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**Provided in Cooperation with:** International Journal of Energy Economics and Policy (IJEEP)

*Reference:* Ngo Ngoc Minh (2020). Foreign direct investment and carbon dioxide emissions : evidence from capital of Vietnam. In: International Journal of Energy Economics and Policy 10 (3), S. 76 - 83. https://www.econjournals.com/index.php/ijeep/article/download/9023/4970. doi:10.32479/ijeep.9023.

This Version is available at: http://hdl.handle.net/11159/8329

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Leibniz-Informationszentrum Wirtschaft Leibniz Information Centre for Economics



INTERNATIONAL JOURNAL

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http://www.econjournals.com

International Journal of Energy Economics and Policy, 2020, 10(3), 76-83.



# **Foreign Direct Investment and Carbon Dioxide Emissions: Evidence from Capital of Vietnam**

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Received: 24 October 2019

Accepted: 16 January 2020

DOI: https://doi.org/10.32479/ijeep.9023

#### ABSTRACT

The purpose of this paper is to investigate the relationship between carbon dioxide  $(CO_2)$  emissions, foreign direct investment (FDI), income per capita and energy consumption (EC) in the capital of Vietnam from 1990 to 2015. The empirical results indicate that EC is a major contributor of environmental degradation while FDI marginally contribute to the current status. Moreover, a one-way causality is found to be running from carbon dioxide (CO<sub>2</sub>) emissions, EC, FDI to income in the long-run. Then, the new empirical findings suggest that municipal government should make urgent regulations to drastically the EC especially for private cars and motorbikes to improve environmental quality in Hanoi.

Keywords: Income Per Capita, Inward Foreign Direct Investment, Energy Consumption, CO<sub>2</sub> Emissions, Hanoi Capital, Vietnam JEL Classification: F21, O44, Q43

### **1. INTRODUCTION**

Since 1986, Vietnam has implemented economic reforms, moving from a centrally-planned economy to market-oriented one. This process have prompted rapid economic growth and transformed Vietnam from one of the world's poorest to a lower middleincome country. Hanoi's economy, capital of Vietnam, is played an important role to attract local and foreign investment and is a driving force behind that impressive growth. By the end of 2015, there was approximately USD 20 billion of disbursed foreign direct investment (FDI) in Hanoi. The FDI capital helped, to a certain extent, increase gross domestic product (GDP) per capita from around USD 1,000 to USD 2,324 between 1990 and 2015. The average growth rate of the economy was 12.2% from 1990 to 1997. Due to the Asian financial crisis in 1998, the growth rates decreased slightly in three subsequent years but picked up its momentum to reach the highest rate 12.5% in 2007. On average, the annual growth rate is 10.5% in the period from 1998 to 2015. Simultaneously, the level of environmental pollution in Hanoi has remarkably increased as a result of increase in energy consumption (EC) and rapid economic growth. Major sources of environmental degradation in Hanoi are construction, transport and industrial activities. Over the past two decades the average rate of  $CO_2$  emissions is approximately 13% per annum.

Hanoi is a rapidly growing city and currently more than 1,000 construction projects are underway. Metro projects are being carried out in Hanoi, which have also contributed to more serious air pollution as well as traffic congestion. The traffic congestion is becoming severe as around 20,000 new motorbikes and around 8000 new cars are registered in the city every month. These numbers are predicted to rise when several vehicle taxes are to be abolished in 2018. Consequently, there will be nearly one million cars and seven million motorbikes by 2020 in the city. In meantime, by the end of 2015, there are approximately 2600 foreign invested enterprises operating in Hanoi. Obviously, these enterprises are playing an important role in speeding up economic growth evidenced by overwhelming export share, employment, contributions to economic restructuring toward industrialization and modernization. However, there also exists the fact that many foreign invested enterprises have imported substandard-obsolete and outdated-technology equipment. Experts warned that if the

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alarming pollution problems are not addressed, in near future, Hanoi might become as polluted as New Delhi and Karachi, two of the ten most polluted cities in the world. Therefore, these facts asking for the investigation of the impact of FDI, income per capita and EC on  $CO_2$  emissions in Hanoi and whether the EKC hypothesis prevails in case of Hanoi. This is the first study to investigate the EKC hypothesis in FDI and EC context for Hanoi.

The paper is structured in such a way that next section will review some relevant empirical studies while the empirical model of the study based on literature and data will be described in third section. Fourth section will present methodology along with interpretation of the results. Conclusions and policy implications are described in the last section of the paper.

#### **2. LITERATURE REVIEW**

Since 1991, the relationship between environmental degradation and economic growth received great concern from researchers. The past literature on this nexus can be categorized into main three strands. The first strand of literature revolves around the testing of EKC hypothesis. The second strand of literature takes into account the role of energy in the growth-emissions relationship while third strand of literature discusses other important determinants of environmental degradation along with income and energy. Although, the significant number of studies agrees that FDI is playing a prominent role in uplifting of the economic growth in host countries, however, FDI as a potential factor of environmental degradation is debated in the literature and its effect on the host country's environment is uncertain. Two prominent and opposite arguments are existing in the literature concerning the relationship between environment and FDI. First, "Pollution Haven Hypothesis" confirms that multinational corporations tend to transfer pollution-intensive technologies from developed to developing countries where environmental regulations are not strictly followed and are less stringent. Second, "Pollution Halo Hypothesis" suggests that the influx of FDI enhances the environmental norms in the host country by bringing cleaner and energy efficient technology and by adopting better environmental management system.

The nexus between environmental degradation and income is hypothesized as EKC hypothesis. The main idea of EKC theory is that in the early phases of economic development, environmental degradation rises with rise in income and after a certain level of income are attained, environmental degradation starts to decline. In other words an inverted U-shape relationship is present between environmental degradation and income. A considerable amount of research papers analyzed the EKC hypothesis and environmental degradation is proxy by either CO<sub>2</sub> emissions or any other element, for instance, nitrous oxide (N<sub>2</sub>O), sulfur dioxide (SO<sub>2</sub>), and methane (CH<sub>4</sub>). This theory has been explained well in the pioneering work of Grossman and Krueger (1991) and it was followed by numerous empirical studies to check the existence of EKC hypothesis such as Lucas et al. (1992), Shafik and Bandyopadhyay (1992), Heil and Selden (1999), Friedl and Getzner (2003), Nohman and Antrobus (2005), Dinda and Coondoo (2006), Coondoo and Dinda (2008), Nasir and Rehman (2011), Shahbaz et al. (2013), Shahbaz et al.

(2016), Haq et al. (2016), Solarin et al. (2017), Salahuddin et al. (2018) among others. However, empirical studies indicate mixed evidences about the existence of the EKC hypothesis. This paper will restrict itself to and will briefly summarize the research papers about the EKC hypothesis and the impacts of EC and FDI on  $CO_2$  emissions in some typical countries.

Salahuddin et al. (2018) investigate the impacts of economic growth, electricity consumption, FDI, and financial development on CO<sub>2</sub> emissions in Kuwait in the period 1980-2013. To this end, they used autoregressive distributed lag (ARDL) bounds testing approach and found that economic growth, electricity consumption, and FDI stimulate CO<sub>2</sub> emissions in both the short and long runs. The VECM Granger causality analysis revealed that FDI, economic growth, and electricity consumption strongly Granger-cause CO<sub>2</sub> emissions. Solarin et al. (2017) investigate the pollution haven hypothesis (PHH) in Ghana in 1980-2012 period. To this end, by using the autoregressive distributed lag (ARDL) method, they found the existence of long-run relationship between the variables. Moreover, GDP, FDI, urban population, financial development and international trade positively impact on CO<sub>2</sub> emission, while institutional quality decreases emissions. The empirical results demonstrate that PHH does exist in Ghana.

Saboori et al. (2012) employs time series data on CO<sub>2</sub> emissions and income in Malaysia to test EKC hypothesis through ARDL technique over the period 1980-2009. The results indicate that there exists inverted U-shape nexus between income and CO<sub>2</sub> emissions. Shahbaz et al. (2013) also supports this conclusion. On the contrary, Azlina et al. (2014) employ time series data and find out that a U-shape relationship is prevailing in Malaysia when investigating the causal nexus between income, EC and CO<sub>2</sub> emissions. Empirical studies about China also yield the same inconclusive results. Song et al. (2008), Dhakal (2009), Jalil and Mahmud (2009), Zhang and Cheng (2009) support the view that EKC hypothesis exists in China while the finding of the study of Wang et al. (2011) is contrary to EKC hypothesis. Same can be concluded about the Turkish economy as empirical studies are inconclusive about the presence of the EKC hypothesis in Turkey. Halicioglu (2009) investigates the dynamic links among variables such as income, EC, foreign trade, CO, emissions and find support for the EKC hypothesis. Ozturk and Acaravci (2013) examine the EKC hypothesis by applying data of income, energy, trade openness, and CO<sub>2</sub> emissions over the period from 1960 to 2007. Their results indicate the presence of the EKC hypothesis in the long-run. Cil (2014) documents the existence of EKC hypothesis in the long-run along with EC as a control by employing time series data from 1960 to 2007. In more recent work, Seker et al. (2015) investigate the causal nexus between EC, FDI, income, and CO, emissions. They also find that EKC hypothesis is valid not just in the long-run but in the short-run as well. The studies carry out by Lise (2006) and Akbostanci et al. (2009) conclude that there is no evidence in support of EKC hypothesis despite of applying the different methodologies.

In Pakistan, Nasir and Rehman (2011) investigate the causal link between  $CO_2$  emission, EC, trade openness and income. They find out an inverted U-shape relationship between  $CO_2$  emission

and income in the long-run, so, the EKC hypothesis holds in Pakistan. This conclusion was reaffirmed in the papers of Ahmed and Long (2012), and Shahbaz et al. (2012). Subsequently, for the Mongolian economy, the study of Ahmed (2014) finds support for the existence of EKC hypothesis.

This paper can find studies that investigated the determinants of environmental degradation in Southeast Asia, for example, in the case of Cambodia; the EKC hypothesis is tested for Cambodia by Ozturk and Al-Mulali (2015). In their paper, they investigate income-energy-emission nexus along with urbanization, good governance, and control of corruption. They find U-shape relationship between carbon emissions and income, thus, results of their study do not support presence of EKC hypothesis in Cambodia. They also conclude that good governance and control of corruption improve environmental degradation in Cambodia.

By adopting ARDL bounds testing approach for five Asian countries, Merican et al. (2007) indicate that FDI inflows has worsen the environmental quality in Thailand, Malaysia and Philippines whereas it has improved environment quality in Indonesia. In case of Singapore, the effect of FDI on environment is not significant. Lean and Smyth (2010), also utilize the panel data for five Asian economies, find out a long-run nexus between CO<sub>2</sub> emissions, EC and income. Similarly, Chandran and Tang (2013) also apply Johansen co-integration and causality tests for selected South-East Asian countries to test the validity of EKC hypothesis. They assert that EKC hypothesis is not valid, furthermore, the causality analysis reveals that FDI granger causes CO<sub>2</sub> emissions in Malaysia and Thailand in the longrun while bidirectional causality exists between FDI and CO, emissions in the case of Indonesia. In a time series study for Malaysia, Lee (2009) examines the relationship between FDI and CO<sub>2</sub> emissions through ARDL bounds test. The results reveal no long-run relationship between aforementioned variables however; FDI is causing CO<sub>2</sub> emissions in the short-run. In another time series study for Malaysia, Hitam and Borhan (2012) find out that FDI is worsening the environmental quality. Zhang (2011) study the effect of FDI on environment in case of China. His results affirm no co-integration and causality between FDI and CO<sub>2</sub> emission. Tang et al. (2016) analyse the relationship between EC and economic growth in Vietnam using the neoclassical Solow growth framework for the 1971-2011 period. The results confirm the existence of cointegration among the variables. In particular, EC, FDI and capital stock were found positively influence economic growth in Vietnam. The Granger causality test revealed unidirectional causality running from EC to economic growth.

This paper only figured out few studies that tested the EKC hypothesis in Vietnam so far. Dinh and Lin (2014) examine the dynamic relationships between  $CO_2$  emissions, income, EC, and FDI. They conclude that EKC hypothesis does not prevail in case of Vietnam. In another study, Al-Mulali et al. (2015) also study the EKC hypothesis for Vietnam. The paper does not affirm the existence of EKC but conclude that GDP has positive impact on  $CO_2$  emission in the long-run and short-run. Tang and Tan

(2015) find the relationship between income and CO<sub>2</sub> emissions as predicted in EKC hypothesis thus; they conclude EKC hypothesis exists in case of Vietnamese economy. Moreover, find that FDI is an important factor of environmental degradation and bidirectional causality is present between FDI and CO<sub>2</sub> emissions. Long et al. (2018) examine the causal relationship between electricity consumption, FDI and economic growth in Vietnam in the period of 1990-2015. By using Toda-Yamamoto approach and autoregressive distributed lag approach, the empirical results provide strong evidence to demonstrate that electricity consumption and FDI positively impact on economic growth in Vietnam in both short and long-runs. And most recently, Phuong and Tuyen (2018) examine the relationship among economic growth, environmental pollution and FDI in Vietnam for the period 1986-2015. By using ARDL approach, the empirical results demonstrate the inverse U-shape exists. Moreover, they found the turning point of GDP per capita is about 3145 USD a year. This study suggests that policy-makers should control strictly the environmental standards in the direction of improving environmental quality and further attract green FDI to ensure sustainable economic development.

From the empirical papers discussed above, it can be asserted that the determinants of environmental degradation grabbed attention from the researchers in case of Vietnamese economy. These studies are inconclusive about the existence of the EKC hypothesis in Vietnam and also about the role of FDI as a potential determinant of environmental degradation. This study also adds to the existing literature on environmental degradation in the Vietnamese perspective however; this study is different in the sense from existing literature that it investigates the relationship between  $CO_2$  emission, income per capita, EC, and FDI in case of Vietnam's capital, Hanoi-where recently considered as the second polluted capital in South-East Asia. Thus, it is the first study that will examine the EKC hypothesis for Hanoi and investigate the role of FDI in environmental degradation in a city of Vietnam.

#### **3. MODEL AND DATA**

This study develops the hypothesis model based on past literature discussed earlier. The hypothesis model of this study is presented in Equation 1 in which  $CO_2$  emissions is the function of EC, FDI, GDP and its square.

$$CO_{2t} = f(EC_t, FDI_t, GDP_t, GDP_t^2)$$
 (1)

Taking natural logarithm of both sides of Equation 1 becomes as shown in Equation 2 as follows:

$$LCO_{2t} = c_0 + \alpha_1 LEC_t + \alpha_2 LFDI_t + \alpha_3 LGDP_t + \alpha_4 LGDP_t^2 + \varepsilon_t$$
(2)

Where as  $CO_2$  is per capita  $CO_2$  emissions and it is measured in metric tons,  $EC_1$  is per capita EC and it is measured in kilogram of oil equivalent,  $FDI_1$  is per capita implemented FDI and is measured in USD. Similarly,  $GDP_1$  is per capita real GDP in

USD, GDP<sub>t</sub><sup>2</sup> is squared of per capita real GDP. Furthermore, L presents the natural log of the respective variable and  $\varepsilon_t$  is the error term. All parameters  $\alpha_1$ ,  $\alpha_2$ ,  $\alpha_3$ ,  $\alpha_4$  are the long run elasticities of CO<sub>2</sub> emissions with respect to LEC<sub>t</sub>, LFDI<sub>t</sub>, LGDP<sub>t</sub> and LGDP<sub>t</sub><sup>2</sup>, respectively. For the EKC hypothesis to be valid, the expected sign of  $\alpha_3$  and  $\alpha_4$  have to be positive and negative, respectively.

Data for this research study has been gathered from various sources. Annual data on FDI and GDP is collected from General Statistical Office of Vietnam; data on  $CO_2$  emissions is taken from Hanoi Environment and Natural Resources Department; whereas data on EC is collected from Hanoi Statistical Office and The Office of World Bank in Vietnam. Table 1 describes the descriptive statistics of the time data. Based on Jarque-Bera test, the study arrives at a conclusion that all the series of the model are normally distributed with zero mean and constant variance. The correlation matrix indicates a positive correlation among variables of the study.

## 4. METHODOLOGY AND EMPIRICAL RESULTS

The paper employs autoregressive distributed lagged (ARDL), also known as the bounds test, to study the long-run relationship between carbon emissions, FDI, EC, and income. This cointegration technique is widely considered the most successful and flexible for measuring the impact of independent variable (s) on a dependent variable in a time series data. ARDL is selected because of the following advantages: it requires a much smaller sample size compared to other co-integration tests; it allows variables to have different optimal lag while it is not possible in conventional co-integration tests; the ARDL employs only a single reduced form equation compare to conventional co-integration tests which estimate the long-run relationship within a context of system of equations; and simultaneously, it gives the short-run and long-run estimates.

#### 4.1. Unit Root Test

Although the ARDL framework does not call for the pre-testing of the non-stationarity problem of variables, however, it is still essential to determine order of integration. This is to ensure that the variables are not integrated of higher order than one. The prerequisite of this approach is that variables either has to be integrated of order zero or order one or combinations of both but none of the variables has to be integrated of higher order than one because the computed F-statistics provided by Pesaran et al. (2001) is not valid in case of integration of order two or higher. This study applies the augmented Dickey-Fuller (ADF) and Phillip-Person (PP) tests to check the stationarity of the variables. The results of these stationarity tests are presented in Table 2. It is observed, all variables are non-stationary in level form but all of them are stationary at first difference thus; variables are integrated of order one, I (1).

#### 4.2. Bounds Test

According to the ARDL approach, lag order of the variables is important for the model specification. This study applies Akaike

Table 1: Descriptive statistics and correlation matrix

-				
LCO <sub>2</sub>	LEC	LFDI	LGDP	LGDP <sup>2</sup>
0.1978	3.0573	4.1916	7.4508	55.5350
0.4753	0.7192	1.0613	0.1475	2.2103
0.8638	3.1165	2.2336	2.2353	2.3180
0.6493	0.2105	0.3273	0.3270	0.3138
1.0000				
0.9642	1.0000			
0.5203	0.3821	1.0000		
0.9181	0.8917	0.5497	1.0000	
0.9166	0.8904	0.5477	0.9999	1.0000
	LCO <sub>2</sub> 0.1978 0.4753 0.8638 0.6493 1.0000 0.9642 0.5203 0.9181 0.9166	LCO2         LEC           0.1978         3.0573           0.4753         0.7192           0.8638         3.1165           0.6493         0.2105           1.0000         0.9642           0.5203         0.3821           0.9181         0.8917           0.9166         0.8904	LCO2         LEC         LFDI           0.1978         3.0573         4.1916           0.4753         0.7192         1.0613           0.8638         3.1165         2.2336           0.6493         0.2105         0.3273           1.0000         0.9642         1.0000           0.5203         0.3821         1.0000           0.9181         0.8917         0.5497           0.9166         0.8904         0.5477	LCO2         LEC         LFDI         LGDP           0.1978         3.0573         4.1916         7.4508           0.4753         0.7192         1.0613         0.1475           0.8638         3.1165         2.2336         2.2353           0.6493         0.2105         0.3273         0.3270           1.0000         0.9642         1.0000         0.5203         0.3821         1.0000           0.9181         0.8917         0.5497         1.0000         0.9166         0.8904         0.5477         0.9999

#### Table 2: Results of ADF and PP tests

Test	At level		At first difference		
	Variables	t-statistics	Variables	t-statistics	
ADF	LCO,	-1.88	ΔLCO <sub>2</sub>	-9.07***	
	LEC	-0.36	ALEC	-4.09***	
	LFDI	-2.97	ΔLFDI	-5.31***	
	LGDP	-0.11	$\Delta LGDP$	-4.79***	
	LGDP <sup>2</sup>	-0.05	$\Delta LGDP^2$	-4.74***	
PP	LCO,	-1.88	$\Delta LCO_2$	-9.07***	
	LEC	-0.39	ALEC	-4.08***	
	LFDI	-2.97	ΔLFDI	-5.35***	
	LGDP	0.48	$\Delta LGDP$	-5.46***	
	LGDP <sup>2</sup>	0.58	$\Delta LGDP^2$	-5.33***	

The asterisk \*\*\* denotes the statistical significance level at 1%

information criterion (AIC) for the select of optimal lag because this criterion gives an efficient and consistent results as comparing to some others criteria. As Lütkepohl (2006) suggested AIC has superior power property to any other criterion particularly for small sample size. For bounds testing, the paper employs the equation (3), where m and t represents number of lags and trend respectively.

$$\begin{split} \Delta LCO_{2t} &= \beta_0 + \beta_1 t + \sum_{i=1}^m \beta_{2i} \Delta LCO_{2t\text{-}i} + \sum_{i=0}^m \beta_{3i} \Delta LEC_{t\text{-}i} + \\ &\sum_{i=0}^m \beta_{4i} \Delta LFDI_{t\text{-}i} + \sum_{i=0}^m \beta_{5i} \Delta LGDP_{t\text{-}i} + \sum_{i=0}^m \beta_{6i} \Delta LGDP_{t\text{-}i}^2 \\ &+ \beta_7 LCO_{2t\text{-}1} + \beta_8 LEC_{t\text{-}1} + \beta_9 LFDI_{t\text{-}1} + \beta_{10} LGDP_{t\text{-}1} + \\ &\beta_{11} LGDP_{t\text{-}1}^2 + \mu_t \end{split}$$
(3)

The long run relationship among the variables in the equation 3 is estimated by conducting an F-test for the joint significance of the coefficients of the lagged levels of the variables, i.e., null hypothesis (H<sub>N</sub>):  $\beta_7 = \beta_8 = \beta_9 = \beta_{10} = \beta_{11} = 0$  against the alternative (H<sub>A</sub>):  $\beta_7 \neq \beta_8 \neq \beta_9 \neq \beta_{10} \neq \beta_{11} \neq 0$ . The paper denotes the test which normalizes on  $CO_2$  emissions by  $F_{CO2}$  (LCO<sub>2</sub> | LEC, LFDI, LGDP, LGDP<sup>2</sup>). The F-test has two asymptotic critical values when the independent variables are integrated of I (0) or I (1) or combination of both. The lower value assumes the regressors are integrated of order I (0), while the upper bound value assumes regressors are purely I (1). We can reject the null hypothesis of no co-integration if the F-statistic is above the upper critical bound value. If this value falls below the lower critical bound value null hypothesis is accepted. Finally, if the F-statistic is between the lower and upper critical bound values, the result of the test is inconclusive.

#### Table 3: Bounds test results

Dependent Variable	Selected ARDL models	<b>F-statistics</b>	Outcomes
$F_{CO2}(LCO_2   LEC, LFDI, LGDP, LGDP^2)$	(1,1,0,1,1)	11.97	Co-integration
F <sub>EC</sub> (LEC   LCO <sub>2</sub> , LFDI, LGDP, LGDP <sup>2</sup> )	(1,0,0,0,0)	0.72	No co-integration
F <sub>FDI</sub> (LFDI   LEC, LCO <sub>2</sub> , LGDP, LGDP <sup>2</sup> )	(1,1,0,1,1)	4.83	Inconclusive
F <sub>GDP</sub> (LGDP   LEC, LFDI, LCO <sub>2</sub> , LGDP <sup>2</sup> )	(1,0,1,1,1)	2.61	No co-integration
F <sub>GDP</sub> <sup>2</sup> (LGDP <sup>2</sup>   LEC, LFDI, LGDP, LCO <sub>2</sub> )	(1,0,1,1,1)	2.61	No co-integration

Table 3 reports the results of the calculated F-statistics for the system of equations under the ARDL regressions. The calculated F-statistic  $F_{CO2}$  (LCO<sub>2</sub> | LEC, LFDI, LGDP, LGDP<sup>2</sup>)=11.97 is higher than the upper bound critical value 5.06 at 1% level. Thus, the null hypothesis is rejected, implying that there is a long run co-integration relationship among variables of the model. For other equations in the system in which LEC, LGDP and LGDP<sup>2</sup> works as dependent variables, the paper gets the F-statistics of 0.72, 2.26 and 2.61 respectively; all are smaller than lower critical bound value of 2.86. In all these cases the null hypothesis cannot be rejected. While the value of the F-statistic is 4.83, within lower and upper critical values at 1% level for running the regression with LFDI as a dependent variable, then result of the F-test is inconclusive in this case.

#### 4.3. ARDL Regression

The ARDL model specification for this study is presented in equation 4:

$$LCO_{2t} = \delta_0 + \sum_{i=1}^{p} \gamma_{1i} LCO_{2t-i} + \sum_{i=0}^{q_1} \gamma_{2i} LEC_{t-i} + \sum_{i=0}^{q_2} \gamma_{3i} LFDI_{t-i} + \sum_{i=0}^{q_3} \gamma_{4i} LGDP_{t-i} + \sum_{i=0}^{q_4} \gamma_{5i} LGDP_{t-i}^2 + \mu_t$$
(4)

Where as the optimal ARDL model is specified as ARDL (1,1,0,1,1). Results of the short-run and long-run estimates are given in Table 4. In the short-run, the results of the study indicate that EC and FDI have significant positive effect on CO<sub>2</sub> emissions. This study takes variables in the log-form so coefficients can be stated as elasticity of the respective variable. The coefficients of EC can be interpreted as 1% increase in EC leads to 0.32% increase in CO<sub>2</sub> emissions while the coefficient of FDI is much smaller and 1% increase in FDI will increase CO<sub>2</sub> emissions by 0.060%. This finding can be explained on the ground that in the early stage of opening an economy, the majority of FDI comes into the service sector where the probability for causing air pollution is much smaller than others. The one period lagged error correction term derived from the co-integration vector is statistically significant at 1% level (-0.96). It means that approximately 96% of disequilibria from any external shock is adjusted annually and relatively coefficient of the ECT (-1) suggests is a quite fast adjustment process to long-run equilibrium.

Contrary to the short-run estimates, the long-run estimates show that all explanatory variables are found to be significant determinants of  $CO_2$  emissions in Hanoi. The long-run coefficient of EC is 0.65 which is more than twice of its coefficient in the

#### **Table 4: Regression results**

Dependent variable: △LCO <sub>2</sub>					
Panel A: Short-run coefficients					
Variable	Coefficient	t-Statistic	<b>P-values</b>		
ΔLEC	0.3164	2.6235	0.0184		
ΔLFDI	0.0601	3.1906	0.0057		
ΔLGDP	4.3561	0.2507	0.8052		
$\Delta LGDP^2$	-0.3333	-0.2846	0.7796		
ECT(-1)	-0.9643	-9.1007	0.0000		
ECT=LCO <sub>2</sub> -(0.65	511*LEC+0.0624*	LFDI-47.4892*LGI	DP+3.1537		
LGDP <sup>2</sup> +176.6919	))				
Panel B: Long-ru	in coefficients				
LEC	0.6511	10.2192	0.0000		
LFDI	0.0624	3.3314	0.0042		
LGDP	-47.4891	-2.9887	0.0087		
LGDP <sup>2</sup>	3.1537	3.0169	0.0082		
С	176.6918	2.9361	0.0097		
Panel C: Diagnostic tests					
$\chi^2_{BG}(A)$	4.0693 (0.0619)				
$\chi^2_{BPG}(B)$	0.4263 (0.8884)				
$\chi^2_{RAMSEY}(C)$	4.0651 (0.0621)				
$\chi^2_{JB}(D)$	2.5199 (0.2837)				

Parenthesis () is the P values. (A) Lagrange multiplier test of residual serial correlation. (B) Based on the regression of squared residuals on squared fitted values. (C) Ramsey's RESET test using the square of the fitted values. (D) Based on a test of skewness and kurtosis of residuals

short-run. It can be interpreted as 1% increase in EC leads to a 0.65% rise in CO<sub>2</sub> emissions. This finding is highly meaningful as it clearly indicates that EC is the major source of environmental degradation in Hanoi. The long-run coefficient of FDI is marginal like in case of the short-run. Concretely, 1% rise in FDI inflow is associated with a 0.062% increase in CO<sub>2</sub> emissions in Hanoi. It means the effect of FDI on CO<sub>2</sub> emission is relatively weak in the long-run just like in case of short-run. The results show that it has very small change in term of percentage, 0.002% approximately. As FDI has not just positive effect on CO, emissions in the long-run but also in the short-run thus; it can be deduced from this finding that the Pollution Haven Hypothesis regarding FDI is prevailing in Hanoi. A non-linear relationship is found to be existed between CO<sub>2</sub> emissions and economic growth, however, a U-shape relationship exists instead of an inverted U-shape relationship between these variables as the coefficient of LGDP and LGDP<sup>2</sup> is significantly negative and positive, respectively. Thus, the validity of the EKC hypothesis is not verified in this case.

The model is tested for several econometric problems through diagnostic tests. Results of these tests show that model is not suffering from serial correlation and heteroskedasticity problem. Furthermore, the diagnostic tests confirm that error term of the model is normally distributed and the functional form of the model is correct. Besides this the stability of the coefficients of the model is tested through cumulative sum of recursive residual (CUSUM) and cumulative sum of squares of recursive residual (CUSUMQ) techniques. Results of these mentioned stability tests are depicted in Figures 1 and 2 respectively. The plots of both CUSUM and CUSUMQ are well within critical bounds. Thus, it confirms that all the coefficients of the model are stable over the sample period.

#### 4.4. Causality Test

The bounds test affirmed the long-run relationship among the variables, which by itself indicating the causality among variables of the model. However, to determine the direction of the causality we need a procedure which not only determines the causal direction in the long-run but in the short-run as well. The





Figure 2: Cumulative sum of squares of recursive residual test results for autoregressive distributed lagged (1,1,0,1,1) model



vector error correction model (VECM) is such a procedure which incorporates the error correction term to find out the long-run causality and F-statistic to determine the short-run causality between variables. To determine the direction of causality, the study conducts Granger causality tests by estimating the following VECM:

$$\begin{bmatrix} \Delta LCO_{2t} \\ \Delta LEC_{t} \\ \Delta LGDP_{t} \\ \Delta LGDP_{t}^{2} \end{bmatrix} = \begin{bmatrix} \Delta LCO_{2t-i} \\ \Delta LFDI_{t-i} \\ \Delta LGDP_{t-i} \\ \Delta LGDP_{t-i}^{2} \end{bmatrix} \begin{bmatrix} \Delta LCO_{2t-i} \\ \Delta LGDP_{t-i} \\ \Delta LGDP_{t-i}^{2} \end{bmatrix} \begin{bmatrix} \Delta LCO_{2t-i} \\ \Delta LGDP_{t-i} \\ \Delta LGDP_{t-i}^{2} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1} \\ \varepsilon_{2} \\ \varepsilon_{3} \\ \varepsilon_{4} \\ \varepsilon_{5} \end{bmatrix} \begin{bmatrix} ECT_{t-1} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \\ e_{4t} \\ e_{5t} \end{bmatrix}$$
(5)

Where as  $\Delta$ ,  $\lambda_i$  and  $e_{it}$  represents the first difference operators; intercepts and error terms, respectively, while & is a parameter for the one period lagged error correction term. The ECT<sub>1-1</sub> indicates the error correction term. If the coefficient of ECT is significant and caries negative sign via t-statistic, then it can be concluded that there exists a causal link running from regressors to dependent variable in the long-run in that equation as VECM is the system of equations. The short-run causality between variables will be determined through Wald F-statistic. The Wald F-statistic of differenced variables offers shortrun causal effects (Asafu-Adjaye, 2000; Oh and Lee, 2004). The values of the F-statistic are provided from 2<sup>nd</sup> column to 5<sup>th</sup> column while t-statistic is presented in last column of Table 5. A unidirectional causality in the long-run can be seen from CO, emission, EC, and FDI to GDP and to the square GDP. Thus, it can be stated that from these findings that CO<sub>2</sub> emission, EC, and FDI Granger caused economic growth of Hanoi in the long-run. In the short-run, there exists a Granger causality running from CO<sub>2</sub> emissions, EC, FDI, and square of GDP to GDP and there is a causality running from CO<sub>2</sub> emissions and GDP to square of GDP. So, this study concludes that there is no evidence of bi-directional causality between CO<sub>2</sub> emissions and economic growth in both time horizons. If one compares the causal relation between CO<sub>2</sub> emissions and economic growth, similar findings are found by Haq et al. (2016) and Gamage et al. (2017).

#### **Table 5: Causality results**

Dependent variables	Short-run				Long-run ECT <sub>t-1</sub>	
	$\Delta LCO_2$	ΔLEC	∆LFDI	∆LGDP	$\Delta LGDP^2$	
ΔLCO <sub>2</sub>	-	0.69	0.98	0.54	0.53	-0.56
ΔLEC	0.66	-	0.33	0.35	0.36	0.53
ΔLFDI	0.29	1.89	-	1.50	1.46	-0.94
ΔLGDP	4.04**	2.71*	2.65*	-	3.17*	-3.89***
$\Delta LGDP^2$	3.83**	2.54	2.48	3.07*	-	-3.84***

The appropriate lag lengths are chosen using Schwarz's Information Criteria. The asterisks \*\*\*; \*\* and \* denote the statistical significance level at the 1, 5 and 10% levels, respectively

# 5. CONCLUSION AND POLICY IMPLICATION

This research study investigates the impacts of FDI, income per capita and EC on CO<sub>2</sub> emission and tests the presence of EKC hypothesis in Hanoi over the period 1990-2015. This study employs bounds testing approach to confirm the presence of longrun relationship among the variables. In the short-run, EC and FDI are found to be positive and significant contributor of CO<sub>2</sub> emission. FDI and EC also have significant and positive effect on CO, emissions in the long-run. However, FDI has marginal effect on CO<sub>2</sub> emission in both time horizons. For the validity of the EKC hypothesis the coefficient of GDP and its squares have to be significantly positive and negative respectively. However, GDP and its squares do not have significant impact on CO, emissions in the short-run. Results estimates show that GDP and its square carry negative and positive sign respectively in the long-run thus; indicating a U-shape relationship between CO<sub>2</sub> emissions and economic growth instead of inverted U-shape. Thus, we conclude that the EKC hypothesis does not exist in Hanoi city. This result is similar to the findings of Al-Mulali et al. (2015) for Vietnam, Ang (2008) for Malaysia, Kareem et al. (2012) for China, and Ozturk and Al-Mulali for Cambodia (2015) and is opposite to what Tang and Tan (2015) and Phuong and Tuyen (2018) find in case of Vietnam. Moreover, the causality based on VECM test is also carried out to detect the causal links between the variables. The study finds one-way causality running from CO<sub>2</sub> emissions, EC, and FDI to economic growth in the long-run.

From these empirical findings, there are several implications that municipal government policymakers need to take into account in order to stimulate economic growth in line with effective environmental protection. First, it is necessary to attract more FDI inflow to speed up economic growth because FDI holds the second position in stirring economic activities over the past 25 years. In 1990-2015 period, there were 21,186 foreign projects investing in Vietnam's economy with about 138.7 billion USD implemented capital. For the time-being, Vietnam is still moving from centrally planned economy to export-oriented one, therefore, in which the state sector does play the first role in this process. After that, FDI sector plays very important role in supplementing investment capital for development, creating job, raising budget revenue, promoting technology transfer and integrating into international economy. Notably, the FDI sector now accounts for 72% of export turnover. This implication is also derived from the noteworthy finding of the paper that FDI has small effect on CO<sub>2</sub> emissions. However, municipal government should boost FDI inflow, especially in technology-intensive and environmentalfriendly industries aiming at protecting environmental pollution in the future. Second, since the impact of EC is relatively strong and doubles from the short-run to long-run, it can be recommended that in the long-run, authorities should concentrate on policies which not only encourage people to increase energy efficiency but also promote the utilization of renewable energy. Furthermore, municipal government can fix solar street lights to light up the street in Hanoi. In the shot-run, municipal government should implement certain strict regulations to limit private vehicles focusing on motorbikes and cars so as to minimize the size of  $CO_2$  emissions resulted from transportation. Third, the efforts of municipal government aimed at reducing  $CO_2$  emissions should be carefully taken into consideration as this would affect the magnitude of GDP. In other words, the policymakers should pay enough attention to the trade-off between economic growth and the reduction of CO<sub>2</sub> emissions.

#### REFERENCES

- Ahmed, K. (2014), Environmental Kuznets Curve for CO<sub>2</sub> emission in Mongolia: An empirical analysis. Management of Environment Quality, 25(4), 505-516.
- Ahmed, K., Long, W. (2012), Environmental Kuznets Curve and Pakistan: An empirical analysis. Procedia Economics and Finance, 1, 4-13.
- Akbostanci, E., Turut-Asik, S., Tunc, G.I. (2009), The relationship between income and environment in Turkey: Is there an environmental Kuznets curve? Energy Policy, 37, 861-867.
- Al-Mulali, U., Saboori, B., Ozturk, I. (2015), Investigating the environmental Kuznets Curve hypothesis in Vietnam. Energy Policy, 76, 123-131.
- Ang, J.B. (2008), Economic development, pollutant emissions and energy consumption in Malaysia. Journal of Policy Modeling, 30(2), 271-278.
- Asafu-Adjaye, J. (2000), The relationship between energy consumption, energy prices and economic growth: Time series evidence from Asian developing countries. Energy Economics, 22, 615-625.
- Azlina, A.A., Law, S.H., Mustapha, N.H.N. (2014), Dynamic linkages among transport energy consumption, income and CO<sub>2</sub> emission in Malaysia. Energy Policy, 73, 598-606.
- Chandran, V.G.R., Tang, C.F. (2013), The impacts of transport energy consumption, foreign direct investment and income on CO<sub>2</sub> emissions in ASEAN-5 economies. Renewable and Sustainable Energy Reviews, 24, 445-453.
- Cil, Y.N. (2014), CO<sub>2</sub> emissions, energy consumption, and economic growth for Turkey: Evidence from a co-integration test with a structural break. Energy Sources, 9(B), 229-235.
- Coondoo, D., Dinda, S. (2008), The carbon dioxide emission and income: A temporal analysis of cross-country distributional patterns. Ecological Economics, 65, 375-385.
- Dhakal, S. (2009), Urban energy use and carbon emissions from cities in China and policy implication. Energy Policy, 37, 4208-4219.
- Dinda, S., Coondoo, D. (2006), Income and emission: A panel data-based co-integration analysis. Ecological Economics, 57, 167-181.
- Dinh, H.L., Lin, S.M. (2014), CO<sub>2</sub> emission, energy consumption, economic growth and FDI in Vietnam. Managing Global Transition, 12(3), 219-232.
- Friedl, B., Getzner, M. (2003), Determinants of CO<sub>2</sub> emissions in a small open economy. Ecological Economics, 45, 133-148.
- Gamage, S.K.N., Kuruppuge, R.H., Haq, I. (2017), Energy consumption, tourism development and environment degradation in Sri Lanka. Energy Sources Part B: Economics, Planning, and Policy, 12, 910-916.
- Grossman, G., Krueger, A. (1991), Environmental Impacts of a North American Free Trade Agreement. National Bureau of Economics Research, NBER, Cambridge, Working Paper, No. 3914. Available from: http://www.nber.org/papers/w3914.pdf.
- Halicioglu, F. (2009), An econometric study of CO<sub>2</sub> emissions, energy consumption, income and foreign trade in Turkey. Energy Policy, 37, 1156-1164.
- Haq, I., Zhu, S., Shafiq, M. (2016), Empirical investigation of environmental Kuznets Curve for carbon emission in Morocco. Ecological Indicators, 67, 491-496.

- Heil, M.T., Seldon, T.M. (1999), Panel stationarity with structural break: Carbon emissions and GDP. Applied Economics Letters, 6, 223-225.
- Hitam, M.B., Borhan, H.B. (2012), FDI, growth and the environment: Impact on quality of life in Malaysia. Procedia-Social and Behavioural Science, 50, 333-342.
- Jalil, A., Mahmud, SF. (2009), Environment Kuznets Curve for CO<sub>2</sub> emissions: A co-integration analysis for China. Energy Policy, 37, 5167-5172.
- Kareem, S.D., Kari, F., Alam, G.M., Adewale, A., Oke, O.K. (2012), Energy consumption, pollutant emissions and economic growth: China experience. International Journal of Applied Economics and Finance, 6, 136-147.
- Lean, H.H., Smyth, R. (2010), CO<sub>2</sub> emission, electricity consumption and output in ASEAN. Applied Energy, 87, 1858-1864.
- Lee, C.G. (2009), Foreign direct investment, pollution and economic growth: Evidence from Malaysia. Applied Economics, 41, 1709-1716.
- Lise, W. (2006), Decomposition of CO<sub>2</sub> emissions over 1980-2003 in Turkey. Energy Policy, 34, 1841-1852.
- Long, P.D., Ngoc, B.H., My, D.T.H. (2018), The relationship between foreign direct investment, electricity consumption and economic growth in Vietnam. International Journal of Energy Economics and Policy, 8(3), 267-274.
- Lucas, G., Wheeler, N., Hettige, R. (1992), The Inflexion Point of Manufacture Industries: International Trade and Environment. Washington, DC: World Bank Discussion Paper. p148.
- Lütkepohl, H. (2006), Structure vector autoregressive analysis for cointegrated variables. Advances in Statistical Analysis, 90, 75-88.
- Merican, Y., Yusop, Z., Noor, Z., M, Hook, L.S. (2007), Foreign direct investment and the pollution in five ASEAN nations. International Journal of Economics and Management, 1, 245-261.
- Nasir, M., Rehman, F.U. (2011), Environmental Kuznets Curve for carbon emission in Pakistan: An empirical investigation. Energy Policy, 39, 1857-1864.
- Nohman, A., Antrobus, G. (2005), Trade and the environment Kuznets Curve: Is Southern Africa a pollution heaven. South African Journal of Economics, 73, 803-814.
- Oh, W., Lee, K. (2004), Causal relationship between energy consumption and GDP revisited: The case of Korea 1970-1999. Energy Economics, 26(1), 51-59.
- Ozturk, I., Acaravci, A. (2013), The long run and causal analysis of energy, growth, openness and financial development on carbon emission in Turkey. Energy Economics, 36, 262-267.
- Ozturk, I., Al-Mulali, U. (2015), Investigating the validity of the environmental Kuznets Curve hypothesis in Cambodia. Ecological Indicator, 57, 324-330.
- Pesaran, M.H., Shin, Y., Smith, R.J. (2001), Bounds testing approach to the analysis of level relationships. Journal of Applied Econometrics, 16, 289-326.

- Phuong, D.N., Tuyen T.M.L. (2018), The relationship between foreign direct investment, economic growth and environmental pollution in Vietnam: An autoregressive distributed lags approach. International Journal of Energy Economics and Policy, 8(5), 138-145.
- Saboori, B., Sulaiman, J., Mohd, S. (2012), Economic growth and CO<sub>2</sub> emissions in Malaysia: A co-integration analysis of the environmental Kuznets Curve. Energy Policy, 51, 184-191.
- Salahuddin, M., Alam, K., Ozturk, I., Sohag, K. (2018), The effects of electricity consumption, economic growth, financial development and foreign direct investment on CO<sub>2</sub> emissions in Kuwait. Renewable and Sustainable Energy Reviews, 81, 2002-2010.
- Seker, F., Ertugrul, H.M., Cetin, M. (2015), The impact of foreign direct investment on environmental quality: A bounds testing and causality analysis for Turkey. Renewable and Sustainable Energy Reviews, 52, 347-356.
- Shafik, N., Bandyopadhyay, S. (1992), Economic Growth and Environmental Quality: Time Series and Cross Section Evidence. World Bank Policy Research Paper Series.
- Shahbaz, M., Lean, H.H., Shabbir, M.S. (2012), Environmental Kuznets Curve hypothesis in Pakistan: Co-integration and Granger causality. Renewable and Sustainable Energy Reviews, 16(5), 2947-2953.
- Shahbaz, M., Solarin, S.A., Mahmood, H., Arouri, M. (2013), Does financial development reduce CO<sub>2</sub> emissions in Malaysian economy? A time series analysis. Economic Modelling, 35, 145-152.
- Shahbaz, M., Solarin, S.A., Ozturk, I. (2016), Environmental Kuznets Curve hypothesis and the role of globalization in selected African countries. Ecological Indicators, 67, 623-636.
- Solarin, S.A., Al-Mulali, U., Musah, I., Ozturk, I. (2017), Investigating the pollution haven hypothesis in Ghana: An empirical investigation. Energy, 124, 706-719.
- Song, T., Zheng, T., Tong, L. (2008), An empirical test of the environmental Kuznets Curve in China: A panel co-integration approach. China Economic Review, 19, 381-392.
- Stern, D.I. (2004), The rise and fall of the environmental Kuznets Curve. World Development, 32, 1419-1439.
- Tang, C.F., Tan, B.W. (2015), The impact of energy consumption, income and foreign direct investment on carbon dioxide emissions in Vietnam. Energy, 79, 447-454.
- Tang, C.F., Tan, B.W., Ozturk, I. (2016), Energy consumption and economic growth in Vietnam. Renewable and Sustainable Energy Reviews, 54, 1506-1514.
- Wang, S.S., Zhou, P., Wang, W.Q. (2011), CO<sub>2</sub> emissions, energy consumption and economic growth in China: A panel data analysis. Energy Policy, 39, 4870-4875.
- Zhang, X.P., Cheng, X.M. (2009), Energy consumption, carbon emissions and economic growth in China. Ecological Economics, 68, 2706-2712.
- Zhang, Y. (2011), The impact of financial development on carbon emissions: An empirical analysis in China. Energy Policy, 39, 2197-2203