The Study of the Relationship between Carbon Dioxide (CO_2) Emission and Economic Growth

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Abstract The study investigates the nexus between carbon dioxide (CO_2) emission per capita and economic growth in Next Eleven (N-11)[1] over the period 1981-2009. The empirical analysis is based on panel unit roots, cointegration in heterogeneous panels and panel causality tests. To evaluate the impact of CO_2 emission on relative variables, this study verifies that there are positive long-run relationship among CO_2 emissions, Electric power consumption, Energy use and GDP. This paper also proves bi-directional causality between CO_2 emission and electric power consumption. The policy makers may evaluate exogenous effect to seeking economic growth for global climate warming and to formulate energy policies.

Keywords: CO_2 Emission, Panel Cointegration, Panel Causality
JEL Classification: F43

1. Introduction

Choosing between economic growth and environmental protection is an emerging dilemma for humans. Global warming alters the ecology. Several studies have reported that global climate warming is closely related to CO2 emission produced by human activities (Azomahou et al., 2006; Dinda and Coondoo, 2006; Lee and Lee, 2009; Jaunky, 2011; Al-mulali, 2012; Liddle, 2012). Moreover, a number of studies on ecological economics have indicated the connection between environmental degradation and economic growth (Coondoo and Dinda, 2002; Hill and Magnani, 2002; Soytas et al., 2007).

Jaunky (2011) indicated that economic growth has a negative influence on environmental quality and that income and pollution have a monotonically increasing relationship. However, Lee (2006) argued that energy consumption and income were neutral with respect to each other in the Group of Eleven countries. Niu et al. (2011) reported that long-term equilibrium relationships exist among energy consumption, GDP growth, and CO2 emission for eight Asia-Pacific countries. Lee et al. (2008) also found that energy consumption and income have a strong long-term equilibrium relationship in 22 Organization for Economic Cooperation and Development (OECD) countries.

The great increase in greenhouse gas emission is the main cause of global warming. In 2013, Intergovernmental Panel on Climate Change[2] (IPCC) advocates that it is extremely likely that most of the warming since 1950 has been due to human influence. That is, human activities clearly influence the climate system. To address the issue, this paper examines the causal relationship among CO_2 emission, relevant energy variables, and relevant economic variables in the Next Eleven (N-11), which is a group of 11 countries identified by the investment bank Goldman Sachs in 2007 as having high potential of becoming the world's largest economies in the 21st century (Wilson and Stupnytska, 2007). The N-11 consists of Bangladesh, Egypt, Indonesia, Iran, Mexico, Nigeria, Pakistan, Philippines, Turkey, South Korea, and Vietnam. These countries would face issues concerning economic growth and CO_2 emission. The N-11 need to determine how they can attain economic growth while conserving energy and reducing emission. To our knowledge, no existing study has analyzed the income–emission trend for the world's largest economies in the 21st century. Thus, this study provides an alternative solution to the problem concerning greenhouse gas emission, which is responsible for global warming. In addition, this study simultaneously uses fully modified ordinary least squares (FMOLS) and dynamic ordinary least squares (DOLS) to estimate the relevant coefficients.

To our knowledge, this paper is the first to simultaneously launch FMOLS and DOLS to empirically study CO_2 emission. The results show that a significant positive correlation exists among CO_2 emission, electric power consumption, energy use, and GDP. We deduce that bidirectional causality exists between CO_2 emission and electric power consumption, whereas unidirectional causality exists from CO_2 emission to GDP, from urbanization to electric power consumption, from energy use to GDP, from foreign direct investment (FDI) to urbanization, and from GDP to urbanization. This paper elucidates the relationship between economic growth and CO_2 emission in specific countries in a multivariate framework. Such information would enable policy makers to make sound decisions on issues concerning economic growth and environmental protection.
The rest of the paper is structured as follows. Section 2 presents a review of related literature. Section 3 explains the panel methodology. Section 4 describes the data and summarizes the empirical results. Section 5 presents the conclusion and proposes a number of policy implications that emerge from the study.

2. Literature Review

Numerous studies have examined the relationship among CO_2 emission, energy consumption, and economic growth. Dinda and Coondoo (2006) explored the short-term dynamics of the income–emission relationship in 88 countries. The results showed that cointegration exists between CO_2 emission and GDP per capita in North America, South America, Asia, and Oceania. Soytas et al. (2007) found that energy consumption Granger eventually causes carbon emission. Warr and Ayres (2010) found that unidirectional causality existed from energy to GDP. An increase in supplied energy has both short-term and long-term effects to increase the output; however, output growth does not increase energy consumption. The researchers suggest that an increase in energy inputs can sufficiently stimulate the output growth in the short run. Meanwhile, over a period of several years, GDP positively responds to increased energy and useful work inputs by readjusting to the long-term equilibrium relationship. Recently, Borhan, Ahmed and Hitam (2013) applied the fixed and random effects model to examine the relation between pollution and economic growth. The result proved that the Environmental Kuznets Curve (EKC) hypothesis was existed in Asian 8[3].

A number of studies have evaluated the relationship of relevant energy consumption to GDP. Holtz-Eakin and Selden (1995) discussed the relation between marginal propensity to emit (MPE) and economic development. They confirmed that the lower and middle income nations had higher MPE. Chen et al. (2007) reported that long-term bidirectional causality exists between electricity consumption and economic growth. Yuan et al. (2008) indicated that Granger causality exists from electricity and oil consumption to GDP. Ozturk et al. (2010) verified that long-term Granger causality exists from GDP to energy consumption for low-income countries, whereas bidirectional causality exists between energy consumption and GDP for middle-income countries. Silva et al. (2011) revealed that increasing the share of renewable energy sources in electricity generation would decrease both the GDP per capita and the CO_2 emission per capita.

A few studies have focused on the influence of foreign direct investment (FDI), foreign trade, and urbanization on CO_2 emission. List and Co (2000) reported that the FDI inflow promotes the energy efficiency and reduces the CO_2 emission of the host countries. Sharif (2011) examined carbon dioxide emission, energy consumption, economic growth, trade openness, and urbanization of newly industrialized countries. The results showed no evidence of a long-term causal relationship; however, a unidirectional short-term causal relationship exists from economic growth and trade openness to CO_2 emission, from economic growth to energy consumption, from trade openness to economic growth, from urbanization to economic growth, and from trade openness to urbanization. Zhang and Lin (2012) indicated that the influence of urbanization on energy consumption is greater than that on CO_2 emission in China. Lee (2013) found that FDI is essential to the economic growth of the G-20 countries but has a limited influence on the increase in CO_2 emission. Onafowora and Owoye (2013) employed Autoregressive Distributed Lag (ARDL) model to test the cointegration between CO_2 emission and economic growth. They also considered exogenous variables such as energy consumption, population density, and trade openness. The results evidenced the study relationship between CO_2 emission and economic growth for all countries, but only three countries (e.g. Mexico, Nigeria and South Africa) were influenced by trade openness on CO_2 emission.

The existing literature on the relationship among energy consumption, economic growth, and CO_2 emission can be grouped into three types. The first type of literature is based on the country level. Oh and Lee (2004) found that unidirectional causality exists from GDP to energy in the long run, implying that enforcing an energy conservation policy is feasible without compromising economic growth in Korea. At the same time, Hung and Shaw (2004) used panel data model to test air pollution and income whether existed EKC relationship or not. They especially observed that making new regulation in 1990 and renovating air-quality monitoring stations in 1994 did not reduce air pollution. Halicioglu (2009) examined the dynamic causal relationships among carbon emission, energy consumption, income, and foreign trade in Turkey; he found that income was the best variable in clarifying the carbon emission in Turkey, and then found energy consumption and foreign trade could explain the carbon emission. However, Talebi et al. (2012) found that there is no relationship from GDP to energy consumption in Iran.

The second type of literature is based on the income level. Huang et al. (2008) evaluated energy consumption and GDP with respect to income levels. The results indicated that a significant environmental improvement can be observed in the high-income group because of the efficient energy use and the reduction in CO_2 emission. Wolde-Rufael and Menyah (2010) corroborated between nuclear energy consumption and real GDP for developed countries; they advocated nuclear energy consumption to economic growth subsisting a uni-directional causality in Japan, Netherlands and Switzerland; but there was the different uni-directional causality from economic growth and nuclear energy consumption in Canada and Sweden; and also evidencing a bi-directional causality between economic growth and nuclear energy consumption for other country (i.e. France, Spain, the United Kingdom and the United States).

The third type of literature is based on location or international organizations. Apergis and Payne (2010) examined the relationship between renewable energy consumption and economic growth in 20 OECD countries. The results showed that bidirectional causality exists between renewable energy consumption and economic growth in both the short and long run. Pao and Tsai (2011) revealed that strong bidirectional causality exists between emission and FDI and that strong unidirectional strong causality exists from output to FDI in BRIC[4] countries.

3. Theoretical Model

Panel data estimation is employed in this study to capture the dynamic behavior of the parameters and to provide an efficient estimation of the parameters. In addition, FMOLS and DOLS techniques are used (Kao and Chiang, 2000; Pedroni, 2000, 2001, 2004) to estimate the long-term relationship among the related variables.

3.1 Panel Unit Root Test

Panel data techniques are used because of their advantages over cross-section and time series analyses in using all of the available information, which are not detectable in pure cross-sections or time series (Baltagi, 2000).

This study examines the factors that influence CO2 emission. In accordance with previous literature, electric power consumption, energy use, FDI, GDP, and urban population are employed as key factors affecting CO2 emission.
The model is given by:

$$CO_{2it} = \alpha_{it} + \beta_1 EPC_{it} + \beta_2 EU_{it} + \beta_3 FDI_{it} + \beta_4 GDP_{it} + \beta_5 UR_{it} + \varepsilon_{it}\,, \quad (1)$$

where CO2 indicates CO2 emission per capita, EPC stands for electric power consumption, EU is energy use, FDI represents foreign direct investment net inflows, GDP indicates real GDP per capita, and URB is urbanization (percentage of urban population). The parameters β1, β2, β3, β4, and β5 are the slope coefficients, ε_{it} is the white noise error, *i* is the country, *t* is the time, and *α* is the scalar. The testing procedure involves three steps, namely, panel unit root test, panel cointegration test, and panel Granger causality test.

The panel-based unit root tests power is more efficient than unit root tests based on individual time series (Levin et al., 2002; Im et al., 2003). This research focused on two types of panel unit root tests, namely, that proposed by Levin, Lin, and Chu (2002) and that proposed by Im et al. (2003).

First, this paper considers the following basic augmented Dickey–Fuller (ADF) specification:

$$\Delta y_{it} = \alpha y_{it-1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{it-j} + X'_{it}\delta + \varepsilon_{it}\,, \quad (2)$$

where Δ is the first difference operator, p_i is the lag length, and X'_{it} stands for the exogenous variable, such as country fixed effects and individual time trend, in the model.

We assume a common $\alpha = \rho - 1$ and allow the lag order for the difference term p_i to vary across cross-sections. The null and alternative hypotheses for the tests are respectively given as follows:

$$H_o : \alpha = 0,$$

$$H_1 : \alpha < 0.$$

A unit root exists under the null hypothesis, whereas no unit root exists under the alternative hypothesis.

Im et al. (2003) specified a separate ADF regression for each cross-section. The null and alternative hypotheses can be respectively written as follows:

$$H_0 : \alpha_i = 0, \text{ for all } i,$$

$$H_1 : \begin{cases} \alpha_i = 0, \\ \alpha_i < 0. \end{cases}$$

The hypothesis interpreted as a nonzero fraction of the individual processes is stationary.

3.2 Panel Cointegration Test and Estimation

In the second procedure, we seek a long-term relationship among the variables by using the panel cointegration techniques developed by Pedroni (1999, 2004) and Maddala and Wu (1999). The Pedroni tests are based on the Engle–Granger two-step cointegration tests. The Johansen tests are based on the Fisher cointegration test.

Pedroni (1999) submitted panel cointegration test with heterogeneous intercepts and coefficients. Maddala and Wu (1999) proposed an alternative approach for testing panel data cointegration by combining the tests from individual cross-sections to obtain a test statistic for the full panel. Thus, four panel statistics and three group panel statistics are employed to test the null hypothesis of no cointegration against the alternative hypothesis of cointegration. We consider the following regression:

$$y_{it} = \alpha_i + \delta_i t + \beta_{1i} x_{1i,t} + \beta_{2i} x_{2i,t} + \cdots + \beta_{Mi} x_{Mi,t} + e_{i,t}, \tag{3}$$

for $t = 1, \cdots, T; i = 1, \cdots, N; m = 1, \cdots M$;

where y and x are assumed to be integrated of order one, such as $I(1)$. The parameters α_i and δ_i are individual and trend effects that may be set to zero if desired.

If these tests indicate that variables are cointegrated, then several methods, such as pooled mean group (Pesaran et al.,1999), FMOLS (Kao and Chiang, 2000; Pedroni, 2000, 2001, and 2004), and DOLS (Kao and Chiang, 2000; Mark and Sul, 2003), can be used to estimate parameters. However, the OLS estimator is a biased and inconsistent estimator when applied to cointegrated panels (Kao and Chiang, 2000). Therefore, we estimate the long-term

relationship by using FMOLS and DOLS, as performed by Kao and Chiang (2000).
The FMOLS estimators modify the inadequacy of OLS estimation to calculate an optimal value of cointegrating regressions. The FMOLS estimator applies asymptotically biased and strictly exogenous assumption. Their statistic estimator is standard Wald tests using asymptotic Chi-square statistical inference. The estimation of the FMOLS denotes the construction of long run covariance matrix estimators.

The FMOLS estimator is given by

$$\hat{\beta}_{FMOLS} = N^{-1}\sum_{i=1}^{N}\left(\sum_{t=1}^{T}\left(x_{i,t}-\bar{x}_i\right)^2\right)^{-1}\left(\sum_{t=1}^{T}\left(x_{i,t}-\bar{x}_i\right)\hat{y}^*_{i,t}-T\hat{\tau}_i\right), \quad (4)$$

where $\hat{y}^*_{i,t}=\left(y_{i,t}-\bar{y}_i\right)-\frac{\hat{L}_{21i}}{\hat{L}_{22i}}\Delta x_{i,t}$ and $\hat{\tau}_i \equiv \hat{\Gamma}_{21i}+\hat{\Omega}^0_{21i}-\frac{\hat{L}_{21i}}{\hat{L}_{22i}}\left(\hat{L}_{22i}+\hat{\Omega}^0_{22i}\right)$.

The DOLS estimator uses parametric by Monte Carlo simulations to deterministic components and accommodates varying orders of integration and the adequate variables. The DOLS estimator is obtained as following:

$$\hat{\beta}_{DOLS} = \sum_{i=1}^{N}\left(\sum_{t=1}^{T} z_{it}z'_{it}\right)^{-1}\left(\sum_{t=1}^{T} z_{it}\hat{y}^+_{it}\right), \quad (5)$$

where $z_{it}=\left[x_{it}-\bar{x}_i, \Delta x_{i,t-q},\ldots,\Delta x_{i,t+q}\right]$ is $2(q+1)\times 1$ vector of regressors.

3.3 Panel Causality Test

After the existence of cointegration is confirmed, we proceed to test for Granger causality by using the abovementioned method. Granger causality is computed by running bivariate regressions. A number of different approaches can be used to test for Granger causality in a panel context. Bivariate regressions are generally in a panel data context.

$$y_{i,t}=\alpha_{0,i}+\alpha_{1,i}y_{i,t-1}+\ldots+\alpha_{l,i}y_{i,t-1}+\beta_{1,i}x_{i,t-1}+\ldots+\beta_{1,i}x_{i,t-1}+\varepsilon_{i,t}, \quad (6)$$

$$x_{i,t}=\alpha_{0,i}+\alpha_{1,i}x_{i,t-1}+\ldots+\alpha_{l,i}x_{i,t-1}+\beta_{1,i}y_{i,t-1}+\ldots+\beta_{l,i}y_{i,t-1}+\varepsilon_{i,t}, \quad (7)$$

where t denotes the time period dimension of the panel and i denotes the cross-sectional dimension.

4. Data Sources and Empirical Results

The methodologies of the paper include unit roots tests, cointegration, and FMOLS and DOLS estimation approach to identify the Granger causality in the panel data. The data sources from the World Bank of World Development Indicators Dataset. There are long relationship between CO2 emission and the other variables. CO2 emission and electric power consumption have bi-directional causality in the short run.

4.1 Data Sources

The annual panel dataset for N-11 between 1981 and 2009 is used. CO_2 emission (metric tons per capita), electric power consumption (kilowatt hour per capita), energy use (kilograms of oil equivalent per capita), FDI (balance of payments, current US$), GDP per capita (current US$), and urban population (percentage of total) are obtained from the World Bank of World Development Indicators Dataset. All the variables are employed with their natural logarithmic form to reduce heteroscedasticity.
Figure 1 described the trend of CO_2 emission per capita over the period 1981–2009. We observed CO_2 emission gradually growing, focusing on newly industrializing countries and least developed country.

4.2 Empirical results

4.2.1 Unit Root Tests

The panel-based unit root tests power is more efficient than unit root tests for individual time series (Levin et al., 2002; Im. et al., 2003). This study performed panel unit root test of the variable by using two standard methods for panel data, namely, that proposed by Levin, Lin, and Chu (2002) and Im et al. (2003). Table 1 presents the results of the panel unit root tests for all the variables. The results show that most of the level values of two variables are panel nonstationary. However, the tests of the first difference reject the null hypothesis, implying that these time series variables appear stationary after the first differencing.

4.2.2 Cointegration Test

The results of the panel cointegration test are provided in Table 2. In the Pedroni panel cointegration test, four panel statistics (excluding panel v-statistic, panel rho-statistic, and group rho-statistic) reject the null hypothesis of no cointegration. In the Johansen Fisher test, we reject the null hypothesis of no cointegration, that is, these time series variables have a long-term relationship.

The results indicate that the series move together in the long run. Therefore, the long-term cointegrating coefficients are estimated using the between-dimension FMOLS and DOLS estimators.

The long-term elasticity estimates by FMOLS and DOLS for the five variables are shown in Table 3. The FMOLS-estimated coefficients are the elasticity of CO_2 emission with respect to

EPC, EU, FDI, GDP, and URB. The results of EPC and EU are positive and statistically significant at the 1% level, whereas GDP is positive and statistically significant at the 10% level. In addition, URB is negative and statistically significant at the 1% level. The DOLS-estimated coefficients revealed that EPC, EU, and GDP are positive and statistically significant for CO_2 emission. Meanwhile, FDI moves in the opposite direction, whereas URB has a positive effect; however, such factors are insignificant to CO_2 emission. Positive long-run relationships exist among CO_2 emission and EPC as well as EU and GDP; such findings are consistent with previous research (Halicioglu, 2009; Lean and Smyth, 2010; Asıcı, 2013).

The two methods have different URB estimations. URB is negative and significant in FMOLS. International organizations, particularly institutions under the United Nations, have strived to reduce the amount of global warming substances; such efforts include the Kyoto Protocol and the United Nations Framework Convention on Climate Change. Therefore, national energy policies should reduce domestic energy consumption. These institutions implement relevant emission-reducing policies to reduce the greenhouse effect in the metropolitan region, resulting in higher urban density, which is beneficial to reducing CO_2 emission. Zhu et al. (2012) found little evidence to support an inverted-U relationship between urbanization and CO_2 emission, and that CO_2 emission appeared to be inelastic in the long run (Dean et al., 2009; Pao and Tsai, 2011). The results of the FMOLS and DOLS panel tests indicate that the estimated cointegration factor β is not close to one, implying that no strong relation exists between CO_2 emission and the EPC, EU, and GDP coefficients.

4.2.3 Results of Panel Granger Causality

This study uses Granger causality to examine the existence and direction of causality between the variables. Table 4 shows that both directions between CO_2 emission and electric power consumption are significant, indicating that an increase in electric power consumption results in an increase in CO_2 emission, and vice versa. The short-term dynamics for uni-directional causality from CO_2 emission to GDP, from urbanization to electric power consumption, from energy use to GDP, from FDI to urbanization, and from GDP to urbanization are also found.
The results suggest that CO_2 emission and energy use contributes to economic growth, whereas urbanization causes electric power consumption to change. Similar evidence was obtained by Dodman (2009), who found a strong inverse relationship between urban density and transport energy use per capita. However, economic growth does not cause changes in CO_2 emission and energy use. Similar evidence was obtained by Warr and Ayres (2010) and Sari and Soytas (2009), who found that output growth does not contribute to increased energy consumption and CO_2 emission. These results serve as a reminder for N-11 policy makers to promote energy conservation and reduce CO_2 emission when considering economic

development.

5. **Conclusion**

In this paper, panel data method is used to test the relationship between CO_2 emission per capita and other variables such as electric power consumption, energy use, FDI, GDP, and urbanization for a panel of N-11 countries from 1981 to 2009.

The following conclusions are drawn: (1) all the series appear stationary in the first difference for the logarithmic form, and a long-term equilibrium relationship exists between CO_2 emission and the other variables such as electric power consumption, energy use, FDI, GDP, and urbanization; (2) panel cointegration tests reveal that CO_2 emission and relative variables have a long-term relationship; and (3) Granger causality test results show that bi-directional causality exists from CO_2 emission to electric power consumption in the short run. Furthermore, uni-directional causality exists from CO_2 emission to GDP, from urbanization to electric power consumption, from energy use to GDP, from FDI to urbanization, and from GDP to urbanization.

The coexistence of high economic growth rate and high CO_2 emission poses important challenges to N-11 policy makers. In the condition of economic growth, developed and developing countries policy makers should undertake the responsibility to devoted to technical innovations in green energy in order to reduce CO_2 emission. Further, Al-mulali and Sab (2013) indicated that the governments should invest more the project resource in innovations of green energy in order to solve the energy in distress. CO_2 emission and energy use contribute to economic growth; however, the opposite causal relationship is insignificant. EPC, EU, and GDP are positive and statistically significant for CO_2 emission, whereas URB is negative. Lariviere and Lafrance (1999) reported that higher urban density is beneficial to reducing energy use. N-11 policy makers should therefore evaluate the exogenous effects when seeking economic growth.

Endnotes

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1.Goldman Sachs introduced the concept of the Next Eleven, including Bangladesh, Egypt, Indonesia, Iran, South Korea, Mexico, Nigeria, Pakistan, Philippines, Turkey and Vietnam.

2. IPCC was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) to access the scientific, technical and

human- induced climate change along with its potential impact and options for mitigation and adoption. It consists of three Working groups (WGI, WG II and WGIII) which comprises of some of the leading scientist from around the globe.

3. that is Thailand, Vietnam, Singapore, Philippines, Malaysia, Laos, Indonesia, and Cambodia.

4. BRIC countries include Brazil, Russia, India and China.

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Figure 1. CO_2 Emission Per Capita for N11 Countries.

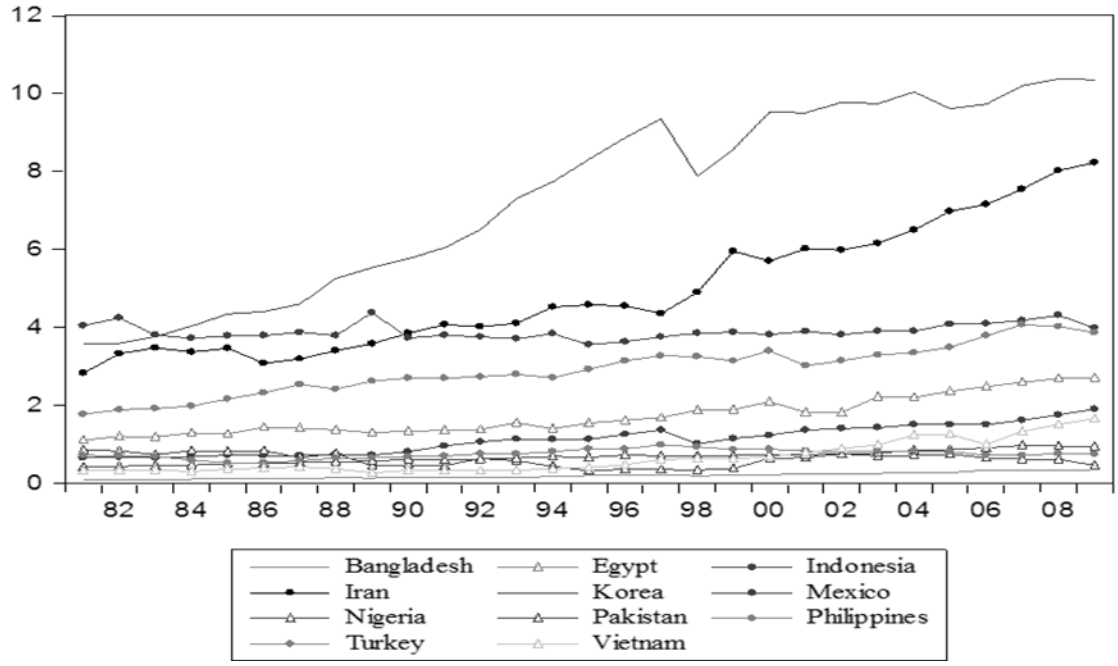

Table 1. Panel Unit Root Test Results

variables	Level		First Different	
Levin, Lin and Chu (2002)				
$lnCO_2$	-1.39740	(0.0811)	-14.6328**	(0.0000)
lnEPC	-4.56616**	(0.0000)	-12.7927**	(0.0000)
lnEU	0.94694	(0.8282)	-16.1924**	(0.0000)
lnFDI	-1.35096	(0.0884)	-14.7881**	(0.0000)
lnGDP	9.93178	(1.0000)	-14.3084**	(0.0000)
lnUR	-3.62198**	(0.0001)	-13.3976**	(0.0000)
Im, Pesaran and Shin (2003)				
$lnCO_2$	1.61072	(0.9464)	-15.6413**	(0.0000)
lnEPC	-0.20311	(0.4195)	-12.1781**	(0.0000)
lnEU	3.82027	(0.9999)	-14.6830**	(0.0000)
lnFDI	1.10378	(0.8652)	-16.3320**	(0.0000)
lnGDP	4.68342	(1.0000)	-12.2648**	(0.0000)
lnUR	-1.20764	(0.1136)	-10.0473**	(0.0000)

Notes: ** denote that rejects the null of no cointegration at the 5% level.

Table 2. Panel Cointegration Test

Test Name	**Test statistic**	**Prob.**
(1) Pedroni Test		
Panel v-Statistic	-3.9064	1.0000
Panel rho-Statistic	3.0153	0.9987
Panel PP-Statistic	-2.8142**	0.0024
Panel ADF-Statistic	-4.9279**	0.0000
Group rho-Statistic	3.4428	0.9997
Group PP-Statistic	-9.1991**	0.0000
Group ADF-Statistic	-6.4530**	0.0000
(2) Johansen Fisher Test		
Fisher Statistic from Trace Test	50.5900**	0.0005
Fisher Statistic from Max-Eigen Test	50.5900**	0.0005

Notes:** denote that rejects the null of no cointegration at the 5% level.

Table 3. Panel Cointegration Estimation

Dependent	**CO_2**				
variable	EPC	EU	FDI	GDP	URB
Panel	0.5204***	0.2336***	0.0003	0.0326*	-0.5154***
(FMOLS)	(14.9137)	(4.1867)	(0.0701)	(1.8397)	(-5.8525)
Panel	0.2182*	0.4721**	-0.0231	0.2322***	0.0455
(DOLS)	(1.6855)	(2.2186)	(-1.2464)	(4.7502)	(0.1109)

Notes: The t-statistics are given in parenthesis. *, **, *** represent significance at 10%, 5% and 1% levels, respectively.

Table 4. Results for Panel Causality Tests

Null Hypothesis:	F-Statistic	Prob.
LNEPC does not Granger Cause $LNCO_2$	4.63705	0.0002**
$LNCO_2$ does not Granger Cause LNEPC	4.60355	0.0002**
$LNCO_2$ does not Granger Cause LNGDP	4.20531	0.0005**
LNURB does not Granger Cause LNEPC	3.00125	0.0076**
LNEU does not Granger Cause LNGDP	2.26229	0.0385**
LNFDI does not Granger Cause LNURB	3.08129	0.0065**
LNGDP does not Granger Cause LNURB	2.56646	0.0200**

Notes: **represent significance at 5% levels.