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Economic Development, Globalization, Political Risk and CO_2 Emission: The Case of Vietnam*

Thi Van VU[1], De Chun HUANG[2]

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Abstract

This study investigates the dynamic effects of economic development, international cooperation, electricity consumption, and political risk on the escalation of CO_2 emission in Vietnam. We adopted autoregressive distributed lag model and Granger causality method to examine the interaction between CO_2 and various economic and political factors, including foreign direct investment, trade openness, economic growth, manufacture, electricity consumption, and political risk in Vietnam since the economic revolution in 1986. The findings reflect opposite influence between these factors and the level of CO_2 in the intermediate and long-term durations. Accordingly, foreign direct investment and CO_2 emission have a bidirectional relationship, in which foreign direct investment accelerates short-term CO_2 emission, but reduces it in the long run through an interactive mechanism. Moreover, economic development increases the volume of CO_2 emission in both short and long run. There was also evidence that political risk has a negative effect on the environment. Overall, the findings confirm lasting negative environmental effects of economic growth, trade liberalization, and increased electricity consumption. These factors, with Granger causality, mutually affect the escalation of CO_2 in Vietnam. In order to control the level of CO_2, more efforts are required to improve administrative transparency, attract high-quality foreign investment, and decouple the environment from economic development.

Keywords: CO_2 Emission, Economic Development, Globalization, Political Risk, Vietnam

JEL Classification Code: C32, P45, Q53

1. Introduction

The sustainable development goal gains more attention and has been incorporated in recent regional economic cooperation strategies in Asia. The distribution of global manufacturing also undergoes a new shift and triggers a huge volume of capital pouring into Asian developing countries. The Green Lancang-Mekong cooperation has a focus on the sustainable development of the economy and society in the sub-region countries under the South-South cooperation mechanism. Moreover, the achievement of current international cooperation such as European-Vietnam Free Trade Agreement (EVFTA) or Trans-Pacific Partnership Agreement (TPP) offers new opportunities for Vietnam to attract high-quality foreign capitals, boost up the industrialization process, and gain access to most global potential and high-standard markets such as EU and America. It can be said that Vietnam is in the most appropriate period to accelerate sustainable economic development nationwide.

Vietnam is a fast-growing country located in the Indochina Peninsula. The nation shares the Mekong River with the other five countries – Laos, Cambodia, Myanmar, Thailand, and China. Since the economic evolution "Doi Moi" initiated in 1986, Vietnam has transformed its former centralized planned economy to an open economy toward the global market (Beresford & Phong, 2000). After the economic liberalization, Vietnam has attracted a vast volume

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[1]First Author. PhD Student, Institute of Industrial Economics, School of Business, Hohai University, Nanjing, Jiangsu, China. Email: vuvan1690@gmail.com
[2]Corresponding Author. Professor, Institute of Industrial Economics, School of Business, Hohai University, Nanjing, Jiangsu, China [Postal Address: No. 8, Focheng West Road, Jiangning, Nanjing, Jiangsu, 211100, China] Email: huangdechun@hhu.edu.cn

of foreign investment and achieved an outstanding economic growth rate of 8% during the 1990s and an average of 6.4% in the period from 1986 to 2016 (Amendolagine et al., 2017). The country is involved in the new trend of regional and international cooperation as a member of Lancang-Mekong cooperation and a connection node linking Asia with Oceania and the Indian Ocean with the Pacific Ocean. The modern international and regional cooperation is expected to open up opportunities for Vietnam to accelerate its economic development. But the fast economic growth also raises concern about the deterioration of environmental quality that entails the expansion of the mass production economy (Islam et al. , 2017; Mudakkar et al., 2013). Furthermore, in the specific case of Vietnam, besides various economic factors such as FDI, growth rate, trade openness, etc., political risk should also be considered in the evaluation of pollution control.

In this study, we investigate the connection between various economic and governmental factors and environmental degradation in Vietnam. CO_2 emission was chosen as an indicator of environmental quality as it represents well the level of production-related pollution. The economic and administrative factors examined for the specific case of Vietnam include the level of FDI, trade openness, manufacture, electricity consumption, and political corruption. The investigation aims to address the following research questions: (1) How do the economic factors (economic growth, trade openness, manufacture, and electricity consumption) accelerate CO_2 emission in Vietnam? (2) Can globalization (FDI and international trade) help to reduce CO_2 emission following the pollution halo theory? And (3) What is the effect of political risk in the control of CO_2 emission? Findings from this study provide insight into the causes behind the escalation of CO_2 emission in Vietnam that help to push forward sustainable economic development and regional cooperation. The understanding is crucial to support the formulation and application of proper strategies and measures for environmental protection. Moreover, the study, although using Vietnam as an example, can offer similar evaluation for other emerging economies, which are also destinations for the production transfer in the new era.

2. Literature Review

Environment and economy share a complex connection that diverts the level of economic development. In developed economies, the environment usually degrades due to increased production scale to fulfill higher demand of material commodity (Dasgupta & Ehrlich, 2013), while the poverty-environment trap that links environmental degradation with exhausted usage of local natural resources was observed in under-developed economies (Boonstra & De Boer, 2014; Nguyen & Le, 2020). The famous inverted U-shape EKC indicated that the early stage of development stimulates environmental damage, then after reaching a certain level of development, negative effects on the environment reduce thanks to the application of innovative technology and sound production management (Stern, 2017).

Besides, the pollution haven hypothesis argued that FDI flows into developing countries to avoid the high cost of environmental treatment in their home (more developed) countries (Candau & Dienesch, 2017). However, it does not necessarily mean the deterioration of the host countries' environment. Previous studies have discussed a range of mechanisms underlying both positive and negative effects of FDI and trade on local environmental conditions (Copeland & Taylor, 2013; Naughton, 2014; Nguyen, 2020). The opposing opinions consider trade and foreign investment as the main drivers behind mass-production, the shift of economic structure, increased energy consumption, and environmental degradation in those pollution-haven countries (Bilgili et al., 2016; Waqih et al., 2019). Meanwhile, the supporting opinions suggest that FDI and international trade have positive effects on the local environment as investment from developed countries usually ties with a higher level of technology and management (Poelhekke & Van der Ploeg, 2015) and generates halo effect for host countries (Jugurnath et al., 2017). The overall effect is a result of multiple factors including national characteristics (administrative regime, environmental policies, etc.) and properties of the trade and investment (Clapp & Helleiner, 2012), and should, therefore, be evaluated for each country based on their specific situation.

Political risk, which is common in developing countries, has an important impact on the environment. The political institution can affect the extent of effluent's output to the extent that directly affects environmental policies. As pollutant increases with production volume, lawmakers and regulators must balance economic benefit and environmental protection. Leniency towards polluters is usually associated with concessions to political or economic supports (Helland & Whitford, 2003). Moreover, the lack of transparent jurisdiction may induce rent-seeking behavior and weaken the efficiency of pollution supervision and control (Biswas et al., 2012; Sekrafi & Sghaier, 2018). Even if higher emissions are reported in the countries with effective regulation, it does not mean weak environmental implementation, because their actual pollution levels are likely to be lower than in the countries with lower regulatory effectiveness (Ivanova, 2011). Because the influence mechanism of economic development, globalization, and political institution on the environment is diversified and multidirectional, we applied the empirical method to examine the effect of these factors in the special case of Vietnam.

3. The ARDL Approach and the Granger Causality Analysis

3.1. Modeling Procedure

The ARDL model proposed by Pesaran et al. (2001) was employed to investigate the effect of various economic and political factors on carbon emission in Vietnam due to its several advantages, i.e., ability to indicate both the short-run interaction and long-run correlation between variables, suitability to small-size sample and applicability for modeling non-stationary time series (Narayan, 2005). Various unit root tests were used before the ARDL model to ensure all variables are stationary at the first order. Afterward, the ARDL model was run to investigate the interrelationship between CO_2 emissions with other indicators. Moreover, several diagnostic tests on regression residual including the Breusch-Godfrey Serial Correlation LM test, the Breusch-Pagan-Godfrey heteroskedasticity test, the ARCH test for autoregressive conditional heteroskedasticity, the omitted variables RESET test, and the Jarque-Bera normality test have been conducted. Since there is cointegration among variables, the Granger causality analysis carried out based on the vector error correction model was also applied to check the directional linkage between variables. Then, the time profile of different variables in the cointegrated system was measured by impulse response function (IRF). Finally, the influence of different factors on the variability of carbon emission was analyzed using variance decomposition analysis.

3.2. Variables Selection and Data Description

To explore the dynamic effect of globalization, economic development, energy consumption, and political corruption on the CO_2 emission in Vietnam, we select seven studied variables including CO2, FDI, OPEN, COR, GRW, ELEC, and MNF. Variable COR is the per-capita volume of CO_2 emission excluding land use, land-use change, and forestry (LULUCF) obtained from the database of the Postdam Institute for Climate Impact Research (PIK) (Gütschow et al., 2019). The GRW represents the level of economic growth and is calculated by the GDP growth rate. Globalization measures the degree of trade openness and foreign investment flow into one country, in which the former is the ratio between total trade and GDP and denoted as OPEN while the latter is the percentage of net flow FDI per GDP and denoted as FDI. Data on GDP growth, total trade, FDI, and population were acquired from the database of the United Nations Conference On Trade And Development (UNCTAD, n.d.). The per-capita electricity consumption denoted as ELEC was computed by electricity consumption data published by the United States Energy Information Administration (The EIA, n.d.). The political corruption index that is symbolized as COR was extracted from the international country risk guide of the Political Risk Services (PRS) group (PRS Group, 2017), in which, the higher value of corruption index equates to lower political risk and vise versa. Variable MNF is the manufacturing value added per GDP that indicates the development level of manufacture and was obtained from the World Development Indicator (WDI) database (The World Bank, n.d.). Our datasets cover 31 years from 1986 to 2016. All data were transformed into a natural logarithmic form to reduce data deviation.

Table 1 summarizes the general characteristics of studying variables including mean, min, max, standard deviation, etc. Overall, there is no extreme value among the time series. The p-values of the Jarque-Bera test confirm the normal distribution of five variables including CO2, OPEN, COR, ELEC and MNF, and the non-normal distribution of FDI and GRW. In general, the ARDL approach does not have a strict requirement for normal distribution; hence it can be used for modeling all the concerned variables.

Table 1: Variables description

	CO2	FDI	OPEN	COR	GRW	ELEC	MNF
Mean	6.6611	1.0589	4.6711	0.8870	1.8316	5.7601	3.2380
Median	6.6952	1.5975	4.7232	0.9163	1.8599	5.7479	3.3916
Max.	7.7521	2.4802	5.2187	1.2528	2.2555	7.3223	3.4815
Min.	5.6026	-7.1425	4.0643	0.4055	0.9357	4.2178	2.8432
Std. Dev.	0.7093	1.9480	0.3795	0.2543	0.2820	1.0361	0.2343
Jarque - Bera	2.8807	142.1901	2.7358	2.9319	11.5270	2.5485	4.1476
Obs.	31	31	31	31	31	31	31

3.3. Model Specification

The effect of globalization, economic development, electricity consumption, and political corruption on CO_2 emission is modeled by the following function:

$$CO2 = f(GRW, FDI, OPEN, MNF, ELEC, COR) \tag{1}$$

The bounds test for seven variables is estimated accordingly to observed the cointegration between variables. The dynamic effects of MNF, ELEC, FDI, GRW, COR, and OPEN on CO2 are obtained based on the estimation result of the following ARDL bounds testing model:

$$\begin{aligned}\Delta CO2 = \ & c_0 + \sum\nolimits_{i=1}^{p_1} a_{1i}\Delta CO2_{t-i} + \sum\nolimits_{i=0}^{p_2} a_{2i}\Delta GRW_{t-i} \\ & + \sum\nolimits_{i=0}^{p_3} a_{2i}\Delta FDI_{t-i} + \sum\nolimits_{i=0}^{p_4} a_{3i}\Delta OPEN_{t-i} \\ & + \sum\nolimits_{i=0}^{p_5} a_{4i}\Delta MNF_{t-i} + \sum\nolimits_{i=0}^{p_6} a_{5i}\Delta ELEC_{t-i} \\ & + \sum\nolimits_{i=0}^{p_7} a_{6i}\Delta COR_{t-i} + b_1 CO2_{t-1} + b_2 GRW_{t-1} \\ & + b_3 FDI_{t-1} + b_4 OPEN_{t-1} + b_5 MNF_{t-1} \\ & + b_6 ELEC_{t-1} + b_7 COR_{t-1} + u_t\end{aligned} \tag{2}$$

where Δ is the difference operator; c_0 is the intercept; a_{ji} and b_j, j = {1, … ,7} are coefficients of variables; p_j, j = (1, …,7) is the lag order, u_t is the uncorrelated residual and subscript t represents the time.

With the existence of cointegration, the long-run effect can be extracted by providing the variables in a different form are equal to zero in the long-run equilibrium. Hence, equation (2) is rewritten as the following error correction-based ARDL model:

$$\begin{aligned}\Delta CO2 = \ & c_0 + \sum\nolimits_{i=1}^{p_1} a_{1i}\Delta CO2_{t-i} + \sum\nolimits_{i=0}^{p_2} a_{2i}\Delta GRW_{t-i} \\ & + \sum\nolimits_{i=0}^{p_3} a_{2i}\Delta FDI_{t-i} + \sum\nolimits_{i=0}^{p_4} a_{3i}\Delta OPEN_{t-i} \\ & + \sum\nolimits_{i=0}^{p_5} a_{4i}\Delta MNF_{t-i} + \sum\nolimits_{i=0}^{p_6} a_{5i}\Delta ELEC_{t-i} \\ & + \sum\nolimits_{i=0}^{p_7} a_{6i}\Delta COR_{t-i} + + \varnothing ECT_{t-1} + u_t\end{aligned} \tag{3}$$

where ECT_{t-1} represents the adjustment in the long-run equilibrium.

Afterward, the Granger causality Wald test for the cointegrated system was carried out based on the VECM model:

$$\begin{bmatrix}\Delta CO2_t \\ \Delta GRW_t \\ \Delta FDI_t \\ \Delta OPEN_t \\ \Delta MNF_t \\ \Delta ELEC_t \\ \Delta COR_t\end{bmatrix} = \begin{bmatrix}a_1 \\ a_2 \\ a_3 \\ a_4 \\ a_5 \\ a_6 \\ a_7\end{bmatrix} + \begin{bmatrix}A_{11,1}A_{12,1}A_{11,1}A_{11,1}A_{11,1}A_{11,1}A_{11,1} \\ A_{21,1}A_{22,1}A_{21,1}A_{21,1}A_{21,1}A_{21,1}A_{21,1} \\ A_{31,1}A_{31,1}A_{31,1}A_{31,1}A_{31,1}A_{31,1}A_{31,1} \\ A_{41,1}A_{41,1}A_{41,1}A_{41,1}A_{41,1}A_{41,1}A_{41,1} \\ A_{51,1}A_{51,1}A_{51,1}A_{51,1}A_{51,1}A_{51,1}A_{51,1} \\ A_{61,1}A_{61,1}A_{61,1}A_{61,1}A_{61,1}A_{61,1}A_{61,1} \\ A_{71,1}A_{71,1}A_{71,1}A_{71,1}A_{71,1}A_{71,1}A_{71,1}\end{bmatrix}\begin{bmatrix}\Delta CO2_{t-1} \\ \Delta GRW_{t-1} \\ \Delta FDI_{t-1} \\ \Delta OPEN_{t-1} \\ \Delta MNF_{t-1} \\ \Delta ELEC_{t-1} \\ \Delta COR_{t-1}\end{bmatrix} + \cdots +$$

$$\begin{bmatrix}A_{11,k}A_{12,k}A_{11,k}A_{11,1}A_{11,k}A_{11,k}A_{11,k} \\ A_{21,k}A_{22,k}A_{21,k}A_{21,k}A_{21,k}A_{21,k}A_{21,k} \\ A_{31,k}A_{31,k}A_{31,k}A_{31,k}A_{31,k}A_{31,k}A_{31,k} \\ A_{41,k}A_{41,k}A_{41,k}A_{41,k}A_{41,k}A_{41,k}A_{41,k} \\ A_{51,k}A_{51,k}A_{51,k}A_{51,k}A_{51,k}A_{51,k}A_{51,k} \\ A_{61,k}A_{61,k}A_{61,k}A_{61,k}A_{61,k}A_{61,k}A_{61,k} \\ A_{71,k}A_{71,k}A_{71,k}A_{71,k}A_{71,k}A_{71,k}A_{71,k}\end{bmatrix}\begin{bmatrix}\Delta CO2_{t-k} \\ \Delta GRW_{t-k} \\ \Delta FDI_{t-k} \\ \Delta OPEN_{t-k} \\ \Delta MNF_{t-k} \\ \Delta ELEC_{t-k} \\ \Delta COR_{t-k}\end{bmatrix} + \begin{bmatrix}\theta_1 \\ \theta_2 \\ \theta_3 \\ \theta_4 \\ \theta_5 \\ \theta_6 \\ \theta_7\end{bmatrix} ECT_{t-1} + \begin{bmatrix}e_{1t} \\ e_{2t} \\ e_{3t} \\ e_{4t} \\ e_{5t} \\ e_{6t} \\ e_{7t}\end{bmatrix} \tag{4}$$

where a is the intercept, e_t is the error term, and θ is the adjustment parameter of error correction term ECT_{t-1}. If θ has a negative value and significant t-statistic, the long-run causality between variables exists. Besides, in the short-run interactive mechanism, one variable Granger causes another variable if its coefficient has a significant chi-square value.

4. The Results and Discussions

4.1. The Result of the Unit Root Test

The variables were first examined with the ADF method, then the results were cross-checked with the PP and KPSS methods. The t-statistics displayed in Table 2 suggest that all seven variables are stationary at the first difference with 5% significant properties. Particularly, the ADF and PP tests suggest that FDI is stationary at the level but the inference was rejected in the KPSS test. Since there was no variable integrated at second-order, the ARDL bounds testing was applied for our dataset.

4.2. The Cointegration Test Results

Before the bound test, the proper lags of all variables in the system were chosen. As suggested by Liew (2004), the lag length selection criterion based on Akaike Information Criteria (AIC) is suitable for a small-size sample and the maximum lag for annual data is 2 according to Pesaran and Shin (1998a). Thus, the optimal model ARDL (2, 2, 1, 2, 2, 0, 1) was chosen for the bound test. The regression result is summarized in Table 4 indicates the existence of cointegration among variables since the F-statistic is larger than the upper bound value. The Durbin-Watson value of 2.0134 suggests no autocorrelation in the residual. Likewise, the significant F-statistic at a 1% level implies the significance of the regression result. They altogether gave confidence to the suitability of the model fitness.

To check the stability of the ARDL model, we performed several diagnostic tests on the regression residual. Since all the statistic values from related tests specified for the ARDL model are insignificant at 5% as shown in Table 5, the estimated model is stable without autocorrelation, heteroskedasticity, and omitted values. Meanwhile, the residual is normally distributed according to the insignificant Jarque-Bera statistic. Besides, the structural stability of the model is confirmed by the CUSUM test and the squared-CUSUM test (Runger et al., 1999). The CUSUM control chart (Fig. 1a) and SQ-CUSUM control chart (Fig. 1b) that are represented by blue lines staying inside 5% significance bounds ensure the structural stability of our regression result and imply that the coefficients are proper for future prediction.

Table 2: The t-statistic of all variables from three unit-root tests

Variables	At level			At the first difference			Integrated order
	ADF	PP	KPSS	ADF	PP	KPSS	
CO2	-2.30	-2.33	0.10	-4.59***	-4.60***	0.16	I(1)
FDI	-7.02***	-8.25***	0.37*	-9.25***	-9.19***	0.16	I(0)
OPEN	-1.55	-1.99	0.10	-3.26**	-3.32**	0.18	I(1)
COR	-2.45	-2.04	0.10	-3.42**	-3.42**	0.09	I(1)
GRW	-3.74***	-5.62***	0.47**	-4.44***	-6.21***	0.21	I(0)
ELEC	-1.55	-1.99	0.10	-3.26**	-3.32**	0.18	I(1)
MNF	-0.76	-0.64	0.15**	-3.81***	-3.85***	0.27	I(1)

***, **, * denote the 1%, 5% and 10% significant level respectively

Table 3: The results of ARDL bounds test and regression model's diagnostic test

Cointegration test	Test method	F-statistic	Sig.Level
	Bounds Test	12.20***	1%
Diagnostic test	Test method	Statistic Value	Prob.
	Breusch-Godfrey Serial Correlation LM Test[1]:	0.033968	0.8571
	Breusch-Godfrey Serial Correlation LM Test [2]:	0.033968	0.8571
	Breusch-Pagan-Godfrey Heteroskedasticity Test:	1.381221	0.2885
	ARCH Test[1]	0.322133	0.5752
	ARCH Test[2]	0.22096	0.8034
	Jarque-Bera Test	1.587716	0.4521
	Ramsey RESET Test	0.008181	0.9296

*** denotes the 1% significant level; [1, 2] denote one and two lags included in the test model, respectively

4.3. The Long-Run and Short-Term Connections Among Variables

Since the cointegration relationships exist among variables, the long-run and short-term dynamic effects of the concerned factors on the CO_2 emission were obtained from the ARDL model regression result. The whole dynamic interaction among variables is depicted in Fig. 2, of which, all the six variables, i.e., the GRW, the FDI, the OPEN, the MNF, the ELEC, and the COR were found to have a long-run influence on CO_2 emission, while only five variables, i.e., the GRW, the FDI, the OPEN, the COR, and the CO2 itself show a significant result in the short-term.

4.3.1. The Long-Run Effect

The long-run impact of variables on CO_2 emission is shown on the left-hand side of Fig. 2. In the long-run relationship, FDI was found to have a negative influence on CO_2 emission, of which about 1 % increase in FDI can reduce 0.109% CO_2 emission. It implies the existence of the halo effect of FDI in Vietnam. The FDI with advanced technologies and environmental-friendly production methods from developed countries can help to control and reduce CO_2 emission. It indicates that FDI is a prior and important force for sustainable development in Vietnam.

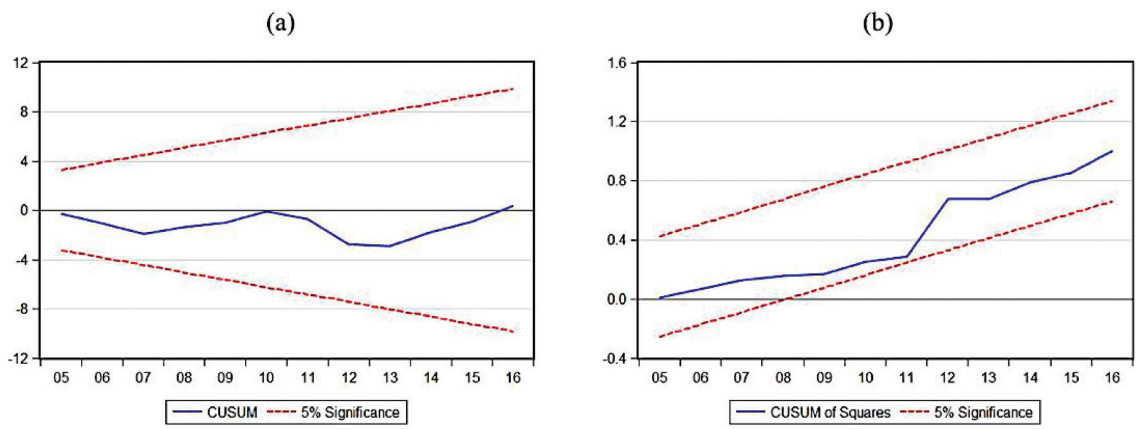

Figure 1: Plot of structural stability test; (a) CUSUM control chart; (b) SQ-CUSUM control chart

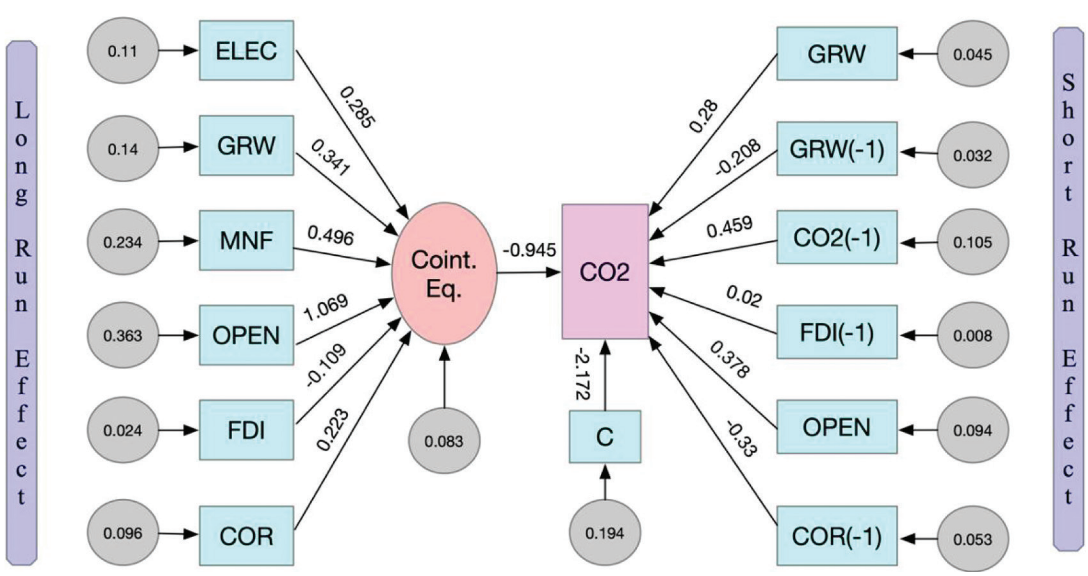

Figure 2: The long-run and short-term effects on CO_2 emission. Note: The two variables are linked by a directional arrow attached to their coefficients and the following regression error

Secondly, the positive coefficient of trade openness reveals that international trade accelerates CO_2 emission in Vietnam. As suggested by the environmental cost-shifting hypothesis (Walter & Martinez-Alier, 2012), many manufacturers in developed countries intentionally transfer their manufacturing bases into developing countries to avoid the high environmental cost and stringent environmental regulation in the home country. The host countries (the recipient) became the main manufacturer and exporter of labor-intensive or environment-intensive products. Thus, in those countries, the trade volume increases rapidly together with the rising level of CO_2 emission. Likewise, the expansion of demand and consumption that arose from international trade can be the other reason causes the increase in CO_2 emission. Since the effects of trade openness on CO_2 emission are much stronger than the effects of FDI and the absolute percentage of trade per GDP is also bigger than the percentage of FDI, we can assume that globalization generally accelerates the escalation of CO_2 emission in Vietnam. To reduce the environmental burden of international trade and economic globalization, Vietnam should adopt proper economic policies and development strategies, put the focus on industries that are less harmful to the environment such as services, high-tech industries, etc. and encourage green production and green consumption inside the national boundary.

Moreover, the finding indicates that every 1% of economic growth gives rise to about 0.34% of CO_2 emission. The economic growth reflects the expansion of economic scale, massive production, and rising demand that together accelerate CO_2 emission. For those countries where the level of production management and technology is still lagged, such as Vietnam, the price of economic development may be accounted for environmental degradation. Although the EKC hypothesis suggests that economic development will finally improve the environment, there is still no guarantee for developing countries such as Vietnam about when and where to reach the turning point. Therefore, the country should rather sooner than later detect and prevents the environmental impacts of economic activities.

Furthermore, the electricity consumption stands for energy indicator is another factor causing CO_2 emission in Vietnam, in which for every 1% of electricity consumption, there is more of 0.28% CO_2 emission pumped into the atmosphere. In Vietnam, electric power generation highly relies on a non-renewable resource such as fossil fuels (coal, oil, and gas) or hydropower without proper environmental concern that causes deforestation and ecological damage. To protect the environment and reduce CO_2 emission, Vietnam should put more efforts into renewable energy projects and exploring different energy sources that are less harmful to the environment such as wind, solar, and biomass energy, together with fostering the general public to change their consciousness from non-renewable energy behavior to green energy consumption.

Likewise, the control of corruption risk was also found significantly positive with the level of CO_2 emission in the long run. In general, the government plays the most important role in protecting the natural environment and ensuring national sustainable development. The positive correlation between these two indexes does not mean that corruption helps to reduce CO_2 emission in Vietnam, on the contrary, it implies that the environmental factor has been neglected or not paid enough attention when formulating and implementing economic policies and incentives. To enhance the effectiveness of emission control, it is necessary to reduce corruption risk, increase the government's transparency, secure proper voice and participation of the public in environmental protection and encourage public disclosure on bribe or environmentally damaging behaviors.

Finally, the manufacture positively correlates with CO_2 emission at a 10% significant level. Manufacturing is considered an important driven force of an independent and sustainable economy as well as the focus of Vietnamese industrialization and development strategy. However, backward manufacturing technologies and management skills will aggravate the environmental burden. Thus, it requires the close attention of the country to apply and develop new advanced techniques in different industries, accelerating the technology transfer process from developed countries and foreign investors to update the old production methods and reduce the negative effects of manufacture on the environment.

4.3.2. The Short-Term Effect and Equilibrium Adjustment

The short-run relationship among variables is depicted in the right-hand side of Fig. 2 wherein trade openness and economic growth demonstrate a positive correlation with CO_2 emission. Instead, the economic growth at the first lag has a negative relationship with CO_2 emission. It implies that the effect of economic growth on the level of CO_2 emission is gradually adjusted over time. The low political corruption index or the high political corruption risk triggers CO_2 emission in the short run. Because corruption is one of the factors that reduce the administrative effectiveness of government and may lead to an overlook in environmental scanning and governing and in the inspection process of investment and business authorization. Moreover, if the emerging countries fail to control corruption, the pollution will remain at a higher level than the reported number in developed countries as income increases (Masron & Subramaniam, 2018; Rehman et al., 2012). On the contrary, the FDI at the first lag positively relates to CO_2 emission.

The underlying reason could be the time required to obtain a technological spillover effect from FDI to offset a part of CO_2 emission.

Moreover, the error correction parameter incorporated in the error-correction-based model with a negative value of -0.94475 and significant property at 0% level suggests a long-run correlation between the variables. Besides, the lag length (-1) following the error correction term represents the adjustment speed for the whole system achieving the equilibrium position. The model will be dynamically re-adjusted from short-term imbalance after one year.

4.4. Granger Causality in VECM and Impulse Response Analysis

Moving to the Granger causality test in VECM, since there are cointegrations between variables, the VECM system is constructed to check for the directional linkages between variables. Table 6 exhibits the results of Granger causality using the Wald test where FDI, trade openness, economic growth, manufacture, electricity, and corruption jointly cause CO_2 emission in the long run. Similarly, there is also evidence of Granger causalities from other regressors toward FDI, manufacture, and economic growth in the long-run duration.

The short-run linkages were found by observing the significance of Chi-square statistics. The finding indicates the unidirectional linkage from corruption to CO_2 emission, the bidirectional connection between CO_2 emission and economic growth. CO2 emission was also found to Granger cause electricity consumption and FDI. The other unidirectional causalities between dependent and independent variables include COR to FDI; electricity consumption to trade openness; FDI to economic growth, and three variables, i.e., FDI, economic growth, and trade openness to manufacture. The Granger result confirms the strong dynamic effects between the concerned factors on the CO_2 emission in Vietnam. The Vietnamese government should develop robust policies with consideration of the multi-aspect causality between energy consumption, economic development, globalization, government, and environment to reduce CO_2 emission and its consequences on climate change.

Besides, impulse response function (IRF) analysis is a useful tool to observe the dynamic interconnections among the variables in a structural cointegrated system (Lütkepohl & Reimers, 1992). By giving a shock to one of the variables in equilibrium relation at a baseline time, we can measure the time paths of the system to reach the new equilibrium providing no further shock. In this study, we applied the generalized impulse response function because it fully takes into consideration the correlation patterns among the different shocks and avoids the heavy reliance on the variables' order of the orthogonalized impulse response function (Pesaran & Shin, 1998). The IRF associated with VECM measures the response of CO_2 emission to the shock on different variables in the system over 35 future periods (Fig. 5). In the first two periods, the response of CO_2 emission to the innovation of corruption is insignificant but it responds significantly afterward. The FDI reports an insignificant influence on CO_2 emission while the shocks in other variables spring increasingly positive responses from CO_2 emission. The impulse response of CO_2 emission to the innovations in the system remains stable after ten periods. The result from IRF analysis suggests lasting effects of the concerned economic and political factors on CO_2 emission.

Table 4: The VEC Granger causality Wald test result

	ΔCO2	ΔCOR	ΔELEC	ΔFDI	ΔGRW	ΔOPEN	ΔMNF
ΔCO2		1.9708	5.7703**	3.4538*	4.1670**	0.7349	0.9246
ΔCOR	7.1004***		0.3559	3.5524*	0.6774	0.0488	4.3176**
ΔELEC	0.1656	0.3048		0.2483	0.0831	3.4412*	1.5270
ΔFDI	1.5671	0.1908	0.0219		3.3295*	0.2650	2.9561*
ΔGRW	11.6390***	0.0347	0.0398	1.8781		0.0043	6.9385***
ΔOPEN	0.0033	0.7800	0.8489	2.5738	0.5290		5.7411**
ΔMNF	0.0194	0.3482	0.2387	1.2748	0.1320	0.0313	
All	24.3137***	3.8445	8.1352	29.8775***	17.8133***	4.3144	19.7868**

(1) The dependent variables are displayed horizontally, the regressors are displayed vertically. (2) ***, **, * denote the 1%, 5% and 10% significant level respectively

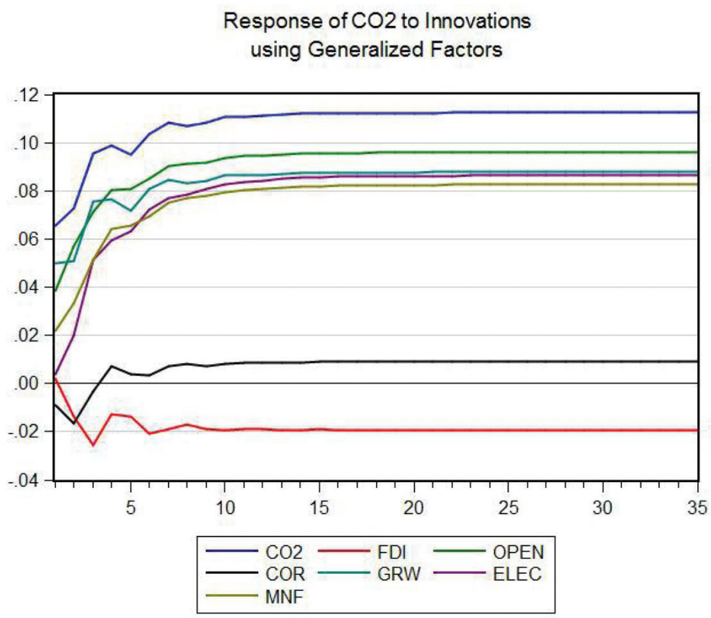

Figure 3: The result of the impulse response function for the current cointegrated system regarding CO_2 emission over 35 future periods

5. Conclusions

This study investigates the nexus between CO_2 emission and economic development, globalization, and political risk in Vietnam after the national economic reform from 1986 to 2016. The ARDL model was adopted for cointegration between variables. Besides, Granger causality and impulse response function are used to check the directional linkages between variables and the time profile of variables responding to exogenous innovation. In short, globalization, electricity consumption, economic growth, manufacture, and corruption are found to have a significant dynamic impact on CO_2 emission in Vietnam in the long run.

Currently, as an emerging country at the beginning of the industrialization and globalization process, economic development and market liberalization would be the major concerns in Vietnam. However, rising problems of climate change and environmental degradation would distort the development direction of the country in the long run. Because FDI was found to have a halo effect in Vietnam, the country should actively and strategically attract high-quality investments together with accelerating technological transfer to improve the local technological level and manufacture methods. Besides, because political corruption as a common problem in developing countries accelerates CO_2 emission in the long run, the country needs to put more effort into improving administrative transparency as well as encouraging the public's participation in environmental protection. Furthermore, due to the gradual increase in electricity demand that is incorporated with consumption, manufacture, and other public and private activities, it requires appropriate energy policies and environmental laws to control the escalation of CO_2 emission. Introducing emission-trading schemes, imposing proper environmental taxation and subsidization are efficient methods that were experimented in developed countries. Likewise, actively exploring and supporting environmental-friendly energy generating projects as well as shifting to clean energy consumption will be the targetable direction in Vietnam.

In brief, the study provides empirical evidence about the role of globalization, economic development, manufacture, and the central government on the escalation of CO_2 emission in Vietnam. As climate change is gaining more and more attention worldwide, this investigation could help to direct the economic development strategy of Vietnam shortly. Besides, the study offers rooms for the next surveys whereas researchers can investigate the interrelation of different variables together with climate change in different countries other than Vietnam.

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