Isagoge, v. 6, 2026, eISSN 2763-7123
Telos Publicações, Rio de Janeiro, Brasil

HUMAN DEVELOPMENT IN VIETNAM: THE EFFECTS OF ECONOMIC GROWTH AND CARBON DIOXIDE EMISSIONS

DESENVOLVIMENTO HUMANO NO VIETNÃ: OS EFEITOS DO CRESCIMENTO ECONÔMICO E DAS EMISSÕES DE DIÓXIDO DE CARBONO

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Abstract

Vietnam's economy has grown strongly over the past decades, while environmental pollution has increased at the same time. This situation makes sustainable human development an important concern for the country. The study examines the relationship between economic growth, carbon dioxide emissions, foreign direct investment, and the Human Development Index (HDI) over the period 1990–2023. The data come from the World Bank and UNDP, and the ARDL model is applied in the analysis. The cointegration test confirms a long-run relationship among the variables. Economic growth, measured by GDP, has a positive effect on the Human Development Index. However, GDP squared has a negative coefficient. This shows that when income becomes higher, its positive contribution to welfare becomes smaller. Carbon dioxide emissions lower human development in the long run, while foreign direct investment does not have a statistically significant effect. These findings mean that Vietnam should improve the quality of economic growth, control emissions more effectively, and select investment projects more carefully to achieve sustainable development.

Keywords: Carbon dioxide emissions; Economic growth; Human development index.

Resumo

A economia do Vietnã tem crescido fortemente nas últimas décadas, enquanto a poluição ambiental aumentou ao mesmo tempo. Essa situação torna o desenvolvimento humano sustentável uma preocupação importante para o país. O estudo examina a relação entre crescimento econômico, emissões de dióxido de carbono, investimento estrangeiro direto e o Índice de Desenvolvimento Humano (IDH) no período de 1990 a 2023. Os dados são provenientes do Banco Mundial e do PNUD, e o modelo ARDL é aplicado na análise. O teste de cointegração confirma uma relação de longo prazo entre as variáveis. O crescimento econômico, medido pelo PIB, tem um efeito positivo sobre o Índice de Desenvolvimento Humano. No entanto, o PIB ao quadrado apresenta um coeficiente negativo. Isso mostra que, à medida que a renda aumenta, sua contribuição positiva para o bem-estar se torna menor. As emissões de dióxido de carbono reduzem o desenvolvimento humano no longo prazo, enquanto o investimento estrangeiro direto não apresenta efeito estatisticamente significativo. Esses resultados indicam que o Vietnã deve melhorar a qualidade do crescimento econômico, controlar as emissões de forma mais eficaz e selecionar os projetos de investimento com maior rigor para alcançar o desenvolvimento sustentável.

Palavras-chave: Emissões de dióxido de carbono; Crescimento económico; Índice de Desenvolvimento Humano.

1. Introduction

Human development is considered the ultimate goal of economic activity. It shifts the focus from only increasing income to improving quality of life and expanding human capabilities (Fakhri et al., 2024; Raj et al., 2023; Ramirez et al., 1997; Ranis, 2004). In this view, people are seen as the most valuable asset of a nation, and investing in them is an effective way to achieve sustainable development (Cao et al., 2018). The Human Development Index is a composite indicator that measures a country's average achievement in three basic dimensions: health (life expectancy), education (knowledge), and living standards (income per capita) (Cao et al., 2018; Costa et al., 2011; Elistia & Syahzuni, 2018; Leiwakabessy & Amaluddin, 2020; Raj et al., 2023; Sharma & Gani, 2004; Taqi et al., 2021). The HDI does not only reflect income growth but also captures broader aspects of human well-being. Therefore, it allows policymakers to compare development levels across countries more clearly than when using GDP alone (Elistia & Syahzuni, 2018; Ranis, 2004; Taqi et al., 2021; Yumashev et al., 2020).

The relationship between economic growth and human development is often described as two-way. On the one hand, economic growth provides financial resources to improve living conditions. On the other hand, higher human development supports long-term and sustainable economic growth (Bloom et al., 2021; Ranis, 2004). Economic growth is therefore viewed as a means to expand human capabilities and choices, which are central goals of development (Ranis, 2004; Taqi et al., 2021).

FDI adds external resources to the domestic economy. When foreign firms invest, they often bring new technology and working methods. This can create better jobs and raise income levels, which may gradually improve social welfare (Gokmenoglu et al., 2018; Sharma & Gani, 2004). On the other hand, countries that improve education and health systems usually become more attractive to foreign investors. Because of this, they are more likely to receive higher-quality FDI inflows (Fakhri et al., 2024). Foreign direct investment (FDI) acts as a channel for transferring capital, technology, and knowledge, thereby directly and indirectly impacting the improvement of workers' incomes and social welfare (Gokmenoglu et al., 2018; Sharma & Gani, 2004). Conversely, countries with high levels of human development and high-quality human resources often have a significant advantage in attracting high-quality FDI flows (Fakhri et al., 2024).

Economic growth can improve the Human Development Index. However, it is usually linked with higher CO_2 emissions, which may harm both public health and the environment (Akbar et al., 2021; Fakhri et al., 2024). Some empirical studies report a one-way causal effect from greenhouse gas emissions to certain aspects of human development. This effect is mainly explained by worsening health conditions and living standards (Akbar et al., 2021; Fakhri et al., 2024). In many developing countries, the HDI tends to increase together with CO_2 emissions because development is still based on high levels of energy consumption (Costa et al., 2011; Yumashev et al., 2020). As a result, reliance on fossil fuel-based growth models creates serious challenges for achieving long-term sustainable development (Fakhri et al., 2024).

Some limitations remain in the current literature. Earlier studies often focus on separate factors such as education, health, or investment capital, rather than examining them together (Bloom et al., 2021). The connection between FDI, environmental quality, and human development is still debated, and empirical results are not consistent across countries (Gokmenoglu et al., 2018; Reiter & Steensma, 2010). Bringing economic growth, CO_2 emissions, and FDI into the same analysis makes it easier to see how these factors interact over time (Fakhri et al., 2024; Khosravi et al., 2025). Considering them together avoids looking at each variable in isolation and offers a broader view of development patterns (Bloom et al., 2021; Khosravi et al., 2025).

In Vietnam, earlier studies report a strong relationship between the HDI and economic growth. However, the interaction between FDI inflows and environmental pressures in shaping human development has not been examined in depth. Studying these factors together may offer more practical insights for the Vietnamese context. It can help clarify how investment attraction and environmental protection can be managed at the same time. This discussion also highlights the importance of improving human development without increasing pressure on natural resources.

2. Methodology

2.1. Data and Variable Description

The analysis is based on annual data for Vietnam covering the period 1990–2023, which gives 34 observations. Information on the Human Development Index (HDI) is taken from the UNDP database. The remaining macroeconomic variables are collected from the World Development Indicators of the World Bank. Although the sample is relatively small, it is adequate for time-series analysis and suitable for applying the ARDL approach to test for cointegration.

HDI is used as the dependent variable. It ranges from 0 to 1 and summarizes development outcomes in terms of income, education, and health.

Three explanatory variables are included. Real GDP per capita (constant 2015 US$) captures income per person after removing inflation effects. CO_2 emissions per capita (excluding LULUCF) reflect the environmental pressure associated with economic activity. Net FDI inflows, measured as a percentage of GDP, indicate the extent to which the economy attracts foreign capital.

For estimation, GDP per capita and CO_2 emissions per capita are converted into natural logarithms. This step helps stabilize variance and makes it possible to interpret the estimated coefficients as elasticities. FDI remains in percentage terms so that its marginal effect can be read more directly.

Table 2.1: Descriptive statistics of variables

Indicator	HDI	GDPPC	CO2PC	FDI
Mean	0.65	1893.08	1.56	5.42
Median	0.66	1744.31	1.31	4.68
Standard Deviation	0.08	924.10	1.08	2.17
Kurtosis	-1.05	-0.89	-0.51	1.46
Skewness	-0.30	0.51	0.76	1.46
Minimum	0.50	687.86	0.31	2.78
Maximum	0.77	3775.46	3.89	11.94
Count	34	34	34	34

2.2. Autoregressive Distributed Lag Model

In this study, the ARDL framework is used to examine both short-run and long-run relationships among the variables within the same regression model. In this approach, the dependent variable is explained by its own past values as well as by lagged values of the explanatory variables. This structure makes ARDL suitable for macroeconomic data, where adjustments toward long-run equilibrium usually take place gradually.

The ARDL method was developed by (Pesaran & Shin, 1999). It is appropriate for small samples and for data series that are integrated at level I(0) or first difference I(1), provided that none of the variables is integrated at order two I(2). In this study, the ARDL model is applied to analyze the relationship between economic development, environmental factors, FDI, and the HDI in Vietnam.

In this model, HDI is specified as the dependent variable. It reflects achievements in income, education, and health within a single composite index. The use of HDI enables the analysis to evaluate development in a broader framework rather than focusing solely on income growth.

GDP per capita (GDP_PC) represents the real level of economic development of the economy. According to human capital theory (Becker, 1964), higher income increases the ability to invest in education, skills, and health care. These factors are forms of capital that can enhance productivity and social welfare in the long run. As average income rises, both households and the government can expand spending on education, health services, and living conditions. This process improves the quality of human resources and the overall level of human development. Therefore, GDP_PC is expected to have a positive effect on the HDI.

CO_2 emissions per capita (CO2_PC) are included to capture the environmental channel affecting human development. Based on health capital theory (Grossman, 1972), environmental pollution reduces health capital by increasing disease and premature mortality, which negatively affects the life expectancy component of the HDI. In addition, under the Environmental Kuznets Curve (EKC) framework, economic growth may involve environmental costs at early stages of development, creating a trade-off between growth and long-term welfare.

Foreign direct investment (FDI) is commonly viewed as an indicator of economic integration and technology transfer. In practice, foreign investment is often linked with higher output, employment expansion, and income growth, which may support improvements in human capital and overall development outcomes, including the HDI. At the same time, the pollution haven hypothesis suggests that FDI can raise environmental pressure when it is concentrated in pollution-intensive sectors. In such cases, the indirect effect on human development may be adverse. For this reason, the overall impact of FDI on human development should be examined through empirical analysis.

In this study, the ARDL framework makes it possible to examine how economic growth (GDPPC), CO_2 emissions (CO2PC), and FDI inflows are related to human development (HDI) within a single model. It also allows the analysis of short-run dynamics and the long-run equilibrium relationship in the Vietnamese context.

The general form of the ARDL–ECM model is given as follows:

$$\text{ARDL: } \Delta HDI_t = \beta_0 + \underbrace{\sum_{j=1}^{p} \beta_j \Delta HDI_{t-j} + \sum_{i=0}^{q} \delta_{1,i} \Delta \ln GDPPC_{t-i} + \sum_{i=0}^{q} \delta_{2,i} \Delta \ln GDPPC_{t-i}^2 + \sum_{i=0}^{q} \delta_{3,i} \Delta \ln CO2PC_{t-i} + \sum_{i=0}^{q} \delta_{4,i} \Delta FDI_{t-i}}_{\text{Short run}} + \underbrace{\lambda\Big(HDI_{t-1} - \big(\varphi_0 + \varphi_1 \ln GDPPC_{t-1} + \varphi_2 \ln GDPPC_{t-1}^2 + \varphi_3 \ln CO2PC_{t-1} + \varphi_4 FDI_{t-1}\big)\Big)}_{\text{Long run}} + \varepsilon_t$$

In the model, the coefficients of the first-difference terms represent the short-run effects, including β_0; $\beta\ _j$; $\delta_{1,\ i}$ $\delta_{2,\ i}$, $\delta_{3,\ i}$, $\delta_{4,\ i}$. The coefficients of the lagged level variables capture the long-run relationship among the variables, denoted by φ_i. The error term ε_t is assumed to have a zero mean and constant variance.

One advantage of the ARDL model is that it allows each variable to have a different optimal lag length. It can also be applied when the variables are integrated at level I(0) or first difference I(1), provided that none is integrated at order two I(2). This flexibility makes ARDL appropriate for studies with relatively small samples, such as this one. The estimation procedure follows several steps. First, the time-series properties of the variables are examined using the Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) unit root tests to ensure that no variable is integrated at order two I(2). Second, the optimal lag structure is selected based on the Schwarz Information Criterion (SC), which is suitable for small samples because it reduces the risk of over-parameterization. The lag selection is conducted automatically in EViews. The Bounds test helps identify whether the variables share a long-run equilibrium relationship. If a cointegrating relationship is found, the model is expressed in an error correction model to capture short-run movements and the speed at which the system returns to equilibrium. When the error correction term (ECT) is negative and statistically significant, it implies that the system tends to return to its long-run equilibrium after short-run shocks. Model performance is also checked using standard diagnostic procedures. These tests examine serial correlation, heteroskedasticity, and the stability of the estimated coefficients through the CUSUM and CUSUMSQ statistics.

3. Results and Discussion

3.1. Unit Root Test and Cointegration Test

The results from the Augmented Dickey–Fuller (ADF) and Phillips–Perron tests show that HDI is stationary at level. In contrast, GDP_PC, CO2_PC, and FDI are not stationary at level but become stationary after taking the first difference.

Table 3.1: Unit Root Test

Null hypothesis (H_0): The variable has a unit root (non-stationary)

Variables	ADF		PP		Order of Integration (with intercept)
	Level	First Difference	Level	First Difference	
HDI	-6.6588***	-1.5628 (ns)	-8.0655***	-4.7397***	I(0)
lnGDPPC	-2.0408 (ns)	-2.6479*	-2.7167*	-4.2145***	I(1)
lnCO2PC	-0.9697 (ns)	-4.4908***	-1.7079 (ns)	-4.4387***	I(1)
FDI	-2.8278*	-5.0085***	-2.6408*	-4.9847***	I(1)

Notes:
***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.
ns: not statistically significant.
All tests include a constant term.
H_0: The series has a unit root (non-stationary). The null hypothesis is rejected when the test statistic is statistically significant.

This means that the variables are integrated at order I(0) and I(1), and none of them is integrated at order I(2). Therefore, the basic condition to apply the ARDL model, as suggested by (Pesaran et al., 2001), is satisfied.

The Bounds test gives an F-statistic of 15.9167, which is higher than the upper bound critical values at the 10%, 5%, and 1% levels. This allows us to reject the null hypothesis that there is no long-run relationship. In other words, the variables move together over time. Therefore, it is appropriate to estimate the ARDL model to examine both the short-run and long-run effects.

Table 3.2: Bounds Test Results

Null hypothesis: There is no long-run cointegration relationship among the variables

F-statistic	**Critical values for the Bounds test**		
	Significance level	**I(0)**	**I(1)**
15.9167	10%	2.730	3.956
	5%	3.323	4.716
	1%	4.697	6.549

Note: I(0) and I(1) are the lower and upper critical bounds of the Bounds test.

If the F-statistic is greater than I(1), the null hypothesis is rejected and cointegration exists.

3.2. Short-Run and Long-Run Relationships

The ARDL results show that a long-run relationship exists among the variables. The error correction term (ECT = -0.6562, $p < 0.01$) is negative and statistically significant, which means the model moves back to equilibrium after a shock. About 65.6% of the gap from the long-run balance is adjusted each year.

Regarding short-run dynamics, GDPPC shows a positive association with HDI, while $GDPPC^2$ is negative. This pattern implies that although economic growth enhances human development, the incremental benefit declines as income rises. The long-run coefficients display the same configuration, with a positive linear term and a negative quadratic term, reinforcing the presence of a concave income–development relationship. CO2PC is positively associated with HDI at the 5% significance level, whereas FDI does not produce a statistically significant effect.

Table 3.3. ARDL–ECM Estimation Results and Diagnostic Tests

Selected model: ARDL(2,1,1,0,0), T = 32 (1992–2023), SIC criterion, Case 3 (unrestricted constant).

Variable	Coefficient	Standard Error	t-Statistic	p-Value
Short-run relationship				
COINTEQ*	-0.6562***	0.0679	-9.6656	0.000
D(HDI(-1))	-0.7669***	0.0972	-7.893	0.000
D(lnGDPPC)	0.6858***	0.0662	10.3642	0.000
D($lnGDPPC^2$)	-0.0444***	0.0047	-9.4274	0.000
C	-0.7703***	0.0806	-9.5545	0.000
Long-run relationship				
Variable	**Coefficient**	**Standard Error**	**t-Statistic**	**p-Value**
lnGDPPC(-1)	0.3676***	0.0356	10.3308	0.0000
$lnGDPPC(-1)^2$	-0.0161***	0.0019	-8.5175	0.0000
lnCO2PC	0.0158**	0.0057	2.7584	0.0101
FDI	0.0001 ns	0.0001	0.5473	0.5885
	Model Diagnostic Tests			
Test	F-Statistic		p-value (Prob.)	
Breusch–Godfrey serial correlation test (LM test)	1.5311 ns	0.229		
Breusch–Pagan–Godfrey heteroskedasticity test	2.0608	0.0837		

Notes:

(1) ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

(2) ns: not statistically significant.

(3) COINTEQ refers to the error correction term (ECT).

3.3. Diagnostic Tests and Model Stability

The diagnostic test results reported in Table 3.3 show that the model does not suffer from serial correlation (LM test, p = 0.229). There is also no strong evidence of heteroskedasticity at the 5% significance level (BP test, p = 0.0837).

In addition, the CUSUM and CUSUMSQ tests presented in Figure 1 indicate that the CUSUM statistic generally stays within the 5% critical bounds. However, the CUSUMSQ line moves outside the critical bounds during the period 2016–2021, suggesting a possible local structural change near the end of the sample. Even so, this deviation does not persist throughout the entire sample period. Therefore, the overall estimation results can still be considered relatively stable.

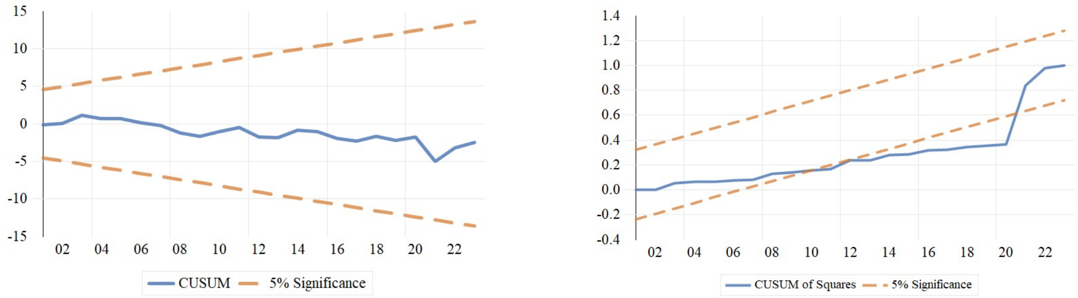

Figura 1: CUSUM and CUSUMSQ Stability Tests

3.4. Discussion

This study in Vietnam finds a long-run relationship between economic growth and the Human Development Index (HDI). When GDP increases, HDI also rises. However, the coefficient of GDP squared is negative. This means that when GDP reaches a higher level, the increase in HDI becomes slower. Previous studies show a similar result. Economic growth can increase public and private spending on education and health, which are important parts of human development (Khodabakhshi, 2011). However, when GDP becomes high, HDI usually increases more slowly. One reason is that indicators such as life expectancy and literacy rate cannot grow without limit because they face biological and physical constraints (Dasic et al., 2020). In Vietnam, research shows that the positive impact of economic growth on HDI tends to slow down and may even become negative if growth is not accompanied by social equity (Thao et al., 2025). This suggests that Vietnam needs to move from a quantity-based growth model to one that focuses more on quality, with greater investment in skills and social welfare to improve human development (Dasic et al., 2020; Quang et al., 2025).

This study in Vietnam finds a long-run relationship between CO_2 emissions and the Human Development Index (HDI). When CO_2 emissions increase, HDI decreases. Compared with previous studies, this negative relationship suggests that environmental degradation directly affects public health and may reduce life expectancy (Nguyen & Do, 2023; Pervaiz et al., 2021). In Vietnam, rapid industrialization has relied heavily on fossil energy, which has increased CO_2 emissions and led to higher health costs and weaker social welfare outcomes (Quang et al., 2025). When environmental quality declines, people face greater health risks, which can weaken the progress of human development (Nguyen & Do, 2023; Pervaiz et al., 2021). However, improvements in education and awareness, which are components of HDI, may help Vietnam develop cleaner technologies and reduce emissions in the long run (Nguyen & Do, 2023).

The long-run relationship between foreign direct investment (FDI) and the Human Development Index (HDI) is not statistically significant. This result indicates that foreign capital in Vietnam has not been effectively converted into long-term social welfare. A possible explanation is that FDI is still concentrated in low-skill labor sectors, where knowledge spillovers remain limited. Sustainable improvements in human development require that FDI be supported by effective human resource training policies and an economy with strong absorptive capacity (Thao et al., 2025).

4. Conclusion and Policy Implications

This paper studies the link between economic growth, CO_2 emissions, foreign direct investment (FDI), and human development in Vietnam from 1990 to 2023 using the ARDL model. The results show a long-run relationship among the variables. The adjustment to long-run equilibrium is relatively fast. Economic growth increases the Human Development Index (HDI). The coefficient of GDP squared is negative. This result shows a nonlinear relationship. The increase in HDI becomes slower at higher income levels. CO_2 emissions reduce HDI in the long run. This result reflects a trade-off between economic growth and environmental quality. FDI has no statistically significant effect on HDI.

The results provide several implications for Vietnam. The country needs to move from quantity-based growth to better growth quality. Investment in education, health care, and labor skills should increase to improve human development. Environmental regulation also needs to be stricter. The government should promote clean energy and apply stronger emission standards to protect public health in the long run. The policy for attracting foreign direct investment (FDI) should be more selective. Vietnam should give priority to high-technology and environmentally friendly projects that can create stronger knowledge spillovers.

Future research can use panel data or other nonlinear methods to study the drivers of sustainable human development in more detail.

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