Nexus Between Energy Consumptions and CO₂ Emissions in Selected Industrialized Countries

Md. Hasanur Rahman¹, Shapan Chandra Majumder²

¹,² Department of economics, Comilla University, Bangladesh

* Corresponding author: hasanur.cou@gmail.com

Abstract

This study examines the nexus between energy consumptions and CO₂ emissions in selected industrialized countries and selects the industrialized countries where three are industrialized and two are a newly industrial growing country out of five. The panel section implies the period from 1980 to 2014 for selected countries. The WDI is the main data source for the selected variables. This study conducts the FMOLS method, which is suggested by unit root and the Johansen co-integration test. The Granger causality also uses to estimate the causality in current variables. The Johansen Fisher co-integration test indicates the long-run association’s among the variable. The FMOLS technique estimates the marginal effect that industrialization and energy outlay is an authentic and significant influence on CO₂ emission. Panel Granger causality also shows a reliable result to estimate the causal relation.

Keywords: CO₂ Emissions, Industrializations, Energy Consumptions, Panel Cointegration, Granger Causality, FMOLS

INTRODUCTION

Carbon dioxide emission is the major concern for industrialized countries, not only industrialized countries it’s also a concern for developing or newly industrial growing countries because the environmental degradations vastly effects of those kinds of countries as lack of environmental management system and lack of controlling pollution. In generally energy consumption positively implies for industrial growth and enhancing GDP for a nation and another issue that energy consumption is one of the causes of increasing CO₂ emissions. According to the UFWCC, the main concern of the Kyoto Protocol is reducing Green House Gases (GHG) that the causes of world climate change. Industrialized countries face environmental degradations like as sea levels increase, Cyclone, Flood, and Drought which are the primary causes of rising CO₂ outlay and global warming. The CO₂ emission is the most vital element of increasing the GHG as the amount 76.7% of total emissions. Shahbaz et al. (2016) predict that the developing countries will be faced a greater challenge from climate change and CO₂ emissions. And he also added that industrialized countries increased CO₂ emissions with energy consumption in both short-run and long run.

In the past several decades’ energy economics open a new door for faster growth and development. Capital intensive countries highly used this kind of opportunities with respect to technology constraints. Modern technology enhances the faster growth in the world, and developing countries also take advantages using the technology as a part and parcel of the economy Masih and Masih (1996). But there was an actual problem is associated with consuming energy and energy input in production. CO₂ discharge is one of the vital problems for this kind of economic enhancement. It is difficult to show the way for eliminating carbon dioxide emission problem but research can make some recommendations and present the impacts of energy consumption on emissions. The environment loses balance with respect to time, and the energy consumption is one of the major reasons for the carbon emission.

To measuring the impact of energy consumption on CO₂ outlay Lean and Smyth (2009) demonstrate that energy consumption has long-run relations to industrial growth and CO₂ emissions. Alam and Huynenbroeck (2011), Perry et al. (2008), Hossain and Hasanuzzaman, (2012) and Sheinbaum et al. (2010) also determine the relations between CO₂ discharge and energy consumption. In this study examined a panel data from 1980 – 2014 for selected industrialized countries those are the USA, China, Malaysia, India and Bangladesh. We know that the USA, China, Malaysia already achieve high industrial progress and India also up-rowing nations for industrial development and Bangladesh achieved the high GDP growth rate with the best contributions of agriculture, service and the industrial sector. As an industrial country China, in 2014 CO₂ emitted 10291926.88 kt and energy use as the amount of 2236.73 (oil equivalent per capita) with achieved 6.9% of GDP growth rate in 2017. China introduced as a high much energy purchasing country in the last several decades. Chinese government take the initiative of one belt one road policy to ensure the energy supply. This initiative is able to create inter-link among nation to nation. Malaysia also achieved a GDP growth rate of 5.89 and industrial value-added the percentage of GDP 38.78 in 2017. The industry and service sector contribute to the USA economy with 91.1% of total GDP. Soytas and Sari (2003) state energy consumption helps to GDP growth in the USA. The growing industrial country India also one of the high energy-consuming agnation, where GDP growth rate in 2017 was 6.68 and emitted CO₂ as the amount of 2238377.17 in 2014. In this study consider that, the case of Bangladesh, because it needs a comparison among industrialized countries. At present Bangladesh attain 8.13 % of GDP growth rate and industrial with service sector contribution to GDP of 85.77%. Energy demand in Bangladesh gradually increases day by day with respect to industrial growth.

* Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

© Readers Insight Publication
This paper investigates the nexus between energy consumption and carbon dioxide emissions in the selected industrial countries over the time period of 1980–2014 with employing several econometric techniques with covering panel unit roots, cointegration. FMOLS technique follows unique rules to estimate the marginal effect of all parameters. Cross-sectional dependence allowing the Granger causality test, and try to make a comparison between industrial and newly industrial selected countries. In the next section of this study, section two for constructing objective, section three relates the summary of the literature review. Section four describes the methodology. Econometric result and findings are discussed in section five and lastly make a conclusion of the overall study.

The Objective of this Study

**Main Objective**

To know the relationship between energy consumption and carbon emission (CO₂) in selected industrialized countries.

**Specific Objectives**

i. To determine the relationship within the energy consumption and carbon emissions by industrial development in selected countries
ii. To find out the effects of energy consumption on industrialization in selected countries
iii. To demonstrate the legitimacy of energy consumption and CO₂ emissions in industrialized and newly industrialized countries like as Malaysia, India, Bangladesh

**Literature Review**

Nexus between energy consumption and CO₂ emissions studied deeply in research from the last few decades in worldwide. Industrialization is one of the growing concerns for carbon emissions. Researchers say that energy extractions as a cause of emitting carbon. There are some several relevant studies are given in Table 1.

In the context of existing literature, most of those kinds of literature show the impacts of energy consumption on CO₂ emissions in industrialized countries. In this study, also examine the effects of energy consumption on CO₂ emissions by comparing industrialized country and newly industrial growing countries.

**Methodology**

Measuring the nexus between energy consumption and CO₂ emissions in selected industrialized countries, we have used panel data with five countries as United State of America, P. R. China, Malaysia, India and Bangladesh. The secondary data are collected from WDI and this study conduct panel estimate from 1980 to 2014 with carbon dioxide emissions (CO₂) as explained variable and energy consumption (Enc), industrialization (Ind) are explanatory variables.

**Model Specifications**

To examine the nexus between energy consumption and CO₂ emissions for selected industrialized countries shows empirical findings to measuring the impact of CO₂ emissions by energy consumption and industrialization. At the impact of energy consumption would be positively significant or negatively significant or insignificant for this study. Now we can specify the model for consumption would be positively significant or negatively significant:

\[ CO₂ = f(Enc, Ind) \]

\[ CO₂_{it} = \beta_0 + \beta_1 Enc_{it} + \beta_2 Ind_{it} + \mu_{it} \]  

(1)

Now, the econometric form of CO₂ Model by taking Log on both sides:

\[ \ln(CO₂)_{it} = \beta_0 + \beta_1 \ln(Enc)_{it} + \beta_2 \ln(Ind)_{it} + \mu_{it} \]  

(2)

Where CO₂ means carbon dioxide emissions, Enc shows the energy consumption (kg of oil equivalent) and Ind represents the industry including construction value-added on GDP. \( \beta_0, \beta_1, \text{and} \beta_2 \) indicate the parameters which are to be estimated and \( \mu_{it} \) is the error term. \( t \) and \( i \) mean the time period and individuals country for panel estimation.

**Panel Unit Root Tests**

There are several techniques to determine the unit root for a specific data set. For estimating the panel unit root, most commonly used ADF, Levin Lin & Chu and another one is PP Fisher chi-square technique. Unit root test needs to determine the integrating level or selecting the optimum lagged period.

**ADF and Levin Lin Chu Technique**

The simple unit root stochastic process follows the procedure

\[ Y_{it} = \rho Y_{it-1} + \mu_{it} \quad -1 \leq \rho \leq 1 \]  

(3)

\[ Y_{it} = Y_{it-1} - \rho Y_{it-1} + \mu_{it} \]  

(4)

\[ Y_{it} - Y_{it-1} = (\rho - 1)Y_{it-1} + \mu_{it} \]  

(5)

\[ \delta Y_{it} = \phi (Y_{it-1}) + \mu_{it} \]  

(6)

Where; \( \phi = (\rho - 1) \) and \( \delta \) is the first difference operator

\[ \delta Y_{it} = Y_{it} - Y_{it-1} = \mu_{it} \]  

(7)

Since, \( \mu_{it} \) is an error term, describe it is stationary, meaning that the panel options are stationary after taking the first difference. Now ADF test has the following equations:

\[ \delta Y_{it} = \theta_1 + \theta_2 \delta Y_{it-1} + \phi Y_{it-1} + \sum_{t=1}^{T} \delta Y_{it-1} + \varepsilon_{it} \]  

(8)

Where; \( \varepsilon_{it} \) is an error component and ADF \( \delta Y_{it-1} \) is the lagged selection criteria.

**Pesaran and Shin Technique**

Shin and Im Pesaran (2003) argue the procedure of unit root testing with consideration of the ADF test, Im et al. (2003) interpreted W-statistics is normally distributed for the unit root test. These criteria are following the procedure:

\[ \Delta Y_{it} = \phi(Y_{it-1}) + \sum_{j=1}^{m} \theta_1 \Delta Y_{it-j} + \delta_t \phi + \varepsilon_{it} \]  

(9)

\[ H_0: \quad \phi_j = 0 \quad \quad j = 1, 2, \ldots, n \]  

(10)

\[ H_1: \quad \phi_j < 0 \quad \text{or} \quad \phi_j > 0 \quad \quad j = 1, 2, \ldots, n \]

Calculating the W-statistics:

\[ W = \sum_{i=1}^{N} \theta_i t_i \]  

(11)

Where, \( t_i \) is a simple t-test for determine of \( H_0 \), under \( H_0 \) condition is panel data series are no stationary and the task hypothesis presents stationary data. W statistics are normally distributed with zero mean value. Here, ‘N’ represents the total unit number across time, ‘m’ present the arbitrary constant.

**PP - Fisher Technique**

A technique of nonparametric stochastic unit root processes has proposed by Maddala and Wu (1999). ADF test enhances PP-Fisher technique without lagged term and considers as error term has serial correlations.
\[
\Delta Y_{it} = \alpha_i + \phi(Y_{it-1}) + \sum_{j=1}^{m_i} \delta_{ij}\Delta Y_{it-j} + \alpha_{2i}\phi + \varepsilon_{it} \tag{12}
\]

Where; first difference showed by \(\Delta\), \(k\) is the arbitrary constant and \(Y_{(t,t-1)}\) represent the optimum time-lagged for developing the null hypothesis (H0) is data has a unit root and task hypothesis (H1) is data has no unit root process.

Johansen - Fisher (J-F) Panel Cointegration technique

Maddala and Wu (1999) and Pedroni (1999) state that J-F test set to emphasis across the unit and also consider panel as time-variant. J-F test involved several kinds of a technique like as Trac test, Rank test and Max-eigenvalue. Cointegrated time-lagged would be selected by using J-F technique as the following equations;

\[
Z_{it} = \theta_i + aX_{it} + \varepsilon_{it} \tag{13}
\]

\[
Z_{it} = Z_{it-1} + \varepsilon_{it} \tag{14}
\]

\[
X_{it} = X_{it-1} + \varepsilon_{it} \tag{15}
\]

Where,

\(Z\) and \(X\) variable assure that the \(l(1)\) order integration. Time and country represented by an \(i\)-\(t\) symbol. \(e_{(it)}\) is an error component at equation no - (11).

**FMOLS technique**

Look into the co-integration prostrate relevance among the variables. OLS sometimes gives the spurious output in econometric analysis. FMOLS helps to eliminate spurious situations in a dynamic econometric model. Philips and Hanson (1990) first introduce FMOLS technique. Pedroni (2000) has demonstrated the FMOLS works to prostrate relevance amongst variables and FMOLS helps to explore the E-G method. Christopoulos and Tsianos (2003), Tajudeen (2005), Shah et al. (2014) also have used FMOLS technique.

**Panel Granger causality technique**

This methodology considers the relation between carbon dioxide (CO2) and energy consumption (ENC), industrialization (IND). Cointegration relation among the variables has expressed by causality technique (Granger, 1969; and Engle and Granger, 1987). Hiffmann et al. (2005) have found that ENC, IND has to the reason of rising CO2. Dritsakis and Stamatiou (2016), Christopoulos and Tsianos (2003) also measure the causality by using a similar kind of variables.

\[
CO2_{it} = \alpha_{0i} + \sum_{l=1}^{L} \gamma_{l,C}CO2_{it-l} + \sum_{l=2}^{L} \beta_{l,C}ENC_{lt-j} + \sum_{l=1}^{L} \alpha_{l,C}IND_{lt-k} + \mu_{1it} \tag{16}
\]

\[
ENC_{it} = \alpha_{0i} + \sum_{l=1}^{L} \theta_{l,E}ENC_{lt-l} + \sum_{l=1}^{L} \phi_{l,E}CO2_{lt-j} + \sum_{l=1}^{L} \rho_{l,E}IND_{lt-k} + \mu_{2it} \tag{17}
\]

\[
IND_{it} = \alpha_{0i} + \sum_{l=1}^{L} \delta_{l,I}IND_{lt-l} + \sum_{l=1}^{L} \phi_{l,I}CO2_{lt-j} + \sum_{l=1}^{L} \theta_{l,I}ENC_{lt-k} + \mu_{3it} \tag{18}
\]

Where, 't' is the time-variant, 'i' present across the unit, \(\mu\) is the residual term or error of white noise. \(\alpha,\beta,\gamma,\delta,\theta,\phi,\rho,\varphi\) and \(\omega\) Represent the parameter of those equations.

**ECONOMETRIC RESULT AND DISCUSSIONS**

**Panel Unit Root Tests**

This study demonstrate the most important and most useable test for make decision for panel unit root testing, here we use the Philips Perron - PP - Fisher Chi-square, Shin W-stat and Pesaran, ADF - testing, Levin, Lin & Chu method to estimate the unit root for panel estimation. Pesaran et al. (2001), Pesaran and Shin (1999), and Levin and Lin (1993) both of them implies several methods for measuring the nature of data and select the optimal lag difference for the zero to mean value for residuals and a constant variance known as stationary. The results are showing in Table 2.

The panel unit root tests results are presented in Table (2). This result shows that the test statistics for taking log levels for each of variables like as CO2, IND and Enc, are statistically insignificant at the level. Here the result says that the logs levels result of all three variables is non-stationary at level with considering the panel estimation. In this case, when we take the first difference of three variables for unit root testing, all four tests reject the H0 (variable is non-stationary or have a unit root) for each variable at the 1% or 5 % level and accept the alternative hypothesis as there have no unit-roots or series have stationary.

**Johansen - Fisher Panel Cointegration Test**

For this study, we have three variables, such as CO2, IND, and ENC. Maddala and Wu (1999) helps to construct JF- cointegration test for the estimating co-integration. Unit root test ensures that at the level both variables are the non-stationary but after ensuring the data series to 1st difference, and then they become stationary from the non-stationary series. So we can apply Johansen Fisher panel cointegration test and our variables and data, cointegrated of the same order, after 1st difference both are stationary, So data is integrated by H(1). The empirical results are described in Table 3.

Table 3 shows that maximum eigenvalue and trace test with measuring the cointegration of variables, where both of the tests accept the alternative hypothesis by rejecting the null hypothesis. The obtained probability value is less than 5% and it is significant to accept the task (H1) hypothesis and reject the null (H0) hypothesis. It means that at most two variables are cointegrated, so we can say that all variables are cointegrated. Our three variables are integrated into the long run all these variables are moved together, meaning that they have long run associations. When they are long-run associations then we can use the panel Fully Modified Ordinary Least Square (FMOLS) method and we can also use the DOLS method. This study used the FMOLS method to estimate the econometric regression model.

**Model selections: Hausman Test Result**

Here this model assuming that H0 as ‘the random effect is better for this model ’ to examine the result shows that the test summary as the probability value bellow 5% so we can reject the H0 hypothesis and accept the task (H1) hypothesis as the fixed effect if better is accepted Arellano(1993). Hausman (1978) and Taylor and Hausman (1981) they mechanized test or method for selection of a better effect. The Hausman Test estimated result is given in Table 4.

The scenario explained that, the fixed effect is better for this model because Hausman test explains that probability value is significant with less or equal than 5% so, Hausman test gives the decisions as accept the alternative hypothesis by rejecting the null hypothesis, that is the fixed effect is better for our estimated model.

**Panel Fully Modified Ordinary Least Squares (FMOLS) Long-run Estimates**

According to Johansen and Fisher cointegration test shows that long-run associations or cointegration in selected explained and explanatory variables and we estimate our model based on the panel version of (FMOLS) Proposed by Philips and Hansen (1990) and
Pedroni (2001) they explore DOLS and FMOLS as the measuring the marginal effects for long term cointegration.

Table 5 illustrates the panel FMOLS results for the estimated model. For the panel of selected industrialized countries at all, each of the coefficients or marginal effect represents the values of independent variables to influence the dependent variables. The expected result or sign are considered as significant with 5% level sometimes ten percent and one percent is better. Form table 4, the results indicate that one an average of 1% raising in energy expense is amalgamated with a carbon discharge raises at 0.338 percent. And carbon dioxide emissions increased 0.414 percent when there one an average, 1% increase in industry value added in GDP in the economy. For the result analysis, the empirical result by Ang (2007) and Payne and Apergis (2009) have found that CO2 per capita increases while the selected panel studied nations per capita energy consumption increased.

**Panel FMOLS Long-run Estimates for Individual Country**

This study conducted with the selected industrialized countries and we find the specific lack of previous studies and this empirical result shows how to explain this, we try to compare the industrialized countries and newly or growing industrial countries impact on CO2 emissions with the specific regressor variables. The empirical FMOLS long-run estimates result for studied Individual countries is given in Table 6.

Current study contact that CO2 is explained variable. Energy consumption & industrializations are the explanatory variables for selected industrialized countries. Now, explain the results for individual countries. From Table 6, each working unit shows an increase in energy consumption (Energy use (kg of oil equivalent) per $1,000 GDP (constant 2011 PPP)) is influenced to raise carbon dioxide (Kilo Ton) emissions. The results of the empirical study indicate that a 1% augmentation in energy outlay appends to increase in carbon emissions of 0.806 percent in the USA, 1.89 percent in Malaysia, 0.39 in China and India. Bangladesh also shows significant positive relations. Baul et al. (2018) also, find a similar result. For the industrial value-added in GDP, 1% increase in industry value added has belonged with enhancement in carbon dioxide (CO2) emissions at 0.28 percent in the USA, 0.107 percent in Malaysia, 0.45 in China and India shows the insignificant negative relations and Bangladesh shows significant negative relations.

**Panel Granger Causality**

Granger causality shows the cause, among the variables to measure both bidirectional or unidirectional relationship. According to Granger (1969) causality explains the relation as the causes by each other in variables. The following Table 7 is describing the empirical result and decision of panel and individuals country causality:

The panel Granger causality shows that the energy use is the cause of rising CO2 emissions as a unidirectional causal relationship, industry and CO2 have the bidirectional causal relationship and Industry and energy consumption also shows the bidirectional causal relationship.

Table 8 represents the Granger causality for individuals studied countries as known as selected industrialized countries. The first column shows the null hypothesis for selected variables and significant probability values are considered as 1%, 5%, 10% to accept the alternative hypothesis by rejecting the null hypothesis. In this study consider a panel data from 1980-2014 for selected industrialized countries. For Bangladesh, we see that is CO2 emission is the cause of energy consumption and shows the unidirectional relationship. Industry and CO2 have a bidirectional in India (Tiwari, 2011) and CO2 emissions and energy wreckage are bidirectional in the largest energy-consuming country China. In Malaysia have the unidirectional cause on industrialization to CO2 emissions and energy outlay. And the last one is that industrialization has unidirectional relation on energy use in the USA.

As discussed above, the economic theory and practices accept the current findings. In the context of macroeconomic indicators like as export, import, foreign direct investment, growth, innovation, and distributions are largely depends on economic activity and production. Industrial growth influence to massive productions and distributions, as these purpose energy resources are a vital element to the massive industrial productions and CO2 is the effect of energy use and industrialization. The marginal effect of FMOLS method shows that the newly growing industrial countries have largely CO2 emitted than industrialized countries, because of industrialized countries take initiatives to control CO2 emission. It is almost difficult to control emission for the growing industrial countries. The Environmental Kuznets curve theory also supports the current findings with the argument of Soyta (2006), Lean and Smyth (2013), Dogan and Turkul (2016) who have found the similar results.

**CONCLUSION**

This perusal examined the nexus between energy consumption and CO2 emissions for selected industrialized countries as a panel-based study from 1980 to 2014. Here the selected countries are US, China, Malaysia, India & Bangladesh. This study finds the inferiority of previous studies and it’s already mentioned that we want to compare with industrialized countries and newly industrial growing countries like Bangladesh, India. From the overall study shows that Bangladesh and India almost similar case for industrialization and energy consumption on CO2 emission and positively influenced by energy consumption were the effect is highly significant than other nations. Nain et al. (2015), Rahman and Kashem (2017) support the findings. This perusal demonstrated that Bangladesh faced energy consumption has positively growing significant impact on CO2 and India also faced energy consumption has definitive significant influence on CO2 emissions but both of the nations have negatory for industrialization on CO2 emissions because we know Bangladesh and India is a developing country, and also they are labour-intensive countries, not capital based in nature and the result also find that the USA, China, and Malaysia both have a weighty positive influence of energy purchases on CO2 emissions and industrialization is the cause of carbon emission as respect to economic enhancement and development supported by Dogan and Seker (2016). The empirical inference is showing that variables are cointegrated and have a long-run relationship, panel causality shows that energy uses is unidirectional to CO2 outlay and industrialization and CO2 bidirectional, industrialization and energy consumption also bidirectional causal relationship.

The contributions of this study will be added extra value in current literature and further research will take place in regional comparison. In the practical sense, this study creates a great awareness to consume energy and policymaker will be considering it when the industrial activities increase with respect in time. This result is valid with the existing literature that’s found in measuring the nexus between energy consumptions and CO2 emissions in selected industrialized countries.

**References:***

Almozaini M S (2019) The Causality Relationship between Economic Growth and Energy Consumption in The World’s Top Energy Consumers. International Journal of Energy Economics and Policy, 9(4):40-53.

Amin S B, Ataur R A (2011) Energy-Growth Nexus in Bangladesh: An Empirical Study. International Review of Business Research Papers, 2(2):182-195.

Arpegis N, Payne J (2009) CO2 emissions, energy usage and output in Central America. Energy Policy 37:3282-3286.

Aurellano M, Bover O, Meghir C, Mizon G (1993) On the testing of correlated effects with panel data. 59:87–97

Begum R A, Sohag K, Abdullah S M S, Jaafar M (2015) CO2 emissions, energy consumption, economic and population growth in Malaysia. Renewable and Sustainable Energy Reviews, 41:594–601.

Chandra Ghosh B (2014) Economic Growth, CO2 Emissions and Energy Consumption: The Case of Bangladesh. International Journal of Business and Economics Research, 3(6):220.
Table 1. Summary of Relevant Literature on Study Areas

| Name of Author | Type of Data | Country & Duration | The framework of the Study | Variables | Results |
|----------------|--------------|---------------------|----------------------------|-----------|---------|
| Ghosh et al. (2014) | Times series data; Bangladesh; 1972 – 2011 | ADF, VAR modelling & EKC | Energy, GDP, CO₂ emissions | This study demonstrated that a definitive relationship with economic enhancement and energy use but CO₂ emission insignificant and negative effect on the growing GDP in Bangladesh. |
| Wang et al. (2011) | Panel estimations; China; 1995-2007 | Cointegration and modelling of panel VECM approach | Energy, Real output (GDP), CO₂ | The empirical study demonstrates that among those variables have long-run association for Carbon dioxide emissions. |
| Dong et al. (2017) | Panel data; BRICS countries; 1985-2016 | VECM modelling | Natural Gases, Energy, Carbon | In this study has found that the long-run causality among the variables for the selected studied countries. USA: unidirectional causality with GDP and gases. Saudi Arabia shows that gas consumption and EC have unidirectional causality. China, India and Japan: almost the same. |
| Almoazini (2019) | Panel Data; Saudi Arabia, China, Japan, India, and the United States; 1968-2016 | Granger causality test, Cointegration test | Oil, Gas, Energy Consumption and GDP as Economic enhancement | China, India and Japan: almost the same. |
| Pao et al. (2012) | Cross Sections data; China; 2004-2009 | NGBM and ARIMA modelling | Output (GDP) CO₂ and Energy use | The empirical output states that CO₂ and output inelastic and CO₂ elastic to energy consumption. |
| Wu et al. (2014) | Panel estimation; BRICS countries; 2004-2010 | NMVGM Modelling | Urban population, Energy consumption, CO₂ emissions and GDP | This study has found that in Brazil have a decreasing economic growth effect on CO₂ emissions but Russia, China, South Africa, India demonstrate have an increasing effect. |

Copyright © 2020 Authors. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.
The hypothesis of there is no cointegration in variables

Table 3.1

| Hypothesized H0 | Fisher Statistics. (trace test) | Probability | Fisher Statistics. (maximum-eigen test) | Probability |
|------------------|---------------------------------|-------------|-----------------------------------------|-------------|
| None             | 84.45                           | 0.00        | 69.84                                   | 0.00        |
| At most 1        | 27.95                           | 0.0018      | 23.61                                   | 0.0007      |
| At most 2        | 21.15                           | 0.0201      | 21.15                                   | 0.0020      |

## Notes

1. This study finds that economic enhancement, Trade, energy use, and GDP growth have a secure legitimacy on CO2 outlay in the prostrate estimate but the opposite case for populations’ growth rate.
2. The CO2 emission is significantly increased in both nations by energy consumption.
3. Income does not cause CO2 emission but energy consumptions show positive relations to CO2 emission.
4. This study shows that in Bangladesh GDP enhancement and energy use has unidirectional causality not bidirectional.
5. The result indicates that CO2 increased by urbanization and energy consumption in the long run while financial growth does not affect it.
6. The empirical result finds that long-run associations within the dependent and independent variables in studied countries.
7. This study finds that energy outlay, population, and GDP growth has statistically cabalistic and deterministic relations of CO2 emissions in studied countries.

## Table 3. Unrestricted Rank Test for Measuring Cointegration with (Trace and Maximum Eigenvalue)

| Hypothesized H0 | Fisher Statistics. (trace test) | Probability | Fisher Statistics. (maximum-eigen test) | Probability |
|------------------|---------------------------------|-------------|-----------------------------------------|-------------|
| None             | 84.45                           | 0.00        | 69.84                                   | 0.00        |
| At most 1        | 27.95                           | 0.0018      | 23.61                                   | 0.0007      |
| At most 2        | 21.15                           | 0.0201      | 21.15                                   | 0.0020      |

## Table 2. Unit Root Tests for the Panel Estimations

| Panel unit root test | Variables | ln(CO2) | Ln(ENC) | Ln(IND) |
|----------------------|-----------|---------|---------|---------|
| at level             | Im, Pesaran and Shin W-statistics | 0.463  | 2.45683 | 1.29734* |
|                      | ADF - Fisher Chi-square | 9.34282 | 2.24864 | 4.68432 |
|                      | PP - Fisher Chi-square test | 8.76186 | 1.9499 | 4.86071 |
|                      | Levin, Lin & Chut | -0.05594 | 0.3768* | 1.1712* |
| at 1st difference    | Im, Pesaran and Shin W-statistics | -7.12953*** | -8.98991*** | -5.45627*** |
|                      | ADF - Fisher Chi-square | 63.043*** | 81.5246*** | 47.2343*** |
|                      | PP - Fisher Chi-square test | 305.41*** | 316.515*** | 44.9557*** |
|                      | Levin, Lin & Chut | -3.89587** | -8.03909*** | -5.36967*** |

## Table 3.1. Individual Country (cross-unit) estimated results

| Cross countries | Statistics | Probability | Statistics | Probability |
|-----------------|------------|-------------|------------|-------------|
| Trace Test      | Maximum-Eign test |
| Bangladesh      | 35.7340    | 0.0092      | 25.6342    | 0.0108      |
| India           | 57.0099    | 0.0000      | 37.0056    | 0.0002      |
| China           | 48.5472    | 0.0001      | 30.7341    | 0.0017      |
| Malaysia        | 26.2984    | 0.1200      | 10.9349    | 0.6538      |
| USA             | 66.0517    | 0.0000      | 56.0232    | 0.0000      |
| H2 = at most 1  | 10.0998    | 0.2731      | 8.8516     | 0.2987      |
| Bangladesh      | 20.0043    | 0.0097      | 19.561     | 0.0066      |
| China           | 17.8131    | 0.0220      | 15.1507    | 0.0361      |
| Malaysia        | 15.3636    | 0.0523      | 9.2564     | 0.2647      |
| USA             | 10.0285    | 0.2786      | 7.8237     | 0.3969      |
| H2 = at most 2  | 1.2481     | 0.2639      | 1.2481     | 0.2639      |
| Bangladesh      | 0.4392     | 0.5075      | 0.4392     | 0.5075      |
| China           | 2.6624     | 0.1027      | 2.6624     | 0.1027      |
| Malaysia        | 6.0982     | 0.0135      | 6.0982     | 0.0135      |
| USA             | 2.2048     | 0.1376      | 2.2048     | 0.1376      |
Table 4. Hausman Test Result

| Variables           | Fixed effect | Random effect | Variance(Diff.) | Probability |
|---------------------|--------------|---------------|-----------------|-------------|
| Energy Consumptions | 1.160318     | 0.761327      | 0.004146        | 0.00        |
| Industry            | 0.900079     | 0.468193      | 0.000008        | 0.00        |

H0 = Random Effects is better - Hausman Test

Test output

| Chi-Sq. Statistic | Chi-Square d.f. | Probability |
|-------------------|-----------------|-------------|
| 57.837268         | 2               | 0.00        |

Table 5. Panel FMOLS Long-run Estimates

| Explanatory Variables | Coefficient | Std. Error | T – Statistics | Probability | R2 / adj R2 |
|-----------------------|-------------|------------|----------------|-------------|-------------|
| Enc                   | 0.338082    | 0.187072   | 1.807223       | 0.0727      | 0.676 / 0.674 |
| Ind                   | 0.414369    | 0.048903   | 8.473317       | 0.00        |             |

Table 6. FMOLS Long-Run Estimates for Studied Countries

| Country            | Enc | Ind | R2/ adj R2 |
|--------------------|-----|-----|------------|
| USA                | 0.806*** (17.34) | 0.289** (20.04) | 0.92/0.91 |
| Malaysia           | 1.89*** (24.89)  | 0.107** (-4.67) | 0.98/0.98 |
| China              | 0.39** (2.13)    | 0.45*** (9.522) | 0.96/0.91 |
| India              | 2.906*** (8.19)  | -0.145** (-1.78) | 0.96/0.96 |
| Bangladesh         | 3.55*** (6.966)  | -0.32*** (-2.97) | 0.94/0.93 |

Note: ( ) means t – statistics ; [ ] presents P-Value & { } shows Standard Error

Table 7. Panel Granger Causality Test

| Null Hypothesis: F-Statistic | Probability | Decision rule |
|------------------------------|-------------|---------------|
| Enc has not Granger cause CO2 | 3.34417**   | Unidirectional causal relationship |
| CO2 has not Granger cause Enc | 0.70170     |              |
| Ind has not Granger cause CO2 | 6.77407***  | Bidirectional causal relationship |
| CO2 has not Granger cause Ind | 7.37253***  |              |
| Ind has not Granger cause Enc | 7.34571***  | Bidirectional causal relationship |
| Enc has not Granger cause Ind | 4.57839**   |              |

The null hypothesis of these tests ***(**)(*) denotes at level 1%(5%)(10%) for statistical significance.

Here: Enc- energy consumptions, Ind- industrial value added in GDP, CO2- carbon dioxide emissions

Table 8. Granger Causality for Individuals Studied Countries

| Constructing the Null Hypothesis: H0 | F – Statistic | Decisions |
|--------------------------------------|--------------|-----------|
| India                               | 2.56534*     | Bidirectional causal relationship |
| China                               | 2.66540*     | Bidirectional causal relationship |
| Bangladesh                          | 2.33052*     | Unidirectional causal relationship |
| Malaysia                            | 3.22619**    | Unidirectional causal relationship |
| United State of America             | 5.12393***   | Unidirectional causal relationship |

The null hypothesis of the tests ***(**)(*) represents at level 1%(5%)(10%) of determining significance level.

Here: Enc- energy consumptions, Ind- industrial value added in GDP, CO2- carbon dioxide emissions.