# The effectiveness of Vietnamese policies response to climate change through ARDL analysis

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ARTICLE INFO	ABSTRACT
<b>DOI:</b> 10.46223/HCMCOUJS. econ.en.11.2.1435.2021	Being a highly vulnerable country due to climate change, Vietnam has issued various climate policies while trying to keep the pace of economic growth. The study evaluates the effectiveness of these policies by examining the effect of economic and energy factors in the efforts of controlling CO <sub>2</sub> emissions.
Received: February 02 <sup>nd</sup> , 2021 Revised: March 18 <sup>th</sup> , 2021 Accepted: April 01 <sup>st</sup> , 2021 <i>Keywords:</i> climate change; economic factors; energy consumption	Approach by Autoregressive Distributed Lag (ARDL) analysis, the model of a linear regression between CO <sub>2</sub> emissions and Gross Domestic Product (GDP), Foreign Direct Investment (FDI) & sources of energy consumption has been developed from 1985 to 2018. The study indicates that the economic factor as Foreign Direct Investment (FDI) is a possible significant element to mitigate the emission. In addition, sources of energy consumption have the important role of controlling CO <sub>2</sub> emissions. In the long run, the consumption of non - renewable energy is a positive and significant effect on CO <sub>2</sub> emissions while renewable energy is vice versa. These outcomes show the Foreign Direct Investment (FDI)
	and renewable energy consumption factors lead to the decrease of $CO_2$ emissions in the long run for Vietnam, which implies the co- exist of economic growth and decarbonization.

## 1. Introduction

After years to years of relative stability, due to the full span of human civilization, the Earth's climate is changing (Woetzel et al., 2020). The increase of average global temperature has driven infrequently extreme weather events and rising sea levels, translating into socioeconomic loss and damage. The continuous increase amount of  $CO_2$  emission in the atmosphere is the main cause of climate change. Along the same lines, Vietnam has achieved remarkable economic development since the reform in 1986, which has resulted in impressive wealth as well as vast amounts of pollutants in the environment. The amount of  $CO_2$  emission is fast growing in Vietnam and its carbon intensity is almost triple the world average (Audinet et al., 2016).

To be a highly vulnerable country, up to date, Vietnam has already engaged in many international climate change negotiations and put climate change issues on the national agenda since the 1990s. The Vietnamese government has announced and implemented a variety of national and regional climate policies. The nation has shown its active role in the battle of fighting climate change by shifting policies from solely relying on aboard funding to take responsibility for  $CO_2$  mitigation (Zimmer, Jakob, & Steckel, 2015). Especially, in 2012,

Vietnam issued the national Green Growth Strategy (VGGS) aiming to restructure the economy to achieve low carbon growth, which are focusing three critical strategic directions as reducing green gas emission by the energy sector, greening production in both manufactory and agriculture, and greening lifestyle and consumption (Prime Minister, 2012). The VGGS committed to reduce a GHG intensity target by national sources and international support. It has requested all line ministries, state agencies, and regional authorities to develop an action plan to meet the targets (Nguyen, 2014).

Vietnam has made some achievements (VPCP, 2019) in response to climate change; however, the overall evaluation of the effectiveness of the policies is still missing. The purpose of this study is to fill the gap by using ARDL analysis between  $CO_2$  emissions and economic factors to show whether the decoupling of environment and economy exists in Vietnam when the nation is on the pathway of pursuing a green economy.

# 2. Literature review

There is clear evidence that economic growth usually leads to environmental degradation (Beckerman, 1992), especially in developing countries. However, from a sustainable development approach, we could have achieved both economic growth and ecological sustainability. Based on the empirical phenomenon of Kuznets (1955), the economists have assumed that economic growth, rather than being a threat to the environment, would be the means to eventual environmental improvement (World Bank, 1993). The Environmental Kuznets Curve (EKC) is an inverted U-shaped between environmental quality and income per capita. In the early stages of economic growth, environmental degradation and pollution increase, but beyond some level of income per capita, the trend reverses. At high-income levels, the more economy grows, the better environmental quality is (Stern, 2004). However, many authors cautioned the mixed results varying in the function of the country and period considered (Apergis, 2016; Iwata, Okada, & Samreth, 2012; Nasir & Ur Rehman, 2011; Shahbaz, Haouas, & Hoang, 2019). Many authors point out that the existence of the EKC curve is mainly in upper-middle-income and high-income countries (Ozturk & Acaravci, 2013; Saboori, Sapri, & bin Baba, 2014; Shahbaz et al., 2019).

According to empirical studies of Shafik and Bandyopadhya (1992), they explained the phenomenon by the social choices about levels of environmental quality at different income levels. The World development report (World Bank, 1993, pp. 38-39) stated that "the view that greater economic activity inevitably hurts the environment is based on static assumption about technology, tastes, and environmental investment [...] and as incomes rise, the demand for improvements in environmental quality will increase, as well the resources available for investment." The pathway for developing countries to sustainable development is to pursue a green economy (UNEP, 2011).

The relationship between  $CO_2$  emission and economic factors as GDP and FDI has been studied for years. In general, in the linear regression, GDP often leads to increase  $CO_2$  emission and the researchers often test the Kuznets curve by quadratic regression and give the mixed results of the validity of EKC. Some countries display an inverted U-shape relation between pollutant emission and income while non-existence (Dinda & Coondoo, 2006; Mrabet & Alsamara, 2017; Saboori & Sulaiman, 2013; Shahbaz et al., 2019; Stern, 2004).

Moreover, the FDI factor also has a controversial discussion in the relationship to the environment because it not only could bring better environmental quality but also cause costly negative externalities for the host countries. There are two hypotheses explaining the above results: the pollution haven and the pollution halo hypothesis. In the pollution haven hypothesis, the polluting industries tend to move to the lessened countries in environmental protection regulations; therefore, the more FDI attracted, the more environmental degradation is (Kearsley & Riddel, 2010). In contrast, those countries attracting green FDI often follow the pollution halo hypothesis, which means that FDI has contributed to a better environment for the host countries. This is because foreign companies use better management practices and advanced technology (Zarsky, 1999; Zhu, Duan, Guo, & Yu, 2016). According to Hoang and Duong (2018), FDI is essential for economic development in Vietnam by attracting capital, enhancing firm-level efficiency. It's also the main factor in transferring cutting-edge technology and encouraging innovation in the Fourth Industrial Revolution in Vietnam.

On the other hand, there is a close relationship between  $CO_2$  emissions and energy consumption. The non-renewable energy consumption has often given out the positive effect of increasing  $CO_2$  emission (Kasman & Duman, 2015; Shahbaz, Mahalik, Shah, & Sato, 2016). However, studies on renewable energy consumption have shown the possibility of decreasing  $CO_2$  emissions (Dogan & Seker, 2016; Dong, Sun, Jiang, & Zeng, 2018; Saudi, Sinaga, & Jabarullah, 2019). According to Saudi et al. (2019), thanks to energy efficiency and green energy, energy consumption would not damage the environment but will contribute to sustainable development.

Based on this literature review, the elements of economic and energy factors will be input into the models to reveal their roles in the effort of controlling  $CO_2$  emissions. The results of this paper will help us indirectly evaluate the effectiveness of policies to reduce CO2 emissions in Vietnam from 1985 to 2018.

# 3. Methodology and data

# 3.1. Data and research model

The study reviewed the data of  $CO_2$  emissions  $(CO_2^1)$ , annual foreign direct investment  $(FDI^2)$ , annual gross domestic product per capita  $(GDP^3)$ , energy consumption from oil  $(OIL^4)$ , total non-renewable energy consumption, which includes oil, gas energy, and coal  $(NONRE^5)$  and hydro-power renewable energy consumption  $(RE^6)$  in Vietnam. The data were chosen from 1985 to 2018 because all the variables in this study are increasing rapidly in this period. The dependent variable  $CO_2$  emission is taken from Knoema and measured in per capita emissions. The independent variables consist of GDP and FDI, are collected from United Nations Conference on Trade and Development, expressed in current US\$; OIL, NONRE, and RE, which are from the project of Our World in Data, at Global Change Data Lab of Oxford university, measured in terawatt-hours (TWh) per year.

The aim of our study is focused on analyzing the effects of economic growth and energy consumption on  $CO_2$  emissions in the short-term and long-term. Besides, the study also tests whether renewable energy will be important in reducing  $CO_2$  emission while there is an existence of FDI. According to Prime Minister (2016) on the decision of National Power Development Master Plan for 2011 - 2020 with the vision to 2030, the nation has to reduce the share of coal-fired energy while given more investment in the oil industry and renewable-energy

<sup>&</sup>lt;sup>1</sup> Annual CO<sub>2</sub> emissions per capita (Unit: metric tons per capita).

<sup>&</sup>lt;sup>2</sup> Foreign direct investment (Unit: US dollar at current price in million).

<sup>&</sup>lt;sup>3</sup> Annual gross domestic product per capita (Unit: US dollar at current and constant (2010) price).

<sup>&</sup>lt;sup>4</sup> Energy consumption from oil (Unit: terawatt-hours (TWh)).

<sup>&</sup>lt;sup>5</sup> Total non – renewable energy consumption: oil, gas and coal (Unit: terawatt-hours (TWh)).

<sup>&</sup>lt;sup>6</sup> Hydro-power renewable energy consumption (Unit: terawatt-hours (TWh)).

(Phan, Nguyen, & Nguyen, 2020). Therefore, we developed the two models with the difference in sources of non-renewable energy consumption (as Equations 1 & 2 below) to test the assumption that the shift in energy policies will be better for the environment. We transformed all variables to their natural logarithmic forms to achieve consistent empirical evidence. The models are presented as follows:

$$\ln CO_{2t} = \beta_0 + \beta_1 \ln GDP_t + \beta_2 \ln FDI_t + \beta_3 \ln OIL_t + \beta_4 \ln RE_t + \varepsilon_t$$
(Model 1)

$$\ln CO_{2t} = \beta_0 + \beta_1 \ln GDP_t + \beta_2 \ln FDI_t + \beta_3 \ln NONRE_t + \beta_4 \ln RE_t + \varepsilon_t$$
(Model 2)

Where t and  $\varepsilon$  denote time and error.

#### 3.2. ARDL estimation

In order to test the role of renewable, non-renewable energy consumption, the study applied the Autoregressive Distributed Lag (ARDL) method. According to Pesaran, Shin, and Smith (2001), ARDL solved the problem that time series variables which integrated in a different order, except for variables are stationary in levels two (I(2)) and above. Thus, many studies have used the ARDL method, and same for the current study (Bölük & Mert, 2015).

Two functions are proposed for the study by ARDL approach as follows:

$$\ln CO_{2t} = \beta_0 + \sum_{t=i}^p \beta_1 \ln CO_{2t-i} + \sum_{t=i}^p \beta_2 \ln GDP_{t-i} + \sum_{t=i}^p \beta_3 \ln FDI_{t-i} + \sum_{t=i}^p \beta_4 \ln OIL_{t-i} + \sum_{t=i}^p \beta_5 \ln RE_{t-i} + \varepsilon_t$$
(3)

$$\ln CO_{2t} = \beta_0 + \sum_{t=i}^{p} \beta_1 \ln CO_{2t-i} + \sum_{t=i}^{p} \beta_2 \ln GDP_{t-i} + \sum_{t=i}^{p} \beta_3 \ln FDI_{t-i} + \sum_{t=i}^{p} \beta_4 \ln NONRE_{t-i} + \sum_{t=i}^{p} \beta_5 \ln RE_{t-i} + \varepsilon_t$$
(4)

If  $CO_2$ , GDP, and FDI have a long-term connection with sources of energy consumption which are presented with the indication in this study. Hence, by utilizing the below equation, we calculate the beta value of the short-run coefficients:

$$\Delta \ln CO_{2t} = \beta_0 + \sum_{t=i}^p \beta_1 \Delta \ln CO_{2t-i} + \sum_{t=i}^p \beta_2 \Delta \ln GDP_{t-i} + \sum_{t=i}^p \beta_3 \Delta \ln FDI_{t-i} + \sum_{t=i}^p \beta_4 \Delta \ln OIL_{t-i} + \sum_{t=i}^p \beta_5 \Delta \ln RE_{t-i} + \theta ECT_{t-1} + \varepsilon_t$$
(5)

$$\Delta \ln CO_{2t} = \beta_0 + \sum_{t=i}^p \beta_1 \Delta \ln CO_{2t-i} + \sum_{t=i}^p \beta_2 \Delta \ln GDP_{t-i} + \sum_{t=i}^p \beta_3 \Delta \ln FDI_{t-i} + \sum_{t=i}^p \beta_4 \Delta \ln NONRE_{t-i} + \sum_{t=i}^p \beta_5 \Delta \ln RE_{t-i} + \theta ECT_{t-1} + \varepsilon_t$$
(6)

The coefficient of the ERROR-CORRECTION TERM (ECT) measures the adjustment speed of the variables back to the long run equilibrium (Nkoro & Uko, 2016). The coefficient of ECT is expected to be negative and statistically significant.

# 4. Results

#### 4.1. Descriptive statistics and unit root tests

The data were chosen from 1985 to 2018 because, in this period, Vietnam has implemented economic reform and transited to a market economy, led to significant changes. Therefore, the country has achieved great growth of wealth, trade, and investment as well as  $CO_2$  emissions. The descriptive statistics of all variables are shown in Table 1 and Figure 1 in the period of 1985 - 2018.

# Table 1

Variables	CO <sub>2</sub> (metric tons per capita)	GDP US dollar at current and constant (2010) price	FDI US dollar at current price in million	OIL (terawatt- hours)	NONRE (terawatt- hours)	RE (terawatt- hours)
Mean	1.0593	811,111.93	34,554.42	124,335.1	274,855	24,112.1
Std.Dev.	0.7474	782,335.3	41,606.92	81,957.3	220,853.8	22,458.4
Min	0.2870	78,774.3	40,791	23,436.7	56,389.8	1,384
Max	2.81	2,558.956	144,991.3	289,018.9	784,088.4	80,706.2

Descriptive statistics

Source: The researcher's data analysis

Generally, Vietnam has achieved more than 811USD gross domestic product per capita, attracted 34,554.42USD annual foreign direct investment. This country used on average 124TWh oil energy, 24.1121TWh renewable energy consumption, and 274.855TWh non-renewable energy consumption, including oil, natural gas energy, and coal energy per year. Consequently, more than 1.0593 metric tons of carbon per capita are emitted into the environment. Referred to Figure 1, all variables as CO<sub>2</sub>, FDI, GDP, OIL, NONRE, and RE are soaring in the study period.

Figure 1 presents the trends of the six-time series, highlighting the tendency toward rising of all the variables over the 1985 - 2018 period. The author used the unit root tests to determine if trending data should be first differenced or regressed on deterministic functions of time to make the data stationary. If these variables are I(0) or I(1), then ARDL techniques can be used to model these long run relations (Pesaran et al., 2001). The Dickey-Fuller test was applied to test the null hypothesis that a unit root is present in a time series data. Table 2 showed the results of the Unit Root test by Augmented Dickey Fuller (ADF). The result concluded that all the variables are stationary at the 1st difference in time series from 1985 to 2018.



Figure 1. Time trends of the considered variables

Note: NONRE is for oil, natural gas and coal energy, RE is for hydropower renewable energy consumption

Thus, ARDL bound test (Pesaran et al., 2001) is used for empirical analysis. It provides better results than multivariate cointegration approaches in the case of small sample properties. This test of cointegration can be used regardless of the stationarity level of the underlying variables whether they are I(0), I(1) or a combination of both.

# Table 2

Unit root tests results

Variables	ADF Test	Order of integration
lnCO <sub>2</sub>	-3.900***	I (1)
lnGDP	-3.346**	I (1)
lnFDI	-2.902*	I (1)
lnOIL	-6.106***	I (1)
InNONRE	-4.992.***	I (1)
lnRE	-4.106***	I (1)

Note: \*: significant at 10%; \*\*: significant at 5%; \*\*\*: significant at 1% Source: Data analysis result of the researcher

# Table 3

ARDL bound test results

Dependent variable: lnCO <sub>2</sub>						
Linear model with OIL and RE (Model 1)			Linear model with NONRE and RE (Model 2)			
F value = 17,930			F value = 4.721			
Prob.	Lower Limit I(0)	Upper Limit I(1)	Prob. Lower Limit I(0)		Upper Limit I(1)	
1%	3.74	5.06	1%	3.74	5.06	
5%	2.86	4.01	5%	2.86	4.01	
10%	2.45	3.52	10%	2.45	3.52	

Source: Data analysis result of the researcher

According to the results in Table 3, for 1% confidence intervals, the calculated F statistic of value in Model 2 is 4.721, higher than the lower-bound critical value (3.74). While Model 1 has an F statistic value is 17,930, which is higher than the upper-bound critical value (5.06) at the 1% level. It concludes that there is a long-term cointegration relationship between the independent variables *GDP*, *FDI*, *OIL*, *NONRE*, *RE*, and the dependent variable *CO*<sub>2</sub>. This result also shows that the CO<sub>2</sub> emissions in the two models have been effected by all the independent variables in the long-term.

# 4.2. ARDL long-run and short-run results

The ARDL long-run and short-run estimates are presented in Table 4. ADJ in the result, which shows the Error Correction Term, has significant with the correct sign at the 5% level (for Model 1) and at the 1% level (for Model 2), supporting the evidence of a stable long run relationship among the variables. The coefficients in the 02 models are respectively -1.5542 (Model 1) and -3.0412 (Model 2), suggesting that a deviation from the long run equilibrium level of CO<sub>2</sub> emissions in one year is corrected by 155.42% and 304.12% over the following year.

The models have the Durbin-Watson d statistic, which is in turn of 2.3483 (Model 1) and 2.4896 (Model 2), which are far from the center of its distribution (d = 3). Therefore, this study doesn't contain auto-correlation. Besides that, Ramsey RESET test (Regression Specification-Error Test) is used to look for either omitted variables or functional form misspecification in this study. Using a significant p-value of 0.05, the RESET test in 2 models is not significant, indicating there are no omitted variables bias problems in diagnostics tests.

# Table 4

Dependent variable: lnCO <sub>2</sub>						
Linear model with OIL and RE (Model 1)			Linear model with NONRE and RE (Model 2)			
Variables	Coefficient	P-value	Variables Coefficient P		P-value	
ADJ	-1.5542**	0.029	ADJ	-3.0412***	0.009	
	Long	g-run coeff	ficient estimates			
lnGDP	0.3305**	0.011	lnGDP	-0.0195	0.857	
lnFDI	-0.1661***	0.000	lnFDI	0.0276**	0.030	
lnOIL	1.2977***	0.001	InNONRE	1.0159***	0.000	
lnRE	-0.1705**	0.044	lnRE	-0.1553***	0.002	
	Shor	t-run coefj	ficient estimates			
$\Delta \ln \text{GDP}(1)$	-0.5472*	0.070	$\Delta \ln GDP(4)$	0.8859**	0.019	
$\Delta \ln FDI(2)$	0.2198*	0.068	$\Delta \ln FDI(1)$	-0.1458*	0.057	
$\Delta \ln OIL(1)$	-0.9342	0.201	$\Delta \ln NONRE1$ (2)	-1.5358**	0.007	
$\Delta \ln RE(2)$	0.3749**	0.029	$\Delta \ln RE(2)$	0.5454**	0.011	
Constant	-9.8688**	0.024	Constant	-16.2881***	0.009	
<b>R</b> <sup>2</sup>	0.9309		<b>R</b> <sup>2</sup>	0.9633		
Adj - R <sup>2</sup>	0.7138		Adj - R <sup>2</sup>	0.8481		
Diagnostic test statistics						
Durbin-Watson test	2.3483		Durbin-Watson test	2.4896		
Ramsey-RESET test	0.96	0.4941	Ramsey-RESET test	2.49	0.1996	

Long-run and short-run carbon functions

Note: \*: significant at 10%; \*\*: significant at 5%; \*\*\*: significant at 1% Source: The researcher's data analysis

As shown in Table 4, in the long run, there are differences on the effects of two economic factors. In Model 1, which is based on oil as non-renewable energy, GDP is to increase CO<sub>2</sub> emission (Dinh & Lin, 2014; Shahbaz et al., 2019) while in Model 2 (total energy as coal, oil, and gas as non-renewable energy) shows no effect (statistically non-significant). The factor FDI helps to decrease CO<sub>2</sub> emission in Model 1 and create a very small positive effect on CO<sub>2</sub> emission in Model 2 ( $\beta_{lnFDI}$ . = 0.027). That means in the growth model based on oil consumption, Vietnam has followed the pollution halo hypothesis, and FDI shows its role in decoupling economic growth and the environment (Dinh & Lin, 2014). This result implied the sign of the initial success of economic policies to attract eco-investment to develop green production. Therefore, we should have more stringent regulations to select the FDI that comes into the country to transition towards a low carbon economy.

For energy consumption, the result is the same as other studies, non -renewable energy is significant to contribute to  $CO_2$  emission in both models while renewable energy let decrease the emissions (Jebli, Youssef, & Ozturk, 2015a; Dogan & Seker, 2016; Dong et al., 2018; Saudi et al., 2019).

To check the stability of the ARDL model, we applied the CUSUMsq tests recommended by Brown, Durbin, and Evans (1975) to examine the constancy of the parameters. This test is based on an established target mean and a reliable value for sigma. The results in Figure 2 of Model 1 and 2 are between the upper and lower critical bounds at the 5% significance level, confirming the stability of the ARDL estimates.



Figure 2. Plot cumulative sum of the squares of Model 1 and Model 2

### 5. Discussion and conclusion

This study has indirectly evaluated the effectiveness of Vietnamese policies' response to climate change by investigating the relationship between economic, energy consumption factors and environmental degradation in Vietnam. The determinants of this study are economical and energy as GDP, FDI, and sources of energy consumption. The two models have been developed by the same economic factors but differentiation energy consumption sources between oil, renewable energy, and non-renewable & renewable energy. Our results reveal that the policies response to climate changes on the shift of energy consumption from coal-fired power to oil and renewable energy have been truly meaningful for the environment with the results of the negative effect of FDI on CO<sub>2</sub> emissions. In the long run, though GDP has caused an increase of emissions, FDI is a significant and different effect in the two models. In the oil & renewable energy model, FDI has a significant negative effect on the emission while the other is vice versa. That implies the initial success of the policies' response to climate change. Economic growth could be an essential solution for environmental sustainability in Vietnam, though it currently relies on FDI only. It suggests the co-existence of economic growth and environment when Vietnam follows the policies on attracting and selecting quality, eco-investment to pursue sustainable development.

On the other hand, the energy consumption factors are both significant and have the same effect on the environment in the long run. The consumption of oil and non-renewable energy has a positive effect and caused an increase of pollutants while renewable energy is negative. That confirms the good impact of green energy in the battle of reducing  $CO_2$  emissions. Therefore, to achieve sustainable development, Vietnam should have put more investment in renewable energy from not only the government but also the private sector in various sources of renewable energy.

Moreover, the government needs to give more incentives to change customer's preferences to environmentally friendly products and promote green lifestyles and sustainable consumption.

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