CO_2 Emissions, Energy Consumption, Economic Growth and FDI in Vietnam

Dinh Hong Linh
Chung Yuan Christian University, Taiwan
dhlinh23@gmail.com

Shih-Mo Lin
Chung Yuan Christian University, Taiwan
shihmolin@gmail.com

This study examines the dynamic relationships between CO_2 emissions, energy consumption, FDI and economic growth for Vietnam in the period from 1980 to 2010 based on Environmental Kuznets Curve (EKC) approach, cointegration, and Granger causality tests. The empirical results do not support the EKC theory in Vietnam. However, the cointegration and Granger causality test results indicate a dynamic relationship among CO_2 emissions, energy consumption, FDI and economic growth. The short-run bidirectional relationship between Vietnam's income and FDI inflows implies that the increase in Vietnam's income will attract more capital from overseas. Inversely, FDI inflow is also driver of national income growth. The existence of bidirectional relationships in the long-run provides important policy implications. We recommend implementing a dual strategy of increasing investment in energy infrastructure and promulgating energy conservation policies to increase energy efficiency and reduce wastage of energy.

Key Words: EKC, Cointegration, Granger Causality, pollution heaven, Vietnam's CO_2 emissions, Vietnam's Energy consumption, FDI inflows, income
JEL Classification: C33, O44, O53

Introduction

Vietnam is one of the fastest growing emerging economies in Asia; averaging around 7.1% annual GDP growth from 2006 to 2009, 6.8% in 2010, and 6.0% in 2011.[1] However, rapid economic growth is usually accompanied by increased energy consumption and may cause unexpected effects on energy resources and the environment. Vietnam's energy consumption in 2010 was four times higher than its consumption in 1980, rising from 14.39 thousand kilotonnes (kt) oil equivalence (1980) to 58.91 thousand kt (2010). CO_2 emissions grew significantly faster than the growth of

energy consumption, from 16.82 thousand kt carbon dioxide emissions to 150.23 thousand kt; an increase of almost ten times for the same period.[2]

There are many reasons that may explain the rapid growth of Vietnam's economy, FDI inflows being one of the most important indicators. It has increased from US$1.4 billion in 1980 to US$1.65 billion in 1990; US$20.6 billion in 2000 and US$65.3 billion in 2010. The average FDI annual growth rates observed for three periods are: 16% for 1980–1990; 29.3% and 12.4% for 1991–2000 and 2001–2010, respectively. This growth in FDI can be attributed to Vietnam's political, social, and macroeconomic stability. Moreover, a country with 90 million people provides a huge potential consumer market. Its labor force offers young, skilled, and relatively well-educated workers, with labor costs that are competitive with other economies in the region. Its geographic location, abundant natural resources, and favorable policies are other factors that attract investments from many countries into Vietnam, propelling its economic development forward.

Many previous papers have investigated the contribution of FDI to economic development of different countries, such as those of Bende-Nabende et al. (2000), Alfaro et al. (2004), and Wang (2009). Vu (2008) and Anwar and Nguyen (2010) examined FDI's influence on Vietnam's economic growth. More recent literature studied the relationships among energy consumption, economic growth, and FDI. Acharyya (2009) and Pao and Tsai (2011) examined the multivariate Granger causality association among CO_2 emissions, energy consumption, FDI, and GDP for India and BRIC, respectively. Nguyen and Amin (2002) analyzed the effect of FDI on energy demand and environmental degradation in Hanoi, the capital city of Vietnam. However, the samples used by these studies are limited, focusing only on one city, one country or on developing countries. To the best of our knowledge, no empirical research has been undertaken yet about the relationships among CO_2 emissions, energy consumption, economic growth and FDI in Vietnam.

This paper investigates the causality relationships among environmental degradation – energy consumption – economic growth – FDI inflows in this country from 1980 to 2010. Investigating the causal nexuses between the above variables, the estimated results show that environmental pollutants are affected by the usage of energy, economic development and the changes in FDI within more than 30 years. Our findings will provide valuable policy implications for Vietnam and other developing countries.

The research is written as follows: the second section explains literature

review and hypotheses, the third section demonstrates methodology and empirical results, and the fourth section presents the conclusion.

Literature Review and Hypotheses

The causal relationship between energy consumption and economic growth has attracted much attention from economists and scholars because this relationship has significant policy implications. Kraft and Kraft (1978) discovered unidirectional causality from income to energy usage in the United States by using sample data for the period 1947–1974. This finding has continuously been supported by other studies. For instance, Chen et al. (2007) has detected the existence of co-movement between environmental productivity and income in China. Lee (2005; 2006) displayed that there have been long-run and short-run causalities from energy consumption to GDP, but did not show evidence of vice versa. This finding suggested that economic growth might have adverse effects on energy conservation, which may be a transitory or permanent trend in developing countries. The two-way directional causality has been represented in the case of the US, and one-way directional causality from energy consumption to income was found for other developed countries. However, the detrimental effects of economic growth to energy conservation are differentiated among these countries.

The relationship between economic growth and environmental pollutants has been analyzed by another pervasive approach known as the Environmental Kuznets Curve theory. The EKC theory claimes that the environmental pollutants has increased at the early stages of economic growth but tends to reverse beyond a certain level of income per capita. This suggests that there is an inverted U-shaped relationship between environmental degradation and other economic variables. Grossman and Krueger (1991) measured income's potential environmental impacts within the North American free trade agreement (NAFTA). Managi and Jena (2008) applied EKC hypothesis and found the appearance of relationship between environmental productivity and income in India. Pao and Tsai (2011) employed EKC theory and recognized the causality relationships among CO_2 emission, energy consumption and GDP in BRIC countries, based on the time series dynamic characteristics of these indicators. This finding provides policy implications for developing countries, on how to qualify foreign investments so that they can mitigate its harmful effects on the environment. In addition, the study of Sari and Soyta (2007) found that energy consumption has a significant relation-

ship with economic development. Other authors such as Keppler and Mansanet-Bataller (2010), Narayan and Narayan (2010) and Pao and Tsai (2010) stated that economic growth and energy consumption are accompanied with environmental degradation in both developed and developing countries. These studies have generated an inverted U-shaped curve representing pollutant magnitude, but there is no inevitability about that. Coondoo and Dinda (2008) and Akbostanci et al. (2009) tested the EKC theory focusing on time series dynamics of income and CO_2 emissions. The relationship between CO_2 and income is revealed in the long-run based on time series analysis, but it also revealed an N-shaped relationship for two kinds of pollutants in Turkey.

The main contribution of this paper is it tests the EKC hypothesis and examines the causality relationships among CO_2 emissions – energy consumption – economic growth – FDI in Vietnam. We accordingly introduce two hypotheses as follows:

H1 *In Vietnam, CO_2 emissions increase in the early stages of economic growth, but tend to decrease beyond a certain level of income per capita. CO_2 emissions, energy consumption, and economic growth have causality relationships with each other and can be observed.*

In recent years, FDI is considered as an important driving force of economic development. Rapid FDI inflows have raised questions whether there is a relationship between FDI, energy consumption, and air pollution deterioration. The issue of FDI, economic growth, and environmental deterioration has been receiving increased attention since the last decade. Several studies have applied time series dynamic with Granger causality test and explored if there are significant nexuses among FDI, economic growth, energy intensity, and CO_2 emissions. Zang (2001) and Kim and Seo (2003) applied a vector autoregression model to present the dynamic correlations between FDI, domestic investment, and output. They found that economic growth has a statistically significant and highly persistent influence on FDI inflows. Li and Liu (2005) found a strong complementary connection between FDI and economic growth, not only in developed but also in developing countries. Chakraborty and Nunnenkamp (2008) discovered the spillover effects between FDI and India's economic output both in the short-run and long-run. Sadorsky (2010) showed evidence that net FDI has a statistically significant impact on energy demand from a sample of 22 emerging countries. Moreover, the relationship between FDI, energy usage, and pollutants has been men-

tioned in many studies. For examples, Mielnik and Goldemberg (2002) examined the linkage between FDI, energy consumption, and CO_2 emissions from a sample of 20 developing countries, and found that energy intensity declines as FDI increases. Pao and Tsai's (2011) findings support the EKC hypothesis with evidence from BRIC. The results showed strong bidirectional causality between emissions and FDI, and significant unidirectional relationship between output and FDI. For Southeast Asia, Chandran and Tang (2013) suggested the long-run association between FDI and CO_2 emissions within five ASEAN countries (excluding Vietnam).

Based on these studies' findings, we predict the relationship among FDI, economic growth, energy consumption and CO_2 emissions in Vietnam, and assume that:

H2 *FDI, economic growth, CO_2 emissions and energy consumption exhibit causal relationships with each other in Vietnam.*

Methodology and Empirical Results

DATA AND VARIABLE FORM

This study used annual GDP per capita, annual FDI inflows and stocks per capita measured by US Dollars at current prices and current exchange rates. All datasets were obtained from UNCTAD statistics database.[3] IN represents GDP per capital and FDI stands for inflows and stocks per capita. The energy consumption and CO_2 emissions were collected from the World Bank Indicator database.[4] The unit that measures energy consumption and CO_2 emissions is kt oil equivalence and kt CO_2 emissions, respectively. All variables are dated from 1980 to 2010, and all are annual data.

The standard EKC regression model has natural logarithmic form for both dependent and independent variables. The logarithmic quadratic form is also taken for independent variables. The new variables in natural logarithmic form are lnIN for IN, lnFDI for FDI, lnCO_2 for CO_2 emissions and lnEN for energy consumption.

MODEL

EKC theory implies that the environmental impact is an inverted U-shaped function of income (IN) and logarithm of the indicator is modeled as a quadratic function of the logarithm of IN. Based on the EKC hypothesis, a linear logarithm quadratic model is formed to perform the

TABLE 1 Unit Root Test Results

Test	Statistic		$\ln CO_2$	lnEN	lnIN	lnIN2	lnFDI
(1)	*t*-statistic	Level	−1.014	−4.239***	−1.096	−0.316	−1.409
		1st dif.	−4.738***	−3.438**	−4.837**	−4.418**	−3.372**
(2)	*t*-statistic	Level	−1.399	−0.448	−4.151***	−2.727	−1.654
		1st dif.	−5.209***	−5.495***	−3.737***	−3.658***	−4.674***

NOTES Row headings are as follows: (1) ADF test, (2) Dickey-Fuller GLS test. ** and *** denotes 5% and 1% level of significance, respectively.

relationships between CO_2 emissions, energy consumption, economic growth and FDI as follows:

$$\ln CO_{2t} = \beta_0 + \beta_1 \ln EN_t + \beta_2 \ln IN_t + \beta_3 \ln IN_t^2 + \beta_4 \ln FDI_t + \nu_t, \qquad (1)$$

where $t = 1, \ldots, T$ denotes the time period, X_t is the vector of explanatory variables and ν_t is the error term which is assumed to be serial uncorrelation. According to the EKC theory, this study expects the signs of $\ln EN_t$, $\ln IN_t$ are positive because the higher ratio in energy consumption and income, the greater CO_2 emissions. In contrast, we expect that $\ln IN_t^2$ will have a negative sign.

UNIT ROOT TEST

As can be seen, table 1 shows the Augmented Dickey-Fuller and Dickey-Fuller GLS unit root tests which are selected to test all series with trend and intercept. The null hypothesis assumed that the data series has a unit root. The results exhibit that all variables are stationary at the first difference at 1% and 5% significance levels, this means that the null hypothesis of a unit root is rejected. Hence, all data series are integrated of order 1 (I(1)) and appropriate for further testing.

Furthermore, assuming that vector Z_t includes $\ln CO_{2t}$ and all other variables in model (2). From the unit root test results, all components of the vector Z_t are I(1), or the first difference $\Delta Z_t = (1 - L)Z_t$ is integrated of order zero; where L is the lag operator of Z_t and $(1 - L)$ is the first difference. Thus, cointegration test should be applied to find the causality relationships among these components.

COINTEGRATION TEST

Johansen (1991) cointegration test is employed to examine whether the series are cointegrated. For example, Gonzalo (1994) pointed out that Jo-

TABLE 2 Results of the Johansen Cointegration Test

Trace test			Maximum eigenvalue test		
(1)	(2)	(3)	(1)	(2)	(3)
$r = 0$	$r \geq 1$	161.273***	$r = 0$	$r = 1$	65.412***
$r \leq 1$	$r \geq 2$	95.862***	$r = 1$	$r = 2$	61.347***
$r \leq 2$	$r \geq 3$	34.514**	$r = 2$	$r = 3$	27.132***
$r \leq 3$	$r \geq 4$	6.848	$r = 3$	$r = 4$	14.265
$r \leq 4$	$r \geq 5$	0.930	$r = 4$	$r = 5$	3.841

NOTES Column headings are as follows: (1) null hypothesis, (2) alternative hypothesis, (3) trace statistic. Trace and max-eigen statistics calculated at 5% level; ** and *** denotes 1% and 5% level of significance, respectively. Probabilities are computed by using asymptotic Chi-square distribution, and r is the number of cointegration equations. SIC criteria is used to choose the lag length, maximum lag lengths are seven.

hansen test is the optimal one when error terms are not normally distributed. Maddala and Wu (1999) suggested the implication of Johansen-Fisher test which allowed some relationships to be cointegrated. Because all variables are integrated in the same order, this paper has applied Johansen test in the term of vector autoregressive model. Johansen cointegration test uses trace and maximum eigenvalue tests to determine the number of cointegration relationships. Table 2 shows the results of Johansen cointegration test with null and alternative hypotheses.

The trace and maximum eigenvalue statistic indicate that there is a difference in significant level of each cointegration equation. The maximum eigenvalue test is carried out with separate tests on each eigenvalue and has the sharper alternative hypothesis. Its results should be used in choosing the number of cointegrated relationships. Based on max-eigen statistic, there are three significant cointegrating vectors at 1% and 5% levels. The findings indicate he existence of long-run relationship among variables and the spurious regression is avoided. The existence of cointegration among model (2) variables suggests that the ordinary least square (OLS) estimation is the best estimator in accordance with the findings of Alves and Bueno (2003).

The estimated equation of model 2 using OLS is presented in table 3. The results from equation (3) illustrate that the estimated coefficient of lnEN present the same sign as expected at 1% level of significance. The estimated signs of lnIN and lnIN2 follow the expectation of hypothesis 1, which indicate that CO_2 emissions increase in the early stages of economic growth, but tend to reverse beyond certain levels of income per

TABLE 3 Estimated Equation of Model 2 Using OLS

$\ln CO_2 =$	− 8.955	+ 1.954lnEN	+ 0.016lnIN	− 0.010lnIN_2	− 0.008lnFDI	(3)
SE	(3.3406)	(0.3096)	(0.2888)	(0.0360)	(0.0078)	
t-stat	− 2.6808**	6.3116***	0.0566	− 0.2781	− 0.7684	

NOTES ** and *** denote 5% and 1% level of significance, respectively.

capita. However, the estimated coefficients of lnIN and lnIN2 are statistically insignificant. As a result, we cannot conclude that EKC hypothesis is supported by the correlation between CO_2 emissions and income in Vietnam during the period 1980 to 2010. Furthermore, the estimated results emphasize that CO_2 emissions is elastic with energy consumption, in which a 1% increase in energy consumption will increase CO_2 emissions by 1.954%, or expressed differently, a one-unit increase in energy consumption increases CO_2 emissions by 1.954% percentage points. The estimated coefficients magnitude of lnFDI has a negative (–0.008) sign. Although this magnitude is very small but the negative sign suggests that FDI can still effect to reduce environment degradation. However, this estimated coefficient of lnFDI is insignificant, meaning that there is no evidence which shows FDI is inelastic in reducing CO_2 emissions.

GRANGER CAUSALITY TEST

The cointegration test has performed the existence of long–run equilibrium relationships among CO_2 emissions, energy consumption, economic growth and FDI. Granger causality test in the term of vector error-correction model (VECM) will reveal whether historical value of one variable might affect the current value of other variables. These results detect the directions of causal relationships among variables in model (2). The Granger causality test in the term of VECM framework is described as follows:

$$\begin{aligned}\Delta Y_t &= \alpha_{10} + \alpha_{11}(Y_{t-1} - X_{t-1}) + \sigma_{11}\Delta Y_{t-p} + \sigma_{12}\Delta X_{t-p} \\ &\quad + \beta_1 \Delta z_{t-p} + \varepsilon_t \\ \Delta X_t &= \alpha_{20} + \alpha_{21}(Y_{t-1} - X_{t-1}) + \sigma 21 \Delta Y_{t-p} + \sigma_{22}\Delta X_{t-p} \\ &\quad + \beta_2 \Delta z_{t-p} + \nu_t \end{aligned} \tag{2}$$

where $t = 1, \ldots, T$ denotes the time period, Δ represents change operator, Y_t and X_t is a pair of endogenous variables, z is the vector of other variables; $\beta 1$ and $\beta 2$ are vectors of its parameters in each equation; ε_t, ν_t are two error terms; and $(Y_{t-1} - X_{t-1})$ is the error correction term (ECT). α_{11}

and α_{21} are the parameters that show the speed of adjustment to the long-run equilibrium which might confirm the long-run relationship among variables.

In this article, the pairs of (X_t, Y_t) include ($\ln CO_2$, lnEN), ($\ln CO_2$, lnIN and lnIN2), ($\ln CO_2$, lnFDI), and other pairs are combinations of each variable with one or two other variables such as lnEN with lnIN and lnIN2 or with lnFDI and so forth.

Table 4 represents short-run Granger causality results with the null hypothesis that there is no causal relationship in each pair of variables. The results support hypothesis 2, indicating the existence of short-run relationships among variables. There are two bidirectional causality relationships between Vietnam's income and FDI inflows and between Vietnam's energy consumption and FDI inflows, which can be interpreted as follows: the rapid development of Vietnamese economy over the last three decades has been driven by the increase in FDI inflows. The higher income in turn attracts more foreign investors. Moreover, increasing economic activity brought about by FDI inflows requires more energy, and the sufficient energy supply in turn attracts more foreign investment. Thus, the effects of FDI vary widely across sectors. FDI has risen up considerably since recent decades, and has close relationships with nation's income and energy consumption. The findings are in line with the previous studies of Zang (2001) and Kim and Seo (2003). The short-run relationships between FDI and output are also implied in the research of Li and Liu (2005) for developed and developing countries and Chakraborty and Nunnenkamp (2008) in study of Indian economy. On the other hand, the unidirectional causations are found from CO_2 emissions to FDI; income to CO_2 emissions and income to energy consumption. These support the investigations of Sadorsky (2010) and Mielnik and Goldemberg (2002), which stated that environmental pollutant has unidirectional effects on promoting FDI inflows.

The significance of the estimated coefficients of ECTs from model (4) expresses long-run causal nexus among data series, which supports hypotheses 1 and 2. Table 5 has exploited four bidirectional causality relationships between: CO_2 emissions and income; energy consumption and income; energy consumption and FDI; income and FDI. These findings are consistent with those of Chen et al. (2007), which found an association between environment and income in China, and Pao and Tsai (2011) in their study of the same phenomenon in BRIC. The relationship between energy consumption and income is also in accordance with the

TABLE 4 Results of Short-Run Granger Causality Test

	D(lnCO_2)	D(lnEN)	D(lnIN)†	D(lnFDI)
D(lnCO_2)→		1.3720	0.8970	29.2203***
D(lnEN)→	1.7469		3.2152	9.0040**
D(lnIN)→	4.6505*	6.3530**		8.2071**
D(lnIN2)→	5.3027*	9.3525***		6.9215**
D(lnFDI)→	4.4345	4.6127*	6.9215**	

NOTES † and D(lnIN2); *, ** and *** denote 10%, 5% and 1% level of significance, respectively; → presents causality direction from *X* to *Y*; ↔ detects bidirectional relationship between *X* and *Y*.

findings of Keppler and Mansanet-Bataller (2010), Narayan and Narayan (2010) and Pao and Tsai (2010). On the other hand, the results indicate one unidirectional causality relationship from CO_2 emissions to FDI inflows, which implies that the relatively lower environmental standard has attracted FDI. The bidirectional causality between economic growth and energy usage implies that these variables are jointly determined and affect each other simultaneously. Furthermore, the bidirectional causalities between CO_2 emissions and energy consumption with income imply that Vietnam has been developing its economy through increasing its energy consumption. With the weakness in environmental protection regulations, the entry of inefficient energy technologies might lead to energy wastage and environmental pollution.

Conclusion

This paper tests the EKC theory in Vietnam's economy. Based on the empirical results, we find that when income per capita is at 0.8 (in logarithms) or 2,226 US dollars, CO_2 emissions begin to decline. However, this estimated result is statistically insignificant. This means that the data does not provide enough evidence to conclude that EKC hypothesis is confirmed in Vietnam's economy.

Second, this study investigates the dynamic relationship between CO_2 emissions, energy consumption, FDI and economic growth in Vietnam for the period 1980 to 2010. By using the Granger causality test in the context of VECM, this paper found two short-run bidirectional relationships between FDI inflows with Vietnam's income and energy consumption. We also found four bidirectional causality relationships in the long-run between: CO_2 and income; energy consumption and income; energy con-

TABLE 5 Long-Run Causality Test

(1)	(2)	(1)	(2)	(3)
$\Delta\ln CO_2 \rightarrow \Delta\ln EN$	0.1964	$\Delta\ln EN \rightarrow \Delta\ln CO_2$	1.1893	No Causality
$\Delta\ln CO_2 \rightarrow \Delta\ln IN$	−8.1572***	$\Delta\ln IN\dagger \rightarrow \Delta\ln CO_2$	−2.3680**	$CO_2 \leftrightarrow$Income
$\Delta\ln CO_2 \rightarrow \Delta\ln IN2$	−9.5787***			
$\Delta\ln CO_2 \rightarrow \Delta\ln FDI$	−3.4668**	$\Delta\ln FDI \rightarrow \Delta\ln CO_2$	−1.3689	$CO_2 \leftrightarrow$FDI
$\Delta\ln EN \rightarrow \Delta\ln IN$	−7.8726***	$\Delta\ln IN\dagger \rightarrow \Delta\ln EN$	−2.2482**	En. use↔Income
$\Delta\ln EN \rightarrow \Delta\ln IN2$	9.1352***			
$\Delta\ln EN \rightarrow \Delta\ln FDI$	3.3017***	$\Delta\ln FDI \rightarrow \Delta\ln EN$	−3.1646***	FDI↔Energy use
$\Delta\ln IN\dagger \rightarrow \Delta\ln FDI$	−3.2590***	$\Delta\ln FDI \rightarrow \Delta\ln IN$	11.2817***	Income↔FDI
		$\Delta\ln FDI \rightarrow \Delta\ln IN2$	−9.3014***	

NOTES Column headings are as follows: (1) causal direction, (2) ECT *t*-stat, (3) conclusion direction. † and lnIN2; *, ** and *** denote 10%, 5% and 1% level of significance, respectively; → presents causality direction from *X* to *Y*.

sumption and FDI; and income and FDI. Both the short-run and long-run bidirectional causality relationships between income and FDI suggest that the increase in Vietnamese income will attract more capital from overseas. In contrast, FDI inflows promote to expand and increase the national income.

Finally, the long-run bidirectional causality between FDI inflows and energy consumption as well as the unidirectional causality from CO_2 emissions to FDI inflows imply the close relationships among FDI, energy consumption and environmental degradation. In these relationships, energy consumption increases as FDI increase in host countries. The findings support the pollution haven hypothesis. Less stringent environmental regulations will attract FDI inflows, which will intensify environmental pollution.[5] Regarding environmental protection and economic development, the existence of long-run causality among CO_2 emissions – energy consumption – economic growth – FDI points out important challenges to Vietnam's policy-makers. It appears that Vietnam focuses on enhancing economic growth but does not implement the necessary measures to protect the environment. These results should be considered as a precaution to policy makers that insufficient environmental laws would accelerate their country's environmental degradation. In order to reduce CO_2 emissions and to avoid an unexpected effect on the economic growth, Vietnam should implement a dual strategy of increasing investment in energy infrastructure and promulgating energy

conservation policies to increase energy efficiency and reduce wastage of energy. Implementation of more stringent laws that require the usage of energy-efficient technologies should reduce CO_2 emissions in the pursuit of economic growth.

Notes

1 These numbers are calculated by the authors from UNCTAD Statistics, 2013. Growth rates are based on GDP constant 2005 US dollars. For the good explanation, the reader is referred to http://unctadstat.unctad.org/TableViewer/summary.aspx

2 These numbers are calculated by the authors based on World Bank database. Available at http://data.worldbank.org/indicator

3 The data is used at current prices due to the lack of data of Vietnam's inflation and GDP deflation for many years; UNCTAD database is available online from http://unctadstat.unctad.org/ReportFolders/reportFolders.aspx

4 This database is available online from http://data.worldbank.org/indicator

5 The pollution haven hypothesis is the idea that for given levels of environmental policy, polluting industries will relocate to countries with weaker environmental regulation.

References

Acharyya, J. 2009. 'FDI, Growth and the Environment: Evidence from India on CO_2 Emission during the Last Two Decades.' *Journal of Economic Development* 34 (1): 43–58.

Akbostanci, E., S. Turut-Asik, and G. L. Tunc. 2009. 'The Relationship between Income and Environment in Turkey: Is There an Environmental Kuznets Curve?' *Energy Policy* 37:861–7

Alfaro, L., A. Chanda, S. Kalemli-Ozcan, and S. Sayek. 2004. 'FDI and Economic Growth: The Role of Local Financial Markets.' *Journal of International Economics* 64 (1): 89–112.

Alves, D. C. O., and R. D. Bueno. 2003. 'Short-Run, Long-Run and Cross Elasticities of Gasoline Demand in Brazil.' *Energy Economics* 25:191–209.

Anwar, S., and L. P. Nguyen. 2010. 'Foreign Direct Investment and Economic Growth in Vietnam.' *Asia Pacific Business Review* 16:183–202.

Bende-Nabende, A., J. L. Ford, S. Sen, and J. Slater. 2000. 'Long-Run Dynamics of FDI and Its Spillovers Onto Output: Evidence from the Asia-Pacific Economic Cooperation Region.' Discussion Papers 00-10, University of Birmingham, Birmingham.

Chakraborty, C., and P. Nunnenkamp. 2008. 'Economic Reforms, FDI, and Economic Growth in India: A Sector Level Analysis.' *World Development* 36:1192–212.

Chandran, V. G. R., and C. F. Tang. 2013. 'The Impacts of Transport Energy Consumption, Foreign Direct Investment and Income on CO_2 Emissions in ASEAN-5 Economies.' *Renewable and Sustainable Energy Review* 24:445–53.

Chen, W. Y., Z. X. Wu, J. K. He, P. F. Gao, and S. F. Xu. 2007. 'Carbon Emission Control Strategies for China: A Comparative Study with Partial and General Equilibrium Versions of the China MARKAL Model.' *Energy* 32:59–72.

Coondoo, D., and S. Dinda. 2008. 'The Carbon Dioxide Emissions and Income: A Temporal Analysis of Cross-Country Distributional Patterns.' *Ecological Economics* 65:375–85.

Gonzalo, J. 1994. 'Five Alternative Methods of Estimating Long-Run Equilibrium Relationships.' *Journal of Econometrics* 60:203–33.

Grossman, G. M., and A. B. Krueger. 1991. 'Environmental Impact of a North American Free Trade Agreement.' NBER Working Paper 3914, National Bureau of Economic Research, Cambridge, MA.

Johansen, S. 1991. 'Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models.' *Econometrica* 59: 1551–80.

Keppler, J. H., and M. Mansanet-Bataller. 2010. 'Causalities between CO_2, Electricity, and Other Energy Variables during Phase 1 and Phase 2 of the EU ETS.' *Energy Policy* 38:3329–41.

Kim, D. D., and J. S. Seo. 2003. 'Does FDI Inflow Crowd out DI in Korea Quest.' *Journal of Economic Studies* 30:605–22.

Kraft, J., and A. Kraft. 1978. 'Note and Comments: On the Relationship between Energy and GNP.' *The Journal of Energy and Development* 3: 401–3.

Lee, C. C. 2005. 'Energy Consumption and GDP in Developing Countries: A Cointegrated Panel Analysis.' *Energy Economics* 27:415–27.

———. 'The Causality Relationship between Energy Consumption and GDP in G-11 Countries.' *Energy Policy* 34:1086–93.

Li, X., and X. Liu. 2005. 'Foreign Direct Investment and Economic Growth: An Increasingly Endogenous Relationship.' *World Development* 33:393–407.

Maddala, G. S., and S. Wu. 1999. 'A Comparative Study of Unit Root Tests with Panel Data and a New Simple Test.' *Oxford Bulletin of Economics and Statistics* 61:631–52.

Managi, S., and P. R. Jena. 2008. 'Environmental Productivity and Kuznets Curve in India, Ecological Economics.' 65:432–40.

Mielnik, O., and J. Goldemberg. 2002. 'Foreign Direct Investment and Decoupling between Energy and Gross Domestic Product in Developing Countries.' *Energy Policy* 30:87–9.

Narayan, P. K., and S. Narayan. 2010. 'Carbon Dioxide Emissions and Economic Growth: Panel Data Evidence from Developing Countries.' *Energy Policy* 38:661–6.

Nguyen, T. B. M., and A. M. Amin. 2002. 'The Role of Foreign Direct Investment in Urban Environmental Management: Some Evidence from Hanoi, Vietnam.' *Environment, Development and Sustainability* 4 (3): 279–97.

Pao, H. T., and C. M. Tsai. 2010. 'CO_2 Emissions, Energy Consumption and Economic Growth in BRIC Countries.' *Energy Policy* 38:7850–60.

———. 2011. 'Multivariate Granger Causality between CO_2 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.

Sadorsky, P. 2010. 'The Impact of Financial Development to Energy Consumption in Emerging Economies.' *Energy Policy* 38:2528–35.

Sari, R., and U. Soytas. 2007. 'The Growth of Income and Energy Consumption in Six Developing Countries.' *Energy Policy* 35:889–98.

Vu, T. B. 2008. 'Foreign Direct Investment and Endogenous Growth in Vietnam.' *Applied Economics* 40 (9): 1165–73.

Wang, M. 2009. 'Manufacturing FDI and Economic Growth: Evidence from Asian Economies.' *Applied Economics* 41 (8): 991–1002.

Zang, K. H. 2001. 'Does Foreign Direct Investment Promote Economic Growth Quest: Evidence from East Asia and Latin America.' *Contemporary Economic Policy* 19:175–85.