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Factors Contributing CO_2 Emissions: A Linear, Nonlinear, and Panel ARDL Model

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Abstract: The study examines the linear and nonlinear relationships between per capita carbon dioxide emissions, per capita real GDP, energy consumption, financial development, foreign direct investment, trade openness, urbanization, agriculture, and industry sectors as potential determining factors of CO_2 emissions in the perspective of Bangladesh all through 44 years, starting from 1974. The study also considers the CO_2 emissions from the selected South Asian countries over the period from 1978 and 2018. The study uses three cointegration approaches. First, we employ linear cointegration method and find that crucial determining factors of CO_2 emissions in Bangladesh are real GDP per capita, energy consumption, and urbanization. Then, we apply the nonlinear cointegration method and find that energy consumption and foreign direct investment have asymmetric impacts on carbon release in the long run. While energy consumption, financial development, and FDI have asymmetric influence in the short run. Finally, we apply a panel cointegration test to compare Bangladesh with other South Asian countries in terms of CO_2 emissions. The estimated results disclose that the vital contributing factors of CO_2 emissions in selected South Asian countries are real GDP, energy consumption, financial development, and urbanization. Our results show that energy consumption, financial development, and urbanization upturn CO_2 emissions, while trade openness lowers emissions. We claim that our results are consistent with the EKC hypothesis for both in Bangladesh and selected South Asian countries. The three cointegration estimation findings disclose that urbanization will deteriorate environmental worth in Bangladesh and selected South Asian countries in the long run.

Keywords: CO_2 Emissions, Energy Consumption, Financial Development, FDI, Urbanization, Linear and Nonlinear ARDL

1. Introduction

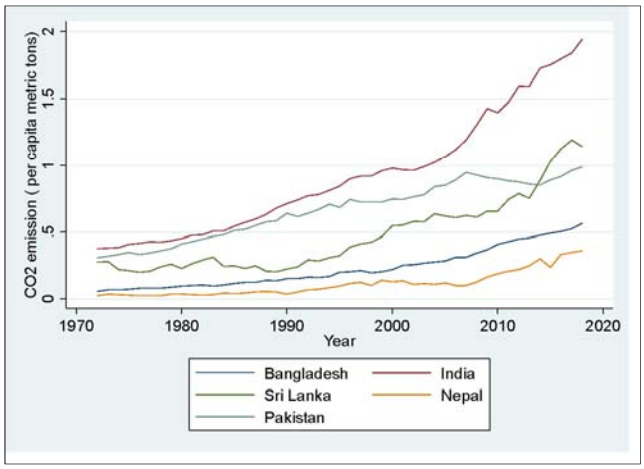
Global warming, the long-term upsurge of the average global surface temperatures, is the major problem of humankind. An IPCC special report 2018 discloses that human-initiated warming stretched just about 1°C higher in 2017 than pre-industrial stage, rising at 0.2°C each decade. The report also cites that warming above the global average has been perceived in many different areas and different seasons; higher average warming is experienced over the land than over the ocean. In accordance with World Bank Group [81], Bangladesh will be one of the most affected countries in South Asia by global warming with increasing sea surface and devastating tropical storms endangering cultivation, livelihood, and infrastructure.

Among greenhouse gases (GHG) emission, CO_2 emission is considered to be the foremost provider of global warming. Economic development since the industrial revolution has amplified the atmospheric concentration of CO_2 from 280 parts per million (ppm) in 1750 to 415.26 ppm in 2019. Human activities, industrial development, fossil fuel vehicles, and household appliances have accelerated the rising demand for energy that causes increasing carbon emissions.

Energy can be considered as an obligatory foundation for social and economic development [41]. Pressure on energy use is rising gradually in Bangladesh owing to mainly

increasing numbers of population, the development of industry on an extensive scale, immense dependency on motor transportation, and use of contemporary domestic equipment. However, the major portion of the energy use in Bangladesh is derived from fossil fuel.

Bangladesh is becoming one of the fastest rising economies in South Asia. In 2019, the average annual growth rate of the country was 8.15%, whereas major contribution was generated from the industry sector (approximately 30 percent). According to the World Bank, the carbon dioxide release of Bangladesh was 0.20 per capita metric tons in 1996 that raised to 0.53 MT per capita in 2016 at an average yearly increasing rate of 8.25%. Carbon emissions created from energy use have been raised considerably in recently grown-in industrial countries since the 1990s with comparison to industrialized countries [43]. Similarly, Bangladesh witnessed a notable amount of economic growth in addition to financial development, urbanization, FDI, and trade openness over the last few years. However, this acceleration of economic activity is made at the cost of environmental dilapidation considered as CO_2 emissions. A few empirical studies have shown the association between all of these variables. Nevertheless, no studies have been undertaken concentrating on the causal association between these variables in the case of Bangladesh.



Source: World Development Indicators (WDI) online database

Figure 1. *The trends of CO_2 emissions in selected South Asian Countries, 1972-2018 (Metric tons).*

South Asia consists of the sub-Himalayan SAARC countries in the southern area of the Asian continent. It is the most heavily populated geographical zone in the world and approximately 800 million people of the South Asian countries are under pressure of climate change. South Asian countries are considered as a minor contributor to the world's carbon dioxide emissions. Total CO_2 emissions of these eight countries was 2736913.12 kilotons (kt) in 2016, which was aesthetically low with comparison to the two massive carbon emission countries, China (9893037.95 kt) and United States (5006302.08 kt). However, CO_2 emissions would not be unheeded because these countries documented a growing trend throughout the years, as presented in figure 1. Therefore, if there are no actions taken in policies related to this issue and if these happen, it is anticipated that the emission values will become more noteworthy. Figure 1 depicts that India was the biggest contributor to CO_2 emissions during 1972 and 2018, followed by Sri Lanka and other countries.

We apply both ARDL and NARDL approaches in this study as the ARDL method explains only positive shocks of the variables, while NARDL shows both positive and negative shocks of the variables. This study is diverse from the present literature in the following sense. Primarily, this study ranges from the empirical application of the frequently used ARDL modeling framework for CO_2 emissions to the nonlinear ARDL model. However, from our knowledge, the nonlinear ARDL model was not applied in any study to see the relationships between the considered variables for Bangladesh. Using the NARDL model, Ndoricimpa [56] found asymmetries linkage between the variables in South Africa. Similarly, Haug & Ucal [35] disclosed significant asymmetric effects of exports, imports, and FDI on CO_2 emissions per capita. Also, AhAtil et al. [3] established that economic growth, financial development, and economic globalization show an asymmetric shock on environmental dilapidation in the long run. Second, this study takes a new set of variables, which are carbon emissions, real GDP per capita, financial development, energy use, FDI, urbanization, trade openness, agriculture, and industry together as CO_2 emissions might not depend on only some of the variables. The study creates value to the contemporary literature by taking all the probable determinants into consideration. Finally, the study also uses the panel ARDL model to compare Bangladesh with other South Asian countries in terms of CO_2 emissions to realize the intensity. In our best knowledge, no one study takes these three cointegration (ARDL, NARDL, and panel ARDL) methods at a time in case of Bangladesh. Therefore, the aim of the study is to scrutinize the short-run and long-run linear and non-linear relationships between real GDP, energy use, FDI, trade openness, financial development, urbanization, agriculture, and industry on CO_2 emissions and to compare Bangladesh with other South Asian countries in terms of CO_2 emissions to realize the intensity.

This paper is structured into five sections. The other sections of the study are designed as: the following section represents the literature review. Section 3 explains the data and methodology, while empirical results are analyzed in section 4. Finally, the conclusion, as well as policy recommendations, are given in the last section.

2. Review of Literature

The causal associations between energy use and economic variables are examined since the 1970s with the leading accomplishments of Kraft and Kraft [48] in the USA, but the pragmatic results are indecisive [10]. At present, there is a comprehensive research on CO_2 emissions and its

determining factors. The aim of this section is to compile present literature concerning important variables that lead to CO_2 emissions. For our ease of understanding, we divided this section into five sub-sections.

2.1. Financial Development (FD) and CO_2 Emissions Nexus

In modern times, financial development is deliberated to be a vital cause forcing amount of carbon emissions, though in theory there prevail two conflicting opinions. Tadesse [79] argues that financial development inspires scientific innovations that stimulate productivity growth which cut environmental dilapidation through economic growth. Moreover, Chousa et al. [18] say that financial development through R&D may lead to higher energy efficiencies and consequently decline environmental degradation. Also, Kahouli [41] urged that by adding financial development, sample nations can minimize the consequences of enormous energy use on economic growth. Besides, Shahbaz et al. [74] discovered that energy use and FDI upsurge the French CO_2 emissions but financial development pulled it down over the period of 1955-2016.

On the other hand, Sadorsky [65, 66] describes that FD may damage the environmental quality with the help of the business, households, and wealth effect channels. Al-mulali & Binti Che Sab [5] and Al-mulali et al. [7] used a panel model in 30 Sub-Saharan African Nations and 23 selected European countries correspondingly and found energy use contributed significantly in rising both economic growth and FD but at the cost of high contamination, while trade openness reduces it. Applying the ARDL model, Farhani and Ozturk [27], Boutabba [16], and Sehrawat et al. [71] explored the consequences of financial development on CO_2 release in Tunisia, India, and Pakistan respectively and established that it tempts CO_2 emissions. Implementing GMM methods, Hao et al. [34] revealed that at the primary phase of economic growth, FD is environmental friendly. While the economy is extremely advanced, a comparatively greater level of FD is damaging to the excellence of the environment in China. Recently, Acheampong [1] used a similar method on a panel of 46 Sub-Saharan African countries and discovered FD modest economic growth to upsurge CO_2 emissions. However, implementing the ARDL procedure, Ozturk & Acaravci [59] revealed FD does not have any important influence on carbon discharges in Turkey in the long term. Likewise, Dogan and Turkekul [21] showed energy consumption and urbanization amplify environmental dilapidation, even as FD has no consequences on it, and trade improves the value of the environment. Analyzing the above literature we can say that there is no consent on the effect of FD on CO_2 emissions.

2.2. FDI and CO_2 Emissions Nexus

Recently, the causal association between FDI, energy use and CO_2 emissions has enlarged growing interest in the present literature [58], but the pragmatic results of the existing energy literature are not univocal [41]. To be specific, Implementing ARDL techniques, Mahmood and Chaudhary [52] found FDI has positive influence on CO_2 emissions. Also, G¨okmeno˘glu and Taspinar [30] established economic growth, energy consumption, and FDI are the long term determining factors of air contamination in Turkey. Their outcomes approve the pollution haven hypothesis. Similarly, Kivyiro & Arminen [45] found FDI seems to intensify carbon emissions in six Sub Saharan African nations. Furthermore, Hamid [33] revealed that FDI causes CO_2 emissions in Pakistan. In the same context, Behera & Dash [14] found that FDI has influence on the carbon emissions in the SSEA region. Applying the panel ARDL model, Tariq et al. [80] uncovered that FDI and trade openness might lift the economy by enhancing employment opportunities but they decay the environment in Pakistan and India.

As opposed to, Shaari et al. [72] showed that FDI does not have any effect on CO_2 release. Furthermore, using the panel model, Linh & Lin [51] established that when income level touches to 8.9341 (in logarithms), environmental depletion begins to diminish which supports the EKC hypothesis. Also, their estimated outcomes confirm that FDI influxes do not strengthen the environment degradation within these 12 Asian countries. In another study, implementing the ARDL approach, Kizilkaya [46] revealed that economic expansion and energy use have affirmative impacts on carbon emissions, yet, no significant association between FDI and carbon dioxide emissions in Turkey.

2.3. Trade Openness and CO_2 Emissions Nexus

In literature, there exists a positive, negative, and also a neutral association between trade and environmental pollution. Farhani et al. [25] used panel data for MENA nations and found energy consumption, GDP, and trade openness lead to further CO_2 release. Applying ARDL methodology, Ertugrul et al. [24] found trade openness leads to carbon emissions in India, Indonesia, China, and Turkey, even as it does not have any significance in the environment in Brazil, Thailand, and Korea during 1971-2011. Conversely, Jayanthakumaran et al. [40] found that international trade will tend to diminish CO_2 discharges in the short term in China. Also, Ozturk and Acaravci [59] established that an upturn in overseas trade raises CO_2 emissions in the long term in Turkey. Moreover, Kohler [47] showed trade openness in South Africa did not show any contribution in the long term growth in pollution concentrated actions nor in greater pollution levels.

2.4. Urbanization and CO_2 Emissions Nexus

The procedure of urbanization may be recognized as an imperative aspect of economic growth and the structure of the economy [29]. Urbanization discloses migration from rural areas to cities as it offers opportunities for employment, education, health services, transport, telecommunication, and other public amenities. Therefore, urbanization creates higher energy demand that leads to carbon emissions [85]. The

linkage between urbanization and CO_2 emissions has been examined comprehensively in current years. Researchers found varied results in their pragmatic studies. Ehrhardt-Martinez et al. [22] described that the association between urbanization and carbon dioxide releases could diverge from nation to nation and even the stage of development of the nation.

Applying the STIRPAT model, Shahbaz et al. [73] found a U-shaped linkage between urbanization and carbon emissions in Malaysia. Recently, Khoshnevis Yazdi and Dariani [44] exhibited that urbanization amplifies energy use and pollution in Asian countries. Similarly, Gasimli et al. [29] applied the ARDL method and revealed urbanization has a remarkable and negative effect on environmental degradation. Besides, Martinez-Zarzoso and Maruotti [54] discovered that an inverted-U shaped linkage between urbanization and CO_2 release, therefore, in some countries once urbanization touches a certain stage, the influence on pollution turns out to be negative, contributing to reducing environmental damage.

2.5. Empirical Literature in Bangladesh

In the context of Bangladesh, the study found a number of empirical literature that has been focused on the determining factors of carbon dioxide emissions. Employing Johansen cointegration test and VECM approach, Alam and Huylenbroeck [4] discovered that CO_2 release Granger causes economic growth. Applying similar methodology, Amin et al. [8] found long term cointegration subsists among the variables. Also, Islam et al. [38] found energy consumption is a key role player for the emissions, where trade liberalization lessens CO_2 emissions, but urbanization makes it worse. Likewise, Shahbaz et al. [75] found financial development and trade liberalization enhances energy pollutants using ARDL and innovative accounting approach.

In contrast, Rabbi et al. [63] showed that pollution in Bangladesh might upsurge due to higher economic growth. Using the ARDL method, Hossain and Hasanuzzaman [36] discovered that a higher level of urbanization and energy use is accountable for CO_2 emissions. Similarly, Oh Yeob and Bhuyan [57] established that energy consumption increases carbon emissions. Applying Johansen cointegration and VECM approaches, Sarker et al. [69] established the association between the variables in their inquiry, while Sharmin and Tareque [77] disclosed that energy intensity, urbanization, industrialization, and economic growth will upsurge more than 60 percent of the CO_2 emissions in Bangladesh in the long run. However, Alam [6] demonstrated that the presence of EKC "U" shape does not hold in Bangladesh.

Typically, the existing literature on the causal link between the contributing factors of carbon emissions in Bangladesh has gone through the linear cointegration test and Granger causality method, but no assured reply to this problem appeared. However, using identical approaches with similar variables will not bring any contribution, as they upturns only the number of contradictory results with different time periods [41]. Moreover, changes in economic activities, energy policy, and energy price may bring structural changes in the shape of energy use for a particular period in research. This makes a scope for the nonlinear association rather than the linear association between the variables [17, 49]. In this study, we apply nonlinear ARDL approach with the linear one to skip this setback, because NARDL portraits the effects of positive and negative shocks of the considered variables that might cause carbon emissions.

3. Data and Methodology

3.1. Data

The empirical analysis of the study is conducted by using annual data during the time of 1974-2018 in the context of Bangladesh. Data relating to per capita CO_2 emissions, real GDP per capita, energy consumption, financial development, FDI, trade openness, urbanization, agriculture, and industry have been collected from secondary sources: the World Development Indicators (WDI) online database[1]. This study also applies yearly data of particular South Asian nations explicitly Bangladesh, Pakistan, India, Nepal, and Sri Lanka for the duration of 1978-2018. Countries and variables have been selected depending on the availability of data.

Among greenhouse gas emissions, carbon dioxide release is deliberated as the major provider of climate change. In the study, CO_2 emission is measured by per capita metric tons. Energy consumption is estimated by kilograms of oil equivalent per capita. Real GDP per capita is in constant 2010 USD. Financial development is calculated by domestic credit to the private sector as a proportion of GDP. Foreign direct investment is enumerated by net inflows of the investment portion of GDP. Trade openness is counted using the number of imports and exports of commodities and services reckoned as a portion of GDP. Urbanization is measured by the urban population as a percentage of the total population. Agriculture is computed by agriculture, forestry, and fishing, as a share of GDP. The industry is measured by industry, including construction, as a share of GDP. Explanations of all the mentioned variables are gathered from the World Bank.

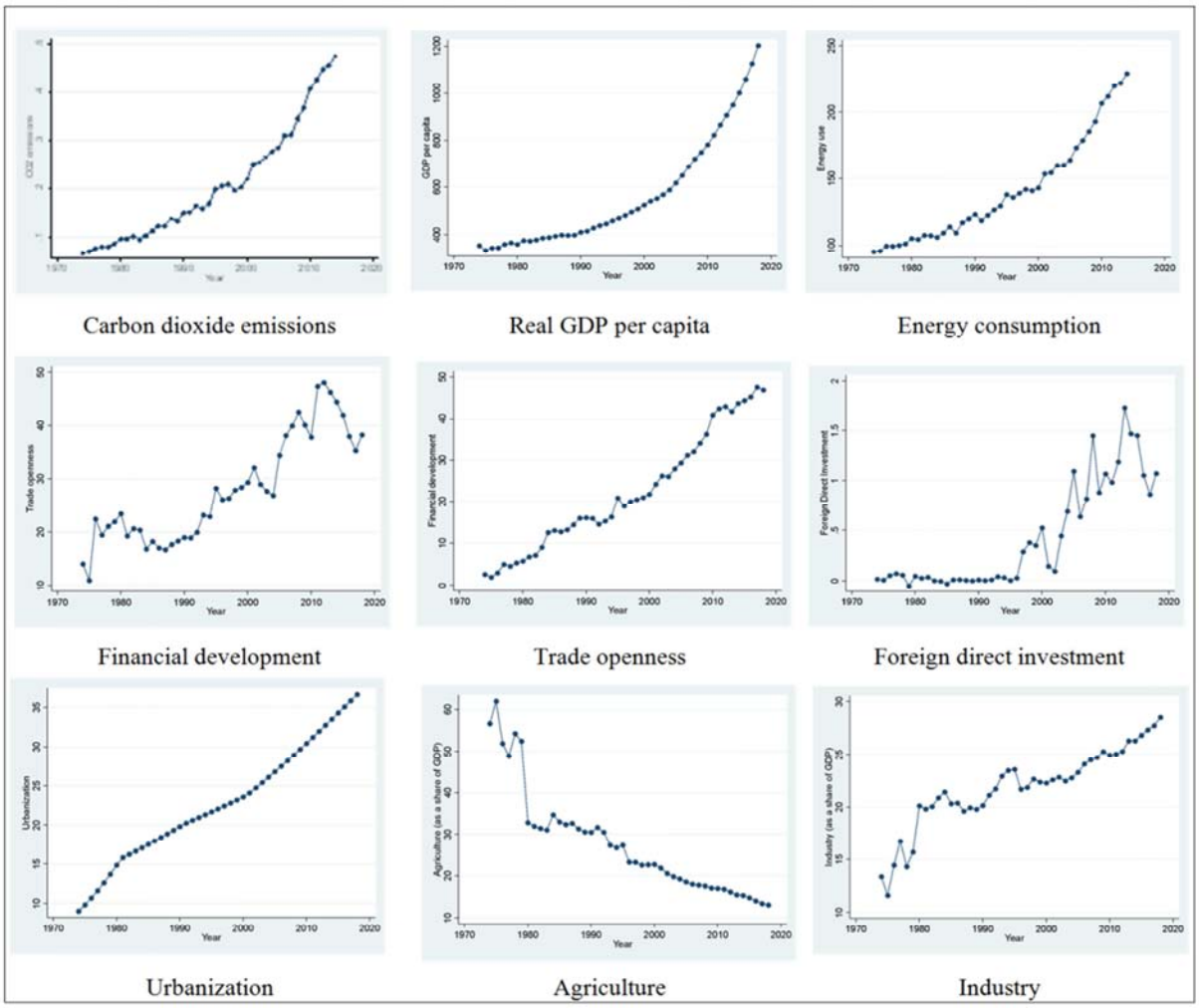
Time series plots of CO_2 emissions per capita and explanatory variables in the case of Bangladesh are presented in Figure 2. As shown in Figure 2, except trade openness and FDI, all the considered variables have been trending strictly upward over time, while trade openness and FDI have an uneven upward trend. Unlike other variables, only agriculture jumped down unevenly till 1990, afterward further descending at a constant gradual pace.

3.2. Methodology

In order to examine the long-term and short-term association between carbon emission per capita and explanatory variables, we apply both linear and nonlinear ARDL models. To understand the intensity, the study also apply the panel ARDL model so as to compare the stage of carbon emissions of Bangladesh compared to other selected

[1]https://data.worldbank.org/indicator

South Asian countries.



Source: World Development Indicators (WDI) online database

Figure 2. *The trends of per capita CO_2 emissions and explanatory variables, 1974-2018.*

3.2.1. Linear ARDL Model

The study apply ARDL bounds testing method launched by Pesaran et al. [61] and error correction representation of ARDL to analytically disclose the linear features of the variables. To detect the association between CO_2 emissions and its probable determining factor, this study will follow the empirical study of Sarkodie and Adams [70]. We divide our model into six specifications. Each specification consists of CO_2 emissions, real GDP per capita, energy consumption, and one of the explanatory variables. Thus, we can examine the influence of the individual variable on carbon emissions. Furthermore, we added financial development, FDI, trade openness, and urbanization together in model six to observe their influences on CO_2 emissions. The linear representation of the models can be expressed as:

Model 1:

$$\ln CO_{2_t} = \alpha_0 + \alpha_1 \ln GDP_t + \alpha_2 \ln GDP_t^2 + \alpha_3 \ln EC_t + \alpha_4 \ln FD_t + \varepsilon_t \quad (1)$$

Model 2:

$$\ln CO_{2_t} = \beta_0 + \beta_1 \ln GDP_t + \beta_2 \ln GDP_t^2 + \beta_3 \ln EC_t + \beta_4 \ln FDI_t + \beta_5 \ln TO_t + \varepsilon_t \quad (2)$$

Model 3:

$$\ln CO_{2_t} = \delta_0 + \delta_1 \ln GDP_t + \delta_2 \ln GDP_t^2 + \delta_3 \ln EC_t + \delta_4 \ln URB_t + \varepsilon_t \quad (3)$$

Model 4:

$$\ln CO_{2_t} = \lambda_0 + \lambda_1 \ln GDP_t + \lambda_2 \ln GDP_t^2 + \lambda_3 \ln EC_t + \lambda_4 \ln AG_t + \varepsilon_t \quad (4)$$

Model 5:

$$\ln CO_{2_t} = \psi_0 + \psi_1 \ln GDP_t + \psi_2 \ln GDP_t^2 + \psi_3 \ln EC_t + \psi_4 IND_t + \varepsilon_t \quad (5)$$

Model 6:

$$\ln CO2_t = \chi_0 + \chi_1 \ln GDP_t + \chi_2 \ln GDP_t^2 + \chi_3 \ln EC_t + \chi_4 \ln FD_t + \chi_5 \ln FDI_t + \chi_6 \ln TO_t + \chi_7 \ln URB_t + \varepsilon_t \quad (6)$$

Where, $\ln CO_2$=Natural logarithm of per capita carbon dioxide emission; lnGDP=Natural logarithm of real GDP per capita; $\ln GDP^2$=Natural logarithm of square of real GDP per capita; lnEC=Natural logarithm of energy consumption; lnFD=Natural logarithm of financial development; lnFDI=Natural logarithm of foreign direct investment; lnTO=Natural logarithm of trade openness; lnURB=Natural logarithm of urbanization; lnAG=Natural logarithm of agriculture; lnIND=Natural logarithm of industry; and e =error term.

(i) Unit Root Tests

ARDL procedure to cointegration can be used to determine whether the time series variables are an integrated order of I(0) or I(1) or mixed order but cannot be applied if any particular variable is greater than one. Therefore, we use two kinds of unit root tests such as a standard univariate Dickey Fuller-generalized least squares (DF-GLS) test, a customized form of the traditional ADF t-test, advanced by Elliott et al. [23] and Phillips and Perron [62] (PP) unit root test. The DF-GLS test does better as opposed to the ADF test for a small sample, can obtain the unknown tendency and mean within the data, and present a more precise predictive ability [53]. The PP test adds credibility to the unit root test results because it uses nonparametric statistical methods to correct heteroscedasticity and serial correlation in the error terms adjusting the test statistics. Also, another advantage of the PP test is that it does not need to specify lag length.

(ii) ARDL Cointegration Test

This paper uses the ARDL bounds test technique to show whether all discussed variables are cointegrated or not. We use ARDL bounds test technique as it is more convenient over other conventional cointegration approaches. First, the ARDL technique may be used whether the variables are I(0), I(1), or mixed order. Second, this method provides appropriate results with small sample size. Finally, it gives impartial estimations in the long-run equilibrium, and eliminates endogeneity problems. However, an error correction model (ECM) can be formed from the ARDL approach by a linear transformation. The error correction representation of the ARDL approach for Equations (1)-(6) are:

Model 1:

$$\Delta \ln CO2_t = \alpha_o + \lambda_1 \ln CO_{2_{t-1}} + \lambda_2 \ln GDP_{t-1} + \lambda_3 \ln GDP_{t-1}^2 + \lambda_4 \ln EC_{t-1} + \lambda_5 \ln FD_{t-1} + \sum_{i=1}^{a1} \beta_i \Delta \ln CO_{2_{t-i}} + \sum_{i=0}^{b1} \eta_i \Delta \ln GDP_{t-i} + \sum_{i=0}^{c1} \delta_i \Delta \ln GDP_{t-i}^2 + \sum_{i=0}^{d1} \varphi_i \Delta \ln EC_{t-i} + \sum_{i=0}^{e1} \phi_i \Delta FD_{t-i} + \varepsilon_t \quad (7)$$

Model 2:

$$\Delta \ln CO2_t = \alpha_o + \lambda_1 \ln CO_{2_{t-1}} + \lambda_2 \ln GDP_{t-1} + \lambda_3 \ln GDP_{t-1}^2 + \lambda_4 \ln EC_{t-1} + \lambda_5 \ln FDI_{t-1} + \lambda_6 \ln TO_{t-1} \sum_{i=1}^{a1} \beta_i \Delta \ln CO_{2_{t-i}} + \sum_{i=0}^{b1} \eta_i \Delta \ln GDP_{t-i} + \sum_{i=0}^{c1} \delta_i \Delta \ln GDP_{t-i}^2 + \sum_{i=0}^{d1} \varphi_i \Delta \ln EC_{t-i} + \sum_{i=0}^{f1} \theta_i \Delta TO_{t-i} + \varepsilon_t \quad (8)$$

Model 3:

$$\Delta \ln CO2_t = \alpha_o + \lambda_1 \ln CO_{2_{t-1}} + \lambda_2 \ln GDP_{t-1} + \lambda_3 \ln GDP_{t-1}^2 + \lambda_4 \ln EC_{t-1} + \lambda_5 \ln URB_{t-1} + \sum_{i=1}^{a1} \beta_i \Delta \ln CO_{2_{t-i}} + \sum_{i=0}^{b1} \eta_i \Delta \ln GDP_{t-i} + \sum_{i=0}^{c1} \delta_i \Delta \ln GDP_{t-i}^2 + \sum_{i=0}^{d1} \varphi_i \Delta \ln EC_{t-i} + \sum_{i=0}^{e1} \phi_i \Delta URB_{t-i} + \varepsilon_t \quad (9)$$

Model 4:

$$\Delta \ln CO2_t = \alpha_o + \lambda_1 \ln CO_{2_{t-1}} + \lambda_2 \ln GDP_{t-1} + \lambda_3 \ln GDP^2_{t-1} + \lambda_4 \ln EC_{t-1} + \lambda_5 \ln AG_{t-1} + \sum_{i=1}^{a1} \beta_i \Delta \ln CO_{2_{t-i}} +$$

$$\sum_{i=0}^{b1} \eta_i \Delta \ln GDP_{t-i} + \sum_{i=0}^{c1} \delta_i \Delta \ln GDP^2_{t-i} + \sum_{i=0}^{d1} \varphi_i \Delta \ln EC_{t-i} + \sum_{i=0}^{e1} \psi_i \Delta \ln AG_{t-i} + \varepsilon_t \quad (10)$$

Model 5:

$$\Delta \ln CO2_t = \alpha_o + \lambda_1 \ln CO_{2_{t-1}} + \lambda_2 \ln GDP_{t-1} + \lambda_3 \ln GDP^2_{t-1} + \lambda_4 \ln EC_{t-1} + \lambda_5 \ln IND_{t-1} + \sum_{i=1}^{a1} \beta_i \Delta \ln CO_{2_{t-i}} +$$

$$\sum_{i=0}^{b1} \eta_i \Delta \ln GDP_{t-i} + \sum_{i=0}^{c1} \delta_i \Delta \ln GDP^2_{t-i} + \sum_{i=0}^{d1} \varphi_i \Delta \ln EC_{t-i} + \sum_{i=0}^{e1} \psi_i \Delta \ln IND_{t-i} + \varepsilon_t \quad (11)$$

Model 6:

$$\Delta \ln CO2_t = \alpha_o + \lambda_1 \ln CO_{2_{t-1}} + \lambda_2 \ln GDP_{t-1} + \lambda_3 \ln GDP^2_{t-1} + \lambda_4 \ln EC_{t-1} + \lambda_5 \ln FD_{t-1} + \lambda_6 \ln FDI_{t-1}$$

$$+\lambda_7 \ln TO_{t-1} + \lambda_8 \ln URB_{t-1} + \sum_{i=1}^{a1} \beta_i \Delta \ln CO_{2_{t-i}} + \sum_{i=0}^{b1} \eta_i \Delta \ln GDP_{t-i} + \sum_{i=0}^{c1} \delta_i \Delta \ln GDP^2_{t-i} + \sum_{i=0}^{d1} \varphi_i \Delta \ln EC_{t-i} +$$

$$\sum_{i=0}^{e1} \phi_i \Delta FD_{t-i} + \sum_{i=0}^{f1} \vartheta_i \Delta FDI_{t-i} + \sum_{i=0}^{g1} \theta_i \Delta TO_{t-i} + \sum_{i=0}^{h1} \varpi_i \Delta URB_{t-i} + \varepsilon_t \quad (12)$$

The terms with summation signs and first difference operator (Δ) in the above equations symbolize the error correction dynamics, while λ_i shows the long term connection, and ε_t represents an error term anticipated having zero mean value and uncorrelated to the regressors. Pesaran et al. [61] demonstrated two asymptotic critical values such as upper bounds and lower bounds for getting decisions whether cointegration exists between the variables or not. The lower bound is conducted to examine cointegration if all the series are integrated to order zero if not use an upper bound. The long term association between the considered variables occurs if the calculated F-statistic is larger than the upper bound. In contrast, if calculated F-statistic does not exceed lower bound, then no cointegration exists between the series. If the calculated value stands between the upper bound and lower bound, then the decision about cointegration is indecisive.

After we find a long-run association depended on F- test, the next step is to assess ECM of ARDL that re-introduces the information lost during the differencing operation, thereby integrating the short-run adjustments with long-run equilibrium. We apply the Akaike information criterion (AIC) for the order of appropriate and optimal lag lengths in the study for ascertaining that there is no indication of residual serial correlation, misspecification of functional form, heteroscedasticity, and non-normality.

3.2.2. Non-linear Autoregressive Distributed Lag (NARDL) Model

Different researchers criticized the classical linear cointegration models and tried to provide the idea of cointegration and error correction modeling. They have written in their research articles as a core contention that linear cointegration approaches are too obstructive. For example, linear approaches may have asymmetry characteristics, which indicates that shocks taking place in a depression period are just as persistent as shocks arising in an expansion phase of business cycle fluctuations. Therefore, these methods may not effectively detect asymmetries that might be present in business cycles. Meanwhile, economic growth and energy consumption are portions of cyclical business fluctuations; linear models would be too obstructive to find out the association between these variables, as well [12]. As the linear cointegration test does not demonstrate the asymmetry relationship between economic variables, it provides minimal evidence of cointegration. Therefore, recently Shin, Yu, and Greenwood-Nimmo [76] developed a nonlinear ARDL (NARDL) approach to accommodate the asymmetric behavior of variables. NARDL is the asymmetric composition of the linear ARDL model of Pesaran et al. [61]. The exceptionality between ARDL and NARDL approaches is that the ARDL model cannot study the negative and positive differences of the exogenous variables that have a diverse effect on the endogenous variable. NARDL method has some avails such as (i) it assists capturing both the long term and short term asymmetry in the ARDL framework coherently; and (ii) NARDL approach helps to detect hidden cointegration. To scrutinize the nonlinear association between the analyzed variables, the study will follow the NARDL model introduced by Shin et al. [76]. The NARDL model takes account of both long-run, and short-run asymmetries can be written as follows:

Model 1:

$$\Delta CO_{2_t} = \alpha_0 + \sigma_{co_2} CO_{2_{t-1}} + \delta^+_{GDP} GDP^+_{t-1} + \delta^-_{GDP} GDP^-_{t-1} + \delta^+_{GDP^2} GDP^{2+}_{t-1} + \delta^-_{GDP^2} GDP^{2-}_{t-1} +$$

$$\delta_{EC}^{+}EC_{t-1}^{+}+\delta_{EC}^{-}EC_{t-1}^{-}+\delta_{FD}^{+}FD_{t-1}^{+}+\delta_{FD}^{-}FD_{t-1}^{-}+\sum_{i=1}^{n-1}\gamma_i\Delta CO_{2_{t-i}}+$$

$$\sum_{j=0}^{m-1}\left(\lambda^{+}\Delta GDP_{t-j}^{+}+\lambda^{-}\Delta GDP_{t-j}^{-}\right)+\sum_{j=0}^{m-1}\left(\lambda^{+}\Delta GDP^{2+}_{t-j}+\lambda^{-}\Delta GDP^{2-}_{t-j}\right)+$$

$$\sum_{j=0}^{m-1}\left(\beta^{+}\Delta EC_{t-j}^{+}+\beta^{-}\Delta EC_{t-j}^{-}\right)+\sum_{j=0}^{m-1}(\phi^{+}\Delta FD_{t-j}^{+}+\phi^{-}\Delta FD_{t-j}^{-})+\xi_t \quad (13)$$

Model 2:

$$\Delta CO_{2_t}=\alpha_0+\sigma_{co_2}CO_{2_{t-1}}+\delta_{GDP}^{+}GDP_{t-1}^{+}+\delta_{GDP}^{-}GDP_{t-1}^{-}+\delta_{GDP^2}^{+}GDP^{2+}_{t-1}+\delta_{GDP^2}^{-}GDP^{2-}_{t-1}+$$

$$\delta_{EC}^{+}EC_{t-1}^{+}+\delta_{EC}^{-}EC_{t-1}^{-}+\delta_{FDI}^{+}FDI_{t-1}^{+}+\delta_{FDI}^{-}FDI_{t-1}^{-}+\delta_{TO}^{+}TO_{t-1}^{+}+\delta_{TO}^{-}TO_{t-1}^{-}+\sum_{i=1}^{n-1}\gamma_i\Delta CO_{2_{t-i}}+$$

$$\sum_{j=0}^{m-1}\left(\lambda^{+}\Delta GDP_{t-j}^{+}+\lambda^{-}\Delta GDP_{t-j}^{-}\right)+\sum_{j=0}^{m-1}\left(\lambda^{+}\Delta GDP^{2+}_{t-j}+\lambda^{-}\Delta GDP^{2-}_{t-j}\right)+$$

$$\sum_{j=0}^{m-1}\left(\beta^{+}\Delta EC_{t-j}^{+}+\beta^{-}\Delta EC_{t-j}^{-}\right)+\sum_{j=0}^{m-1}(\phi^{+}\Delta FDI_{t-j}^{+}+\phi^{-}\Delta FDI_{t-j}^{-})+\sum_{j=0}^{m-1}(\theta^{+}\Delta TO_{t-j}^{+}+\theta^{-}\Delta TO_{t-j}^{-})+\xi_t \quad (14)$$

Model 3:

$$\Delta CO_{2_t}=\alpha_0+\sigma_{co_2}CO_{2_{t-1}}+\delta_{GDP}^{+}GDP_{t-1}^{+}+\delta_{GDP}^{-}GDP_{t-1}^{-}+\delta_{GDP^2}^{+}GDP^{2+}_{t-1}+\delta_{GDP^2}^{-}GDP^{2-}_{t-1}+$$

$$\delta_{EC}^{+}EC_{t-1}^{+}+\delta_{EC}^{-}EC_{t-1}^{-}+\delta_{URB}^{+}URB_{t-1}^{+}+\delta_{URB}^{-}URB_{t-1}^{-}+\sum_{i=1}^{n-1}\gamma_i\Delta CO_{2_{t-i}}+$$

$$\sum_{j=0}^{m-1}\left(\lambda^{+}\Delta GDP_{t-j}^{+}+\lambda^{-}\Delta GDP_{t-j}^{-}\right)+\sum_{j=0}^{m-1}\left(\lambda^{+}\Delta GDP^{2+}_{t-j}+\lambda^{-}\Delta GDP^{2-}_{t-j}\right)+$$

$$\sum_{j=0}^{m-1}\left(\beta^{+}\Delta EC_{t-j}^{+}+\beta^{-}\Delta EC_{t-j}^{-}\right)+\sum_{j=0}^{m-1}(\phi^{+}\Delta URB_{t-j}^{+}+\phi^{-}\Delta URB_{t-j}^{-})+\xi_t \quad (15)$$

Model 4:

$$\Delta CO_{2_t}=\alpha_0+\sigma_{co_2}CO_{2_{t-1}}+\delta_{GDP}^{+}GDP_{t-1}^{+}+\delta_{GDP}^{-}GDP_{t-1}^{-}+\delta_{GDP^2}^{+}GDP^{2+}_{t-1}+\delta_{GDP^2}^{-}GDP^{2-}_{t-1}+$$

$$\delta_{EC}^{+}EC_{t-1}^{+}+\delta_{EC}^{-}EC_{t-1}^{-}+\delta_{AG}^{+}AG_{t-1}^{+}+\delta_{AG}^{-}AG_{t-1}^{-}+\sum_{i=1}^{n-1}\gamma_i\Delta CO_{2_{t-i}}+$$

$$\sum_{j=0}^{m-1}\left(\lambda^{+}\Delta GDP_{t-j}^{+}+\lambda^{-}\Delta GDP_{t-j}^{-}\right)+\sum_{j=0}^{m-1}\left(\lambda^{+}\Delta GDP^{2+}_{t-j}+\lambda^{-}\Delta GDP^{2-}_{t-j}\right)+$$

$$\sum_{j=0}^{m-1}\left(\beta^{+}\Delta EC_{t-j}^{+}+\beta^{-}\Delta EC_{t-j}^{-}\right)+\sum_{j=0}^{m-1}(\phi^{+}\Delta AG_{t-j}^{+}+\phi^{-}\Delta AG_{t-j}^{-})+\xi_t \quad (16)$$

Model 5:

$$\Delta CO_{2_t}=\alpha_0+\sigma_{co_2}CO_{2_{t-1}}+\delta_{GDP}^{+}GDP_{t-1}^{+}+\delta_{GDP}^{-}GDP_{t-1}^{-}+\delta_{GDP^2}^{+}GDP^{2+}_{t-1}+\delta_{GDP^2}^{-}GDP^{2-}_{t-1}+$$

$$\delta_{EC}^{+}EC_{t-1}^{+}+\delta_{EC}^{-}EC_{t-1}^{-}+\delta_{IND}^{+}IND_{t-1}^{+}+\delta_{IND}^{-}IND_{t-1}^{-}+\sum_{i=1}^{n-1}\gamma_i\Delta CO_{2_{t-i}}+$$

$$\sum_{j=0}^{m-1}\left(\lambda^{+}\Delta GDP_{t-j}^{+}+\lambda^{-}\Delta GDP_{t-j}^{-}\right)+\sum_{j=0}^{m-1}\left(\lambda^{+}\Delta GDP^{2+}_{t-j}+\lambda^{-}\Delta GDP^{2-}_{t-j}\right)+$$

$$\sum_{j=0}^{m-1}\left(\beta^{+}\Delta EC_{t-j}^{+}+\beta^{-}\Delta EC_{t-j}^{-}\right)+\sum_{j=0}^{m-1}(\phi^{+}\Delta IND_{t-j}^{+}+\phi^{-}\Delta IND_{t-j}^{-})+\xi_t \quad (17)$$

Model 6:

$$\Delta CO_{2_t} = \alpha_0 + \sigma_{co_2} CO_{2_{t-1}} + \delta^+_{GDP} GDP^+_{t-1} + \delta^-_{GDP} GDP^-_{t-1} + \delta^+_{GDP^2} GDP^{2+}_{t-1} + \delta^-_{GDP^2} GDP^{2-}_{t-1} +$$

$$\delta^+_{EC} EC^+_{t-1} + \delta^-_{EC} EC^-_{t-1} + \delta^+_{FD} FD^+_{t-1} + \delta^-_{FD} FD^-_{t-1} + \delta^+_{FDI} FDI^+_{t-1} + \delta^-_{FDI} FDI^-_{t-1} +$$

$$\delta^+_{TO} TO^+_{t-1} + \delta^-_{TO} TO^-_{t-1} + \delta^+_{URB} URB^+_{t-1} + \delta^-_{URB} URB^-_{t-1} + \sum_{i=1}^{n-1} \gamma_i \Delta CO_{2_{t-i}} +$$

$$\sum_{j=0}^{m-1} \left(\lambda^+ \Delta GDP^+_{t-j} + \lambda^- \Delta GDP^-_{t-j} \right) + \sum_{j=0}^{m-1} \left(\lambda^+ \Delta GDP^{2+}_{t-j} + \lambda^- \Delta GDP^{2-}_{t-j} \right) +$$

$$\sum_{j=0}^{m-1} \left(\beta^+ \Delta EC^+_{t-j} + \beta^- \Delta EC^-_{t-j} \right) + \sum_{j=0}^{m-1} (\phi^+ \Delta FD^+_{t-j} + \phi^- \Delta FD^-_{t-j}) + \sum_{j=0}^{m-1} (\theta^+ \Delta FDI^+_{t-j} + \theta^- \Delta FDI^-_{t-j}) +$$

$$\sum_{j=0}^{m-1} \left(\beta^+ \Delta TO^+_{t-j} + \beta^- \Delta TO^-_{t-j} \right) + \sum_{j=0}^{m-1} (\phi^+ \Delta URB^+_{t-j} + \phi^- \Delta URB^-_{t-j}) + \xi_t \quad (18)$$

Assuming that x is all independent variables then, x_t^+ and x_t^- are the partial sum processes of positive and negative changes in x_t as follows:

$$x_t^+ = \sum_{j=1}^{t} \Delta x_j^+ = \sum_{j=1}^{t} \max(\Delta x_j, 0) \text{ and}$$

$$x_t^- = \sum_{j=1}^{t} \Delta x_j^- = \sum_{j=1}^{t} \min(\Delta x_j, 0)$$

In equation (13)-(18), δ^+ and δ^- are the asymmetric distributed lag parameters and ξ_t is an error term. The long term positive and negative coefficients can be computed as $\theta^+_{GDP} = -\frac{\delta^+_{GDP}}{\sigma_{CO_2}}$ and $\theta^-_{GDP} = -\frac{\delta^-_{GDP}}{\sigma_{CO_2}}$; $\theta^+_{EC} = -\frac{\delta^+_{EC}}{\sigma_{CO_2}}$ and $\theta^-_{EC} = -\frac{\delta^-_{EC}}{\sigma_{CO_2}}$; $\theta^+_{FD} = -\frac{\delta^+_{FD}}{\sigma_{CO_2}}$ and $\theta^-_{FD} = -\frac{\delta^-_{FD}}{\sigma_{CO_2}}$; $\theta^+_{FDI} = -\frac{\delta^+_{FDI}}{\sigma_{CO_2}}$ and $\theta^-_{FDI} = -\frac{\delta^-_{FDI}}{\sigma_{CO_2}}$; $\theta^+_{TO} = -\frac{\delta^+_{TO}}{\sigma_{CO_2}}$ and $\theta^-_{TO} = -\frac{\delta^-_{TO}}{\sigma_{CO_2}}$; $\theta^+_{URB} = -\frac{\delta^+_{URB}}{\sigma_{CO_2}}$ and $\theta^-_{URB} = -\frac{\delta^-_{URB}}{\sigma_{CO_2}}$; $\theta^+_{AG} = -\frac{\delta^+_{AG}}{\sigma_{CO_2}}$ and $\theta^-_{AG} = -\frac{\delta^-_{AG}}{\sigma_{CO_2}}$; $\theta^+_{IND} = -\frac{\delta^+_{IND}}{\sigma_{CO_2}}$ and $\theta^-_{IND} = -\frac{\delta^-_{IND}}{\sigma_{CO_2}}$ respectively. The long term symmetry of the stimulus of real GDP, real GDP squared, EC, FD, FDI, TO, URB, AG, and IND are confirmed with the Wald test of the particular null hypotheses $\delta^+_{GDP} = \delta^-_{GDP}$, $\delta^+_{EC} = \delta^-_{EC}$, $\delta^+_{FD} = \delta^-_{FD}$, $\delta^+_{FDI} = \delta^-_{FDI}$, $\delta^+_{TO} = \delta^-_{TO}$, $\delta^+_{URB} = \delta^-_{URB}$, $\delta^+_{AG} = \delta^-_{AG}$, $\delta^+_{IND} = \delta^-_{IND}$. Also, short-term symmetry of the influence of explanatory variables on carbon dioxide emissions can each be confirmed by using Wald tests of the respective null hypothesis $\lambda^+ = \lambda^-$, $\beta^+ = \beta^-$, $\phi^+ = \phi^-$, $\sigma^+ = \sigma^-$, $\varphi^+ = \varphi^-$, $\pi^+ = \pi^-$, $\kappa^+ = \kappa^-$, $\rho^+ = \rho^-$. Finally, this study will develop the asymmetric dynamic multiplier effects of a unit change in x_t^+ and x_t^- separately on CO_{2t} as the following equation:

$$m_q^+ = \sum_{j=0}^{q} \frac{\partial CO_{2t+j}}{\partial x_t^+}, m_q^- = \sum_{j=0}^{q} \frac{\partial CO_{2t+j}}{\partial x_t^-}, q = 0, 1, 2\ldots\ldots \quad (19)$$

Shin et al. (2014) illustrated that when $q \to \infty$ $m_q^+ \to \theta^+$ and $m_q^- \to \theta^-$. Multiplier adds valuable evidence to the asymmetry long term and short term patterns to inquiry the paths of adjustment from disequilibrium to long term equilibrium with the subsequent initial positive or negative partial sum of x_t^+ and x_t^- [2].

3.2.3. Panel Autoregressive Distributed Lag Model (P-ARDL)

This study applies panel ARDL method to empirically evaluate the long-term and short-run causal connection between CO_2 emissions and its contributing factors in selected SAARC countries depend on three alternative estimators, which are mean group (MG), pooled mean group (PMG), and dynamic fixed effects (DFE) estimators.

Pesaran et al. [60] have presented the PMG approach in the panel ARDL framework. The PMG approach is considered as an intermediary process between the MG, and the DFE approaches. However, which method will be applied in the study depends on the null hypothesis of homogeneity through a Hausman test based on the comparison between the MG estimator and the PMG estimator or the DFE estimator and the PMG estimator. If we cannot reject the null hypothesis, we use the PMG estimator as it is efficient. The PMG approach consents the intercept, short term coefficients, and error variances to vary across groups (as would the MG approach), but the long term coefficients are constrained to

be identical across groups (as would the FE approach). Pesaran et al. [60] suggest the PMG technique for dynamic heterogeneous panels that fits an ARDL model to the data. In the study, we use an ARDL heterogeneous panel regression given by Pesaran et al. [60] as follows:

$$\left(CO_2\right)_{it} = \sum_{j=1}^{p} \lambda_{ij} \left(CO_2\right)_{i,t-j} + \sum_{n=0}^{q} \chi_{ij}^{/} P_{i,t-j} + \eta_i + \varsigma_{it} \quad (20)$$

There subsists a long term association between the variables in equation (20), if the variables are cointegrated. The key characteristic of cointegrated variables is that short term dynamics of the variables are influenced by the deviation from equilibrium. Therefore, it is required to re-parameterize equation (21) into the error correction equation.

$$\Delta\left(CO_2\right)_{it} = \alpha_i \left(\left(CO_2\right)_{i,t-1} - \beta_i^{/} X_{it}\right) + \sum_{j=1}^{p-1} \varphi_{ij}^{*} \Delta\left(CO_2\right)_{i,t-1} + \sum_{j=o}^{q-1} \delta_{ij}^{/*} \Delta X_{i,t-j} + \nu_i + \varsigma_{it} \quad (21)$$

Where

$$\alpha_i = -\left(1 - \sum\nolimits_{j=1}^{p} \varphi_{ij}\right), \beta_i = \sum\nolimits_{j=0}^{q} \delta_{ij} \Big/ \left(1 - \sum\nolimits_{k} \varphi_{ik}\right),$$

$$\varphi_{ij}^{*} = -\sum\nolimits_{m=j+1}^{p} \varphi_{im}, \ j = 1, 2, ..., p-1, \text{ and}$$

$$\delta_{ij}^{*} = -\sum\nolimits_{m=j+1}^{q} \delta_{im}, \ j = 1, 2, ..., q-1.$$

The parameter α_i is the error-correcting speed of adjustment term and the value of it requires non zero. If $\alpha_i = 0$, then there would be no proof of a long term association. The sign of α_i is anticipated to be negative and statistically significant under the assumption of bringing back the variables to the long term equilibrium. Where, $\beta_i^{/}$ comprises the long term association between the variables. Mean group parameters are the unweighted means of the individual coefficients. The MG specification of the error correction coefficient, α, is

$$\hat{\alpha} = P^{-1} \sum_{i=1}^{P} \hat{\alpha}_i \quad (22)$$

With the variance

$$\hat{\Pi}_{\hat{\alpha}} = \frac{1}{P(P-1)} \sum_{i=1}^{P} (\hat{\alpha}_i - \hat{\alpha})^2 \quad (23)$$

The DFE method is also identical to the PMG approach. The DFE approach confines the speed of adjustment and allows panel-specific intercepts [64]. Equation (20) can be assessed by three different methods e.g. MG, PMG, and DFE techniques.

We apply three panel unit root tests, which are Levin-Lin-Chu (LLC) test, Im-Pesaran-Shin (IPS) test, and Maddala and Wu (MW) test. The LLC test considers the heterogeneity of several units, however, it has low power in small data sizes due to serial correlation that would not be totally omitted. On the other hand, the IPS test weighs the heterogeneity among the units and is able to eliminate the serial correlation and also has a robust capability of examining small data sizes. Finally, the MW test consents various lags throughout the different ADF test.

4. Empirical Results

4.1. Descriptive Statistics and Preliminary Tests

The descriptive statistics of the study are described in Table 1. All the variables are expressed in level form. As indicated by the results of mean, standard deviation, skewness, and kurtosis, we are in a position to consider that our data to be correct from all aspects.

Table 1. *Descriptive Statistics.*

Variables	CO_2	GDP	EC	FD	FDI	TO	URB	AG	IND
Mean	0.234	565.0	149.8	22.1	0.427	27.9	22.7	27.6	21.8
SD*	0.145	235.9	47.4	13.9	0.523	10.05	7.41	12.4	3.80
Skewness	0.760	1.17	0.773	0.387	0.939	0.480	0.113	1.16	-.735
Kurtosis	2.34	3.31	2.33	1.95	2.51	2.06	2.17	3.65	3.42

Source: Computed by authors. *SD indicates standard deviation.

Next, we consider the pairwise correlation between the variables. The pairwise correlation matrix is depicted in Table 2. Given the correlation results, we regard that the variables are highly correlated to each other, which is evident as they are trended.

Table 2. *Pairwise correlation matrix.*

	$lnCO_2$	lnGDP	$lnGDP^2$	lnEC	lnFD	lnFDI	lnTO	lnURB	lnAG	lnIND
$lnCO_2$	1.0000									
lnGDP	0.9644	1.0000								
$lnGDP^2$	0.9644	1.0000	1.0000							
lnEC	0.9869	0.9914	0.9914	1.0000						
lnFD	0.9483	0.8612	0.8612	0.9007	1.0000					
lnFDI	0.7861	0.8113	0.8113	0.8084	0.6467	1.0000				
lnTO	0.9025	0.8818	0.8818	0.9064	0.8302	0.8606	1.0000			
lnURB	0.9713	0.9051	0.9051	0.9362	0.9872	0.6959	0.8593	1.0000		
lnAG	-0.968	-0.914	-0.907	-0.942	-0.961	-0.741	-0.873	-0.981	1.0000	
lnIND	0.878	0.800	0.792	0.833	0.948	0.571	0.788	0.948	-0.943	1.0000

Source: Computed by authors.

In the next step, we perform unit root test. The findings are presented in Table 3. We get URB is stationary at level. Nevertheless, CO_2, GDP, GDP^2, EC, FD, FDI, TO, AG, and IND have a unit root at the level but turn into stationary after the first difference. Therefore, we can surely use the ARDL method in this study to observe the being of a long term link between the discussed variables.

Table 3. *Results of Unit root Test.*

	DF-GLS Test		PP Test		Conclusion
	Level	1st Difference	Level	1st Difference	
lnCO2	-2.605	-6.581***	-4.069	-9.699***	I(1)
lnGDP	-1.481	-4.034***	0.326	-10.065***	I(1)
$lnGDP^2$	-1.544	-4.190***	1.120	-8.990***	I(1)
lnEC	-1.282	-9.346***	-1.296	-9.505***	I(1)
lnFD	-1.644	-5.046***	-2.068	-8.316***	I(1)
lnFDI	-2.862	-4.562***	-2.893	-7.721***	I(1)
lnTO	-3.251	-7.651***	-3.038	-9.533***	I(1)
lnURB	-5.141***	-	-6.425***	-	I(0)
lnAG	-1.217	-7.234***	-1.889	-9.466***	I(1)
lnIND	-1.571	-3.202**	-3.030	-10.779***	I(1)

Source: Authors' calculation. ***, **, * represent reject null hypothesis at 1%, 5% and 10% significant level respectively.

4.2. Linear Cointegration

With the purpose of observing the long term and short term linear connection between carbon emissions and exogenous variables, the present study conducts the ARDL model. First, we divide our model into six specifications to observe the impact of every individual exogenous variable on carbon emissions using the same lag for each variable. Then, we apply AIC as a statistical tool to select the best model. Thus, we find the lower value of AIC in model six which is the best model among other models. For this reason, we only explain model six in the results. However, agriculture and industry are not included in our main model as they are highly correlated with financial development and urbanization.

The long-run findings are exhibited in Table 4. The ARDL bounds test illustrates that variables are cointegrated in model six. The value of calculated F-statistic is greater than upper bound I(1) at the 5% critical value of Pesaran et al. [61]. Therefore, the study can reject the H_0 hypothesis for no cointegration and approves the presence of a long term affiliation among the included variables. All the estimations are computed, taking variables in their level form using Stata 15.

We get statistically significant a positive coefficient of real GDP per capita and negative of real squared GDP per capita in the model six, which confirms an inverted U-shape curve exists between the connection of CO_2 emissions and real GDP per capita in Bangladesh in the course of 1974-2018. An increase in GDP will positively affect the CO_2 emissions up to the turning point at approximately 451.4 US dollars (2010 constant prices). Following the EKC hypothesis, the turning point defines the level of income where a country experiences the maximum level of carbon emissions. This outcome is consistent with the EKC hypothesis. According to the hypothesis, an increase in the level of GDP leads to environmental dreadful conditions in the short-run, and after a certain level, the rise in the GDP per capita will cause environmental improvement in the long-run.

Energy consumption carries a positive sign and statistically significant at a one percent confidence level, which means that a one percent upsurge in energy consumption may significantly raise CO_2 emission per capita by 2.21 percent in Bangladesh in the long-run. This result is line with the previous studies such as Jalil and Feridun [39], Islam et al. [38], and Begum et al. [13].

Table 4. *Long-run results of linear ARDL model (dependent variable $lnCO_2$).*

Long-run estimates (dependent variable $lnCO_2$)						
Regressors	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
lnGDP (no lag)	3.76 (2.33)	6.19** (2.46)	3.53* (2.00)	4.90 (4.28)	5.30* (2.79)	5.88** (2.61)
$lnGDP^2$ (no lag)	-.315* (0.158)	-.544*** (.158)	-.309** (.135)	-.420 (.290)	-.443** (.185)	-0.481** (0.184)
lnEC (two lags)	2.03** (0.589)	2.18** (.621)	2.12*** (.491)	2.45** (.926)	2.34** (.684)	2.21*** (0.360)
lnFD (no lag)	.163** (0.049)					0.151 (0.171)
lnFDI (two lags)		-0.015 (0.015)				0.003 (0.011)
lnTO (two lags)		-0.244* (0.127)				-0.217** (0.080)
lnURB (no lag)			.467*** (.120)			0.539** (0.168)
lnAG (two lags)				-.158 (.194)		
lnIND (two lags)					.374** (.167)	
F-statistic	3.085	2.367	3.016	1.343	2.102	4.141**
AIC	-154.5	-153.1	-154.2	-144.0	-147.5	-160.1
Turning Point	390.82	295.70	302.47	341.50	396.21	451.36

Source. Calculated by authors using Stata 15. ***, **, * indicates the rejection of a significant test at 1%, 5%, and 10% significant level correspondingly. The standard errors are in the parenthesis.

The study gets a positive sign, but the statistically insignificant result for foreign direct investment. Also, the study finds a positive and statistically insignificant outcome for financial development in the model six. It may because financial development is highly positively correlated with urbanization. On the contrary, the study gets negative and statistically significant results for trade openness. A rise in trade openness leads to a decline in CO_2 emissions in Bangladesh in the long term. A one percent increase in trade openness may decrease carbon dioxide emission per capita by 0.22 percent at five percent statistically significant level. According to the result, attracting trade openness would improve the environmental quality in Bangladesh. This result is similar to Islam and others [38], and Al-Mulali and others [7]. However, our finding is also consistent with the scale, composition, and technique effect theory. According to the theory, the technique effect is supposed to be always environmentally improving since the technology may cut carbon emissions as an outcome of the invasion of overseas funds after opening to trade.

Urbanization carries a positive significant sign, which means that a one percent increase in urbanization may significantly raise CO_2 emission per capita by 0.54 percent in Bangladesh in the long-run. Also, Hossain and Hasanussan [36] found an almost similar size coefficient (0.45) for urbanization in the case of Bangladesh. This outcome is consistent with Farhani and Ozturk [27], Sehrawat et al. [71], and Al-Mulali and others [7]. Since urbanization has a positive influence on CO_2 emissions, therefore, it can be said that Bangladesh with higher urbanization will contaminate the environment in the long-run.

The study finds a long-run association between CO_2 emissions and exogenous variables. Thus, we estimate error correction representations of the ARDL model. Error correction term predicts the speed of adjustment of CO_2 emissions towards the long term equilibrium after a short run shock. ECT includes using the lagged value of residual to correct the short-term deviations from the equilibrium. Therefore, the expected sign of the ECT should be negative and statistically different from zero. This negative sign reports a convergence of the variables towards equilibrium. The short term findings of considered variables are exhibited in Table 5. We dropped most of the insignificant results in the table.

Table 5. *Short-run estimation results.*

Short-run estimates: (dependent variable Δ $lnCO_2$)						
Regressors	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
ECT_{t-1}	-0.573** (0.151)	-0.635** (.171)	-0.678** (.181)	-0.386** (.168)	-0.505** (.161)	-.819** (.159)
Δ $lnCO_{2t-1}$	.499** (0.135)	.593** (.158)	.480** (.191)	.655*** (.140)	.607*** (.132)	0.451** (0.170)
Δ lnGDP	1.81 (1.42)	4.72** (2.01)	3.08 (2.09)	1.89 (1.53)	2.25 (1.51)	6.00* (2.99)
Δ $lnGDP^2$	-0.181* (0.103)	-.511** (.147)	-.590 (1.48)	-.160 (.108)	-.188* (.107)	-.491** (0.219)
Δ lnEC	1.27** (0.284)	1.37*** (.325)	1.38** (.363)	1.24*** (.307)	1.24*** (.300)	1.50*** (0.324)
Δ $lnEC_{t-1}$						-1.20** (0.399)
Δ lnFD	0.084** (0.034)					-0.053 (0.076)
Δ lnFDI		.007 (.008)				0.011 (0.008)
Δ $lnFDI_{t-1}$						-0.014* (0.007)
Δ lnTO		.077 (.061)				0.174** (0.068)
Δ $lnTO_{t-1}$						0.131** (0.056)
Δ lnURB			.521 (.999)			0.550** (0.232)
Δ lnAG				-.033 (.071)		
Δ lnIND					.121 (.092)	
Constant	-13.3** (5.30)	-14.2** (8.77)	-15.9** (5.58)	-10.5* (5.86)	-15.2** (6.03)	-31.9** (11.1)

Source: Calculated by authors using Stata 15. ***, **, * indicates the rejection of a significant test at 1%, 5%, and 10% significant level correspondingly. The standard errors are in the parenthesis.

We get a negative and statistically significant coefficient of ECT in the linear ARDL model relating to carbon dioxide emissions as an endogenous variable. The coefficient of ECT is -0.819, indicating that almost 0.82 percent of disequilibrium in the previous year is corrected in the current year. It entails that carbon emissions will converge to the long run equilibrium path when there is any short run deviation.

We find statistically significant a positive coefficient of real GDP per capita and negative of square of per capita real GDP, suggesting that EKC hypothesis be present in Bangladesh in the short-term. CO_2 emissions rise with the increases in energy consumption; the signs we get are expected. However, one-period lag of EC shows a negative statistically significant sign, signifying that a one percent increase in energy consumption reduces carbon emissions by 1.20 percent, holding other variables constant.

The study gets only the first lag of foreign direct investment is negative at ten percent level of significance, although the magnitude is small (-0.014). According to the result, attracting FDI would improve the environmental worth in Bangladesh in the short-term. Our outcome is also consistent with the pollution HALO hypothesis that asserts multinational enterprises (MNEs) use advanced technologies, creates new job opportunities, innovative activities, bring new production methods, and better management practices that bring about a clean environment in host countries. The hypothesis proposes that FDI reduces CO_2 emissions in host countries as MNEs use an advanced technology, which is less destructive to the environment and has a favorable outcome on the quality of the atmosphere. Conversely, the study gets a positive and significant coefficient for both trade openness and urbanization in the short-term. In the study, foreign direct investment reduces carbon emissions, while trade openness and urbanization drive up carbon emissions in Bangladesh in the short-term. However, there is no significant coefficient of financial development in the short term.

Besides, we assess several diagnostic tests for the estimated models, as given in Table 6. We perform the Breusch-Godfrey LM test for autocorrelation, the test of Skewness and Kurtosis of residuals for normality, and the White's test for heteroskedasticity. The results fail to reject the null hypothesis. Thus, there is no serial correlation, no heteroscedasticity, and normality of disturbances at a 10% significance level. Besides, high R^2 values of every specification suggest that the adjustment of the models is relatively perfect; also, Durbin–Watson statistic is nearly 2.

Table 6. *Results of Diagnostic Tests.*

Tests	Serial Correlation	Normality	Heteroscedasticity	Durbin-Watson	R2	CUSUMQ
Coefficients	0.375 (0.540)	3.43 (0.180)	42.6 (0.356)	1.82	0.997	stable

Source: Calculated by authors using Stata 15. Parenthesis indicates p-value.

Furthermore, we carry out the cumulative sum of squares (CUSUMQ) tests as a stability test of the model for checking goodness of fit. The parameters of the model are gone through the 95% critical boundary which approves the estimated parameters that are stable over time.[2]

4.3. Nonlinear Cointegration

The study performs the nonlinear ARDL to inspect the long term and short term asymmetry connection between CO_2 emission per capita and exogenous variables. Table 7 exhibits the results of Wald statistics and their conforming p-values of model six that shows the long-term and short-term asymmetry in the NARDL method[3]. The results display that the effect of energy consumption and FDI on CO_2 release are asymmetric in the long-run. Contrarily, the influence of GDP, GDP^2, FD, TO, and URB on CO_2 emissions is discovered to be a symmetric and linear way in the long-run. However, the impact of GDP, GDP^2, TO, and URB is found to be symmetric in the short term. In the case of short-term, Wald statistics show energy consumption, FDI, and financial development stimulate CO_2 release in an asymmetric way.

Table 8 displays the findings of the cointegration test statistics of the NARDL estimator under a long term and short term asymmetric assumption. The value of calculated F_{PSS}-statistic is larger than upper bound I(1) at the 1% critical value of Pesaran et al. [61]. Thus, we can reject the null hypothesis of no asymmetry cointegration in the model. This study does not discover any asymmetry effect of real GDP per capita, the square of real GDP per capita, trade openness, and urbanization; thus, these variables have a symmetry effect on CO_2 emission per capita.

Table 7. *Results of Long-run and short-run Asymmetry Test (dependent variable $lnCO_2$).*

Regressors	Long-run asymmetry (Wald test)	Short-run asymmetry (Wald test)
Model 6		
lnGDP	16.6 (0.110)	0.112 (0.917)
lnGDP2	16.5 (0.101)	0.111 (0.922)
lnEC	33.7** (0.002)	9.87** (.026)
lnFD	2.68 (0.243)	32.6** (0.021)
lnFDI	2.57* (0.063)	12.8** (0.016)
lnTO	0.136 (0.727)	0.491 (0.515)
lnURB	2.10 (0.207)	6.60 (0.501)

Source: Calculated by authors using Stata 15. ***, **, * indicates the rejection of a significant test at 1%, 5%, and 10% significant level correspondingly. The standard errors are in the parenthesis.

The results show a one percent increase in real GDP per capita may raise carbon dioxide emissions by 4.25 percent, where a one percent increase in the square of real GDP per

2 To save space, we don't specify the CUSUMQ graph. However, the graph is available upon request.

3 We don't put the results of Wald statistics of model one to five here to converse space, but are available upon request.

capita may significantly decrease CO_2 emissions by 0.30 percent. We get asymmetry effects of energy consumption per capita in the model. The magnitudes of symmetry and asymmetry energy consumption are 1.64 and -1.65, correspondingly at 5% significance level, suggesting that an upsurge in EC raises CO_2 emissions, while a decrease in EC lowers the CO_2 emissions in the long term. Therefore, we can say that energy consumption worsens the environment in the long-term since more EC leads to more CO_2 emissions in Bangladesh.

The study does not find any asymmetric effect of FD in the long term and gets an insignificant coefficient. We find a significant coefficient for the trade openness in the NARDL procedure. The finding indicates that an upturn in trade openness will improve environmental excellence in Bangladesh in the long term. However, we find FDI has an asymmetric effect on CO_2 emissions, where the only negative shock of the variable is statistically significant at five percent significance level. Reduces in FDI lower the carbon emissions; however, the magnitude of FDI is small only -0.013. The result shows that increases in urbanization will contaminate environmental excellence in Bangladesh in the long term. A one percent increase in urbanization may raise carbon dioxide emissions by 0.77 percent at five percent significance level.

Table 8. *Results of Long-run asymmetry based on NARDL estimation.*

Regressors	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
lnGDP	0.580 (.039)	2.15 (.469)	0.470 (.117)	0.431 (.037)	1.42 (.431)	4.25**(12.2)
$lnGDP^-$			-0.593** (8.84)			
$lnGDP^2$	-0.033 (.022)	-0.127 (.275)	-0.024 (.056)	-0.029 (.032)	-0.100 (.420)	-0.299**(1.28)
$lnGDP^{2-}$			-.523** (8.80)			
lnEC	1.19** (17.6)	1.26** (8.16)	1.93*** (68.6)	1.62*** (28.6)	1.69*** (20.7)	1.64**(33.8)
$lnEC^-$	-0.870 (.961)	-0.865 (.989)	-0.448 (1.43)		- 0.568 (.222)	-1.65**(6.81)
lnFD	0.209** (7.67)					0.176 (1.53)
lnFDI		0.018* (1.15)				0.007 (0.371)
$lnFDI^-$						-0.013**(1.08)
lnTO		-0.047 (0.207)				-0.230*(12.5)
$lnTO^-$		0.417** (14.9)				
lnURB			0.696** (14.1)			0.771**(21.0)
lnAG				0.439 (2.12)		
$lnAG^-$				-0.285* (3.48)		
lnIND					0.324 (.742)	
Results of NARDL bounds test						
F_{pss}-statistic	4.905**	4.050**	8.979*	4.559**	4.860**	9.58**
Lag Selection	p(3), q(2)	p(4), q(2)	p(2), q(2)	P(2), q(2)	P(2), q(2)	P(3), q(2)
AIC	-183.91	-212.08	-188.58	-176.79	-165.04	-257.95

Source: Calculated by authors. The computations were done in Stata 15 using the nonlinear ARDL command for Stata (nardl) and retrieved from Matthew Greenwood-Nimmo's web page. ***, **, * indicates the rejection of a significant test at 1%, 5%, and 10% significant level correspondingly. The standard errors are in the parenthesis.

Table 9. *Results of Short-run asymmetry based on NARDL estimation.*

Regressors	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
ECT_{t-1}	-0.723** (.243)	-0.745** (.238)	-0.509** (.153)	-0.474* (.179)	-0.463** (0.212)	-.696** (0.289)
$\Delta CO2_{t-1}$	.403** (.147)	.379** (.100)	.359* (.177)	.473** (.210)	.623** (.322)	0.827** (0.208)
ΔGDP_t	4.71 (12.1)	74.6* (33.0)	19.9 (14.2)	22.1 (17.8)	9.89 (19.0)	32.6** (27.5)
ΔGDP_{t-1}	17.0 (15.7)	45.3 (29.2)	17.0 (15.6)	18.6 (18.7)	3.63 (19.6)	12.9 (22.2)
ΔGDP^2_t	-.440 (1.75)	-5.90* (2.58)	-1.52 (1.12)	-1.68 (1.43)	-.696 (1.52)	-2.63* (1.13)
ΔGDP^2_{t-1}	-1.35 (1.26)	-3.57 (2.39)	-1.35 (1.27)	-1.50 (1.51)	-.297 (1.61)	-1.04 (2.59)
ΔEC_t	.810* (.444)	.760* (.424)	1.84*** (.307)	1.87** (0.455)	1.94** (0.483)	1.99** (.726)
ΔEC_{t-1}	1.01** (.435)	.928 (.521)	.694* (.372)	.245 (.450)	0.184 (.493)	.609 (.354)
ΔEC^-_t			-.219 (.638)	-.536 (1.09)	-1.16 (1.12)	-3.42** (1.14)
ΔEC^-_{t-1}			-1.35* (.673)	-3.33** (1.53)	-.962 (1.22)	-2.73** (0.990)
ΔFD_t	.294** (.114)					0.821 (0.362)
ΔFD_{t-1}	-.168** (.069)					.056 (.801)
ΔFD^-_t						-2.70** (0.371)
ΔFD^-_{t-1}						-1.53** (.204)
ΔFDI_t		.011** (.020)				0.051* (0.023)
ΔFDI_{t-1}		.024 (.017)				0.034** (0.011)
ΔFDI^-_t						-0.022** (0.020)
ΔFDI^-_{t-1}						-0.034* (0.020)
ΔTO_t		.079 (.128)				0.223* (0.092)
ΔTO_{t-1}		.021 (.099)				0.140 (0.077)
ΔURB_t			3.17* (1.65)			8.38 (4.72)
ΔURB_{t-1}			1.97 (.130)			2.87* (1.34)
ΔAG_t				-.100 (0.414)		
ΔAG_{t-1}				-.326 (.572)		
ΔIND_t					-.306 (0.496)	

Regressors	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Δ IND_{t-1}					.339 (.296)	
Constant	-4.85** (2.05)	-9.67** (2.73)	-7.74*** (1.20)	-2.11* (1.10)	-6.14** (2.45)	-17.0** (4.14)

Source: Calculated by authors using Stata 15. ***, **, * indicates the rejection of a significant test at 1%, 5%, and 10% significant level correspondingly. The standard errors are in the parenthesis.

Turning to the analysis of short-term asymmetry, we find that the Wald test of energy consumption, financial development and FDI confirm significant results of asymmetry test. Table 9 describes the outcomes of the short-term asymmetry of the study applying NARDL approach.

The study finds a negative and significant coefficient of ECTs in the model, which explains how promptly regressors converge to equilibrium. More specifically, approximately 0.70 percent of disequilibrium in the preceding year is corrected in recent years.

The findings reveal that the coefficients of real GDP and the square of real GDP are statistically significant in the short-term. We find significant results for both symmetric and asymmetric energy consumption in the model. In the short run, increases in EC boost CO_2 release and vice versa. The findings of asymmetric FD (-2.70) and FDI (-.022) show that decreases in both variables reduce carbon dioxide in the short term, though the magnitude of FDI is too small. We find an insignificant coefficient of symmetric financial development in the NARDL approach. However, the result shows that increases in trade openness and urbanization will contaminate environmental quality in Bangladesh in the short term.

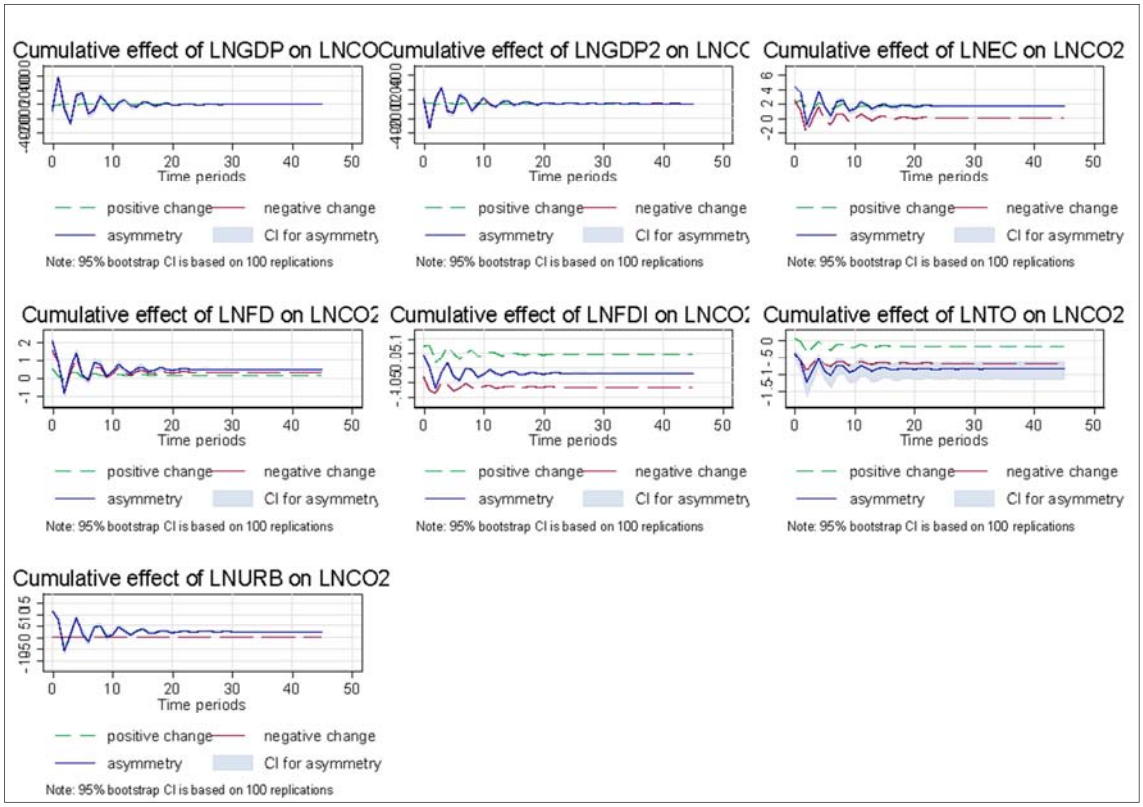
We also assess several diagnostic tests for the estimated NARDL model. Table 10 shows the diagnostic test of the NARDL approach. Results show that the p-value of all tests is insignificant; thus, the model does not contain any autocorrelation, heteroscedasticity, misspecification, and normality problem correspondingly.

Table 10. *Results of Diagnostic Tests.*

Tests	Serial Correlation	Heteroscedasticity	Functional form	Normality	R^2
Coefficients	36.7 (0.281)	0.282 (0.595)	0.472 (0.732)	1.74 (0.417)	0.991

Source: Calculated by authors using Stata 15. Parenthesis indicates p-values.

Also, we perform a dynamic multiplier graph of the specification that are shown in Figure 3, which confirms the stable impact of carbon emissions and explanatory variables as the parameter for them goes through the 95% critical boundary.



Source: World Development Indicators (WDI) online database

Figure 3. *Dynamic multiplier graph of CO_2 emissions and explanatory variables.*

4.4. Panel Cointegration

This study uses three different panel unit root tests and finds CO_2, GDP, squared GDP, EC, FD, FDI, TO, and URB have a unit root at I(0), but turn into stationary in their first differences, and also ascertain that no variable is I(2) order. The outcomes of panel unit root tests are described in Table 11. We find similar results from these three tests.

Table 11. *Results of Panel unit root test.*

Variables	At level			At first difference		
	LLC test	IPS test	MW test	LLC test	IPS test	MW test
$lnCO_2$	-0.03 (0.485)	2.01 (0.978)	1.93 (0.973)	-3.89*** (0.000)	-6.13*** (0.000)	-6.61*** (0.000)
lnGDP	0.36 (0.642)	9.00 (1.000)	4.07 (1.000)	-4.24*** (0.000)	-5.36*** (0.000)	-5.67*** (0.000)
$lnGDP^2$	1.20 (0.884)	9.83 (1.000)	1.64 (0.949)	-4.10*** (0.000)	-4.49*** (0.000)	-4.79*** (0.000)
lnEC	1.78 (0.963)	6.04 (1.000)	3.17 (0.999)	-4.66*** (0.000)	-5.18*** (0.000)	-5.55*** (0.000)
lnFD	-0.85 (0.195)	1.23 (0.891)	1.29 (0.901)	-4.34*** (0.000)	-5.39*** (0.000)	-5.84*** (0.000)
lnFDI	-2.03 (0.221)	-1.28 (0.098)	1.45 (0.073)	-6.60*** (0.000)	-10.8*** (0.000)	-11.0*** (0.000)
lnTO	-0.80 (0.210)	1.21 (0.888)	1.27 (0.898)	-3.86*** (0.000)	-7.03*** (0.000)	-7.47*** (0.000)
lnURB	0.91 (0.819)	2.59 (0.995)	1.97 (0.975)	-8.65*** (0.000)	-8.09*** (0.000)	-8.14*** (0.000)

Source: Calculated by authors using Stata 15. Parenthesis indicates p-values.

Table 11 suggests that the variables we considered might be cointegrated. Therefore, we will perform a panel ARDL cointegration test.

With the intention of getting efficiency and consistency among the estimators, we apply a Hausman test in the study. Table 12 displays the findings of the Hausman test. The Hausman test suggests that we cannot reject the null hypothesis of homogeneity restrictions in the long term variables, which confirms that PMG is the most efficient estimator over the MG and DFE estimators in the model.

Table 12. *Results of the Hausman Test.*

Test	Model 1	Model 2	Model 3	Model 4	Model 5
PMG and MG	0.59 (0.964)	7.78 (0.099)	2.39 (0.664)	3.40 (0.493)	6.38 (0.496)
PMG and DFE	0.61 (0.962)	0.52 (0.971)	0.53 (0.970)	1.45 (0.835)	0.53 (0.999)

Source: Calculated by authors using Stata 15. Parenthesis indicates p-values.

Table 13 describes the findings of the long-run panel ARDL regression of selected SAARC countries applying pooled mean group estimator. We get an insignificant p-value of the Hausman test in the case of mean group and DEF in the model. Therefore, the PMG estimator is more appropriate in the long-run.

From Table 13, the coefficient of real GDP per capita is statistically significant in the model and the size of the coefficient is 2.03. Besides, the coefficient size of squared real GDP per capita is diverse (-0.109) and statistically significant in the model. The estimated results indicate that the upper level of earning encourages higher emissions. In the study, we discover a positive coefficient of real GDP per capita and negative of real GDP^2 per capita in the model, which approves an Environmental Kuznets curve be present in selected South Asian countries during 1978-2018.

We get a positive coefficient of energy consumption and significant at one percent confidence level in the model, which means that a raise in EC may significantly upswing carbon dioxide emissions in selected South Asian countries. The magnitude of energy consumption in the model is 0.850. These findings are in line with the outcomes of the preceding works of Arouri et al. [9] and Farhani et al. [26].

Table 13. *Results of Panel ARDL Estimation (Long-run), $lnCO_2$ is the dependent variable.*

Variables	Pooled Mean Group				
	Model 1	Model 2	Model 3	Model 4	Model 5
lnGDP	0.893 (0.861)	2.86** (1.13)	1.46** (0.674)	6.35* (3.26)	2.03** (1.01)
$lnGDP^2$	-0.015 (0.062)	-0.174** (0.083)	-.092* (0.049)	-.442* (0.251)	-0.109* (0.064)
lnEC	1.03*** (0.100)	1.20*** (0.121)	1.04*** (0.103)	1.19*** (0.107)	0.850*** (0.80)
lnFD	0.074** (0.026)				0.116*** (0.022)
lnFDI				0.035 (0.029)	0.004 (0.005)
lnTO		-0.052 (0.049)			-0.018 (0.039)
lnURB			1.02*** (.145)		0.678*** (0.118)

Source: Calculated by authors using Stata 15. ***, **, * indicates the rejection of a significant test at 1%, 5%, and 10% significant level correspondingly. The standard errors are in the parenthesis.

We get statistically insignificant results for trade openness and FDI, while significant results for FD and urbanization in selected South Asian countries. The estimated result shows that financial development brings about an increase in CO_2 emissions by around 0.12 percent in selected South Asian countries in the long run. This outcome is in line with the results of Rafindadi & Yousuf, [64]. The long-run outcomes show that urbanization raises carbon emissions significantly in selected South Asian countries. This is because urbanization influences various industrial work and transportation. Salim et al. [68] also found the same result. Since urbanization has a statistically significant positive influence on CO_2 emissions, therefore, it can be said that selected South Asian countries with higher urbanization will contaminate the environment in the long-run.

Table 14 indicates the findings of the short term panel ARDL regression applying the PMG estimator. The results illustrate that the value of ECTs is -0.560, which means around 0.56 percent of disequilibrium in the preceding year is adjusted in the present year in the model.

Table 14 shows that the coefficients of real GDP and squared real GDP are statistically insignificant in the specification; also, the coefficients of financial development, trade openness and FDI are statistically insignificant in the short run. The estimated result shows that the value of energy consumption is positive and statistically significant at 10% significance level, which specifies that an upturn in EC may significantly raise CO_2 emission per capita selected South Asian countries in the short-run. Similarly, a rise in urbanization leads to an increase in carbon emissions in selected South Asian countries in the short run.

Table 14. *Results of Panel ARDL Estimation (Short-run), $\Delta\, lnCO_2$ is the dependent variable.*

Variables	Pooled Mean Group				
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**
ECT	-.379** (0.146)	-0.334** (0.134)	-0.459*** (0.114)	-0.333** (0.137)	-.560* (0.183)
Δ lnGDP	2.69 (5.68)	2.43 (7.68)	3.44 (14.5)	1.40 (6.45)	0.854 (11.1)
Δ $lnGDP^2$	-0.162 (0.481)	-0.247 (.655)	-0.320 (1.25)	- 0.153 (0.548)	-0.071 (0.937)
Δ lnEC	0.560** (0.289)	0.760** (.280)	0.431* (.174)	0.578** (0.260)	0.485* (0.217)
Δ lnFD	0.028 (0.070)				0.010 (0.006)
Δ lnTO		-.044** (.018)			-0.087 (0.088)
Δ lnURB			1.79 (1.74)		2.42** (1.15)
Δ lnFDI				0.009* (0.005)	0.003 (0.064)
Constant	-4.69** (1.76)	-6.33** (2.52)	-7.31*** (1.82)	-3.82** (1.54)	-9.54** (3.09)

Source: Calculated by authors using Stata 15. ***, **, * indicates the rejection of a significant test at 1%, 5%, and 10% significant level correspondingly. The standard errors are in the parenthesis.

4.5. Comparison Between Bangladesh and Selected South Asian Countries in Terms of CO_2 Emissions

In this study, we use linear and nonlinear ARDL models in the case of Bangladesh, while panel ARDL has been applied for selected South Asian countries. The coefficients of all the three models show positive effects from the real GDP per capita and EC and negative from the square of real GDP per capita, though we get the different magnitude of these variables using the three cointegration methods. This result is consistent with the environmental Kuznets curve hypothesis. The EKC hypothesis describes the nonlinear association between environmental improvement or degradation and economic growth. Following the EKC hypothesis, the rise in the level of GDP per capita would lead to environmental degradation at a certain level; then, it would fall. Furthermore, the negative mark in the value of GDP squared proves the existence of an EKC hypothesis in Bangladesh and selected South Asian countries.

In the three cointegration approaches, we find positive results for financial development in the long-term. We get insignificant coefficient of financial development using ARDL and NARDL techniques in case of Bangladesh. The probable reason for this is that financial development is highly positively correlated with urbanization. However, the study finds a statistically significant coefficient of financial development (0.12) in panel ARDL model. Therefore, financial development could stimulate industrialization resulting in industrial contamination and environmental degradation [1]. Furthermore, financial development could also damage the environment through households, businesses, and wealth effect channels. South Asian countries are the most populous region in the world, and it holds approximately 24.89% of the total world population. Thus, financial development may damage the environmental worth in selected South Asian countries.

We get positive but statistically insignificant coefficient of foreign direct investment in Bangladesh and also in selected South Asian countries in the long-run. The coefficients of trade openness in all models are negative. We get almost same magnitude of statistically significant coefficients of trade openness such as (-0.22) and (-0.23) using ARDL and NARDL approaches respectively, in case of Bangladesh, whereas the magnitude is smaller and statistically insignificant in panel ARDL model (-0.02). Nonetheless, this finding is consistent with the scale, composition, and technique effect theory. According to the theory, the technique effect is supposed to be always environmentally improving since the technology may cut emissions as an outcome of the invasion of overseas funds after opening to trade. For this reason, it can be said that trade openness may reduce CO_2 emissions in Bangladesh and other selected South Asian countries.

Finally, the coefficients of urbanization concerning carbon dioxide emissions are positive and statistically significant in both ARDL and NARDL models in the case of Bangladesh, and also for panel ARDL model in selected SAARC countries. These results are consistent with the theory of ecological modernization. The theory of ecological modernization suggests that, when societies progress from low to middle-stage of development, economic growth takes prevalence over environmental sustainability. As societies keep advancing into upper levels of development, environmental destruction tends to be more crucial; consequently societies search for ways to be converted into more environmentally sustainable. Since URB has a statistically significant positive influence on carbon emissions, thus, it can be said that Bangladesh and selected South Asian countries with higher urbanization will contaminate the environment in the long-run.

5. Conclusion

In this study, we tried to find out all plausible determinants of carbon emissions in Bangladesh and also tried to compare it with other South Asian countries. The study examines the linear and nonlinear relationships between per capita CO_2 emissions, per capita real GDP, energy consumption, financial development, foreign direct investment, trade openness, urbanization, agriculture, and industry sectors as potential contributing factors of CO_2 emissions in the perspective of Bangladesh all through 44 years, starting from 1974. The study also considers the CO_2 emissions from the selected South Asian countries over the period from 1978 and 2018.

The study uses three cointegration approaches, which are the linear, nonlinear, and panel ARDL methods, to ascertain the association between the variables. Using the linear ARDL approach, we find that the crucial determining factors of CO_2 emissions in Bangladesh are real GDP, energy consumption, and urbanization. Then, we apply the nonlinear cointegration method and find that EC and FDI have asymmetric impacts on carbon release in the long run. While EC, financial development, and FDI have asymmetric influence in the short run. Finally, we apply a panel cointegration test to compare Bangladesh with other South Asian countries in terms of CO_2 emissions. The estimated results disclose that the vital contributing factors of CO_2 emissions in selected South Asian countries are real GDP, EC, FD, and URB.

In conclusion, the three cointegration estimations findings disclose that urbanization will deteriorate environmental worth in Bangladesh and selected South Asian countries in the long run. Our results show that EC, FD, and URB upturn CO_2 emissions, while trade openness lowers emissions. We also claim that our results are consistent with the EKC hypothesis for both Bangladesh and selected South Asian countries, indicating that after achieving a certain level of income, CO_2 emissions incline to drop.

We draw several policy recommendations from the findings of our study. In modern days, energy is crucial in every sphere of human life. According to the World Bank [82], the share of total fossil fuel energy consumption in Bangladesh was 74% in 2014. Also, the study finds energy consumption increases CO_2 emissions; the government should focus on investing in production of renewable energy. For instance, Bangladesh is a tropical country where scorching sunlight is found almost everywhere round the year. According to the World Economic Forum [83], South Korea targets to yield 35% of its electricity from renewable sources, particularly from sunlight by 2040. Bangladesh's government can follow this target to turn down the CO_2 emissions. For implementing this, the government should formulate policy imposing terms of installing solar panels on every structure and also engage citizens and private businesses with a host of intimate to make solar energy more affordable, accessible, and in some cases, compulsory. This study finds FDI increases emissions, while trade openness reduces it. According to the pollution HALO hypothesis, MNCs use advanced technologies, bring new production methods and better management practices that result in a clean environment in host countries. Also, scale, composition, and technique effect says technique effect is always supposed to be environmentally friendly as technology may cut the pollution productions. Therefore, the government should take steps to attract FDI in these sectors and advise them to adopt environment-friendly technology for reducing carbon emissions.

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References

[1] Acheampong, A. O. (2019). Modelling for insight: Does financial development improve environmental quality? *Energy Economics, 83*, 156-179.

[2] Ahad, M., & Dar, A. A. (2017). Modelling the asymmetric impact of defence spending on economic growth an evidence from non-linear ARDL and multipliers. *Journal of Economic and Administrative Sciences, Vol. 33 No. 2*, pp: 131-149. doi: 10.1108/JEAS-03-2017-0010.

[3] AhAtil, A., Bouheni, F. B., Lahiani, A., & Shahbaz, M. (2019). Factors influencing CO_2 emission in China: A Nonlinear Autoregressive Distributed Lags Investigation. MPRA Paper No. 91190, 8 January 2019, 15: 01 UTC.

[4] Alam, M. J., & Huylenbroeck, G. V. (2011). Energy Consumption, CO_2 Emissions and the Economic Growth Nexus in Bangladesh: Cointegration and Dynamic Causality Analysis. *Conference paper, 2011*, Honolulu, Hawaii, USA.

[5] Al-mulali, U., & Binti Che Sab, C. N. (2012). The impact of energy consumption and CO_2 emission on the economic growth and financial development in the Sub Saharan African countries. *Energy, 39* (1), 180-186. doi: 10.1016/j.energy.2012.01.032.

[6] Alam, J. (2014). On the Relationship between Economic Growth and CO_2 Emissions: The Bangladesh Experience. IOSR *Journal of Economics and Finance (IOSR-JEF), e-ISSN: 2321-5933, p-ISSN: 2321-5925, Volume 5, Issue 6*, Ver. I (Nov.-Dec. 2014), PP 36-41.

[7] Al-Mulali, U., Ozturk, I., & Lean, H. H. (2015). The influence of economic growth, urbanization, trade openness, financial development, and renewable energy on pollution in Europe. *Natural Hazards, 79* (1), 621-644. doi: 10.1007/s11069-015-1865-9.

[8] Amin, S. B., Ferdaus, S. S., & Porna, A. K. (2012). Causal Relationship among Energy Use, CO_2 Emissions and Economic Growth in Bangladesh: An Empirical Study. *World Journal of Social Sciences, Vol. 2,* No. 4, pp. 273–290.

[9] Arouri, M. E. H., Ben Youssef, A., M'Henni, H., & Rault, C. (2012). Energy consumption, economic growth and CO_2 emissions in Middle East and North African countries. *Energy Policy, 45*, 342-349. doi: 10.1016/j.enpol.2012.02.042.

[10] Ayinde, A. R., Celik, B., & Gylych, J. (2019). Effect of Economic Growth, Industrialization, and Urbanization on Energy Consumption in Nigeria: A Vector Error Correction Model Analysis. *International Journal of Energy Economics and Policy, 9* (5), 409-418. doi: 10.32479/ijeep.8175.

[11] Bangladesh Bureau of Statistics, (2018). Statistical Yearbook of Bangladesh 2008. Bangladesh Bureau of Statistics, Agargaon.

[12] Bayramoglu, A. T., & Yildirim, E. (2017). The Relationship between Energy Consumption and Economic Growth in the USA: A Non-Linear ARDL Bounds Test Approach. *Energy and Power Engineering, 9*, 170-186, ISSN Print: 1949-243X.

[13] Begum, R. A., Sohag, K., Abdullah, S. M. S., & Jaafar, M. (2015). CO_2 emissions, energy consumption, economic and population growth in Malaysia. *Renewable and Sustainable Energy Reviews, 41*, 594-601. doi: 10.1016/j.rser.2014.07.205.

[14] Behera, S. R., & Dash, D. P. (2017). The effect of urbanization, energy consumption, and foreign direct investment on the carbon dioxide emission in the SSEA (South and Southeast Asian) region. *Renewable and Sustainable Energy Reviews, 70*, 96-106. doi: 10.1016/j.rser.2016.11.201.

[15] Blackburne, E. F., & Frank, M. W. (2007). Estimation of nonstationary heterogeneous panels. *The Stata Journal, 7*, Number 2, pp. 197-208.

[16] Boutabba, M. A. (2014). The impact of financial development, income, energy and trade on carbon emissions: Evidence from the Indian economy. *Economic Modelling, 40*, 33-41. doi: 10.1016/j.econmod.2014.03.005.

[17] Chiou-Wei, S. Z., Chen, C. F., & Zhu, Z. (2008). Economic growth and energy consumption revisited evidence from linear and nonlinear Granger causality. *Energy Economics, vol. 30*, No. 6, 3063–3076.

[18] Chousa, J. P., Tamazian, A. & Vadlamannati, K. C. (2009). Does Higher Economic and Financial Development lead to Environmental Degradation: Evidence from BRIC Countries? *Energy Policy, 37* (1), 2009. https://ssrn.com/abstract=2894442.

[19] CO_2 in the atmosphere just exceeded 415 parts per million for the first time in human history. Retrieved from https://techcrunch.com/2019/05/12/co2-in-the-atmosphere-just-exceeded-415-parts-per-million-for-the-first-time-in-human-history/.

[20] Dickey, D. A. & Fuller, W. A. (1979). Distribution of the Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association, Vol. 74*, No. 366 (Jun., 1979), pp. 427-431.

[21] Dogan, E., & Turkekul, B. (2016). CO_2 emissions, real output, energy consumption, trade, urbanization and financial development: testing the EKC hypothesis for the USA. *Environ SciPollut Res Int, 23* (2), 1203-1213. doi: 10.1007/s11356-015-5323-8.

[22] Ehrhardt-Martinez, K., Crenshaw, E. M., & Carig Jenkins, J. (2002). Deforestation and the environmental Kuznets curve: A cross-national investigation of intervening mechanisms. *Social Science Quarterly, 83* (1), 226-245.

[23] Elliott, G., Rothenberg, T. J., & Stock, J. H. (1996). Efficient Tests for an Autoregressive Unit Root. Econometrica, vol. 64, no. 4, pp. 813-836.

[24] Ertugrul, H. M., Cetin, M., Seker, F., & Dogan, E. (2016). The impact of trade openness on global carbon dioxide emissions: Evidence from the top ten emitters among developing countries. *Ecological Indicators, 67*, 543-555. doi: 10.1016/j.ecolind.2016.03.027.

[25] Farhani, S., Shahbaz, M., & Arouri, M. (2013). Panel analysis of CO_2 emissions, GDP, energy consumption, trade openness and urbanization for MENA countries. MPRA Paper No. 49258.

[26] Farhani, S., Chaibi, A., & Rault, C. (2014). CO_2 emissions, output, energy consumption, and trade in Tunisia. *Economic Modelling, 38*, 426-434. doi: 10.1016/j.econmod.2014.01.025.

[27] Farhani, S., & Ozturk, I. (2015). Causal relationship between CO_2 emissions, real GDP, energy consumption, financial development, trade openness, and urbanization in Tunisia. *Environ SciPollut Res Int, 22* (20), 15663-15676. doi: 10.1007/s11356-015-4767-1.

[28] Frankel, J. A., & Romer, D. H. (1999). Does Trade Cause Growth? *The American Economic Review. 89* (3), 379-399.

[29] Gasimli, Haq, Gamage, Shihadeh, Rajapakshe, & Shafiq. (2019). Energy, Trade, Urbanization and Environmental Degradation Nexus in Sri Lanka: Bounds Testing Approach. *Energies, 12* (9). doi: 10.3390/en12091655.

[30] Gökmenoğlu, K., & Taspinar, N. (2015). The relationship between CO_2 emissions, energy consumption, economic growth and FDI: the case of Turkey. *The Journal of International Trade & Economic Development, 25* (5), 706-723. doi: 10.1080/09638199.2015.1119876.

[31] Granger, C. W. J. (1969). Investigating Causal Relations by Econometric Models and Cross-spectral Methods. *Econometrica, Vol. 37*, No. 3 (Aug., 1969), pp. 424-438.

[32] Grether, J.-M., Mathys, N. A., & de Melo, J. (2008). Scale, Technique and Composition Effects in Manufacturing SO2 Emissions. *Environmental and Resource Economics, 43* (2), 257-274. doi: 10.1007/s10640-008-9237-5.

[33] Hamid, K. (2016). Is Foreign Direct Investment a Cause of Environmental Degradation in Pakistan? An ARDL Approach to Cointegration. *Journal of Management and Research Volume 3*, Number 2, 2016.

[34] Hao, Y., Zhang, Z. Y., Liao, H., Wei, Y. M., & Wang, S. (2016). Is CO_2 emission a side effect of financial development? An empirical analysis for China. *Environ SciPollut Res Int, 23* (20), 21041-21057. doi: 10.1007/s11356-016-7315-8.

[35] Haug, A. A., & Ucal, M. (2019). The role of trade and FDI for CO_2 emissions in Turkey: Nonlinear relationships. *Energy Economics, 81*, 297-307. doi: 10.1016/j.eneco.2019.04.006.

[36] Hossain, A. K. M. N., & Hasanuzzaman, S. (2016). The Impact of Energy Consumption, Urbanization, Financial Development and Trade openness on the Environment in Bangladesh: An ARDL Bound Test Approach. Retrieved November, 2016, from http://bea-bd.org/site/images/pdf/28.pdf.

[37] Intergovernmental Panel on Climate Change (2018). Retrieved from https://www.ipcc.ch/.

[38] Islam, F., Shahbaz, M., & Butt, M. S. (2013). Is There an Environmental Kuznets Curve for Bangladesh? Evidence from ARDL Bounds Testing Approach. *Bangladesh Development Studies, Vol. XXXVI*, No. 4, December 2013.

[39] Jalil, A., & Feridun, M. (2011). The impact of growth, energy and financial development on the environment in China: A cointegration analysis. *Energy Economics, 33* (2), 284-291. doi: 10.1016/j.eneco.2010.10.003.

[40] Jayanthakumaran, K., Verma, R., & Liu, Y. (2012). CO_2 emissions, energy consumption, trade and income: A comparative analysis of China and India. *Energy Policy, 42*, 450-460. doi: 10.1016/j.enpol.2011.12.010.

[41] Kahouli, B. (2017). The short and long run causality relationship among economic growth, energy consumption and financial development: Evidence from South Mediterranean Countries (SMCs). *Energy Economics, 68*, 19-30. doi: 10.1016/j.eneco.2017.09.013.

[42] Kaika, D., & Zervas, E. (2013). The Environmental Kuznets Curve (EKC) theory—Part A: Concept, causes and the CO_2 emissions case. *Energy Policy, 62*, 1392-1402. doi: 10.1016/j.enpol.2013.07.131

[43] Kasman, A., & Duman, Y. S. (2015). CO_2 emissions, economic growth, energy consumption, trade and urbanization in new EU member and candidate countries: A panel data analysis. *Economic Modelling, 44*, 97-103. doi: 10.1016/j.econmod.2014.10.022..

[44] Khoshnevis Yazdi, S., & Dariani, A. G. (2019). CO_2 emissions, urbanisation and economic growth: evidence from Asian countries. *Economic Research-EkonomskaIstraživanja, 32* (1), 510-530. doi: 10.1080/1331677x.2018.1556107.

[45] Kivyiro, P., & Arminen, H. (2014). Carbon dioxide emissions, energy consumption, economic growth, and foreign direct investment: Causality analysis for Sub-Saharan Africa. *Energy, 74*, 595-606. doi: 10.1016/j.energy.2014.07.025.

[46] Kizilkaya, O. (2017). The Impact of Economic Growth and Foreign Direct Investment on CO_2 Emissions: The Case of Turkey. *Turkish Economic Review, 4* (1), pp. 106-118.

[47] Kohler, M. (2013). CO_2 emissions, energy consumption, income and foreign trade: A South African perspective. *Energy Policy, 63*, 1042-1050. doi: 10.1016/j.enpol.2013.09.022.

[48] Kraft, J., & Kraft, A. (1978). On the relationship between energy and GNP. *Journal of Energy and Development, Springer*, 401-403.

[49] Lee, C.-C., & Chang, C.-P. (2007). The impact of energy consumption on economic growth: Evidence from linear and nonlinear models in Taiwan. *Energy, 32* (12), 2282-2294. doi: 10.1016/j.energy.2006.01.017.

[50] Levinson, A., & Taylor, M. S. (2008). Unmasking the pollution haven effect. *International Economic Review, Vol. 49*, No. 1, February 2008.

[51] Linh, D. H., & Lin, S. M. (2015). CO_2 Emissions, Energy Consumption, Economic Growth and FDI in Vietnam. *Managing Global Transitions, 12* (3), 219–232.

[52] Mahmood, H., & Chaudhary, A. R. (2012). FDI, Population Density and Carbon Dioxide Emissions: A Case Study of Pakistan. *Iranica Journal of Energy & Environment 3* (4): 355-361, ISSN 2079-2115. doi: 10.5829/idosi.ijee.2012.03.04.1760.

[53] Mamun, A. M., Sohag, K., Samargandi, N., & Yasmeen, F. (2016). Does remittance fuel labour productivity in Bangladesh? The application of an asymmetric non-linear ARDL approach. *Applied Economics, 48*: 50, 4861-4877. doi: 10.1080/00036846.2016.1167825.

[54] Martínez-Zarzoso, I., & Maruotti, A. (2011). The impact of urbanization on CO_2 emissions: Evidence from developing countries. *Ecological Economics, 70* (7), 1344-1353. doi: 10.1016/j.ecolecon.2011.02.009.

[55] Mol, A. P. J., & Spaargaren, G. (2007). Ecological modernisation theory in debate: A review. *Environmental Politics, 9* (1), 17-49. doi: 10.1080/09644010008414511.

[56] Ndoricimpa, A. (2017). Analysis of asymmetries in the nexus among energy use, pollution emissions and real output in South Africa. *Energy, 125*, 543-551.

[57] Oh, K.-Y., & Bhuyan, M. I. (2018). Trade Openness and CO_2 Emissions: Evidence of Bangladesh. *Asian Journal of Atmospheric Environment, 12* (1), 30-36. doi: 10.5572/ajae.2018.12.1.030.

[58] Omri, A. (2013). CO_2 emissions, energy consumption and economic growth nexus in MENA countries: Evidence from simultaneous equations models. *Energy Economics, 40*, 657-664. doi: 10.1016/j.eneco.2013.09.003.

[59] Ozturk, I., & Acaravci, A. (2013). The long-run and causal analysis of energy, growth, openness and financial development on carbon emissions in Turkey. *Energy Economics, 36*, 262-267. doi: 10.1016/j.eneco.2012.08.025.

[60] Pesaran, M. H., Shin, Y., & Smith, R. P. (1999). Pooled Mean Group Estimation of Dynamic Heterogeneous Panels. *Journal of the American Statistical Association, 94* (446), 621-634. doi: 10.1080/01621459.1999.10474156.

[61] Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics, Vol. 16*, No. 3, pp. 289-326.

[62] Phillips, P. C. B., & Perron, P. (1988). Testing for a Unit Root in Time Series Regression. *Biometrika, Vol. 75*, No. 2, pp. 335-346.

[63] Rabbi, F., Akbar, D., & Kabir, S. M. Z. (2015). Environment Kuznets Curve for Carbon Emissions: A Cointegration Analysis for Bangladesh. *International Journal of Energy Economics and Policy, Vol. 5*, No. 1, 2015, pp.45-53, ISSN: 2146-4553. www.econjournals.com.

[64] Rafindadi, A. A., & Yosuf, Z. (2013). An Application of Panel ARDL in Analysing the dynamics of Financial Development and Economic Growth in 38 Sub-Saharan African Continents. *Proceeding – Kuala Lumpur International Business, Economics and Law Conference, Vol. 2*, December 2-3, 2013. ISBN 978-967-11350-2-0.

[65] Sadorsky, P. (2010). The impact of financial development on energy consumption in emerging economies. *Energy Policy, 38* (5), 2528-2535. doi: 10.1016/j.enpol.2009.12.048.

[66] Sadorsky, P. (2011). Financial development and energy consumption in Central and Eastern European frontier economies. *Energy Policy, 39* (2), 999-1006. doi: 10.1016/j.enpol.2010.11.034.

[67] Salim, R., Yao, Y., Chen, G., & Zhang, L. (2017). Can foreign direct investment harness energy consumption in China? A time series investigation, *Energy Economics*, doi: 10.1016/j.eneco.2017.05.026.

[68] Salim, R., Rafiq, S., Shafiei, S., & Yao, Y. (2019). Does urbanization increase pollutant emission and energy intensity? Evidence from some Asian developing economies. *Applied Economics*, doi: 10.1080/00036846.2019.1588947.

[69] Sarker, S., Khan, A., & Mahmood, R. (2016). FDI, Economic Growth, Energy Consumption & Environmental Nexus in Bangladesh. *Economics and Applied Informatics, no.1*, 33-44, ISSN-L 1584-0409.

[70] Sarkodie, S. A., & Adams, S. (2020). Electricity access and income inequality in South Africa: Evidence from Bayesian and NARDL analyses. *Energy Strategy Reviews, 29*. doi: 10.1016/j.esr.2020.100480.

[71] Sehrawat, M., Giri, A. K., & Mohapatra, G. (2015). The impact of financial development, economic growth and energy consumption on environmental degradation. *Management of Environmental Quality: An International Journal, 26* (5), 666-682. doi: 10.1108/meq-05-2014-0063.

[72] Shaari, M. H., Hussain, N. E., Abdullah, H., & Kamil, S. (2014). Relationship among Foreign Direct Investment, Economic Growth and CO_2 Emission: A Panel Data Analysis. *International Journal of Energy Economics and Policy Vol. 4*, No. 4, pp.706-715, ISSN: 2146-4553.

[73] Shahbaz, M., Loganathan, N., Muzaffar, A. T., Ahmed, K., & Ali Jabran, M. (2016). How urbanization affects CO_2 emissions in Malaysia? The application of STIRPAT model. *Renewable and Sustainable Energy Reviews, 57*, 83-93. doi: 10.1016/j.rser.2015.12.096.

[74] Shahbaz, M., Nasir, M. A., & Roubaud, D. (2018). Environmental degradation in France: The effects of FDI, financial development, and energy innovations. *Energy Economics, 74*, 843-857. doi: 10.1016/j.eneco.2018.07.020.

[75] Shahbaz, M., Salah Uddin, G., Ur Rehman, I., & Imran, K. (2014). Industrialization, electricity consumption and CO_2 emissions in Bangladesh. *Renewable and Sustainable Energy Reviews, 31*, 575-586. doi: 10.1016/j.rser.2013.12.028.

[76] Shin, Y., Yu, B., & Greenwood-Nimmo, M. (2014). Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. In Sickles, R. C. and Horrance, W. C. (Eds), Festschrift in Honor of Peter Schmidt, Springer, New York, NY, pp. 281-314.

[77] Sharmin, M., & Tareque, M. (2018). Econometric Analysis of the Effect of Economic Globalization, Energy Intensity, Urbanization, Industrialization and Growth on co_2 Emissions of Bangladesh. *Managing Global Transitions International Research Journal, 16* (4), 335–354, ISSN 1854-6935. https://doi.org/10.26493/1854-6935.16.335-354

[78] Suri, V., & Chapman, D. (1998). Economic growth, Trade and the Energy: Implications for the Environmental Kuznets Curve. *Ecological Economics, 25* (2), 195-208.

[79] Tadesse, S. (2005). Financial Development and Technology. Working paper, William Davidson Institute, Working Paper Number 749.

[80] Tariq, G., Sun, H., Haris, M., Kong, Y., & Nadeem, M. A. (2018). Trade liberalization, FDI inflows economic growth and environmental sustainability in Pakistan and India. *Journal of Agriculture and Environment for International Development, 112* (2), 253-269. doi: 10.12895/jaeid.20182.722.

[81] World Bank (2013). Warming Climate to Hit Bangladesh Hard with Sea Level Rise, More Floods and Cyclones, World Bank Report Says. World Bank, Washington, DC. Retrieved from https://www.worldbank.org/en/news/press-release/2013/06/19/warming-climate-to-hit-bangladesh-hard-with-sea-level-rise-more-floods-and-cyclones-world-bank-report-says.

[82] World Bank (2019). World development indicators. World Bank, Washington, DC. Available at: https://data.worldbank.org/indicator.

[83] World Economic Forum (2019). Available at: https://www.weforum.org/agenda/2019/11/solar-power-seoul-south-korea?fbclid=IwAR2n30awRWf_fS-RU4GKXhgA4mQXKEv8wmNtFr0pzOORON8jbp9z3sXJoFs.

[84] Zarsky, L. (1999). Havens, halos and spaghetti: Untangling the evidence about foreign direct investment and the environment. *Conference on Foreign Direct Investment and the Environment: The Hague, Netherlands*, 28-29 January 1999. 1-25.

[85] Zheng, W., & Walsh, P. P. (2019). Economic growth, urbanization and energy consumption — A provincial level analysis of China. *Energy Economics, 80*, 153-162. doi: 10.1016/j.eneco.2019.01.004.

[86] Zeshan, M., & Ahmed, V. (2013). Energy, environment and growth nexus in South Asia. *Environment, Development and Sustainability, 15* (6), 1465-1475.