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Article

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The Relationship between Foreign Direct Investment, Economic Growth and Environmental Pollution in Vietnam: An Autoregressive Distributed Lags Approach

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ABSTRACT

The nexus between economic growth, environmental pollution, and foreign direct investment (FDI) inflows has been intensively analyzed by a number of studies, but the empirical evidence more often than not remains controversial and ambiguous. This paper investigates the causal relationship between CO2 emissions, FDI and economic growth for Vietnam over the period 1986–2015. The empirical results provide a strong statistical evidence that overall there is the relationship, which has inverse U-shape between income per capita and environmental degradation in Vietnam. The turning point's GDP per capita is about 3,145 US Dollar/year. This study suggests that policy-makers should control the environmental standards in the projects to improve environmental pollution and has attracted FDI of stability to achieve sustainable economic development for the long-run.

Keywords: Foreign Direct Investment, CO2 Emissions, Economic Growth, Vietnam
JEL Classifications: F21, F43, O44, Q43

1. INTRODUCTION

Environmental pollution is always a concerned issue to both Vietnamese government and its residents, especially when certain problems associated with the environment in Vietnam are recently found. Environmental pollution not only has negative effects on the development of the natural world but also contributes to the causes of diseases that are human health- and life-threatening. In the region, Vietnam shares a boundary with China, a "black spot" in terms of environmental quality according to the ranking of International Energy Agency. Environmental pollution is attributed to 2 main causes: Energy consumption and economic growth. As a developing country, Vietnam faces a great demand for energy to promote economic growth. Duong and Trinh (2017) observe that 3 major types of fuels that are being used in economic activities in Vietnam including: Coal, petroleum and gas. These are main types of fuel that are responsible for CO_2 emission into the environment.

Zhang (2011) and Acaravci and Ozturk (2012) claim that beside energy consumption and economic growth, many other factors also affect environmental pollution. One typical factor among those is the attraction and management of foreign direct investment (FDI) projects. In recent years, FDI is instrumental in producing positive changes in the economy of Vietnam, such as: Adding to the investment capital of society, changing the economic structure, transferring technology, improving the living standard, spreading management experience, etc. However, alongside positive contributions to the economic growth, FDI also has negative impacts on the investment recipient country, according to the common assessment of the World Economic Forum WEF 2010/2011. Typical undesirable effects pointed out are: Overexploitation of natural resources; challenges in development of domestic enterprises; national identity erosion; risk of reduction in living standard due to environmental pollution that exceeds permissible limits.

There have been many empirical research on impacts of FDI on environmental quality, such as ones conducted by Pao and Tsai (2011), Omri et al. (2014), Boluk and Mert (2015), Zhu et al. (2016), Al-Mulali et al. (2015), Baek (2015), Ozturk and Acaravci (2016), Nguyen and Wongsurawat (2017), Long et al. (2018), Salahuddin et al. (2018), Solarin et al. (2017), yet their conclusions are different. Typically, Hoffman et al. (2015); Nadia and Merih (2016) study the relationship between FDI and environmental pollution in 3 types of countries. To underdeveloped countries, statistical evidence is found to conclude that an increase of CO_2 emissions will encourage FDI attraction. Regarding developing countries, greater FDI attraction will result in more serious environmental pollution. However, in the case of developed countries, no relationship is noticed between these 2 elements.

The relationship between FDI, CO_2 emissions and economic growth in Vietnam has rarely been studied. Dinh et al. (2014) discover adverse effect, which means increase in FDI attraction will reduce environmental pollution; however, the authors cannot provide statistical evidence to prove that point. The differences in preceding empirical research and the importance of environmental preservation and conservation require further experimental research on the relationship between these elements.

2. LITERATURE REVIEWS

Describing the relationship between economic growth and environmental quality, Kuznets (1955) has given the idea of an inverted U curve Environmental Kuznets Curve (EKC). He said that in the first stage of economic growth, the Government has tended to loosen environmental regulations to attract FDI because of the high growth pressure and the capital accumulation scale of the whole economy limited. Thanks to FDI, the average income has improved; however, with the increase in average income, the environmental pollution has also increased. At this stage, the large fuel consumption, has resulted in huge amounts of CO_2 emissions into the environment because countries have mainly exploited natural resources in raw form, production technology has been backward, management level has been weak.

As the average income increases to some extent and life is improved, people begin to perceive the importance of quality of life and the quality of the surrounding ecological environment. In addition, along with the improved economic conditions, the economic integration and the advantage of the later developed countries will help nations, businesses and citizens to be able to choose green, clean technologies and friendly with environment. Environmental pollution will decelerate, reverse and then reduce, so then environmental quality will be enhanced.

The environment - FDI - economic growth nexus has mainly been examined with respect to the following three competing hypotheses: The feedback hypothesis, the unidirectional hypothesis, and the neutrality hypothesis. The validation of the unidirectional hypothesis implies that there is unidirectional causality running from one or two particular variables to the remaining variable (i.e., from CO_2 emissions and FDI inflows to economic growth; from economic growth and CO_2 emissions to FDI inflows; and from economic growth and FDI inflows to CO_2 emissions), whereas the acceptation of the feedback and neutrality hypotheses entails the existence of bidirectional causality between these variables, respectively. In the following, we review some empirical results in this literature.

2.1. Unidirectional Hypothesis

Ang (2008), Menyah and Wolde-Rufael (2010) employ different estimation techniques to examine the causal relationships between CO_2 emissions and economic growth for Malaysia and for South Africa respectively. They report evidence of unidirectional causality running from CO_2 emissions to economic growth. Jaunky (2010) investigates the EKC hypothesis for a sample of 36 high-income economies over the period 1980–2005. Unidirectional causality running from per capita GDP to per capita CO_2 emissions is uncovered in both the short and the long run. Fodha and Zaghdoud (2010); Pao and Tsai (2011) also examine the causal relationship between CO_2 emissions and economic growth using VECM - based Granger causality tests, and they find evidence of unidirectional causality running from economic growth to CO_2 emissions. In a more recent research, Lee (2013) adopts a panel cointegration approach to examine the nexus between renewable CO_2 emissions, FDI, and economic growth for 19 of the G20 countries from 1971 to 2009. The empirical evidence supports the existence of unidirectional causality from FDI to economic growth and from economic growth to CO_2 emissions.

2.2. Feedback Hypothesis

Tsai (1994) uses Granger causality tests to identify the two-way linkages between FDI and economic growth for 62 countries over the period 1975–1978 and for 51 countries over the period 1983–1986. The author shows that FDI promotes economic growth and, in turn, economic growth is viewed as a tool to attract FDI. This finding is thus consistent with the feedback hypothesis. Soytas and Sari (2009) use the Toda and Yamamoto (1995) test to examine the causality relationship between CO_2 emissions and economic growth for Turkey over the period 1960–2000, and find evidence to support the feedback hypothesis. Ghosh (2010) also documents two-way links between CO_2 emissions and economic growth in India over the period 1971–2006. Pao and Tsai (2011) look at the causal links between FDI and CO_2 emissions for a panel of BRIC countries. The results from their Granger causality tests indicate the existence of strong bidirectional causality between these variables over the period 1992–2007.

2.3. Neutrality Hypothesis

Several studies have found no causality between CO_2 emissions, FDI inflows, and economic growth. For example, Richmond and Kaufmann (2006) find no significant causality between carbon emissions and economic growth for 36 nations over the period from 1973 to 1997, which validates the neutrality hypothesis. Similarly, the results reported by Lee (2013) are also in favor of the neutrality hypothesis for FDI inflows and CO_2 emission interactions, using panel data of 19 nations in the G20 over the period from 1971 to 2009.

2.4. Some Mixed Results

Some studies have found mixed empirical evidence about the causal relationship between income and CO2 emissions (e.g., Zhang (2011) for East Asian and Latin American countries; Lee and Lee (2009) for a panel of 109 countries; Hwang et al. (2014) for Indonesia; Ibrahiem (2015) for Egypt; Narayan and

Narayan (2010) for a panel of 43 developing countries). A potential reason is that the past studies have not considered the two-way linkages between CO2 emissions and FDI inflows, the joint dynamics of which can be simultaneously determined. In this article, we address this issue by applying simultaneous-equation models to a time series data of Viet Nam over the period from 1986 to 2015. We summarize the empirical results in Table 1.

3. RESEARCH MODELS

Following the recent empirical literature such as Boluk and Mert (2015), Mugableh (2013), it is possible to test whether there is a two-way relationship between CO_2 emissions, FDI and economic growth in Vietnam. Paper deployed a system of two equations, these simultaneous regression equations are formulated as follows:

$$CO_{2t} = \beta_0 + \beta_1 FDI_t + \beta_2 GDP_t + \beta_3 GDP_t^2 + u_t \tag{1}$$

$$FDI_t = \alpha_0 + \alpha_1 CO_{2t} + \alpha_2 GDP_t + u_t \tag{2}$$

Where: u_t denotes error, annual data is collected from 1986 to 2015, sources of data and detailed illustrations of variables are shown in Table 2.

Under the EKC hypothesis, in Eq. 1 coefficient β_2 is expected positive sign and the coefficient β_3 is expected negative sign. That the coefficient β_2 is positive means that the greater economic growth the greater carbon emissions. At the same time, that the coefficient β_3 is significant and negative means that there is a turning down point on the curve. At this point, increasing economic growth begins to make carbon emissions reduction. In this situation, the peak point of GDP is calculated to be $\beta_2/|2.\beta_3|$. However, when the coefficient β_3 is insignificant, carbon emissions increase monoto- nously. The coefficient α_1 in Eq. 2 is expected positive sign. Moreover, the empirical evidence more often than not remains controversial and ambiguous.

4. EMPIRICAL RESULTS AND DISCUSSION

4.1. Descriptive Statistics

Since the implementation of the economic open door policy in 1986, the economy of Vietnam has observed positive changes. GDP per capita increases from 80.98 USD (1986) to 2,065.17 USD (2015) (at constant 2010 prices). The amount of FDI net inflows and the number of FDI projects in Vietnam also rise rapidly. As of March 2018, 126 countries and territories have valid investment projects in Vietnam. Along with economic growth, the issue of environmental pollution is becoming more serious. Although the pollution level is still below the world's average level, it is undeniable that Vietnam has been affected by consequences of environmental pollution, as its situation is becoming complicated in large cities and industrial estates. The trend and descriptive statistics of variables are presented in Figure 1 and Table 3.

Figure 1 shows that there is no inverted U-shaped effect as of Kuznets' hypothesis in the relationship between economic growth and environmental pollution in Vietnam.

4.2. Unit Root Test

Nelson and Plosser (1982) believe that most time series are non-stationary at same level. Thus, to avoid spurious regression, this

Figure 1: Scatter graph of CO_2 (in metric tons) and GDP (in constant 2010 US Dollar)

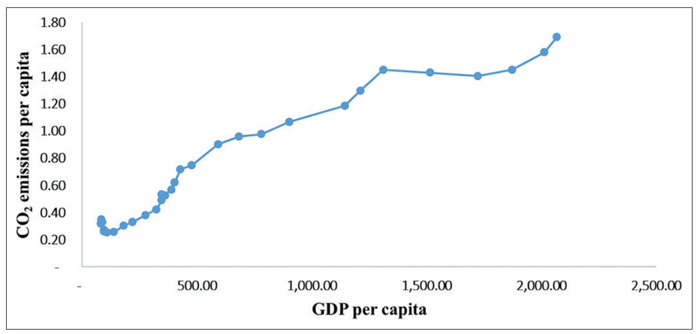


Table 1: Summary of existing empirical studies

Author(s)	Countries	Methodology	Conclusion
List et al. (2000)	United State	VAR	CO_2→FDI
Pao and Tsai (2011)	BRIC	VECM	FDI↔CO_2
Soytas and Sari (2009)	Turkey	ARDL, Toda and Yamamoto	CO_2↔GDP
Baek (2015)	Asean 5	Pool mean group	FDI→CO_2
Dijkgraaf and Herman (2005)	OECD	FEM	No relationship
Dinh et al. (2014)	Viet Nam	ECM and Granger causality	FDI≠CO_2
Ang (2008)	Malaysia	ECM and Granger causality	CO_2→GDP
Boluk and Mert (2015)	Turkey	ARDL and Granger causality	GDP→CO_2
Lee (2013)	BRIC	Panel cointegration	FDI→GDP GDP□CO_2 FDI≠CO_2
Liu et al (2018)	China	Spatial regression	FDI→SO_2 GDP□CO_2, SO_2
Zhang and Zhou (2016)	China	Panel cointegration	FDI□CO_2

ARDL: Autoregressive distributed lags

Table 2: Sources of data and measurement method of variables in the model

Variable	Description	Unit	Sources
CO_2	Is the carbon dioxide emissions per capita	Metric ton	IEA
FDI	Is the total FDI inflows and stocks per capita	USD	UNCTAD
GDP	Is the Gross Domestic Product per capita (in constant 2010 US Dollar)	USD	UNCTAD
GDP^2	Is the square of GDP	USD	UNCTAD

paper will examine the stationarity of variables in the model. The ADF test was introduced by Dickey and Fuller in 1981 with models as follows:

a. Model with no trend: $\Delta Y_t = \alpha_0 + \beta.Y_{t-1} + \sum_{i=1}^{k} \rho_i.\Delta Y_{t-i} + \varepsilon_t$
b. Model with trend:

$$\Delta Y_t = \alpha_0 + \beta.Y_{t-1} + \sum_{i=1}^{k} \rho_i.\Delta Y_{t-i} + \gamma.T + \varepsilon_t$$

Note: Δ is first difference, ε_t is white noise residual and T is trend. Null hypothesis H_0: $\beta = 0$ and alternative hypothesis H_1: $\beta \neq 0$. If H_0 is accepted, then Y_t has unit root and it can be concluded that the series is non-stationary and vice versa. Phillips and Perron (1988) develop Dickey and Fuller's test for series that error are not white noise. The results of the test for variable stationarity using the method of Dickey and Fuller, Phillips and Perron are shown in Table 4.

Table 4 reveals that all three variables are non-stationary at root level I(0) but stationary at first level I(1) in both cases of trend and no trend. Therefore, the application of the Autoregressive distributed lags (ARDL) method into Eq. 1 and Eq. 2 is reasonable.

4.3. Selection of Optimal Lag Length

In analysis of time series, the selection of optimal lag length is of vital importance. If the lag length is too high, the estimates will be inefficient. Meanwhile, if the lag length is too low, residuals of the estimates will not be white noise, leading to bias in analyzed results. Some criteria of optimal lag length selection: Akaike Information Criterion (AIC), Schwart Bayesian Criterion (SC) and Hannan Quinn Information Criterion (HQ). According to AIC, SC and HQ, the optimal lag length has the smallest value. Results of optimal lag length selection for Eq. 1 and Eq.2 are presented in Table 5.

The statistical results show that AIC, SC and HQ criteria unanimously choose optimal lag length of 4 for model in regression analysis. This is also appropriate to reality as the infrastructure quality of Vietnam is relatively inferior and procedures for issuance of investment registration certificate are still prolonged. As a result, the time required to proceed from registration for an investment certificate to completion and smooth operation is usually 3–4 years.

4.4. Granger Causality

For determine the causal relationship between variables, the author used the Granger causality test (Engle and Granger, 1987). Granger causality test in the term of vector errorcorrection model (VECM) will reveal whether historical value of one variable might aect the current value of other variables. These results detect the directions of causal relationships among variables in model. The Granger causality test in the term of VECM framework is described as follows:

$$\Delta Y_t = \alpha_{10} + \alpha_{11}(Y_{t-1} - X_{t-1}) + \delta_{11}\Delta Y_{t-p} + \delta_{12}\Delta X_{t-p} + \beta_1 \Delta z_{t-p} + \varepsilon_t$$

$$\Delta X_t = \alpha_{20} + \alpha_{21}(Y_{t-1} - X_{t-1}) + \delta_{21}\Delta Y_{t-p} + \delta_{22}\Delta X_{t-p} + \beta_2 \Delta z_{t-p} + \vartheta_t$$

where t = 1..., T denotes the time period, Δ represents change operator, Y_t and X_t is a pair of endogenous variables, z is the vector of other variables; β_1 and β_2 are vectors of its parameters in each equation; ε_t, υ_t are two error terms; and $(Y_{t-1} - X_{t-1})$ is the error correction term (ECT). α_{11} and α_{21} are the parameters that show the speed of adjustment to the long-run equilibrium which might confrm the long-run relationship among variables. In this article, the pairs of (X_t, Y_t) include (FDI, CO_2), (CO_2, GDP and GDP^2), (GDP, FDI), and other pairs are combinations of each variable with one or two other variables such as FDI with GDP and GDP^2 or with FDI and so forth.

Results of Granger causality test are shown in Table 6 and Figure 2. The results of Granger causality test in Table 6 show that there are one-way relationships between CO_2 and FDI; two-way relationships between CO_2 and GDP; one-way relationships between GDP and FDI. Engle and Granger (1987) explain this as follows: The pollution level is dependent on not only itself but also changes in FDI attraction and economic growth. FDI attraction is dependent on not only itself but also rate of economic growth.

4.5. Cointegration Test and Research Method

Cointegration test was introduced by Engle and Granger in 1987. Engle and Granger's test was then developed by Johansen (1996) to apply for multiple variable models. Engle and Granger

Table 3: Descriptive statistics of the variable for the period 1986–2015

Variables	Mean±SD	Minimum	Maximum
CO_2	0.769±0.472	0.254	1.690
FDI	39.46±39.74	0.001	126.27
GDP	675.03±631.53	80.98	2,065.17

SD: Standard deviation

Table 4: Unit root test

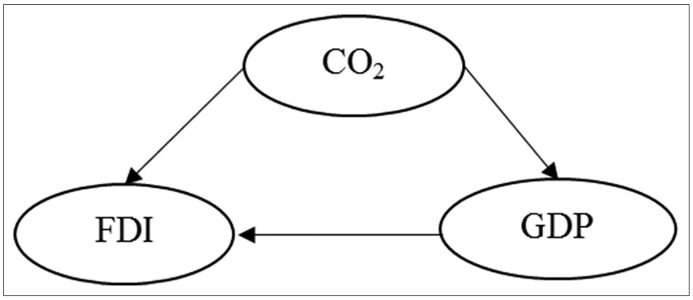
Variables	Level		First difference	
	Dickey and Fuller	Phillips and Perron	Dickey and Fuller	Phillips and Perron
CO_2	−1.937	−3.775**	−4.169**	−4.075**
FDI	−1.576	−1.747	−4.197**	−4.010**
GDP	2.672	−0.074	−0.637	−3.367*

***,** and * respectively showed for the significance level of 1%; 5% và 10%

Table 5: Results of optimum lag selection

Lag	LogL	LR	FPE	AIC	SC	HQ
3	−434.8269	33.76155	3.20e+11	37.44822	39.96442	38.17280
4	−383.5501	35.49932*	3.98e+10*	34.73462*	38.02503*	35.68214*

Figure 2: Plot of the granger causality test



(1987) suggest that even non-stationary time series can produce reliable regression results if a linear combination exists between variables in the long run. Later, Pesaran et al. (2001) demonstrated a new estimation method called ARDL with a new cointegration technique named Bound test. According to Pesaran et al. (2001); Davoud et al., 2013; Nkoro and Uko, 2016) the ARDL estimation method has a number of strengths:

(i) variables in the model are only required to be stationary at first level and below, which means they can be stationary at different levels (root level I(0) or first level I(1));
(ii) Endogeneity can be avoided and results of small samples are more reliable as lagged dependent variables are added as independent variables;
(iii) Long-run and short-run coefficients can estimate simultaneously, the error correction model (ECM) can combine short-run adjustments and long-run equilibrium without missing long-run information;
(iv) Model itself choose optimal lag length and allow different optimal lag lengths for different variables, thus remarkably improving the compatibility of the model.

Then, using ARDL model, Eq.1 and Eq.2 can be rewritten as follows:

$$\Delta CO_{2t} = \beta_0 + \beta_1 CO_{2t-1} + \beta_2 FDI_{t-1} + \beta_3 GDP_{t-1} + \beta_4 GDP^2{}_{t-1} + \sum_{i=0}^{m} \beta_{5i} \Delta CO_{2t-i} + \sum_{i=0}^{m} \beta_{6i} \Delta FDI_{t-i} + \sum_{i=0}^{m} \beta_{7i} \Delta GDP_{t-i} + \sum_{i=0}^{m} \beta_{8i} \Delta GDP^2{}_{t-i} + \mu_t \quad (3)$$

$$\Delta FDI_t = \delta_0 + \delta_1 FDI_{t-1} + \delta_2 CO_{2t-1} + \delta_3 GDP_{t-1} + \sum_{j=0}^{n} \delta_{4j} \Delta FDI_{t-j} + \sum_{j=0}^{n} \delta_{5j} \Delta CO_{2t-j} + \sum_{j=0}^{n} \delta_{6j} \Delta GDP_{t-j} + \vartheta_t \quad (4)$$

Trong đó: Δ: Is first difference

$\beta_1,\beta_2,\beta_3,\beta_4$ are regression coefficients that present long-run impacts of Eq. 1.

δ_1, δ_2, δ_3 are regression coefficients that present long-run impacts of Eq. 2.

m, n are optimal lag lengths of the models, μ_t is error term.

Table 6: Results of pairwise granger causality test

Null hypothesis	Obs	F-statistic	Prob
FDI does not granger cause CO_2	28	0.50006	0.6129
CO_2 does not granger cause FDI		4.01383	0.0320
GDP does not granger cause CO_2	28	0.38754	0.6831
CO_2 does not granger cause GDP		5.77547	0.0093
GDP does not granger cause FDI	28	5.34730	0.0124
FDI does not granger cause GDP		1.45010	0.2552

If long-run cointegrated relationships exist between variables of Eq. 3 and Eq. 4, regression coefficients will be estimated with the ECM based on the following equations:

$$CO_{2t} = \lambda_0 + \alpha.ECM_{t-1} + \sum_{i=0}^{p} \lambda_{1i} \Delta CO_{2t-i} + \sum_{i=0}^{q} \lambda_{2i} \Delta FDI_{t-i} + \sum_{i=0}^{r} \lambda_{3i} \Delta GDP_{t-i} + \sum_{i=0}^{s} \lambda_{4i} \Delta GDP^2{}_{t-i} + \rho_t \quad (5)$$

$$FDI_t = \gamma_0 + \alpha.ECM_{t-1} + \sum_{j=0}^{g} \gamma_{1j} \Delta FDI_{t-j} + \sum_{j=0}^{h} \gamma_{2j} \Delta CO_{2t-j} + \sum_{j=0}^{l} \gamma_{3j} \Delta GDP_{t-j} + \tau_t \quad (6)$$

Note: p, q, s, r, g, h, l are optimal lag lengths calculated by ARDL model following AIC, SC criteria. In both Eq.5 and Eq.6, if there exists α in which $\alpha \neq 0$ and α is statistically significant, α will present the speed of dependent variables' adjustment to long-run equilibrium after each short-run shock.

4.6. ARDL Bound Test

To examine if cointegrated relationships exist between variables, this paper use the technique of Bound test, with the Eq.3 of null hypothesis (No cointegration) H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$, and alternative hypothesis H_1: $\beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq 0$. The same theory is applied to Eq. 4. If the value of F-statistic > value of I(1) critical bound, H_0 is rejected, which means long-run cointegrated relationships exist between variables of the model. Results of Bound test for Eq. 3 and Eq. 4 are presented in Table 7.

According to the Bounds test results, F-statistic of Eq. 3 = 7.39 > I(1) = 4.66; F-statistic of Eq. 4 = 5.67 > I(1) = 5.00 at the significance level of 1%, hence H_0 is rejected, which means long-run cointegrated relationships exist between variables of both Eq. 3 and Eq. 4.

4.7. Additional Tests

To ensure reliability of research results, the paper will conduct additional diagnostic tests including: Heteroscedasticity test, autocorrelation test, normal distribution of residuals test, model stability test through examining cumulative sum of recursive residuals (CUSUM) and cumulative sum of square recursive residuals *(CUSUMSQ)*. Results of additional diagnostic tests are shown in Table 8.

According to results in Table 8, in both Eq. 3 and Eq. 4, there are no problems of heteroskedasticity, serial autocorrelation and non-normal distribution of residuals. The results of CUSUM and CUSUMSQ examination are presented in Figure 3a and b.

Figure 3a shows that both CUSUM và CUSUMSQ lines (solid lines) of Eq. 3 are within the critical bounds at significant level of 5% (dashed lines), thus it can be concluded that Eq.3 is stable, and estimated results are reliable.

Figure 3b reveals that the CUSUMSQ line (solid line) of Eq. 4 is beyond the critical bounds at significant level of 5% (dashed lines), thus it can be concluded that Eq. 4 is unstable, and this model should be rejected in following analyses.

4.8. Results of Estimation with the ECM

As shown in Table 5, the optimal lag length of the model is 4, according to AIC standard and observant sample data, optimal ARDL model of Eq. 3 is ARDL (3,3,1,2). Moreover, variables are only stationary at first level and cointegrated relationships exist between variables. Hence, the paper applies the ECM to examine the relationships between FDI, economic growth and environmental pollution in Vietnam. Results of estimation with the ECM are shown in Table 9.

As examined, the variable FDI of the present period has a trend of reducing, yet this variable of the previous period has a trend of increasing environmental pollution. The coefficient of variable GDP is positive; the coefficient of variable EC(-1) = −0.273 and is significant, thus environmental pollution level in Vietnam is capable of adjusting to reach long-run equilibrium. Noticeably, this coefficient is relatively small, so the time for self-adjustment is prolonged (approximately 4 years).

4.9. Results of Long-run Estimation

Lastly, this paper determines long-run relationships between CO_2 emissions, FDI and economic growth of Vietnam for the 1986–2015 period. Results of long-run estimation are shown in Table 10.

Estimation results in Table 10 indicate that FDI variable is insignificant negative. Hence, there is not enough statistical evidence to conclude that FDI has impacts on environmental pollution in Vietnam. GDP variable is significant positive, GDP^2 variable is significant negative. That is to be expected, which means the inverted U-shaped effect of Kuznets' hypothesis exists in the relationship between economic growth and environmental quality in Vietnam. Turning point is at the level of 3,145 US Dollar per capita. Presently, GDP per capita of Vietnam in 2015 is 2,065 $\beta_2/|2.\beta_3| \cong$ 3,145 US Dollar (at constant 2010 prices), which means there is a quite large gap till the turning point in Kuznets' hypothesis is reached.

This conclusion is in agreement with conclusions of Boluk and Mert (2015) for Turkey, of Pao and Tsai (2011) for the BRIC Group, yet in disagreement with conclusions of Mugableh (2013) for Malaysia and of Baek (2015) for Asean 5. In Vietnam, the number of empirical research on the relationship between FDI and environmental pollution using time series data is still limited. As the research of Dinh et al. (2014), this research does not find enough statistical evidence to state that FDI has impacts on environmental pollution or relaxation of regulations on environment will encourage FDI attraction in Vietnam.

Table 7: ARDL bounds test results

F-Bounds test for Eq. 3		Null hypothesis: No levels relationship		
Test statistic	Value	Signif	I (0)	I (1)
F-statistic	7.393685	10%	2.37	3.20
k	3	5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66
F-Bounds test for Eq. 4				
F-statistic	5.673667	10%	2.63	3.35
k	2	5%	3.10	3.87
		2.5%	3.55	4.38
		1%	4.13	5.00

Table 8: Diagnostic test

Type of test	Equation 3	Equation 4
χ^2 value	F statistic	
Heteroskedasticity test	0.2032	0.5175
Serial correlation LM test	0.4457	0.6805
Normality test	0.2842	0.6208

Table 9: Results of ECM

Variables	Coefficient	Std.Error	t-statistic	Prob
EC(-1)	−0.273414	0.039658	−6.894261	0.0000
ΔCO_2(-1)	−0.338583	0.139037	−2.435197	0.0289
ΔCO_2(-2)	−0.393132	0.133664	−2.941187	0.0107
ΔFDI	−0.001345	0.000514	−2.615751	0.0203
ΔFDI(-1)	0.000454	0.000583	0.778767	0.4491
ΔFDI(-2)	0.001773	0.000493	3.597023	0.0029
ΔGDP	0.001524	0.000285	5.339642	0.0001
ΔGDP^2	−6.27E-07	1.17E-07	−5.349504	0.0001
ΔGDP^2(-1)	−4.26E-07	9.66E-08	−4.408377	0.0006

Table 10: Results of long-run estimation

Variables	Coefficient	SE	t-statistic	Prob
FDI	−0.002827	0.002974	−0.950279	0.3581
GDP	0.002742	0.000783	3.501472	0.0035
GDP^2	−4.36E-07	1.54E-07	−2.824941	0.0135
Intercept	−0.133127	0.148779	−0.894800	0.3860

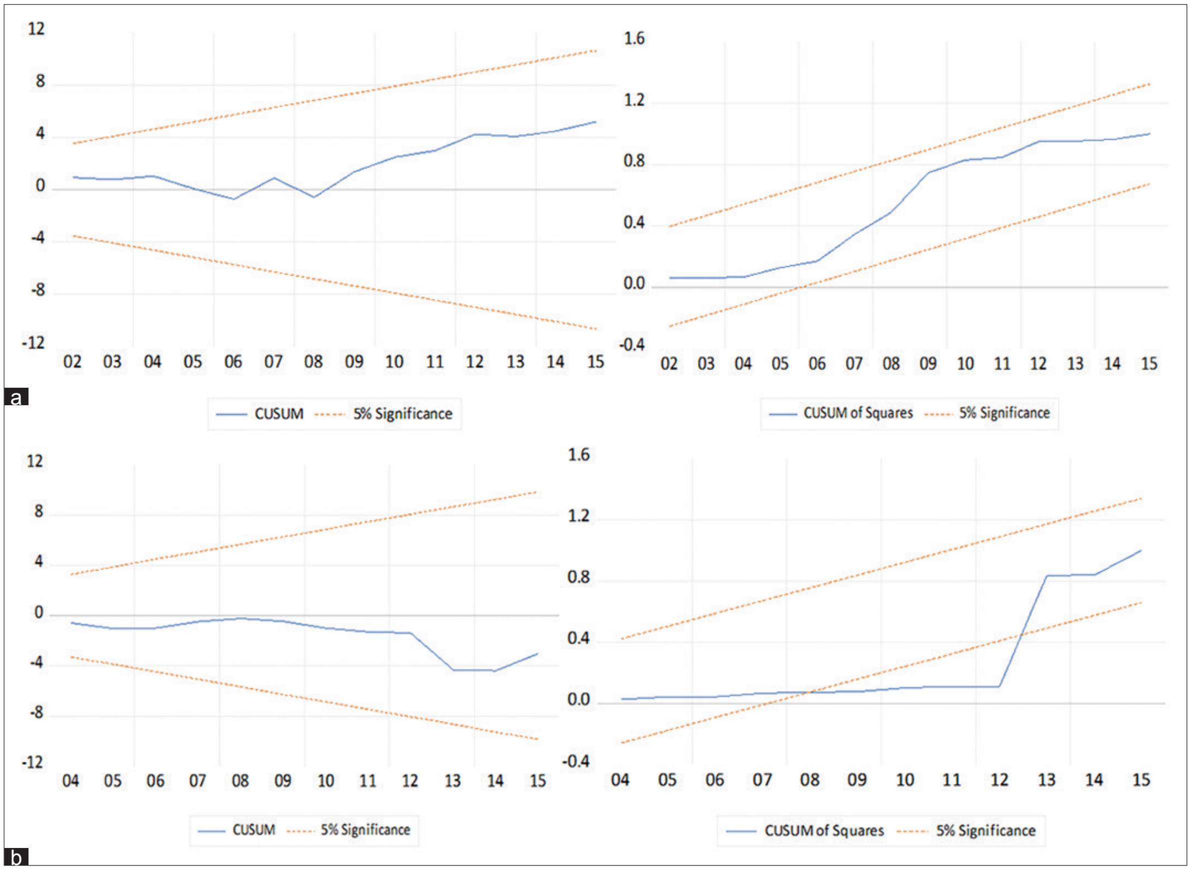
$EC=CO_2$ - (−0.0028*FDI+0.0027*GDP−0.0000*GDP^2−0.1331)

5. CONCLUSION AND POLICY IMPLICATIONS

It is natural and rightful for every member of the society to pursue a life in green and clean environment. Using the data of the 1986-2015 period, two simultaneous regression equations, applying ARDL method and Granger causality test, this paper emphasizes these 2 following main points:

- As another empirical research on the relationships between economic growth, FDI and environmental pollution in Vietnam, this paper concludes that Kuznets' hypothesis of inverted U-shaped effect exist in the relationship between economic growth and environmental quality in Vietnam. The

Figure 3: (a-b) Graph of CUSUM and CUSUMSQ of Equation 3, Graph of CUSUM and CUSUMSQ of Equation 4



turning point is at the level of approximately 3,145 US Dollar per capita (at constant 2010 prices).

- Although one-way causal relationship does exist between CO_2 emissions and FDI, there is not enough statistical evidence to conclude that FDI has impacts on environmental pollution in Vietnam, or relaxation of regulations on environment will boost the economic attraction of Vietnam to foreign investors.

Based on the results of the research, this paper suggests some considerations when applying these results in practice as follows:

Firstly, it is not necessary for Vietnam to delay changing environmental behaviors until the turning point is reached. Increase in CO_2 emissions is directly health-threatening to Vietnamese residents. As the environmental pollution in Vietnam has been a long-term problem, environmental conservation requires long-term effort. Thus, in any situation, each small action of any person or any organization will raise the awareness of environmental preservation and conservation.

Secondly, this research does not find evidence showing that environmental pollution is affected by FDI attraction. However, this is only true in the case of the whole country. This does not mean that no FDI projects contribute to environmental pollution. Even the slightest amount of environmental pollution is not encouraged, yet it is unrealistic to require FDI projects not to produce any pollutant. This implicates that government administrative agencies need to improve processes of verification and validation of FDI projects before, during and after investments to keep CO_2 emissions under acceptable level.

The situation of environmental pollution in Vietnam is becoming more serious, and there are still some differences in the conclusion of this paper with others. Future research can add variables of energy consumption, as Duong and Trinh (2017) note that environmental pollution in Vietnam is mainly attributed to coal, petroleum and gas. Regarding estimation method, we suggest using other methods such as Spatial Regression. There are usually strong economic interactions between nearby regions and countries by many factors like direction of investment flows, labour force and import-export turnover. As a result of commonalities in geography, climate, natural resources, effective policies are usually replicated, leading to the spillover effect of economic policies on neighboring regions and countries. Such policies include FDI attraction and environmental management policies.

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