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Impacts of Trade Liberalisation on CO_2 Emissions in Vietnam

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Abstract

This study examines the impact of economic development, trade openness, and energy usage on Vietnam's CO_2 emissions from 1985 to 2013 by applying an Auto-regression Distributed Lag (ARDL) model. The empirical results show a long-run relationship between economic development and CO_2 emissions in Vietnam that can be expressed in an inverted U-curved function. Trade liberalization exhibits a positive impact on CO_2 emissions, as a 1% increase in trade openness leads to a 0.191% increase in CO_2 emissions for long-run elasticity. Furthermore, trade liberalisation has lag effects on CO_2 emissions, which are estimated to reverse from negative to positive after a two year period. A 1% increase in energy usage leads to a 1.391% increase in CO_2 emissions for long-run elasticity. Thus, environmental quality improves with cleaner technology and stricter regulations on environmental protection incorporated into international economics at the policy level in Vietnam.

Key words: Trade openness, Energy consumption, CO_2 emissions, Auto-regression distributed lag model, Vietnam.

JEL classifications: C32, F15, F18, O53, Q56

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1. Introduction

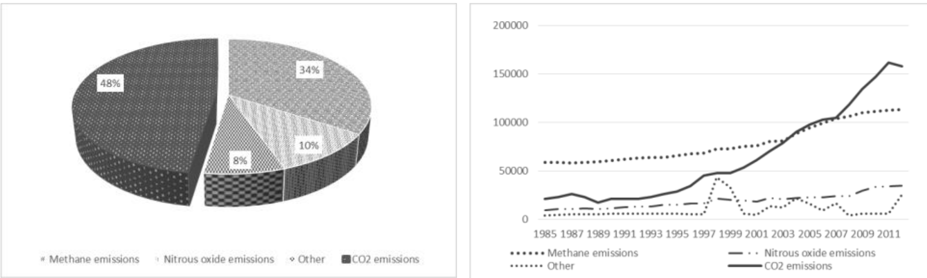
Since the Innovation policy in 1986, the government of Vietnam (GoV) has negotiated a number of free trade agreements to attract foreign investment and to boost the national economy. The country has experienced remarkable achievements, such as an increase in gross domestic product (GDP) by 6.43% per year and real GDP per capita by 4.93% per year from 1985 to 2017 (WDI, 2018). Moreover, GoV has strengthened its effort and commitment to integrate environmental concerns into trade policies.

With regard to trade liberalization, GoV has signed sixteen free trade agreements (FTAs). Of these sixteen FTAs, ten FTAs have been implemented including six FTAs signed as part of ASEAN and four FTAs signed as a nation. Vietnam has also recently completed negotiations for two FTAs with the European Union and Trans-Pacific countries in 2015. As of September 2018, Vietnam is still negotiating for four FTAs, which include the Regional Comprehensive Economic Partnership (RCEP) between ASEAN and China, South Korea, Japan, India, Australia, and New Zealand; an FTA between ASEAN and Hong Kong; an FTA between Vietnam and Israel; and an FTA between Vietnam and the European free trade area. In addition, Vietnam has signed bilateral trade agreements (BTAs) with about ninety countries. The U.S., Japan, and countries of the EU are Vietnam's main trading partners (GoV, 2018).

Vietnam has a noticeable comparative advantage in natural resources intensive products, and closer international economic integration with trading partners is a prime source of additional pressures on the country's natural resources and the environment. The natural resources give it open access to international trading partners, causing the acceleration of environmental damage and natural resources depletion. In the case of poor management by the central government and/or local provinces, the environmental consequences from economic development activities such as environmental pollution and over-exploitation of natural resources are worsening.

Vietnam has also experienced a degradation of the environment. For instance, Vietnam's CO_2 (carbon dioxide) emissions increased about seven-fold between 1985 and 2013 (see Figure 1.a) and accounted for 48% of total greenhouse-effect-gases (GHG) emissions in 2012 (see Figure 1.b). Consequently, CO_2 has become the main make-up of energy-related GHG emissions in Vietnam. In terms of energy consumption, the demand for energy in Vietnam depends heavily on the exploitation of fossil fuels, such as oil and coal (Zimmer et al., 2014) and other renewable energy sources, such as family-sized biomass and hydro power. Statistical data from the World Development Indicator (WDI) show a rising trend in the energy consumption of fossil fuels, which accounted for 29.6% in 1985 and 66.2% in 2012 of the country's total energy consumption (WDI, 2018).

Figure 1. Development of CO_2 Emissions in Vietnam (1985-2012)



(a) Trends of GHG emissions from 1985 to 2012 (b) GHG inventories in 2012

Source: Authors' calculation from the World Bank's WDI, 2018.

The emissions of CO_2 from energy use for production activities can be considered as one of the most important indicators to show the direct relationship between trade openness activities and the extent of environmental degradation. The literature on economic growth and environmental pollution is well established. The theory of the Environmental Kuznet Curve (EKC) is widely applied to show the link between economic development and environmental conservation (Kohler, 2013; Stern, 2003). However, studies to assess the impact of trade liberalization on Vietnam's CO_2 emissions are limited. There has been no integration of environmental commitments into trade agreements that Vietnam has signed so far. If our study shows a close relation and long-term impact of trade openness on CO_2 emissions, then there would be a change in policy aspect for Vietnam.

This study explores the relationship between trade openness and CO_2 emissions in Vietnam using time series data from 1985 to 2013. The use of time series data provides a better framework to study a single country case (Ren et al., 2014) and allows our study to capture the overall impact of trade liberalization, economic development, and energy use on the environment during the last 29 years of the country's innovation process.

2. Literature Review

2.1 Trading Activities and Environmental Consequences

The impact of trade liberalization on the environment has increasingly been investigated by both researchers and policy makers (Cole and Elliott, 2003) and become an emerging issue, particularly for developing countries (Muradian and Martinez-Alier, 2001; Jayadevappa and Chhatre, 2000). The debate on how to protect the environment, when free trade agreements are being negotiated bilaterally and regionally, is of particular concern (Mukhopadhyay and Thomassin, 2010). The relationship between trade liberalization and the environment is complex and is the most debated issue in trade policy (Baghdadi et al., 2013).

Environmental supporters argue that freer trade can be seen as environmentally unfriendly, because it expands production activities, increases the exploitation of natural resources, and discharges pollutants into the environment. If the discharge from production to the environment overcomes the dissolving ability of the environment, then the environment will be degraded.

Supporters of an open trade policy contend that trade liberalization is environmentally friendly in several ways. First, trade liberalization creates a transparent business environment in trading activities and reduces the distortion in the market. Therefore, domestic pollution industries and excessively intensified production will not be encouraged by trade liberalization. Second, capital and technology can move and transfer freely within the free trade area. This enables the developing countries to access advanced technology or environmentally friendly technology in their production activities through trade (Muradian and Martinez-Alier, 2001). Third, countries financially benefit from trade openness (Delpachitra & Pham, 2012). This is considered as one of the most convincing arguments raised by the supporters of trade liberalization (Carrapatoso, 2008). Thus, developing countries such as Vietnam can internalize the cost of environmental protection measures into the prices of products, including the cost to pursue high environmental standards or provide environmental protection measures. The terms of trade will increase as northern consumers are willing to pay higher prices for products that are environmentally friendly (Repetto, 1994, as cited in Muradian and Martinez-Alier, 2001).

2.2 Determinants of Trade Openness on the Environment

It is documented in the literature that the impact of trade activities on the environment is complex and inconclusive. However, it is plausible to divide the impact of trade openness on the environment into three main categories: scale effect, composition effect and technique effect (Antweiler et al., 2001; Coxhead and Jayasuriya, 2003; Cole and Elliott, 2003; Fauchald et al., 2011; Managi et al., 2009; UNEP 2000, 2005).

Scale Effects

Scale effect, which could either be negative or positive, occurs if there is a change in economic activity that leads to a change in the environment through the total level of contaminants, energy use, and CO_2 emissions (Stern, 2003). As the environment provides input for production activities, trade openness and economic expansion increase demand for all goods and services and therefore spur natural resources exploitation and CO_2 emissions (Strutt and Anderson, 2000). To this end, the scale impact of trade openness on the environment is negative. Grossman and Krueger (1991) explain that even if the structure of an economy does not change and the technology does not improve, then the scale effect of a trade policy can still be defined as the production activities that generate environmental pollution. An increase in production will result in an increase in pollution and negatively affect the environment (Akbostancı et al., 2009).

A nation can expand its production activities more effectively as a result of trade openness. Given the same set of natural resources, labor, machinery, and technology allocation, the economic activities can more effectively improve the efficiency of production activities (UNEP, 2005). The long-run environmental outcomes are also influenced by other conditions such as the assimilative ability of the environment or the application of environmentally friendly technology in production. Therefore, the growth of an economy cannot be seen as a negative indicator for environmental quality.

Composition Effects

Composition effect refers to the impact on the environment as a result of a change in the structure of production and consumption (Coxhead and Jayasuriya, 2003). When a country commits itself to an open trade policy, it then tries to expand economic activities to a greater extent in a certain sector or production in which the country has an abundance of comparative advantages (Halicioglu, 2009). The change in economic structure leads to change and an adjustment in the levels of pollution, water use, resource use, and energy use. Therefore, the composition effect of the production changes on the environment depends on the comparative advantage in production of the country under study (Cole and Elliott, 2003).

The local environmental position could positively improve if the country attempts to promote less environmentally-intensive and greener sectors or the country trades with partners that have strong requirements on environmental protection. If a country has favorable advantages on pollution-intensive sectors, then freer trade may worsen the environment further. In order to expand the economy, a nation may emit more air pollutants and discharge more loads of waste into the environment. According to Stern (2003) developing economies tend to follow this direction in their growth practices. Honma and Yoshida (2011) find that the composite effect on the environment of free trade is only consistent with the pollution haven hypothesis on the export side. From this, they predict that developing countries export dirtier industries and import cleaner industries as a result of free trade agreements.

Technical Effects

Technical effect refers to the effect that is generated by a change in the flow of technology applied in the production chain. This effect transpires when there is a change in production methods that are induced by a free trade agreement (Cole and Elliott, 2003). According to a study by UNEP (2000, 2005), there is a high possibility that technological evolution takes place during the implementation of trade openness policies. The technical effect of trade openness helps to save input sources and minimize the cost of waste discharging into the environment (UNEP, 2000, 2005). The advanced technology helps to increase production yield and promote environmental protection. Therefore, the technical effect of trade openness is assumed to positively affect the environment (Cole and Elliott, 2003).

2.3 Effect of Trade Openness and Income on the Environment

The linkage between trade liberalization and environmental quality is theoretically examined by integrating the EKC theory. The EKC hypothesis is a theoretical tool that has been extensively used to examine the effect of economic variables on the environment (Tan et al., 2014; Ren et al., 2014). It is based on the hypothesis proposed by Kuznet (1955) that the relationship between GDP per capita and environment pollutants, or the long-run correlation between economic growth and environmental damage, can be expressed in a parabolic function (Grossman and Krueger, 1995; Stern, 2003; Baek and Kim, 2013). Specifically, at the beginning of economic development the environment will be degraded. However, at the later stage of economic development, with higher income levels, people can spend more money to rehabilitate the environment. Consequently, environmental quality will improve along with economic development.

Reviews of EKC theory studies have been extensively surveyed in the literature ever since the pioneering work of Grossman and Krueger (1991) and are significantly followed by Jayadevappa and Chhatre (2000), Cole (2003), Stern (2003), and Dinda (2004). In particular, EKC theory studies has been updated comprehensively by Tan et al. (2014), Farhani et al. (2014), Ren et al. (2014), and Al-Mulali et al. (2015). Al-Mulali et al. (2015) reviews 48 studies from 2003 to 2014 concerning the existence of the EKC theory. They find that around 70% of these studies are consistent with the EKC theory and most are conducted for developed countries.

International trade is one of the foremost factors in explaining the EKC theory (Dinda, 2004) as freer trade is expected to lead to expansion in the size of an economy and an increase in per capita income. The overall complexity of trade openness on the environment is a cumulative combination of the country under study, the level of economic development, the level of trade openness, and the domestic requirements on environmental protection, among others.

Per capita income is expected to increase as a result of trade liberalization, which then leads to the demand for environmental protection regulations (Cole and Elliott, 2003; Baek et al., 2009). Trade liberalization policies may also aim at protecting the environment and reducing pollution, thus leading to a positive effect on the demand for a good environment (Muradian and Martinez-Alier, 2001).

An increase in per capita income and an expansion of the economy do not mean that environmental quality will improve. It is strongly believed that the long-term relationship between environmental damage and trade openness or per capita income may be displayed in the form of a quadratic function and should be examined for each individual country (Akbostancı et al., 2009; Jalil and Mahmud, 2009; Kohler, 2013; Halicioglu, 2009; Grossman and Krueger, 1991, 1995). Specifically, a nation experiences a common pattern of increasing its pollution levels in the early stage of economic development, which exhibits a positive relationship between environmental degradation and trade openness. This pattern is then followed by a declining trend of environmental degradation from freer trade. To this end, a country that moves beyond the turning point of the EKC curve experiences a higher level of trade openness. This may bring a change in the structure of the domestic production of the country towards less polluted or greener production.

2.4 Review of Literature on the Impact of Trade Liberalization on the Environment in Vietnam

Table 1 presents the limited number of published studies that specifically investigate the long-run impact of trade openness on the environment in Vietnam. These studies consistently find long-run causality between economic growth and CO_2 emissions. The studies use different variables to capture the effect of economic development on CO_2 emissions in Vietnam, such as FDI (Linh and Lin, 2014; Tang and Tan, 2015) and exports and imports (Al-Mulali et al., 2015). To the best of our knowledge, Anwar and Alexander (2016) are the only study that includes the trade openness variable to assess the impact of trade liberalization on the environment in Vietnam. They present evidence that trade openness has minor effects on the level of pollution, indicating the possibility for Vietnam to further open up to trade. The presence of the EKC theory in Vietnam is dissimilar among studies, supported by Tang and Tan (2015) and rejected by Linh and Lin (2014) and Al-Mulali et al. (2015).

Table 1. Studies on the Link between Trade Liberalization and the Environment in Vietnam

Authors	Time period	Energy	GDP square	FDI	Trade	EKC (*) (+/-)	Main results
Linh and Lin (2014)	1980-2010	Yes	Yes	Yes	No	-	- GDP-FDI: bidirectional - Long-run causality among CO_2 emissions, energy use, economic growth, and FDI
Tang and Tan (2015)	1976-2009	Yes	Yes	Yes	No	+	- Energy consumption and income positively affect CO_2 emissions - Long-run integration between CO_2 emissions, energy use, economic growth, and FDI
Al-Mulali, Saboori, and Ozturk (2015)	1981-2011	Yes	No	No	No	-	- Exports have no effect on pollution - Imports increase pollution
Anwar and Alexander (2016)	1980-2011	Yes	No	No	Yes	NA	Long-run integration between trade openness, energy consumption, income, and pollution

Notes: (*): (+): supports the EKC theory.
(-): does not support the EKC theory.
(NA): no information available.

Our study contributes to the gap in examining the impact of trade openness on the environment and the existence of the EKC theory in the context of the Vietnam economy. Scaling the data to per capita value for each variable helps us to avoid bias estimation for several reasons. First, as the population of Vietnam has changed dramatically from 1985 to 2013, scaling the annual data variables with the same measurement is necessary to interpret the magnitude of change. Second, the EKC theory is conventionally explained based on the willingness of people to spend money to protect the environment. Thus, scaling the economic development variable from GDP to per capita income is necessary to understand the willingness of the people to pay to protect the environment. Third, the variable in the per capita term has been widely and extensively applied in the literature. Therefore, using the per capita measurement for all variables enables us to compare the magnitude of the impact of the economy on the environment with previous studies. The inclusion of the squared value of the real per capita income variable in our empirical models contributes to the limited evidence of the EKC hypothesis in Vietnam.

3. Research Model

3.1 Empirical Model

Grossman and Krueger (1995) examine the basic relationship between the size of an economy and the intensity of CO_2 emissions, reporting that pollution tends to rise during the first stage of a country's development and decrease after reaching a certain income level: $CO_2 = f(e,y,y^2)$. The standard EKC regression model is:

$$\ln(E/P)_{it} = \gamma_i + \delta_t + \varphi_1 \, ln \, (\frac{GDP}{P})_{it} + \varphi_2 \, \{ln\left(\frac{GDP}{P}\right)\}_{it}^2 + \varepsilon_{it}, \quad (1)$$

where E is emissions; P is population; GDP is gross domestic product; γ_i and δ_t are intercept parameters that may vary across countries or regions i and year t; and ε_{it} is stochastic shock (Stern, 2003).

Our study follows the methods of Tan et al. (2014), Jalil and Mahmud (2009), and Halicioglu (2009) by putting the nexuses of output-energy and output-pollution under the same framework, in a quadratic function, as:

$$C_t = \beta_0 + \beta_1 E_t + \beta_2 Tr_t + \beta_3 Y_t + \beta_4 Y_t^2 + \varepsilon_t, \quad (2)$$

where C_t is CO_2 emissions per capita; E_t is commercial energy use per capita; Y_t is the real per capita income; Y_t^2 is the square of real per capita income; Tr_t is the openness ratio; and ε_t is the regression error terms.

It is generally expected that higher levels of energy consumption result in greater economic activity and stimulate CO_2 emissions; therefore, it is expected that β_1 is positive and significant in equation (2). Under the EKC hypothesis, the sign of β_3 is expected to be positive whereas a negative sign is expected for β_4. Linh and Lin (2014) find that β_4 is statistically insignificant, indicating that there is not enough statistical evidence to confirm that the environment will be rehabilitated at a specific higher per capita income in Vietnam. Tang and Tan (2015), in contrast, note that β_4 is statistically significant, reflecting that the environment can be restored at a higher income in Vietnam. The expected sign of β_2 is mixed depending on the stage of economic development of the country under study. For developed countries, β_2 is expected to be negative as the technology improvement allows them to produce less energy and pollution intensive goods; meanwhile, this sign is expected to be positive for developing countries (Kohler, 2013). Therefore, in our study β_2 is expected to be positive.

3.2 Estimation Methods

Our study applies an autoregressive distributed lag (ARDL) model to test for the existence of the long-run relationship among the variables. The ARDL technique can be applied irrespective of whether the variable is I(0) or I(1) or fractionally co-integrated (Pesaran and Pesaran, 1997). The ARDL model takes a sufficient number of lags to capture the dynamic impacts of all dependent and independent variables as well as from the error term. The error correction model (ECM), which can be simply derived from the ARDL model, helps to integrate short-run adjustments with long-run equilibrium without losing long-run information. Furthermore, ARDL estimation is possible even when the explanatory variables are endogenous (Pesaran et al., 2001). Finally, the ARDL model has been proved to be suitable for small sample size studies (Farhni et al., 2014). The estimation procedures are described next.

(i) Checking the Eligibility of Data

We first check that none of our data is I(2) or beyond that based on the computed F-statistics provided by Pesaran et al. (2001), which are not valid for I(2) data.

(ii) Choosing the Optimal Lag Length of Each Variable

The optimal lag length for each variable in the ARDL model can be selected on the basis of Schwarz (SC), also known as the Bayesian information criterion (BIC or SC) and Akaike's information criteria (AIC) (Hill et al., 2011).

(iii) Checking the Existence of Co-integration Among the Variables

The ARDL framework for equation (2) is given as follows:

$$\begin{aligned}\Delta C_t = \lambda_0 + \sum_{i=1}^{p1} \delta_i \, \Delta C_{t-i} + \sum_{i=0}^{p2} \varphi_i \, \Delta E_{t-i} + \sum_{i=0}^{p3} \omega_i \, \Delta Trt_{t-i} \\ + \sum_{i=0}^{p4} \gamma_i \, \Delta Y_{t-i} + \sum_{i=0}^{p5} \theta_i \, \Delta Y_{t-i}^2 + \lambda_1 C_{t-1} + \lambda_2 E_{t-1} \\ + \lambda_3 Trt_{t-1} + \lambda_4 Y_{t-1} + \lambda_5 Y_{t-1}^2 + U_t,\end{aligned} \tag{3}$$

where λ_0 is the drift component; and U_t is white noise. The terms with summation signs represent the error correction dynamics; λ_i (i=1-5) corresponds to the long-run relationship; and p_i (i=1-5) is the maximum lag levels of each variable.

The F-test is conducted to test the existence of the long-run relationship among the variables, with the null hypothesis $H_0: \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = 0$ (the nonexistence of the long-run relationship), and the alternative hypothesis is $H_1: \lambda_1 \neq \lambda_2 \neq \lambda_3 \neq \lambda_4 \neq \lambda_5 \neq 0$. The calculated F-statistic value is then compared with two sets of critical values provided by Pesaran et al. (2001). One set assumes that all variables are I(0), and the other assumes they are I(1).

(iv) Estimating Long-run and Short-run Elasticities

Following the selection of the ARDL model by AIC or SC criterion, the long-run relationship among the variables can be estimated by the ordinary least squares (OLS) method for equation (3), and then the ECM framework for equation (3) is estimated using equation (4). The error correction mechanism helps the variables move closely together over time, while allowing for a wide range of short-run dynamics (Engle and Granger, 1987, as cited in Baek, 2013, p. 746). The coefficient of the ECM term is expected to be negative and statistically significant.

$$\Delta C_t = \beta_0 + \sum_{i=1}^{p1} \delta_i \, \Delta C_{t-i} + \sum_{i=0}^{p2} \varphi_i \, \Delta E_{t-i} + \sum_{i=0}^{p3} \omega_i \, \Delta Trt_{t-i} + \sum_{i=0}^{p4} \gamma_i \, \Delta Y_{t-i} + \sum_{i=0}^{p5} \theta_i \, \Delta Y^2_{t-i} + \alpha ECM_{t-1} + U_t, \tag{4}$$

where U_t is the regression error term; and Δ stands for the first difference of the variables. All variables in equations (2), (3), and (4) are in their natural logarithmic form.

(v) Checking the Diagnostics and Stability of the Estimated Model

The selected ARDL specification is checked for robustness and stability.

3.3 Data

The data used in the study cover a 29-year period from 1985 to 2013, obtained from the World Bank's World Development Indicator (2018). The variables in our empirical models are measured by different units. In particular, GDP is in current US$, energy is in kg of oil, CO_2 emissions are in metric tons, and the trade openness ratio is the sum of exported and imported goods and services as a share of GDP. Therefore, we convert all data to the natural log values into a common scale to compare among the variables.

4. Empirical Results

4.1 Unit Root Test

To test the stationarity of the variables in equation (2), we use three different unit root tests: (i) the Augmented-Dickey-Fuller (ADF) test; (ii) the Dickey-Fuller

GLS unit root test; and (iii) the Kwiatkowski-Phillips-Schmidt-Shin (KPSS). The data series at the levels of C_t, E_t, Y_t, Y_t^2, and Tr_t appear to fluctuate around a linear trend. Therefore, the third form of the ADF test, which includes constant and trend terms, is chosen to perform the unit root test for all variables at level. The second form of the ADF test, which includes a constant term, is selected to perform the unit root test for the first difference of variables DC_t, DE_t, DY_t, DY_t^2, and DTr_t, as the visual plots of these variables appear to drift around a constant without a trend (Hill et al., 2011). The lag length is automatically selected by Eviews 9 software based on the Schwarz information criterion. The maximum number of lags is set to be six. Table 2 presents the results of the unit root tests.

Table 2. Unit Root Test Results

t-statistic		lnC_t	lnE_t	$LnTr_t$	LnY_t	LnY_t^2
ADF test	Level	-2.355	-2.198	-2.518	-0.48	-1.806
	1st dif.	-4.358***	-3.44**	-3.978***	-4.012***	-3.86***
Dickey-Fuller GLS(a)	Level	-1.874	-1.861	-2.25	-0.81	-1.81
	1st dif.	-4.339***	-3.46***	-4.93***	-2.45**	-3.52***
KPSS(b)	Level	0.128*	0.165**	0.16*	0.14*	0.15*

Notes: *, **, and *** denote 10%, 5%, and 1% levels of significance, respectively.
(a): Mackinnon (1996) one-sided p-values; (b): LM-statistic.
For the ADF and GLS tests, the null hyphothesis (Ho) presents a unit root. For the KPSS test, the null hyphothesis (Ho) presents stationarity.

The results of unit root tests (see Table 2) for unit root and stationarity on all the variables at the levels and the first differences show that C_t, E_t, Tr_t, Y_t, and Y_t^2 appear to contain a unit root in their levels, but are stationary in their first differences. The null hypothesis is rejected at the 1% level of significance (for C_t, Tr_t, and Y_t^2) and at the 5% level of significance (for E_t), indicating that the variables are integrated of the same order 1 or I(1) according to the results of ADF and Dickey-Fuller GLS tests and I(0) according to the results of the KPSS test. This means that none of the variables is I(2) or beyond I(2), which is eligible for the ARDL estimation technique and the Bounds test (Jajil & Madmud, 2009).

4.2 Selection of ARDL Models

The selection of ARDL models (equation 3) is estimated using the software Eviews 9. Eviews allows users to set a particular lag level or automatically select the lag level within the maximum lags of dependent and independent variables. The levels of lags can be selected differently for each variable. As our sample size is small (29 observations) and to capture the essential lag effects without introducing an excessive number of parameters, we set the maximum number of lags to 4 and then run the model selection downward from 4. Table 3 reports the results of the model selection criterion for the ARDL models.

Table 3. Model Selection Criterion

LogL	AIC	BIC	HQ	Adj. R-sq	Specification
49.58	-3.1987	**-2.811**	-3.087	0.9958	**ARDL (1,0,2,0,0)**(*1)
53.54	**-3.225**	-2.745	-3.082	0.9956	**ARDL(1,2,2,0,0)**(*2)
58.50	-3.222	-2.503	-3.008	**0.9960**	**ARDL(2,2,2,2,2)**(*2)

Notes: AIC – Akaike Information Criterion; BIC – Schwarz Bayesian Criterion; HQ – Hannn-Quinn Information Criterion; LogL – Log likelihood
(*1) – Model is chosen when maximum lags for model selection are set to 2 or 3.
(*2) – Model is chosen when maximum lags for model selection are set to 2.

We evaluate a total of 162 models for the maximum lag 2 and evaluate 768 models for the maximum lag 3. The smallest value of the BIC is -2.811 for the ARDL specification [1,0,2,0,0], and the AIC value (-3.225) is smallest for the ARDL specification [1,2,2,0,0]. The highest adjusted R-squared value, 0.9960, is reported for the ARDL specification [2,2,2,2,2].

It is expected that the energy use coefficient is positive and significant since the more energy that is consumed, the higher are the CO_2 emissions (Ang, 2008; Hossain, 2012; Tan et al., 2014). However, we further find that the energy use (E_t) variable in the long-run relationship with CO_2 emissions is insignificant or has a negative sign in ARDL specifications [1,2,2,0,0] and [2,2,2,2,2]. The finding of the insignificant impact of energy use on CO_2 emissions contradicts the energy literature that fossil fuel consumption is the main source of greenhouse gas emissions (Al-Mulali et al., 2015), and we would expect that the increase in energy use causes the increase in pollution (Anwar and Alexander, 2016), or the higher energy consumption is, the greater are the CO_2 emissions (Linh and Lin, 2014). This indicates that the ARDL specifications [1,2,2,0,0] and [2,2,2,2,2] are inadequate to model the impact of energy use, trade openness, and GDP per capita on CO_2 emissions. This may be because of lag effects of the C_t, E_t, Y_t, and Y_t^2 variables in equation (2). Increasing the length of the lag order leads to an increase in the number of parameters. The excessive number of parameters may lead to the biased least square estimation. Therefore, the ARDL specification [1.0.2.0.0] based on the BIC criterion is selected in order to further examine the dynamic relationship among CO_2 emissions and energy use, trade openness, and GDP per capita in Vietnam.

The above findings are supported by Pesaran and Shin (1999) in that the ARDL-BIC performance is slightly better compared to ARDL-AIC in their study. This may indicate that the Schwarz criterion is a consistent model-selection criterion in the ARDL technique (Pesaran and Shin, 1999, p. 347). Similarly, Jalil and Mahmud (2009) argue that BIC is known as a parsimonious model, since it selects the smallest possible lag length and minimizes the loss of degrees of freedom as well. AIC is also known for selecting the maximum lag length (Jalil and Mahmud, 2009), which may lead to an excessive lag effect of energy use on CO_2 emissions in equation (3).

The estimation equation for the long-run relationships among CO_2 emissions, trade openness, energy use, and per capita income, as specified in the form of ARDL (1,0,2,0,0), is accordingly described in equation (5):

$$C_t = \beta_0 + \beta_1 * C_{t-1} + \beta_2 * E_t + \beta_3 * Tr_t + \beta_4 * Tr_{t-1} + \beta_5 * Tr_{t-2} + \beta_6 * Y_t + \beta_7 * Y_t^2 + \varepsilon, \quad (5)$$

where ε is the error term, which captures all the factors that may affect the CO_2 emissions in Vietnam rather than energy use, trade openness, GDP per capita, and their lags.

4.3 Bound Tests for Co-integration among the Variables of the ARDL Models

We perform the Bound Test to check for the existence of co-integration among the variables and present results in Table 4. The computed F-statistic is larger than the upper bound of the F-test at the 1% level of significance. Thus, we reject the null of no long-run relationship. This implies the CO_2 emissions are jointly affected by per capita income, energy use, and trade openness in the case of Vietnam.

Table 4. Bound Test Co-integration Results

Equation	**Model**	**F-statistic**	**ECT_{t-1}**
Equation 5	ARDL(1.0.2.0.0)	11.05***	-0.585***

Notes: ** and *** denote 5% and 1% levels of significance, respectively.
Null hypothesis - Ho: No long-run relationship exists.
Alternative hypothesis - H1: Long-run relationship exists.

4.4 Results of Equation (5) - ARDL (1.0.2.0.0)

Table 5 lists the long-run and short-run estimation results for equation (3). Table 6 reports the estimated results of the ARDL specification (1.0.2.0.0) for equation (5).

Table 5. Long-run and Short-run Results of Equation (3) - ARDL Model (1.0.2.0.0)

Normalized cointegration - Long-run elasticities			Error-correction model - Short-run elasticities		
Dependent variable: C_t			Dependent variable: DC_t		
Regressors	Coefficient	t-Values	Regressors	Coefficient	t-Values
E_t	1.391	4.861***	DE_t	0.918	3.441***
Tr_t	0.191	2.412**	DTr_t	0.150	1.95*
Y_t	1.916	5.210***	DTr_{t-1}	0.209	4.805***
Y_t^2	-0.139	-4.578***	DY_t	1.136	2.81**
Intercept	-15.92	-9.708***	DY_t^2	-0.082	-2.33**
R-squared = 0.996, F-statistic = 888.5*** DW = 2.23, SSR = 0.034			Intercept	-9.26	-5.12***
			ECM_{t-1}	-0.581	-5.36***

Notes: *, **, and *** represent 10%, 5%, and 1% levels of significance, respectively.
DW indicates Durbin-Watson statistics; SSR stands for sum squared residuals.

Table 6. Estimated Results of Equation (5) - ARDL Model (1.0.2.0.0)

C_{t-1}	E_t	Tr_t	Tr_{t-1}	Tr_{t-2}	Y_t	Y_t^2	β_0
0.399	0.836	0.149	0.177	-0.211	1.151	-0.08	-9.575
(0.001)	*(0.005)*	*(0.03)*	*(0.005)*	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*

Notes: () the number in the parenthesis is the reported p-value.

In terms of long-run elasticity, E_t, Y_t, and Y_t^2 are significant at the 1% level, and Tr_t is significant at the 5% level. For short-run elasticity, the error correction term is negative and significant at the 1% level. The adjusted R-square (0.996) and the F-statistic (significant at the 1% level) indicate that the equation (5) - ARDL model (1.0.2.0.0) can be used to examine the impact of trade openness and energy consumption on the environment.

(i) Impact of Per Capita Income on CO_2 Emissions

We see that Y_t and DY_t are significant at the 1% and 5% levels, respectively (see Table 5), which indicates that per capita income has long-run and short-run positive impacts on CO_2 emissions. This reflects that economic development in Vietnam is accompanied by an increase in CO_2 emissions. The long-run elasticity of CO_2 emissions with reference to economic growth is 1.916, which implies that a 1% increase in per capita income is associated with a 1.916% in CO_2 emissions. The short-run elasticity of economic growth on CO_2 emissions is 1.136, which means a 1% increase in per capita income leads to a 1.136% increase in CO_2 emissions. The accumulative characteristic of pollutants is one of possible explanations for the greater impact of economic development on CO_2 emissions in long-run elasticity than that in short-run elasticity. Environmental quality worsens if the pollutants from production activities cannot be treated efficiently. Another reason could be the poor technology available to treat the production pollutants in Vietnam. Consequently, over time larger CO_2 emissions accumulate in the environment. Tang and Tan (2015) explain that it is hard or almost impossible for Vietnam to immediately learn and adopt advanced environmentally friendly technology or new production techniques that Vietnam benefits from its trading partners.

In the long-run equilibrium (see Table 5), Y_t and Y_t^2 are significant at the 1% level. Moreover, Y_t has a positive sign, and Y_t^2 has a negative sign that shows that the per capita income affects CO_2 emissions in an inverted U-curved function. This finding supports the EKC hypothesis that pollution emissions initially increase with income and then decrease after the income reaches a certain level (Jalil and Mahmud, 2009; Saboori et al., 2012; Baek and Kim, 2013; Ren et al., 2014; Tan et al., 2014).

Our finding is similar to that in Tang and Tan (2015). Using foreign direct investment (FDI) as one of the main determinants of CO_2 emissions, Tang and Tan also show the existence of an inverted U-curved relationship between CO_2 emissions and economic growth in Vietnam. They also note taht the long-run impact of CO_2 emissions as a result of economic growth is 15.851 - 0.918 lnGDP. On the contrary, Linh and Lin (2014) presents that Y_t is positive and Y_t-squared is negative, however, both Y_t and Y_t-squared are statistically insignificant, and thus their result does not support the EKC theory in Vietnam. Al-Mulali et al. (2015) also reject the existence of the EKC theory in Vietnam when the authors assess the impact of energy use, per capita GDP, capital, labor force, and exports and imports on CO_2 emissions. They examine the EKC theory by comparing the short-run and long-run coefficients of GDP impact on CO_2 emissions. They claim that following Narayan and Narayan's (2010) approach, if the long-run income elasticity is smaller than the short-run income elasticity, then over time income leads to less CO_2 emissions. In our view the linear function in Al-Mulali et al.'s study is inadequate to model the relationship among economic development, energy consumption, trade openness, and CO_2 emissions in Vietnam. We find an insignificant impact of energy consumption on CO_2 emissions when the relationship is expressed in a linear function.

(ii) Impact of Energy Consumption on CO_2 Emissions

Per capita energy consumption has significant long-run and short-run impacts on CO_2 emissions. The positive signs of E_t and DE_t indicate a negative impact of energy consumption on CO_2 emissions, as hypothesized, which implies that the more energy that is used, the higher are the CO_2 emissions. Specifically, a 1% increase in per capita energy use leads to an increase of 1.391% in CO_2 emissions in the long run and 0.918% in CO_2 emissions in the short run (see Table 5). The significance of the long-run and short-run relationships between energy consumption and CO_2 emissions strongly suggests the inefficiency of CO_2 treatment of energy use in Vietnam.

(iii) Impact of Trade Openness on CO_2 Emissions

The estimation result shows a negative impact of trade openness on the environment, which means the higher the level of trade openness is, the stronger is the negative impact on the environment. However, the magnitude of this impact on the environment is quite small (marginally). In the short run, a 1% increase in trade openness leads to a 0.150% increase in CO_2 emissions. In the long run, a 1% increase in trade openness leads to a 0.191% increase in CO_2 emissions (see Table 5).

In terms of the lag effects, the impact of trade openness on CO_2 emissions in Vietnam does not occur instantaneously, but is distributed over two future time periods. More specifically, a 1% increase in trade openness leads to a 0.149% increase in CO_2 emissions in the same year, a 0.177% increase in CO_2 emissions one year later, and a 0.211% decrease in CO_2 emissions two years later. The coefficient of the lag two of trade openness has a negative sign (-0.211) and is significant at the 1% level, indicating that the impact of trade openness on CO_2 emissions is estimated to reverse from negative to positive after a two-year period.

In a different specification of trade openness by using FDI, Tang and Tan (2015) find a negative elasticity of FDI on CO_2 emissions, even though the magnitude of the impact is very small (-0.065%). Moreover, they fail to find any significant evidence of the impact of FDI on CO_2 in the short run. Similarly, Linh and Lin

(2014) also note a negative and insignificant value of the FDI coefficient (-0.008%), which implies there is no evidence to show FDI is elastic in reducing CO_2 emissions.

To the best of our knowledge, the only published study on the same topic employing a trade openness ratio as a proxy for trade liberalization in Vietnam is that of Anwar and Alexander (2016). They also find a long-run impact of trade openness on CO_2 emissions at a rate of 0.374%. Thus, a 1% increase in trade openness leads to a 0.374% increase in CO_2 emissions in the long run. Anwar and Alexander apply a monotonic function to describe the relationship between CO_2 emissions and real national income. Monotonic function-based models are excluded from our study due to the insignificance of energy impact on CO_2 emissions.

(iv) Adjustment Speed from a Shock to Long-run Equilibrium

The coefficient of ECM (-0.581) is negative and significant at the 5% level, which suggests that a deviation from the long-run equilibrium level of CO_2 emissions in one year corrects by 58.1% over the following year. This finding is consistent with Tang and Tan (2015), who find the coefficient of ECM is -0.641, which implies that if the system is exposed to a shock, then it takes about one and a half years to return to the long-run equilibrium. The finding of Anwar and Alexander (2016) is far higher than our finding, which shows that at a 1% level of confidence the pollution in Vietnam can return to its equilibrium at a ratio 0.923. This means the pollution in Vietnam responds quickly to any shocks, and about 92.3% of the adjustment can be made within a year.

4.5 Granger Causality Test

We proceed to examine whether CO_2 emissions impact trade openness and per capita income or vice versa by the Granger causality test. Table 7 shows the F-statistic and probability of the Granger causality test under the null hypothesis of no causality.

Table 7. Pair Wise Granger Causality Tests

Null hypothesis	F-statistic	Prob.
Tr_t does not Granger cause C_t	10.034	0.0008
C_t does not Granger cause Tr_t	5.718	0.01
Y_t does not Granger cause C_t	4.55	0.04
C_t does not Granger cause Y_t	7.014	0.01

Note: Ho: there is no Granger causality.
H1: there is Granger causality.

The Granger causality test shows bi-direction causality between trade openness and CO_2 emissions and between per capita income and CO_2 emissions in Vietnam under the 29-year period of our study.

4.6 Test of Goodness of Fit of the ARDL Specification [1,0,2,0,0] – Equation (5)

In terms of the goodness of fit, equation (5) - [ARDL (1.0.2.0.0)] passes the diagnostic tests, including being free of serial correlation, heteroscedasticity, and the normality of residuals (see Table 8).

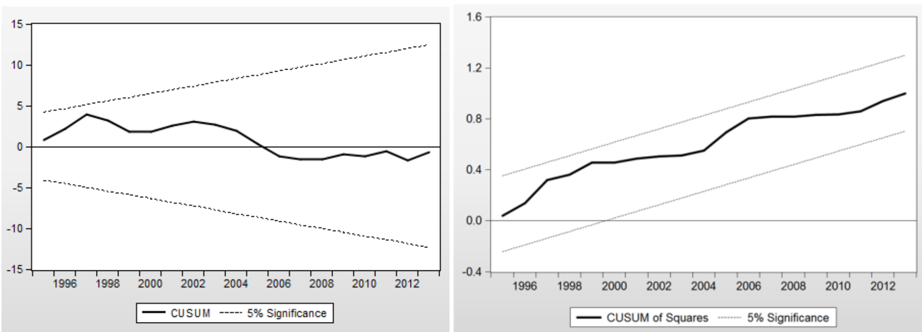
Table 8. Diagnostic Tests

Lagranger Multiplier Test (*)		Breusch-Pagan-Godfrey Heteroscedasticity Test (**)		Normality Test	
F-statistic	0.4017	F-statistic	0.619		
Obs R-squared	1.218	Obs. R-squared	0.5018		
Prob. F(2,17)	0.6754	Prob. F(7.19)	0.7334	Jarque-Bera	0.67
Prob. Chi-Square	0.5438	Prob. Chi-Square(7)	0.6577	Prob.	0.71

Note: (*) Ho: there is no serial correlation in the residuals up to lag 2.
(**) Ho: there is no heteroscedasticity.

We finally perform the test on the stability of the short-run movement and the long-run equilibrium for the equation (5) - ARDL (1.0.2.0.0). The model is tested by using the cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMSQ) tests. The results appear in Figure 2, in which the straight dotted lines represent critical bounds at the 5% level of significance. The plots of CUSUM and CUSUMSQ statistics from the ECM model are well within the 5% significance lines, indicating that equation (5) can be used to model the impact of energy use, trade openness, and per capita income on CO_2 emissions in Vietnam.

Figure 2. Plots of the Cumulative Sum of Recursive Residuals and Square Recursive Residuals



Notes: CUSUM - Cumulative sum of recursive residual.
CUSUM of Squares - Cumulative sum of square recursive residual.

5. Conclusions and Policy Implications

Driven by the limited number of studies and their inconsistent results on the impact of trade liberalization on Vietnam’s environment, particularly the lack of empirical evidence on the possibility of rehabilitating the environment and improving the efficiency of energy use during the country’s trade liberalization, this study investigates the effect of trade openness on the environment (measured by

CO_2 emissions) and the EKC hypothesis in Vietnam over the last 30 years. Vietnam has experienced outstanding performances in economic development and trade liberalization since 1986. In particular, it exhibits huge potential to be much more open to trade when the country negotiates free trade agreements with developed economies, such as the United States, European Union countries, Canada, and Japan. This case study on Vietnam's economy contributes significantly to the literature in terms of the possibility to protect and rehabilitate the environment during developing countries' economic development. Taking into consideration the dynamic and comprehensive effects (scale, composition, and technical effects) of economic development, trade liberalization, and energy consumption on CO_2 emissions in Vietnam, this study also provides evidence and recommendations to reduce CO_2 emissions as a consequence of the country's own economic development.

First, the study's results reveal that trade openness has a negative impact on CO_2 emissions and that an increase in free trade activities brings more CO_2 emissions into Vietnam's environment. The impact of trade openness on its CO_2 emissions does not occur instantaneously, but is distributed over two future time periods. The impact of trade openness on CO_2 emissions is estimated to reverse from negative to positive after a two-year period. More specifically, in terms of the lag effect, a 1% increase in trade openness leads to a 0.149% increase in CO_2 emissions in the same year, a 0.177% increase in CO_2 emissions one year later, and a 0.211% decrease in CO_2 emissions two years later. The positive effect of trade openness may occur due to the technology transfer from Vietnam's trading partners. Alternatively, trade liberalization enables Vietnam to equip itself with advanced technology in its domestic productions and to reduce CO_2 emissions.

Our explanation can, in fact, be supported by some studies in the literature in which technological evolution is more likely to happen during the implementation of trade policy (Cole and Elliott, 2003; Tang and Tan, 2015; UNEP, 2005; Wu, 2017). This indicates a positive signal for Vietnam to continue opening up to trade in a sustainable manner by integrating environmental protection requirements into free trade policy. Vietnam is experiencing a thriving trend in negotiating free trade agreements, and thus the country should take the advantages of trade openness to protect its environment. This could be achieved by efficiently adopting several measures, such as the promulgation of stricter requirements on environmental protection during trade and production activities; investing in and adopting environmentally friendly technology to be applied in domestic production activities; and improving the implemention efficiency of environmental protection requirements. This finding is supported by Campbell (2003), whereby firms will only invest in new technology when environmental regulations are put in place with tariff protection. However, without tariff protection, firms will invest in new technology irrespective of whether environmental regulations are in place.

Second, the positive sign of per capita income and the negative sign of square of per capita income indicate that the relationship between per capita income and CO_2 emissions in Vietnam can be expressed in an inverted U-curve that reflects the existence of the EKC theory in this study, where CO_2 emissions increase at the initial stage of economic growth and decrease thereafter. The EKC theory may help to explain the negative impact of economic development on the environment in Vietnam. This means at the beginning stage of economic development, the country relies heavily on nature or trades off the environment for economic benefits.

While the study shows the existence of the EKC theory in Vietnam, it does not indicate that there exists a simple way to rehabilitate the environment simply by developing the economy further. The reason is due to the complicated interaction among the scale, technique, and composition effects of economic development on the environment. Vietnam has comparative advantages in international trade due to its abundant natural resources, low labor cost, and favorable geographic conditions; thus, Vietnam may develop further the production of naturally-intensive sectors as a result of trade openness. In other words, the domestic production pattern of Vietnam may change towards environmentally-intensive sectors. Therefore, in order to efficiently protect the environment, Vietnam needs to invest in energy efficient technology and move toward a low carbon economy, as well as strictly monitor the implementation of environmental protection requirements in production activities.

Third and finally, the empirical results reflect the need to improve the efficiency of environmental protection measures in production in Vietnam due to high CO_2 emissions as a result of energy consumption. Based on the forecasts of Vietnam's electricity production and the National Electricity Development Program for the 2006-2030 period, thermal and hydroelectricity remain Vietnam's main sources of electricity. Of these, coal thermal power accounts for 49.3% of the power infrastructure in 2020. The exploitation of coal, crude oil (domestic and import sources), and gas will continue in the decades to come (GoV, 2017). With the heavy dependency on fossil fuel, it is likely that the environmental quality in Vietnam can be improved with cleaner and energy efficient technology along with improved implementation efficiency of environmental requirements during the production activities.

In summary, this study contributes to the limited studies on the effect of economic development, trade liberalization, and energy use on the environment in Vietnam. The study provides significant evidence and recommendations to protect the environment and reduce CO_2 emissions as a result of production activities in Vietnam. The findings herein reveal that Vietnam's environment would improve if environmental protection is integrated into free trade policy and by increasing energy use efficiency. While the EKC theory exists in Vietnam, which indicates a possibility for rehabilitating the environment at a higher economic development level, Vietnam needs to take full advantage of any economic development and trade liberalization to build a cleaner domestic production system, adopt energy efficient and environmentally friendly technology, and implement environmental protection requirements in production and trading activities.

References

Akbostancı, E., S. Türüt-Aşık, and G. İ. Tunç, (2009), "The Relationship between Income and Environment in Turkey: Is There an Environmental Kuznets Curve?" *Energy Policy*, 37(3), 861-867.

Al-Mulali, U., B. Saboori, and I. Ozturk, (2015), "Investigating the Environmental Kuznets Curve Hypothesis in Vietnam," *Energy Policy*, 76, 123-131.

Ang, B., (2008), "Economic Development, Pollutant Emissions and Energy Consumption in Malaysia," *Journal of Policy Modeling*, 30(2), 271-278.

Antweiler, W., B. Copeland and S. Taylor, (2001), "Is Free Trade Good for the Environment," *The American Economic Review*, 91(4), 877-907.

Anwar, S. and W. Alexander, (2016), "Pollution, Energy Use, GDP and Trade: Estimating the Long-run Relationship for Vietnam," *Applied Economics*, 1-12.

Baek, J., Y. Cho, and W. Koo, (2009), "The Environmental Consequences of Globalization: A Country-Specific Time-Series Analysis," *Ecological Economics*, 68(8-9), 2255-2264.

Baek, J. and S. Kim, (2013), "Is Economic Growth Good or Bad for the Environment? Empirical Evidence from Korea," *Energy Economics*, 36, 744-749.

Baghdadi, L., I. Martinez-Zarzoso, and H. Zitouna, (2013), "Are RTA Agreements With Environmental Provisions Reducing Emissions?" *Journal of International Economics*, 90(2), 378-390.

Campbell, N., (2003), "Does Trade Liberalization Make the Porter Hypothesis less Relevant?" *International Journal of Business and Economics*, 2(2), 129-140.

Carrapatoso, A., (2008), "Environmental Aspects in Free Trade Agreements in the Asia-Pacific Region," *Asia Europe Journal*, 6(2), 229-243.

Cole, M. and R. Elliott, (2003), "Determining the Trade-Environment Composition Effect: the Role of Capital, Labor and Environmental Regulations," *Journal of Environmental Economics and Management*, 46(3), 363-383.

Cole, M., (2003), "Development, Trade and the Environment: How Robust is the Environmental Kuznets Curve?" *Environment and Development Economics*, 8(4), 557-580.

Coxhead, I. and S. Jayasuriya, (2003), *The Open Economy and the Environment: Development, Trade and Resources in Asia*, Edward Elgar Publishing, Inc.

Dinda, S., (2004), "Environmental Kuznets Curve Hypothesis: A Survey," *Ecological Economics*, 49(4), 431-455.

Delpachitra, S. and V. D., Pham, (2012), "The Determinants of TFP Growth in Middle Income Economies in ASEAN: Implication of Financial Crisis," *International Journal of Business and Economics*, 11(1), 63-68.

Engle, R. and C. Granger, (1987), "Cointegration and Error-Correction: Representation, Estimation and Testing," *Econometrica*, 55, 251–276.

Farhani S., A. Chaibi ,and C. Rault, (2014), "CO_2 Emission, Output, Energy Consumption, and Trade in Tunisia," *Economic Modelling*, 38, 426-434.

Fauchald, O. and H. Vennemo, (2011), *Environmental Impacts of a Free Trade Agreement between China and Norway - Methodology Framework*, Fridtjof Nansen Institute Report.

GoV, (2017), Decision No. 428/QD-TTg dated 18/3/2016 Approving the Adjustment of the National Energy Development Planning in the Period 2011-2020 with the Vision to 2030, https://policy.asiapacificenergy.org/node/2760.

GoV, (2018), Vietnam World Trade Organisation Center, [Online] (accessed on 04 September 2018), http://wtocenter.vn/fta.

Grossman, G. and A. Krueger, (1991), "Environmental Impacts of a North American Free Trade Agreement," NBER Working Paper, No. 3914.

Grossman, G. and A. Krueger, (1995), "Economic Growth and the Environment," *The Quarterly Journal of Economics*, 353-377.

Halicioglu, F., (2009), "An Econometric Study of CO_2 Emissions, Energy Consumption, Income and Foreign Trade in Turkey," *Energy Policy*, 37(3), 1156-1164.

Hill, C., W. Griffiths, and G. Lim, (2011), *Principles of Econometrics*, Fourth Edition, John Wiley & Sons, Inc.

Honma, S. and Y. Yoshida, (2011), "Did International Trade Become Dirtier in Developing Countries? On the Composition Effect of International Trade on the Environment", *Faculty of Economics Discussion Paper*, Kyushu Sangyo University, No. 52.

Hossain S., (2012), "An Econometric Analysis for CO_2 Emissions, Energy Consumption, Economic Growth, Foreign Trade and Urbanisation of Japan," *Low Carbon Economy*, 3, 92-105.

Jalil, A. and S. Mahmud, (2009), "Environment Kuznets Curve for CO_2 Emissions: A Cointegration Analysis for China," *Energy Policy*, 37(12), 5167-5172.

Jayadevappa, R. and S. Chhatre, (2000), "International Trade and Environmental Quality: A Survey," *Ecological Economics*, 32, 175-194.

Kohler, M., (2013), "CO_2 Emissions, Energy Consumption, Income and Foreign Trade: A South African Perspective," *Energy Policy*, 63, 1042-1050.

Kuznet, S., (1955), "Economic Growth and Income Inequality," *American Economic Review*, 49, 1-28 .

Linh, D. and S. Lin, (2014), "CO_2 Emission - Energy - Economic Growth and FDI in Vietnam," *Managing Global Transtitions*, 12(3), 219-232.

Managi, S., A. Hibiki, and T. Tsurumi, (2009), "Does Trade Openness Improve Environmental Quality?" *Journal of Environmental Economics and Management*, 58(3), 346-363.

Mukhopadhyay, K. and P. Thomassin, (2010), "Impact of Regional Economic Integration in East Asia," *International Economic Journal*, 24(2), 125-153.

Muradian, R. and J. Martinez-Alier, (2001), "Trade and the Environment: From a "Southern" Perspective," *Ecological Economics*, 36, 281-297.

Narayan, K. and S. Narayan, (2010), "Carbon Dioxide Emissions and Economic Growth: Panel Data Evidence from Developing Countries," *Energy Policy*, 38(1), 661–666.

Pesaran, M. and B. Pesaran, (1997), *Mirocofit 4.0: Interactive Econometric Analysis (Windows Version)*. Oxford University Press.

Pesaran, M. and Y. Shin, (1999), "An Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis. in S Strom (ed.)," *Econometrics and Economic Theory in the 20th century: The Ragnar Frish Centennial Symposium*, Cambridge University Press, 371-413.

Pesaran, M., Y. Shin and R. Smith, (2001), "Bounds Testing Approaches to the Analysis of Level Relationships," *Journal of Applied Econometrics*, 16, 289-326.

Ren, S., B. Yuan, X. Ma, and X. Chen, (2014), "International Trade, FDI (Foreign Direct Investment) and Embodied CO_2 Emission: A Case Study of Chinas Industrial Sectors," *China Economic Review*, 28, 123-134.

Repetto, R., (1994), "Trade and Sustainable Development," *Environment and Trade Series*, Vol. 1, United Nations Environment Programme, Geneva.

Saboori, B., J. Sulaiman, and S. Mohd, (2012), "Economic Growth and CO_2 Emissions in Malaysia: A Cointegration Analysis of the Environmental Kuznets Curve," *Energy Policy*, 51, 184-191.

Stern, D. I., (2003), "The Environmental Kuznets Curve," *International Society for Ecological Economics*.

Strutt, A. and K. Anderson, (2000), "Will Trade Liberalization Harm the Environment? The Case of Indonesia to 2020," *Environmental and Resource Economics*, 17, 203-232.

Tan, F., H. Lean and H. Khan, (2014), "Growth and Environmental Quality in Singapore: Is There any Trade-off?" *Ecological Indicators*, 47, 149-155.

Tang, F. and B. Tan, (2015), "The Impact of Energy Consumption, Income and Foreign Direct Investment on Carbon Dioxide Emissions in Vietnam," *Energy*, 79, 447-454.

UNEP, (2000), "*Environment and Trade - A Hand Book*", Canada.

UNEP, (2005), *"Environment and Trade - A Hand Book - Second Edition*", Canada.

WDI, (2018), The World Bank - World Development Indicators, Washington, DC [Online] (accessed on 04 September 2018), https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?locations=VN.

Wu, W. L., (2017), "Institutional Quality and Air Pollution: International Evidence," *International Journal of Business and Economics*, 16(1), 49-74.

Zimmer, A., M. Jakob and C. Steckel, (2014), "What Motivates Vietnam to Strive for a Low-Carbon Economy? – On the Drivers of Climate Policy in a Developing Country," *Energy for Sustainable Development*, 24, 19-32.