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Relationship among Foreign Direct Investment, Economic Growth and CO2 Emission: A Panel Data Analysis

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ABSTRACT: This study aims to investigate the effects of foreign direct investment and economic growth on CO2 emission. The panel data for the period of 1992 to 2012 from 15 developing countries were collected. The Johansen co-integration was conducted and the results show that there is co-integrated relationship between the variables (FDI, CO2 and GDP). Then the FMOLS was done and it was found that in the long run foreign direct investment does not have any effect on CO2 emission. Therefore, it suggests that an increase in FDI does not influence CO2 emission. However an increase in economic growth can intensify CO2 emission. Therefore, the developing countries should formulate policies on the environment in order to accomplish economic sustainability. At last, Granger causality based on VECM was employed and the results suggest there is no effect of FDI and GDP on CO2 emission in the short run.

Keywords: CO_2 emissions; economic growth; foreign direct investment
JEL Classifications: Q4; Q5

1. Introduction

Although the pattern of foreign direct investment (FDI) slightly changes with time, FDI is positively and inextricably connected with economic growth. FDI boosts the economy of most countries. Thus, many studies have suggested policies that encourage FDI (Rahlan, 2006; Shaari et al., 2012; Mun et al., 2008). Joshi and Ghosal (2009), Lin and Wang (2004), Driffield and Tailor (2000), Acaravci and Ozturk (2012), and Schemerer (2012) found that FDI creates jobs. Productivity and competitiveness intensifies with increased FDI and thus accelerates economic growth (Denisia, 2010). FDI drives more production, especially in the manufacturing sector, and thus improves exports and boosts economic growth. Chowdhury and Mavrotas (2003) found that FDI positively affects economic growth in Malaysia and Thailand. Baharumshah and Almasaied (2009) and Shaari et al. (2012) found the same positive effects of FDI in Malaysia. The Organization for Economic Co-operation Development (OECD) (2012) reported that countries with weak economies consider FDI as the only source of economic growth and modernization. Thus, policy makers and governments, especially in developing countries, focus on foreign capital (Carkovic and Levine, 2002).

The bivariate Granger approach causality tests employed to conclude the results is appropriate for its simplicity. The approach turns problematic when there are at least two accounts. Therefore to examine the relationship between two or more series, bivariate specifications cannot capture the relevant information. Glasure (2002) included money, government spending and energy price to examine the relationship between energy and economic growth. Ighodaro (2010) employed the Johansen co-integration and multivariate Granger causality approach by including monetary policy variable and another representing government activity to explore the linkage between energy consumption and economic growth.

Hansen and Rand (2004) stated that FDI is strongly connected with economic growth in 31 developing countries. Zhang (2001) added that FDI is a driver of economic growth because it ensures efficiency in production and management and highly skilled workers. FDI brings many business activities, especially in transportation and industries (Jalil & Mahmud, 2009; Apergis & Payne, 2009). Thus, economic growth accelerates. However, Zeshan and Ahmad (2013) stated that more energy consumption will be used as an increase in economic growth. As a result, the combustion of fossil fuels, such as coal, natural gas, and oil, for energy in transportation and manufacturing to generate economic activities can inevitably emits carbon dioxide emission.

Every country faces a big challenge when the issue of environmental Kuznet curve emerged (the relationship between economic growth and pollution). This issue has attracted several researchers to study on the environmental Kuznet curve and they confirmed its existence (Mugableh, 2013; Shahbaz and Leitao, 2013; Saboori et.al. 2012) Policy makers should consider the negative effects of FDI before formulating any policy on FDI. Chandran and Tang (2013) consider the effects of foreign direct investment on economic growth and also the environment in their study. However the results are still not convincing. Hitam and Borhan (2012) included FDI, GDP per capita, population, export and import in their function of CO2. But, multicollinearity probability exists in their function as GDP per capita and population are inter-related.

Mahmood and Chaudhary (2012) found that FDI has three kinds of effects on the environmental quality of developing countries. The first is a scale effect, which is positive when the economy is growing and a demand for environmental goods exists and facilitates the solution of environmental problems. A negative scale effect occurs when a country experiences economic growth without considering environmental management and regulations. The second is a technological effect, which is positive when foreign investors use environment-friendly technology and have spillovers on domestic investment through competition. The third is a policy effect, which is positive when the host government makes tight regulations on the protection of the environment and compels foreign investors to follow such regulations. A negative policy effect occurs when competition exists among developing countries to attract FDI, and host governments relax their environmental regulations for FDIs.

Companies move to less developed countries to avoid environmental regulations. Several countries undervalue the environment to encourage considerable investment without being concerned about environmental impacts (Mabey and McNally, 1999). The negative effects of FDI should be addressed to ensure appropriate policies on FDI. A significant increase in trade and investment flows reduces efficiency in the use of scarce natural resources and incurs environmental and social costs, especially among the disadvantaged. The long-term welfare effects of having substantial FDI remain perplexing as environmental issues arise. Some countries do not take the environmental issue seriously especially in developing countries. Economic growth escalates as manufacturing expands in developing countries. The lenient environmental policies in developing countries can have greater effects on the environment than those developed countries. Most of the developing countries change its policy towards more open market. Hence, the trade barriers have been reduced. Therefore, FDI inflows has exhibited a rapid increases in the developing countries. This will encourage more polluting companies from the developed counties with strict environmental policy to the countries with lenient environmental policy.

Groosman and Krueger (1991) is the first to study on the trade, growth and the environment. They stated that an increase in income will cause pollution to increase in poor countries. However, pollution decreases in rich countries. They divided into various channels. One of the channels is scale effect which is detrimental to the environment. As more foreign investment comes to the country, it can have more industrial output that can remain undesirable effects on the environment. Another channel is the technique effect which can be good to the environment. The domestic plants can have advanced technology to produce more output. Therefore, trade openness and foreign direct investment can improve the quality of the environment. The income effect is also one of the channels that can have more jobs in the host country and local income can soar, and therefore they will demand environmental improvement. This study is to investigate the effects of FDI and economic growth on CO2 emission.

This study is organized as follows: The next section discusses the economic background of Malaysia, especially with regard to FDI, GDP, and CO_2 emissions. Literature is reviewed in the second section, and the research methodology is described in the third section. Section four discusses the findings, and section five concludes the study.

2. Literature Review

Economic growth is inextricably connected with carbon dioxide emission. The causal relationship has been discussed by several researchers, such as Han and Lee (2013), Tiwari, (2011) Chebbi and Boujelbene (2008), and Maddison and Rehdanz (2008). Tiwari (2011) used the Granger approach (VECM framework) and Dolado and Lutkepohl's approach to examine causality by using static and dynamic frameworks. The study considered energy consumption, CO_2 emissions, and economic growth in India from 1971 to 2005. CO2 emission influences GDP, but energy consumption does not affect GDP; GDP has no influence on CO2, but energy consumption contributes to CO2 emissions; and CO2 emissions affects energy consumption, but GDP does not change CO2 emissions. Thus, the Indian government should formulate policies on energy conservation to ensure the efficient consumption of energy.

In Malaysia, Mugableh (2013) as well as Borhan et.al. (2012) examined the relationship between CO2 emission and economic growth by using different approach but the results remain similar that an increase in economic growth causes an increase in CO2 emission. Mugableh used autoregressive distributed lag approach to reanalyse the CO2 emission. The data from 1971 to 2012 were collected. The findings indicate that economic growth is dependent on energy consumption but energy consumption can be harmful to the environment as it can contribute to CO2 emission. Borhan et al. (2012) had expanded the study by adding FDI. They used a larger number of observations from 1965 to 2010. They included income, FDI, population, export and import in their function of CO2. Non-linear model was employed and the results show that an increase in FDI describes an increase in CO2. Akin (2014) investigated the impact of energy consumption economic growth and especially trade openness on CO_2 emissions for 85 countries using 1990-2011 period. According to the results, positive relationship is found between CO_2 emissions and energy consumption, per capita income and trade openness. On the other hand, trade openness can reduce CO_2 emissions in the long run. Findings indicate that in the short run unidirectional causality from CO_2 emissions to trade openness (TRD). Also there is unidirectional causality from per capita income (GDP) to CO_2 emissions and energy consumption (EN).

Ozturk and Uddin (2012) examined the long-run Granger causality relationship between energy consumption, carbon dioxide emission and economic growth in India over the period 1971-2007. The augmented Dickey–Fuller test (ADF), Phillips-Perron test (PP) and KPSS test are used to test for Granger causality in cointegration models which take account of the stochastic properties of the variables. The most important result is that there is feedback causal relationship between energy consumption and economic growth in India which implies that the level of economic activity and energy consumption mutually influence each other; a high level of economic growth leads to a high level of energy consumption and vice versa. The value of the error correction term confirms the expected convergence process in the long-run for carbon emissions and growth in India which implies that emission reduction policies will hurt economic growth in India if there are no supplementary policies which seek to modify this causal relationship.

Most researchers are interested in studying these relationships in various countries. However, results have been mixed. Maddison and Rehdanz (2008), Azomahou et al. (2005), and Stolyrova (2009) used panel data to study CO_2 emission. Maddison and Rehdanz (2008) investigated the causal relationship between GDP and carbon emission in 134 countries from 1990 to 2005. In North America, Asia, and Oceania, CO_2 emissions are not connected with GDP when heterogeneity is ignored. Han and Lee (2013) examined the directional causal relationship between pollution and economic growth in OECD countries and used a dynamic model for panel data from 1981 to 2009. The linkage between economic growth and pollution indicates the need for technological progress toward economic growth with little pollution and thus supports the environmental Kuznets curve hypothesis. The same method for panel data from 1960 to 1996 was also used by Azomahou et al. (2005) to achieve the same objective in 100 countries. CO_2 emission per capita is positively related with GDP per capita. Stolyrova (2009) investigated the short-term relationship between CO_2 emissions, income, and energy mix in 93 countries. Data from 1960 to 2008 were collected, and the results showed the optimal partition of 93 countries into seven groups, each with its own characteristics. The results of unit root and co-integration tests indicated a short-term relationship. The short-term relationship indicated a relationship between CO_2 emission and its determinants. Dynamic panel data and WITHIN models were then used. The findings show that the growth rate of per capita CO_2 emissions is positively connected with the growth rate of per capita GDP and negatively associated with the growth rate of energy mix. Boopen and Vinesh (2010) found a positive relationship between economic growth and carbon dioxide emission. Furthermore, economic and human activities have increasing negative effects on the environment.

Silva et al. (2012) evaluated the existence and extent of the economic and environmental effects of growing dependence on renewable energy sources (RES). The study used structural vector autoregressive and collected data from the US, Denmark, Portugal, and Spain. Increased RES-E share initially and negatively affects economic growth (except in the US) but reduces CO_2 emissions. The Danish, Portuguese, and Spanish governments should formulate policies on energy to support RES, such as demand-side management and energy conservation, to ensure that environmental goals are achieved at the lowest cost.

Chebbi and Boujelbene (2008) investigated the long- and short-term linkages between economic growth, energy consumption, and CO_2 emission in Tunisia. Data from 1971 to 2004 indicated that GDP, CO_2, and energy consumption are related in the long term and thus confirm the inefficient use of energy in the region because environmental pressure rises faster than economic growth. In the short run, economic growth positively affects the growth of energy consumption

3. Methodology

This study uses the annual panel series data from 1992 to 2012. The data from 15 developing Asian countries are selected for the analysis, namely, Malaysia, China, Bangladesh, Thailand, Philippines, Vietnam, Sri Lanka, Cambodia, Kazakhstan, Kyrgyz Republic, Mongolia, Pakistan and Tajikistan. All the data were extracted from World Bank; the equation 1 below has been developed:

$$lnCO_{2\,it} = \alpha + \beta_1 lnGDP_{it} + \beta_2 lnFDI_{it} + \varepsilon \qquad (1)$$

where CO_2 represents carbon dioxide emission, i is country, t is the year, GDP represents economic growth, FDI is foreign direct investment and ε is an error. All the data are in log. Unit root test was performed to test the stationarity of all the variables. Then, panel Johansen co-integration, Fully Modified Ordinary Least Squares (FMOLS) and granger causality based on Vector Error Correction Model (VECM) were done. The equation for the unit root test is as follows:

$$y_{it} = P_1 y_{it-1} + z_{it}\, y + \mu_{it}, \qquad i=1,\ldots,N;\ t-1,\ldots,T \qquad (2)$$

Where is Z_{it} is the deterministic component and μ_{it} is error term. Z_{it} could be zero, one, the fixed effects, μ_{it}, or fixed effect as well as time trend, t. the Levin, Lin and Chu (LLC) are interested in testing the hypothesis:

$$H_0: \rho = 1$$
$$H_a: \rho < 1 \qquad (3)$$

Let $\hat{\rho}$ be the OLS estimator of ρ in (3.2) and define

$$z_t = (z_{it},\ldots,z_{nt})$$

$h(t,s)= z_t(\sum_{t=1}^{T} z_t z'_t)z_s$ $\tilde{u}_{it} = u_{it} - \sum_{s=1}^{T} h(t,s)\, u_{is}$

and,

$$\tilde{y}_{it}= y_{it} \sum_{s=1}^{T} h(t,s)\, u_{is}$$

then we have,

$$\frac{\sqrt{N}\, T\, (\hat{p}-1)=\frac{1}{\sqrt{N}}\sum_{s=1}^{T}\frac{1}{T}\sum_{t=1}^{T} \tilde{y}_{i,t-1}\tilde{u}_{it}}{\frac{1}{\sqrt{N}}\sum_{T}^{N}\frac{1}{T^2}\sum_{t=1}^{T} \tilde{y}^2{}_{i,t-1}}$$

And the corresponding t-statistic, under the null hypothesis is given by:

$$t_p = \frac{(\hat{p}-1)\left(\sqrt{\sum_{i=1}^{N}\sum_{t=1}^{T} t=1 \tilde{y}^2_{i,t-1}}\right.}{se}$$

Assume that there exists a scaling matrix D_T and piecewise continuous function Z(r) such that

$$D^{-1}{}_T Z \,|\, Tr \,| \rightarrow Z(r)$$

Uniformly for r $\sum$ [0,1] for a fixed N, we have

$$\frac{1}{\sqrt{N}}\sum_{i=1}^{N}\frac{1}{T}\sum_{t=1}^{T}\tilde{y}_{i,t-1}\,\tilde{u}_{it} \Rightarrow \frac{1}{\sqrt{N}}\sum_{i=1}^{N}\int W_{iz}\ \ d\,W_{iz}$$

and

$$\frac{1}{\sqrt{N}}\sum_{i=1}^{N}\frac{1}{T^2}\sum_{t=1}^{T}\tilde{y}^{2i}{}_{,t-1} \Rightarrow \frac{1}{\sqrt{N}}\sum_{i=1}^{N}\int W^2{}_{iz}$$

as T $\rightarrow\infty$. Next we assume that $\int W_{iz}\ d\,W_{iz}$ and $\int W^2{}_{iz}$ are independent across I and have finite second moments. Then it follows that

$$\frac{1}{N}\sum_{i=1}^{N}\int W^2{}_{iz} \overset{p}{\rightarrow} \sum\left[\int W^2{}_{iz}\right]$$

One of the important aspects to use cointegration test in the panel data is to see relative dimensions in pooled data. Pedroni (2001) proved that the relative dimension skewness in a sample is small. Pedroni developed a set of five statistics based on panel data regression standard as follows:

$$y_{it} = \alpha_i + \delta_i + \beta_i\, X_{it} + \varepsilon_{it} \qquad (4)$$

where y_{it} and X_{it} are panel data for each variable used where i=1, … , N and t is time where t = 1, … ,T. For each panel data, X_{it} and β_i are column and row vectors of m-dimension. One of y_{it} and X_{it} variables must be integrated of order 1 or I(1). Parameter α_i and δ_I are the fixed effect and deterministic trend which are specific for each variable. The hypotheses for the co-integration are as follows:

H_0: No co-integration
H_1: Co-integration exists

The residual ε_{it}, concept must be I(1) if put in the null hypothesis and I(0) under the alternative hypothesis. Among the five statistics developed by Pedroni (2001), there are three important steps based on pooled data along the panel data dimension. Meanwhile the second set of statistics are based on pooled data along the panel dimension. The panel co-integration equation as follows:

Panel variance ratio static: $Z_{\hat{v}_{NT}} = L^2{}_{11}\left(\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{e}^2{}_{it-1}\right)^{-1}$

Panel rho static: $Z_{\tilde{p}_{NT-1}}\left(\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{e}^2{}_{it-1}\right)^{-1}\sum_{i=1}^{N}\sum_{t=1}^{T}(\hat{e}_{it-1}\Delta\hat{e}_{it-1} - \lambda_i$

Panel t static: $Z_t\sigma^2{}_{NT^{-1}} = (\sigma^2{}_{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{e}^2{}_{it-1})^{-1/2}\sum_{i=1}^{N}\sum_{t=1}^{T}(\hat{e}_{it-1}\Delta\hat{e}_{it-1}-\lambda_i)$

Group rho static: $\breve{z}_{t\,NT} = \sum_{i=1}^{N}(\sum_{t=1}^{T}\hat{e}^2{}_{it-1})^{-1}\sum_{t-1}^{T}(\hat{e}_{it-1}\Delta\hat{e}_{it-1}-\lambda_i)$

Group t static: $\breve{z}_{t\,NT} = \sum_{i=1}^{N}(\sum_{t=1}^{T}\sigma_{i^{-2}}\,\hat{e}^2{}_{it-1})^{-1/2}\sum_{t=1}^{T}(\hat{e}_{it-1}\Delta\hat{e}-\lambda_i)$ (5)

FMOLS was introduced by Pedroni in 2000 which is to estimate the long run individual country (Abdullah et al., 2006). FMOLS method is modified from the Ordinary Least Squares (OLS) and the OLS equation is as follows:

$$Y_{it} = \alpha_i + X'_{it}\beta + e_{it}$$
$$X_{it} = X_{i,t\,1} + \varepsilon_{it} \qquad (6)$$

The OLS weaknesses depends on the parameters of a chaotic, biased and inconsistent estimators when used in co-integrated panel (Ramirez, 2006). So, FMOLS is used to improve these weaknesses. The hypothesis for this test is:

H_0 : $\beta_1 = \beta_0$ for all i
H_1: $\beta_1 \neq \beta_0$

So, the FMOLS equation for all state are as follows:

$$\beta_i^* = (X_i'X_i)^{-1}(X_i'Y_i^* - T\delta) \qquad (7)$$

where Y * is transformed endogenous variables, T is the number of time periods and δ is the autocorrelation adjustment. To test the Granger causality based on VECM, error correction term (ECT) is used and the equation as follows:

$$lnCo_{2\,it} = \alpha_i + \delta_i t + \beta_i lnGDP_{it} + \gamma_i lnFDI_{it} + \varepsilon_{it}$$
$$lnGDP_{it} = \alpha_i + \delta_i t + \beta_i lnCO_{2\,it} + \gamma_i lnFDI_{it} + \eta_{it}$$
$$lnFDI_{it} = \alpha_i + \delta_i t + \beta_i lnCO_{2\,it} + \gamma_i lnGDP_{it} + \varphi_{it} \quad (8)$$

According to Costantini and Martini (2009), to build granger causality model, Vector Auto-Regressions (VAR) with fixed and time effect as follows:

$$lnCO_{2\,it} = \sum_{j=1}^{m} \alpha_j^y\, lnCO_{2\,i,t-j} + \sum_{s=0}^{q} \beta_s^y\, lnGDP_{i,t-s} + \sum_{v=0}^{r} \lambda_v^y\, lnFDI_{i,t-v} + \varphi_i^y + \emptyset_i^y + u_{it}$$
$$lnGDP_{it} = \sum_{j=0}^{m} \alpha_j^e\, lnCO_{2\,i,t-j} + \sum_{s=1}^{q} \beta_s^e\, lnGDP_{i,t-s} + \sum_{v=0}^{r} \lambda_v^e\, lnFDI_{i,t-v} + \varphi_i^e + \emptyset_i^e + v_{it}$$
$$lnFDI_{it} = \sum_{j=0}^{m} \alpha_j^p\, lnCO_{2\,i,t-j} + \sum_{s=0}^{q} \beta_s^p\, lnGDP_{i,t-s} + \sum_{v=1}^{r} \lambda_v^p\, lnFDI_{i,t-v} + \varphi_i^p + \emptyset_i^p + \eta_{it} \quad (9)$$

There is a bias in the model (3.9) above for the lagged dependent variables are correlated with the error term. So, to solve this problem, the fixed effect is removed from the equation by a differentiation the equation above to be:

$$\Delta lnCO_{2\,it} = \sum_{j=1}^{m} \alpha_j^y\, \Delta lnCO_{2\,i,t-j} + \sum_{s=0}^{q} \beta_s^y\, \Delta lnGDP_{i,t-s} + \sum_{v=0}^{r} \lambda_v^y\, \Delta lnFDI_{i,t-v} + u_{it}$$
$$\Delta lnGDP_{it} = \sum_{j=0}^{m} \alpha_j^e\, \Delta lnCO_{2\,i,t-j} + \sum_{s=1}^{q} \beta_s^e\, \Delta lnGDP_{i,t-s} + \sum_{v=0}^{r} \lambda_v^e\, \Delta lnFDI_{i,t-v} + v_{it}$$
$$\Delta lnFDI_{it} = \sum_{j=0}^{m} \alpha_j^p\, \Delta lnCO_{2\,i,t-j} + \sum_{s=0}^{q} \beta_s^p\, \Delta lnGDP_{i,t-s} + \sum_{v=1}^{r} \lambda_v^p\, \Delta lnFDI_{i,t-v} + \eta_{it} \quad (10)$$

Finally, the equation for granger causality based on VECM are:

$$\Delta lnCO_{2\,it} = \alpha_i^y + \beta_1^y ECT_{i,t-1}^y + \sum_{j=1}^{m} \delta_{ij}^y\, \Delta lnCO_{2\,i,t-j} + \sum_{s=1}^{q} \gamma_{is}^y\, \Delta lnGDP_{i,t-s} + \sum_{v=1}^{r} \lambda_{iv}^y\, \Delta lnFDI_{i,t-v} + u_{it}$$
$$\Delta lnGDP_{it} = \alpha_i^e + \beta_1^e ECT_{i,t-1}^e + \sum_{j=1}^{m} \delta_{ij}^e\, \Delta lnCO_{2\,i,t-j} + \sum_{s=1}^{q} \gamma_{is}^e\, \Delta lnGDP_{i,t-s} + \sum_{v=1}^{r} \lambda_{iv}^e\, \Delta lnFDI_{i,t-v} + v_{it}$$
$$\Delta lnFDI_{it} = \alpha_i^p + \beta_1^p ECT_{i,t-1}^p + \sum_{j=1}^{m} \delta_{ij}^p\, \Delta lnCO_{2\,i,t-j} + \sum_{s=1}^{q} \gamma_{is}^p\, \Delta lnGDP_{i,t-s} + \sum_{v=1}^{r} \lambda_{iv}^p\, \Delta lnFDI_{i,t-v} + \eta_{it} \quad (11)$$

4. Findings

Table 1 shows the results of the panel unit root tests for all the variables (GDP, CO2, and FDI). All the variables are not significant, suggesting that they are stationary in level under LLC test and MW test. However under IPS only the CO2 is significant in level at 10%. In first difference, the results suggest that all the variables are statistically significant. Thus the variables are stationary in the first difference under all the tests (LLC, IPS and MW). Therefore, it can be concluded that every variable is integrated of order one. Then the Johansen co-integration test will be performed.

Table 2 shows the results of the panel co-integration. There are two panel statistics that reject null hypothesis as the values are significant at 5% for example panel v-stat and panel ADF-stat. These results imply that there is co-integration between the variables in the long run. However, the other two statistics exhibit insignificance such as panel rho-stat and panel pp-stat. Thus it indicates that there is no co-integration. In group, two group statistics for example pp-stat which is significant at 10% and group ADF which is significant at 1%, accept the alternative hypothesis and prove the existence of co-integration. However group rho-stat denies the co-integration. Table 3 shows the results of FMOLS. It is found that GDP is statistically significant at 1%. Therefore, a 1% increase in GDP can increase 0.6% CO2. However FDI is not significant and the result indicate that there is no effect of FDI on CO2.

Table 1. Results of panel unit root tests

Variables	LLC test		IPS test		MW test	
	Level	First Difference	Level	First difference	Level	First Difference
GDP	53.9862 (1.0000)	-5.07736* (0.0000)	-0.92941 (0.1763)	-4.06732* (0.0000)	35.4860 (0.1562)	63.9666* (0.0001)
CO2	36.0021 (1.0000)	-7.80573* (0.0000)	- 1.33617*** (0.0907)	-8.87468* (0.0000)	37.3320 (0.1677)	123.528* (0.0000)
FDI	23.4045 (1.0000)	-12.2395* (0.0000)	1.49859 (0.9330)	-12.3465* (0.0000)	21.9595 (0.5817)	163.587* (0.0000)

Notes: All panel unit root tests were performed with restricted intercept and trend for all variables. *, represent significance at 10%, respectively. In addition, P-values are in brackets.
*** and ** represent significance at 10% and 5%, respectively.
* Represent significance at 1%.

Table 2. Results of panel co-integration

Panel (within dimension)			Group (between dimension)		
Statistics	Value	Prob.	Statistics	Value	Prob.
Panel v-stat	2.150508	0.0158**			
Panel rho-stat	0.728252	0.7668	Group rho-stat	2.076907	0.9811
Panel PP-stat	-0.236880	0.4064	Group pp-stat	-1.519816	0.0643***
Panel ADF-stat	-1.768816	0.0385**	Group ADF-stat	-3.679156	0.0001*

Notes: *** and ** represent significance at 10% and 5%, respectively.
* Represent significance at 1%.

Table 3. Results of FMOLS (Dependent Variable = CO2)

Variable	Coefficient	Std. Error	t-statistic	Prob.
GDP	0.625372*	0.194597*	3.213672*	0.0015*
FDI	0.061022	0.040732	1.498144	0.1352

Notes: *** and ** represent significance at 10% and 5%, respectively.
* Represent significance at 1%.

Table 4 shows the results of panel short run Granger causality tests. In the short run, there is Granger causality running from CO2 to GDP. The findings reveal that there is no Granger causality relationship between GDP and CO2. Thus it suggests that an increase in GDP does not cause CO2 emission to increase. Other than that, FDI also does not show any Granger causality relationship with CO2 emission. Therefore any increase in FDI does not contribute to CO2 emission.

Table 4. Results of panel Granger Causality test results.

Dependent variables	Independent variables			
	ΔGDP	ΔCO2	ΔFDI	ECM
ΔGDP	-	7.519430***	0.665954	0.0000705
ΔCO2	0.092567	-	1.274116	-0.002880
ΔFDI	0.602421	0.800671	-	-0.155996*

Notes: *** and ** represent significance at 10% and 5%, respectively.
* Represent significance at 1%.

5. Conclusion

This study aims to investigate the effects of foreign direct investment and economic growth on CO2 emission by using panel data for 15 developing countries for the period of 1992-2012. The Johansen co-integration has been performed and the results show that there is co-integrated relationship between foreign direct investment, economic growth and CO2 emission. The FMOLS is also conducted and the results indicate that in the long run foreign direct investment does not have any effect on CO2 emission. Therefore, any increase in FDI does not have cause any problem to the environment. However in the developing countries, an increase in economic growth can be positively related with the environment as it can contribute to CO2 emission. The results from Granger causality based on VECM shows that in the short run there is no relationship between foreign direct investment, economic growth and CO2 emission.

The findings are very important in formulating policies on the environmental. Therefore, the developing countries should find the alternative energy such as natural gas and biomass in the production to ensure that there is no effect on the environment. As economic growth escalates, energy consumptions also increases. The use of green technology is also important to reduce CO2 emission.

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