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RESEARCH ARTICLE

Influences of foreign direct investment and carbon emission on economic growth in Vietnam

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Abstract
Over the course of the previous three decades, Vietnam has seen a phase of economic growth, resulting in the influx of foreign direct investment (FDI). However, it is essential to note that there was an extensive rise in carbon dioxide (CO_2) emissions throughout this period. The objective of this research is to analyze the impact of FDI and CO_2 emissions on Vietnam's economic growth, utilizing time series data from 1990 to 2021. The stationarity of the data was assessed using unit root tests, while an autoregressive distributed lag (ARDL) procedure was utilized to examine the long- and short-run associations between the components. Based on the research outcomes, it is seen that a marginal rise of one percent in both FDI and CO_2 emissions is associated with a corresponding long-term gain of 1.36 percent and 1.11 percent in gross domestic product (GDP). Furthermore, in the short term, these increments yield an increase of 0.61 percent and 0.29 percent in GDP. The conclusions of this study will provide valuable insights for policymakers in crafting policies that effectively promote sustainable development. Specifically, these policies would aim to strike a balance between capital growth derived from foreign investments and economic expansion, while concurrently mitigating carbon emissions.

Keywords: Economic growth; FDI; Environmental degradation; CO_2 emissions; Sustainable development

Introduction

Over the last few years, Vietnam's economy has witnessed a rapid expansion. The country experienced a notable rise in its GDP per capita, which escalated from 1562 US dollars in 2010 to 3561 US dollars in 2020. The government has set an ambitious objective of achieving a GDP per capita of 7500 US dollars by the year 2030. FDI shows a crucial function in both the early stages of an economy's development and its later stages of industrialization, modernization, and the establishment of a knowledge-based economy (Quoc & Thi, 2018; Raihan, 2023a). The aforementioned statement can be attributed to the observation that FDI shows a crucial function in fostering economic expansion through the augmentation of overall investment capital (Raihan & Voumik, 2022a). Vietnam, a nation situated in Southeast Asia, is currently through a process of economic transition characterized by industrialization and modernization (Raihan, 2023b). Vietnam's economic growth has been greatly influenced by the substantial influx of foreign capital, a trend that has been observed since the enactment of the Law on Foreign Investment in 1978. The allocation of these money has resulted in the promotion of exports and the improvement of human resources and technology. The attraction of FDI shows a pivotal function in the advancement of Vietnam's economic and social infrastructure (Nguyen et al., 2022).

The significant increase in FDI flowing into Vietnam since 1988 has been commonly perceived as indicative of the state's successful shift from a command economy to a market-oriented system, as noted by Cung (2020). The implementation of capital and FDI inflows into Vietnam has had a substantial increase over the years. From 1988, when it stood at US$0.32 billion, to about US$16.2 billion in 2023. This growth can be attributed to the introduction of the Doi Moi reform program in 1986. Since then, FDI inflows into Vietnam have displayed an average annual growth rate of 15.4 percent (Nguyen et al., 2022). Vietnam has had significant advantages as a result of foreign direct investment throughout this time frame. These measures encompass enhancing Vietnam's capital and production capacity, strengthening export endeavors, generating employment opportunities, and facilitating the transfer of both tangible and intangible assets, such as technology and international knowledge. FDI is often considered a significant determinant in the economic advancement of emerging nations, exemplified by the case of Vietnam. The correlation between FDI and economic growth has been a subject of significant scholarly attention within the realm of international development studies. In the context of volatile global capital flows, FDI has emerged as a dependable avenue for promoting accelerated growth in underdeveloped nations. The promotion of foreign direct investment is crucial for the mobilization and sustainable utilization of capital. However, it is imperative to adopt a cautious approach in formulating regulations that take into consideration the unique characteristics of each stage of development. Hence, it is imperative to analyze the influence of FDI on the economic enhancement of Vietnam.

The rapid economic growth experienced by Vietnam in recent decades has resulted in some notable impacts on the local ecosystem. Vietnam is presently grappling with notable environmental challenges, with global warming emerging as the most pressing concern, despite the country's notable economic achievements (Begum et al., 2020; Raihan et al., 2023a). Vietnam persistently exhibits a concerning lack of awareness on the importance of protecting a sustainable ecosystem. According to Raihan et al. (2022a), there has been an approximately sixfold rise in the total quantity of CO_2 emissions over the course of the past three decades. The rate of CO_2 emissions in Vietnam is experiencing a significant and concerning upward trend. The majority of CO_2 emissions are generated by coal-fired electricity bases (Raihan et al., 2022b; Voumik et al., 2022; Sultana et al., 2023a). It is projected that by the year 2020, the energy industry in Vietnam will produce an estimated annual carbon dioxide emission of 224 million tons, whereas other significant industries are expected to create roughly 10 million tons.

Vietnam has made a commitment to achieve carbon neutrality by the year 2050. In the pursuit of sustainable development, it is imperative to achieve a harmonious equilibrium between fostering GDP growth and sustaining the inflow of FDI to ensure the maintenance of stable levels of carbon emissions. Vietnam, akin to numerous other nations, endeavors to attain sustainable economic growth and development that upholds environmental integrity and avoids burdening future generations with any adverse consequences. To achieve this goal, it is imperative to protect the integrity of the ecosystem (Raihan, 2023c; Raihan, 2023d; Raihan, 2023e; Raihan, 2023f; Raihan, 2023g; Raihan, 2024a). The research undertaken on the relationship between CO_2 emissions and economic growth has incorporated multiple studies examining the influence of economic progress on CO_2 emissions (Raihan & Tuspekova, 2022a; Raihan et al., 2022c). However, there is a scarcity of study about the impacts of CO_2 emissions on the progress of economic development. This article makes a scholarly contribution by analyzing the influence of environmental degradation, specifically carbon dioxide emissions, on the economic growth of Vietnam.

The total volume of FDI in Vietnam exhibited a consistent annual growth pattern. Furthermore, there was a pointed simultaneous expansion in both the pace of economic expansion and the emission rate. One pertinent inquiry regarding the social milieu is to the potential correlation between the surge in FDI and CO_2 emissions in Vietnam, and the concomitant rise in economic advancement. In view of this, a research study was undertaken in Vietnam spanning the years 1990 to 2021, with the aim of examining the immediate and enduring impacts of FDI and CO_2 emissions on GDP. The stationarity and stability of the variables were verified through the implementation of three unit root tests. Additionally, the ARDL technique was employed to establish the associations between these variables and their long- and short-term causal dynamics. The findings of this research will specify constructive

visions for legislators in crafting policies that effectively promote sustainable development. Specifically, these insights would help policymakers strike a delicate equilibrium between capital growth derived from foreign investments, economic expansion, and the imperative to mitigate carbon emissions.

Literature Review

Due to the rising concern about global warming and climate change (Raihan & Said, 2022; Raihan & Himu, 2023; Raihan & Bijoy, 2023; Raihan, 2023h),a considerable body of literature has been dedicated to exploring the liaison between CO_2 emissions and GDP (Raihan, 2023i; Raihan et al., 2023b). According to Bello et al. (2018), there exists a U-shaped inverted relationship between CO_2 emissions and economic prosperity. However, it is seen that the positive alliance between economic evolution and CO_2 emissions tends to decrease once the economy achieves a particular level of development. This assertion can be adequately evaluated since a rise in income levels is often associated with an improvement in the standard of living, which in turn tends to result in an increased requirement for ecological excellence (Raihan, 2023j).

The interconnections between nations in relation to economic endeavor and commerce have prompted scholarly investigations into possibilities concerning the liaison between pollution, economic outgrowth, and trade integration. Grossman and Krugger (1995) conducted the primary inquiry into the relationship between the Carbon Index and its impact on economic progress. The authors posited that the mitigation of trade obstacles and the amplification of economic endeavors will have an impact on the environment. This study additionally presents empirical evidence to evaluate the comparative magnitude of these three consequences through the implementation of trade liberalization in Mexico. In their study, Naranpanawa (2011) employed the ARDL method and Johansen cointegration procedure to examine the enduring association between economic development and the trading environment. The ends of this analysis suggest that there exists a transient association between business and CO_2 emissions. In a study conducted by Keho (2015), the ARDL model was employed to examine the enduring consequences of the ecological bearing resulting from universal trade in 11 nations within the Economic Community of West African States (ECOWAS) during the retro spanning from 1970 to 2010. The findings of this investigation led to the determination that global commerce is a significant contributor to environmental deterioration. In their study, Rahman and Kashem (2017) employed Toda and Yamamoto's causal model to examine the interrelationships among carbon emissions, energy consumption, and economic evolution in Bangladesh from the 1970s to the 2010s. The bulk of these research demonstrate a sustained relationship and a significant connection among the parameters. Furthermore, empirical research has demonstrated a significant positive association between the growth of GDP and the concurrent rise in CO_2 levels across the examined timeframe. Esso and Keho (2016) have demonstrated the existence of causal and enduring associations between energy use, CO_2 emissions, and economic advancement in diverse African states.

Alvarez-Herranz et al., (2017) utilized the Kuznets curve framework to assess the relationship between GDP and CO_2 emissions in a sample of 16 associate states of the Organization for Economic Cooperation and Development (OECD) throughout the retro from 1995 to 2016. The investigation outcomes imply that the presence of institutional misalliances during the energy development procedure negatively impacts ecological sustainability within economies. The study substantiated the Kuznets curve hypothesis and demonstrated that the proliferation of economic progress and the adoption of renewable power sources resulted in a reduction of environmental pollution across 17 OECD countries throughout the retro straddling from 1990 to 2012. In a research conducted by Sarkodie (2018), a sample of developing nations was utilized to examine the relationship between FDI and energy intensity. The findings of the study revealed a significant decrease in energy concentration as FDI levels grew. The aforementioned decline can be ascribed to the utilization of contemporary technology in conjunction with FDI, representing a significant advancement from the antiquated conventional technologies employed in other nations. This transition has resulted in a reduction of environmentally harmful emissions.

Several studies have investigated the correlation capital flows, between FDI, and ecological degradation in different countries or commercial regions. Frankel and Romer (2017) have conducted a study in which they found evidence suggesting that financial development and deregulation have the potential to attract FDI, drive economic growth, and thus enhance the dynamics of environmental performance. Shahbaz (2014) employed the ARDL framework to investigate the long-term relationships between renewables, FDI, natural resource trade, CO_2 emission, and GDP in the United Arab Emirates (UAE) during the period spanning from 1975 to 2011. The authors assert that there exists a correlation between these factors over a period of time. It has been determined that the process of trade integration and the influx of FDI are associated with a reduction in greenhouse gas (GHG) emissions. The phenomenon of economic expansion yields positive effects on energy use.

In their study, Hakimi and Hamdi (2016) examined the relationship between FDI inflows, trade openness, environmental attribute, and GDP in Tunisia and Morocco. They employed the Vector Error Correction Model (VECM) and cointegration techniques to analyze the data. This study posited that trade liberalization has resulted in mutual economic benefits for both economies, often leading to consequential impacts on CO_2 emissions. The research acted by Michieka et al. (2013) investigated the impact of energy exhaustion, trade, and monetary progress on the economic progression of China. The results suggest that the influence of economic and commercial development on pollution is significant, and it also has enduring consequences for CO_2 levels.

Corresponding to research accomplished by Ren et al. (2014), the substantial trade surplus and the influx of FDI are identified as the primary considerations providing to the significant rise in CO_2 emissions in China. In their study, Michieka et al. (2013) examined a sample including around 20 developing nations and saw a significant reduction in energy intensity in conjunction with the rise in foreign direct investment. The aforementioned fall can be ascribed to the adoption of contemporary technology in conjunction with foreign direct investment, representing a significant departure from the antiquated old technologies employed in other nations. This transition has resulted in a reduction of environmentally harmful emissions (Raihan, 2023k).

Soytas and Sari (2007) employed a VECM to assess the correlation between energy intake and the production divisions in Turkey. The conclusions of the analysis exhibit a significant and positive correlation between the parameters included in the model. Furthermore, the parameters inside the model exhibit a causal relationship. In 2009, the authors undertook an additional analysis utilizing the linear regression method to assess the correlation between economic expansion, energy consumption, and CO_2 emissions. The research findings also indicate the occurrence of a co-integration relationship midst the parameter parameters. Furthermore, the research also revealed a lack of enduring correlation between CO_2 emissions and the advancement of economic progress. Hence, the investigation arrived at the determination that it is feasible to mitigate CO_2 emissions without impeding the pace of economic advancement. The findings of Öztürk and Acaravcı's (2010) study exhibited analogous outcomes when employing the ARDL model and examining causality using authentic data from Turkey. The factors employed by the author encompassed energy, employment ratio, and emissions. The findings indicate a reversal of the Kunetz curve.

According to the findings of Begum et al. (2015), the empirical analysis conducted using the ARDL approach demonstrated a negative link between emissions and GDP in Malaysia between 1970 and 1980. Nevertheless, between 1980 and 2009, there was a prominent surge in per capita CO_2 emissions, which subsequently resulted in a corresponding rise in per capita GDP. The research findings indicate that the EKD hypothesis was shown to be invalid in Malaysia within the specified study duration. The conclusions of the study also indicate a significant and positive association between energy intake, GDP, and carbon emissions. The study additionally demonstrates that over an extended period, economic expansion can exert a detrimental influence on CO_2 emissions. Hence, the adoption of advanced technological gear and equipment that have little emissions (Raihan, 2023l), along with the utilization of alternative energy sources, will effectively mitigate emissions without compromising economic progress (Raihan, 2023m).

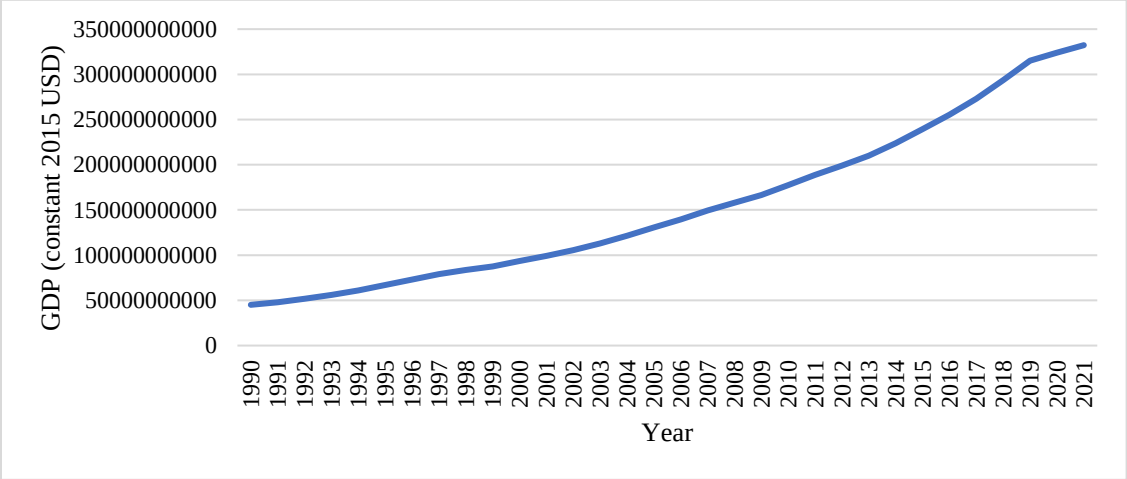
Numerous empirical studies have investigated the association between FDI, economic growth, economic integration, and CO_2 emissions. Nevertheless, there exist variations in research findings across different countries

with respect to the short-term and long-term impacts, the presence of cointegration relationships, and the positive and negative effects observed in the interplay between various components. In light of the divergent outcomes observed across nations, the author intends to undertake an empirical investigation aimed at assessing the interrelationship between the rate of GDP growth, CO_2 emissions, and FDI in Vietnam. The empirical findings have the potential to assist policymakers in striking a compromise between the reduction of CO_2 emissions, the augmentation of FDI attractiveness, and the attainment of economic growth in forthcoming periods.

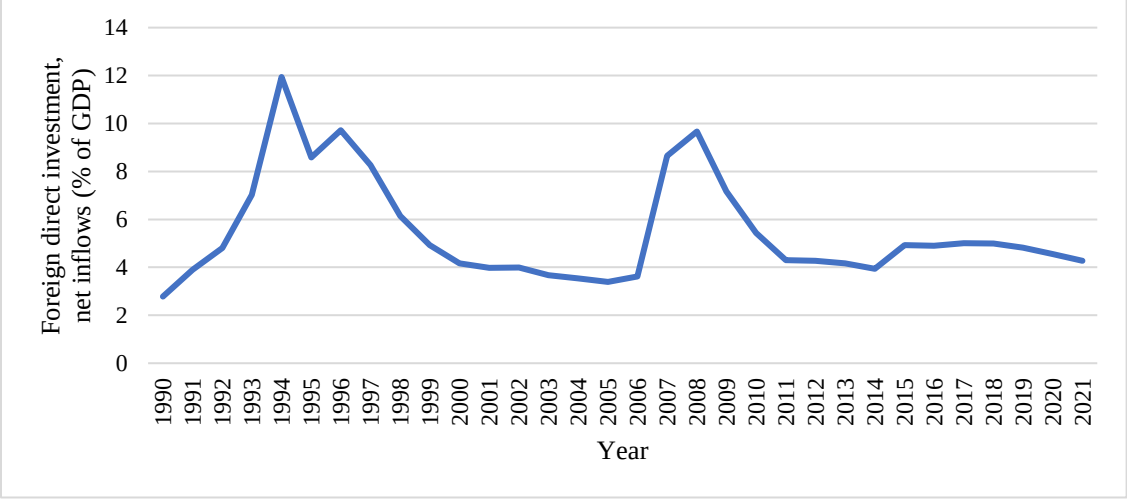
Methodology

Data and empirical model

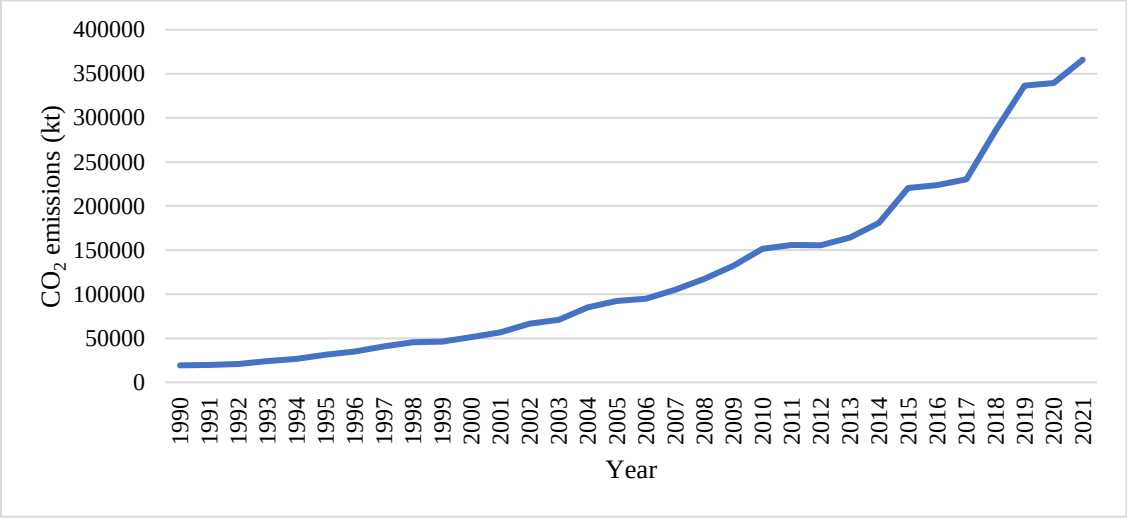
To assess the validity of the hypothesis pertaining to the association between the parameters, the methodology employed in this study involved the integration of ARDL bounds analysis with cointegrating regression investigation. The World Development Indicators (WDI) were specifically created to compile comprehensive time series data spanning the years 1992 to 2021. FDI is quantified as a proportion of the overall GDP, whereas CO_2 emissions are evaluated in terms of kilotons. Figure 1 illustrates the temporal trends of the variables.



(a) GDP



(b) FDI



(c) CO_2 emissions

Figure 1. The annually fads of GDP, FDI, and CO_2 emissions in Vietnam.

The present investigation employed a defined model at time t to illustrate the relationship between variables.

$$GDP_t = \tau_0 + \tau_1 FDI_t + \tau_2 CO2_t + \varepsilon_t \quad (1)$$

Here, τ_1 and τ_2 are the coefficients, though ε is the error term. The logarithmic function was utilized to enhance the clarity of the data by manipulating the variables.

$$LGDP_t = \tau_0 + \tau_1 LFDI_t + \tau_2 LCO2_t + \varepsilon_t \quad (2)$$

Stationarity check

The present study initially investigates the relationships between the response variable and its explanatory components in order to ascertain if the dataset exhibits stationarity at either integrated of order zero (I(0)) or integrated of order one (I(1)). Furthermore, it is not necessary for every regressor to exhibit a seasonal effect or be included with an order of one (Raihan & Tuspekova, 2022b; Raihan et al., 2023c). The avoidance of the I(2) sequence is deemed invalid and has the potential to generate misleading outcomes (Raihan & Tuspekova, 2023a; Raihan et al., 2023d). Furthermore, in the event that a variable exhibits nonstationarity, there is a possibility of obtaining erroneous results (Raihan et al., 2022d; Raihan & Tuspekova, 2023b; Raihan et al., 2023e). Nevertheless, the shift to I(2) is unparalleled, and the limited size of the sample raises apprehension (Raihan & Tuspekova, 2022c; Raihan et al., 2023f). The present study utilizes the Augmented Dickey-Fuller (ADF), Dickey-Fuller generalized least squares (DF-GLS), and Phillips-Perron (P-P) unit root tests in order to ascertain the absence of I(2) variables.

ARDL approach

The ARDL bounds testing technique for cointegration, as introduced by Pesaran et al. (2001), was employed to examine the enduring association between the parameters. The cointegration test mentioned in the text has several

advantages compared to standard approaches in terms of the order of integration (Raihan & Tuspekova, 2022d; Raihan et al., 2022e; Voumik et al., 2023a; Raihan et al., 2023g). If the parameters are determined to be stable at either the integrated of order 1 (I(1)) or integrated of order 0 (I(0)) level, or the I(1)/I(0) level, then this approach can be employed (Raihan et al., 2022f; Raihan & Tuspekova, 2022e; Raihan et al., 2022g). The ARDL bounds testing econometric study employs an adequate amount of lags inside a general-to-specific modeling framework in order to effectively represent the data creation process (Raihan et al., 2023h; Raihan, 2023n). The ARDL framework allows for the computation of the ARDL F-statistic, which serves as a means to assess the existence of cointegration across variables (Raihan et al., 2023i; Raihan, 2023o). This is achieved by considering several optimal lags for each variable, as discussed by Raihan and Tuspekova (2022f). The establishment of cointegration among variables can be determined if the ARDL F-statistic exceeds a preset upper critical threshold (Raihan, 2023p). If the F-statistic of the ARDL model is below the lower critical limit, it indicates that the variables under consideration are not cointegrated (Raihan, 2023q). When the F-statistic of the ARDL model is within the range of the upper critical bound and the lower critical value, the empirical findings may lack persuasiveness (Raihan & Tuspekova, 2022g; Raihan et al., 2023j). The ARDL bounds analysis method, which is commonly used for studying cointegration, can be described by the following approximation model:

$$\Delta LGDP_t = \tau_0 + \tau_1 LGDP_{t-1} + \tau_2 LFDI_{t-1} + \tau_3 LCO2_{t-1} + \sum_{i=1}^{q} \gamma_1 \Delta LGDP_{t-i} + \sum_{i=1}^{q} \gamma_2 \Delta LFDI_{t-i} + \sum_{i=1}^{q} \gamma_3 \Delta LCO2_{t-i} + \varepsilon_t \quad (3)$$

The symbol Δ represents the first difference operator, whereas the variable q denotes the optimal lag duration. The ARDL bounds testing approach has the capability to undergo linear transformation in order to derive the error correction model (ECM). Despite the use of very small sample sizes, this methodology produces dependable empirical findings (Raihan & Tuspekova, 2022h; Raihan, 2023r). In order to maintain a comprehensive outlook, the ECM integrates immediate intricacies with enduring stability (Raihan & Voumik, 2022b). The method employed in this study aims to ascertain the cointegrating vectors that arise from the empirical model when numerous cointegrating vectors are present (Raihan, 2023s). The symbol "θ" represents the coefficient of the ECM. The ECM exhibits a consistently positive value, seldom descending below 0 and never beyond 1. When the ECM exhibits a negative and statistically significant coefficient, it becomes imperative to address the variance in order to attain equilibrium (Raihan, 2024b). Following the establishment of the long-term relationship between the series, the investigation proceeded to calculate the short-run coefficients of the parameters utilizing Equation (4).

$$\Delta LGDP_t = \tau_0 + \tau_1 LGDP_{t-1} + \tau_2 LFDI_{t-1} + \tau_3 LCO2_{t-1} + \sum_{i=1}^{q} \gamma_1 \Delta LGDP_{t-i} + \sum_{i=1}^{q} \gamma_2 \Delta LFDI_{t-i} + \sum_{i=1}^{q} \gamma_3 \Delta LCO2_{t-i} + \theta ECM_{t-1} + \varepsilon_t \quad (4)$$

Results and Discussion

Table 1 presented below provides descriptive statistics. Grounded on the data that was collected and examined, it can be observed that the median and mean values of all parameters exhibit a high degree of similarity. All variables exhibit a normal distribution, as seen by their skewness values approaching zero, kurtosis values below three, and Jarque-Bera test statistics falling below their respective thresholds.

Table 1. Descriptive statistics

Variables	LGDP	LFDI	LCO2
Mean	25.59704	1.635640	11.37495
Median	25.62874	1.571155	11.44691
Maximum	26.52922	2.479851	12.81034
Minimum	24.53122	1.022927	9.869414
Std. Dev.	0.608397	0.356427	0.906434
Skewness	-0.119250	0.747708	-0.127089
Kurtosis	1.859924	2.674778	1.854348
Jarque-Bera	1.808874	3.122716	1.836166
Probability	0.404770	0.209851	0.399284

The initial stair is verifying that the order one, I(1), encompasses the complete dataset, particularly the response parameters. The accomplishment of this task involves the analysis of the strong suit of link concerning response parameters and analyst parameters. Furthermore, it is deemed improper to incorporate all first-order regressors or to illustrate transient unit roots. The ADF, DF-GLS, and P-P tests for three-unit root were devoted to assess the parameter order and verify adherence to the precondition. The conclusions of the unit root tests are presented in Table 2. Based on the information displayed, it was observed that all assessed metrics exhibited stationarity at the initial discrepancy. The data are therefore fitting for the use of the ARDL estimator.

Table 2. The results of unit root examinations

Logarithmic form of the variables	ADF		DF-GLS		P-P	
	Log levels	Log first difference	Log levels	Log first difference	Log levels	Log first difference
LGDP	-0.581	-4.178***	-0.383	-4.385***	-0.418	-4.329***
LFDI	-0.499	-4.117***	-0.414	-3.966***	-0.277	-4.009***
LCO2	-0.262	-5.753***	-0.161	-4.715***	-0.786	-7.302***

*** stand for significance at 1% level

Following the confirmation of the reliability of the unit roots of the variable, this study employed the ARDL bounds test to analyze the characteristics of the variables' enduring association. The empirical findings of using the ARDL bounds testing method to cointegration are shown in Table 3. Based on the observation that the estimated F-statistic exceeded the upper critical constraint, the experimental results presented compelling evidence supporting the presence of long-term cointegration among the variables under investigation.

Table 3. Results of ARDL bounds analysis

F-bounds test		Null hypothesis: No degrees of relationship		
Test statistic	Estimate	Significance	I(0)	I(1)
F-statistic	13.854226	At 10%	2.63	3.35
K	2	At 5%	3.10	3.87
		At 2.5%	3.55	4.38
		At 1%	4.13	5.00

Following the establishment of a durable association, this research endeavor aims to assess both the long-term and short-term variables. The outcome of both the long- and short-term investigations are showed in Table 4. Based on the findings derived from the ARDL analysis, it can be concluded that FDI exerts a positive and statistically significant sway on GDP in both the short-term and long-term periods. In the context of this study, it has been observed that a marginal rise of 1 percent in FDI leads to a corresponding short-term gain of 0.61 percent in GDP,

while in the long term, this relationship is strengthened, resulting in a 1.36 percent increase in GDP. Trinh and Nguyen (2015), Quoc and Thi (2018), Cung (2020), and Nguyen et al. (2022) have together posited that FDI exerts a favorable impact on the GDP of Vietnam. The findings derived from the ARDL calculation provide empirical evidence that there exists a positive and statistically significant liaison between CO_2 emissions and GDP in both the short and long run. Given a fixed level of FDI, it can be shown that a 1% rise in CO_2 emissions leads to a subsequent increase in GDP by 1.11% in the long run and 0.29% in the short run. The ARDL research indicated a favorable relationship between elevated levels of CO_2 emissions and Vietnam's GDP. Raihan (2023b) provides empirical evidence that establishes a positive correlation between Vietnam's GDP and CO_2 emissions.

Table 4. ARDL results over the long and short term.

Variables	Long-run			Short-run		
	Coefficient	t-Statistic	p-value	Coefficient	t-Statistic	p-value
LFDI	1.361***	4.007	0.000	0.613***	3.102	0.001
LCO2	1.112***	3.089	0.000	0.291***	3.107	0.002
C	9.678	3.428	0.147	-	-	-
ECM (-1)	-	-	-	-0.601***	-3.692	0.000
R^2	0.9871					
Adjusted R^2	0.9765					

*** denotes significance at 1% level

The findings of this inquiry indicate a statistically significant negative appraisal of ECM, as determined at the 1% significance level. The estimation of the ECM allows for the determination of both the magnitude and sign of the ECM. These indicators can be utilized to make inferences on the speed at which a structure advances from a state of short-run uncertainty to a state of long-run equilibrium. This finding suggests that the state of long-term equilibrium is achieved once 60 percent of the short-term errors have been rectified. Furthermore, the R^2 and adjusted R^2 values for the long-run evaluation are 0.9871 and 0.9765, respectively. These values suggest that the regression model provided in this study has a high level of conformity with the data. This finding suggests that the independent factors have the ability to explain approximately 97% of the variability observed in the dependent variable. Table 5 displays the empirical estimations of various diagnostic statistics. The application of the Jarque-Bera test can be employed to ascertain the uniform distribution of residuals. The Lagrange multiplier (LM) technique was employed to examine the issue of serial correlation. The LM test outcome suggests that the model does not exhibit any issues related to serial correlation. The Breusch-Pagan-Godfrey analysis was utilized to examine the presence of heteroscedasticity in the forecast model. Based on the findings, it can be concluded that the proposed model does not display heteroscedasticity. The determination of the model's validity was conducted through the utilization of the Ramsey reset test.

Table 5. The findings obtained from diagnostic examinations.

Diagnostic probes	Coefficient	p-value	Decision
Jarque-Bera analysis	0.406007	0.8162	The residuals have a normal distribution
Breusch-Godfrey LM analysis	0.724124	0.5009	There is no serial correlation
Breusch-Pagan-Godfrey analysis	0.885297	0.5707	There is no heteroscedasticity
Ramsey RESET analysis	0.396329	0.6971	The model is precisely described

This study assessed the structural stability of the model by employing the summation cumulative of recursive residuals (CUSUM) and squares of the summation cumulative of recursive residuals (CUSUMSQ) functions. Figure 2 illustrates the graphical representation of the CUSUM and CUSUMQ studies. For example, the stability of model parameters can be determined by assessing scatter plots that exhibit deviations from the critical limit of

no more than 5%. The graphs demonstrate that throughout the trial, the CUSUM and CUSUMSQ values consistently fell within the acceptable range of +/- 5%.

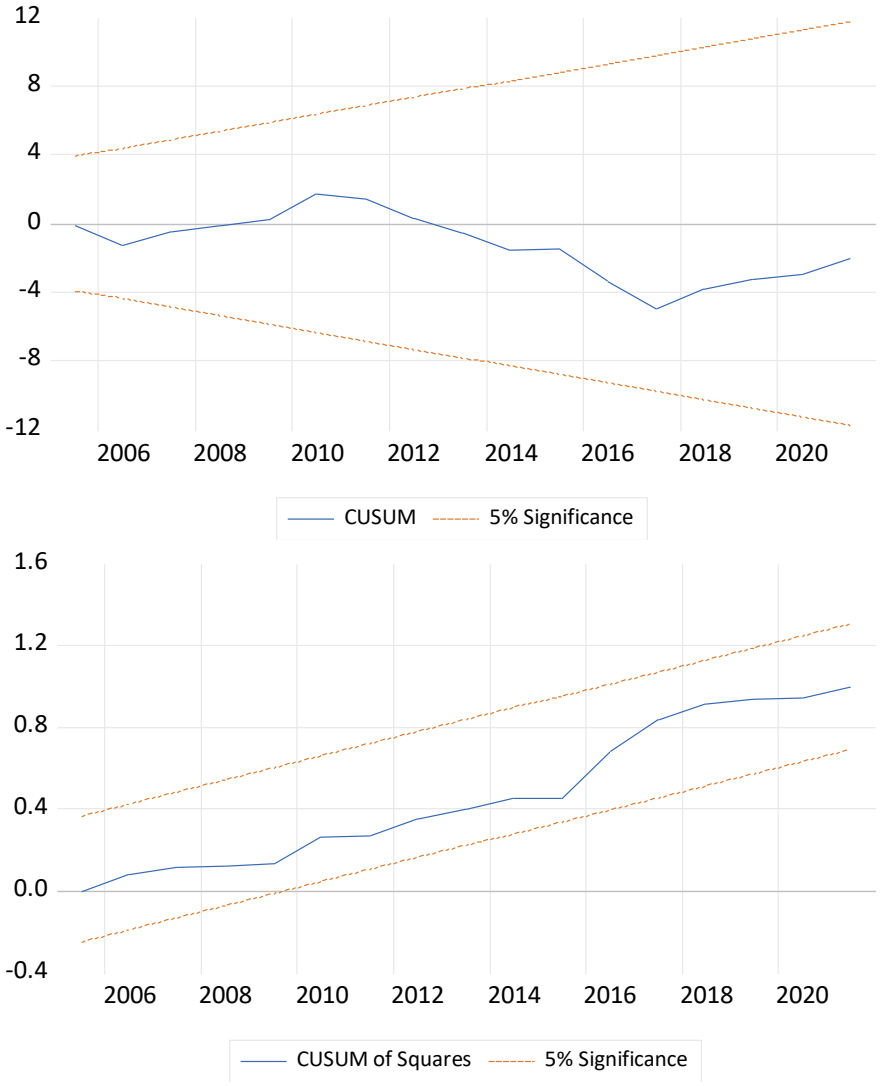


Figure 2. The findings of both the CUSUM and CUSUMQ analyses.

FDI is a significant macroeconomic determinant that exerts a profound impact on the process of economic development (Voumik et al., 2023b). The economy is directly impacted by various factors such as technological advancements, advancements in related fields, resource accumulation, and the manifestation of human inventiveness (Raihan & Tuspekova, 2022i). The aforementioned objectives are achieved by means of funding the deficit in the current account, facilitating investment finance for numerous host markets, generating positive externalities, integrating new managerial competencies across diverse sectors, and bolstering economic performance by generating a significant number of employment opportunities and government returns. Raihan and Tuspekova (2022j) posited that this phenomenon plays a significant role in fostering economic expansion. Hence, it is imperative for political and economic strategies to maintain a coherent connection between the growth of industries and the inflow of FDI. Vietnam continues to be a highly preferred destination for FDI. The attractiveness of the place for investments and its projected sustainability can be attributed to the indices of its macroeconomic environment and demographic composition, as elucidated by Nguyen et al. (2022). FDI has played a vital role in facilitating the advancement of Vietnam's machinery manufacturing, energy, computer, and telecommunications

sectors. These industries necessitate technological complexity and yield high-value output (Cung, 2020). The importance of the impact of FDI on a nation's exports and imports, foreign currency accessibility, and balance of payments has progressively amplified through time.

In the meanwhile, the observation that CO_2 emissions yield favorable outcomes for economic progress underscores the necessity for implementing suitable measures to mitigate pollution inside the nation, thereby fostering sustainable economic growth (Sultana et al., 2023b). The decrease of GHG emissions can be achieved by the simultaneous advancement of renewable power technologies and the optimization of energy resource utilization (Raihan & Tuspekova, 2022k; Voumik et al., 2023c; Raihan, 2023t; Raihan, 2023u; Raihan, 2023v, Raihan, 2023w). At present, the Vietnamese government has enacted several regulations with the objective of mitigating the emission of GHGs within the nation. The policies encompassed under the scope are the "National Strategy on Green Growth," the "National Strategy on Climate Changes," and the "National Target Programme on Energy Efficiency." Furthermore, the country has demonstrated significant engagement in international organizations and conferences, aiming to collaborate with other nations in tackling this pressing global concern. However, Vietnam's efforts to mitigate GHG emissions encounter several challenges. Several challenges exist, including inadequate financial support and investments, limited utilization of sophisticated technology, and a lack of interagency collaboration mechanisms. In order to attain sustained economic growth and development, Vietnam must surmount a range of challenges.

Conclusions and Policy Implications

This analysis aimed to investigate the potential dynamic relationship between FDI, CO_2 emissions, and the economic growth of Vietnam. The analysis utilized a dataset spanning from 1992 to 2021. The stationarity of the data can be assessed by employing unit root tests, such as the ADF, the DF-GLS, and the P-P tests. Furthermore, the ARDL methodology was applied to examine the correlation between the variables under both long-term and short-term analysis. Based on the research outcomes, it can be observed that a marginal augmentation of one percent in both FDI and CO_2 emissions is associated with a corresponding long-term growth of 1.36 percent and 1.11 percent in GDP. Additionally, in the near term, such increments in FDI and CO_2 emissions are linked to a rise of 0.61 percent and 0.29 percent in GDP, respectively. The conclusions of this inquiry will offer constructive comprehensions for legislators in crafting policies that effectively promote sustainable development. Specifically, these policies would aim to strike a balance between capital growth resulting from foreign investments and economic expansion, while concurrently mitigating carbon emissions.

The outcomes of the research indicate that FDI shows a pivotal function in the economic advancement of Vietnam. The compiled data formed the foundation for the obtained outcomes. In order to prioritize economic improvement and attract FDI, there is a tendency to routinely reduce environmental protection criteria below the acceptable threshold. As a result, FDI exerts a significant influence on the environment, necessitating the implementation of environmental rules by the Vietnamese government across the nation. The persistent enhancement of the public administration system has resulted in an ongoing transformation of the current governance frameworks. Various factors, such as Vietnam's membership in international trade organizations and its participation in the signing of agreements, exert an influence on the scale and dynamics of its economic growth. The enactment of a new act by the National Assembly represents a substantial stride towards governmental reform and the advancement of many industries, with the aim of expediting domestic progress and aligning them with global benchmarks. The legislative embodiment under consideration is represented by the Law on Environmental Protection, Land, and Resource Management. This exemplifies the progression of the interplay between the state, enterprises, and citizens.

In the foreseeable future, irrespective of the government's dedication to environmental preservation, the Vietnamese government will be required to formulate suitable rules aimed at augmenting the economy and fostering a more liberalized trading environment. The formulation of these policies should be guided by the research findings. In order to attain a decrease in CO_2 emissions, with advancements in the economy and trade liberalization, it is imperative to construct methodologies for sustainable growth that are intricately linked to

policies aimed at safeguarding the environment. The Vietnamese economy is experiencing a notable increase in its accessibility to worldwide commerce due to the implementation of growth plans that focus on attracting FDI and employing a amalgamation of import and export methods. The economy of Vietnam has been adversely impacted by the rise in trade openness, which is indicative of the broader global trend towards increased international integration. The implementation of environmental management changes is vital to attract both domestic and international investors. Furthermore, it is imperative to facilitate the dissemination of ecologically beneficial technologies and promote the advancement of sustainable development in order to effectively address the growing levels of pollution attributable to multinational enterprises. By implementing laws that promote the manufacture and utilization of ecologically sustainable energy sources and green technologies, lawmakers have the potential to effectively mitigate carbon emissions and achieve long-term economic growth that is environmentally sustainable. In addition, it is imperative that these policies effectively promote the widespread adoption of renewable technology. One limitation of this investigation is the absence of industry-specific data, which represents a notable downside. Given this context, the forthcoming studies would endeavor to use disaggregated data or data from diverse industries on the symmetry of econometric models.

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