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Granger Causality among Economic Development, Energy Consumption, and Carbon Dioxide in ASEAN+6 Countries

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Abstract

The issues of global warming, environmental change, carbon dioxide (CO2) emissions, energy consumption (EC), and economic growth have concerned many countries. Hence, the present study uses the time-series method to verify the causality among gross domestic product, CO2 emissions, and EC in the developing ASEAN plus six countries, namely Singapore, Thailand, Indonesia, Malaysia, Vietnam, the Philippines, Brunei, Myanmar, Laos, Cambodia, China, Japan, Korea, New Zealand, Australia, and India, for the period 1980–2013. In this study, the unit root test of the three variables is carried out to determine whether each variable is stationary. If a variable has a unit root, it is non-stationary, and the multivariate co-integration analysis proposed by Johansen (1991) is then used to test whether there is a co-integration relationship among the variables. If the co-integration relationship exists, the vector error correction model (VECM) is used to modify the short- and long-term Granger causality that coexists simultaneously among the variables; however, if the relationship does not exist, the vector auto-regression (VAR) model is used to analyze the causality. The results show that EC plays an important role in economic growth in ASEAN plus six countries.

Keywords: *Gross Domestic Product, carbon dioxide emissions, energy consumption, Johansen co-integration, Granger causality*

1. Introduction

The countries around the world are coming closer, hence making the society a global village. The division of labor and the trade activities between countries are growing, and the regional integration has become the trend of trade. “ASEAN plus six” refers to the 10 member countries of ASEAN plus China, Japan, South Korea, Australia, New Zealand, and India—also known as “ASEAN 10+6,” “ASEAN+6,” etc. The specific cooperation framework of ASEAN plus six started in December 14, 2005, at the First East Asia Summit (EAS) in Kuala Lumpur, Malaysia. The declaration stated expectations of contributing to a broader dialogue among East Asian countries in political and economic issues involved in common interest and security. ASEAN and China, Japan, Korea, New Zealand, Australia, India, and other 16 countries launched the “Regional Comprehensive Economic

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Partnership Agreement" (RCEP) in May 2013. Today, while the economic growth of countries is no longer confined to the domestic use of resources and manufacturing and international cooperation and trade are booming under the consideration of comparative advantages, countries apply their expertise to gain more benefits. However, there are many segments in the procedure of trade import and export. Whether it is manufacturing, packaging, transportation, or customs, it will be accompanied by energy consumption (EC) and environmental pollution. Recently, environmental protection, energy saving, and carbon-reduction energy have been playing an important role in economic growth in the developed and developing countries. This study investigates the impact of EC and CO_2 emissions on economic growth in the ASEAN plus six countries.

2. Literature Review

2.1 Causality between GDP and EC

Chang (2011) employed the causality approach to measure the nexus among CO_2 emissions, EC, and economic growth in China for the period 1981–2006, and concluded the existence of bidirectional causality between EC and economic growth. Climent and Pardo (2007) used the causality verification method to study the nexus between GDP and EC in Spain for the period 1984–2003. The results showed that in the short run, there was unidirectional causality between EC and economic growth. It can be speculated that primary EC was very important to economic growth in Spain. Lise and Montfort (2007) used the causality research method to assess the relationship between GDP and EC in Turkey for the period 1970–2003. The results showed unidirectional causality from economic growth to EC, indicating that the adoption of energy-saving policies would not affect economic growth in Turkey.

2.2 Causality between GDP and CO_2 Emissions

Chang (2011) used the causality research method to measure the causality among CO_2 emissions, EC, and economic growth in China for the period 1981–2006 and concluded the existence of unidirectional causality from CO_2 emissions to economic growth. The policy development in each country takes strengthening research and development of energy technology as strategy and formulating comprehensive policy as core supporting measures. The direction of energy technology development includes research and development of low-carbon technologies, development of new energy technologies, utilization of renewable energy, and improvement of energy usage per unit. The goal is to reduce dependence on petroleum, which is believed to be able to effectively reduce greenhouse gas emissions and take into consideration EC control, economic development, and environment protection. Gradually, carbon tax and related measures will be imposed and comprehensive green tax reforms will be implemented.

3. Method

The variables of this study are GDP, CO_2 emissions, and EC. Granger causality will be used to test the causality among the variables.

3.1 Granger Causality Test

In order to investigate the causal relationship between variables X and Y, Granger (1969) proposed the causality test to investigate the mutual forecast accuracy between the variables. Y can be added into the forecast of X, and if through this, the forecast's accuracy is increased, four causalities will be produced: (1) Y causes X; (2) X causes Y; (3) If the former two coexist, X and Y have feedback causality; and (4) If X and Y are unrelated, they have independent causality. The model is formulated as follows:

$$\begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} = \begin{bmatrix} m_1 \\ m_2 \end{bmatrix} + \begin{bmatrix} \beta_{11}^{(1)} & \beta_{12}^{(1)} \\ \beta_{21}^{(1)} & \beta_{22}^{(1)} \end{bmatrix} \begin{bmatrix} y_{1,t-1} \\ y_{2,t-1} \end{bmatrix} + \begin{bmatrix} \beta_{11}^{(2)} & \beta_{12}^{(2)} \\ \beta_{21}^{(2)} & \beta_{22}^{(2)} \end{bmatrix} \begin{bmatrix} y_{1,t-2} \\ y_{2,t-2} \end{bmatrix} + \cdots + \begin{bmatrix} \beta_{11}^{(p)} & \beta_{12}^{(p)} \\ \beta_{21}^{(p)} & \beta_{22}^{(p)} \end{bmatrix} \begin{bmatrix} y_{1,t-p} \\ y_{2,t-p} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$$

$H_0 : \beta_{ij}^{(q)} = 0 \ , \ q = 1, 2, \cdots, p \ ; \ i = 1, 2 \ ; \ j = 1, 2$

H_1: there is at least one q, so that $\beta_{ij}^{(q)} \neq 0$

In the null hypothesis, all lag items y_{jt} cannot explain the present value y_{it}. The test statistic of this joint test is the same as that in chapter IV. The F statistic is used to test

$$F = \frac{\frac{(ESS_R - ESS_U)}{(DF_R - DF_U)}}{\frac{ESS_U}{DF_U}} \sim F_{(p, T-2p-1)}$$

Or

$$F \equiv \frac{T \cdot (ESS_R - ESS_U)}{ESS_U} \sim \chi^2_{(p)}$$

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At α significance level, if $F > F_{\alpha(p, T-2p-1)}$ or $\chi^2 > \chi^2_{\alpha(p)}$, the null hypothesis is rejected, indicating that y_{jt} can Granger-cause y_{it}.

4. Empirical Analysis

The three variables of each country, i.e., GDP, EC, and CO_2 emissions, are tested through the Johansen co-integration and Granger causality test, shown as follows:

4.1 Johansen Co-integration Test and Granger Causality [Remark 2]

Table1 Australia Johansen Co-integration Tests

Date: 05/18/14 Time: 09:27
Sample (adjusted): 1982 2010
Included observations: 29 after adjustments
Trend assumption: Linear deterministic trend
Series: CO_2 ENERGY GDP
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.392817	20.15708	29.79707	0.4123
At most 1	0.142531	5.688244	15.49471	0.7320
At most 2	0.041490	1.228891	3.841466	0.2676

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Co-integration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.392817	14.46883	21.13162	0.3278
At most 1	0.142531	4.459353	14.26460	0.8080
At most 2	0.041490	1.228891	3.841466	0.2676

Max-eigenvalue test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

CO_2	ENERGY	GDP
2.94E−06	−2.077352	7.12E−12
1.98E−05	2.152018	−5.25E−12
5.32E−05	−3.496271	−6.81E−12

Unrestricted Adjustment Coefficients (alpha):

D(CO_2)	−3287.178	−34.94437	−1208.507
D(ENERGY)	0.094620	−0.078259	−0.014650
D(GDP)	1.73E+10	1.91E+10	−6.01E+09

1 Cointegrating Equation(s): Log likelihood −1058.795

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP
1.000000	−706736.4	2.42E−06
	(326015.)	(6.9E−07)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	−0.009662
	(0.00432)
D(ENERGY)	2.78E−07
	(1.5E−07)
D(GDP)	50901.56
	(37390.6)

2 Cointegrating Equation(s): Log likelihood −1056.566

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP
1.000000	0.000000	9.30E−08
		(1.3E−07)
0.000000	1.000000	−3.30E−12
		(5.7E−13)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	−0.010355	6753.426
	(0.02946)	(4398.96)
D(ENERGY)	−1.27E−06	−0.364973
	(9.7E−07)	(0.14430)
D(GDP)	428664.8	5.05E+09
	(242606.)	(3.6E+10)

Table2、Australia Granger Causality Tests

Pairwise Granger Causality Tests
Date: 05/18/14 Time: 09:38
Sample: 1980 2013
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
ENERGY does not Granger Cause CO_2	29	2.18764	0.1340

CO_2 does not Granger Cause ENERGY		1.78098	0.1900
GDP does not Granger Cause CO_2	29	7.44766	0.0030
CO_2 does not Granger Cause GDP		0.09661	0.9083
GDP does not Granger Cause ENERGY	31	5.70783	0.0088
ENERGY does not Granger Cause GDP		1.00817	0.3787

Table3、Brunei Darussalam Johansen Co-integration Tests

Date: 05/18/14 Time: 09:42
Sample (adjusted): 1982 2010
Included observations: 29 after adjustments
Trend assumption: Linear deterministic trend
Series: CO_2 ENERGY GDP
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.715401	44.79478	29.79707	0.0005
At most 1	0.240166	8.351242	15.49471	0.4286
At most 2	0.013230	0.386242	3.841466	0.5343

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Co-integration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.715401	36.44353	21.13162	0.0002
At most 1	0.240166	7.965000	14.26460	0.3823
At most 2	0.013230	0.386242	3.841466	0.5343

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

CO_2	ENERGY	GDP
−0.000520	9.212406	2.06E−10
0.000780	−0.762181	−2.80E−10
7.53E−05	−1.726663	3.62E−10

Unrestricted Adjustment Coefficients (alpha):

D(CO_2)	137.2922	−582.6194	25.25641
D(ENERGY)	−0.020904	−0.002318	−0.001011
D(GDP)	3.32E+08	−2.11E+08	−97827300

1 Cointegrating Equation(s): Log likelihood −806.5956

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP
1.000000	−17702.93	−3.95E−07
	(1818.54)	(9.6E−08)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	−0.071445
	(0.12875)
D(ENERGY)	1.09E−05
	(1.8E−06)
D(GDP)	−172951.8
	(103642.)

2 Cointegrating Equation(s): Log likelihood −802.6131

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP
1.000000	0.000000	−3.57E−07
		(1.9E−07)
0.000000	1.000000	2.15E−12
		(1.2E−11)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	−0.526069	1708.853
	(0.20348)	(2005.49)
D(ENERGY)	9.07E−06	−0.190813
	(3.1E−06)	(0.03090)
D(GDP)	−337290.2	3.22E+09
	(182394.)	(1.8E+09)

Table4 Brunei Darussalam Granger Causality Tests

Pairwise Granger Causality Tests
Date: 05/18/14 Time: 09:46
Sample: 1980 2013
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
ENERGY does not Granger Cause CO_2	29	0.75254	0.4820
CO_2 does not Granger Cause ENERGY		1.22816	0.3106
GDP does not Granger Cause CO_2	29	2.25718	0.1264
CO_2 does not Granger Cause GDP		0.20243	0.8181

GDP does not Granger Cause ENERGY	30	0.27639	0.7608
ENERGY does not Granger Cause GDP		0.68357	0.5140

Table5 Cambodia Johansen Co-integration Tests

Date: 05/18/14 Time: 09:53
Sample (adjusted): 1997 2010
Included observations: 14 after adjustments
Trend assumption: Linear deterministic trend
Series: CO_2 ENERGY GDP
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.793256	30.87555	29.79707	0.0374
At most 1	0.438276	8.807700	15.49471	0.3835
At most 2	0.051028	0.733267	3.841466	0.3918

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Co-integration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.793256	22.06785	21.13162	0.0368
At most 1	0.438276	8.074434	14.26460	0.3712
At most 2	0.051028	0.733267	3.841466	0.3918

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

CO_2	ENERGY	GDP
0.002781	0.839763	−1.42E−09
−0.007472	0.383840	1.39E−09
−0.002216	−0.743580	2.65E−09

Unrestricted Adjustment Coefficients (alpha):

D(CO_2)	112.2135	35.38553	16.84825
D(ENERGY)	0.715536	−0.864077	0.526210
D(GDP)	2.69E+08	−1.69E+08	57687856

1 Cointegrating Equation(s):		Log likelihood	−398.9280

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP
1.000000	301.9427	−5.10E−07
	(72.0676)	(1.4E−07)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	0.312088
	(0.10028)
D(ENERGY)	0.001990
	(0.00250)
D(GDP)	749359.1
	(358570.)

2 Cointegrating Equation(s):		Log likelihood	−394.8907

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP
1.000000	0.000000	−2.34E−07
		(4.8E−08)
0.000000	1.000000	−9.15E−10
		(2.5E−10)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	0.047671	107.8151
	(0.27168)	(31.4617)
D(ENERGY)	0.008447	0.269213
	(0.00678)	(0.78569)
D(GDP)	2015058.	1.61E+08
	(924152.)	(1.1E+08)

Table6、Cambodia Granger Causality Tests

Pairwise Granger Causality Tests
Date: 05/18/14 Time: 09:56
Sample: 1980 2013
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
ENERGY does not Granger Cause CO_2	14	4.94222	0.0356
CO_2 does not Granger Cause ENERGY		0.69915	0.5221
GDP does not Granger Cause CO_2	16	8.97041	0.0049
CO_2 does not Granger Cause GDP		0.03908	0.9618
GDP does not Granger Cause ENERGY	15	0.50831	0.6163
ENERGY does not Granger Cause GDP		1.62482	0.2449

Table7 China Johansen Co-integration Tests

Date: 05/18/14 Time: 10:04
Sample (adjusted): 1982 2010
Included observations: 29 after adjustments
Trend assumption: Linear deterministic trend
Series: CO_2 ENERGY GDP
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.532929	32.23052	29.79707	0.0257
At most 1	0.291544	10.15356	15.49471	0.2691
At most 2	0.005440	0.158200	3.841466	0.6908

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Co-integration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.532929	22.07697	21.13162	0.0367
At most 1	0.291544	9.995356	14.26460	0.2122
At most 2	0.005440	0.158200	3.841466	0.6908

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

CO_2	ENERGY	GDP
−4.24E−06	0.536409	1.06E−12
3.98E−06	−0.531156	−3.79E−12
−2.94E−07	0.412818	−1.25E−12

Unrestricted Adjustment Coefficients (alpha):

D(CO_2)	35241.91	−78330.38	−2458.520
D(ENERGY)	0.180958	−0.108484	−0.033319
D(GDP)	−9.26E+10	−3.09E+09	−1.60E+09

1 Cointegrating Equation(s): Log likelihood −1174.728

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP

1.000000	−126478.4	−2.50E−07
	(16884.2)	(1.1E−07)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	−0.149465	
	(0.13199)	
D(ENERGY)	−7.67E−07	
	(4.5E−07)	
D(GDP)	392609.1	
	(77504.2)	

2 Cointegrating Equation(s): Log likelihood −1169.731

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP
1.000000	0.000000	1.23E−05
		(3.5E−06)
0.000000	1.000000	9.93E−11
		(2.7E−11)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	−0.460996	60509.72
	(0.15524)	(20155.5)
D(ENERGY)	−1.20E−06	0.154690
	(6.1E−07)	(0.07878)
D(GDP)	380313.7	−4.80E+10
	(106188.)	(1.4E+10)

Table8 China Granger Causality Test

Pairwise Granger Causality Tests
Date: 05/18/14 Time: 10:05
Sample: 1980 2013
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
ENERGY does not Granger Cause CO_2	29	0.06583	0.9365
CO_2 does not Granger Cause ENERGY		2.51500	0.1019
GDP does not Granger Cause CO_2	29	1.65192	0.2127
CO_2 does not Granger Cause GDP		3.84404	0.0356
GDP does not Granger Cause ENERGY	30	0.26683	0.7680
ENERGY does not Granger Cause GDP		0.54584	0.5861

Table9 India Johansen Co-integration Tests

Date: 05/18/14 Time: 10:09
Sample (adjusted): 1982 2010

Included observations: 29 after adjustments
Trend assumption: Linear deterministic trend
Series: CO_2 ENERGY GDP
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.610885	47.82256	29.79707	0.0002
At most 1 *	0.381220	20.45001	15.49471	0.0082
At most 2 *	0.201618	6.529873	3.841466	0.0106

Trace test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Co-integration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.610885	27.37255	21.13162	0.0058
At most 1	0.381220	13.92014	14.26460	0.0566
At most 2 *	0.201618	6.529873	3.841466	0.0106

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

CO_2	ENERGY	GDP
9.29E−07	0.109332	5.10E−12
2.68E−05	−0.720356	−2.50E−11
−8.13E−06	0.422835	−3.09E−12

Unrestricted Adjustment Coefficients (alpha):

D(CO_2)	−3140.912	−17662.78	849.4908
D(ENERGY)	−0.301970	−0.171654	−0.114026
D(GDP)	3.58E+10	8.52E+09	−1.91E+10

1 Cointegrating Equation(s): Log likelihood −1103.264

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP
1.000000	117672.5	5.48E−06
	(41748.7)	(2.1E−06)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	−0.002918
	(0.00546)
D(ENERGY)	−2.81E−07
	(8.5E−08)
D(GDP)	33303.21
	(10068.6)

2 Cointegrating Equation(s): Log likelihood −1096.304

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP
1.000000	0.000000	2.62E−07
		(3.6E−07)
0.000000	1.000000	4.44E−11
		(1.3E−11)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	−0.475619	12380.09
	(0.12420)	(3379.21)
D(ENERGY)	−4.87E−06	0.090637
	(2.3E−06)	(0.06139)
D(GDP)	261343.3	−2.22E+09
	(286430.)	(7.8E+09)

Table10 India Granger Causality Tests

Pairwise Granger Causality Tests
Date: 05/18/14 Time: 10:12
Sample: 1980 2013
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
ENERGY does not Granger Cause CO_2	29	0.97235	0.3926
CO_2 does not Granger Cause ENERGY		4.29468	0.0254
GDP does not Granger Cause CO_2	29	3.13661	0.0616
CO_2 does not Granger Cause GDP		0.07367	0.9292
GDP does not Granger Cause ENERGY	30	1.38152	0.2697
ENERGY does not Granger Cause GDP		1.40972	0.2630

Table11 Indonesia Johansen Co-integration Tests

Date: 05/18/14 Time: 10:15
Sample (adjusted): 1982 2010
Included observations: 29 after adjustments
Trend assumption: Linear deterministic trend
Series: CO_2 ENERGY GDP
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.496330	24.70320	29.79707	0.1723
At most 1	0.152941	4.814037	15.49471	0.8283
At most 2	1.63E−05	0.000473	3.841466	0.9843

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Co-integration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.496330	19.88916	21.13162	0.0739
At most 1	0.152941	4.813564	14.26460	0.7652
At most 2	1.63E−05	0.000473	3.841466	0.9843

Max-eigenvalue test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

CO_2	ENERGY	GDP
−2.85E−05	0.296201	5.26E−13
−4.11E−05	0.515855	1.49E−11
−4.04E−05	0.180858	2.52E−11

Unrestricted Adjustment Coefficients (alpha):

D(CO_2)	3435.782	3077.701	−61.31186
D(ENERGY)	−0.025503	−0.364868	−0.003139
D(GDP)	−2.55E+10	3.48E+09	−77786914

1 Cointegrating Equation(s): Log likelihood −1110.574

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP
1.000000	−10388.69	−1.84E−08
	(1712.30)	(1.0E−07)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	−0.097961
	(0.10151)
D(ENERGY)	7.27E−07
	(7.1E−06)
D(GDP)	727284.8

	(193900.)	

2 Cointegrating Equation(s):		Log likelihood	−1108.167

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP
1.000000	0.000000	1.64E−06
		(7.3E−07)
0.000000	1.000000	1.60E−10
		(6.6E−11)

Adjustment coefficients (standard error in parentheses)

$D(CO_2)$	−0.224487	2605.331
	(0.17532)	(2084.55)
D(ENERGY)	1.57E−05	−0.195773
	(1.2E−05)	(0.14064)
D(GDP)	584377.5	−5.76E+09
	(338382.)	(4.0E+09)

Table12 Indonesia Granger Causality Tests

Pairwise Granger Causality Tests
Date: 05/18/14 Time: 10:16
Sample: 1980 2013
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
ENERGY does not Granger Cause CO_2	29	0.56187	0.5775
CO_2 does not Granger Cause ENERGY		0.17942	0.8369
GDP does not Granger Cause CO_2	29	2.97505	0.0701
CO_2 does not Granger Cause GDP		0.98592	0.3877
GDP does not Granger Cause ENERGY	30	0.06455	0.9376
ENERGY does not Granger Cause GDP		0.08437	0.9194

Table13 Japan Johansen Co-integration Tests

Date: 05/18/14 Time: 10:22
Sample (adjusted): 1982 2010
Included observations: 29 after adjustments
Trend assumption: Linear deterministic trend
Series: CO_2 ENERGY GDP
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**

None *	0.412599	33.28554	29.79707	0.0190
At most 1 *	0.365048	17.85615	15.49471	0.0216
At most 2 *	0.149154	4.684186	3.841466	0.0304

Trace test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Co-integration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.412599	15.42939	21.13162	0.2599
At most 1	0.365048	13.17197	14.26460	0.0738
At most 2 *	0.149154	4.684186	3.841466	0.0304

Max-eigenvalue test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

CO_2	ENERGY	GDP
1.23E−05	−0.668667	−1.90E−12
−2.11E−05	−0.308205	1.20E−12
6.07E−06	−0.237419	−1.68E−12

Unrestricted Adjustment Coefficients (alpha):

D(CO_2)	−344.3380	23845.19	−375.2906
D(ENERGY)	0.537872	0.403952	−0.045191
D(GDP)	1.62E+10	5.21E+10	1.21E+11

1 Cointegrating Equation(s): Log likelihood −1185.823

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP
1.000000	−54538.93	−1.55E−07
	(15169.5)	(3.1E−08)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	−0.004222
	(0.09880)
D(ENERGY)	6.59E−06
	(2.3E−06)
D(GDP)	198269.6
	(811700.)

2 Cointegrating Equation(s): Log likelihood −1179.237

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP
1.000000	0.000000	−7.73E−08
		(8.8E−09)
0.000000	1.000000	1.42E−12
		(2.8E−13)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	−0.508531	−7118.957
	(0.15702)	(4729.08)
D(ENERGY)	−1.95E−06	−0.484157
	(4.2E−06)	(0.12658)
D(GDP)	−903896.1	−2.69E+10
	(1597429)	(4.8E+10)

Table14 Japan Granger Causality Tests

Pairwise Granger Causality Tests
Date: 05/18/14 Time: 10:23
Sample: 1980 2013
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
ENERGY does not Granger Cause CO_2	29	4.05580	0.0304
CO_2 does not Granger Cause ENERGY		2.36634	0.1154
GDP does not Granger Cause CO_2	29	4.09024	0.0296
CO_2 does not Granger Cause GDP		0.37334	0.6924
GDP does not Granger Cause ENERGY	31	0.13235	0.8766
ENERGY does not Granger Cause GDP		0.94324	0.4023

Table15 Korea Johansen Co-integration Tests

Date: 05/18/14 Time: 10:27
Sample (adjusted): 1982 2010
Included observations: 29 after adjustments
Trend assumption: Linear deterministic trend
Series: CO_2 ENERGY GDP
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.288977	18.51707	29.79707	0.5280
At most 1	0.214789	8.626592	15.49471	0.4010
At most 2	0.054145	1.614319	3.841466	0.2039

Trace test indicates no co-integration at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Co-integration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.288977	9.890480	21.13162	0.7549
At most 1	0.214789	7.012273	14.26460	0.4877
At most 2	0.054145	1.614319	3.841466	0.2039

Max-eigenvalue test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

CO_2	ENERGY	GDP
1.18E−06	−0.280678	−2.16E−12
2.15E−05	0.049305	−1.01E−11
−1.12E−05	−0.204363	−8.12E−13

Unrestricted Adjustment Coefficients (alpha):

D(CO_2)	4040.120	−1865.994	4522.760
D(ENERGY)	0.674400	−0.309587	0.082971
D(GDP)	1.76E+10	1.80E+10	8.52E+09

1 Cointegrating Equation(s): Log likelihood −1125.986

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP
1.000000	−237382.8	−1.83E−06
	(88828.0)	(1.5E−06)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	0.004777
	(0.00503)
D(ENERGY)	7.97E−07
	(3.1E−07)
D(GDP)	20846.66
	(14515.2)

2 Cointegrating Equation(s): Log likelihood −1122.480

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP
1.000000	0.000000	−4.81E−07
		(7.0E−08)
0.000000	1.000000	5.68E−12

		(4.4E−12)
Adjustment coefficients (standard error in parentheses)		
$D(CO_2)$	−0.035391	−1225.974
	(0.09133)	(1207.20)
D(ENERGY)	−5.87E−06	−0.204553
	(5.6E−06)	(0.07350)
D(GDP)	408800.4	−4.06E+09
	(252494.)	(3.3E+09)

Table16 Korea Granger Causality Tests

Pairwise Granger Causality Tests
Date: 05/18/14 Time: 10:27
Sample: 1980 2013
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
ENERGY does not Granger Cause CO_2	29	1.23395	0.3090
CO_2 does not Granger Cause ENERGY		0.61165	0.5507
GDP does not Granger Cause CO_2	29	0.11903	0.8883
CO_2 does not Granger Cause GDP		5.27774	0.0126
GDP does not Granger Cause ENERGY	31	0.13269	0.8763
ENERGY does not Granger Cause GDP		1.65284	0.2110

Table17 Lao PDR Johansen Co-integration Tests

No energy consumption statistics
Date: 05/18/14 Time: 10:32
Sample (adjusted): 1986 2010
Included observations: 25 after adjustments
Trend assumption: Linear deterministic trend
Series: CO_2 GDP
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.490473	17.27353	15.49471	0.0267
At most 1	0.016530	0.416707	3.841466	0.5186

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Co-integration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.490473	16.85683	14.26460	0.0190
At most 1	0.016530	0.416707	3.841466	0.5186

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

CO_2	GDP
−0.002939	3.18E−10
0.001987	−1.48E−09

Unrestricted Adjustment Coefficients (alpha):

D(CO_2)	−39.09614	8.514697
D(GDP)	−2.44E+08	−23068375

1 Cointegrating Equation(s): Log likelihood −668.0482

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	GDP
1.000000	−1.08E−07
	(7.9E−08)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	0.114922
	(0.04958)
D(GDP)	715890.5
	(196465.)

Table18 Lao PDR Granger Causality Tests

No energy consumption statistics
Pairwise Granger Causality Tests
Date: 05/18/14 Time: 10:34
Sample: 1980 2013
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
GDP does not Granger Cause CO_2	25	0.92728	0.4120
CO_2 does not Granger Cause GDP		3.97913	0.0351

Table19 Malaysia Johansen Co-integration Tests

Date: 05/18/14 Time: 10:42
Sample (adjusted): 1982 2010
Included observations: 29 after adjustments
Trend assumption: Linear deterministic trend
Series: CO_2 ENERGY GDP
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.393097	21.86677	29.79707	0.3059
At most 1	0.213079	7.384553	15.49471	0.5334
At most 2	0.014900	0.435364	3.841466	0.5094

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Co-integration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.393097	14.48222	21.13162	0.3268
At most 1	0.213079	6.949190	14.26460	0.4952
At most 2	0.014900	0.435364	3.841466	0.5094

Max-eigenvalue test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

CO_2	ENERGY	GDP
0.000123	−1.106370	−4.66E−11
−8.19E−05	0.780261	5.21E−11
−0.000107	0.318531	9.07E−11

Unrestricted Adjustment Coefficients (alpha):

D(CO_2)	−2274.627	1647.148	−1036.678
D(ENERGY)	0.015779	−0.226916	−0.069627
D(GDP)	3.55E+09	3.86E+09	−1.15E+09

1 Cointegrating Equation(s): Log likelihood −1040.828

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP

1.000000	−8969.163	−3.77E−07
	(1098.81)	(7.9E−08)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	−0.280581	
	(0.24262)	
D(ENERGY)	1.95E−06	
	(1.9E−05)	
D(GDP)	438119.1	
	(336594.)	

2 Cointegrating Equation(s): Log likelihood −1037.354

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP
1.000000	0.000000	3.79E−06
		(1.7E−06)
0.000000	1.000000	4.65E−10
		(1.9E−10)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	−0.415502	3801.785
	(0.28695)	(2623.63)
D(ENERGY)	2.05E−05	−0.194511
	(2.2E−05)	(0.19849)
D(GDP)	121770.3	−9.16E+08
	(386817.)	(3.5E+09)

Table20 Malaysia Granger Causality Tests

Pairwise Granger Causality Tests
Date: 05/18/14 Time: 10:45
Sample: 1980 2013
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
ENERGY does not Granger Cause CO_2	29	1.24150	0.3069
CO_2 does not Granger Cause ENERGY		0.00765	0.9924
GDP does not Granger Cause CO_2	29	0.82509	0.4502
CO_2 does not Granger Cause GDP		0.97763	0.3907
GDP does not Granger Cause ENERGY	30	0.24797	0.7823
ENERGY does not Granger Cause GDP		0.05735	0.9444

Table21 Myanmar Johansen Co-integration Tests

East Asia & Pacific (developing only). No GDP data
Date: 05/18/14 Time: 10:48
Sample (adjusted): 1982 2010
Included observations: 29 after adjustments

Trend assumption: Linear deterministic trend
Series: CO_2 ENERGY
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.322782	12.82752	15.49471	0.1213
At most 1	0.051208	1.524414	3.841466	0.2170

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Co-integration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.322782	11.30311	14.26460	0.1397
At most 1	0.051208	1.524414	3.841466	0.2170

Max-eigenvalue test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

CO_2	ENERGY
−0.002273	1.206817
0.000967	−0.297405

Unrestricted Adjustment Coefficients (alpha):

D(CO_2)	67.32436	−241.2324
D(ENERGY)	−0.717340	−0.351370

1 Cointegrating Equation(s): Log likelihood −289.3040

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY
1.000000	−530.9094
	(25.3040)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	−0.153036
	(0.48666)
D(ENERGY)	0.001631
	(0.00085)

Table22 Myanmar Granger Causality Tests
East Asia & Pacific (developing only). No GDP data

Pairwise Granger Causality Tests
Date: 05/18/14 Time: 10:50
Sample: 1980 2013
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
ENERGY does not Granger Cause CO_2	29	1.04463	0.3673
CO_2 does not Granger Cause ENERGY		2.08706	0.1460

Table23 New Zealand Johansen Co-integration Tests

Date: 05/18/14 Time: 10:54
Sample (adjusted): 1982 2010
Included observations: 29 after adjustments
Trend assumption: Linear deterministic trend
Series: CO_2 ENERGY GDP
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.341270	24.75039	29.79707	0.1705
At most 1	0.298550	12.64457	15.49471	0.1285
At most 2	0.078188	2.361002	3.841466	0.1244

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Co-integration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.341270	12.10581	21.13162	0.5372
At most 1	0.298550	10.28357	14.26460	0.1940
At most 2	0.078188	2.361002	3.841466	0.1244

Max-eigenvalue test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

CO_2	ENERGY	GDP
0.000422	−1.151295	−7.91E−11
0.000263	−0.612483	−9.93E−12

−0.000278	−0.123191	4.25E−11	

Unrestricted Adjustment Coefficients (alpha):

D(CO_2)	60.17273	−650.9604	−45.54740
D(ENERGY)	0.654705	−0.658002	0.091697
D(GDP)	9.26E+08	7.67E+08	−2.34E+09

1 Cointegrating Equation(s): Log likelihood −989.2330

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP
1.000000	−2725.224	−1.87E−07
	(501.185)	(2.2E−08)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	0.025421
	(0.10394)
D(ENERGY)	0.000277
	(0.00013)
D(GDP)	391052.7
	(741253.)

2 Cointegrating Equation(s): Log likelihood −984.0913

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP
1.000000	0.000000	8.42E−07
		(3.0E−07)
0.000000	1.000000	3.78E−10
		(1.2E−10)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	−0.145741	329.4256
	(0.10304)	(270.043)
D(ENERGY)	0.000104	−0.350744
	(0.00014)	(0.37193)
D(GDP)	592777.2	−1.54E+09
	(869615.)	(2.3E+09)

Table24 New Zealand Granger Causality Tests

Pairwise Granger Causality Tests
Date: 05/18/14 Time: 10:55
Sample: 1980 2013
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
ENERGY does not Granger Cause CO_2	29	2.02804	0.1535

CO_2 does not Granger Cause ENERGY		3.31822	0.0534
GDP does not Granger Cause CO_2	29	1.36955	0.2734
CO_2 does not Granger Cause GDP		2.44367	0.1082
GDP does not Granger Cause ENERGY	31	4.22289	0.0258
ENERGY does not Granger Cause GDP		1.49351	0.2432

Table25 Philippines Johansen Co-integration Tests

Date: 05/18/14 Time: 10:58
Sample (adjusted): 1982 2010
Included observations: 29 after adjustments
Trend assumption: Linear deterministic trend
Series: CO_2 ENERGY GDP
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.471808	27.39075	29.79707	0.0924
At most 1	0.225737	8.880169	15.49471	0.3766
At most 2	0.049121	1.460687	3.841466	0.2268

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Co-integration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.471808	18.51058	21.13162	0.1119
At most 1	0.225737	7.419482	14.26460	0.4408
At most 2	0.049121	1.460687	3.841466	0.2268

Max-eigenvalue test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

CO_2	ENERGY	GDP
−0.000190	0.371249	3.43E−11
−0.000135	0.306312	−1.92E−11
5.90E−05	0.108299	−3.71E−11

Unrestricted Adjustment Coefficients (alpha):

D(CO_2)	638.1015	162.2981	−707.1186
D(ENERGY)	−0.540930	−0.628243	−0.440865
D(GDP)	3.41E+09	−2.84E+09	−2.58E+08

1 Cointegrating Equation(s): Log likelihood −1028.519

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP
1.000000	−1954.534	−1.81E−07
	(256.239)	(5.4E−08)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	−0.121202
	(0.12713)
D(ENERGY)	0.000103
	(9.5E−05)
D(GDP)	−646881.1
	(274662.)

2 Cointegrating Equation(s): Log likelihood −1024.809

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP
1.000000	0.000000	−2.22E−06
		(5.9E−07)
0.000000	1.000000	−1.04E−09
		(3.0E−10)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	−0.143156	286.6080
	(0.15588)	(321.752)
D(ENERGY)	0.000188	−0.393258
	(0.00011)	(0.23328)
D(GDP)	−262090.5	3.93E+08
	(308814.)	(6.4E+08)

Table26 Philippines Granger Causality Tests

Pairwise Granger Causality Tests
Date: 05/18/14 Time: 11:00
Sample: 1980 2013
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
ENERGY does not Granger Cause CO_2	29	0.96802	0.3942
CO_2 does not Granger Cause ENERGY		1.43941	0.2568
GDP does not Granger Cause CO_2	29	0.89174	0.4231
CO_2 does not Granger Cause GDP		3.33254	0.0528

GDP does not Granger Cause ENERGY	30	0.36626	0.6970
ENERGY does not Granger Cause GDP		0.20509	0.8159

Table27 Singapore Johansen Co-integration Tests

Date: 05/18/14 Time: 11:04
Sample (adjusted): 1982 2010
Included observations: 29 after adjustments
Trend assumption: Linear deterministic trend
Series: CO_2 ENERGY GDP
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.416426	31.51384	29.79707	0.0314
At most 1 *	0.319726	15.89492	15.49471	0.0435
At most 2 *	0.150274	4.722403	3.841466	0.0298

Trace test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Co-integration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.416426	15.61893	21.13162	0.2479
At most 1	0.319726	11.17251	14.26460	0.1458
At most 2 *	0.150274	4.722403	3.841466	0.0298

Max-eigenvalue test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

CO_2	ENERGY	GDP
−4.84E−05	−0.212385	2.13E−11
−2.07E−05	−3.527747	−3.25E−11
7.38E−05	−0.321324	7.81E−12

Unrestricted Adjustment Coefficients (alpha):

D(CO_2)	−2234.062	86.13897	−2479.666
D(ENERGY)	−0.145947	0.136672	0.059333
D(GDP)	2.79E+09	3.10E+09	−5.28E+08

1 Cointegrating Equation(s):		Log likelihood	−1001.899
Normalized cointegrating coefficients (standard error in parentheses)			
CO_2	ENERGY	GDP	
1.000000	4387.625	−4.40E−07	
	(17410.0)	(2.0E−07)	
Adjustment coefficients (standard error in parentheses)			
D(CO_2)	0.108141		
	(0.06841)		
D(ENERGY)	7.06E−06		
	(3.3E−06)		
D(GDP)	−135011.1		
	(64691.2)		

2 Cointegrating Equation(s):		Log likelihood	−996.3131
Normalized cointegrating coefficients (standard error in parentheses)			
CO_2	ENERGY	GDP	
1.000000	0.000000	−4.93E−07	
		(1.3E−07)	
0.000000	1.000000	1.21E−11	
		(2.3E−12)	
Adjustment coefficients (standard error in parentheses)			
D(CO_2)	0.106360	170.6039	
	(0.07438)	(4994.22)	
D(ENERGY)	4.24E−06	−0.451148	
	(3.3E−06)	(0.22002)	
D(GDP)	−199141.4	−1.15E+10	
	(61942.3)	(4.2E+09)	

Table28 Singapore Granger Causality Tests

Pairwise Granger Causality Tests
Date: 05/18/14 Time: 11:06
Sample: 1980 2013
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
ENERGY does not Granger Cause CO_2	29	1.66641	0.2101
CO_2 does not Granger Cause ENERGY		1.20065	0.3184
GDP does not Granger Cause CO_2	29	3.40958	0.0497
CO_2 does not Granger Cause GDP		1.36122	0.2754
GDP does not Granger Cause ENERGY	30	3.79502	0.0364
ENERGY does not Granger Cause GDP		2.80666	0.0795

Table29 Thailand Johansen Co-integration Tests

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Date: 05/18/14 Time: 11:08
Sample (adjusted): 1982 2010
Included observations: 29 after adjustments
Trend assumption: Linear deterministic trend
Series: CO_2 ENERGY GDP
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.335546	18.14252	29.79707	0.5555
At most 1	0.194917	6.287604	15.49471	0.6615
At most 2	3.81E−06	0.000110	3.841466	0.9928

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Co-integration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.335546	11.85491	21.13162	0.5621
At most 1	0.194917	6.287493	14.26460	0.5766
At most 2	3.81E−06	0.000110	3.841466	0.9928

Max-eigenvalue test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

CO_2	ENERGY	GDP
6.37E−05	−0.331210	−1.78E−11
1.46E−06	0.092861	−2.70E−12
−1.88E−05	−0.043837	3.69E−11

Unrestricted Adjustment Coefficients (alpha):

D(CO_2)	−1869.627	725.6745	14.24760
D(ENERGY)	−0.100975	−0.889035	0.001939
D(GDP)	6.05E+09	2.41E+09	23524462

1 Cointegrating Equation(s): Log likelihood −1080.429

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP
1.000000	−5201.306	−2.80E−07

	(760.176)	(1.4E−07)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	−0.119055	
	(0.10313)	
D(ENERGY)	−6.43E−06	
	(2.9E−05)	
D(GDP)	385487.3	
	(204633.)	

2 Cointegrating Equation(s): Log likelihood −1077.285

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP
1.000000	0.000000	−3.98E−07
		(3.5E−07)
0.000000	1.000000	−2.28E−11
		(6.7E−11)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	−0.117994	686.6264	
	(0.10273)	(554.776)	
D(ENERGY)	−7.73E−06	−0.049113	
	(2.7E−05)	(0.14513)	
D(GDP)	389015.6	−1.78E+09	
	(202267.)	(1.1E+09)	

Table30 Thailand Granger Causality Tests

Pairwise Granger Causality Tests
Date: 05/18/14 Time: 11:10
Sample: 1980 2013
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
ENERGY does not Granger Cause CO_2	29	0.30748	0.7382
CO_2 does not Granger Cause ENERGY		0.37645	0.6903
GDP does not Granger Cause CO_2	29	0.28319	0.7559
CO_2 does not Granger Cause GDP		0.38338	0.6857
GDP does not Granger Cause ENERGY	30	0.05864	0.9432
ENERGY does not Granger Cause GDP		0.01199	0.9881

Table31 Vietnam Johansen Co-integration Tests

Date: 05/18/14 Time: 11:12
Sample (adjusted): 1987 2010
Included observations: 24 after adjustments
Trend assumption: Linear deterministic trend

Series: CO_2 ENERGY GDP
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.502296	30.69036	29.79707	0.0394
At most 1	0.420367	13.94439	15.49471	0.0845
At most 2	0.035028	0.855745	3.841466	0.3549

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Co-integration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.502296	16.74597	21.13162	0.1843
At most 1	0.420367	13.08865	14.26460	0.0760
At most 2	0.035028	0.855745	3.841466	0.3549

Max-eigenvalue test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

CO_2	ENERGY	GDP
0.000171	−0.327036	−1.05E−10
−8.90E−05	−0.034203	9.03E−11
−8.79E−05	0.260519	−5.43E−11

Unrestricted Adjustment Coefficients (alpha):

D(CO_2)	−434.5158	−1732.862	411.2790
D(ENERGY)	0.527463	−0.318459	0.260382
D(GDP)	2.03E+09	−3.45E+09	57706857

1 Cointegrating Equation(s): Log likelihood −828.9055

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP
1.000000	−1914.467	−6.17E−07
	(293.170)	(1.5E−07)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	−0.074225
	(0.13666)

D(ENERGY)	9.01E−05
	(6.1E−05)
D(GDP)	345948.3
	(223099.)

2 Cointegrating Equation(s): Log likelihood −822.3611

Normalized cointegrating coefficients (standard error in parentheses)

CO_2	ENERGY	GDP
1.000000	0.000000	−9.48E−07
		(1.8E−07)
0.000000	1.000000	−1.73E−10
		(1.0E−10)

Adjustment coefficients (standard error in parentheses)

D(CO_2)	0.079982	201.3718
	(0.13371)	(228.269)
D(ENERGY)	0.000118	−0.161607
	(6.8E−05)	(0.11567)
D(GDP)	652609.9	−5.44E+08
	(200233.)	(3.4E+08)

Table32 Vietnam Granger Causality Tests

Pairwise Granger Causality Tests
Date: 05/18/14 Time: 11:13
Sample: 1980 2013
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
ENERGY does not Granger Cause CO_2	29	1.19766	0.3193
CO_2 does not Granger Cause ENERGY		0.86697	0.4330
GDP does not Granger Cause CO_2	24	1.11910	0.3472
CO_2 does not Granger Cause GDP		7.03859	0.0052
GDP does not Granger Cause ENERGY	25	1.64003	0.2190
ENERGY does not Granger Cause GDP		1.43355	0.2619

5. Conclusions

This study employs time-series, Johansen co-integration, and Granger causality test to analyze the causality among economic growth, EC, and CO_2 emissions in ASEAN+6 countries for the period 1980–2013. It obtains the conclusions of causality through empirical analysis. In the pursuit of GDP of economic growth, the developing countries should emphasize on environmental protection and energy conservation; restrict the development direction of industries; encourage industries of high-tech, high value-added, high-profit, low EC, low pollution, and low resource usage; and actively improve the overall structure and continually reduce products of EC and CO_2 emissions. Based on the past experience of the advanced countries, the economy should continually grow and CO_2 emissions should be reduced. As to the worldwide pressure of CO_2 emissions reduction, it should be a help rather than a hindrance, and we regard it as the future goal for the entire country.

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