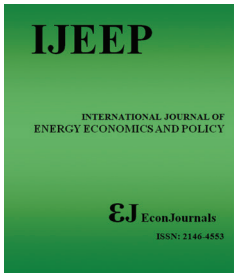

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The Disproportional Impact of Foreign Direct Investment, Carbon Dioxide Emissions and Economic Growth: Empirical Evidence from Vietnam

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ABSTRACT

The study analyzes issues related to foreign direct investment flows into Vietnam, Vietnam's CO_2 emissions and their positive and negative impacts on the growth rate of the Vietnamese economy in the period from 1986 to 2023. This study not only provides empirical evidence on the relationship between environmental pollution, foreign direct investment and economic growth, but also uses the NARDL model to test the asymmetric impact of foreign investment flows on environmental pollution and economic growth in Vietnam. Specifically, the research results show that there is an asymmetric impact of foreign direct investment flows into Vietnam, CO_2 emissions into the environment and the level of economic development. This capital flow includes both positive and negative impacts on long-term economic performance, reflecting changes in two different directions. When foreign direct investment flows increase by 1%, the economy tends to improve with an increase of 0.18%. On the contrary, when capital flows decrease by 1%, the economy is negatively affected with a decrease of 0.46% after a lag period. The results of this study are the basis for making recommendations for planning policies related to the environment, economic growth and attracting investment capital effectively.

Keywords: Foreign Direct Investment, Carbon Dioxide Emissions, Economic Growth, NARDL, Vietnam
JEL Classifications: F21, Q56, O44

1. INTRODUCTION

Foreign direct investment (FDI) greatly supports the economic growth activities of developing countries. FDI projects significantly affect business efficiency and production expansion by improving capital productivity (Todaro, 2000). International direct investment (FDI) flows contribute to the economic growth of countries, however, the effectiveness of receiving and managing international direct investment flows will depend on certain conditions of the country receiving foreign capital (Osano and Koine, 2016). Economic activities, especially in the manufacturing sector, to bring economic benefits to countries are having to trade off with environmental degradation, especially emerging markets with hot economic growth rates. Fossil fuel power plants have emitted a large amount of emissions into the environment, commonly carbon dioxide emissions, which have caused environmental quality to decline. Attracting international capital flows to promote the development of domestic economic activities of a country but at the same time also affects climate change on a global scale (Huberty et al., 2011).

Countries are increasingly facing major challenges related to economic growth and environmental protection. Foreign investment flows into countries to bring economic benefits to investors in the host country, often investors will not care about the environmental quality of the country receiving the investment capital. Investors can even ignore environmental protection measures of the country receiving the investment for profit. The economic development and environmental quality of a country will depend on the policy of receiving foreign capital, the level

of technology applied in the economy and the implementation of economic management and environmental protection policies of the country. Foreign investment flows without reasonable management policies will cause the environmental quality of the investment recipient country to decline due to the amount of emissions into the environment from human production and living activities. Receiving foreign investment capital needs to be encouraged in the direction of improving technology in production (Mello, 1999; Sabir et al., 2020).

Vietnam is a country with a rapid growth rate in recent times. However, the internal potential of the economy is not strong enough to meet the needs, especially the capital needs for economic development. Requires the government to implement policies to attract foreign capital sources to supplement capital sources for economic activities. In addition, management agencies also face challenges from receiving foreign direct investment flows. If the policy to manage foreign capital flows is not effectively implemented, Vietnam may have to trade off between economic benefits and environmental degradation (Nguyen, 2019; Le et al., 2022).

The strategy of countries to attract foreign direct investment flows for economic development but must protect the environment to maximize economic efficiency through increasing international financial capital flows to promote economic growth without harming the environment is very necessary. This study examines the asymmetric impact of foreign direct investment flows and environmental pollution on economic growth in Vietnam. Determining the impact direction of foreign direct investment and environmental pollution on economic growth is of great significance to policy makers of developing countries like Vietnam.

2. EMPIRICAL STUDIES ON THE RELATIONSHIP BETWEEN FOREIGN DIRECT INVESTMENT, ENVIRONMENTAL POLLUTION AND ECONOMIC GROWTH

Loiseau et al. (2016) developed a framework for the green economy that demonstrates the capacity of green economy concepts, approaches and tools to support the transition towards sustainability. Green economy frameworks aim at sustainable development, economic benefits do not affect environmental quality. The United Nations Environment Programme (UNEP) believes that a green economy is an economy that improves human life without degrading the environment and damaging the natural resources of future generations (UNEP, 2010). After the world experienced a global economic crisis in 2008, the green economy has received more attention from many countries and is one of the main pillars in the sustainable development policies of many countries (Musango et al., 2014). Green growth directs economies to implement economic activities and daily life using renewable energy, reducing emissions, emissions into the environment, preventing environmental degradation, improving the ecological environment, and improving the quality of human life. Musango et al. (2014) show that South Africa has implemented a number of measures to develop the green economy through improving a number of key environmental indicators, investing in improving the ecosystem and supporting production areas that reduce carbon emissions into the environment. Smit and Musango (2015) examine the relationship between the green economy and the informal economy in South Africa. The research results show that there is a relationship between the green economy and the informal economy. If the government has a reasonable plan for the informal economy, it will lead to more positive socio-economic impacts and contribute to green economic growth. Yuan and Xiang (2021) studied the relationship between FDI and CO_2 emissions in China. The study confirms an inverted U-shaped relationship between FDI and CO_2 emissions, meaning that FDI initially increases emissions, but well-managed FDI can have positive environmental impacts later.

The goal of the green economy is to achieve economic benefits combined with the protection of natural resources and without damaging the environment. Developed countries have continuously proposed policies and implemented many measures to move towards a green economy. For example, from 2009 to 2015, South Korea and China respectively implemented 5-year development plans, which devoted a large portion of their investment to green initiatives (Mathews, 2012). On the other hand, the European Union has used green economic metrics and criteria in its sustainable development programs (Mazza and Ten, 2012). Sbia et al. (2021) used simultaneous-equation models to examine FDI, economic growth, and CO_2 emissions in the MENA region. The results showed that FDI has a positive impact on economic growth, but increases CO_2 emissions in the short run. However, in the long run, this relationship depends on the regulatory policies and the ability of the FDI recipient country to absorb green technology.

Diverse perspectives on the green economy focus on environmental and economic issues. Other issues are ecological, social and human health (UNEP, 2010). OECD (2020) argues that green growth measures the level of efficient use of natural capital for economic activities without harming the environment. The green growth index is one of the important indicators of sustainable development (OECD, 2020). The goal of green growth is to combine the use of natural assets to achieve economic goals without compromising the interests of future generations. The goal is to achieve an economy that improves human well-being and reduces inequality among people in the long run, while not exposing future generations to environmental risks (OECD, 2020). Nathaniel and Iheonu (2022) studied the relationship between FDI and urbanization and increased environmental pollution in Sub-Saharan Africa. The results recommended that FDI should be linked to clear environmental protection commitments to avoid severe pollution.

Existing studies are not unanimous on the relationship between international investment flows and the environment. According to the pollution haven hypothesis (Walter and Ugelow, 1979), critics of internationalization argue that foreign direct investment acts as a channel for transferring highly polluting activities from one country to another. Therefore, there is a link between foreign

direct investment flows and poor environmental pollution in the host country (Beradovic, 2009). Haug and Ucal (2019) confirm this and argue that the baseline effect of foreign direct investment on carbon emissions is positive, implying that increased FDI leads to environmental deterioration. However, other studies have found no long-term effect of foreign direct investment on carbon emissions (Ayamba et al., 2019). The reduction in CO_2 emissions in developed countries may be due to the transfer of high-emission production capacity from developed economies to low-emission economies (Essandoh et al., 2020). Other studies suggest that foreign direct investment facilitates the transfer of technology and practices that can be transferred from developed to developing countries (Ayamba et al., 2019; Zhu et al., 2016). Shahbaz et al. (2019) suggest that investments in technological innovation, capital stock, and the implementation of strict environmental policies will divert FDI to green investment. Furthermore, foreign direct investment has promoted healthy economic development but not without contributing to pollution. Muhammad et al. (2020) provide evidence of a positive impact of internationalization on the environment. Foreign direct investment may not have a negative impact on the environment if there are appropriate institutions and policies for receiving and managing international capital. Nguyen and Le (2023) to examine FDI, economic growth, and regional CO_2 emissions in Southeast Asia, including Vietnam. The study highlights the role of industry structure and technological investment in transforming FDI into a driver of sustainable development. Acheampong et al. (2022) examine the impact of globalization and renewable energy in Africa. The results of this study indicate that FDI may not have a negative impact on the environment, especially when combined with clean energy policies.

3. RESEARCH METHODS

3.1. NARDL Model

The general NARDL equation in a linear relationship is usually expressed in the following form:

$$\Delta GDP_t = \beta_0 + \beta_1 GDP_{t-i} + \beta_2 FDI_{t-i} + \beta_3 CDE_{t-i} + \beta_4 EX_{t-i} + \beta_5 M2_{t-i} + \sum_{i=1}^{a} \beta_6 GDP_{t-i} + \sum_{i=1}^{b} \beta_7 FDI_{t-i} + \sum_{i=1}^{c} \beta_8 CDE_{t-i} + \sum_{i=1}^{d} \beta_9 EX_{t-i} + \sum_{i=1}^{e} \beta_{10} M2_{t-i} + \varepsilon_t$$

In there:

$\beta_1,\beta_2,\beta_3,\beta_4,\beta_5$, long-run coefficients of the linear ARDL model, $\beta_6,\beta_7,\beta_8,\beta_9,\beta_{10}$, short-run coefficients of the linear ARDL model.

The NARDL asymmetric model including the non-linear positive and negative effects of the relationship between foreign direct investment and environmental pollution on economic growth is shown as follows:

$$GDP_t = \beta^+ FDI_t^+ + \beta^- FDI_t^- + \beta^+ CDE_t^+ + \beta^- CDE_t^- + \beta^+ EX_t^+ + \beta^- EX_t^- + \beta^+ M2_t^+ + \beta^- M2_t^- + \varepsilon_t$$

The total positive and negative volatility of foreign direct investment and environmental pollution is given by the following equations:

$$FDI_t^+ = \sum_{i=1}^{t} "FDI_t^+ = \sum_{i=1}^{t} \max("FDI_t, 0)$$

$$FDI_t^- = \sum_{i=1}^{t} "FDI_t^- = \sum_{i=1}^{t} \min("FDI_t, 0)$$

$$CDE_t^+ = \sum_{i=1}^{t} "CDE_t^+ = \sum_{i=1}^{t} \max("CDE_t, 0)$$

$$CDE_t^- = \sum_{i=1}^{t} "CDE_t^- = \sum_{i=1}^{t} \min("CDE_t, 0)$$

$$EX_t^+ = \sum_{i=1}^{t} "EX_t^+ = \sum_{i=1}^{t} \max("EX_t, 0)$$

$$EX_t^- = \sum_{i=1}^{t} "EX_t^- = \sum_{i=1}^{t} \min("EX_t, 0)$$

$$M2_t^+ = \sum_{i=1}^{t} "M2_t^+ = \sum_{i=1}^{t} \max("M2_t, 0)$$

$$M2_t^- = \sum_{i=1}^{t} "M2_t^- = \sum_{i=1}^{t} \min("M2_t, 0)$$

To estimate the nonlinear NARDL model between foreign direct investment, environmental pollution and economic efficiency based on Shin et al. (2014), the model:

$$\Delta GDP_t = \beta_0 + \beta_1 GDP_{t-i} + \beta_2 FDI_{t-i}^+ + \beta_3 FDI_{t-i}^- + \beta_4 CDE_{t-i}^+ + \beta_5 CDE_{t-i}^- + \beta_6 EX_{t-i}^+ + \beta_7 EX_{t-i}^- + \beta_8 M2_{t-i}^+ + \beta_9 M2_{t-i}^- + \sum_{i=1}^{a} \beta_{10} GDP_{t-i} + \sum_{i=1}^{b} \beta_{11} FDI_{t-i}^+ + \sum_{i=1}^{c} \beta_{12} FDI_{t-i}^- + \sum_{i=1}^{b} \beta_{13} CDE_{t-i}^+ + \sum_{i=1}^{c} \beta_{14} CDE_{t-i}^- + \sum_{i=1}^{b} \beta_{15} M2_{t-i}^+ + \sum_{i=1}^{c} \beta_{16} M2_{t-i}^- + \varepsilon_t$$

In there:

β_0 is the blocking coefficient, β_1, β_2, β_3, β_4, β_5, β_6, β_7, β_8, β_9 are the long-run coefficients of the nonlinear ARDL model, β_{10}, β_{11}, β_{12}, β_{13}, β_{14}, β_{15}, β_{16}, are the short-run coefficients of the nonlinear ARDL model, ε_t is random error.

Testing for unit roots is the first and important step in time series regression models. Therefore, this study uses the Dickey-Fuller test to test the stationarity of the series. For the NARDL model, testing for unit roots is required because the distributed-lag autoregressive model applies to series that are stationary at I(0) or I(1) or a mixture of I(0) and I(1).

3.2. Model Variable Description

This study includes five variables: Foreign direct investment flows into Vietnam, USD/VND exchange rate, CO_2 emissions, money supply in the economy, and economic growth measured by per capita gross domestic product. The study examines the asymmetric impact of foreign direct investment flows into Vietnam and carbon dioxide emissions on economic growth in the case of Vietnam, with annual data collected from 1986 to 2023. The data source is collected from the World Bank's World Development Indicators. The variables are described in detail in Table 1.

Descriptive statistics of variables used in the model are presented in Table 2. The study uses time series in the period 1986-2023. Vietnam's national output (GDP) is taken as a percentage from the IMF's international financial statistics. The variables of CO_2 emissions, USD/VND exchange rate, foreign direct investment in Vietnam, and money supply in the economy are taken from the IMF's international financial statistics. These are trend variables that do not have a normal distribution and a very high right skew. The study converts these variables to natural logarithmic form to meet the input requirements of the study.

4. RESULTS AND DISCUSSION

4.1. Model Tests

4.1.1. Ramsey test

The study used the Ramsey test to examine the stability of the NARDL model in Table 3.

The results show that $P > \alpha$, so the Ho hypothesis is rejected. The model has a suitable functional form and achieves reliability for regression.

Table 1: Sources of variables used in the model

Symbol	Variables	Data source	Expected hypothesis
FDI	Foreign direct investment	World Bank	Non-linear
CDE	Carbon dioxide emissions	World Bank	Non-linear
EX	Exchange rate USD/VND	World Bank	Control variable
M2	Money supply into the economy	World Bank	Control variable
GDP	Gross domestic product per capita	World Bank	

4.1.2. Breusch/Pagan Test

To test the Jarque-Bera test of the residuals and the heteroscedasticity test, the Breusch/Pagan test is used in Table 4.

Breusch/Pagan test shows that $P = 0.0108 < \alpha$ so reject the null hypothesis Ho. Therefore, the model used for regression is not subject to heteroscedasticity.

The NARDL model is presented in Table 5. The results confirm that the model is suitable for regression, there is no phenomenon of inappropriate functional form or heteroscedasticity.

4.1.3. Nonlinear cointegration test

In addition, Table 6 shows that F = 7.837774 has a larger value than t_BDM = 0.193145, so there is a relationship between foreign direct investment flows, environmental pollution and Vietnam's economic growth in the long run.

4.1.4. Testing for asymmetric impacts in the short and long run

To assess the asymmetric impact of foreign direct investment inflows and environmental pollution on economic growth, the asymmetry test was conducted. The results of Table 7 show that WLR = 3.417426 (with P = 0.0039) and WLR = 0.513165 (with P = 0.0086) show that there is a statistically significant impact of foreign direct investment inflows on economic growth in the long run and in the short run.

4.1.5. VEC residuals test

On the other hand, to assess the asymmetric impact of foreign direct investment inflows and environmental pollution on economic growth, the VEC residual test of the time series was performed. The results of Figure 1 show that the VEC residuals of the time series are all within the limits, which indicates that the asymmetric impact of foreign direct investment inflows and environmental pollution on economic growth is statistically significant in the short and long term.

4.2. NARDL Model Results

4.2.1. Model stability

The NARDL model achieves stability when performing the residual accumulation tests within the critical path. The Cusum and Cusumsq plots are considered in Figures 2 and 3. The results show that the Cusum and Cusumsq residual

Table 2: Descriptive statistics of variables used in the model

Variables	CDE	EX	FDI	GDP	M2
Mean	11.22674	6.219253	21.20701	6.252245	3.885874
Median	11.45392	6.562169	21.45696	6.119451	3.962245
Maximum	12.45000	6.971685	26.12707	8.728579	5.109644
Minimum	9.770523	0.010000	10.59663	2.741917	2.128487
Standard deviation	0.866598	1.334727	2.784704	1.296554	0.880951
Skewness	−0.275972	−3.428903	−1.893091	−0.624268	−0.136666
Kurtosis	1.585975	14.90690	7.493946	3.484661	1.700931
Jarque-Bera	3.648171	298.9392	54.67365	2.840089	2.790292
Probability	0.161365	0.000000	0.000000	0.241703	0.247797
Sum	426.6161	236.3316	805.8662	237.5853	147.6632
Sum squares deviation	27.78670	65.91534	286.9194	62.19893	28.71476
Observations	38	38	38	38	38

Source: Author's synthesis and calculation

Table 3: Ramsey test

Ramsey RESET Test				
Equation: NARDL				
Specification: DGDP DGDP(−1) DEX_POS DEX_POS(−1) DEX_POS(−2) DEX_NEG DFDI_POS DFDI_POS(−1) DFDI_POS(−2) DFDI_NEG DM2_POS DM2_POS(−1) DM2_POS(−2) DM2_NEG C				
Omitted Variables: Squares of fitted values				
Test	**Value**	**df**		**Probability**
t-statistic	0.054515	19		0.0392
F-statistic	0.029719	(1, 19)		0.0392
F-test summary				
SSR	**Sum of squares**	**df**		**Mean squares**
Test SSR	0.225517	1		0.225517
Restricted SSR	14.64330	20		0.732165
Unrestricted SSR	14.41779	19		0.758831
Sample: 1990-2023				
Included observations: 34				
Maximum dependent lags: 2 (Automatic selection)				
Model selection method: Akaike info criterion (AIC)				
Dynamic regressors (2 lags, automatic):				
Fixed regressors: C				
Variable	**Coefficient**	**Standard error**	**t-Statistic**	**Probability***
DGDP(−1)	1.029918	0.573152	1.796937	0.0883
DEX_POS	3.996168	8.740602	0.457196	0.6527
DEX_POS(−1)	0.251301	10.06567	0.024966	0.9803
DEX_POS(−2)	16.28130	8.714673	1.868263	0.0772
DEX_NEG	14.20656	9.032819	1.572771	0.1323
DFDI_POS	1.086377	1.259682	0.862421	0.3992
DFDI_POS(−1)	1.235646	0.582725	2.120463	0.0474
DFDI_POS(−2)	1.382497	0.899520	1.536928	0.1408
DFDI_NEG	2.781099	0.735333	3.782093	0.0013
DM2_POS	1.137546	3.561382	0.319411	0.7529
DM2_POS(−1)	−5.156749	2.980103	−1.730393	0.0998
DM2_POS(−2)	−3.769613	2.366075	−1.593192	0.1276
DM2_NEG	−4.125370	1.988005	−2.075130	0.0518
C	45.43758	27.12088	1.675373	0.1102
FITTED^2	−0.077686	0.142503	−0.545151	0.5920
R-squared	0.796243	Mean dependent var		0.025654
Adjusted R-squared	0.646106	S.D. dependent var		1.464321
S.E. of regression	0.871109	Akaike info criterion		2.862332
Sum squared resid	14.41779	Schwarz criterion		3.535726
Log likelihood	−33.65965	Hannan-Quinn criter.		3.091979
F-statistic	5.303456	Durbin-Watson stat		1.753187

Source: Synthesized from regression results

accumulation curves lie within the critical paths with a significance coefficient of 5%, so the model achieves stability and does not suffer from sudden breaks or structural breakdowns.

Asymmetric impacts of foreign investment flows, environmental pollution and economic growth.

In order to analyze in detail the asymmetric impact of foreign direct investment inflows and environmental pollution on economic growth in the short and long term, the study conducts a cumulative dynamic multiplier analysis, derived from the NARDL model. Figure 4 presents the impact of positive and negative changes in foreign direct investment inflows on economic growth. In the short term, economic growth responds more immediately and faster to increased foreign direct investment inflows than to decreased foreign direct investment inflows. However, in the long term, increased foreign direct investment inflows have negative impacts on economic growth in some periods and increased foreign direct investment inflows have positive impacts on economic growth, meaning that foreign direct investment inflows will have both negative and positive impacts on economic growth. Thus, foreign direct investment inflows have asymmetric impacts on economic growth in both the short and long term. Developing countries like Vietnam always require large capital for economic development activities. In the early stages, the production process of the economy always requires a large amount of capital support from outside the country because domestic resources cannot fully meet the needs of the economy. However, in the long term, if the economic management and operation policies are ineffective, international capital sources

Table 4: Breusch/Pagan test

Heteroskedasticity Test: Breusch-Pagan-Godfrey				
F-statistic	0.970982	Prob. F (13,20)		0.0108
Obs*R-squared	13.15566	Prob. Chi-Square (13)		0.0435
Scaled explained SS	28.86623	Prob. Chi-Square (13)		0.0068
Test Equation:				
Dependent Variable: RESID^2				
Method: Least Squares				
Sample: 1990-2023				
Included observations: 34				
Variable	**Coefficient**	**Standard error**	**t-Statistic**	**Probability**
C	−111.65824	3.27731	−2.580064	0.0179
DGDP(−1)	−1.292430	0.931685	−1.387195	0.1806
DEX_POS	−16.82357	14.67384	−1.146501	0.2651
DEX_POS(−1)	11.97608	16.80553	0.712627	0.4843
DEX_POS(−2)	−27.46119	15.66296	−1.753257	0.0949
DEX_NEG	−34.74198	15.00826	−2.314857	0.0314
DFDI_POS	1.754624	1.246908	1.407179	0.1747
DFDI_POS(−1)	−1.747522	0.998942	−1.749373	0.0956
DFDI_POS(−2)	−3.334526	1.489805	−2.238229	0.0367
DFDI_NEG	−3.883545	1.319653	−2.942853	0.0080
DM2_POS	−10.86804	4.414200	−2.462063	0.0230
DM2_POS(−1)	9.420384	5.355778	1.758920	0.0939
DM2_POS(−2)	7.395844	4.250182	1.740124	0.0972
DM2_NEG	6.643478	3.428522	1.937709	0.0669
Prob (F-statistic)		0.0108		

Source: Synthesized from regression results

Table 5: NARDL model

Dependent variable: DGDP				
Method: ARDL				
Sample (adjusted): 1990 2023				
Included observations: 34 after adjustments				
Maximum dependent lags: 2 (Automatic selection)				
Model selection method: Akaike info criterion (AIC)				
Dynamic regressors (2 lags, automatic): DEX_POS DEX_NEG DFDI_POS DFDI_NEG DM2_POS DM2_NEG				
Fixed regressors: C				
Number of models evalulated: 1458				
Selected Model: ARDL (1, 2, 0, 2, 0, 2, 0)				
Variable	**Coefficient**	**Standard error**	**t-Statistic**	**Probability***
DGDP(−1)	0.896556	0.509134	1.760944	0.0935
DEX_POS	5.698927	8.018746	0.710701	0.4855
DEX_POS(−1)	−1.781673	9.183639	−0.194005	0.8481
DEX_POS(−2)	16.21168	8.559265	1.894050	0.0728
DEX_NEG	16.08535	8.201495	1.961271	0.0639
DFDI_POS	0.513165	0.681392	0.753113	0.4602
DFDI_POS(−1)	1.331199	0.545887	2.438598	0.0242
DFDI_POS(−2)	1.573061	0.814127	1.932206	0.0676
DFDI_NEG	2.803740	0.721145	3.887901	0.0009
DM2_POS	2.543654	2.412207	1.054492	0.3042
DM2_POS(−1)	−5.125935	2.926747	−1.751410	0.0952
DM2_POS(−2)	−3.816773	2.322577	−1.643336	0.1159
DM2_NEG	−3.819861	1.873568	−2.038816	0.0549
C	52.243702	3.64955	2.209078	0.0390
Prob (F-statistic)		0.000229		

*P-values and any subsequent tests do not account for
Source: Synthesized from regression results

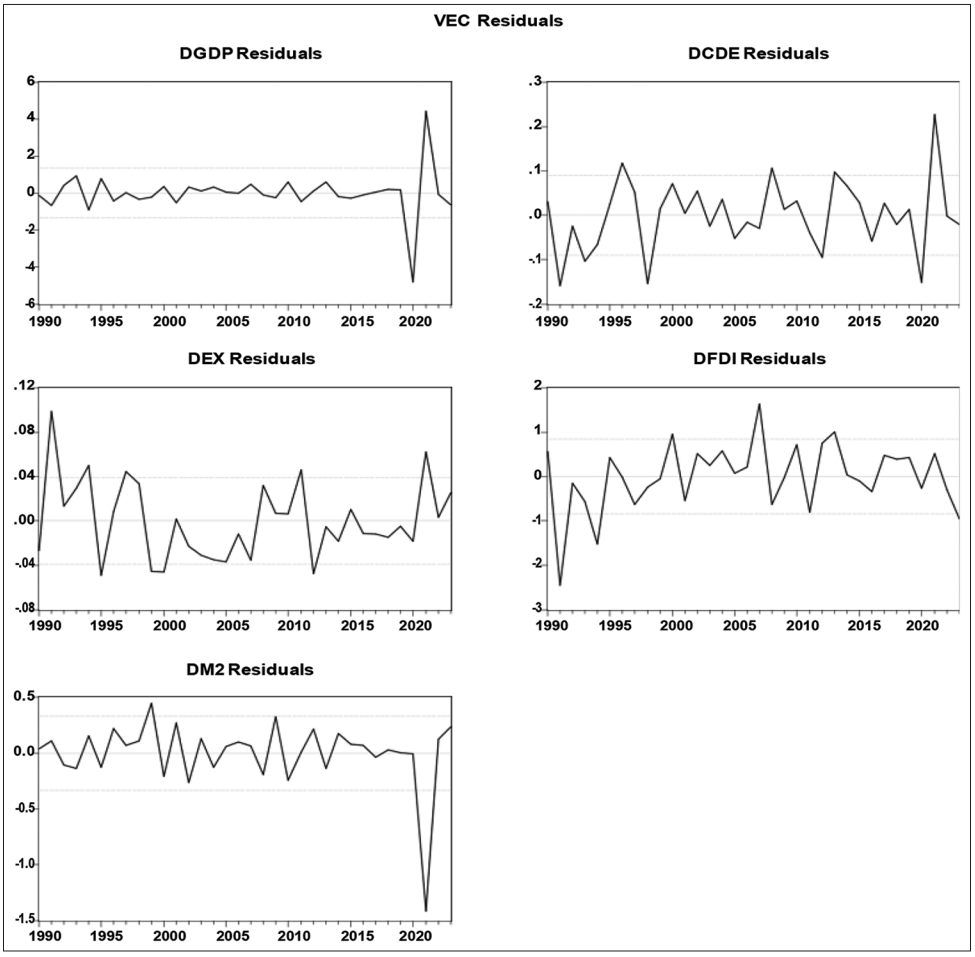
Table 6: Nonlinear cointegration test

Co-integrated test statistics	F-stat: 7.837774
	t_{BDM}: 0.193145

Source: Synthesized from regression results

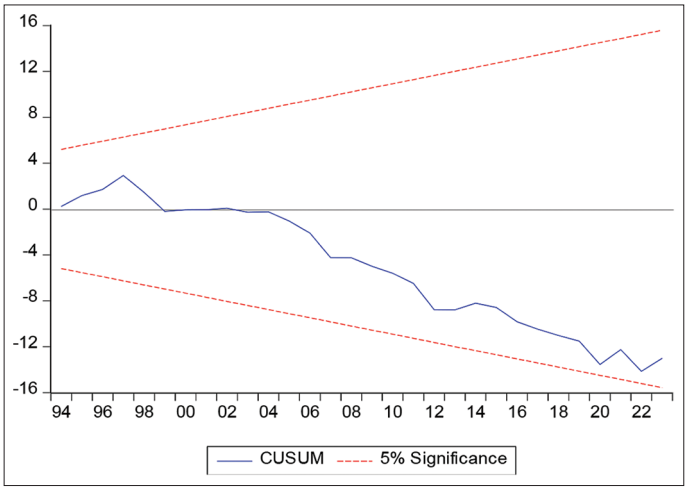
often do not support well and cause pressure on the economy. The research results are consistent with previous empirical studies. The relationship between foreign direct investment flows and economic growth is asymmetric, especially in

Figure 1: VEC residuals test



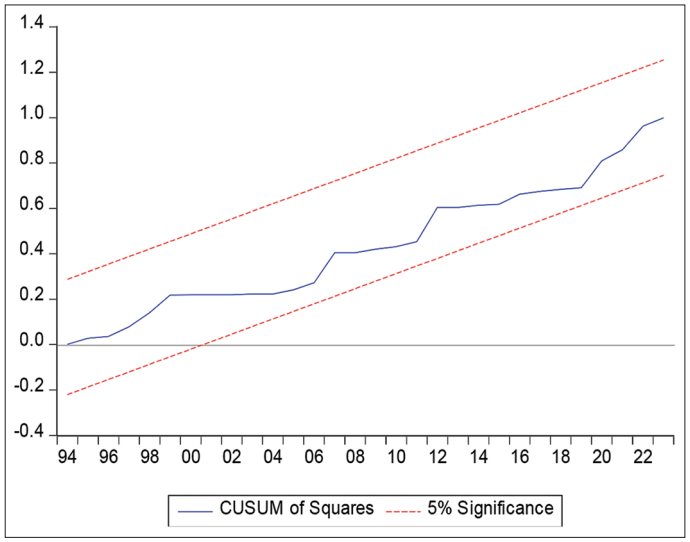
Source: Synthesized from regression results

Figure 2: Cusum residual cumulative sum chart



Source: Synthesized from regression results

Figure 3: Cumulative sum adjusted plot of Cusumsq residuals

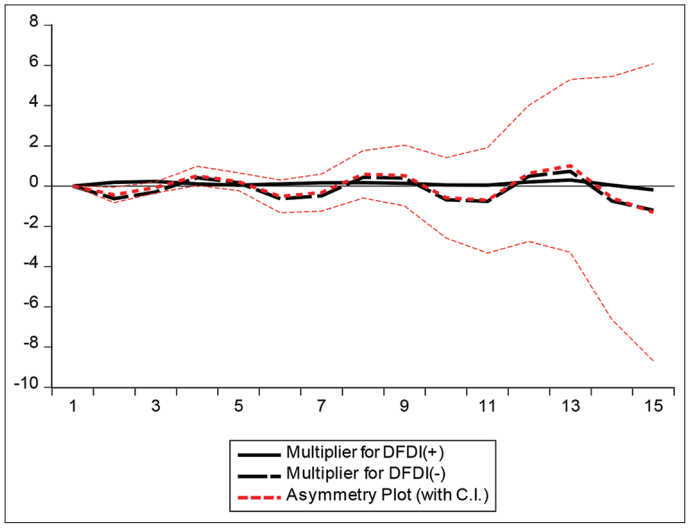


Source: Synthesized from regression results

developing countries like Vietnam. The difference between the increases and decreases shown in the red dashed line shows that the research results are statistically significant in the entire period considered. Thus, foreign direct investment flows have asymmetric impacts on Vietnam's economic growth in both the short and long term. Specifically, this study shows the asymmetric impact of FDI on GDP in Table 8 It includes the positive and negative components of foreign direct investment inflows on long-run economic performance with both positive and negative signs. More specifically, a 1% increase in foreign

direct investment inflows leads to a positive change in economic activity of 0.18%. Conversely, a 1% decrease in foreign direct investment inflows leads to a negative change in economic activity of 0.46% with a one-period lag.

Figure 4: Graph of the asymmetric cumulative dynamic multiplier of foreign investment and economic growth



Source: Synthesized from regression results

Table 7: Test for asymmetric effects

Test	Long-term asymmetric impact		Short-term asymmetric impact	
	F-stat	Sig.	F-stat	Sig.
	WLR=3.417426	0.0039	WSR=0.513165	0.0086
Result	Disproportionate impact		Disproportionate impact	

Source: Synthesized from regression results

Figure 5 shows the impact of changes in carbon dioxide concentrations on economic growth. In the short term, economic growth responds immediately and more quickly to increases in carbon dioxide concentrations. However, in the long term, increases in carbon dioxide concentrations will have positive impacts on economic growth. This is completely consistent with the current situation in Vietnam. Countries with developing economies like Vietnam often face a trade-off between increased environmental pollution and economic growth. In the early stages, the production process of the economy is always focused on promoting national interests, environmental factors may not be given due attention. However, in the long term, if the policy of operating and managing economic activities is not effective, environmental pollution will occur rapidly and cause negative impacts on the economy. This study also reveals that the influence of environmental pollution, whether positive or negative, is significantly and inversely related to short-term economic growth, as indicated in Table 9. Specifically, a 1% rise in carbon dioxide emissions contributes to a 5.9% increase in economic growth in the subsequent period. Conversely, a 1% reduction in carbon dioxide emissions leads to a 4.1% rise in economic growth over the next two periods. These findings suggest that carbon dioxide emissions play a crucial role in shaping short-term economic growth. Moreover, the economic boost resulting from an increase in emissions is greater than that from a decrease in emissions. This phenomenon may reflect the tendency of many developing nations to prioritize economic expansion over environmental protection in the short run.

Table 8: Asymmetric impact of FDI on GDP in the long run

Dependent variable: DGDP				
Method: ARDL				
Sample (adjusted): 1989-2023				
Included observations: 35 after adjustments				
Maximum dependent lags: 3 (Automatic selection)				
Model selection method: Akaike info criterion (AIC)				
Dynamic regressors (2 lags, automatic): DFDI_POS DFDI_NEG				
Fixed regressors: C				
Number of models evalulated: 27				
Selected Model: ARDL (2, 0, 1)				
Final equation sample is larger than selection sample				
Variable	**Coefficient**	**Standard error**	**t-Statistic**	**Probability***
GDP(−1)	0.167938	0.174796	0.960765	0.3446
GDP(−2)	−1.086904	0.285770	−3.803419	0.0007
FDIPOS	0.181133	0.295521	0.612928	0.5447
FDINEG	0.632343	0.195810	3.229365	0.0031
FDINEG(−1)	−0.469812	0.199331	−2.356945	0.0254
C	0.851456	1.244910	0.683950	0.4994
R-squared	0.672665	Mean dependent var	−0.015591	
Adjusted R-squared	0.616227	S.D. dependent var	1.463116	
S.E. of regression	0.906391	Akaike info criterion	2.796114	
Sum squared resid	23.82482	Schwarz criterion	3.062745	
Log likelihood	−42.93200	Hannan-Quinn criter.	2.888155	
F-statistic	11.91883	Durbin-Watson stat	2.037867	
Prob (F-statistic)	0.000003			

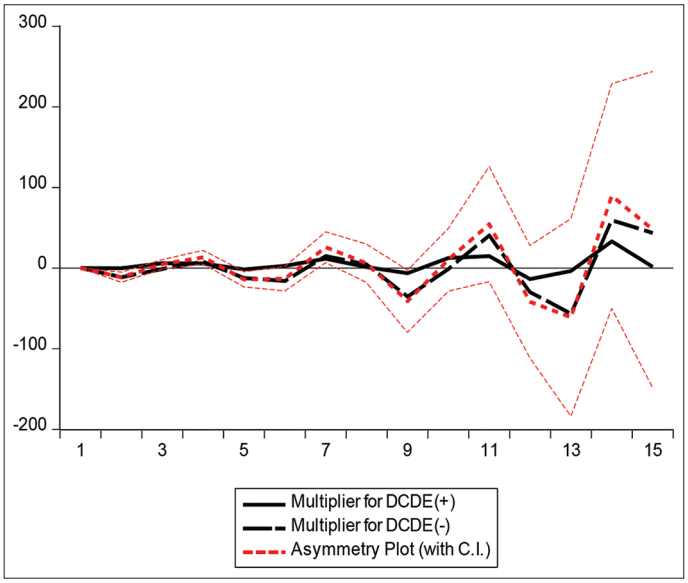
*P-values and any subsequent tests do not account for model selection
Source: Synthesized from regression results

Table 9: Asymmetric impact of CDE on GDP in the long run

Dependent Variable: DGDP				
Method: ARDL				
Sample (adjusted): 1990-2023				
Included observations: 34 after adjustments				
Maximum dependent lags: 3 (Automatic selection)				
Model selection method: Akaike info criterion (AIC)				
Dynamic regressors (2 lags, automatic): DCDE_POS DCDE_NEG				
Fixed regressors: C				
Number of models evalulated: 27				
Selected Model: ARDL (3, 1, 2)				
Variable	**Coefficient**	**Standard error**	**t-Statistic**	**Probability***
DGDP(−1)	−0.074279	0.185103	−0.401282	0.6916
DGDP(−2)	−1.233283	0.164161	−7.512663	0.0000
DGDP(−3)	0.626518	0.268026	2.337524	0.0277
DCDE_POS	−0.153421	2.789158	−0.055006	0.9566
DCDE_POS(−1)	5.908458	2.107236	2.803891	0.0096
DCDE_NEG	11.46377	2.520575	4.548077	0.0001
DCDE_NEG(−1)	−9.304265	3.333365	−2.791253	0.0099
DCDE_NEG(−2)	4.136413	3.185874	1.298361	0.2060
C	1.037947	0.610677	1.699667	0.1016
Prob (F-statistic)	0.000000			

*P-values and any subsequent tests do not account for model selection
Source: Synthesized from regression results

Figure 5: Asymmetric cumulative dynamic multiplier diagram of environmental pollution and economic growth



Source: Synthesized from regression results

5. CONCLUSION

Economic activities are often considered the main cause of CO_2 emissions. Economic growth is essential to improve people's lives. The Environmental Kuznets Curve (EKC) theory suggests that in the long run, better environmental quality is beneficial for both higher economic growth and better human well-being. The results are consistent with empirical studies, with developing countries often prioritizing economic growth over environmental protection factors. Developed countries, with higher income levels, can pursue greater technological progress due to higher investment in technology. These expenditures can enable them to adopt energy-efficient and carbon-reducing materials. Adopting energy efficiency can help economies reduce their use of the earth's natural resources and reduce environmental pollution through proper waste management and pollution internalization. Therefore, investment in infrastructure and energy consumption is crucial to meet ecological challenges, such as biodiversity loss, frequent floods and rising temperatures (Ayamba et al., 2019; António and Rafaela, 2020).

6. ACKNOWLEDGMENTS

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