CO_2 Emissions, Energy Consumption, GDP, and Foreign Direct Investment in ANICS Countries:

Suyi Kim*

Abstract

This study examines the causal relationship between CO_2 emissions, energy consumption, output and FDI (foreign direct investment) in ANICs (Asian newly industrialized countries: Hong Kong, Republic of Korea, Singapore, Taiwan) from 1971 to 2011. The result based on VECM (Vector Error Correction Model) implied that there is a long run cointegrated relationship between CO_2 emissions, energy consumption, output and FDI. The result supports the environmental Kuznets curve hypothesis in this region. Short run dynamics show the Granger Causality from economic growth to CO_2 emissions. There is an also indirect causality from FDI (inward FDI and outward FDI) to CO_2 emissions in the short run. In the long run, there was unidirectional granger causality from the other variables to CO emissions.

Keywords: CO emissions, Energy Consumption, ANICs, FDI, VECM

JEL Classifications: Q54, Q43

1. Introduction

The ANICs (Asian Newly Industrialized Countries) called **Four Asian Tigers** or **Four Asian Dragons** is a term used in reference to the highly free-market and developed economies of Hong Kong, Singapore, South Korea, and Taiwan. These nations and areas

* College of Business Management, Hongik University, 2639 Sejong-ro, Jochiwon-eup, Sejong-si, Republic of Korea, suyikim@hongik.ac.kr

were notable for maintaining exceptionally high growth rates (in excess of 7 percent a year) and rapid industrialization between the early 1960s (mid-1950s for Hong Kong) and 1990s. By the 21st century, all four had developed into advanced and high-income economies, specializing in areas of competitive advantage. Their economic success stories have served as role models for many developing countries.

In particular, energy consumption in these countries has also increased in proportion to economic growth while these countries have achieving rapid economic growth. And this energy consumption has also causing an increase in the greenhouse gases. In addition, the foreign direct investment has also increased rapidly due to the change of world economic environment such as the collapse of the Soviet Union, China's reform and opening up policy etc. However, the research on economic growth and energy consumption for the Asian Nicks are relatively lacking. In particular, it is a question what is the associated causal relationship between energy consumption, greenhouse gas emissions and foreign direct investment in the process of achieving rapid economic growth. These causal relationships will supply great implications for other countries ahead of the future economic development.

Hence, this study analyzes the causal relationships between GHG emissions, energy consumption, economic development, and FDI in ANICs countries: Korea, Hong Kong, Singapore, and Taiwan. To our knowledge, this is the first study to explore the causal links between the four variables in these countries using VECM (Vector Error Correction Model) from 1971 to 2011. This issue is particularly important because these countries experienced high economic growth over past 40 years. Therefore, understanding the causality relationships between the variables will help policy-makers in designing the appropriate policies. The study is structured as follows: section 2 reviews the previous literature, section 3 presents the methodologies employed in this study, section 4 reports and discusses the empirical findings, and finally, section 5 concludes.

2. Literature Review

The causality relationships between CO_2 emissions, energy consumption, GDP and FDI have been a subject of debate in empirical and theoretical literature for the past twenty years. The first category of the literature focuses on the causal relationships between CO_2 emissions and economic growth. It has been investigated under the EKC that demonstrates a U-shaped relationship between economic growth and environmental pollution emissions. The pollution levels increase with national income and then decrease after a certain level of national income. A series of empirical studies have been made to verify this EKC hypothesis. Hettige et al. (1992), Cropper and Griffiths (1994), Selden and Song (1994), Grossman and Krueger (1995), Martinez-Zarzoso and Bengochea-Morancho (2004) supported this EKC hypothesis. Holtz-Eakin and Selden (1995), Shafik (1994) demonstrated that there was a linear relationship between national income and environmental pollution levels.

The second category of the literature investigates the relationships between energy consumption and economic growth. This relationship has an important implication for energy policy. (Apergis and Payne 2009a, Squalli 2007, Chen et al., 2007, Mozumder and Marathe 2007, Yoo 2005 Jumbe 2004, Shiu and Lam 2004). Ozturk (2010) categorized the causal relationship between energy consumption and economic growth into four types: neutrality hypothesis, conservative hypothesis, growth hypothesis, feedback hypothesis. Recent studies comprehensively consider the causal relationship between energy consumption and economic growth, and between greenhouse gas emissions and economic growth. Ang (2007) examined the dynamic causal relationship among CO_2 emissions, energy consumption and GDP for France and employed a cointegration and vector error correction model for the period 1960-2000, which resulted in long-run causal relationships from economic growth to energy consumption and also from economic growth to CO_2 emissions. Economic growth exerts a causal influence on the expansion of energy use and CO_2 emissions in the long run. In the short run, the causality runs from the growth of energy use to output growth. Since Ang's (2007) work, there have been several studies on the dynamic causal relationship, and the results may appear differently for the different target countries (Halicioglu 2008, Zhang and Cheng 2009, Apergis and Payne 2009b, Soytas and Sari 2009, Pao and Tsai 2010, Arouri et al. 2012). Table 1 presents an overview of comprehensive studies on the causal relationship between CO_2 emissions, energy consumption and economic growth. Halicioglu (2008) demonstrated the existence of bidirectional Granger causality between CO_2 emissions and energy consumption and of bidirectional granger causality between CO emissions and income. Zhang and Cheng (2009) indicated the existence of unidirectional Granger causality running from GDP to energy consumption and also of unidirectional Granger causality running from energy consumption to carbon emissions in the long run for China, but neither carbon emissions nor energy consumption causing economic growth. For the BRIC countries, Pao and Tsai (2010) demonstrated the existence of bidirectional strong causality between energy consumption and emissions, and between energy consumption and output in the long run, along with unidirectional short run causalities from emissions and energy consumption, respectively, to output. For 12 Middle East and North African Countries (MENA), Arouri et al. (2012) demonstrated the existence of short run causality from energy consumption to CO_2 emissions and also from GDP to CO_2 emissions. Salahuddin (2015) investigated the relationship between carbon dioxide emissions, economic growth, electricity consumption and financial development in the Gulf Cooperation Council (GCC) countries. Shahbaz et al. (2014) explored the relationship between economic growth, electricity consumption, and environmental degradation in case of United Arab Emirates (UAE).

Table 1. Overview of comprehensive studies on the causal relationship among CO_2 emissions, economic growth, energy consumption

Authors	Period	Country	Methodology	Causality relationship
Ang (2007)	1960-2000	France	Cointegration, Vector Error Correction Model	GDP→EC (long run) GDP→CO_2 (long run) EC→GDP (short run)
Halicioglu (2008)	1960-2005	Turkey	Cointegration Granger Causality ARDL	CO_2 ↔ EC CO_2 ↔ GDP
Zhang and Cheng (2009)	1960-2007	China	Granger Causality	GDP → EC EC → CO_2
Apergis and Payne (2009b)	1971-2004	7 Central America (Costa Rica, El Salvador, Guatemala, Honduras, Panama)	Panel Vector Error Correction Model	EC → CO_2 (short run) GDP → CO_2 (short run) EC ↔ GDP (short run) EC ↔ CO_2 (long run)
Soytas and Sari (2009)	1960-2000	Turkey	Granger Causality	CO_2 → EC
Pao and Tsai (2010)	1971-2005	BRIC countries (Brazil, China,	Panel Cointegration Granger Causality Panel VECM	CO_2 ↔ EC (long run) GDP ↔ EC (long run) EC → GDP (short run)

		India, Russia)		$CO_2 \rightarrow GDP$ (short run)
Arouri et al.(2012)	1981-2005	12 Middle East and North African Countries (MENA)	Bootstrap panel unit root tests, Cointegration	$GDP \rightarrow CO_2$ (short run) $EC \rightarrow CO_2$ (short run)

The last category of the literature investigates the relationships between CO_2 emissions, energy consumption, GDP and FDI, comprehensively. The impact of FDI (foreign direct investment) on the host country's environment has also been a subject of debate. Two conflicting hypotheses have been presented in previous studies: the pollution haven hypothesis and the halo effect hypothesis. According to the halo effect hypothesis, the presence of foreign investors will spur positive environmental spill-overs to the host country because MNCs (multinational companies) have more advanced technology than their domestic counter parts and will tend to disseminate cleaner technology that will be less harmful to the environment. In contrast, the pollution haven hypothesis postulates that MNCs will flock more into countries where environmental regulations are less strict. This strategy might h arm the environment in the host country if the issue is not taken seri-ously. The results are both theoretically and empirically mixed.

Merican et al.(2007) investigate the causal link between FDI and pollution by employing the ARDL model approach. According to the results, FDI increases emissions in Malaysia, Thailand, and the Philippines, while there seems to be an inverse relationship between the variables in Indonesia. Hoffmann et al.(2005) find one way causality running from FDI to CO2 emissions. Pao and Tsai (2001) examine the causal links between CO2 emissions, energy consumption, FDI, and GDP in the BRIC (Brazil, Russia, India and China) countries, using a multi variate Granger causality approach. According to the results, there is bi-directional causality between emissions and FDI, and a one-way causality running from output to FDI.

3. Empirical Models

Following Kivyiro and Arminen (2014), the long run relationship between CO_2 emissions, energy consumption, output and FDI (Foreign Direct Investment) is modeled as indicated by Equation (1) below. According to the EKC(Environment Kuznets Curve) hypothesis, there is inverted U shaped relationship between environmental pollution and output. We can apply this relationship between CO_2 emissions and GDP which can be captured mathematically by including the squared value of GDP per capita in the set of regressors.

$$CO_{2,\mathrm{it}}=\alpha_0+\alpha_1 EN_{\mathrm{it}}+\alpha_2 FDI_{it}+\alpha_3 Y_{it}+\alpha_4 Y_{it}^2+V_i+\epsilon_{\mathrm{it}} \quad (1)$$

Where $\mathrm{i}(\mathrm{i}=1,2,\ldots,\mathrm{N})$ denotes countries and $\mathrm{t}\,(\mathrm{t}=1,2,\ldots,\mathrm{T})$ denotes the period. CO denotes the CO_2 emissions per capita, EN denotes for energy consumption per capita, FDI denotes Foreign Direct Investment (hereafter, IFDI denotes inward FDI, OFDI denotes outward FDI). Y denotes GDP per capita, and Y^2 denotes GDP per capita squared. All the variables are in their natural logarithmic form. Individual fixed country effects are denoted by V, and ϵ denotes the stochastic error term.

This paper uses panel cointegration techniques to investigate the relationship. Panel estimation techniques are attractive because models estimated from cross-sections of time series have more degrees of freedom and efficiency than models estimated from individual time series. This is particularly useful if the time series dimension of each cross-section is short. Panel cointegration techniques have recently been used by a number of authors to investigate the relationship between energy consumption and output (e.g. Apergis and Payne, 2009, 2010; Chen et al., 2007; Lee, 2005; Lee and Chang, 2008; Lee et al., 2008; Mahadevan and Asafu-Adjaye, 2007; Mehrara, 2007; Narayan and Smyth, 2008, 2009; Narayan et al., 2007; Sadorsky, 2009a, 2009b, 2011).

First, we tests whether these time series have unit roots. If so, I use panel cointegration techniques to investigate the relationship between energy consumption and trade. Panel cointegration tests have recently been used by a number of authors to investigate the relationship between energy consumption and output (Apergis and Payne, 2009, 2010; Chen et al., 2007; Lee, 2005; Lee and Chang, 2008; Lee et al., 2008; Mahadevan and Asafu-Adjaye, 2007; Mehhara, 2007; Narayan and Smyth, 2008, 2009; Narayan et al., 2007; Sadorsky, 2009a, 2009b, 2011, 2012).

If the time series are I (1) and these variables are cointegrated, a panel vector error correction model (VECM) can be used to estimate causality, as in Engel and Granger (1987). Finding cointegration between groups of variables is very important because it ensures that an error correction mechanism exists according to which changes in the dependent variable are modeled as a function of the level of the equilibrium in the cointegration relationship and changes in other explanatory variables. Eq. 1 can be written as the following VECM model.

$$\Delta CO_{it} = c_{1i} + \sum_{j=1}^{q} \gamma_{11ij}\Delta CO_{it-j} + \sum_{j=1}^{q} \gamma_{12ij}\Delta EN_{it-j} + \sum_{j=1}^{q} \gamma_{13ij}\Delta FDI_{it-j}$$

$$+ \sum_{j=1}^{q} \gamma_{14ij}\Delta Y_{it-j} + \sum_{j=1}^{q} \gamma_{15ij}\Delta Y^{2}{}_{it-j} + \gamma_{16i}\varepsilon_{1t-1} + v_{1it}$$

$$\Delta EN_{it} = c_{2i} + \sum_{j=1}^{q} \gamma_{21ij}\Delta CO_{it-j} + \sum_{j=1}^{q} \gamma_{22ij}\Delta EN_{it-j} + \sum_{j=1}^{q} \gamma_{23ij}\Delta FDI_{it-j}$$

$$+ \sum_{j=1}^{q} \gamma_{24ij}\Delta Y_{it-j} + \sum_{j=1}^{q} \gamma_{25ij}\Delta Y^{2}{}_{it-j} + \gamma_{26i}\varepsilon_{1t-1} + v_{2it}$$

$$\Delta FDI_{it} = c_{3i} + \sum_{j=1}^{q} \gamma_{31ij}\Delta CO_{it-j} + \sum_{j=1}^{q} \gamma_{32ij}\Delta EN_{it-j} + \sum_{j=1}^{q} \gamma_{33ij}\Delta FDI_{it-j}$$

$$+ \sum_{j=1}^{q} \gamma_{34ij}\Delta Y_{it-j} + \sum_{j=1}^{q} \gamma_{35ij}\Delta Y^{2}{}_{it-j} + \gamma_{36i}\varepsilon_{1t-1} + v_{3it}$$

$$\Delta Y_{it} = c_{4i} + \sum_{j=1}^{q} \gamma_{41ij}\Delta CO_{it-j} + \sum_{j=1}^{q} \gamma_{42ij}\Delta EN_{it-j} + \sum_{j=1}^{q} \gamma_{43ij}\Delta FDI_{it-j}$$

$$+ \sum_{j=1}^{q} \gamma_{44ij}\Delta Y_{it-j} + \sum_{j=1}^{q} \gamma_{45ij}\Delta Y^{2}{}_{it-j} + \gamma_{46i}\varepsilon_{1t-1} + v_{4it}$$

$$\Delta Y^{2}{}_{it} = c_{5i} + \sum_{j=1}^{q} \gamma_{51ij}\Delta CO_{it-j} + \sum_{j=1}^{q} \gamma_{52ij}\Delta EN_{it-j} + \sum_{j=1}^{q} \gamma_{53ij}\Delta FDI_{it-j}$$

$$+ \sum_{j=1}^{q} \gamma_{54ij}\Delta Y_{it-j} + \sum_{j=1}^{q} \gamma_{55ij}\Delta Y^{2}{}_{it-j} + \gamma_{56i}\varepsilon_{1t-1} + v_{5it}$$

(2)

Where Δ is the first difference operator, q is the lag length, Y is the natural log of real output, FDI is the natural log of foreign Direct Investment, CO is the natural log of the CO_2 emissions, EN is the natural log of energy consumption, ε is the error correction term, and v

is the random error term. The VECM is estimated using a seemingly unrelated regression (SUR) technique that allow for cross-sectional specific coefficient vectors and cross-sectional correlations in the residuals.

4. Data

The Asian Newly Industrialized Countries are Hong Kong, Korea (i.e., Republic of Korea), Singapore, and Taiwan. The data used are the annual time series data covering from 1971 to 2011. CO2 emissions per capita (measured in kg of oil equivalent per capita), energy consumption per capita (in metric tons per capita) and GDP per capita (constant 2005 US dollars) of Hong Kong, Korea (i.e., Republic of Korea), Singapore are taken from the World Bank (2015), World Development Indicators online database. The FDI series (in percentage of gross fixed capital) for all countries are taken from the UNCTAD (United Nations Conference on Trade and Development). The data on CO2 emissions, energy consumption and GDP of Taiwan is from the "Indicators for CO2 emissions from fuel combustion". Table 2 shows descriptive statistics of the actual variables used in this analysis, for each country.

Table 2. Descriptive statistics (before data transformation), 1971-2011

	CO_2		EN		Y	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Hong Kong	4.068	1.265	1527.415	498.267	17706.930	7843.877
Singapore	11.395	3.918	3747.677	1662.486	18262.360	9158.456
Korea	6.431	3.148	2544.210	1547.505	10470.000	6606.025
Taiwan	6.675	3.369	2654.244	1358.344	9469.980	5444.583
	IFDI		OFDI			
	Mean	S.D.	Mean	S.D.		
Hong Kong	42.070	45.775	42.663	50.414		
Singapore	39.561	29.144	18.156	22.819		
Korea	2.468	3.285	2.057	2.231		
Taiwan	2.529	1.862	4.864	4.773		

Time series plots of the natural logs of CO_2 emissions per capita for each of the countries are shown in Fig. 1. The CO_2 emissions per capita of Hong Kong Singapore have been increasing until middle of 1990's but have been decreased and fluctuating since that. The CO_2

emissions per capita of Korea and Taiwan have been steadily increased over time but the growth rate decreased in recent years.

Time series plots of the natural logs of energy consumption per capita for each of the countries are shown in Fig. 2. Energy consumption per capita has been increasing over time, although the strength of this trend varies by country. Energy consumption per capita in Korea, and Taiwan has increased steadily over time whereas that in Singapore and Hong Kong has been fluctuating since the mid-1990s.

Fig. 3 shows time series plots of natural logs of the real GDP per capita for each country, and overall, GDP has been increasing over time. In the case of Hong Kong, Japan, Korea, and Singapore, the GDPs dropped temporarily in the mid-1990s because of the Asian financial crisis and once again temporarily at the end of the 2000s by the global financial crisis. However, overall GDP has shown an increasing trend.

The time series plots of the natural logs of Inward FDI measured in percentage of gross fixed capital formation for each country are shown in Fig. 4. Despite that it has been fluctuating over times by the economic conditions, the trends have been generally upward sloping. It is largest in Hong Kong and followed by Singapore in recent years. The percentage of inward FDI is relatively small in Korea and Taiwan. The time series plots of the natural logs of Outward FDI measured in percentage of gross fixed capital formation for each country are shown in Fig. 5. The trend has been generally upward sloping.

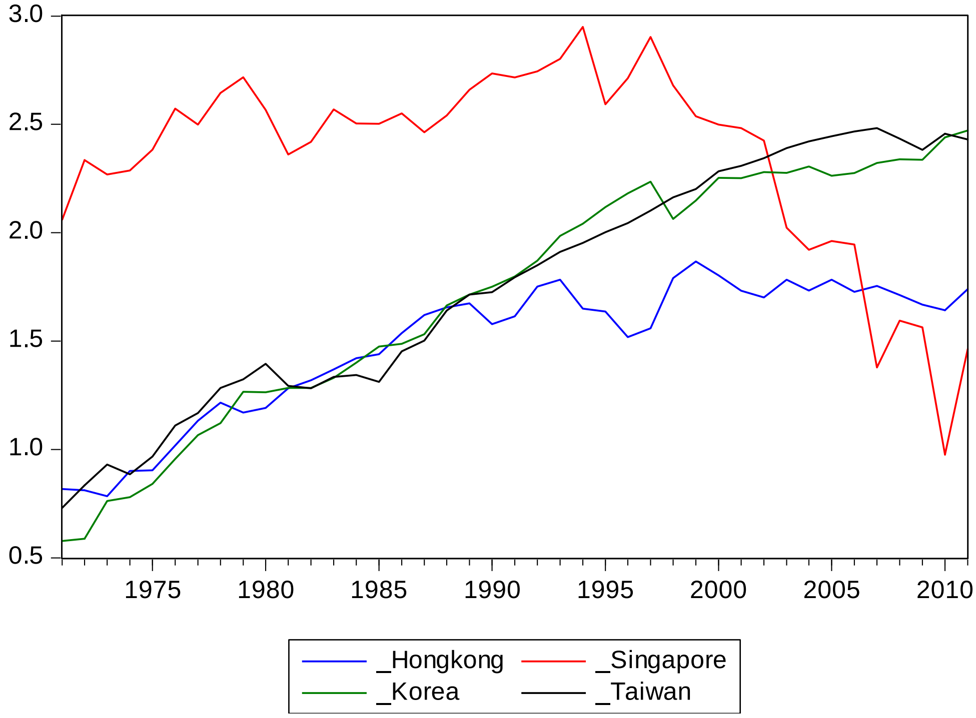

Fig. 1. Natural Log of CO2 emissions per capita (metric tons per capita)

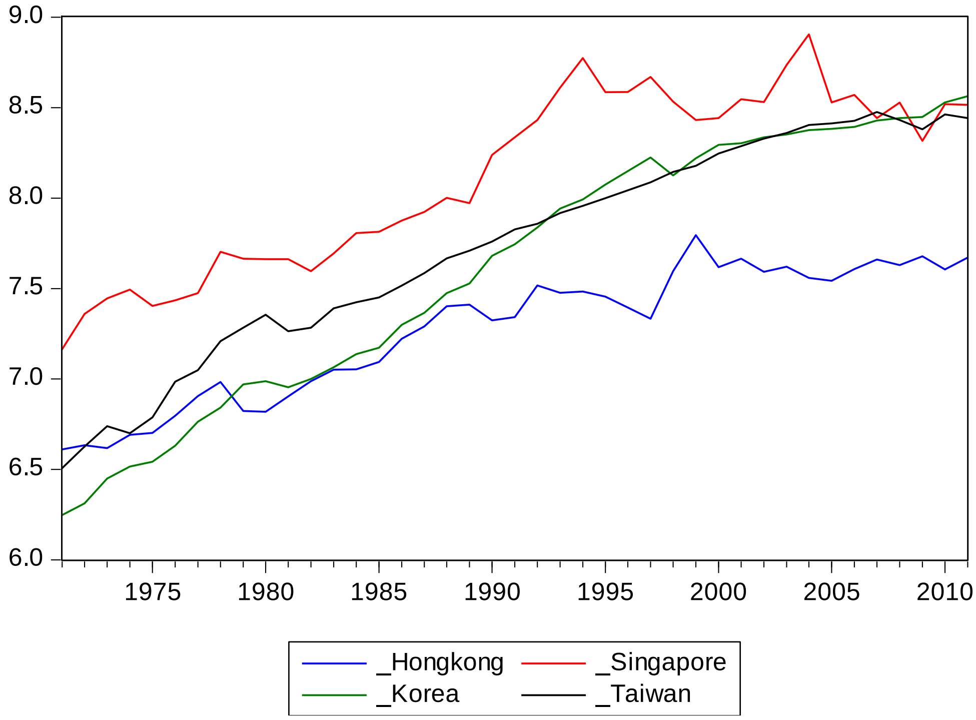

Fig. 2. Natural Log of Energy consumption per capita (kg of oil equivalent)

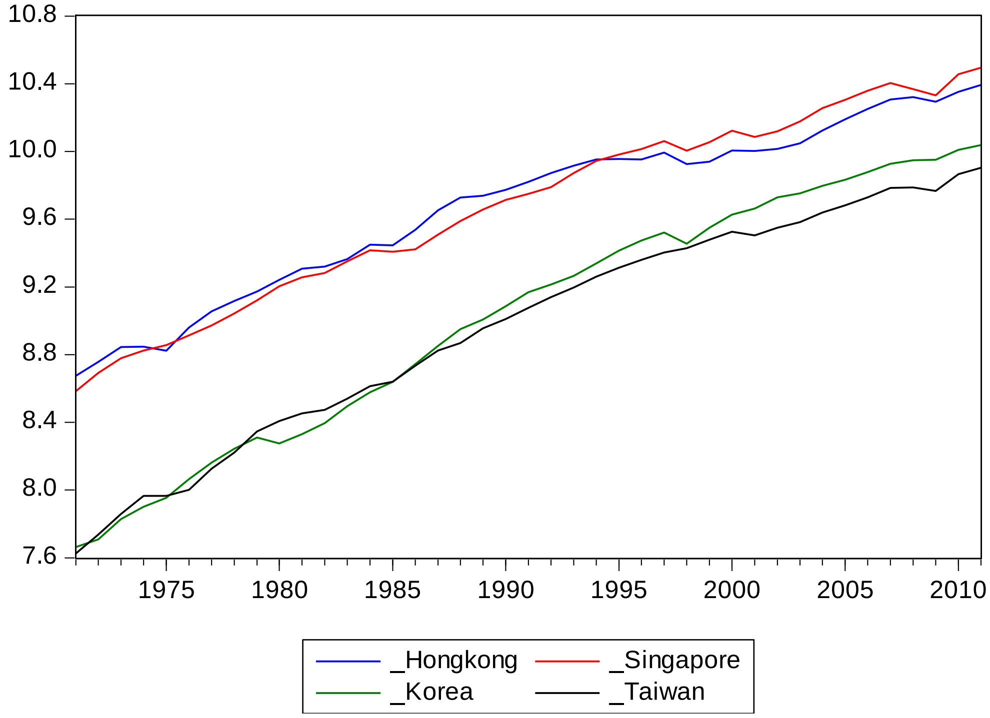

Fig. 3. Natural Log of GDP per capita (constant 2005 US dollars).

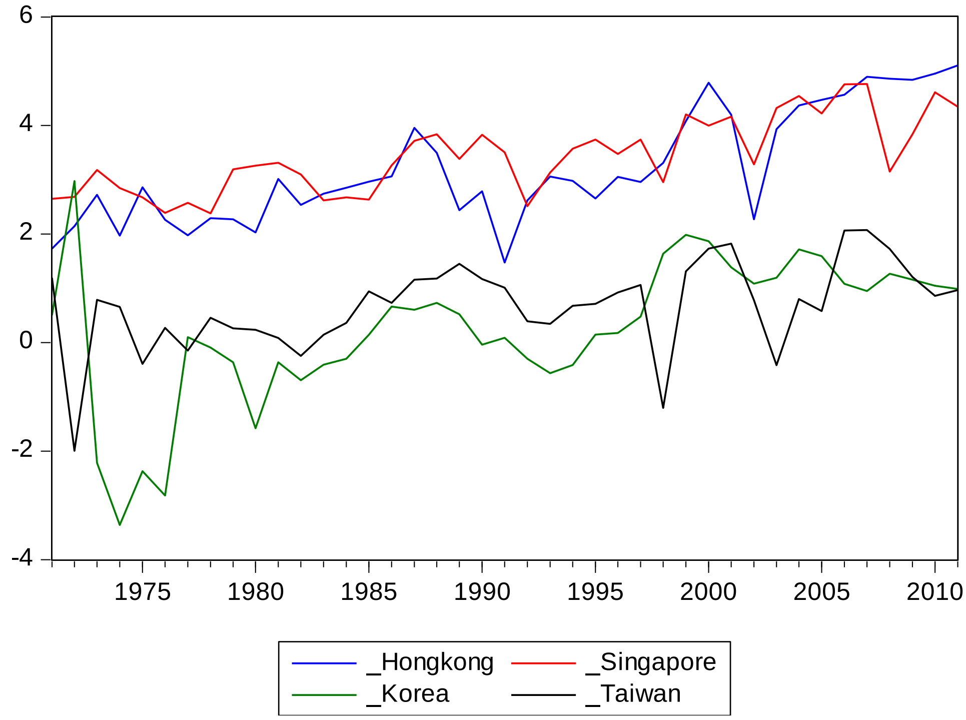

Fig. 4. Natural Log of Inward FDI (percentage of gross fixed capital formation)

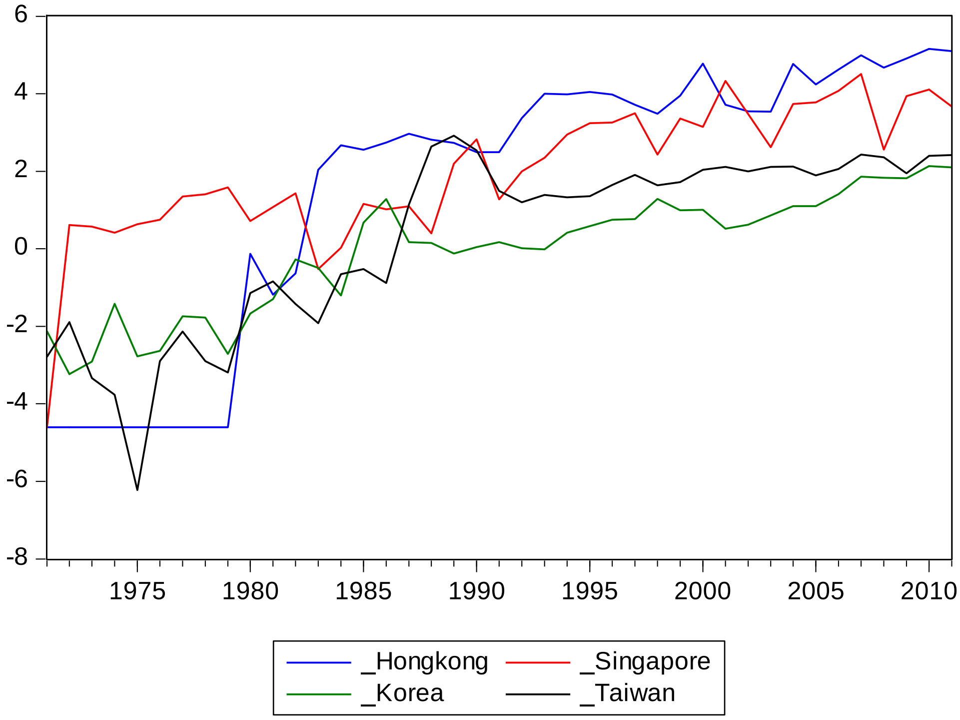

Fig. 5. Natural Log of Outward FDI (percentage of gross fixed capital formation)

Table 3. Correlations for the panel data set (variables in natural log), 1971-2011

	CO_2	EN	Y	IFDI	OFDI
CO_2	1				
EN	0.810163	1			
Y	0.579752	0.75678	1		
IFDI	0.325305	0.33164	0.697433	1	
OFDI	0.544538	0.659935	0.824931	0.574287	1

Table 3 shows the correlations among the panel data variables in natural log. Most of correlations are positive. The natural of CO_2 emissions is highly correlated with the natural log of energy consumption, followed respectively by correlations with the natural log of GDP, outward FDI, inward FDI. The natural log of CO_2 emissions is more highly correlated with the natural of outward FDI than with that of inward FDI. The natural log of GDP is highly correlated with the natural log of outward FDI, followed by that of inward FDI, energy consumption and CO_2 emissions.

4. Empirical Findings

4.1 Unit root tests

In this paper, we conducted four types of panel unit root tests that assume cross-sectional independence (Levin et al., 2002; Im et al., 2003; Dickey and Fuller, 1979; Phillips and Perron, 1988). For these tests, the null hypothesis is that there is a unit root while the alternative hypothesis is that there is no unit root. The result of these tests is that for each series in levels, the null hypothesis cannot be rejected at the 5% level. According to Table 4, in case of Inward FDI (IFDI), the ADF and PP tests indicate that we can reject the null hypothesis at the 5% level. For each series in the first differences, the null hypothesis that there is no unit root can be rejected at the 1% level.

Table 4. Panel unit root tests

Method	CO		ΔCO		EN		ΔEN		Y		ΔY	
	statistic	prob.	Statistic	prob.	Statistic	prob.	Statistic	prob.	Statistic	prob.	Statistic	prob.
Null: Unit root (assumes common unit root process)												
Levin, Lin & Chu t*	-0.05	0.48	-5.31	0.00	0.71	0.76	-7.67	0.00	-0.79	0.21	-7.74	0.00
Null: Unit root (assumes individual unit root process)												
Im, Pesaran and Shin W-stat	2.03	0.98	-7.62	0.00	2.13	0.98	-6.72	0.00	1.93	0.97	-6.91	0.00
ADF – Fisher Chi-square	1.84	0.99	66.66	0.00	2.11	0.98	57.41	0.00	1.70	0.99	59.24	0.00
PP – Fisher Chi-square	1.35	0.99	95.89	0.00	1.93	0.98	101.05	0.00	2.36	0.97	74.64	0.00

Method	Y^2		ΔY^2		IFDI		ΔIFDI		OFDI		ΔOFDI	
	statistic	prob.	Statistic	prob.	Statistic	prob.	Statistic	prob.	Statistic	prob.	Statistic	prob.
Null: Unit root (assumes common unit root process)												
Levin, Lin & Chu t*	-0.38	0.35	-8.00	0.00	-0.20	0.42	-12.46	0.00	-1.48	0.07	-8.78	0.00
Null: Unit root (assumes individual unit root process)												
Im, Pesaran and Shin W-stat	1.74	0.96	-7.41	0.00	-	-	-	-	-0.07	0.47	-11.98	0.00
ADF – Fisher Chi-square	2.20	0.97	64.39	0.00	17.56	0.02	148.10	0.00	5.75	0.68	109.29	0.00
PP – Fisher Chi-square	2.61	0.96	81.78	0.00	24.76	0.00	660.45	0.00	16.71	0.03	121.74	0.00

Notes: 1) the test equations in the level series include the constant and the linear trend components except IFDI series where neither constant nor trend componets. 2) In the first difference series, the test equations include only the constant terms. 3) Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

4.2 Cointegration tests

We tested whether these I (1) variables are cointegrated using the tests of Pedroni (1999, 2004). The Pedroni panel cointegration tests are to test the residuals from the following equation for the unit root variables.

$$\hat{\varepsilon}_{it} = \rho_i \hat{\varepsilon}_{it-1} + \delta_{it}$$

In total, Pedroni (1999, 2004) provides seven statistics for tests of the null hypothesis of no cointegration in heterogeneous panels. These tests can be classified as either within-dimension (panel tests) or between-dimension (group tests). For the within-dimension approach, the null of no cointegration ($\rho_i = 1$ for all i) is tested against the alternative of ($\rho_i < 1$ for all i). The group means approach is less restrictive because it does not require a common value of ρ under the alternative hypothesis ($\rho_i < 1$ for all i).

According to table 5, the cointegration test results for a model with inward FDI are mixed. Five of the within-dimension statistics indicate cointegration at the 5% level, and one of them indicates cointegration at the 10% level. In the between-dimension case, one of the statistics indicates cointegration at the 1% level and one of them indicates cointegration at the 10% level. According to table 6, the results for the model with outward FDI are also mixed. Four of the within-dimension statistics indicate cointegration at the 1% level and one of them indicates cointegration at the 5% level. In the between-dimension case, one of the statistics indicates cointegration at the 1% level and one of them indicates cointegration at the 10% level.

Table 5. Panel cointegration tests for a model with inward FDI

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	3.793***	0.000	1.633*	0.051
Panel rho-Statistic	-2.294**	0.011	-0.915	0.180

	Statistic	Prob.	Weighted Statistic	Prob.
Panel PP-Statistic	-3.590***	0.000	-2.148**	0.016
Panel ADF-Statistic	-3.021***	0.001	-1.120	0.131
Alternative hypothesis: individual AR coefs. (between-dimension)				
	Statistic			Prob.
Group rho-Statistic	-0.565			0.286
Group PP-Statistic	-2.374***			0.009
Group ADF-Statistic	-1.384*			0.083

Null Hypothesis: No cointegration
Trend assumption: Deterministic intercept and Trend
Automatic lag length selection based on SIC with a max lag of 5
Newey-West automatic bandwidth selection and Bartlett kernel

Table 6. Panel cointegration tests for model with outward FDI

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	4.165***	0.000	1.579*	0.057
Panel rho-Statistic	-2.614***	0.005	-0.868	0.193
Panel PP-Statistic	-4.132***	0.000	-2.065**	0.020
Panel ADF-Statistic	-3.299***	0.001	-1.062	0.144
Alternative hypothesis: individual AR coefs. (between-dimension)				
	Statistic			Prob.
Group rho-Statistic	-0.576			0.282
Group PP-Statistic	-2.460***			0.007
Group ADF-Statistic	-1.411*			0.079

Null Hypothesis: No cointegration
Trend assumption: Deterministic intercept and Trend
Automatic lag length selection based on SIC with a max lag of 5
Newey-West automatic bandwidth selection and Bartlett kernel

4.3 VECM Tests

4.3.1 Short run dynamics

Short-run dynamics for equations with exports are estimated by Engle and Granger (1987). The vector auto regression lag length q is set at 2 which was determined using SC

(Schwarz Information Criterion) and HQ (Hannan-Quinn Information Criterion). The results of the short-run Granger causality test are shown in Tables 7 and 8.

The main interest of this paper is a feedback relationship among CO_2 emissions, GDP, energy consumption, and foreign direct investment (inward FDI and outward FDI). Table 7 shows short-run granger causality results for VECM with inward FDI. According to Table 4, there is some evidence of short-run causality from GDP to CO_2 emissions at the 5% significance level, from inward FDI to GDP at the 1% significance level. In addition, there is short-run causality from CO_2 emissions to energy consumption at the 1% significance level but there is no short-run direct causality from inward FDI to CO_2 emissions. However, we can conclude that there is short run causality indirectly from inward FDI to CO_2 emissions (Inward FDI cause GDP and GDP cause CO_2 emissions). The error correction term is significant at the 1% level in the first equation of equation (2). Therefore, there is long-run causality from energy consumption, GDP, inward FDI to CO_2 emissions.

Table 8 shows short-run granger causality results for VECM with outward FDI. According to Table 5, there is some evidence of short-run causality from GDP to CO_2 emissions at the 10% significance level, from outward FDI to GDP at the 1% significance level. In addition, there is short-run causality from CO_2 emissions to energy consumption at the 1% significance level but there is no short-run direct causality from outward FDI to CO_2 emissions. However, we can conclude that there is short run causality indirectly from outward FDI to CO_2 emissions (outward FDI causes GDP and GDP causes CO_2 emissions). The error correction term is significant at the 1% level in the first equation of equation (2). Therefore, there is long-run causality from energy consumption, GDP, outward FDI to CO_2 emissions.

Table 7. Short-run Granger causality results for VECM with inward FDI.

From	To				
	ΔCO	ΔEN	ΔIFDI	ΔY	ΔY^2
ΔCO		9.02***	3.90	0.87	1.13
		(0.01)	(0.15)	(0.65)	(0.56)
ΔEN	3.69		0.03	0.74	0.60
	(0.15)		(0.98)	(0.69)	(0.74)
ΔIFDI	1.38	0.91		7.02***	6.18**
	(0.50)	(0.63)		(0.03)	(0.05)
ΔY	5.72*	0.05	1.22		0.96
	(0.06)	(0.97)	(0.54)		(0.61)
ΔY^2	(6.27)**	0.12	1.37	1.18	
	(0.04)	(0.94)	(0.50)	(0.55)	

ε_{1t-1}	13.4*** (<0.01)	1.18 (0.27)	0.05 (0.82)	4.32** (0.04)	1.73 (0.19)

The table reports chi-sq statistics with p values in parenthesis.
The chi-sq tests for short-run Granger causality have 2 degrees of freedom.
The system of equation is estimated using OLS with SUR technique.
*: means 10% significance level, ** means 5% significance level, *** means 1% significance level.

Table 8. Short-run ranger causality results for VECM with outward FDI.

From	To				
	ΔCO	ΔEN	ΔOFDI	ΔY	ΔY^2
ΔCO		9.89*** (<0.01)	3.59 (0.16)	1.19 (0.38)	2.18 (0.33)
ΔEN	3.68 (0.16)		0.27 (0.87)	0.67 (0.71)	0.53 (0.76)
ΔIFDI	0.79 (0.67)	0.83 (0.65)		1.49 (0.47)	1.69 (0.43)
ΔY	4.18 (0.12)	0.003 (0.99)	6.49*** (0.04)		0.39 (0.82)
ΔY^2	4.67* (0.09)	0.03 (0.98)	6.19 (0.04)	0.49 (0.78)	
ε_{1t-1}	10.70*** (<0.01)	1.30 (0.25)	5.95*** (0.01)	1.56 (0.21)	4.00*** (0.05)

The table reports chi-sq statistics with p values in parenthesis.
The chi-sq tests for short-run Granger causality have 2 degrees of freedom.
The system of equation is estimated using OLS with SUR technique.
*: means 10% significance level, ** means 5% significance level, *** means 1% significance level.

4.4.2 Long-run equilibrium

Long-run output elasticities are estimated using ordinary least squares (OLS), or fully modified OLS (FMOLS; Pedroni, 2001). The estimated coefficients are elasticities because the variables are measured in natural logarithms. The equations with inward FDI shown in Table 9 tell the following facts. According to the results of FMOLS, the long-run elasticity of GDP to CO2 emissions is 6.113, which means that a 1% increase in output increases CO_2 emissions by 6.1% and the long-run elasticity of energy consumption to CO2 emissions is 0.846, which means that a 1% increase in energy consumption increases CO_2 emissions by 0.85%, respectively. 1% increase in inward FDI increases CO_2 emissions by 0.029% which is not statistically significant. Furthermore, we can find EKC hypothesis respectively. In the long run, economic growth and energy use had a major role in the increase in CO_2 emissions.

Table 9. Long-run equilibrium for equations

	Equations with inward FDI		Equations with outward FDI	
	OLS	FMOLS	OLS	FMOLS
EN	0.791***(0.179)	0.846***(0.325)	0.967***(0.173)	1.145***(0.308)
IFDI	0.014(0.027)	0.029(0.049)		
OFDI			0.065***(0.014)	0.079***(0.026)
Y	5.830***(0.846)	6.113***(1.604)	5.698***(0.786)	5.688***(1.480)
Y^2	-0.329***(0.042)	-0.348***(0.080)	-0.340***(0.039)	-0.351***(0.074)
R^2	0.808	0.799	0.831	0.822
Fixed Effects F value	9.481***		22.963***	

*: means 10% significance level, ** means 5% significance level, *** means 1% significance level.

The equations with outward FDI shown in Table 9 tell the following facts. According to the results of FMOLS, the long-run elasticity of GDP to CO2 emissions is 5.688, which means that a 1% increase in output increases CO_2 emissions by 5.7% and the long-run elasticity of energy consumption to CO2 emissions is 1.145, which means that a 1% increase in energy consumption increases CO_2 emissions by 1.15%, respectively. 1% increase in outward FDI increases CO_2 emissions by 0.079% which is significant in 1% level. Furthermore, we can also find EKC hypothesis in this equation. In the long run, economic growth and energy use had a major role in the increase in CO_2 emissions and outward FDI also contributed in the increase in CO_2 emissions.

5. Conclusion and Policy Implications

In the previous section, the short-run causality and long-run equilibrium for ANICs countries were analyzed. First, there is some evidence of direct short-run causality from GDP to CO_2 emissions and indirect evidence from inward FDI to CO_2 emissions. There is also indirect short-run causality from outward FDI. However, the effect of inward FDI on CO_2 emissions was not statistically significant in the long run. It means that inward FDI did not contributed on the increase of CO emission in ANICs countries for the last four decades. On the other hand, the effect of outward FDI on CO_2 emissions was statistically significant and has positive coefficients in the long run. It means that outward FDI did not contribute on the increase of CO_2 emission in this region. It supports the claim that the purpose of outward FDI of this region was not for the pollution haven and for securing competitiveness. ANICS countries does not have greenhouse gas reduction obligation in Kyoto protocol. According to the Copenhagen Accord which was adopted at the 15th session of the Conferences of Parties

(COP 15) in Copenhagen, December 2009, the countries to pledge a reduction in their GHG emissions levels voluntarily. Therefore, foreign Direct Investment in the region is expected to have an impact on greenhouse gas emissions. Second, in the long-run equilibrium, CO_2 emissions have been increased by the economic growth and energy consumption, but the long run results supported environmental Kuznets Curve hypothesis respectively. Therefore, there will be a possibility of green growth which bring greenhouse gas mitigation and economic growth at the same in this region.

References

Albornoz F, M. A. Cole, R. J. Elliott, M. G. Ercolani, (2009) "In search of environmental spillovers". *World Economy* 32, 136-63.

Ang, J. B. (2007), "CO_2 emissions, energy consumption, and output in France," *Energy Policy*, 35, 4772-4778.

Apergis, N. and J. E. Payne, (2009a), "Energy Consumption and economic growth in Central America: evidence from a panel cointegration and error correction model," *Energy Economics*, 31, 211-216.

Apergis, N. and J. E. Payne, (2009b), "CO emissions, energy usage, and output in Central America," Energy Policy, 37, 3282-3286.

Asafudjaye, J. (2000), "The relationship between energy consumption, energy prices and economic growth: time series evidence from Asian developing countries," *Energy Economics,* 22, 615–625.

Arouri, M, E, H., A. B. Youssef, H. M'henni, C. Rault, (2012), "Energy Consumption, Economic Growth and CO emissions in Middle East and North African Countries," Institute for the Study of labor Discussion Paper Series IZA DP No. 6412.

Chen, S-T., H-I. Kou, C-C. Chen, (2007), "The relationship between GDP and electricity consumption in 10 Asian Countries," *Energy Policy,* 35, 2611-2621.

Cheng, B. S., T. W. Lai, (1997), "An investigation of co-integration and causality between energy consumption and economic activity in Taiwan," *Energy Economic*s, 19, 435–444.

Cheung, Y-W., K. S. Lai, (1993), "Finite-sample sizes of Johansen's likelihood ratio tests for cointegration," *Oxford Bulletin of Economics and Statistics,* 55, 313–328.

Cole M.A, R J. Elliott, (2005) "FDI and the capital intensity of "dirty" sectors: a missing piece of the pollution haven puzzle”. *Review of Development Economics* 2005, 9, 530-48.

Cole M. A, R. JR. Elliott, P. G. Fredriksson, (2006) “Endogenous pollution havens: does FDI influence environmental regulations?” *Scandinavian Journal of Economics*, 108, 157-78.

Cropper, M., C. Griffiths, (1994), “The interaction of population growth and environmental quality,” *American Economic Review,* 84, 250–254.

Elliott, G., R. Thomas, S. James, (1996), “Efficient tests for an autoregressive unit root,” *Econometrica,* 64, 813–836.

Engle, R. F., C. W. J. Granger, (1987), “Cointegration and error correction: representation, estimation, and testing,” *Econometrica,* 55, 251–276.

Glasure, Y. U., A. R. Lee, (1997), “Cointegration, error-correction, and the relationship between GDP and energy: the case of South Korea and Singapore,” *Resource and Energy Economics,* 20, 17–25.

Görg H, E. Strobl, (2005) “Spillovers from foreign firms through worker mobility: an empirical investigation”. *Scandinavian Journal of Economics*, 107, 693-709.

Goldenman G., (1988) “The environmental implications of foreign direct investment: policy and institutional issues”, OECD Paper. CCNM/EMEF/EPOC/CIME. vol.3.

Grossman, G. M., A. B. Krueger, (1995), “Economic growth and the environment,” *Quarterly Journal of Economics,* 110, 353–377.

Halicioglu, F. (2008), “An econometric study of CO emissions, energy consumption, income and foreign trade in Turkey,” *Munich Personal RePEc Arcfhive Paper* No. 11457.

Hettige, H., R. E. B. Lucas, D. Wheeler, (1992), “The toxic intensity of industrial production: global patterns, trends, and trade policy,” *American Economic Review,* 82, 478–481.

Holtz-Eakin, D., T. M. Selden, (1995), “Stoking the fires? CO2 emissions and economic growth,” *Journal of Public Economics,* 57, 85–101.

Hoffmann R, C. G. Lee, B. Ramasamy, M. Yeung, (2005) “FDI and pollution: a Granger causality test using panel data”. *Journal of International Development*, 17, 311-7.

Johansen, S. (1988), “Statistical analysis of cointegration vectors,” *Journal of Economic Dynamics and Control,* 12, 231–254.

Kivyiro P., H. Arminen, (2014) “Carbon Dioxide emissions, energy consumption, economic growth and foreign direct investment: Causality analysis for Sub-Saharan Africa”. *Energy* 74, 595-606.

Martinez-Zarzoso, I., A. Bengochea-Morancho, (2004), “Pooled mean group estimation of an environmental Kuznets curve for CO2,” *Economics Letters,* 82, 121–126.

Masih, A. M. M., R. Masih, (1996), “Energy consumption, real income and temporal causality: results from a multi-country study based on cointegration and error-correction modelling techniques,” *Energy Economics,* 18, 165–183.

Masih, A. M. M., R. Masih, (1997), “On temporal causal relationship between energy consumption, real income and prices; some new evidence from Asian energy dependent NICs based on a multivariate cointegration/vector error correction approach,” *Journal of Policy Modeling*, 19, 417-440.

Merican Y, Z. Yusop, Z. MohdNoor, S. H. Law, (2007) “Foreign direct investment and the pollution in Five ASEAN Nations”. *International Journal of Economics and Management* 1, 245-61.

Mozumder, P., A. Marathe, (2007), “Causality relationship between electricity consumption and GDP in Bangladesh,” *Energy Policy,* 35, 395-402.

Narayan P. (2005) “The saving and investment nexus for China: evidence from cointegration tests”. Applied Economics 37, 1979-90.

OECD (Organization for Economic Cooperation and Development), Indicators for CO2 emissions from fuel combustion Accessed at: http://www.oecd.org/data

Ozturk, I. (2010), “A literature survey on energy-growth nexus,” *Energy Policy*, 38, 340-349.

Pao, H-T., C-M. Tsai, (2010), “CO emissions, energy consumption and economic growth in BRIC countries,” *Energy Policy,* 38, 7850-7860.

Pao H.T., C.M. Tsai, (2011) “Multivariate Granger causality between CO2 emissions, energy consumption, FDI (foreign direct investment) and GDP (gross domestic product): evidence from a panel of BRIC (Brazil, Russian Federation, India, and China) countries”. *Energy* 36, 685-93.

Pesaran, M. H., Y. Shin, (1998), “An auto regressive distributed-lag modelling approach to cointegration analysis,” In: Strom, S.(Ed.), *Econometrics and Economic Theory in the Twentieth Century: The Ragnar Frisch Centennial Symposium.* Cambridge University Press, Cambridge, MA, 371–413.

Pesaran, M. H., Y. Shin, R. J. Smith, (2001), “Bounds testing approaches to the analysis of level relationships,” *Journal of Applied Econometrics,* 16, 289–326.

Reinsel, G. C., S. K. Ahn, (1992), “Vector autoregressive models with unit roots and reduced rank structure: estimation, likelihood ratio test, and forecasting," *Journal of Time Series Analysis,* 13, 353–375.

Selden, T. M., D. Song, (1994), "Environmental quality and development: is there a Kuznets curve for air pollution emissions?," *Journal of Environmental Economics and Management,* 27, 147–162.

Shafik, N. (1994), "Economic development and environmental quality: an econometric analysis," *Oxford Economic Papers,* 46, 757–773.

Shahbaz, M., R. Sbia, and I. Ozturk, (2014), "Economic Growth, electricity consumption, urbanization and environmental degradation relationship in United Arab Emirates," *Ecological Indicators,* 45, 622-631.

Shafik, N., S. Bandyopadhyay, (1992), "Economic growth and environmental quality: time series and cross country evidence," *World Bank Policy Research Working Paper* No. 904.

Shiu, A., P. Lam, (2004), "Electricity consumption and economic growth in China," *Energy Policy,* 32, 47-54.

Soytas, U., Sari, R., 2003 Energy consumption and GDP: causality relationship in G-7 countries and emerging markets. *Energy economics* 25, 33-37.

Soytas, U., R. Sari, (2009), "Energy consumption, economic growth, and carbon emissions; challenges faced by an EU candidate member," *Econological Economics*, 68, 2706-2712

Yoo, S. (2005), "Electricity consumption and economic growth : evidence from Korea," *Energy Policy,* 33, 1627-1632

Zarsky L., (1999) "Havens, halos, and spaghetti: intangling the evidence about foreign direct investment and the environment". OECD paper: CCNM/EMEF/EPOC/CIME(98) 5.

Zhang, X-P., X-M. Cheng, (2009), "Energy consumption, carbon emissions, and economic growth in China," *Ecological Economics,* 68, 2706-2712.

Xing Y, C. D. Kolstad, (2002) "Do lax environmental regulations attract foreign investment?" *Environment and Resource Economics* 21, 1-22.

World Bank, World Development Indicators Accessed at: http://www.worldbank.org/data

UNCTAD (United Nations Conference on Trade and Development), UNCTADSTAT, Accessed at: http://unctadstat.unctad.org/EN/