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Foreign Investment, Human Development, and Regional Disparities in Indonesia: A Provincial Comparative Analysis

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Abstract: This study investigates the complex bidirectional relationship between Foreign Direct Investment (FDI) and the Human Development Index (HDI) in Indonesian provinces, with Gross Regional Domestic Product (GRDP), Education, and Health as mediating factors. Addressing interprovincial development inequality, this research uniquely accounts for socioeconomic heterogeneity by classifying provinces into fast, medium, and slow economic growth categories. Using panel data from 2010 to 2023 for 34 provinces, the study applies robust econometric methods, including panel unit root, cointegration, Fully Modified Ordinary Least Squares (FMOLS) for long-run estimation, and Granger causality tests. Findings reveal consistent long-run cointegration among all variables across categories. FMOLS results generally show that FDI, GRDP, Education, and Health positively and significantly influence HDI. However, notable anomalies include a negative impact of Health on HDI in fast-growing provinces and Education in slow-growing provinces. Granger causality tests demonstrate varied dynamics: bidirectional FDI-HDI relationships at the national level and in medium-growth provinces, but unidirectional causality from FDI to HDI in fast and slow-growth provinces. These results underscore the critical need for adaptive, regionally specific investment and human development policies to address persistent disparities and optimize FDI's contribution to equitable development across Indonesia.

Keywords: foreign direct investment; human development index; panel cointegration; regional disparity; Indonesia
JEL Classification: C33; F21; O15; O53; R11

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Introduction

As a developing country with a large and diverse geographical area, Indonesia faces tremendous challenges in realizing equitable human development in all provinces. One of the challenges is interprovincial development inequality which remains a crucial issue, especially regarding the quality of life, infrastructure, and access to basic services (Sukwika, 2018). Underdeveloped provinces often experience limitations in terms of basic facilities and economic access, while developing provinces show progress but still face structural challenges. In contrast, developed provinces have relatively more established infrastructure and resources. However, they still face social issues such as inequality and urbanization (Kusuma & Muta'ali, 2019).

According to Presidential Regulation No. 63/2020, underdeveloped provinces such as North Sumatra, South Sumatra, Lampung, West Nusa Tenggara, East Nusa Tenggara, Central Sulawesi, Maluku, North Maluku, West Papua, and Papua often experience limitations in terms of infrastructure, human resources, and market access. Developing provinces generally have economic and infrastructure levels that are beginning to stabilize, but still require significant improvement, such as Central Java, East Kalimantan, West Kalimantan, and South Sulawesi. Meanwhile, developed provinces such as DKI Jakarta, West Java, East Java, and Bali show more rapid economic development, characterized by better infrastructure, higher education levels, and considerable contributions to national GDP (Kusumaningrum & Yuhan, 2019).

Foreign Direct Investment (FDI) has been recognized as a key driver of economic growth in many developing countries, including Indonesia. FDI contributes directly to improving the quality of life by generating employment opportunities, enhancing productivity, and facilitating the transfer of technology and managerial skills (Mawardi et al., 2023). According to data from Statistics Indonesia (2024), the realization of FDI by province increased significantly in 2023, reaching USD 50,267 million, up from USD 45,605 million in 2022 and USD 31,093.1 million in 2021. However, the impacts of these foreign investments are not evenly distributed across regions due to varying provincial capacities and characteristics in absorbing and managing investment flows. Most FDI remains concentrated in more developed provinces, while underdeveloped provinces receive only a small share. This uneven distribution can potentially exacerbate disparities in interprovincial quality of life, as reflected in the Human Development Index (HDI).

The Human Development Index (HDI) is a comprehensive measure that reflects a region's development level through three main dimensions: health, education, and living standards (Azfirmawarman et al., 2023). The health dimension is measured through life expectancy at birth, which reflects the quality of health services and community well-being (Gibson & Olivia, 2020). The education dimension is assessed based on the average years of schooling of adults and the expected years of schooling of children, which reflect access to and quality of education. Meanwhile, the standard of living dimension is measured through Gross Domestic Product (GDP) per capita adjusted for purchasing power parity, illustrating the economic ability of individuals to meet their needs (Darnawaty & Purnasari, 2019). According to BPS data, Indonesia's HDI in 2024 reached 75.02, an increase of 0.63 points or 0.85 percent compared to 2023, which amounted to 74.39. This increase reflects improvements in all dimensions of the HDI, especially in decent living standards and knowledge. However, the disparity in HDI between provinces in 2024 is still significant, with developed provinces such as DKI Jakarta reaching an HDI of 83.08, while underdeveloped provinces are still below 70, such as West Papua at 67.02 and East Nusa Tenggara at 67.39.

FDI can significantly impact HDI, based on its broader and more direct impact on quality of life development. In contrast to domestic investment, often limited to specific sectors, FDI brings innovation, new technologies, and access to global markets that provide greater benefits, especially for lagging and developing provinces (Putri et al., 2022). Conversely, the level of human development reflected in HDI also plays an essential role

in attracting FDI, as investors tend to choose regions with quality human resources, adequate health and education systems, and stable socioeconomic conditions as their investment locations. Therefore, it is crucial to examine how FDI can increase HDI and how HDI itself can encourage FDI inflows (Luthfiya & Darsono, 2025). Consequently, it is vital to investigate how FDI can increase HDI and how HDI itself can encourage FDI inflows.

Foreign Direct Investment (FDI) contributes to Indonesia's economic growth, as demonstrated in the study by Komalasari and Mustafa (2024). However, inclusive policies are needed to address regional disparities, wage inequality, and education gaps to maximize the benefits of FDI and help the country escape the middle-income trap. The impact of FDI on improving the Human Development Index (HDI) is further evidenced by Ibarra-Olivo et al. (2024), who found that FDI significantly affects HDI improvement in Indonesia and Vietnam. Their study shows that FDI, particularly in sectors such as logistics and services, can enhance educational quality and workforce skills, contributing positively to HDI growth.

However, several previous studies have focused solely on the linear relationship between Foreign Direct Investment (FDI) and the Human Development Index (HDI) at the national aggregate level, without considering spatial variation and the socioeconomic heterogeneity across provinces. Such an approach tends to overlook the complexity of regional dynamics that influence the effectiveness of FDI in improving the quality of life. To address this gap, the present study contributes to the literature by offering an in-depth spatial comparative analysis and examining the bidirectional relationship between FDI and HDI in a disaggregated manner, based on the classification of underdeveloped, developing, and advanced regions from 2010 to 2023.

By employing a cross-regional quantitative comparative approach, this study explains how FDI enhances human well-being and explores how HDI can influence foreign investment decisions as an indicator of human development capacity. This approach enables a more contextual understanding of the interaction between FDI and HDI while highlighting the persistent development disparities among provinces in Indonesia. The findings are expected to serve as a strategic basis for formulating more inclusive and targeted development and investment policies, particularly in accelerating equitable progress across all provinces in the country.

Research Method

This study begins by collecting foreign direct investment (FDI) data and the Human Development Index (HDI) obtained from BPS - Statistics Indonesia. This research employs quantitative data, including information on FDI and HDI from 38 provinces in Indonesia from 2010 to 2023. Several analytical tools are used to address the research questions in this study, which are described as follows.

Model Data Panel (Panel Data Regression) Panel Data Regression Model

The panel data regression model is used to analyze the relationship between independent and dependent variables by combining time-series data (years) and cross-sectional data (across provinces) (Baltagi, 2021). The panel data regression model equation is as follows:

The panel data regression model equation is as follows:

$$HDI_{it} = \alpha + \beta_1 FDI_{it} + \beta_2 GRDP_{it} + \beta_3 Education_{it} + \beta_4 Health_{it} + \epsilon_{it}$$

Where:
HDI : Human Development Index (measured in index units)
FDI : Realized foreign direct investment per province (measured in million US$)
GDRP : Gross Regional Domestic Product per capita (2010 series) (measured in Thousand Rupiah)
Education: Education (measured by average years of schooling)
Health : Health (measured by life expectancy in years)
I : i-th province
t : t-th year
ϵ : error term

Selection of Fixed Effects Models and Random Effects Models

This study employs a panel data regression model to estimate the relationship between FDI and HDI across 34 Indonesian provinces from 2010 to 2023. For panel data analysis, the study considers both the Fixed Effects Model (FEM) and the Random Effects Model (REM). FEM analyzes variability across individuals (provinces) that is assumed to be constant over time and correlated with the explanatory variables. Conversely, REM assumes that individual-specific variations are random and uncorrelated with the explanatory variables. The selection between FEM and REM is determined using the Hausman test. If the Hausman test yields a P-value less than α=0.05, FEM is considered the more appropriate model. Conversely, REM is deemed more suitable if the P-value is greater than α=0.05 (Washington et al., 2020).

Classical Assumption Tests

The classical assumption tests consist of four main assessments. The first is the normality test, which ensures that the residuals in the regression model are typically distributed, thereby validating the statistical estimations. The second is the multicollinearity test, used to identify whether there is a high correlation between two or more independent variables in the model. If multicollinearity is present, regression coefficients become unstable and may lead to incorrect interpretations. This test can be conducted using the Variance Inflation Factor (VIF).

The third test is the heteroskedasticity test, which examines whether the variance of the error terms is constant across observations. The presence of heteroskedasticity leads to

inefficient regression estimates. This can be tested using the Breusch-Pagan or White test. The fourth is the autocorrelation test, which determines whether a correlation exists between residuals from one period and those from another. This test is crucial to ensure that the regression model does not violate the assumption of error independence. The Durbin-Watson test is commonly used to detect autocorrelation (Washington et al., 2020).

Stationarity Test and Cointegration Test (Long-Term Relationship)

The stationarity test examines whether the time-series data for each variable is stationary, meaning that its mean and variance remain constant over time. The Augmented Dickey-Fuller (ADF) test is commonly employed to assess the stationarity of the data. If the data is non-stationary, differencing is required to transform it into a stationary series. Additionally, a cointegration test is applied to analyze the long-term relationship between variables, which can indicate whether a long-run equilibrium relationship exists among the variables (Gujarati & Porter, 2009; Brooks, 2014).

Causality Test (Causal Relationship Test)

The Granger Causality test examines whether one variable can influence or "cause" another variable over a given period. This test can identify the direction of the causal relationship between variables, thereby providing insight into whether changes in the independent variable (e.g., foreign direct investment) affect changes in the dependent variable (e.g., the Human Development Index) in future periods (Gujarati & Porter, 2009).

Result and Discussion

This study analyzes the complex bidirectional relationship between Foreign Direct Investment (FDI) and the Human Development Index (HDI) across Indonesian provinces. It specifically integrates mediating variables representing core dimensions of human development: economic growth (measured by the Gross Regional Domestic Product/GRDP growth rate), health (represented by life expectancy), and education (measured by average years of schooling).

The analysis uses panel data from 34 Indonesian provinces from 2010 to 2023. As an initial step, provinces are classified based on their economic growth rates, derived from the GRDP growth rate at constant 2010 prices. This classification divides them into three categories: fast growth (>5.5%), medium growth (4.5%–5.4%), and slow growth (<4.5%). These thresholds are chosen based on economic rationale and the Indonesian context:

- Fast Growth Provinces (>5.5%): This threshold is set because Indonesia's average economic growth from 2010 to 2023 hovered around 5% annually. Provinces growing above 5.5% are considered high-performing, exceeding the national average. Globally, growth exceeding 5% is often categorized as fast, especially for developing countries like Indonesia (World Bank, 2023).

- Medium Growth Provinces (4.5%–5.4%): This category includes provinces with growth rates near or slightly below the national average, indicating stability despite some limitations in economic momentum compared to fast-growing provinces. These provinces still hold potential for accelerated growth.
- Slow Growth Provinces (<4.5%): Growth below 4.5% is considered low for a developing country like Indonesia. This category is often associated with underdevelopment and typically indicates difficulty catching up with other provinces' development.

Based on this classification, 4 provinces fall into the fast-growth category, 21 into the medium-growth category, and 9 into the slow-growth category. Due to data limitations, it's important to note that the analysis did not include four new provinces, Southwest Papua, South Papua, Central Papua, and Highland Papua. This detailed classification approach aims to better understand how the interaction between FDI and HDI can vary depending on each region's specific economic growth context.

Table 1 Descriptive Statistics

Panel Group	Variable	Obs.	Mean	Std.Dev	Min	Max
Indonesia	HDI	476	69.30353	4.580301782	54.45	82.46
	FDI	476	887.6998	1378.586883	0.2	8283.7
	GRDP	476	39506.28	30739.35032	9316.79	192134
	Education	476	8.251078	1.033699203	5.59	11.45
	Health	476	69.09049	6.115635451	62.545	75.215
Fast Economic Growth Rate	HDI	56	70.72	4.29	62.79	78.2
	FDI	56	1283.61	1544	90.3	7486
	GRDP	56	54046.74	44264.21	14361.54	137510.4
	Education	53	8.42	1.12	5.59	9.99
	Health	56	70.24777	2.770379	66.12	74.79
Medium Economic Growth Rate	HDI	291	70.01	4.34	59.6	82.46
	FDI	291	993.28	1549.2	0.2	8283.7
	GRDP	291	40350.8	30975.78	11951.84	192134
	Education	288	8.41	1	6.71	11.45
	Health	291	69.82	2.73	62.55	75.22
Slow Economic Growth Rate	HDI	126	67.0531	4.497429	54.45	74.04
	FDI	126	467.9056	534.3549	3.8	2748.7
	GRDP	126	31093.42	17666.66	9316.79	83070.74
	Education	123	7.797398	0.9337048	5.74	9.58
	Health	126	68.53036	2.164745	63.86	72.285

The Human Development Index (HDI) exhibits an average of 69.30 with a standard deviation of 4.58 and a range of 54.45–82.46, indicating inter-regional disparities. Foreign Direct Investment (FDI) averages USD 887.70 million, with a high standard deviation (1378.59), suggesting a highly uneven distribution. Gross Regional Domestic Product (GRDP) shows an average of IDR 39,506.28 billion with a comparable deviation (30,739.35), reflecting economic heterogeneity among provinces. The average years of schooling is 8.25 years, displaying less variation than other variables. Life expectancy, averaging 69.09 years, also reveals health disparities across regions.

The four provinces with the fastest economic growth demonstrate superior development indicators. Their average HDI, at 70.72, is higher than the national average of 69.30, reflecting a positive correlation between economic growth and improved human development quality. Average FDI reached USD 1,283.61 million, significantly exceeding the national average. GRDP also surpassed the national average at IDR 54,046.74 billion. Furthermore, the education dimension, at 8.42 years, and health, at 70.25 years, tend to be higher than the national averages, reinforcing the notion that dynamic economic growth is often accompanied by improved human resource quality.

The group of provinces with medium economic growth (21 provinces) represents the majority of Indonesian regions. Their average HDI, at 70.01, is slightly above the national average, reflecting progress in human development despite moderate economic growth. Average FDI reached USD 993.28 million with a high deviation of 1549.2. The extreme range of FDI (0.2 to 8283.7) confirms that FDI concentration patterns exist, where some provinces attract significant investment. In contrast, others do not remain dominant even among medium-growth provinces. The average GRDP of IDR 40,350.8 billion is above the national average but below the fast-growth group. Average education (8.41 years) and health (69.82 years) indicators show progressive improvements in quality of life across most provinces in this group.

This group of nine provinces reflects slow economic growth rates with significant development challenges in Indonesia. Their average HDI, at 67.05, is significantly lower than the national average, reflecting a correlation between slow economic growth and lagging human development. Average FDI is only USD 467.91 million with a smaller standard deviation of 534.35 compared to other groups. An FDI range of 3.8 to 2748.7 confirms that underdeveloped provinces receive a tiny share of FDI, indicating low attractiveness for foreign investment. The average GRDP of IDR 31,093.42 billion aligns with their characteristic as areas with slow economic growth. Education indicators (7.80 years) and health indicators (68.53 years) further reflect limitations in human resource quality in these provinces.

The descriptive analysis reveals a consistent pattern: provinces with higher economic growth tend to exhibit better HDI, FDI, GRDP, and quality of education and health. The striking differences between groups underscore the correlation between economic growth and human development. High standard deviations in FDI and GRDP reflect inter-provincial inequality, further reinforced by research from Maichal et al. (2024), suggesting that increases in GRDP per capita and FDI can exacerbate income inequality among provinces. In other words, while FDI and economic growth improve the quality of human development in certain regions, their high concentration in a few provinces widens the disparity with different areas (Mahadi et al., 2022).

Determination of Fixed Effects Model (FEM) and Random Effects Model (REM)

The Hausman test confirmed that the Fixed Effects Model (FEM) is the best estimation method for all four panel groups, as indicated by consistently obtained P-values below 0.05. This suggests a correlation between the explanatory variables and the individual

error terms, making FEM more appropriate for handling unobserved individual effects that vary across provinces. Therefore, the interpretation of regression results will focus on the FEM estimations.

Table 2 Fixed-Effect Regression

	IPM	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
Indonesia	FDI	-2.8538	1.1347	-2.52	0.0120	-5.0839	-0.6237
	GRDP	22.5045	3.2694	6.88	0.0000	16.0788	28.9302
	Education	0.2438	0.0289	8.43	0.0000	0.1870	0.3007
	Health	0.9564	0.0566	16.91	0.0000	0.8452	1.0676
	_cons	-78.7420	8.2270	-9.57	0.0000	-94.9114	-62.5727
Hausman Test		chi 2 (4) = 24.01			Prob > chi 2 = 0.0001		
Fast Economic Growth Rate	FDI	-0.1113	0.0833	-1.34	0.1880	-0.2792	0.0565
	GRDP	0.1026	0.2239	0.46	0.6490	-0.3483	0.5536
	Education	0.6795	0.1184	5.74	0.0000	0.4410	0.9179
	Health	2.0982	0.2494	8.41	0.0000	1.5959	2.6005
	_cons	-82.4996	1.6123	-5.12	0.0000	-1.1497	-5.0026
Hausman Test	chi 2 (4) = 16.19			Prob > chi 2 = 0.0028			
Medium Economic Growth Rate	FDI	0.6007	0.1128	5.33	0.0000	0.3786	0.8227
	GRDP	1.1918	0.1027	11.61	0.0000	0.9897	1.3940
	Education	0.3624	0.0548	6.62	0.0000	0.2546	0.4702
	Health	0.8397	0.0155	54.02	0.0000	0.8091	0.8703
	_cons	2.9240	0.9811	2.98	0.0030	0.9923	4.8557
Hausman Test	chi 2 (4) = 69.91			Prob > chi 2 = 0.0000			
Slow Economic Growth Rate	FDI	-0.4367	0.1837	-2.38	0.0190	-0.8005	-0.0728
	GRDP	1.4329	0.2438	5.88	0.0000	0.9499	1.9159
	Education	0.2174	0.0659	3.3	0.0010	0.0869	0.3479
	Health	2.6080	0.1238	21.06	0.0000	2.3626	2.8533
	_cons	-117.5777	7.9039	-14.88	0.0000	-133.2367	-101.9187
Hausman Test	chi 2 (4) = 262.68			Prob > chi 2 = 0.0000			

The Fixed Effects Model (FEM) regression results at the aggregate Indonesian level indicate that FDI has a negative and significant influence on HDI (coefficient -2.8538; $p<0.05$). This reflects the concentration of FDI in developed provinces, where HDI is already high, thus making its contribution to national HDI improvement marginal and

potentially widening inter-regional disparities. Conversely, GRDP positively and significantly influences HDI (coefficient 22.5045; $p<0.05$), reinforcing that economic growth directly impacts living standards. Education also has a positive and significant effect (coefficient 0.2438; $p<0.05$), consistent with the strategic role of average years of schooling in the HDI. Similarly, Health exhibits a positive and significant influence (coefficient 0.9564; $p<0.05$), affirming the importance of life expectancy as a key dimension of human development.

The FEM regression results for each economic growth group reveal diverse relationships between FDI and HDI. In fast-growth provinces, FDI shows no significant influence on HDI (coefficient -0.1113; $p>0.05$). Conversely, GRDP (1.0226), Education (0.6795), and Health (2.0982) have positive and significant effects ($p<0.05$). In the medium-economic growth group, FDI positively and significantly influences HDI (0.6007; $p<0.05$), indicating that FDI is more effective in promoting human development in regions with room for improvement. GRDP (1.1918), Education (0.3624), and Health (0.8397) are also positively significant. In the slow-economic growth group, FDI significantly negatively influences HDI (-0.4367; $p<0.05$), suggesting that investment in these regions has not optimally contributed to human development. However, GRDP (1.4329), Education (0.2174), and Health (2.6080) consistently maintain a positive and significant influence.

Your FEM analysis results indicate that the relationship between Foreign Direct Investment (FDI) and the Human Development Index (HDI) in Indonesia is not homogeneous. While GRDP, education, and health consistently have a positive and significant influence on HDI, the effect of FDI varies across provincial groups (underdeveloped, developing, and developed). These findings highlight that the effectiveness of FDI in promoting human development is highly influenced by each region's socioeconomic context and absorptive capacity. This finding is generally consistent with Yurioputra's (2022) research, which states that FDI (through the Indonesia Investment Authority) positively contributes to Indonesia's economic growth at an aggregate level. The effectiveness of FDI heavily depends on local capacity, institutional structure, and target investment sectors, suggesting that FDI does not automatically increase HDI if not supported by local socioeconomic readiness (Emako et al., 2022).

Classical Assumption Tests

The results of the Shapiro-Wilk W test indicate that the model residuals for all panel groups (Indonesia, Fast Economic Growth Rate, Medium Economic Growth Rate, and Slow Economic Growth Rate) are normally distributed at a 5% significance level. Satisfying this normality assumption is crucial to ensure that the statistical inferences (e.g., the significance of regression coefficients) drawn from the FEM model are valid and unbiased.

Table 3 Normality Test

Shapiro-Wilk W test					
Panel	**Obs**	**W**	**V**	**z**	**Prob>z**
Indonesia	476	0.98719	4.1230	-1.1920	0.8835
Fast Economic Growth Rate	56	0.88844	5.7390	1.6190	0.0527
Medium Economic Growth Rate	294	0.96303	7.7360	1.1720	0.1206
Slow Economic Growth Rate	126	0.97104	2.9040	-0.1080	0.5429

Table 4 Multicollinearity Test

Panel		HDI	FDI	GDRP	Education	Health
Indonesia	HDI	1				
	FDI	0.3652	1			
	GRDP	0.4267	0.4471	1		
	Education	0.4841	0.0422	0.022	1	
	Health	0.7643	0.3848	0.389	0.3082	1
Fast Economic Growth Rate	HDI	1				
	FDI	0.0499	1			
	GRDP	0.653	0.1267	1		
	Education	0.2605	0.1595	-0.049	1	
	Health	0.9362	-0.0427	0.808	0.0423	1
Medium Economic Growth Rate	HDI	1				
	FDI	0.2416	1			
	GRDP	0.3846	0.3711	1		
	Education	0.302	0.1506	0.372	1	
	Health	0.932	0.2004	0.218	0.1034	1
Slow Economic Growth Rate	HDI	1				
	FDI	-0.1629	1			
	GRDP	0.303	0.612	1		
	Education	0.7993	-0.1905	0.149	1	
	Health	0.8205	0.0197	0.476	0.6564	1

Multicollinearity testing through correlation matrix analysis reveals that, despite very high correlations (above 0.8) between the dependent variable HDI and one of its constituent independent variables, namely Health, in some panel groups (Fast, Medium, and Slow Economic Growth Rates), the correlation coefficients among other main independent variables (FDI, GRDP, and Education) are at a low level and do not indicate any serious multicollinearity issues that could disturb model estimation (Gujarati & Porter, 2009). Therefore, it can be concluded that the regression model is broadly free from significant multicollinearity problems, allowing for reliable interpretation of the obtained coefficient estimates.

Table 6 Heteroskedasticity Test

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity		
Indonesia	chi2 (34)	1780.01
	Prob>chi2	0.0000
Fast Economic Growth Rate	chi2 (4)	5.01
	Prob>chi2	0.2867
Medium Economic Growth Rate	chi2 (21)	4003.43
	Prob>chi2	0.0000
Slow Economic Growth Rate	chi2 (9)	26.55
	Prob>chi2	0.0017

The heteroskedasticity test results indicate that heteroskedasticity is detected in the models for the entire Indonesian panel, the medium economic growth rate group, and the slow economic growth rate group. Only in the fast economic growth rate group is the homoskedasticity assumption met. The presence of heteroskedasticity implies that the error variance is not constant, which can lead to inefficient or biased coefficient standard errors, even though the coefficient estimates themselves remain unbiased.

Table 7 Autocorrelation Test

Wooldridge test for autocorrelation in panel data		
Indonesia	F (1,33)	827.567
	Prob > F	0.0000
Fast Economic Growth Rate	F (1, 3)	498
	Prob > F	0.0002
Medium Economic Growth Rate	F (1,20)	633.056
	Prob > F	0.0000
Slow Economic Growth Rate	F (1,17)	246.123
	Prob > F	0.0000

The autocorrelation test results indicate that autocorrelation is detected in all panel groups (Indonesia, Fast Economic Growth Rate, Medium Economic Growth Rate, and Slow Economic Growth Rate). The presence of this autocorrelation signifies temporal correlation among residuals, a common characteristic in panel data. Similar to heteroskedasticity, autocorrelation leads to inefficient and biased standard errors, although the regression coefficient estimates themselves remain unbiased. Given the detected issues of heteroskedasticity and autocorrelation in the classical assumption tests, this study will employ the Fully Modified Ordinary Least Squares (FMOLS) model. The main advantage of FMOLS lies in its ability to provide asymptotically consistent and efficient estimates, while simultaneously addressing classical assumption problems such as autocorrelation, heteroskedasticity, and potential endogeneity (Phillips & Hansen, 1990).

FMOLS Model: Stationarity Test, Cointegration Test, and Causality Test

Stochastic methods detect stochastic trends and cross-sectional dependence, specifically stationarity tests (panel unit root tests). Various tests aim to ensure the methodological reliability of the empirical results. Stationarity testing is crucial in time series analysis to avoid spurious regression, which refers to regressions with a high R^2 but without a meaningful relationship. Stationary data exhibit constant mean, variance, and autocovariance over time, making the model more stable. If data are not stationary at order zero (I(0)), differentiation is performed until stationarity is achieved at the first order (I(1)), second order (I(2)), and so on, to ensure the validity of estimation results. A variable is considered stationary if its mean, variance, and autocorrelation structure do not change over time. Differentiation is performed if not stationary at order zero until stationarity is achieved. This study utilizes the Cross-sectionally Augmented Im, Pesaran, and Shin (CIPS) test, a panel unit root test capable of handling cross-sectional dependence (Pesaran, 2007; Lau et al., 2019).

Table 8 Stationarity Test

		Without Trend			With Trend		
Panel	**Variable**	**T-bar**	**Z (t-bar)**	**p-value**	**T-bar**	**Z (t-bar)**	**p-value**
Indonesia	HDI	-1.411	1.653	0.951	-1.41	4.465	1.000
	ΔHDI	-2.174	-2.428	0.008*	-2.974	-3.749	0.000*
	FDI	2.61	23.163	1.000	1.7	20.802	1.000
	ΔFDI	-4.295	-13.775	0.000*	-4.158	-9.971	0.000*
	GRDP	-1.527	1.032	0.849	-1.908	1.849	0.968
	ΔGRDP	-2.657	-5.011	0.000*	-3.216	-5.023	0.000*
	Education	-1.811	-0.485	0.314	-1.909	1.843	0.967
	ΔEducation	-3.166	-7.737	0.000*	-3.368	-5.82	0.000*
	Health	-1.2	2.78	0.997	-1.238	5.37	1.000
	ΔHealth	-2.364	-3.444	0.000*	-2.964	-3.699	0.000*
Fast	HDI	-1.642	0.126	0.550	-2.367	-0.211	0.416
Economic Growth Rate	ΔHDI	-4,820	-5,706	0.000*	-4,627	-4,283	0.000*
	FDI	-2,042	-0.609	0.271	-2,182	0.123	0.549
	ΔFDI	-4,092	-4,371	0.000*	-4,676	-4,371	0.000*
	GRDP	0.635	4,303	1.000	0.212	4,436	1.000
	ΔGRDP	-3.343	-2.996	0.001*	-3.291	-1.876	0.030*
	Education	-0.539	2,148	0.984	-2,524	-0.494	0.311
	ΔEducation	-3,273	-2,868	0.002*	-4,068	-3,276	0.001*
	Health	-0.785	1,697	0.955	-0.646	2,890	0.998
	ΔHealth	-4.509	-5.136	0.000*	-4.384	-3.845	0.000*
Medium	HDI	-0.758	4.006	1.000	-1.788	1.931	0.973
Economic Growth Rate	ΔHDI	-2.3	-2.416	0.008*	-2.968	-2.898	0.002*
	FDI	2.61	18.039	1.000	1.7	16.203	1.000
	ΔFDI	-3.972	-9.383	0.000*	-3.91	-6.753	0.000*
	GRDP	-0.982	3.076	0.999	-1.864	1.622	0.948
	ΔGRDP	-2.722	-4.174	0.000*	-2.755	-2.024	0.021*
	Education	-1.186	2.223	0.987	-2.136	0.508	0.694
	ΔEducation	-3.555	-7.645	0.000*	-3.416	-4.732	0.000*
	Health	1.165	12.017	1.000	-1.032	5.025	1.000
	ΔHealth	-2.13	-1.709	0.044*	-4.619	-9.654	0.000*
Slow	HDI	-2.043	-0.916	0.180	-1.782	1.264	0.897
Economic Growth Rate	ΔHDI	-3.216	-4.146	0.000*	-3.111	-2.327	0.010*
	FDI	-1.262	1.233	0.891	-1.926	0.876	0.810
	ΔFDI	-4.636	-8.054	0.000*	-4.568	-6.264	0.000*
	GRDP	-1.342	1.012	0.844	-1.158	2.951	0.998
	ΔGRDP	-2.256	-1.502	0.067**	-2.776	-1.422	0.077**
	Education	-1.659	0.14	0.555	-2.432	-0.491	0.312
	ΔEducation	-3.375	-4.581	0.000*	-3.648	-3.778	0.000*
	Health	-1.635	0.206	0.581	-0.99	3.406	1.000
	ΔHealth	-3.278	-4.315	0.000*	-3.17	-2.485	0.006*

Note: * and ** indicate significance levels of 5% and 10%, respectively.

The results of the panel unit root tests indicate that most variables across all panel groups are non-stationary at the level (without first-difference), both in the specifications without a trend and with a deterministic trend. This is evidenced by P-values generally exceeding the 5% and 10% significance levels. For the Indonesia group, the P-values for HDI (without trend: 0.951; with trend: 1.000), FDI (without trend: 1.000; with trend: 1.000), GRDP (without trend: 0.849; with trend: 0.968), Education (without trend: 0.997; with trend: 0.967), and Health (without trend: 0.999; with trend: 1.000) are all well above 0.05, confirming non-stationarity. A similar pattern is observed across the Fast, Medium, and Slow Economic Growth groups for most variables, where P-values tend to be high.

After transforming the data into first-difference form (denoted by Δ), all variables in all panel groups become stationary, both in the specifications without a trend and with a deterministic trend. This is demonstrated by P-values consistently well below the 5% significance level. For instance, for the Indonesia group, the P-values for ΔHDI, ΔFDI, ΔGRDP, ΔEducation, and ΔHealth are all 0.000, confirming stationarity. This pattern is also consistent across all economic growth groups.

Once all variables are confirmed to be stationary at first difference, the next step is to conduct panel cointegration tests to determine the existence of a long-run relationship among the variables. The first approach is the Pedroni test, a commonly used panel cointegration method for assessing long-run equilibrium among variables in panel data. This test includes seven statistics, comprising four within-dimension and three between-dimension statistics. It can also evaluate short-run dynamics and the stability of long-run relationships across cross-sectional units. The basic cointegration model proposed by Pedroni (2000) is expressed as:

$$Y_{i,t} = \alpha_0 + \alpha_{1,i}X_{1i,t} + \alpha_{2,i}X_{2i,t} + \cdots + \alpha_{z,i}X_{zi,t} + e_{i,t}$$

Here, t represents the time period, i denotes the panel unit, and z signifies the number of independent variables. This model assumes heterogeneity in both slopes and intercepts across cross-sectional units.

Aggregately, the Pedroni cointegration statistics, across all seven Pedroni statistics (Panel v, Panel rho, Panel PP, Panel ADF, Group rho, Group PP, and Group ADF), show significant p-values (Prob < 0.05, indicated by ***), in both specifications, with and without a deterministic trend (Pedroni, 2000). This strongly suggests a cointegrating relationship or a robust long-run relationship among the variables in the model for the entire panel data in Indonesia.

The test results reveal that only the Indonesian panel group consistently exhibits a cointegrating relationship across all statistics, without and with a deterministic trend. Cointegration is not found for panel rho and group ADF, which has a trend in the fast economic growth panel. The medium growth group fails to show cointegration for panel ADF without a trend. Meanwhile, the slow growth group does not exhibit cointegration for panel ADF and group ADF with a trend. These findings reinforce Risamawan's (2020) study, demonstrating a long-run relationship between development and economic growth variables (HDI, FDI, GRDP, Education, and Health) across all panel groups.

Table 9 Pedroni Test

Panel	Dimension	Statistic	Without Trend		With Trend	
			Statistic	P-value	Statistic	P-value
Indonesia	Within-Dimenssion	Panel v-statistic	-2.045	0.0409**	-2.055	0.0399**
		Panel rho-statistic	6.355	0.0000***	6.655	0.0000***
		Panel PP-statistic	-2.154	0.0312**	-11.86	0.0000***
		Panel ADF-statistic	4.494	0.0000***	4.578	0.0000***
	Between-Dimenssion	Group rho-statistic	9.479	0.0000***	8.966	0.0000***
		Group PP-statistic	-9.078	0.0000***	-25.73	0.0000***
		Group ADF-statistic	5.05	0.0000***	5.604	0.0000***
Fast Economic Growth Rate	Within-Dimenssion	Panel v-statistic	-2.463	0.0138**	-3.339	0.0008***
		Panel rho-statistic	1.412	0.1580	1.466	0.1426
		Panel PP-statistic	-5.392	0.0000***	-10.41	0.0000***
		Panel ADF-statistic	2.058	0.0396**	2.221	0.0264**
	Between-Dimenssion	Group rho-statistic	2.421	0.0155**	2.408	0.0160**
		Group PP-statistic	-6.796	0.0000***	-13.92	0.0000***
		Group ADF-statistic	1.691	0.0908*	1.32	0.1868
Medium Economic Growth Rate	Within-Dimenssion	Panel v-statistic	-3.5	0.0005***	-5.106	0.0000***
		Panel rho-statistic	3.708	0.0002***	4.558	0.0000***
		Panel PP-statistic	-9.108	0.0000***	-17.95	0.0000***
		Panel ADF-statistic	1.008	0.3135	2.986	0.0028***
	Between-Dimenssion	Group rho-statistic	5.672	0.0000***	6.215	0.0000***
		Group PP-statistic	-16.73	0.0000***	-24.05	0.0000***
		Group ADF-statistic	4.031	0.0001***	2.327	0.0200**
Slow Economic Growth Rate	Within-Dimenssion	Panel v-statistic	-2.64	0.0083***	-3.669	0.0002***
		Panel rho-statistic	2.726	0.0064***	2.953	0.0031***
		Panel PP-statistic	-2.061	0.0393**	-7.531	0.0000***
		Panel ADF-statistic	1.938	0.0526*	-1.284	0.1991
	Between-Dimenssion	Group rho-statistic	4.013	0.0001***	4.273	0.0000***
		Group PP-statistic	-2.822	0.0048***	-10.57	0.0000***
		Group ADF-statistic	2.049	0.0405**	1.03	0.3030

Note: ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.

This study also employs the Westerlund panel cointegration test to complement the Pedroni test to obtain more valid and reliable results. This second-generation test accounts for heterogeneity and cross-sectional dependence through a bootstrapping approach. Four statistics are used: two panel statistics (Pτ and Pα) that evaluate cointegration for the entire panel, and two group statistics (Gτ and Gα) that test for the presence of cointegration in at least one cross-sectional unit.

Table 10 Westerlund Test

Group	Statistic	Without Trend			With Trend		
		Value	P-Value	Robust P-Value	Value	P-Value	Robust P-Value
Indonesia	Gt	-1.053	1.000	0.000***	-1.663	1.000	0.000***
	Ga	-1.242	1.000	0.000***	-0.814	1.000	0.000***
	Pt	-2.371	1.000	0.000***	-3.908	1.000	0.000***
	Pa	-1.065	1.000	0.000***	-0.74	1.000	0.000***
Fast Economic Growth Rate	Gt	-1.087	0.998	0.000***	-1.697	0.995	0.000***
	Ga	-0.686	0.999	0.000***	-1.483	1.000	0.000***
	Pt	-1.793	0.990	0.000***	-1.356	1.000	0.000***
	Pa	-1.107	0.985	0.000***	-0.966	0.999	0.000***
Medium Economic Growth Rate	Gt	-1.894	0.996	0.000***	-2.453	0.981	0.000***
	Ga	-1.657	1.000	0.000***	-0.5	1.000	0.000***
	Pt	-2.432	1.000	0.000***	-5.961	1.000	0.000***
	Pa	-1.061	1.000	0.000***	-0.599	1.000	0.000***
Slow Economic Growth Rate	Gt	-1.447	0.999	0.000***	-3.445	0.027**	0.000***
	Ga	-1.911	1.000	0.000***	-1.494	1.000	0.000***
	Pt	-3.542	0.996	0.000***	-5.661	0.987	0.000***
	Pa	-1.93	0.998	0.000***	-1.366	1.000	0.000***

Note: ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively. A robust P-value is derived from bootstrapping and used to account for cross-sectional dependence due to common factors in time-series data.

Table 11 FMOLS Test Results

Panel	HDI	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
Indonesia	FDI	1.063554	1.12E-06	9.50E+05	0.0000	1.063552	1.063557
	GRDP	25.04752	7.19E-06	3.50E+06	0.0000	25.0475	25.04753
	Eduaction	0.260183	1.35E-07	1.90E+06	0.0000	0.260183	0.260183
	Health	1.127035	1.87E-07	6.00E+06	0.0000	1.127034	1.127035
	_cons	-12.0118	4.86E-06	-2.50E+06	0.0000	-12.0118	-12.0118
	R2	0.997046					
	Adj. R2	0.995569					
Fast Economic Growth Rate	FDI	.0303279	9.78E-08	3.10E+05	0.0000	0.030328	0.030328
	GRDP	.5724981	4.20E-07	1.40E+06	0.0000	0.572497	0.572499
	Eduaction	3,532,641	6.52E-07	5.40E+06	0.0000	353,264	3,532,642
	Health	-.7740241	5.44E-07	-1.40E+06	0.0000	-0.77403	-0.77402
	_cons	8,894,617	0.0000334	2.70E+06	0.0000	88.9461	88.94623
	R2	.989741					
	Adj. R2	.9846115					
Medium Economic Growth Rate	FDI	0.277958	9.39E-07	3.00E+05	0.0000	0.277956	0.27796
	GRDP	6.706054	1.15E-06	5.80E+06	0.0000	6.706052	6.706057
	Eduaction	0.035513	2.52E-08	1.40E+06	0.0000	0.035513	0.035513
	Health	0.877732	2.98E-07	2.90E+06	0.0000	0.877731	0.877732
	_cons	-0.32893	0.0000179	-1.80E+04	0.0000	-0.32896	-0.32889
	R2	0.998438					
	Adj. R2	0.997656					
Slow Economic Growth Rate	FDI	0.291366	6.90E-07	4.20E+05	0.0000	0.291365	0.291368
	GRDP	4.006581	1.53E-06	2.60E+06	0.0000	4.006578	4.006584
	Eduaction	-0.38882	5.84E-07	-6.70E+05	0.0000	-0.38882	-0.38882
	Health	1.96068	6.16E-07	3.20E+06	0.0000	1.960678	1.960681
	_cons	-78.6095	0.0000372	-2.10E+06	0.0000	-78.6096	-78.6095
	R2	0.996962					
	Adj. R2	0.995443					

The test results indicate that for all panel groups (Indonesia, Fast, Medium, and Slow Economic Growth Rates), the Westerlund Cointegration Test strongly confirms the existence of a long-run cointegrating relationship among the research variables, both in specifications without a trend and with a deterministic trend. This is evidenced by Robust P-values that are mostly 0.000, significantly smaller than the α=0.05 or even α=0.01 levels. This test strengthens the results from the previous Pedroni Test. It confirms that, although the variables may be non-stationary at their levels, they move together in the long run. The confirmed presence of cointegration by the Westerlund Test is a vital prerequisite for the validity of FMOLS estimations, which are designed to analyze long-run relationships among cointegrated variables, thereby increasing the reliability of the empirical findings in the study (Westerlund, 2008).

The Fully Modified Ordinary Least Squares (FMOLS) model was utilized to estimate the long-run relationship among variables. FMOLS estimation results show that all independent variables significantly influence HDI at the aggregate national level within the Indonesian panel group. FDI exhibits a positive coefficient of 1.0635 ($p<0.05$), indicating that increased FDI positively contributes to HDI by transferring knowledge, technology, and managerial practices, which can enhance human resource quality. GRDP also demonstrates a positive and significant influence (coefficient 25.0475; $p<0.05$), reflecting that economic growth boosts income and access to basic services, strengthening HDI dimensions. Education has a positive influence with a coefficient of 0.2602 ($p<0.05$), indicating that an increase in average years of schooling strengthens human resource quality and development. Similarly, Health shows a positive and significant influence (coefficient 1.1270; $p<0.05$), affirming the importance of life expectancy as a key dimension of human development. The Adjusted R^2 value of 0.9970 suggests that 99.7% of the variation in HDI can be explained by the variables in the model, indicating an extreme predictive power of the model. This finding is reinforced by Setiana et al. (2023), who demonstrated that FDI contributes positively to economic growth in the short term, becoming more effective when accompanied by strengthening education and health sectors to ensure its long-term impact on human development.

FMOLS estimation results indicate that all independent variables significantly influence HDI for the group of provinces with fast economic growth. FDI has a positive and significant influence (coefficient 0.0303; $p<0.05$), albeit with a marginal contribution, likely due to the high baseline HDI in these regions. GRDP positively and significantly influences HDI (0.5725; $p<0.05$), showing the role of economic growth in improving welfare. Education exhibits the most substantial positive influence (3532.641; $p<0.05$), affirming the importance of average years of schooling in driving human development. However, the Health variable shows a significant negative coefficient (- 7.7402; $p<0.05$). This significant negative finding for the health variable may reflect a mismatch between formal healthcare service indicators and local needs in high-growth regions. Hasibuan et al. (2024) reinforce this by emphasizing the importance of localized approaches in human development, including healthcare services, to be more adaptive to the local social and cultural context. The Adjusted R^2 value of 0.9846 indicates that the model has a very high capability in explaining HDI variation in this group.

FMOLS estimation results indicate that all independent variables positively and significantly influence HDI for the group of provinces with medium economic growth. FDI has a coefficient of 0.2779 ($p<0.05$), demonstrating a more substantial contribution to promoting human development than the fast-growth group, likely due to greater room for improvement in infrastructure and human resource quality. GRDP (6.7061; $p<0.05$) also strongly influences welfare improvement. Education (0.0355; $p<0.05$) and Health (0.8777; $p<0.05$) also significantly contribute to strengthening HDI. The synergy between increased FDI and strengthened education and health is key to fostering sustainable human development, especially in medium economic growth regions, as Sembiring (2021) affirmed. The Adjusted R^2 value of 0.9977 indicates that the model effectively explains HDI variation in this group.

For the group of provinces with slow economic growth, FMOLS results show that all variables, except Education, positively and significantly influence HDI. FDI has a coefficient of 0.2914 ($p<0.05$), demonstrating a contribution to HDI improvement, possibly through job creation or local capacity building. GRDP also has a positive and significant influence (4.0066; $p<0.05$), reflecting the role of economic growth in human development. Health shows a strong positive influence (1.9607; $p<0.05$). However, Education exhibits a significant negative coefficient (-0.3888; $p<0.05$), which indicates a mismatch between formal education and local needs. The Adjusted R^2 value of 0.9954 suggests that the model has very high explanatory power in explaining HDI variation in this group. These findings align with the study by Goh et al. (2024) in the International Journal of Social Economics, which emphasizes that high-value FDI and human capital development are crucial in poverty reduction, particularly in regions with weak economic capacity. This reinforces the argument that in slow economic growth regions, FDI will have an optimal impact on human development if accompanied by strategies for improving education and health quality that are locally relevant.

After identifying the existence of a long-run cointegration among the variables, the next step is to determine the direction of causality or the cause-and-effect relationship between these variables. Causality testing in this study aims to analyze the bidirectional relationship between FDI and HDI and the roles of mediating variables, GRDP, Education, and Health. The decision rule is that a Granger causality relationship exists if the p-value is less than the significance level α (e.g., 0.05 or 0.10).

The Indonesian panel group shows bidirectional causality among all pairs of primary variables. A mutual influence between FDI and HDI indicates that FDI contributes to HDI improvement. Conversely, a high HDI attracts more FDI. Bidirectional relationships are also found between FDI and GRDP, as well as between HDI and GRDP, demonstrating a close link between economic and human development. Furthermore, a reciprocal causal relationship exists between HDI and education and health, reflecting a simultaneous interaction between quality of life and human resource development. FDI also exhibits a bidirectional relationship with education and health, showing that foreign investment can strengthen human resource quality. Conversely, good human resource quality attracts FDI. Similarly, the bidirectional relationship between GRDP and education and health affirms that economic growth and social development mutually reinforce each other. A

study by (2024) indicates that FDI significantly positively impacts provincial economic growth in Indonesia, especially in the manufacturing, mining, and utility sectors. These findings support that provinces with high economic growth rates attract greater FDI, improving HDI. Finally, education and health significantly influence each other, underscoring the importance of synergy among human development dimensions.

Table 12 Causality Test Results

Causal Relationship	W-bar	Z-bar	P-Value	W-bar	Z-bar	P-Value
Indonesia				**Fast Economic Growth Rate**		
FDI=>HDI	3.1284	3.2897	0.001***	5.6507	3.6507	0.000***
HDI=>FDI	3.2831	3.7408	0.000***	1.6546	0.9258	0.000***
GRDP=>HDI	5.8348	11.1804	0.000***	4.7102	2.7102	0.007***
HDI=>GRDP	14.1282	35.3594	0.000***	6.9845	4.9845	0.000***
Education=>HDI	4.5321	7.3823	0.000***	0.1126	-1.255	0.000***
HDI=>Education	4.6001	7.5805	0.000***	4.841	5.432	0.000***
Health=>HDI	5.2254	9.4037	0.000***	0.2996	-0.9905	0.000***
HDI=>Health	2.293	5.3313	0.000***	3.2203	1.2203	0.000***
FDI=>GRDP	3.0725	3.1269	0.002***	4.4402	4.8651	0.000***
GDRP=>FDI	3.5323	4.4674	0.000***	3.8727	1.8727	0.061*
FDI=>Education	1.6816	-0.9282	0.000***	0.5432	-0.646	0.000***
Education=>FDI	0.6763	-1.3347	0.000***	1.7685	-0.2315	0.000***
FDI=>Health	2.7323	2.1351	0.000***	6.3958	4.3958	0.000***
Health=>FDI	3.1051	3.2218	0.000***	2.9092	2.7	0.007***
GDRP=>Education	4.7606	8.0486	0.000***	0.5113	-0.6911	0.000***
Education=>GDRP	8.3141	18.4087	0.000***	1.1541	0.218	0.000***
GDRP=>Health	1.4692	1.9346	0.000***	2.6918	2.3925	0.017**
Health=>GDRP	7.2621	15.3414	0.000***	4.4234	2.4234	0.015**
Education=>Health	2.7185	2.0947	0.000***	1.8109	1.1468	0.000***
Health=>Education	3.5517	4.524	0.000***	0.5962	-0.571	0.000***
Medium Economic Growth Rate				**Slow Economic Growth Rate**		
FDI=>HDI	1.4802	1.5559	0.000***	1.6072	1.288	0.000***
HDI=>FDI	1.2446	0.7925	0.000***	1.74	1.5697	0.000***
GRDP=>HDI	3.0386	2.3797	0.000***	3.292	1.938	0.053*
HDI=>GRDP	3.0472	2.3994	0.016**	2.1172	2.3699	0.018**
Education=>HDI	3.0138	2.3228	0.020**	0.4486	-1.1697	0.000***
HDI=>Education	3.8913	4.3334	0.000***	2.8798	3.9876	0.000***
Health=>HDI	3.3565	3.1082	0.002***	3.7328	2.5991	0.009***
HDI=>Health	1.4474	-1.2662	0.000***	0.6333	-2.05	0.040**
FDI=>GRDP	2.1707	0.3911	0.000***	0.6737	-1.9894	0.047**
GDRP=>FDI	1.2344	0.7596	0.448	3.2472	4.767	0.000***
FDI=>Education	1.867	2.8093	0.005***	3.5377	2.3066	0.021**
Education=>FDI	1.6309	2.0444	0.041**	1.5007	1.0621	0.000***
FDI=>Health	2.1656	0.3795	0.704	3.8867	2.83	0.005***
Health=>FDI	2.7579	1.7366	0.083*	2.3188	0.4782	0.000***
GDRP=>Education	3.2383	7.2529	0.000***	1.8056	1.7089	0.088*
Education=>GDRP	0.9666	-2.3678	0.018**	3.4711	2.2067	0.027**
GDRP=>Health	2.1941	0.4448	0.000***	2.3872	0.5808	0.000***
Health=>GDRP	1.9309	3.0163	0.003***	4.1281	3.1922	0.001***
Education=>Health	2.3255	4.295	0.000***	1.4543	0.9637	0.000***
Health=>Education	2.2763	4.1356	0.000***	1.4654	-0.8019	0.000***

Note: ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.

In the fast economic growth group of provinces, Granger causality tests show a unidirectional causal relationship from FDI to HDI, but no reverse causality from HDI to FDI, with a p-value of 0.9258. FDI and GRDP mutually influence each other, as do HDI with GRDP, Education, and Health, indicating strong bidirectional causal relationships. There is no causality between FDI and Education (P-value = 0.646), nor from Education to FDI (P-value = 0.2315). However, a unidirectional causal relationship exists between FDI and health (P-value = 0.000), with no causality between health and FDI (P-value = 0.007). GRDP also unidirectionally influences education, meaning causality exists between GRDP and education.

In contrast, no causality is found from Education to GRDP (P-value = 0.211). The relationship between GRDP and Health is bidirectional. Lastly, Education and Health significantly influence each other. These findings emphasize the importance of inter-variable interactions in fast-growth regions. FDI plays a significant role in HDI and the health sector, but not directly in education. The link between FDI and human development depends on supporting national policies, as highlighted in Widiatedja et al. (2019) research, which asserts that while FDI positively impacts the economy and health, the absence of a causal link with education indicates that this sector has not optimally supported the benefits of investment. This underscores the importance of integrating investment and human development policies for broader and more sustainable FDI benefits.

In the medium economic growth group, Granger causality tests show a bidirectional relationship between FDI and HDI, reflecting the interconnectedness of foreign investment and human development. Bidirectional relationships are also found between FDI and GRDP, as well as between HDI and GRDP. Similarly, there are significant reciprocal relationships between HDI, education, and health. Interestingly, no causality is found between FDI and education (p-value = 0.083). Still, the reverse direction from Education to FDI is significant (p-value = 0.000), indicating that education quality drives increased FDI. A bidirectional relationship exists between FDI and Health, although the influence of FDI on Health is relatively weak (significant at 10%). Bidirectional relationships are also observed between GRDP and Education and between GRDP and Health, indicating a strong link between economic growth and social development. Zulfikar & Chandrawulan (2019) emphasize that FDI effectiveness is determined by its magnitude and ability to foster equitable and inclusive socioeconomic development. This perspective aligns with the need for strategic guidance of FDI to connect with key sectors such as education, health, and local economic empowerment (MSMEs). Since HDI is closely related to GRDP, investment policies that consider human development will be more effective in realizing sustainable economic growth.

In the group of provinces with slow economic growth, the Granger test shows a unidirectional causal relationship from FDI to HDI, but no reverse causality from HDI to FDI (p-value = 0.0539). This indicates that in the slow-growth group, FDI influences HDI. Still, HDI does not significantly influence FDI, likely because in underdeveloped regions, investment often misses its target due to weak infrastructure and human resources. There are bidirectional relationships between FDI and GRDP and HDI and GRDP, indicating a

close link among foreign investment, human development, and economic growth. HDI also has a significant bidirectional causal relationship with Education and Health. FDI unidirectionally influences education, while no relationship is found between education and FDI (P-value = 0.0661).

Meanwhile, FDI and Health mutually influence each other bidirectionally. The relationship between GRDP and Education is also bidirectional. However, the direction from Education to GRDP is only significant at the 10% level. GRDP and Health mutually influence each other significantly. Lastly, a strong bidirectional relationship between education and health has also been found. These findings align with Feriyanto's (2016) research, which demonstrates the complexity of interactions among development variables, indicating that foreign investment flows can enhance human development dimensions such as education, health, and living standards. Still, the quality of human development is not yet strong enough to be a primary determinant in attracting FDI, especially in regions with slow economic growth.

Conclusion

This study successfully identifies a complex, long-run bidirectional relationship between Foreign Direct Investment (FDI) and the Human Development Index (HDI) in Indonesian provinces, with the mediating roles of Gross Regional Domestic Product (GRDP), Education, and Health. The study explicitly uncovers this relationship's heterogeneity based on the classification of provinces into fast, medium, and slow economic growth categories.

Generally, a strong long-run cointegrating relationship is found among FDI, GRDP, Education, Health, and HDI across all provincial categories. The Fully Modified Ordinary Least Squares (FMOLS) estimation results consistently show that FDI, GRDP, Education, and Health positively and significantly influence HDI in the long run, both at the aggregate Indonesian level and in most provincial groups. However, interesting anomalies exist, such as the negative influence of the Health variable on HDI in fast economic growth groups and the negative influence of the Education variable in slow economic growth groups, which highlight the complexity and differing development dynamics in each regional context.

Furthermore, the Granger causality analysis reveals varied patterns of causal relationships among provincial groups. A bidirectional causality is found between FDI and HDI at the national level (Indonesia) and in medium economic growth groups. This indicates that FDI drives HDI improvement, and a higher HDI attracts more FDI. However, in fast and slow economic growth groups, causality tends to be unidirectional from FDI to HDI, implying that although FDI contributes to HDI in these regions, the existing level of human development has not yet significantly become a primary attraction for foreign investment. Mediating variables like GRDP, Education, and Health also show diverse causal patterns (unidirectional or bidirectional) regarding FDI and HDI in each group, confirming that the transmission pathways of development impact depend highly on regional characteristics.

The policy implications of this research emphasize the critical need for adaptive and region-specific investment and human development strategies, tailored to the provincial economic growth rates. It is crucial to view investment in HDI dimensions (education, health, living standards) as a prerequisite and driver of economic growth and FDI. Moreover, an in-depth analysis of anomalous findings (e.g., the negative influence of health or education on HDI in certain groups) is necessary to formulate appropriate interventions and target areas for improving service quality or adjusting investments.

While providing crucial insights, this study identifies two main limitations. First, the classification of provinces, based solely on GRDP growth rates, may not fully capture the complexity of regional development status. Additionally, data limitations led to the exclusion of the newest provinces, restricting the generalizability of findings. Second, although Granger causality was analyzed, this study did not explicitly test mediation pathways using a more advanced structural framework. Future researchers are encouraged to deepen the analysis of regional heterogeneity through a more comprehensive classification of provinces, not limited to GRDP growth rates, to reflect development status multidimensionally. Lastly, extending the study period will further strengthen the validity of long-term findings.

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