Does Globalization Impede Environmental Quality in Bangladesh? The Role of Real Economic Activities and Energy Use

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Abstract: This research investigates the relationship between globalization, environment degradation, industrial production, energy consumption and economic growth over the period of 1972-2015 for Bangladesh. The long run relationship between variables is examined using ARDL bound test and combined cointegration approach. These cointegration approaches predict the long run relationship between underlying variables. The empirical findings demonstrate that globalization, industrial production and energy consumption drives environmental degradation positively, but economic growth pushes environmental degradation negatively in the long run as well as short run. Further, the direction of causality is examined by VECM Granger causality which shows bidirectional causality between energy consumption and environment degradation, economic growth and environment degradation, industrial production and economic growth, and energy consumption and economic growth for both short-long run. Our results suggest a unidirectional causality runs from environmental degradation and energy consumption to industrial production. The empirics of Innovative Accounting Approach (IAA) confirm the findings of VECM Granger causality. Our findings suggest that Policymakers may focus on imports of advance technology and export led growth strategy to control environmental pollution.

Keywords: Globalization, Environment Degradation, Industrial Production, Energy consumption, Combine Cointegration, VECM causality, Bangladesh

***JEL* classification:** F64, Q4

I. Introduction

Environmental pollution is a worldwide problem that affecting human being in every part of the world. Give the pace of development and growth; countries across the globe are trying to boost its GDP per capita by increasing production levels. In last few decades, a rapid increase in industrialization and foreign direct investment caused high CO_2 and SO_4 emission. Previous studies suggest a continuous rise in CO_2 emission in the lower middle income group, low and middle income group, and upper middle income group, whereas, CO_2 emission are reduced in the high income group (Sharma, 2011). It has noted that CO_2 emission per capita has increased from 0.58 metric tons to 1.63 metric tons over the period of 1972-2015 for the lower middle-income group. During the same period, CO_2 emission has risen from 1.06 metric tons to 3.65 metric tons in the low and middle-income group countries. For middle-income group, CO_2 emission per capita was 1.12 metric tons in 1972 that rose to 4.05 metric tons in 2015 and for non-OECD high-income group, it has increased from 12.45 metric tons to 13.73 metric tons for period of 1972- 2015. CO_2 emission per capita has also experience an increasing trend for group of upper middle income as it increased from 1.58 metric tons to 6.97 metric tons over the period of 1972-2015 (World Development Indicator, 2015). A regional analysis has shown a reduction in CO_2 emission trend in Central Europe, the Baltics, Euro area and the European Union and at the same time increase in CO_2 emission in the Arab countries has been witnessed (World Development Indicator, 2015).

Our interest is to examine the role of globalization in environmental degradation by considering the effect of energy consumption and real economic activities in the case of Bangladesh. Bangladesh as a South Asian country belongs to a lower middle-income group has increased its GDP per capita from $ 257 to $ 747 for a period of 1972-2014. The industrial sector has major contribution in GDP by 17% of GDP Bangladesh (Abdullah, 2015). Due to industrialization in Bangladesh, industrial output has witnessed a swift increase from $ 0.38 billion in 1972 to $45.48 billion in 2014, thus accounting 27 % industrial production of GDP in 2014. The increase in industrial production is accompanied by high levels of CO_2 emissions due to increased level of energy usage. For instance, per capita CO_2 emission has increased from 0.05 metric tons to 0.41 metric tons from 1972-2015 for Bangladesh (World Development Indicator, 2015).

In CO_2 emission literature, many research tried to find out the existence of Environmental Kuznets Curve (EKC) hypothesis. Firstly, Grossman and Kruger (1991) introduced Environmental Kuznets Curve (EKC) hypothesis. The EKC hypothesis states that CO2 emission moves upward with an increase in income at primary stage. When the economy reaches the threshold level of income per capita, the emission begins to decline with the rise in income per capita. Exiting literature has recorded several studies that investigated the EKC hypothesis for Bangladesh such as Miah *et al*. (2011), Rabbi *et al*. (2015), Islam *et al*. (2013), Shahbaz *et al*. (2014). The relationship between economic growth, energy consumption and CO_2 emission has taken much attention in the past few years. Therefore, many researchers have investigated the relationship between economic growth, CO_2 emission and energy consumption[1]. Moreover, some studies incorporated trade openness, industrialization and foreign direct investment in CO_2

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[1] Tiwari, (2011) for India; Glasure, (2002) for South Korea; Jumbe, (2004) for Malawi; Pao and Tsai, (2011b) for Brazil; Pao *et al*. (2011) for Russia; Yoo, (2005) for Korea; Shahbaz *et al*. (2012a) for Pakistan; Acaravci and Ozturk, (2010) for Europe and Ozcan, (2013) for Middle East countries.

emission function[2]. The higher level of openness or globalization of any economy means external links, trade links and investments with the rest of the world for economic growth. These trade and investment activities increase energy consumption that releases CO_2 and SO_4. According to World Bank (2007), one tenth of world CO_2 emission has been discharged by Bangladesh in 2006 with 160 million populations that as 2.4% of the world's population. The role of globalization in environmental degradation has been noted in recent in energy and environment literature. Globalization creates a threat for environmental regulations. Environmental pollution increases at low level of income. People have to accept this pollution, if they want a higher level of consumption. Once the standard of living has been attained, then they care for environmental quality. Therefore, international markets can be merged with global warming through globalization process.

The aim of this study is to investigate the impact of overall globalization (Social, economic and political globalization) on CO_2 emission over the period of 1972-2015 in case of Bangladesh. Previous studies have used the trade openness to measure liberalization or/and globalization, which is not a correct measure for globalization. Therefore, we apply KOF overall globalization index for authentic results. This study contributes to the existing literature by four-folds. (1) We use of KOF overall globalization Index while determining environmental degradation function for Bangladesh (2) we examine the impact of globalization, industrial production, energy consumption and economic growth on environmental degradation collectively which is not previously considered (3) We applied recently introduced Bayer and Hanck, (2013) combine cointegration approach to examine the long run relationship. (4) We examine the causal relation between the considered variables through VECM Granger causality and Innovative Accounting Approach (IAA) is utilized to examine the relative strength, direction, and magnitude of casual relationship.

Our findings suggest that globalization, industrial production and energy consumption have a positive and significant impact on environment degradation, but economic growth has negative significant impact on environmental degradation in long and short run. The results of VECM suggest that bidirectional causality exists between energy consumption, environment degradation and economic growth in long run as well as short run.

II. Review of Literature

Table-1 shows the summary of previous studies that attempt to identify some potential variables as determinants of CO_2 emission.

[2] Jalil and Mahmud, (2009) for China; Shahbaz *et al*. (2012b) for Pakistan; Shahbaz *et al*. (2014) for Bangladesh; Shahbaz *et al*. (2013a) for Malaysian economy; Shahbaz *et al*. (2013b) for South Africa; Jalil and Feridum, (2011) for china; Pao and Tsai, (2011a) for BRIC countries; Sharma, (2011) for 69 countries; and Ozturk and Acaravci, (2013) for Turkey.

Table-1: Summary of Previous Studies

Authors name and Publication Year	Time period and Countries	Methodology	Determinants of CO_2 emission	Cointegration	Causality	EKC Exist?
Ozturk & Al-Mulali (2015)	1996-2012 Cambodia	Generalized Method of moments and Two-stage Least square	Y, Ur. EC, TO, Cr. and Gv.	---	---	Not
Shahbaz et al. (2013)	1971-2011 Malaysia	ARDL Cointegration and VECM Granger causality	EC, Y, FD	Yes	FD, EC⇔CO_2 Y⇔EC Y=>CO_2	---
Saboori et al. (2012)	1980-2009 Malaysia	ARDL Bound testing and VECM Granger causality	Y	Yes	Y=> CO_2	Yes
Lau, et. al. (2014)	1970-2008 Malaysia	ARDL Bound test, Granger causality	Y, FDI and TO	Yes	TO, FDI ⇔ CO_2 CO_2⇔Y Y ⇔ FDI	Yes
Halicioglu (2009)	1960-2005 Turkey	ARDL Bound test, Granger causality	EC, Y and TO	Yes	EC, Y ⇔ CO_2	Yes
Saboori & Sulaiman (2013a)	1971-2009 ASEAN countries	ARDL and VECM causality	EC and Y	Yes	EC=>CO_2	Yes
Saboori & Sulaiman (2013b)	1980-2009 Malaysia	ARDL bound testing and VECM Causality	EC (Disaggregated and Aggregated) and GDP	Yes	EC=>CO_2	Yes, only for disaggregated energy consumption data
Lean & Smyth (2010)	1980-2006 ASEAN	Panel VECM model, Johansen	EC and Y	Yes	EC, CO_2 => Y	Yes

	countries	Fisher Panel Cointegration, Panel VECM Causality.				
Pao & Tsai (2010)	1971-2005 BRIC	Pedroni and Johenson Fisher Cointegration, Panel VECM	EC and Y	Yes	EC ⇔ CO_2, Y	Yes, But except Brazil
Ang (2007)	1960-2000 France	Johansen Cointegratio, ARDL and Causality	EC and Y	Yes	EC,Y=>CO_2	Yes
Kohler (2013)	South Africa 1960-2009	ARDL and Johansen Cointegration	EC, Y and T	Yes	EC⇔ CO_2 TO⇔Y	Not
Jayanthakumaran, et al. (2012)	1971-2007 China and India	ARDL Cointegraton	EC, Y and TO	Inconclusive	---	Yes
Govindaraju and Tang (2013)	1965-2009 China and India	BH Combine cointegration and Granger causality	CC and Y	Yes for China only.	China: Y=> CO_2 Y⇔CC CO_2⇔CC India: Y⇔ CO_2 ⇔CC	Yes for China.
Zhang and Lin (2012)	1995-2010 China	STIRPAT model,	Ur, EC, Y, IND and SS	---	---	---
Jalil and Feridun (2011)	1953-2006 China	ARDL bound testing	EC, Y, FD and TO	Yes	---	Yes
Jalil & Mahmud (2009)	1975-2005 China	ARDL Cointegration	EC, Y and TO	Yes	Y=> CO_2	Yes
Wang, et. al. (2011)	1995-2007 China	Panel Cointegration and Panel Granger causality	EC and Y	Yes	EC⇔Y, CO_2	Yes
Apergis & Payne (2009)	1971-2004 Central America	Panel VECM,	EC and Y	---	EC=>Y CO_2⇔Y, EC	Yes

Farhani, et al. (2014)	1971-2008 Tunisia	ARDL bound testing and VECM Granger causality	EC, Y and TO	Yes	EC, Y => CO_2	Yes
Sharma (2011)	69 Countries Based on Income	Panel GMM estimation	EC, Y, Ur, TO	---	---	---
Al-mulali & Ting (2014)	1990-2011 Countries categories by region	FMOLS, Panel Granger causality	TT and EC	---	TT, EC ⇔CO_2	---
Arouri et al. (2012)	1981-2005 12-MENA countires	Bootstrap Panel unit root test and Cointegration	EC and Y	Yes	---	Yes
Jafari et al. (2012)	1971-2007 Indonesia	Toda-Yamamota causality,	EC, Ur and Ca.	---	Ur=> EC	---
Shahbaz et al. (2012b)	1971-2009 Pakistan	ARDL Bound testing and Granger causality	EC, Y and TO	Yes	Y=> CO_2	Yes
Shahbaz et al. (2013c)	1980-2010 Romania	ARDL bound testing	EC and Y	Yes	---	Yes
Al-Mulali (2012)	1990-2009 12 Middle East countries	Pedroni Cointegration, OLS and Panel Granger Causality	EC, Y, FDI and TT.	Yes	Y, FDI, TT,CO_2, EC⇔GDP, FDI, TT,CO_2, EC	---
Hamit-Haggar (2012)	1990-2007 Canada	Pedroni Cointegration and Panel Granger causality	EC and Y	Yes	EC, Y=>CO_2	Yes
Shahbaz et. al. (2014)	1975-2010 Bangladesh	ARDL Bound testing and Innovative	EC(+), IP, FD(+) and TO	Yes	EC=>CO_2, IP, FD FD=>TO=>IP	Yes

		accounting approach				
Al-mulali (2014)	1990-2010 30 major nuclear energy countries	FMOLS, Pedroni cointegration	NEC, FFEC, Y and Ur	No	NEC=>Y, CO_2	No
Pao and Tsai (2011b)	1980-2007 Brazil	Grey Prediction model, ARIMA model	EC and Y	---	EC,Y, CO_2 ⇔ EC, Y, CO_2	Yes
Pao et. al. (2011)	1990-2007 Russia	Johansen Cointegration and VECCM Granger causality	EC and Y	Yes	CO_2=>EC, Y	No
Pao and Tsai (2011a)	1980-2007 BRIC	Pedroni cointegration and Panel causality.	EC, Y, FDI	Yes	CO_2⇔ FDI, Y EC=>CO_2 Y, EC=>FDI Y⇔ECC	Yes
Shafiei and Salim (2014)	1980-2011 OECD	STIRPAT model, Johansen Fisher and Westerlund Cointegration, Panel VECM	REC, NREC, Y and P	Yes	P, Y=> CO_2 NREC⇔CO_2 P.=>Y Y=>NREC	Yes
Acaravci and Ozturk (2010)	1965-2005 19 European Countries	ARDL bound testing,	EC and Y	Yes for Denmark, Germany, Iceland, Italy, Portugal and Switzerland	EC=>CO_2 Only for Cointegrating countries	Yes for Denmark and Italy only.
Shahbaz et. al. (2013)	1965-2008 South Africa	ARDL bound testing, Pair-wise granger causality	CC, FD and TO	Yes	Y, TO, CC=>CO_2 CO2=>FDI	Yes
Apergis and Payne (2010)	1992-2004 11 Common wealth Independent States	Panel VECM, Panel Coinntegration and Causality	EC and Y	Yes	EC, Y=> CO_2	Yes
Ozturk and	1960-2007	ARDL bound	EC, Y, FD and	Yes	FD=>EC,Y	Yes

Acaravci (2013)	Turkey	testing, Granger causality	TO			
Iwata et al. (2012)	1963-2003 11 OECD	ARDL cointegration	EC, NEP and Y	Yes	----	Yes for Finland, Japan, Korea and Spain

Note: CO_2, Y, Ur. EC, TO, Cr, Gv, FDI, FD, TT, Ca, IP, NEC, FFEC, P, REC, NREC, IND, SS, CC, NEC denotes CO_2 emission, GDP, Urbanization, Energy Consumption, Trade Openness, Corruption, Governance, Foreign Direct Investment, Financial Development, Total Trade, Capital, Industrial Production, Nuclear Energy Consumption, Fossil Fuel Energy Consumption, Population, Renewable Energy Consumption, Non-Renewable Energy Consumption, Industrial Sector, Services Sector, Coal Consumption Production, respectively.

III. Data Collection, Model Construction and Estimation Strategy:

We draw on three key channels through which globalization affects CO_2 emission and hence environmental degradation namely Composition, Scale (resource allocation) and technique effects. In the first case, CO_2 emission increases with an increase in industrial structure through trade liberalization. In the second case, the scale effect deals with efficient allocation of resources. The efficient allocation of resources shifts the global production upward. Resultantly, this causes increase in industrial pollution. The last case refers to technology transfer facility by trade. The Imports of advance technology and machineries assist in the production of more output by controlling CO2 emission. Moreover, Globalization improves total factor productivity via trade. In addition, Grossman and Kruueger, (1991) predicted that trade openness (globalization) affects environmental degradation through scale effect.

Except these three principles, the other sources of CO2 emission include transportation and deforestation, accelerated by globalization. The transportation system has expanded due to globalization. The road transportation (cars and Lorries) within a country has increased CO2 emission significantly, but more so within national borders. Similarly, the deforestation is an indirect but significant source of CO2 emission. The clearing and logging trees without replanting cause to increase in volume of CO2 emission because plants convert CO2 into oxygen. On the other side, burning the wood releases huge quantities of CO2. Further, globalization increases foreign direct investment that enhances economic activities and financial markets.

Since our prime interest is to examine the impact of globalization on environment degradation by incorporating economic growth, industrial production, and energy consumption. We utilized annual data of Bangladesh over the period of 1972-2015. The functional form of environmental quality function is following:

$$ED_t = f\,(Glob_t, IP_t, EC_t, Y_t) \qquad (1)$$

Now we have converted all series into the natural log to get elasticity. The log linear form of environmental degradation function is following:

$$\ln ED_t = \beta_0 + \beta_{Globt} \ln Glob_t, + \beta_{IPt} \ln IP_t + \beta_{ECt} \ln EC_t, + \beta_{Yt} \ln Y_t + \mu_t \qquad (2)$$

Here, ln ED_t is natural log of environment degradation proxy by CO_2 emission measured in Kg per 2005 US $ of GDP, ln $Glob_t$ is natural log of KOF index of globalization introduced by Dreher, (2006), ln IP_t is natural log of industrial production proxy by industrial value added (constant 2005 US $), ln EC_t is natural log of energy consumption per capita and ln Y_t is natural log of economic growth proxy by real GDP per capita. μ_t is error term that supposed to be normal distributed having zero mean and constant variance. The data for environmental degradation, industrial production, energy consumption and economic growth is extracted from the World Bank database, World Development Indicator. The data on globalization index is borrowed from the database of KOF website[3]. The overall globalization index is developed by taking three measures: social, economic and political globalization. The evolutions of these series are shown in figures 1-5.

Figure-1, Energy Consumption (Per capita)

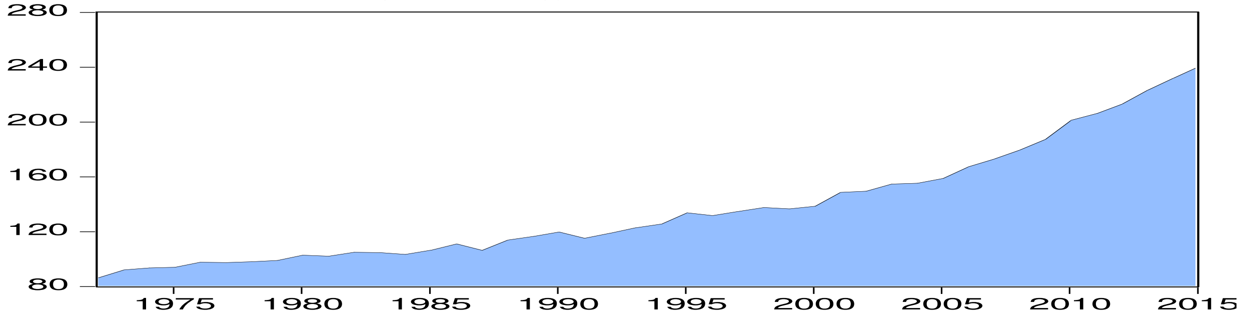


Figure-2, CO_2 Emission (Kg per 2005 US $ of GDP)

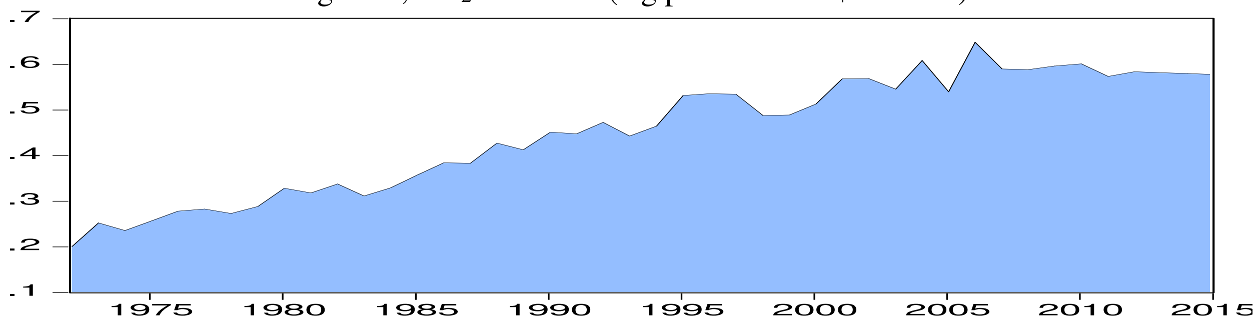
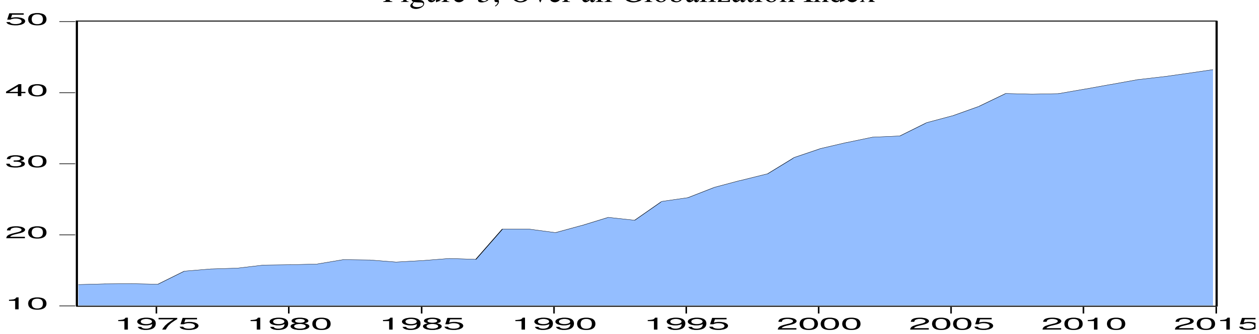


Figure-3, Over all Globalization Index



[3] KOF globalization index has been collected from the website of http://globalization.kof.ethz.ch/

Figure-4, Industrial value added (Constant 2005 US $)

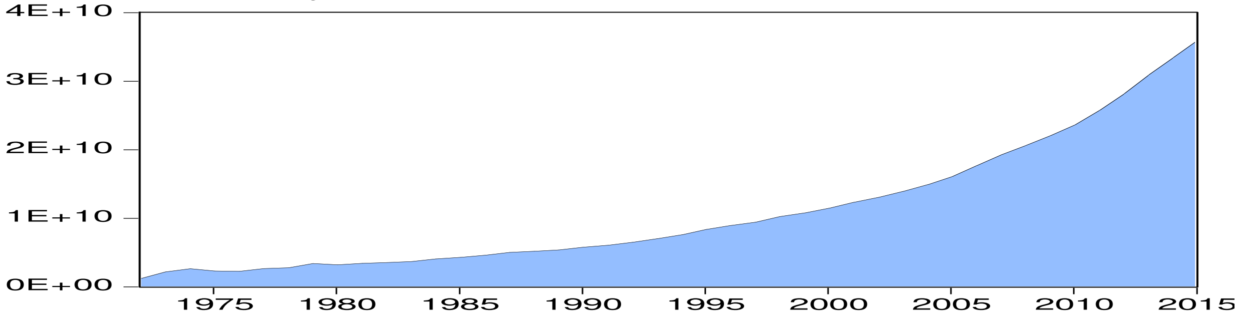
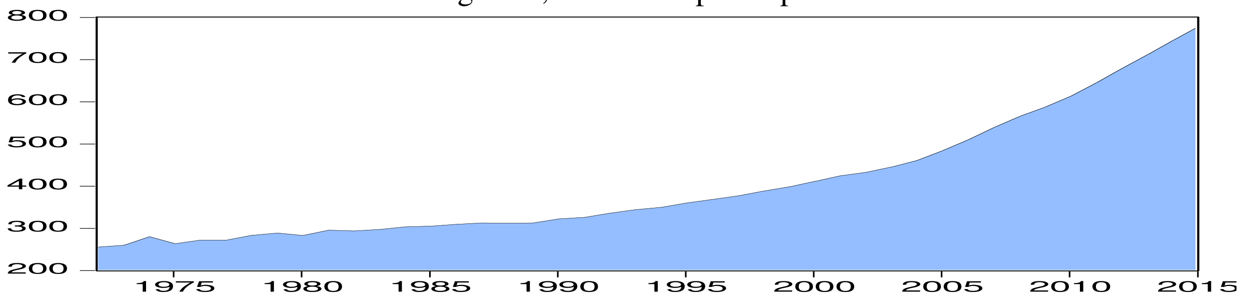


Figure-5, Real GDP per Capita



III.I. ARDL Bound Testing Approach to Cointegration

In econometric literature, many techniques have been developed to test cointegration phenomena. These techniques included Engle and Granger, (1987) cointegration, Johansen cointegration, (1991), Phillips and Ouliaris, (1990) cointegration, Boswijk, (1994) F-test and the Banerjee *et al*. (1998) T-test. Following all techniques are required for integration of series at same order, i.e. *I(0)* or *I(1)*. The ARDL bound testing approach of Pesaran and Shin, (1999) and Pesaran *et al.* (2001) are more flexible regarding unit root properties of variables. So, it can be applying on all conditions i.e. *I(0)* or *I(1) or I(0)/I(1)*. But, there should be no series integrated at 2nd difference, i.e. *I(2).* On the other side, it is appropriate for a small sample set. The estimated model for ARDL model is following:

$$\Delta \ln ED_t = \alpha_1 + \alpha_T T + \alpha_{ED} \ln ED_{t-1} + \alpha_{Glob} \ln Glob_{t-1} + \alpha_{IP} \ln IP_{t-1} + \alpha_{EC} \ln EC_{t-1} + \alpha_Y \ln Y_{t-1}$$
$$+ \sum_{j=0}^{q} \alpha_j \Delta \ln Glob_{t-j} + \sum_{k=0}^{r} \alpha_k \Delta \ln IP_{t-k} + \sum_{l=0}^{s} \alpha_l \Delta \ln EC_{t-l} + \sum_{m=0}^{t} \alpha_m \Delta \ln Y_{t-m} + \mu_t \quad (3)$$

$$\Delta \ln Glob_t = \beta_1 + \beta_T T + \beta_{Glob} \ln Glob_{t-1} + \beta_{ED} \ln ED_{t-1} + \beta_{IP} \ln IP_{t-1} + \beta_{EC} \ln EC_{t-1} + \beta_Y \ln Y_{t-1}$$
$$+ \sum_{j=0}^{q} \beta_j \Delta \ln ED_{t-j} + \sum_{k=0}^{r} \beta_k \Delta \ln IP_{t-k} + \sum_{l=0}^{s} \beta_l \Delta \ln EC_{t-l} + \sum_{m=0}^{t} \beta_m \Delta \ln Y_{t-m} + \mu_t \quad (4)$$

$$\Delta \ln IP_t = \gamma_1 + \gamma_T T + \gamma_{IP} \ln IP_{t-1} + \gamma_{Glob} \ln Glob_{t-1} + \gamma_{ED} \ln ED_{t-1} + \gamma_{EC} \ln EC_{t-1} + \gamma_Y \ln Y_{t-1}$$

$$+\sum_{j=0}^{q}\gamma_j \Delta \ln Glob_{t-j} + \sum_{k=0}^{r}\gamma_k \Delta \ln ED_{t-k} + \sum_{l=0}^{s}\gamma_l \Delta \ln EC_{t-l} + \sum_{m=0}^{t}\gamma_m \Delta \ln Y_{t-m} + \mu_t \quad (5)$$

$$\Delta \ln EC_t = \delta_1 + \delta_T T + \delta_{EC} \ln EC_{t-1} + \delta_{Glob} \ln Glob_{t-1} + \delta_{IP} \ln IP_{t-1} + \delta_{ED} \ln ED_{t-1} + \delta_Y \ln Y_{t-1}$$
$$+\sum_{j=0}^{q}\delta_j \Delta \ln Glob_{t-j} + \sum_{k=0}^{r}\delta_k \Delta \ln IP_{t-k} + \sum_{l=0}^{s}\delta_l \Delta \ln ED_{t-l} + \sum_{m=0}^{t}\delta_m \Delta \ln Y_{t-m} + \mu_t \quad (6)$$

$$\Delta \ln Y_t = \phi_1 + \phi_T T + \phi_Y \ln Y_{t-1} + \phi_{Glob} \ln Glob_{t-1} + \phi_{IP} \ln IP_{t-1} + \phi_{EC} \ln EC_{t-1} + \phi_{ED} \ln ED_{t-1}$$
$$+\sum_{j=0}^{q}\phi_j \Delta \ln Glob_{t-j} + \sum_{k=0}^{r}\phi_k \Delta \ln IP_{t-k} + \sum_{l=0}^{s}\phi_l \Delta \ln EC_{t-l} + \sum_{m=0}^{t}\phi_m \Delta \ln ED_{t-m} + \mu_t \quad (7)$$

The decision of cointegration relationship of ARDL bound testing approach depends on upon the tabulated values of upper and lower critical bound by Peraran *et al.* (2001). The null hypothesis of no cointegration in five models is $\alpha_{ED} = \beta_{ED} = \gamma_{ED} = \delta_{ED} = \phi_{ED} = 0$, $\alpha_{Glob} = \beta_{Glob} = \gamma_{Glob} = \delta_{Glob} = \phi_{Glob} = 0$, $\alpha_{IP} = \beta_{IP} = \gamma_{IP} = \delta_{IP} = \phi_{IP} = 0$, $\alpha_{EC} = \beta_{EC} = \gamma_{EC} = \delta_{EC} = \phi_{EC} = 0$ and $\alpha_Y = \beta_Y = \gamma_Y = \delta_Y = \phi_Y = 0$. The Alternative hypothesis of cointegration in five models is $\alpha_{ED} \neq \beta_{ED} \neq \gamma_{ED} \neq \delta_{ED} \neq \phi_{ED} \neq 0$, $\alpha_{Glob} \neq \beta_{Glob} \neq \gamma_{Glob} \neq \delta_{Glob} \neq \phi_{Glob} \neq 0$, $\alpha_{IP} \neq \beta_{IP} \neq \gamma_{IP} \neq \delta_{IP} \neq \phi_{IP} \neq 0$, $\alpha_{EC} \neq \beta_{EC} \neq \gamma_{EC} \neq \delta_{EC} \neq \phi_{EC} \neq 0$ and $\alpha_Y \neq \beta_Y \neq \gamma_Y \neq \delta_Y \neq \phi_Y \neq 0$. Once the F-statistics exceeds the UCB, we reject the null hypothesis otherwise accept. If calculated F-statistics lies between lower critical bound (LCB) and upper critical bound (UCB), our results for cointegration are inconclusive and uncertain.

III.II. Bayer and Hanck Combined Cointegration

The cointegration tests of Engle and Granger, (1987); Johansen, (1991); Phillips and Ouliaris, (1990); Boswijk, (1994) and Banerjee *et al*. (1998) have conflict in their results. To enhance the power of cointegration test, Bayer and Hanck generated a new statistic by combining all cointegration approaches for the null of no-cointegration. So, it is called B*ayer-Hanck* test, newly proposed by Bayer and Hanck, (2013). Therefore, we also applied this approach to test the robustness of ARDL approach. The Fisher's formulas of computing Bayer and Hanck cointegration is following:

$$EG - JOH = -2\,[\ln(P_{EG}) + (P_{JOH})] \quad (8)$$

$$EG - JOH - BO - BDM = -2[\ln(P_{EG}) + (P_{JOH}) + (P_{BO}) + (P_{BDM})] \quad (9)$$

Where P_{EG}, P_{JOH}, P_{BO} and P_{BDM} describes the p-value of individual cointegration tests. When calculated Fisher values exceed the critical values provided by Bayer and Hanck (2013), the null hypothesis of no-cointegration is rejected.

III.III VECM Granger Causality

If cointegration has confirmed between the variables, we may proceed to VECM Granger causality to test the direction of causality. The Granger causality test with VECM frame work is as follow:

$$\Delta LED_t = \vartheta_1 + \sum_{i=1}^{p} \vartheta_i \Delta LED_{t=i} + \sum_{j=1}^{q} \vartheta_j \Delta LGlob_{t=j} + \sum_{k=l}^{n} \vartheta_k \Delta LIP_{t=k} + \sum_{l=1}^{m} \vartheta_l \Delta LEC_{t=l}$$
$$+ \sum_{o=1}^{r} \vartheta_o \Delta LY_{t=o} + \eta_1 ECM_{t-1} + \mu_i \quad (10)$$

$$\Delta LGlob_t = \lambda_1 + \sum_{i=1}^{p} \lambda_i \Delta LGlob_{t=i} + \sum_{j=1}^{q} \lambda_j \Delta LED_{t=j} + \sum_{k=l}^{n} \lambda_k \Delta LIP_{t=k} + \sum_{l=1}^{m} \lambda_l \Delta LEC_{t=l}$$
$$+ \sum_{o=1}^{r} \lambda_o \Delta LY_{t=o} + \eta_2 ECM_{t-1} + \mu_i \quad (11)$$

$$\Delta LIP_t = \delta_1 + \sum_{i=1}^{p} \delta_i \Delta LIP_{t=i} + \sum_{j=1}^{q} \delta_j \Delta LGlob_{t=j} + \sum_{k=l}^{n} \delta_k \Delta LED_{t=k} + \sum_{l=1}^{m} \delta_l \Delta LEC_{t=l}$$
$$+ \sum_{o=1}^{r} \delta_o \Delta LY_{t=o} + \eta_3 ECM_{t-1} + \mu_i \quad (12)$$

$$\Delta LEC_t = \gamma_1 + \sum_{i=1}^{p} \gamma_i \Delta LEC_{t=i} + \sum_{j=1}^{q} \gamma_j \Delta LGlob_{t=j} + \sum_{k=l}^{n} \gamma_k \Delta LIP_{t=k} + \sum_{l=1}^{m} \gamma_l \Delta LED_{t=l}$$
$$+ \sum_{o=1}^{r} \gamma_o \Delta LY_{t=o} + \eta_4 ECM_{t-1} + \mu_i \quad (13)$$

$$\Delta LY_t = \pi_1 + \sum_{i=1}^{p} \pi_i \Delta LY_{t=i} + \sum_{j=1}^{q} \pi_j \Delta LGlob_{t=j} + \sum_{k=l}^{n} \pi_k \Delta LIP_{t=k} + \sum_{l=1}^{m} \pi_l \Delta LEC_{t=l}$$
$$+ \sum_{o=1}^{r} \pi_o \Delta LED_{t=o} + \eta_5 ECM_{t-1} + \mu_i \quad (14)$$

Where, Δ is a difference, ECM denotes the error correction term. $\vartheta_1, \lambda_1, \delta_1, \gamma_1$ and π_1 are constant and η (i=1,2,3,4,5) are error term having zero mean. We use Akaike Information Criterion (AIC) for optimal lag selection. The long run causality can be express by lagged value of *ECM* terms. For short run causality, we use Wald test.

III.IV Impulse Response Function

The impulse response function is an substitute of variance decomposition approach. It explains the effect of shocks stemming in the independent variables by considering time dimensions. To understand impulse response function, a VAR framework takes into the account the following form:

$$V_t = \sum_{i=1}^{k} \delta_i V_{t-1} + \eta_t$$

where, $V_t = (\mathrm{ED}_t, \mathrm{Glob}_t, \mathrm{IP}_t, \mathrm{EC}_t, \mathrm{Y}_t)$

$\eta_t = (\eta_{\mathrm{ED}}, \eta_{\mathrm{Glob}}, \eta_{\mathrm{IP}}, \eta_{\mathrm{EC}}, \eta_{\mathrm{Y}})$

Where, $\delta_1 - \delta_k$ are 5x5 matrices of coefficients, and η is a vector of error terms.

IV. Results and Discussion

Table-2 explains the results of descriptive statistics. The standard deviation in globalization is highest which shows high volatility compare to other variables. The high instability seems in economic growth by comparing with environmental degradation. Similarly, energy consumption is less volatile by comparing with other variables. Jarque-Bera shows that our data series are stable, having zero mean and constant variance. This suggests that we should move for further analysis.

Table-2: Descriptive Statistics

Variables	ln ED_t	ln $Glob_t$	ln IP_t	ln EC_t	ln Y_t
Mean	-0.8417	3.1850	22.777	4.4884	5.9529
Median	-0.7552	3.1622	22.723	4.8257	5.8534
Maximum	-0.4310	3.7708	24.310	5.4847	6.6599
Minimum	-1.5992	2.5712	21.010	4.4648	5.5491
Std. Dev.	0.3159	0.4117	0.8613	0.2813	0.3209
Skewness	-0.6497	0.0080	0.0675	0.5718	0.7425
Kurtosis	2.2048	1.5031	1.9871	2.2615	2.3625
Jarque-Bera	4.2549	4.1082	1.9141	3.3982	4.7880
Prob.	0.1191	0.1282	0.3840	0.1828	0.0912

There are many unit root tests available in the literature to investigate the unit root properties of time series data such as ADF by Dicky and Fuller, (1981); PP by Phillips and Perron, (1988); DF-GLS by Elliote *et al*. (1996) and Ng-Perron, (2001). ADF and PP unit root tests are used in this study to ensure that no variable is integrated at *I(2)* because these tests have best predicting power and suitable for the short sample period such as ours. The results of ADF and PP unit root tests are reported in table-3. Empirical evidence shows that data series is not stationary at level, but found to be stationary after taking first difference. This implies that the data series are integrated at *I(1)*. After confirming the order of integration, we estimate the VAR lag length criteria to select optimal lag length. The results of the VAR lag length approach are displayed in table-4. We follow Akaike Information Criterion (AIC) for optimal lag selection because AIC has superior properties for a small sample set, pointed by Lütkepohl, (2006). Akaike information criterion provides efficient and consistent results compare to other criteria's such as final prediction error (FPE), Schwarz information criterion (SBC) and Hannan Quinn Information criterion (HQ). The result of AIC shows that the optimal lag is 2 in the yearly data of 1972-2015 for Bangladesh.

Table-3: Unit root Analysis

Variables	ADF Unit Root Test.			Phillips-Perron Unit Root Test.		
	T-statistics "Intercept	Prob. Value	Decision	T-statistics "Intercept	Prob. Value	Decision

	and Trend			and Trend		
$\ln ED_t$	-0.9412	0.9413	Not stationary	-2.6950	0.2437	Not stationary
$\ln Glob_t$	-2.2784	0.4361	Not stationary	-2.2681	0.4415	Not stationary
$\ln IP_t$	0.3172	0.9981	Not stationary	-1.2276	0.6539	Not stationary
$\ln EC_t$	0.2743	0.9978	Not stationary	0.3154	0.9981	Not stationary
$\ln Y_t$	0.4631	0.9989	Not stationary	1.2457	0.9999	Not stationary
$\Delta\ln ED_t$	-11.613*	0.0000	Stationary	-26.026*	0.0000	Stationary
$\Delta\ln Glob_t$	-7.6111*	0.0000	Stationary	-7.6111*	0.0000	Stationary
$\Delta\ln IP_t$	-5.1399*	0.0008	Stationary	-14.378*	0.0000	Stationary
$\Delta\ln EC_t$	-9.2629*	0.0000	Stationary	-10.8428*	0.0000	Stationary
$\Delta\ln Y_t$	-9.6283*	0.0000	Stationary	-9.7956*	0.0000	Stationary
Note: * shows the significance at 1 percent level of significance.						

Table-4: Lag Length Criteria

VAR Lag Order Selection Criteria						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	222.6591	NA	1.29e-11	-10.88295	-10.67184	-10.80662
1	447.4432	382.1331	6.00e-16	-20.87216	-19.60550*	-20.41418
2	488.0187	58.83452*	2.93e-16*	-21.65094*	-19.32873	-20.81130*
3	505.8028	21.34081	4.94e-16	-21.29014	-17.91238	-20.06885
4	533.9444	26.73459	5.97e-16	-21.44722	-17.01391	-19.84428
* indicates lag order selected by the criterion.						
LR: sequential modified LR test statistic (each test at 5% level) FPE: Final prediction error AIC: Akaike information criterion SC: Schwarz information criterion HQ: Hannan-Quinn information criterion **Source:** Author's calculations						

All unit root tests confirm the integration at 1st difference, i.e. *I(1)*. This unique order of integration suggests us to apply ARDL bound testing approach of cointegration by Pesaran *et al.* (2001). The result of the ARDL bound testing approach is reported in table-5. The critical values of Pesaran *et al.* (2001) are inappropriate for small data set. Therefore, we use critical value taken from Narayan, (2005). The results reveal that calculated F-statistics is exceeded from upper critical value 1 per cent level of significance, once we take environment degradation, industrial production, energy consumption and economic growth as predicted variables, but it is not true for globalization. This shows the existence of four cointegration vectors that confirm the long run relationship between underlying variables for the period of 1972-2015 in Bangladesh. The sensitivity analysis, such as LM test for serial correlation, normality of residual term and white heteroscedasticity provide no evidence of serial correlation, autoregressive conditional heteroscedasticity and white heteroscedasticity while investigating the ARDL model of environment degradation, industrial production, economic growth, and energy consumption.

Table-5: ARDL Approach to Cointegration

Bound testing to cointegration	Diagnostic tests

Estimated Models	Optimal lag length	F-statistics	χ^2 Normal	χ^2 ARCH	χ^2 RESET	χ^2 SERIAL
ln ED_t	(3, 1, 1, 4, 4)	11.160*	0.5624	[1]: 0.3130	[1]: 0.8063	[5]: 0.1797
ln $Glob_t$	(1, 0, 0, 0, 2)	1.1509	0.0111	[1]: 0.9473	[1]: 0.1201	[1]: 0.4540
ln IP_t	(3, 4, 0, 0, 0)	7.1499*	0.9148	[2]: 0.1572	[1]: 0.9613	[1]: 0.5416
ln EC_t	(1, 3, 0, 0, 2)	6.7872*	0.1944	[1]: 0.7434	[1]: 0.1638	[1]: 0.5510
ln Y_t	(5, 5, 5, 3, 5)	6.6517*	0.3423	[1]: 0.5712	[1]: 0.4798	[1]: 0.3963
Critical values (T=44) # Narayan, (2005)[4]						
Significance level.		Lower bounds $I(0)$		Upper Bounds $I(1)$		
1 %		4.628		5.865		
5 %		3.512		4.587		
10 %		2.985		3.918		
Note: * shows the significance at 1 percent level of significance. The optimal lag length is determined by AIC. [] is the order of diagnostic tests. # shows that critical values are collected from Narayan, (2005).						

The robustness of the ARDL bounds testing is checked by applying combine cointegration proposed by Bayer and Hanck, (2013). It also satisfies the precondition of 1st order of integration for applying combine cointegration. The result of combine cointegration is displayed in table-6. The findings reveal that calculated F-statistics of EG-JOH and EG-JOH-BO-BDM for environmental degradation is greater than the critical value of F-statistics. Therefore, we reject the null hypothesis of no cointegration. Similarly, calculated F-statistics of EG-JOH and EG-JOH-BO-BDM for industrial production is also significant at 1 per cent and 5 per cent level of significance respectively. When we use the energy consumption as dependent variables, we find that F-statistic for EG-JOH and EG-JOH-BO-BDM tests exceed the critical values at the 5% level of significance. Similarly, the F-statistic for EG-JOH and EG-JOH-BO-BDM tests exceed the critical values at 5 percent and 10 percent level of significance respectively once we use the economic growth as a dependent variable. Only for globalization, calculated F-statistics of EG-JOH and EG-JOH-BO-BDM is not significant. This confirms the existence of four cointegration vectors. It means a long run relationship exists between globalization, environment degradation, economic growth, industrial production and energy consumption over the period of 1972-2015 for Bangladesh. The findings of Bayer and Hanck, (2013) cointegration approach are robust and consistent with the ARDL bounds testing estimates.

Table-6: Bayer and Hanck Combine Cointegration

Estimated models	EG-JOH	EG-JOH-BO-BDM	Lags	Cointegration
ln ED_t	14.1107**	48.7549*	2	Yes
ln $Glob_t$	9.6689	10.6533	2	No
ln IP_t	20.8453*	21.0916**	2	Yes

[4] The critical values of bounds from Pesaran *et al*. (2001) are suitable for large sample size (T = 500 to T = 40, 000). Narayan and Narayan, (2005) argue that the critical values of bounds from Pesaran *et al*. (2001) are smaller, so may produce biased results for large sample size. Narayan's (2005) values are more appropriate for small samples of size T = 30 to T = 80.

ln EC_t	11.3234**	27.2300**	2	Yes
ln Y_t	11.6882**	17.3421***	2	Yes
Significance level				
1%	15.845	30.774		
5%	10.576	20.143		
10%	8.301	15.938		
Note: *, ** and *** represent significant at 1 percent, 5 percent and 10 percent level of significance. Lag length is based on minimum value of AIC.				

The long run coefficients are reported in the Table 7. The long run coefficients suggest that globalization, industrial production and energy consumption have a positive and significant impact on environmental degradation. We noted that one percent increase in globalization and industrial production lead to increase in environmental degradation by 0.3 and 0.52 percent respectively in the long run by holding the effect of other variables constant. In late 90's, Bangladesh government has adopted trade liberalization policy for import of inputs and technologies however, an increase in consumers and non-productions goods caused to rise in environmental degradation. Similarly, energy consumption has a positive and significant relationship with CO_2 emission. Bangladesh has developed many policies to control environment degradation for the time period of 2010-2021 such as national energy policy (NEP), national renewable energy policy (NREP) and strategic transportation plans (STP). The core objectives of these plans are fuel switch, introduction of renewable and nuclear energy, energy efficient equipment and Advance technology for public transport. It is necessary to understand socioeconomic variables such as, energy consumption (demand) or CO_2 emission (Rahman, 2002). This analysis provides required information for underlying planes. Economic growth has negative and significant impact on environmental degradation.

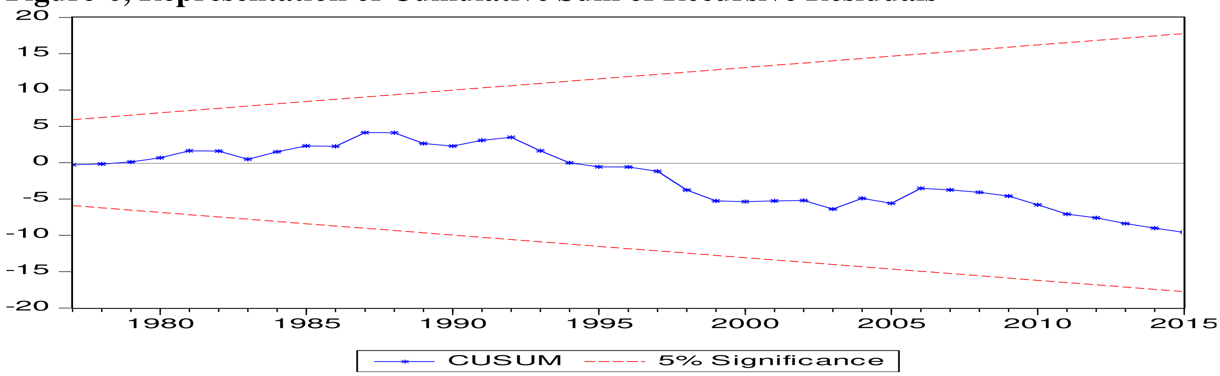
All variables are significant at 1 per cent level of significance. R-squared value is 0.977 which shows that 97 per cent of the independent variable is explained by dependent variables. The diagnostic tests of long run analysis survive the problem of serial correlation, white heteroscedasticity and normal distribution of residuals. Further, we have applied a cumulative sum and the cumulative sum of square tests to check the stability of long run parameters. Figure 6 and 7 suggest that long run parameters are stable.

Table-7: Long Run Analysis

Dependent variable: ln ED_t			
Variables	Coefficient	Std. error	T-statistics
ln $Glob_t$	0.3010*	0.0974	3.0899
ln IP_t	0.5213*	0.0687	7.5814
ln EC_t	1.0626*	0.3434	3.0941
ln Y_t	-1.8300*	0.2327	-7.8645
R-squared	0.9777		
Durbin-Watson	1.5768		
F-statistics	428.31		
Prob.	0.0000		
Diagnostic tests:			

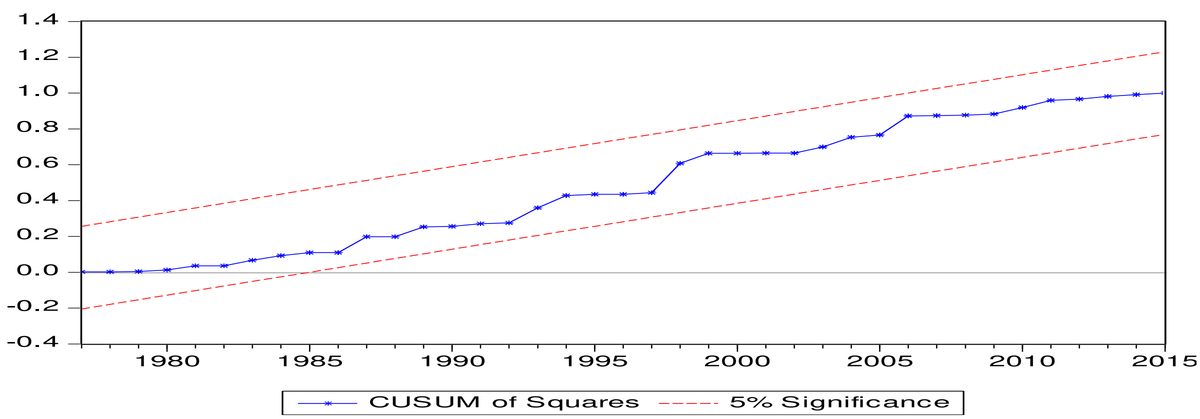
	Statistics	Prob.
Breusch-Godfrey LM test	0.7521	0.4784
ARCH test	0.1458	0.8648
White Heteroskedasticity test	0.9774	0.4902
Ramsey RESET test	2.0485	0.1433
J-B Normality test	0.6640	0.7174
CUSUM	Stable	5% significance
CUSUM of Square	Stable	5% significance
Note: * shows the significant at 1 percent level of significance.		

Figure-6, Representation of Cumulative Sum of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

Figure-7, Representation of Cumulative Sum of Squares of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

The results of the short run analysis are reported in table-8. The short run results suggest that globalization and industrial production have positive and significant impact on environmental degradation at 10 and 1 percent level of significance respectively. Economic growth has negative and significant impact on environmental degradation at 1 per cent level of significance in short run. We suppose that all else is same, 1 percent increase in globalization, industrial production and energy consumption increase the environment degradation by 0.3, 0.38 and 1.17 per cent respectively in the short run. Similarly, 1 percent rise in economic growth is linked with a 1.8 percent decrease in environmental degradation by remaining other things constant. These results are also consistent with the results of Dogan and Turkekul, (2016); Farhani and Ozturk, (2015); Farhani *et al.* (2014) and Ahmad et al. (2015). The lagged value of ECM is -0.75 that is significant at 1 per cent level of significance. $ECM_{(t-1)}$ shows the speed of adjustment from disequilibrium to equilibrium. This indicates that movement from short run towards long run are corrected by 75 percent in each year and it will take almost 1 years and 3 months to reach the equilibrium path. R-square value is 0.64 that shows 64 percent of the dependent variable is explained by the independent variables. F-statistics confirms the significance of overall model in the short run. The diagnostic tests provide no evidence of serial correlation, normality of residual term, autoregressive conditional heteroscedasticity and white heteroscedasticity in the short run.

Table-8: Short Run Analysis

Dependent variable: $\Delta \ln ED_t$			
Variables	Coefficient	Std. error	T-statistics
$\Delta \ln Glob_t$	0.3287***	0.1740	1.8891
$\Delta \ln IP_t$	0.3896*	0.0930	4.1860
$\Delta \ln EC_t$	1.1788*	0.2942	4.006
$\Delta \ln Y_t$	-1.7022*	0.3381	-5.0341
ECM_{t-1}	-0.7599*	0.1605	-4.7327
R-square	0.6442		
Durbin-Watson	2.0494		
F-statistics	13.4003		
Prob.	0.0000		
Diagnostic tests:			
	Statistics	Prob.	
Breusch-Godfrey LM test	0.2064	0.8145	
ARCH test	0.2978	0.7442	
White Heteroscedisticity test	0.8836	0.6074	
Ramsey RESET test	0.4316	0.6528	
J-B Normality test	0.2887	0.8655	
CUSUM	Stable	5% significance	
CUSUM of Square	Stable	5% significance	
Note: * and *** represent the significant at 1 percent and 10 percent level of significance.			

Once the cointegration has confirmed between globalization, environment degradation, economic growth, energy consumption and industrial production, we proceeded to detect the direction of causality to understand the causal relationship between considered variables. Engle-Granger (1987) demonstrated that if variables are cointegrated, there must be short run and the long run causal relationship between them. The Vector Autoregressive model is likely to be used for this purpose. Table-9 describes the results of the VECM Granger causality approach. The findings show that bidirectional causality exists between energy consumption and environmental degradation in the short run as well as the long run. Similarly, bidirectional causality seems between economic growth and environmental degradation in the long run as well as in the short run. These findings are confirmed by Ahamd *et al*. (2015); Glasure, (2002); Yoo, (2005); Jumbe, (2004) and Shahbaz *et al.* (2012a). Environment degradation causes industrial production in granger sense for both long run and short run. Unidirectional causality has found running form energy consumption to industrial production for short-long run. Bidirectional causality exists between economic growth and industrial production in short-long run. Moreover, bidirectional causality has found between economic growth and energy consumption in the short run as well as the long run.

Table-9: VECM Granger Causality Analysis

Dependent variables	Short run					Long Run
	$\Delta\ln ED_t$	$\Delta\ln Glob_t$	$\Delta\ln IP_t$	$\Delta\ln EC_t$	$\Delta\ln Y_t$	ECM_{t-1}
$\Delta\ln ED_t$	---	2.0576 (0.1448)	1.9458 (0.1599)	6.6615* (0.0040)	6.0196* (0.0062)	-0.7246* (0.0019)
$\Delta\ln Glob_t$	0.3435 (0.7119)	---	0.2582 (0.7740)	1.3676 (0.2696)	0.2226 (0.8017)	---
$\Delta\ln IP_t$	2.8124*** (0.0754)	1.1501 (0.3297)	---	2.5236*** (0.0965)	12.598* (0.0001)	-0.4364** (0.0203)
$\Delta\ln EC_t$	5.8620* (0.0069)	2.1116 (0.1381)	1.1272 (0.3368)	---	7.5016* (0.0022)	-0.7109* (0.0013)
$\Delta\ln Y_t$	5.9358* (0.0066)	3.1349*** (0.0576)	13.1018* (0.0001)	9.5744* (0.0006)	---	-0.3374*** (0.0718)
Note: *, ** and *** represent the significant at 1, 5 and 10 percent level of significance.						

It is argued that Granger causality has some limitations. It does not show the strength of causal relationship. This weakness is covered by variance decomposition approach. The Variance Decomposition Approach (VDA) not only explain the strength of causal relationship but also indicates the magnitude of the predicted error variance for a series accounted for by innovations from each of the independent variable over different time-horizons beyond the selected time period. Pesaran and Shin (1999) pointed that variance decomposition approach shows the proportionate contribution in one variable due to shocks stemming in other variable. Engle and Granger (1987) and Ibrahim (2005) argued that variance decomposition procedure provides improved results as compared to other approaches.

The findings of variance decomposition approach are reported in table-10. The results suggest that 69 percent portion of globalization is explaining by its own innovative shock while innovative shocks of industrial production, economic growth, environmental degradation and energy consumption contribute in explaining globalization by 23.9 %, 2.4 %, 2.8 % and 1.5 % respectively. Similarly, globalization, environmental degradation and energy consumption explain industrial production by 26.9 %, 14.36 % and 0.2 % respectively. Industrial production has higher portion in explaining globalization while globalization and environmental degradation have greater share in explaining industrial production. Further, variance decomposition of globalization, industrial production, environmental degradation and energy consumption attribute to economic growth by 59.6 %, 6.02 %, 3.14 % and 2.8 % respectively. The 2.8 %, 51.7 %, 7.4 % and 1.2 % of environmental degradation is attributed by globalization, industrial production, economic growth and energy consumption respectively. The innovative shocks stemming in globalization, industrial production, economics growth and environmental degradation explain energy consumption by 36.9 %, 13.3 %, 12.4 % and 15.2 % respectively. Overall results of variance decomposition method validate that the results of VECM Granger causality are robust and reliable.

Table-10: Variance Decomposition Approach

Variance Decomposition of ln *Glob*.						
Period	S.E.	ln *Glob*	ln *IP*	ln *Y*	ln *ED*	ln *EC*
1	0.0427	100.00	0.0000	0.0000	0.0000	0.0000
2	0.0529	95.781	0.0602	0.1613	0.2677	3.7294
3	0.0588	94.077	2.3652	0.1452	0.2782	3.1340
4	0.0644	92.055	4.1999	0.8315	0.2514	2.6618
5	0.0693	89.340	6.9843	0.9859	0.3956	2.2937
6	0.0735	86.003	9.7384	1.4988	0.7198	2.0397
7	0.0776	82.082	13.127	1.7646	1.1677	1.8574
8	0.0815	78.027	16.318	2.1942	1.7506	1.7091
9	0.0854	73.895	19.613	2.4725	2.4041	1.6141
10	0.0983	69.246	23.948	2.4021	2.864	1.5378
Variance Decomposition of ln *IP*.						
Period	S.E.	ln *Glob*	ln *IP*	ln *Y*	ln *ED*	ln *EC*
1	0.0491	0.6598	99.340	0.0000	0.0000	0.0000
2	0.0665	5.0806	87.529	0.0065	7.0612	0.3223
3	0.0778	10.169	76.069	0.0101	13.273	0.4809
4	0.0863	13.681	71.085	0.0082	14.804	0.4203
5	0.0942	16.242	68.428	0.0079	14.960	0.3607
6	0.1017	18.707	65.987	0.0068	14.980	0.3176
7	0.1089	21.111	63.659	0.0060	14.9395	0.2829
8	0.1157	23.283	61.660	0.0056	14.796	0.2534
9	0.1223	25.204	59.971	0.0060	14.589	0.2288
10	0.1288	26.902	58.514	0.0077	14.367	0.2082
Variance Decomposition of *ln Y*.						
Period	S.E.	ln *Glob*	ln *IP*	ln *Y*	ln *ED*	ln *EC*
1	0.0127	0.0624	53.055	46.881	0.0000	0.0000
2	0.0146	2.6498	43.461	43.042	10.516	0.3297
3	0.0182	13.863	28.762	45.626	11.534	0.2127

4	0.0206	22.154	22.575	43.229	10.431	1.6099
5	0.0237	30.167	17.081	42.733	8.2362	1.7820
6	0.0267	38.042	13.561	39.217	6.7619	2.4174
7	0.0301	44.895	10.665	36.513	5.4212	2.5047
8	0.0333	50.739	8.6959	33.309	4.4716	2.7825
9	0.0368	55.554	7.1567	30.7732	3.7083	2.8068
10	0.0401	59.684	6.0273	28.2551	3.1476	2.8851
Variance Decomposition of ln *ED*.						
Period	S.E.	ln *Glob*	ln *IP*	ln *Y*	ln *ED*	ln *EC*
1	0.0532	3.4626	4.3514	0.6632	91.522	0.0000
2	0.0576	2.9557	15.897	1.6716	79.241	0.2341
3	0.0655	2.5217	31.954	2.4412	62.878	0.2044
4	0.0718	2.8616	38.078	3.6292	55.053	0.3775
5	0.0771	3.2562	41.422	4.5114	50.231	0.5781
6	0.0819	3.3265	44.279	5.3444	46.343	0.7056
7	0.0866	3.2583	46.850	5.9566	43.085	0.8493
8	0.0909	3.1351	48.827	6.5334	40.5228	0.9807
9	0.0950	2.9863	50.443	6.9937	38.4673	1.1092
10	0.0989	2.8208	51.760	7.4184	36.780	1.2194
Variance Decomposition of ln *EC*.						
Period	S.E.	ln *Glob*	ln *IP*	ln *Y*	ln *ED*	ln *EC*
1	0.0193	3.2627	0.7162	1.3281	23.970	70.722
2	0.0210	12.229	4.1027	1.1455	21.548	60.973
3	0.0232	10.398	14.020	4.7986	20.642	50.139
4	0.0246	10.245	17.167	5.7653	22.274	44.547
5	0.0264	12.961	17.913	8.0417	22.228	38.854
6	0.0279	16.406	17.546	9.4290	21.643	34.973
7	0.0296	20.866	16.837	11.051	20.174	31.069
8	0.0315	26.107	15.728	11.781	18.585	27.796
9	0.0336	31.595	14.532	12.381	16.823	24.667
10	0.0357	36.912	13.368	12.482	15.200	22.036

Figure-8 shows the results of impulse response function. The results indicate that the response in environmental degradation due to forecast error stemming in energy consumption initially move to negative horizon then increase after 3^{rd} time horizon. The response of environmental degradation to industrial production is positive but, economic growth contributes negatively. The response in energy consumption due to shocks stemming into environmental degradation and economic growth is positive. The response of energy consumption to globalization and industrial production is positive, increase and decrease after 3^{rd} time horizon respectively. The globalization reacts positively and increasing when shocks accrue in environmental degradation and industrial production but, it response negatively with economic growth. The energy consumption has minimum response to globalization. The response of industrial production to environmental degradation is positive, initially increasing then decline till 4-time horizon. The globalization has positive and upward response to industrial production. The environmental degradation and globalization contribute positively but energy consumption contributes negatively to economic growth.

V. Conclusion and Implications

This paper investigates CO_2 emission function for an annual period of 1972-2015 in case of Bangladesh. The ADF and PP unit root tests have used to analyze the stationary of data and their results reveal that data is stationary at 1st difference or *I(1).* We employed ARDL bound test to analysis the long run relationship between energy consumption, globalization, economic growth, and industrialization and Environmental degradation. Further, we applied Bayer-Hanck combine cointegration to test the findings of ARDL approach. Our empirical results indicate the presence of cointegration among variables in environment degradation model as well as industrial production, economic growth and energy consumption. This study is using an overall globalization index that is a combination of the three indexes, "Social Globalization", "Political Globalization" and "Economic Globalization". Globalization has a positive and significant impact on environmental damages in the short run as well as in the long run. Globalization has found main determinant of CO_2 emission in Bangladesh. Similarly, energy consumption and industrial production also have a positive significant impact on environmental quality for both the long and short run while; economic growth has found a negative and significant relationship with CO_2 emission for short-long run.

The findings of VECM Granger causality explain that bidirectional causality exists between energy consumption and environment degradation, industrial production and economic growth, and energy consumption and economic growth. Although, globalization does not cause environmental degradation in the short run, but causes environmental quality in the long run. A unidirectional causality has found running from environmental degradation and energy consumption to industrial production. Economic growth is granger caused by environmental degradation and reverse holds true. The results of VECM Granger causality are also verified by innovative accounting approach. The Porter's Hypothesis states that when income increases with trade openness, developing countries tend to impose stricter environmental regulations on themselves to adopt environmental friendly production patterns. In result, pollution reduces and competitiveness improves. Policymakers may focus on imports of advance technology, inputs goods and export led growth strategy that will help in reduction of CO_2 emission. When Bangladesh's economy will move higher stage of development by adopting advanced technologies and export led growth strategy, they will get economic progress, and they will try to limit on their carbon emissions.

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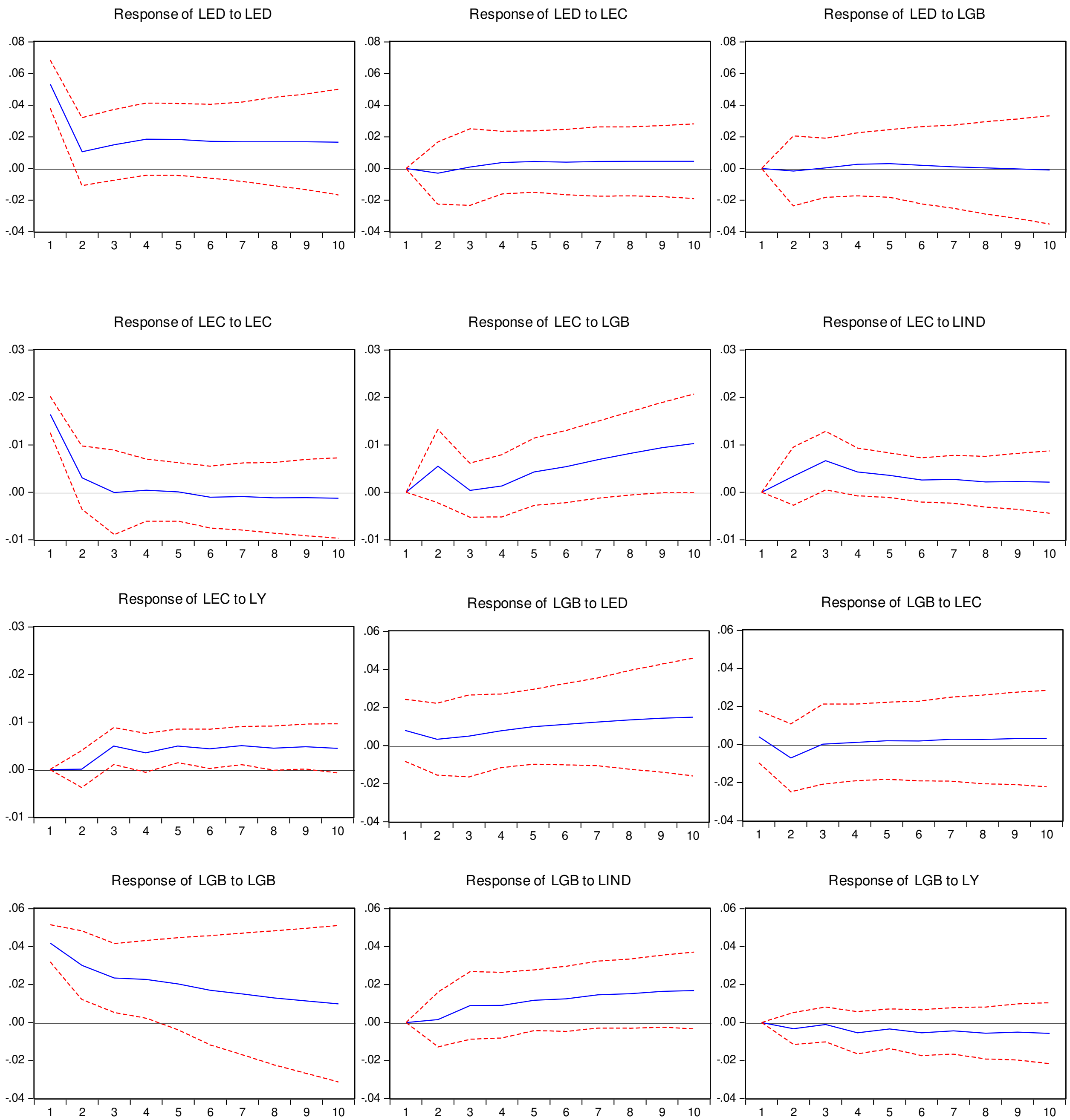
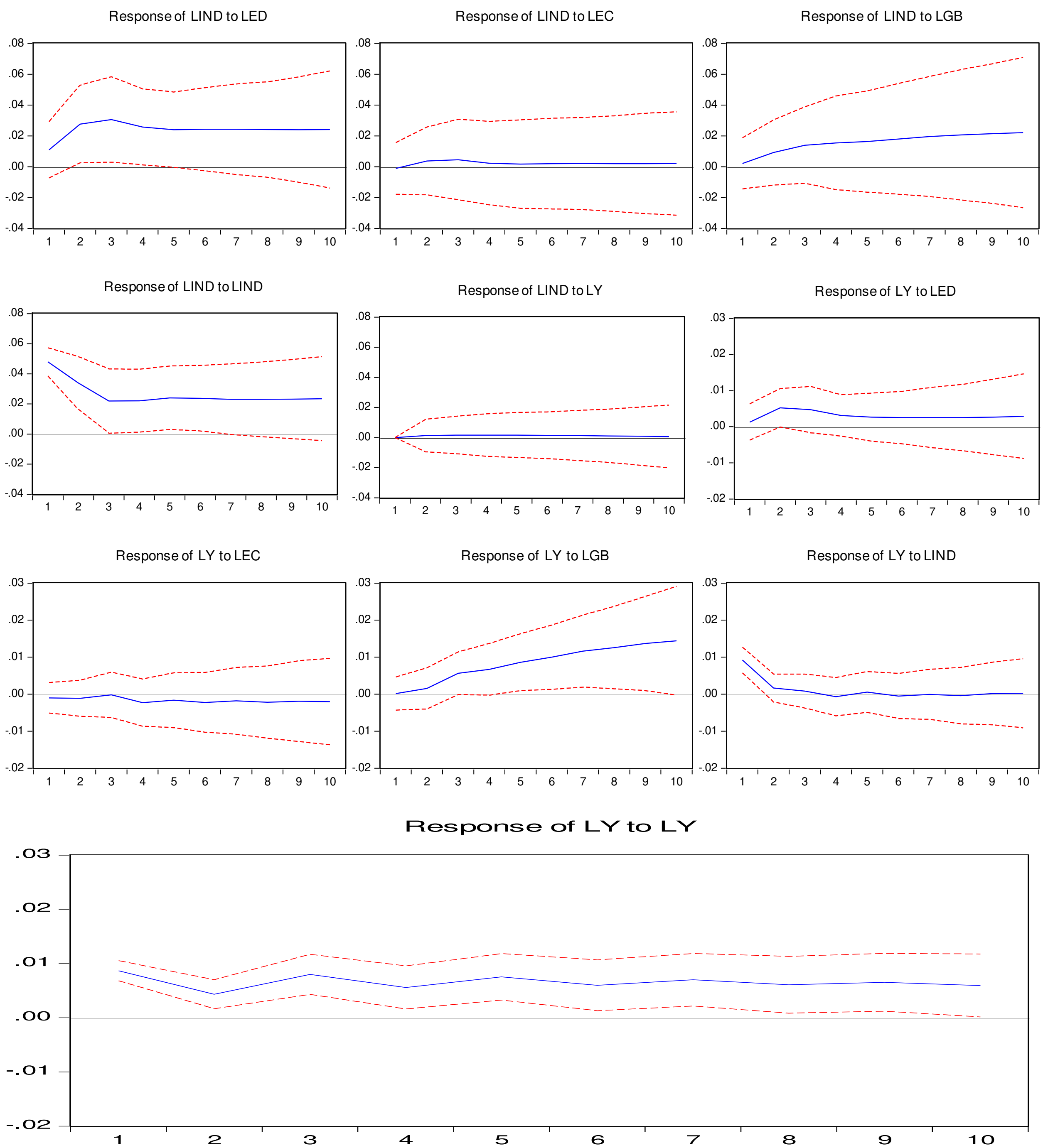
Appendix:

Figure-8: Impulse Response Function

Response to Cholesky One S.D. Innovations ± 2 S.E.




Response of LIND to LED
Response of LIND to LEC
Response of LIND to LGB
Response of LIND to LIND
Response of LIND to LY
Response of LY to LED
Response of LY to LEC
Response of LY to LGB
Response of LY to LIND
Response of LY to LY