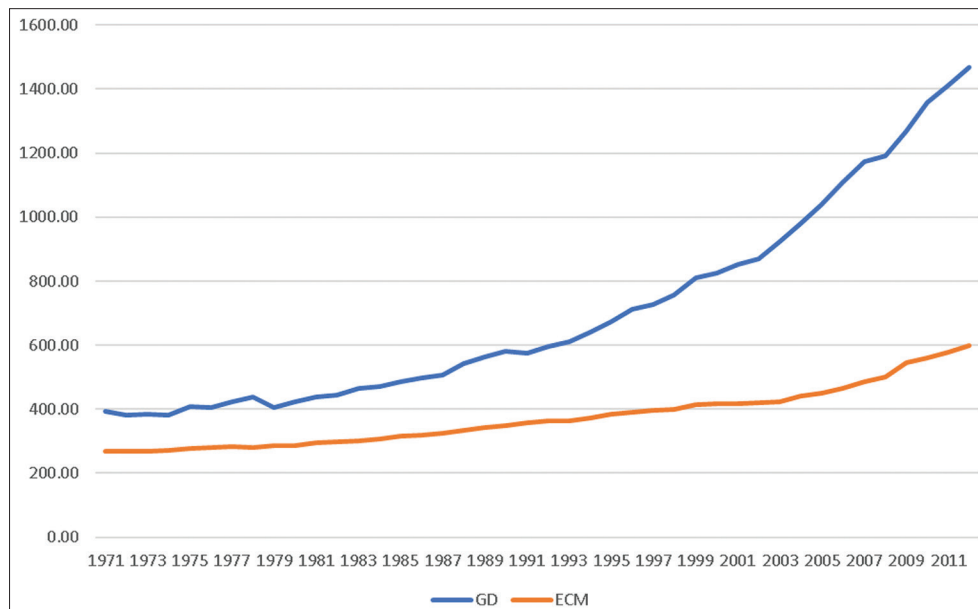
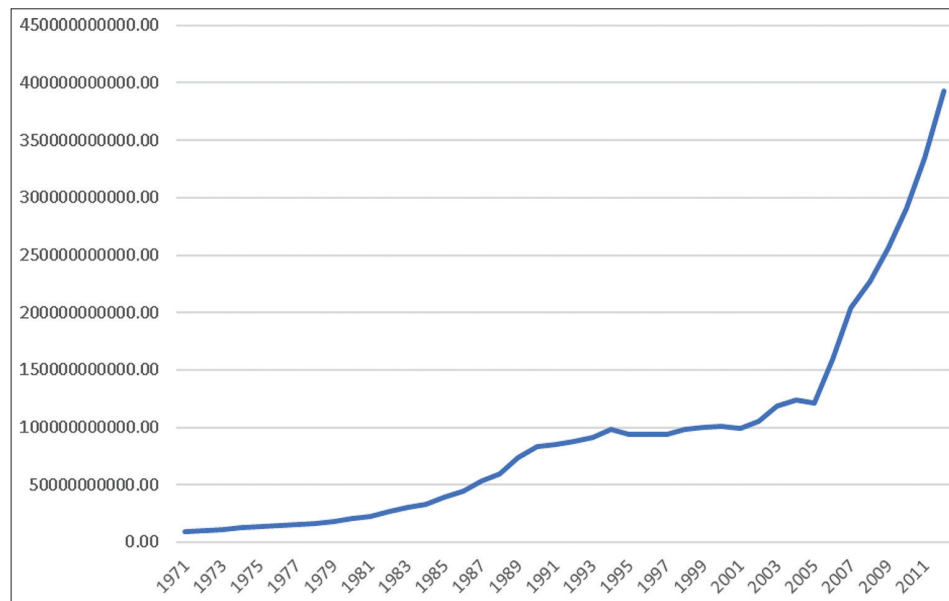


Figure 3: EX



H<sub>7</sub>: EX has a significant impact on LFCO in India for the period 1971-2012.

H<sub>8</sub>: There is inverted U relationship between LFCO and GD in India for the period 1971-2012.

H<sub>9</sub>: EX has a significant impact on GFCO in India for the period 1971-2012.

H<sub>10</sub>: There is inverted U relationship between GFCO and GD in India for the period 1971-2012.

Second part discusses literature for the EKC hypothesis and external debt. Third part discusses the methodology used in this study. Fourth part discusses results and discussion of this study. Fifth and final part is conclusion.

## 2. REVIEW OF LITERATURE

In this part, most recent studies in the literature are discussed. Overall summary of this part is given in Table 1.

Saxena and Shanker (2017) confirmed negative relationship between external debt and economic development for India for the period 1991 to 2016. Although a negative relationship is found, up to a certain level of external debt, external debt positively affects economic development. Nath (2020) examined the relationship between external debt, export and economic development in India for the period 1970-2018. Nath confirmed that the effect of external debt on economic growth is positive in India. Irfan et al., (2020) analyzed the moderating effect of capital formation for external debt and stock market performance for Pakistan, Sri Lanka, Bangladesh and India for the period 1992-2017. Irfan, Rao, Akbar, and Younis confirmed that capital formation has a positive effect for external debt and stock performance and external debt has negative effect on economic development. Chisti and Shabir (2019) analyzed the effect of external debt on economic development, government spending, revenue, inflation and exports in India for the period 2007-2017 on quarterly data. Chisti and Shabir confirmed that there is no significant relationship

**Table 1: Summary of literature review**

Study	Main findings
Saxena and Shanker (2017)	Confirmed negative relationship between EX and economic development
Nath (2020)	Confirmed the positive effect of EX on economic development
Irfan et al., (2020)	Confirmed the negative effect of EX on economic development
Chisti and Shabir (2019)	Confirmed no significant relationship between EX and economic development
Pahwa (2018)	Confirmed the negative effect of EX on economic development
Joy and Panda (2019)	Confirmed EX negatively affected non-developmental expenditure and positively affected inflation
Sinha and Bhatt (2017)	Confirmed N-shaped relationship between emissions and economic development
Sultan et al., (2021)	Confirmed the EKC hypothesis in India
Murthy and Gambhir (2018)	Confirmed N-shaped relationship between emissions and economic development
Khan et al. (2020)	Confirmed the EKC hypothesis for panel countries of India, China, and Pakistan
Alam and Adil (2019)	Did not confirm the EKC hypothesis in India
Katircioglu and Celebi (2018)	Did not confirm the effect of EX on emissions
Beşe et al., (2021)	Confirmed the effect of EX on emissions
Beşe et al., (2020)	Confirmed the coal Kuznets curve
Magazzino et al., (2020)	Confirmed the coal Kuznets curve
Qiao et al., (2019)	Confirmed the coal Kuznets curve
Shahbaz and Sinha (2019)	Recommended new methodologies to be used to investigate the EKC hypothesis
Purcel (2020)	Recommended new methodologies to be used to investigate the EKC hypothesis

between external debt and economic development, external debt and export, external debt and revenue, and external debt and government spending. They found that external debt causes increase in inflation. Pahwa (2018) examined the relationships between external debt, internal debt, population, investment and trade openness for India for the period 1980-2014. Pahwa confirmed that external debt and internal debt affect economic growth significantly and negatively.

Joy and Panda (2019) analyzed the relationship between external debt, external debt servicing, gross domestic capital formation, gross domestic savings, developmental expenditure, non-developmental expenditure, export, inflation and foreign direct investment for India. Joy and Panda confirmed the long run relationship between the variables. Joy and Panda confirmed that external debt positively affected inflation but negatively affected non-developmental expenditure.

Sinha and Bhatt (2017) analyzed the relationship between nitrogen dioxide emissions (NO<sub>2</sub>), CE and economic growth for India. Sinha and Bhatt examined CE for 1960-2011 and NO<sub>2</sub> for 1970-2012. Sinha and Bhatt confirmed N-shaped relationship between emissions and economic growth for NO<sub>2</sub> and CE. Sultan et al., (2021) confirmed the EKC hypothesis in India for the period 1978 to 2014. Murthy and Gambhir (2018) confirmed N-shaped relationship between CE and economic development in India for the period 1991-2014. Khan et al. (2020) confirmed the EKC hypothesis for panel countries of China, India and Pakistan for the period 1970-2016. Khan et al. confirmed U-shaped relationship between ecological footprint and economic development for India and China, and the EKC hypothesis for Pakistan for the period 1970-2016. Alam and Adil (2019) did not confirm the EKC hypothesis in India for the period 1971-2016.

For the effect of external debt on emissions, the most recent studies are belong to Katircioglu and Celebi (2018) and Beşe et al., (2021). Katircioglu and Celebi (2018) analyzed the case in Turkey and Beşe et al., (2021) analyzed the case in China. While Katircioglu and Celebi (2018) did not find any evidence for the effect of EX on emissions in Turkey, Beşe et al., (2021) confirmed the effect of EX on emissions in China.

Since this study analyzed the emissions from coal consumption, the most recent studies for coal consumption and economic development are belong to Beşe et al., (2020), Magazzino et al., (2020) and Qiao et al., (2019).

For literature review studies for the EKC hypothesis, the most recent studies are belong to Shahbaz and Sinha (2019) and Purcel (2020). Both literature reviews stated that new methodologies should be included for the investigation of the EKC hypothesis.

Literature review shows that the general tendency in the literature is to analyze the relationship between external debt and economic development. There is a gap in the literature for the analysis of the effect of external debt on emissions for India.

### 3. DATA AND METHODOLOGY

#### 3.1. Data

The variables used in this study are as follows. CE are emissions from manufacturing of cement and burning of fossil fuels. CE are in kilo tons term. MTHN are emissions from industrial methane production and agriculture. MN are in kilo tons of CE equivalent. SFCO are in kilo tons term. SOFC are emissions from mainly of coal use as energy source. LFCO are in kilo tons term. LFCO are emissions from mainly of petroleum derived fuels as energy source. GFCO are in kilo tons term. GFCO are emissions from mainly of natural gas use as energy source. EX is in current US dollars term. EX is the total external debt which includes long-term debt and short-term debt. Economic development (GD) which is gross domestic per capita are in terms of constant 2010 US\$. GD<sup>2</sup> is the square of GD. Energy consumption (ECM) is in terms of kg of oil equivalent per capita.

Data used in this study are retrieved from world bank website. Data used in this study range between 1971 and 2012 since the data in world bank website is limited till 2016 for used variables in this study. Range is determined till 2012 for the analyzed variables to provide the stability for established models.

#### 3.2. Methodology

$$\ln(CE)_t = r_0 + r_1 \ln(GD)_t + r_2 \ln(GD)_t^2 + r_3 \ln(ECM)_t + r_4 \ln(EX)_t + e_t \quad (1)$$

$$\ln(MN)_t = r_0 + r_5 \ln(GD)_t + r_6 \ln(GD)_t^2 + r_7 \ln(ECM)_t + r_8 \ln(EX)_t + e_t \quad (2)$$

$$\ln(GFCO)_t = r_0 + r_9 \ln(GD)_t + r_{10} \ln(GD)_t^2 + r_{11} \ln(ECM)_t + r_{12} \ln(EX)_t + e_t \quad (3)$$

$$\ln(LFCO)_t = r_0 + r_{13} \ln(GD)_t + r_{14} \ln(GD)_t^2 + r_{15} \ln(ECM)_t + r_{16} \ln(EX)_t + e_t \quad (4)$$

$$\ln(SFCO)_t = r_0 + r_{13} \ln(GD)_t + r_{14} \ln(GD)_t^2 + r_{15} \ln(ECM)_t + r_{16} \ln(EX)_t + e_t \quad (5)$$

Relationship between GD, square of GD, ECM and EX, with CE, MN, GFCO, LFCO and SFCO are modelled above in equation 1-5.

For the equation 6 below,  $v_0, v_1, v_2, v_3, v_4$  are coefficients for the examined variables which are GD, square of GD, EM and EX and  $b_t$  is for error term. EM is for emissions which are CE, MN, GFCO, LFCO and SFCO.

$$\ln(EM)_t = v_0 + v_1 \ln(GD)_t + v_2 \ln(GD)_t^2 + v_3 \ln(ECM)_t + v_4 \ln(EX)_t + b_t \quad (6)$$



The ARDL model which is used as to investigate the relationship between the variables is mentioned as below in equation 7. In the model below, M coefficients are long run coefficients. N coefficients are short run coefficients.  $b_t$  is for white noise residuals.

$$\begin{aligned} \Delta \ln EM_t = & M_0 + M_1 \ln EM_{t-1} + M_2 \ln GD_{t-1} \\ & + M_3 \ln(GD)_{t-1}^2 + M_4 \ln ECM_{t-1} + M_5 \ln EX_{t-1} \\ & + \sum_{i=1}^s N_{1i} \ln EM_{t-i} + \sum_{i=0}^h N_{2i} \ln GD_{t-i} + \sum_{i=0}^c N_{3i} \ln(GD)_{t-i}^2 \\ & + \sum_{i=0}^m N_{4i} \ln ECM_{t-i} + \sum_{i=0}^p N_{5i} \ln EX_{t-i} + b_t \end{aligned} \quad (7)$$

Hypothesis of no cointegration is  $H_0 = M_1 = M_2 = M_3 = M_4 = M_5 = 0$

Hypothesis of cointegration is  $H_1 = M_1 \neq M_2 \neq M_3 \neq M_4 \neq M_5 \neq 0$

When cointegration is confirmed, short-run coefficients, long-run coefficients, and error correction model of the ARDL model are as below in equation 8, equation 9 and equation 10.

$$\begin{aligned} \ln EM_t = & C_0 + \sum_{i=1}^s C_{1i} \ln EM_{t-i} + \sum_{i=0}^h C_{2i} \ln GD_{t-i} \\ & + \sum_{i=0}^c C_{3i} \ln(GD)_{t-i}^2 + \sum_{i=0}^m C_{4i} \ln ECM_{t-i} \\ & + \sum_{i=0}^p C_{5i} \ln EX_{t-i} + b_t \end{aligned} \quad (8)$$

$$\begin{aligned} \ln EM_t = & D_0 + \sum_{i=1}^s D_{1i} \Delta \ln EM_{t-i} + \sum_{i=0}^h D_{2i} \Delta \ln GD_{t-i} \\ & + \sum_{i=0}^c D_{3i} \Delta \ln(GD)_{t-i}^2 + \sum_{i=0}^m D_{4i} \Delta \ln ECM_{t-i} \\ & + \sum_{i=0}^p D_{5i} \Delta \ln EX_{t-i} + \gamma ECT_{t-1} + b_t \end{aligned} \quad (9)$$

$$\begin{aligned} ECT_t = & \ln EM_t - \sum_{i=1}^s Y_{1i} \Delta \ln EM_{t-i} - \sum_{i=0}^h Y_{2i} \Delta \ln GD_{t-i} \\ & - \sum_{i=0}^c D_{3i} \Delta \ln(GD)_{t-i}^2 - \sum_{i=0}^m D_{4i} \Delta \ln ECM_{t-i} - \sum_{i=0}^p D_{5i} \Delta \ln EX_{t-i} \end{aligned} \quad (10)$$

Equation 8 is to determine the long-run coefficients of ARDL model and equation 9 is to determine the short-run coefficients of ARDL model. Error correction model is specified in equation 10.

Zivot and Andrews (1992) unit root test is used to investigate the unit root of the variables in this study. The break dates for the variables are 1997 for CE, 1985 for GD, 1985 for square of GD, 2004 for ECM, 1990 for MTHN, 1982 for GFCO, 2001 for

LFCO and 1992 for SOFC. All the variables used in this study are stable at I(1) level.

Ramsey Reset Test (RRAT), Heteroskedasticity Test: Breusch-Pagan-Godfrey (BPGODT), Heteroskedasticity Test: ARCH (HTAHT), Heteroskedasticity Test: White (HTWT), Breusch-Godfrey Serial Correlation LM Test (BDGODLMT), Normality Test (NMTT), Cusum Test (CTU) and Cusum square Test (CTUSQ) are used in this study to investigate the stability of each model.

1997 is used as a break for CE-EX relationship. 1990 is used as a break for MN-EX relationship. 1991 is used as a break for GFCO-EX relationship and SFCO-EX relationship. 1991 is used as a break date for LFCO-EX relationship.

After carrying out stability tests for each model, bounds test of the ARDL model is applied to decide whether cointegration between the variables exist or not. After cointegration is confirmed, cointegration and long run form is run to investigate the long-run relationships between the variables. Eviews is used for all the calculations in this study.

## 4. RESULTS AND DISCUSSION

Analysis of the relationship between CE-EX, MN-EX, GFCO-EX, LFCO-EX and SFCO-EX in each sub-chapter. ARDL model is used for each relationship and the effect of EX on emissions is analyzed for the period 1971-2012 in India.

### 4.1. Analysis of CE-EX Relationship

Bounds test results show that F-statistics value is 6.69 and it is above I1 value of 1% which is 5.06. Long-run relationship between the analyzed variables is confirmed. For further analysis, ARDL-ECM model is applied to calculate short-run and long-run coefficients for each variable. 1997 is used as structural break in the analysis. Further analysis show that inverted U relationship is not confirmed between CE and GD, and EX has positive and significant effect on CE (Table 3). The long-run relationship between the variables is confirmed with negative coefficient of cointegration equation with significance of 1%. RRAT, BPGODT, HTAHT, HTWT, BDGODLMT and NMTT shows that the model satisfies the criteria for stability (Table 2). Further stability tests are carried out by CTU and CTUSQ tests and the model satisfies the criteria for stability for these tests as well (Figures 4 and 5). This analysis confirms the main aim of the study that EX has positive and significant effect on CE.

### 4.2. Analysis of MN-EX Relationship

Bounds test results show that F-statistics value is 13.17 and it is above I1 value of 1% which is 5.06. Long-run relationship between the analyzed variables is confirmed. For further analysis, ARDL-ECM model is applied to calculate short-run and long-run coefficients for each variable. 1990 is used as structural break in the analysis. Further analysis show that inverted U relationship is confirmed between MN and GD, and EX has positive and significant effect on MN (Table 5). The long-run relationship between the variables is confirmed with negative coefficient of

cointegration equation with significance of 1%. RRAT, BPGODT, HTAHT, HTWT, BDGODLMT and NMTT shows that the model satisfies the criteria for stability (Table 4). Further stability tests are carried out by CTU and CTUSQ tests and the model satisfies the criteria for stability for these tests as well (Figures 6 and 7). The analysis shows that there is inverted U relationship between MN and economic growth for India for the period 1971-2012. This analysis confirms the main aim of the study that EX has positive and significant effect on MN.

### 4.3. Analysis of GFCO-EX Relationship

Bounds test results show that F-statistics value is 13.48 and it is above I1 value of 1% which is 5.06. Long-run relationship

**Table 2: Stability Test Results for ARDL Model of CE-EX Relationship**

Test	F-statistic	Jarque-Bera	Prob
RRAT	0.057861	-	0.8130
BPGODT	0.777274	-	0.7077
HTAHT	0.266431	-	0.8971
HTWT	0.752802	-	0.7305
BDGODLMT	1.469063	-	0.2677
NMTT	-	0.897383	0.6384

**Table 3: ARDL-ECM test results for CE-EX relationship**

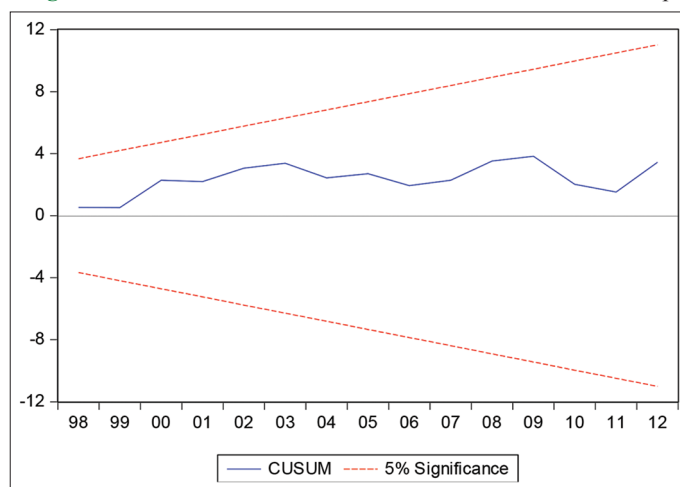
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Short-run coefficients				
D(CE(-1))	-0.433507	0.179387	-2.416608	0.0272
D(CE(-2))	-0.452926	0.142230	-3.184459	0.0054
D(CE(-3))	-0.333486	0.118207	-2.821203	0.0118
D(GD)	8.254545	2.218748	3.720361	0.0017
D(GD(-1))	7.619568	2.857079	2.666909	0.0163
D(GD2)	-0.638575	0.177909	-3.589344	0.0023
D(GD2(-1))	-0.647722	0.230572	-2.809192	0.0121
D(ECM)	1.472394	0.280417	5.250725	0.0001
D(ECM(-1))	0.953091	0.428490	2.224300	0.0400
D(ECM(-2))	1.142190	0.332804	3.432015	0.0032
D(EX)	0.063998	0.039061	1.638409	0.1197
D(EX(-1))	-0.071699	0.071397	-1.004225	0.3294
D(EX(-2))	0.025794	0.080463	0.320565	0.7524
D(EX(-3))	-0.176854	0.061796	-2.861898	0.0108
D(D1997)	0.026637	0.022372	1.190616	0.2502
CointEq(-1)	-0.600626	0.150815	-3.982542	0.0010
Long-run coefficients				
GD	2.468839	2.642847	0.934159	0.3633
GD2	-0.094888	0.220521	-0.430289	0.6724
ECM	-1.242166	1.120652	-1.108432	0.2831
EX	0.451679	0.134558	3.356761	0.0037
D1997	0.044348	0.035762	1.240096	0.2318
C	-2.349624	10.726289	-0.219053	0.8292

**Table 4: Stability test results for ARDL Model of MN-EX relationship**

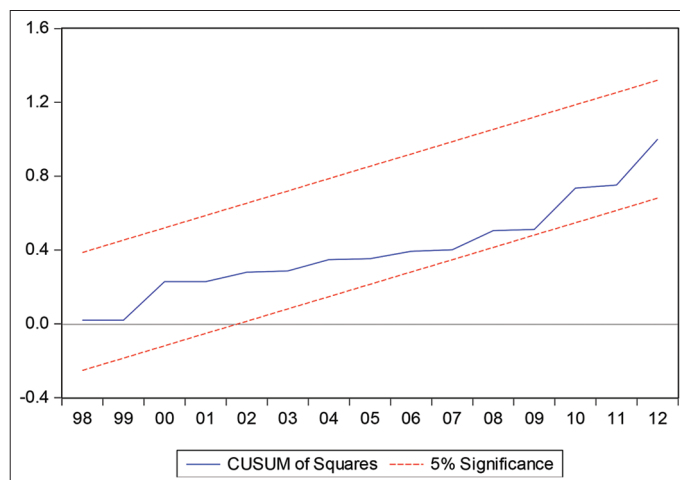
Test	F-statistic	Jarque-Bera	Prob.
RRAT	0.346012	-	0.5621
BPGODT	0.956173	-	0.5202
HTAHT	0.595183	-	0.5571
HTWT	0.939207	-	0.5349
BDGODLMT	0.788675	-	0.4669
NMTT	-	2.706450	0.2584

between the analyzed variables is confirmed. For further analysis, ARDL-ECM model is applied to calculate short-run and long-run coefficients for each variable. 1991 is used as structural break in the analysis (Table 6). Further analysis show that inverted U relationship is confirmed between GFCO and GP, and EX has

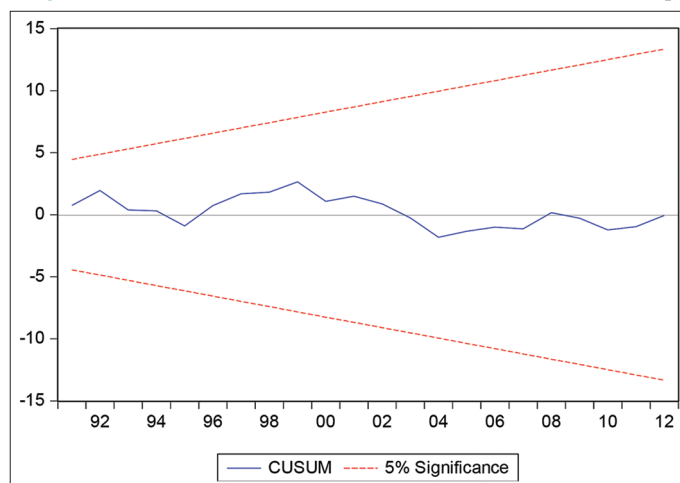
**Figure 4: CTU test results for ARDL Model of CE-EX relationship**



**Figure 5: CTUSQ test results for ARDL model of CE-EX relationship**



**Figure 6: CTU test results for ARDL model of MN-EX relationship**



positive and significant effect on GFCO (Table 7). The long-run relationship between the variables is confirmed with negative coefficient of cointegration equation with significance of 1%. RRAT, BPGODT, HTAHT, HTWT, BDGODLMT and NMNTT shows that the model satisfies the criteria for stability (Table 5). Further stability tests are carried out by CMM and CMMSQ tests and the model satisfies the criteria for stability for these tests as well (Figures 8 and 9). The analysis shows that there is inverted U relationship between GFCO and economic growth for India for the period 1971-2012. This analysis confirms the main aim of the study that EX has positive and significant effect on GFCO.

#### 4.4. Analysis of LFCO-EX Relationship

Bounds test results show that F-statistics value is 10.84 and it is above I1 value of 1% which is 5.06. Long-run relationship between the analyzed variables is confirmed. For further analysis, ARDL-ECM model is applied to calculate short-run and long-run coefficients for each variable. 2001 is used as structural break in the analysis. Further analysis show that inverted U relationship is not confirmed between LFCO and GP, and EX has positive and insignificant effect on LFCO (Table 9). The long-run relationship between the variables is confirmed with negative coefficient of cointegration equation with significance of 5%. RRAT, BPGODT, HTAHT, HTWT, BDGODLMT and NMNTT shows that the model satisfies the criteria for stability (Table 8). Further stability tests are carried out by CTU and CTUSQ tests and the model satisfies the criteria for stability for these tests as well (Figures 10 and 11).

**Table 5: ARDL-ECM test results for MN-EX relationship**

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Short-run coefficients				
D(MN(-1))	-0.192606	0.094999	-2.027446	0.0539
D(GD)	0.510976	0.717617	0.712045	0.4833
D(GD(-1))	0.538228	0.773099	0.696195	0.4930
D(GD(-2))	-1.692379	0.693996	-2.438599	0.0225
D(GD2)	-0.027690	0.057137	-0.484626	0.6323
D(GD2(-1))	-0.043899	0.062236	-0.705359	0.4874
D(GD2(-2))	0.129929	0.055772	2.329635	0.0286
D(ECM)	0.221518	0.079634	2.781709	0.0104
D(EX)	0.015420	0.017009	0.906573	0.3736
D(D1990)	-0.055863	0.004976	-11.227411	0.0000
CointEq(-1)	-0.847836	0.121827	-6.959325	0.0000
Long-run Coefficients				
GD	3.146752	0.261553	12.031014	0.0000
GD2	-0.235291	0.021665	-10.860388	0.0000
ECM	0.261275	0.094311	2.770358	0.0106
EX	0.063899	0.010036	6.366885	0.0000
D1990	-0.065889	0.009644	-6.831824	0.0000
C	-0.408473	1.028746	-0.397059	0.6948

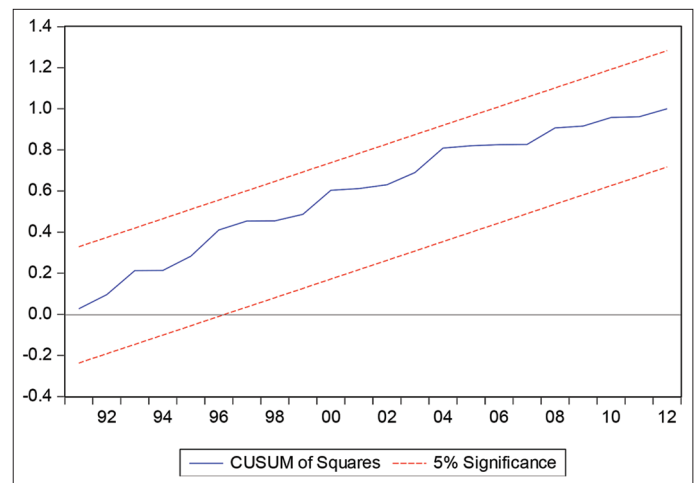
**Table 6: Stability test results for ARDL Model of GFCO-EX relationship**

Test	F-statistic	Jarque-Bera	Prob.
RRAT	0.273494	-	0.6050
BPGODT	1.017255	-	0.4488
HTAHT	1.003738	-	0.3768
HTWT	0.968455	-	0.4846
BDGODLMT	0.796760	-	0.4607
NMNTT	-	0.469341	0.7908

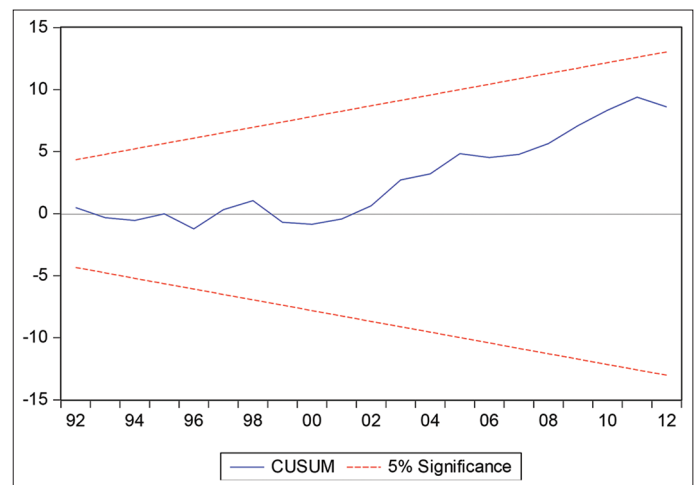
#### 4.5. Analysis of SFCO-EX Relationship

Bounds test results show that F-statistics value is 4.46 and it is above I1 value of 5% which is 4.01. Long-run relationship

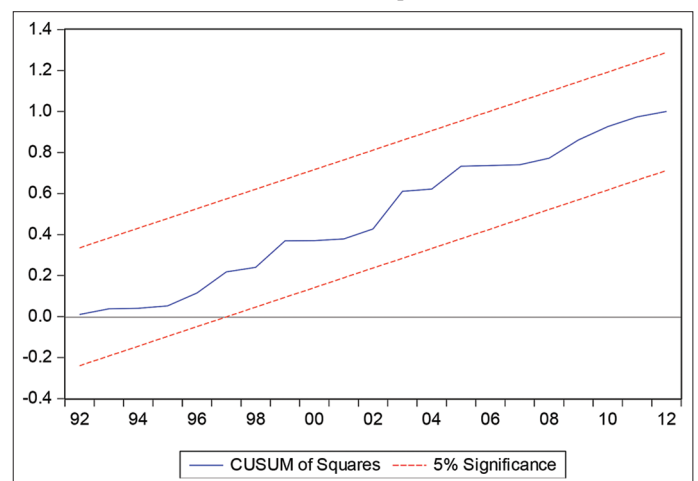
**Figure 7: CTUSQ test results for ARDL Model of MN-EX relationship**



**Figure 8: CTU test results for ARDL Model of GFCO-EX relationship**



**Figure 9: CTUSQ test results for ARDL Model of GFCO-EX relationship**





**Table 7: ARDL-ECM test results for GFCO-EX relationship**

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Short-run coefficients				
D(GFCO(-1))	0.488247	0.105460	4.629695	0.0001
D(GD)	18.074163	8.526407	2.119786	0.0424
D(GD2)	-1.475396	0.680229	-2.168971	0.0381
D(ECM)	5.163414	0.973284	5.305145	0.0000
D(EX)	0.229352	0.096956	2.365528	0.0247
D(D1991)	-0.072736	0.060475	-1.202733	0.2385
CointEq(-1)	-0.867392	0.095171	-9.114030	0.0000
Long-run Coefficients				
GD	41.141068	2.550409	16.131166	0.0000
GD2	-3.189567	0.204377	-15.606289	0.0000
ECM	5.952802	1.012707	5.878110	0.0000
EX	0.264416	0.106311	2.487181	0.0187
D1991	-0.083856	0.071675	-1.169948	0.2512
C	-164.165369	9.989036	-16.434555	0.0000

**Table 8: Stability test results for ARDL model of LFCO-EX relationship**

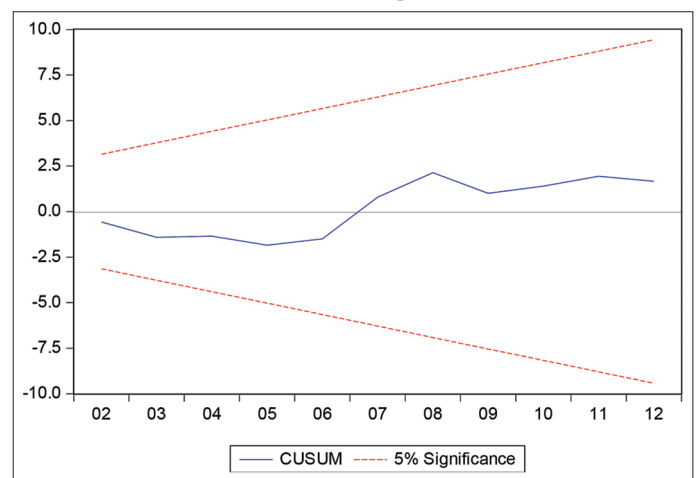
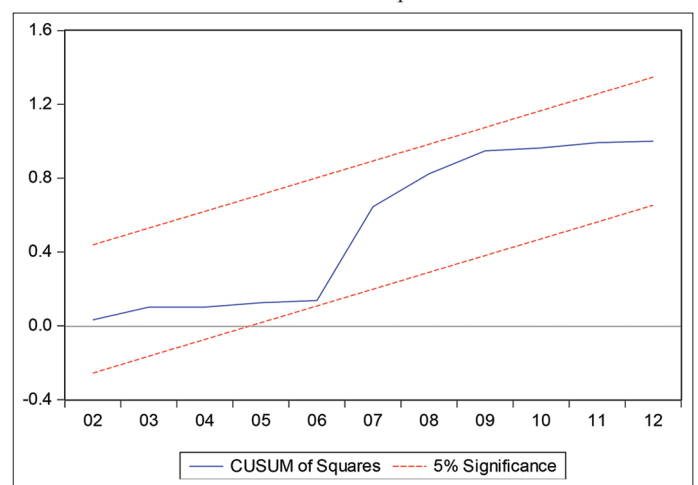
Test	F-statistic	Jarque-Bera	Prob.
RRAT	2.410850	-	0.1362
BPGODT	1.092169	-	0.4180
HTAHT	1.870781	-	0.1801
HTWT	1.084328	-	0.4240
BDGODLMT	0.671995	-	0.4220
NMTT	-	1.199199	0.5490

**Table 9: ARDL-ECM test results for LFCO-EX relationship**

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Short-run coefficients				
D(GD)	12.543669	4.404050	2.848212	0.0096
D(GD(-1))	18.731811	4.818237	3.887690	0.0008
D(GD2)	-0.993277	0.353822	-2.807279	0.0106
D(GD2(-1))	-1.560840	0.388453	-4.018089	0.0006
D(ECM)	-0.265872	0.828896	-0.320754	0.7516
D(ECM(-1))	1.236287	0.606389	2.038768	0.0543
D(ECM(-2))	1.147087	0.592453	1.936165	0.0664
D(ECM(-3))	-1.762657	0.617923	-2.852553	0.0095
D(EX)	0.100969	0.087785	1.150184	0.2630
D(EX(-1))	-0.205482	0.128926	-1.593791	0.1259
D(D2001)	-0.199082	0.041550	-4.791439	0.0001
CointEq(-1)	-0.300436	0.131110	-2.291477	0.0324
Long-run Coefficients				
GD	-1.685412	11.253471	-0.149768	0.8824
GD2	0.562308	1.083166	0.519134	0.6091
ECM	-7.538468	6.546226	-1.151575	0.2624
EX	0.667089	0.505226	1.320377	0.2009
D2001	-0.662643	0.362383	-1.828571	0.0817
C	27.989636	51.982378	0.538445	0.5959

**Table 10: Stability test results for ARDL model of N2-ETLN relationship**

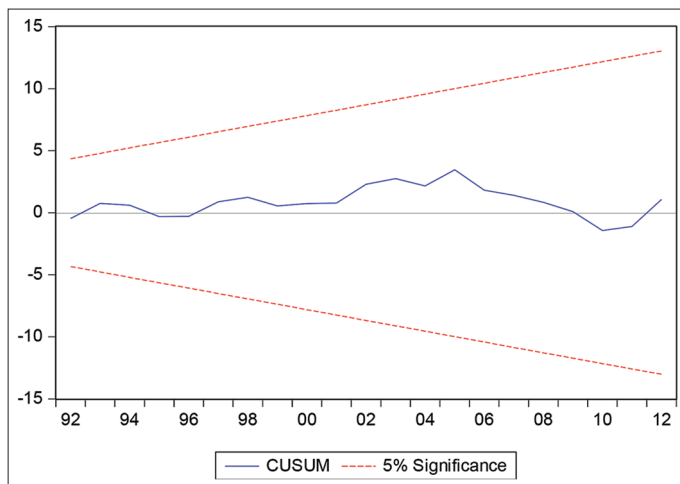
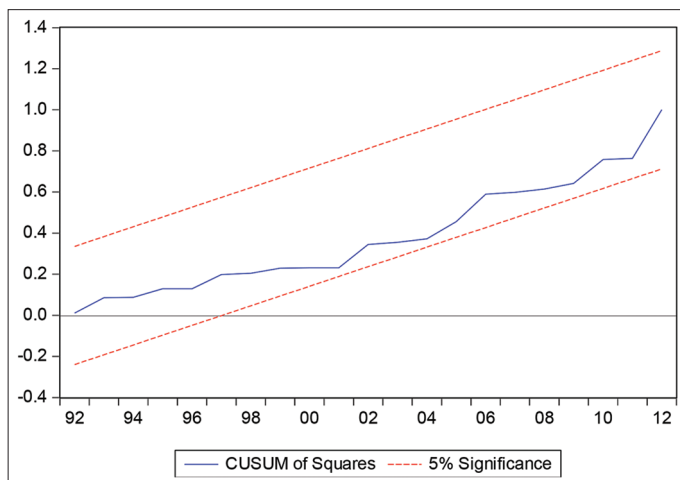
Test	F-statistic	Jarque-Bera	Prob.
RRAT	0.675745	-	0.4207
BPGODT	0.940736	-	0.5426
HTAHT	0.515670	-	0.4775
HTWT	0.957380	-	0.5280
BDGODLMT	3.605245	-	0.0721
NMTT	-	0.760169	0.6838

**Figure 10: CTU test results for ARDL model of LFCO-EX relationship****Figure 11: CTUSQ test results for ARDL model of LFCO-EX relationship**

between the analyzed variables is confirmed. For further analysis, ARDL-ECM model is applied to calculate short-run and long-run coefficients for each variable. 1991 is used as structural break in the analysis. Further analysis show that inverted U relationship is not confirmed between SFCO and GD, and EX has positive and

**Table 11: ARDL-ECM test results for N2-ETLN relationship**

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Short-run coefficients				
D(GD)	3.283821	2.747638	1.195143	0.2454
D(GD(-1))	2.564799	3.425273	0.748787	0.4623
D(GD(-2))	-7.836568	3.080892	-2.543603	0.0189
D(GD2)	-0.242091	0.218190	-1.109543	0.2797
D(GD2(-1))	-0.227386	0.275263	-0.826071	0.4181
D(GD2(-2))	0.641744	0.244523	2.624474	0.0158
D(ECM)	0.931616	0.333519	2.793292	0.0109
D(ECM(-1))	0.141965	0.382550	0.371101	0.7143
D(ECM(-2))	0.065501	0.370397	0.176840	0.8613
D(ECM(-3))	-0.802893	0.396938	-2.022715	0.0560
D(EX)	0.149908	0.032383	4.629278	0.0001
D(D1991)	0.030137	0.020592	1.463546	0.1581
CointEq(-1)	-0.618359	0.162180	-3.812789	0.0010
Long-run coefficients				
GD	2.922026	1.952837	1.496298	0.1495
GD2	-0.210805	0.145462	-1.449213	0.1620
ECM	1.237978	0.456519	2.711775	0.0131
EX	0.242429	0.055891	4.337518	0.0003
D1991	0.048737	0.029651	1.643700	0.1151
C	-10.392346	5.953342	-1.745632	0.0955

**Figure 12:** CTU test results for ARDL model of METH-ETLN relationship**Figure 13:** CTUSQ test results for ARDL model of METH-ETLN relationship

significant effect on SFCO (Table 11). The long-run relationship between the variables is confirmed with negative coefficient of cointegration equation with significance of 1%. RRAT, BPGODT, HTAHT, HTWT, BDGODLMT and NMTT shows that the model satisfies the criteria for stability (Table 10). Further stability tests are carried out by CTU and CTUSQ tests and the model satisfies the criteria for stability for these tests as well (Figures 12 and 13). This analysis confirms the main aim of the study that EX has positive and significant effect on SFCO.

## 5. CONCLUSION

Main findings of this study are as below.

1. No inverted U relationship between CE and GD (Hypothesis 2)
2. EX has significant and positive effect on CE (Hypothesis 1)
3. Inverted U relationship between MN and GD (Hypothesis 4)
4. EX has significant and positive effect on MN (Hypothesis 3)
5. Inverted U relationship between GFCO and GD (Hypothesis 10)
6. EX has significant and positive effect on GFCO (Hypothesis 9)
7. No Inverted U relationship between LFCO and GD (Hypothesis 8)
8. EX has insignificant and positive effect on LFCO (Hypothesis 7)
9. No inverted U relationship between SFCO and GD (Hypothesis 6)
10. EX has significant and positive effect on SFCO (Hypothesis 5).

Time period of this study for India is from 1971 to 2012. Period is chosen according to the availability of data on energy consumption side. India's external debt continued to rise after 2012 till today. The results of this study confirmed hypothesis 1, 3, 4, 5, 9 and 10. The results of this study did not confirm hypothesis 2, 6, 7 and 8. MN Kuznets curve and GFCO Kuznets curve are confirmed by this study. The main aim of this study is to prove the effect of EX on emissions. According to study results, EX has significant and positive effect on SFCO, GFCO, MN and CE. The results of this study confirm that India finances its emissions through external debt. As stated above, although the study period covers from 1971 to 2012, India's external debt continued to increase after 2012. It is highly likely India continued to finance its emissions through external debt after 2012 till today. Since sustainability is the main issue in current world and reduction of emissions is one of the highest priorities of humanity, necessary measures should be taken into account to reduce financing of emissions through external debt in India.

Although this study did not confirm inverted U relationship between SFCO and GD, we recommend further studies to investigate coal Kuznets curve for India which is another gap in the literature and coal is one of the major contributors to greenhouse gas emissions. Beşe et al., (2020), Magazzino et al., (2020) and Qiao et al., (2019) are the most recent studies in the literature that confirmed coal Kuznets curve.

The time period analyzed and the country of the study which is India are the limits of this study. This study recommends further policies to be taken to control the use of external debt for creating environmental pollution in India. For future research direction,

further studies need to be carried out to analyze the effect of external debt on emissions for developing countries.

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