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

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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_2) 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_2 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 middle-income 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 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_2 emissions or any other element, for instance, nitrous oxide (N_2O), sulfur dioxide (SO_2), and methane (CH_4). 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_2 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_2 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_2 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_2 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_2 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_2 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_2 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_2 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_2 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_2 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_2 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_2 emissions in Malaysia and Thailand in the long-run while bidirectional causality exists between FDI and CO_2 emissions in the case of Indonesia. In a time series study for Malaysia, Lee (2009) examines the relationship between FDI and CO_2 emissions through ARDL bounds test. The results reveal no long-run relationship between aforementioned variables however; FDI is causing CO_2 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_2 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_2 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_2 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.

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

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

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

Where as CO_2 is per capita CO_2 emissions and it is measured in metric tons, EC_t is per capita EC and it is measured in kilogram of oil equivalent, FDI_t is per capita implemented FDI and is measured in USD. Similarly, GDP_t is per capita real GDP in

USD, GDP_t^2 is squared of per capita real GDP. Furthermore, L presents the natural log of the respective variable and ε_t is the error term. All parameters α_1, α_2, α_3, α_4 are the long run elasticities of CO_2 emissions with respect to LEC_t, $LFDI_t$, $LGDP_t$ and $LGDP_t^2$, respectively. For the EKC hypothesis to be valid, the expected sign of α_3 and α_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 co-integration 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 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.

Table 1: Descriptive statistics and correlation matrix

Variables	LCO_2	LEC	LFDI	LGDP	$LGDP^2$
Mean	0.1978	3.0573	4.1916	7.4508	55.5350
Std. Dev.	0.4753	0.7192	1.0613	0.1475	2.2103
Jarque-Bera	0.8638	3.1165	2.2336	2.2353	2.3180
Probability	0.6493	0.2105	0.3273	0.3270	0.3138
LCO_2	1.0000				
LEC	0.9642	1.0000			
LFDI	0.5203	0.3821	1.0000		
LGDP	0.9181	0.8917	0.5497	1.0000	
$LGDP^2$	0.9166	0.8904	0.5477	0.9999	1.0000

Table 2: Results of ADF and PP tests

Test	At level		At first difference	
	Variables	t-statistics	Variables	t-statistics
ADF	LCO_2	−1.88	ΔLCO_2	−9.07***
	LEC	−0.36	ΔLEC	−4.09***
	LFDI	−2.97	ΔLFDI	−5.31***
	LGDP	−0.11	ΔLGDP	−4.79***
	$LGDP^2$	−0.05	$\Delta LGDP^2$	−4.74***
PP	LCO_2	−1.88	ΔLCO_2	−9.07***
	LEC	−0.39	ΔLEC	−4.08***
	LFDI	−2.97	ΔLFDI	−5.35***
	LGDP	0.48	ΔLGDP	−5.46***
	$LGDP^2$	0.58	$\Delta LGDP^2$	−5.33***

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

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

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_N): $\beta_7=\beta_8=\beta_9=\beta_{10}=\beta_{11}=0$ against the alternative (H_A): $\beta_7\neq\beta_8\neq\beta_9\neq\beta_{10}\neq\beta_{11}\neq 0$. The paper denotes the test which normalizes on CO_2 emissions by F_{CO2} (LCO_2 | LEC, LFDI, LGDP, $LGDP^2$). 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	F-statistics	Outcomes
$F_{CO2}(LCO_2 \mid LEC, LFDI, LGDP, LGDP^2)$	(1,1,0,1,1)	11.97	Co-integration
$F_{EC}(LEC \mid LCO_2, LFDI, LGDP, LGDP^2)$	(1,0,0,0,0)	0.72	No co-integration
$F_{FDI}(LFDI \mid LEC, LCO_2, LGDP, LGDP^2)$	(1,1,0,1,1)	4.83	Inconclusive
$F_{GDP}(LGDP \mid LEC, LFDI, LCO_2, LGDP^2)$	(1,0,1,1,1)	2.61	No co-integration
$F_{GDP^2}(LGDP^2 \mid LEC, LFDI, LGDP, LCO_2)$	(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 $F_{CO2}(LCO_2 \mid LEC, LFDI, LGDP, LGDP^2)=11.97$ 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 $LGDP^2$ 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:

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

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_2 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_2 emissions while the coefficient of FDI is much smaller and 1% increase in FDI will increase CO_2 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 short-run. It can be interpreted as 1% increase in EC leads to a 0.65% rise in CO_2 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_2 emissions in Hanoi. It means the effect of FDI on CO_2 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_2 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_2 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 $LGDP^2$ is significantly negative and positive, respectively. Thus, the validity of the EKC hypothesis is not verified in this case.

Table 4: Regression results

Variable	Coefficient	t-Statistic	P-values
Dependent variable: ΔLCO_2			
Panel A: Short-run coefficients			
ΔLEC	0.3164	2.6235	0.0184
$\Delta LFDI$	0.0601	3.1906	0.0057
$\Delta LGDP$	4.3561	0.2507	0.8052
$\Delta LGDP^2$	−0.3333	−0.2846	0.7796
ECT(-1)	−0.9643	−9.1007	0.0000
$ECT=LCO_2$-(0.6511*LEC+0.0624*LFDI-47.4892*LGDP+3.1537 $LGDP^2$+176.6919)			
Panel B: Long-run coefficients			
LEC	0.6511	10.2192	0.0000
LFDI	0.0624	3.3314	0.0042
LGDP	−47.4891	−2.9887	0.0087
$LGDP^2$	3.1537	3.0169	0.0082
C	176.6918	2.9361	0.0097
Panel C: Diagnostic tests			
χ^2_{BG}(A)	4.0693 (0.0619)		
χ^2_{BPG}(B)	0.4263 (0.8884)		
χ^2_{RAMSEY}(C)	4.0651 (0.0621)		
χ^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

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 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:

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

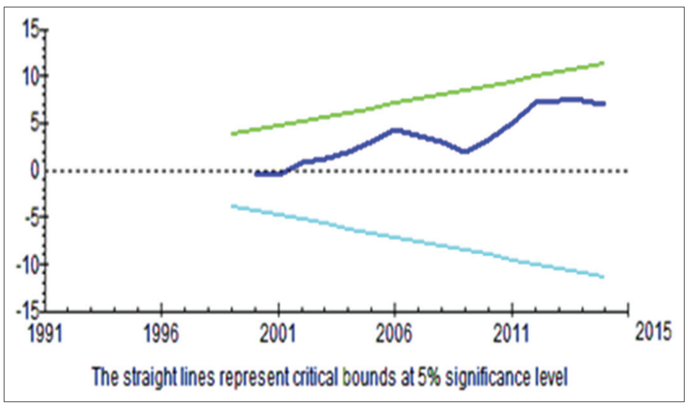
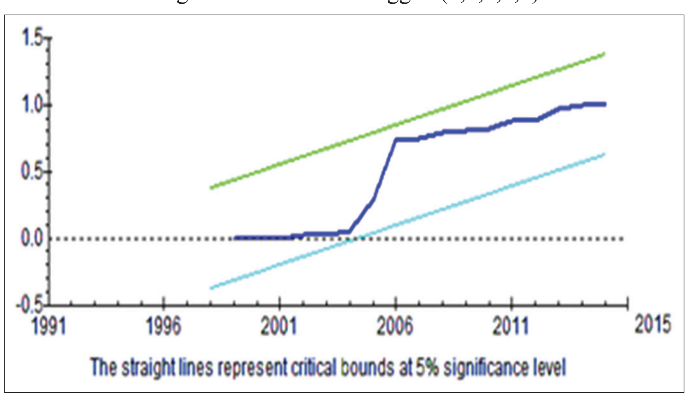


Figure 2: Cumulative sum of squares of recursive residual test results for autoregressive distributed lagged (1,1,0,1,1) model



$$\begin{bmatrix}\Delta LCO_{2t}\\ \Delta LEC_t\\ \Delta LFDI_t\\ \Delta LGDP_t\\ \Delta LGDP_t^2\end{bmatrix} = \begin{bmatrix}\lambda_1\\ \lambda_2\\ \lambda_3\\ \lambda_4\\ \lambda_5\end{bmatrix} + \sum_{i=1}^{m}\begin{bmatrix}\delta_{11i}\delta_{12i}\delta_{13i}\delta_{14i}\delta_{15i}\\ \delta_{21i}\delta_{22i}\delta_{23i}\delta_{24i}\delta_{25i}\\ \delta_{31i}\delta_{32i}\delta_{33i}\delta_{34i}\delta_{35i}\\ \delta_{41i}\delta_{42i}\delta_{43i}\delta_{44i}\delta_{45i}\\ \delta_{51i}\delta_{52i}\delta_{53i}\delta_{54i}\delta_{55i}\end{bmatrix}\begin{bmatrix}\Delta LCO_{2t-i}\\ \Delta LEC_{t-i}\\ \Delta LFDI_{t-i}\\ \Delta LGDP_{t-i}\\ \Delta LGDP_{t-i}^2\end{bmatrix} + \begin{bmatrix}\varepsilon_1\\ \varepsilon_2\\ \varepsilon_3\\ \varepsilon_4\\ \varepsilon_5\end{bmatrix}\left[ECT_{t-1}\right] + \begin{bmatrix}e_{1t}\\ e_{2t}\\ e_{3t}\\ e_{4t}\\ e_{5t}\end{bmatrix} \quad (5)$$

Where as Δ, λ_i and e_{it} represents the first difference operators; intercepts and error terms, respectively, while ε_i is a parameter for the one period lagged error correction term. The ECT_{t-1} 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 short-run causal effects (Asafu-Adjaye, 2000; Oh and Lee, 2004). The values of the F-statistic are provided from 2nd column to 5th column while t-statistic is presented in last column of Table 5. A unidirectional causality in the long-run can be seen from CO_2 emission, EC, and FDI to GDP and to the square GDP. Thus, it can be stated that from these findings that CO_2 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_2 emissions, EC, FDI, and square of GDP to GDP and there is a causality running from CO_2 emissions and GDP to square of GDP. So, this study concludes that there is no evidence of bi-directional causality between CO_2 emissions and economic growth in both time horizons. If one compares the causal relation between CO_2 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_{t-1}
	ΔLCO_2	ΔLEC	$\Delta LFDI$	$\Delta LGDP$	$\Delta LGDP^2$	
ΔLCO_2	-	0.69	0.98	0.54	0.53	−0.56
Δ LEC	0.66	-	0.33	0.35	0.36	0.53
$\Delta LFDI$	0.29	1.89	-	1.50	1.46	−0.94
$\Delta LGDP$	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_2 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 long-run relationship among the variables. In the short-run, EC and FDI are found to be positive and significant contributor of CO_2 emission. FDI and EC also have significant and positive effect on CO_2 emissions in the long-run. However, FDI has marginal effect on CO_2 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_2 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_2 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_2 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_2 emissions. However, municipal government should boost FDI inflow, especially in technology-intensive and environmental-friendly 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_2 emissions.

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