

## Regional Development Performance and Poverty Reduction in Aceh: A Panel ARDL Analysis of Regencies and Municipalities, 2010–2025

Nival Misbahul Amin<sup>1</sup>, Helmi<sup>\*2</sup>, Wais Alqarni<sup>3</sup>, Maimun<sup>4</sup>

Universitas Syiah Kuala, Indonesia

e-mail: [nival@mhs.usk.ac.id](mailto:nival@mhs.usk.ac.id), [waisalqarni@usk.ac.id](mailto:waisalqarni@usk.ac.id), [maimunaceh@usk.ac.id](mailto:maimunaceh@usk.ac.id)

\*Corresponding Author: [helmi\\_fisip@usk.ac.id](mailto:helmi_fisip@usk.ac.id)

### ABSTRACT

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Poverty remains a persistent development challenge in Aceh, particularly given the differences in human development, labor market conditions, and economic characteristics across regencies and municipalities. This study examines the dynamic relationship between the Human Development Index (HDI), Open Unemployment Rate (OUR), and Gross Regional Domestic Product (GRDP) per capita and poverty in 23 regencies and municipalities in Aceh Province over the period 2010–2025, with particular attention to short-run and long-run dynamics and the adjustment process toward long-run equilibrium. Using a quantitative approach, the study employs the Panel Autoregressive Distributed Lag (ARDL) method. The Pooled Mean Group (PMG) and Mean Group (MG) estimators are compared, with the Hausman test used to determine the appropriate estimator, while the lag structure is selected based on the Akaike Information Criterion (AIC). The MG estimates show that HDI has a negative and statistically significant relationship with poverty in the long run, with a coefficient of  $-1.384952$  ( $p < 0.01$ ). In contrast, OUR and GRDP per capita do not exhibit statistically significant long-run relationships with poverty. In the short run, lagged changes in GRDP per capita are negatively and significantly associated with changes in poverty, with a coefficient of  $-0.000299$  ( $p < 0.01$ ), whereas changes in HDI, OUR, and current GRDP per capita are not statistically significant. The Error Correction Term (ECT) of  $-0.789703$  ( $p < 0.01$ ) indicates that approximately 78.97% of deviations from the long-run equilibrium are corrected within one period. These findings contribute empirical evidence to the study of regional development by demonstrating that the relationship between development and poverty in Aceh is dynamic and heterogeneous, highlighting the importance of considering both temporal dynamics and differences across regions in understanding poverty reduction.



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### Introduction

Poverty is an important indicator for assessing development performance, but it cannot be fully understood solely in terms of income or consumption. Poverty is also associated with limited access to education, health, employment opportunities, and adequate living standards. The capability perspective views development as a process of expanding people's freedoms and capabilities to achieve lives they have reason to value (Sen, 1999). The multidimensional approach further emphasizes that poverty may involve simultaneous forms of deprivation that should be considered in assessing well-being (Alkire & Foster, 2011).

In the context of regional development, poverty reduction is not determined solely by economic growth but also by the quality of human development and the capacity of labor markets to provide economic opportunities. The literature on poverty in Indonesia indicates that the relationships among economic

growth, human development, unemployment, and poverty may differ across regions. Regional development performance therefore needs to be understood through the interaction of several economic and social indicators rather than through a single development indicator (Wau, 2022; Wibowo & Ridha, 2021; Rini & Tambunan, 2021).

Aceh provides a relevant setting for examining these relationships because development characteristics vary substantially across its regencies and municipalities. Differences in human development, labor-market conditions, economic structures, and regional economic capacity may generate different poverty patterns across localities. Evidence on human development in Aceh also indicates considerable variation in Human Development Index (HDI) outcomes across regencies and municipalities (Varlitya et al., 2023). Therefore, poverty analysis in Aceh needs to account for regional heterogeneity as an important component of the development process.

HDI is widely used to represent human development through health, education, and living-standard dimensions. Empirically, Ferayanti et al. (2023) found a negative and significant relationship between HDI and poverty across 23 regencies and municipalities in Aceh during 2011–2019. This finding indicates that improvements in human development are associated with lower regional poverty. Consistent evidence has also been reported in studies of Indonesia that identify human development as an important factor in explaining differences in poverty (Samiani et al., 2024; Purwanti, 2024).

Labor-market conditions constitute another important dimension of poverty. The Open Unemployment Rate (OUR) represents the proportion of the labor force that is unemployed but available for and actively seeking employment. When employment opportunities are limited, unemployment may be associated with lower household income and greater vulnerability to poverty. Ferayanti et al. (2023) reported a significant relationship between OUR and poverty in Aceh, while other studies indicate that the relationship between unemployment and poverty may depend on labor-market characteristics and regional economic structures (Zizzamia, 2020; Faharuddin & Endrawati, 2022).

Another relevant indicator is GRDP per capita, which represents the average economic capacity of a region. In principle, greater economic activity may expand income-generating opportunities and improve people's ability to meet basic needs. However, economic growth does not necessarily generate equal benefits across population groups. Empirical evidence suggests that the relationship between economic growth and poverty depends on the distribution of growth benefits, economic structure, and the ability of low-income groups to participate in economic activity (Bhattacharyya & Resosudarmo, 2015; Rini & Tambunan, 2021; Jamil, 2022).

Recent evidence from Aceh also indicates that the relationships between development indicators and poverty are not necessarily uniform. Hardianti et al. (2026), using data from 23 Aceh regencies and municipalities for 2020–2024, found significant relationships between HDI, OUR, and poverty, whereas GRDP did not exhibit a significant relationship in their model. This finding suggests that improvements in regional economic capacity do not automatically translate into changes in poverty when the benefits of development are not distributed evenly. It also reinforces the importance of examining human development, labor-market conditions, and economic capacity jointly.

Previous research by Yusnuri and Abubakar (2023) also identified relationships among HDI, unemployment, poverty, and economic growth in the Indonesian context. Other studies in Indonesia indicate that human development, economic growth, and labor-market conditions may produce different relationships depending on regional characteristics and the observation period (Amanatillah & Mukhlis, 2022; Wibowo & Ridha, 2021; Ali et al., 2024). These differences indicate that the relationship between regional development and poverty requires further investigation at the regional level, particularly by accounting for short-run and long-run dynamics.

A substantial part of the literature on regional poverty employs static panel models that assume relatively stable relationships among variables over the observation period. Although such approaches are useful for identifying average relationships across regions, they may not fully capture adjustment processes when changes in development conditions take time to be reflected in poverty outcomes. For panels with adequate cross-sectional and time dimensions, dynamic approaches allow short-run responses to differ across regions while estimating long-run relationships (Pesaran & Smith, 1995).

Panel ARDL provides an appropriate framework for examining these relationships because it allows short-run dynamics and long-run relationships to be analyzed simultaneously. It also permits short-run

coefficients and adjustment speeds to differ across regions. The Pooled Mean Group (PMG) approach constrains long-run coefficients to be common across units while allowing short-run coefficients and error variances to differ, whereas the Mean Group (MG) estimator estimates relationships separately for each unit and then averages the resulting coefficients (Pesaran, Shin, & Smith, 1999). These distinctions are particularly relevant for Aceh because its regencies and municipalities do not share identical economic structures and development conditions.

Accordingly, this study examines the relationship between poverty, human development, unemployment, and GRDP per capita across 23 regencies and municipalities in Aceh over the 2010–2025 period using a Panel ARDL framework. The study specifically investigates whether long-run relationships exist among the variables, how short-run relationships are formed, and how deviations from long-run equilibrium are adjusted over time.

The study also compares the PMG and MG estimators to assess the extent to which the relationships between regional development and poverty are homogeneous or heterogeneous across localities. The final estimator is selected using the Hausman specification test. This approach enables the analysis to move beyond average cross-sectional relationships by explicitly considering dynamic adjustment and regional heterogeneity, as emphasized in the dynamic heterogeneous panel literature (Pesaran & Smith, 1995; Pesaran, Shin, & Smith, 1999).

The contribution of this study lies in its use of panel data covering all 23 regencies and municipalities in Aceh over 2010–2025 and its examination of poverty in relation to HDI, OUR, and GRDP per capita within a Panel ARDL framework. By employing a relatively long observation period and a dynamic approach, the study provides a more comprehensive empirical assessment of the relationship between regional development and poverty in Aceh while also accounting for potential differences in adjustment processes across regions.

## Method

This study employs a quantitative approach with an explanatory research design to analyze the relationship between the poverty rate and several key indicators of regional development, namely the Human Development Index (HDI), Open Unemployment Rate (OUR), and Gross Regional Domestic Product (GRDP) per capita. The use of panel data allows the analysis to account not only for changes over time but also for differences in characteristics across regions. This approach is relevant in the context of regencies and municipalities in Aceh because development conditions, economic structures, and labor-market characteristics are not completely homogeneous across regions. In dynamic panel analysis, such cross-sectional heterogeneity is an important consideration because long-run relationships and adjustment dynamics may differ across individual units (Pesaran & Smith, 1995).

The study uses secondary panel data covering 23 regencies and municipalities in Aceh Province over the period 2010–2025. The dependent variable is the poverty rate (POV), while the independent variables consist of HDI, OUR, and GRDP per capita. Conceptually, the poverty rate is considered an outcome indicator of regional development that may be associated with improvements in human capital, labor-market conditions, and the development of regional economic activity.

Data on the poverty rate, HDI, OUR, and GRDP per capita were obtained from publications of Statistics Indonesia (Badan Pusat Statistik/BPS), particularly Aceh in Figures and relevant statistical publications for individual regencies and municipalities. The initial dataset consists of 23 regencies and municipalities observed over 16 years, yielding 368 observations for each variable. During the Panel ARDL estimation, the use of lag structures resulted in an effective sample of 322 observations covering the period 2012–2025.

## Model Specification

To represent the long-run relationship between the poverty rate and regional development indicators, the research model is specified as follows:

$$POV_{it} = \alpha_i + \beta_{1i}IPM_{it} + \beta_{2i}TPT_{it} + \beta_{3i}PDRB_{it} + \varepsilon_{it}$$

where  $i$  denotes the regency or municipality and  $t$  denotes the time period. The parameter  $\alpha_i$  represents region-specific characteristics, while  $\beta_{1i}$ ,  $\beta_{2i}$ , and  $\beta_{3i}$  represent the long-run relationships of the respective variables

with the poverty rate. The use of the subscript  $i$  in the coefficients allows the long-run relationships to differ across regions, consistent with the framework of dynamic heterogeneous panels (Pesaran & Smith, 1995).

Based on the conceptual framework of the study, HDI is expected to have a negative relationship with the poverty rate, OUR is expected to have a positive relationship, while GRDP per capita is expected to have a negative relationship with the poverty rate. These expected relationships provide the theoretical basis of the study and are subsequently examined empirically through model estimation.

### Panel ARDL and Error Correction Model

To capture dynamic relationships, this study employs the Panel Autoregressive Distributed Lag (Panel ARDL) approach. This approach is selected because it allows short-run and long-run relationships to be analyzed simultaneously while accommodating intertemporal dynamics and cross-sectional heterogeneity. The Panel ARDL framework also allows short-run coefficients to differ across units, while long-run relationships can be treated according to the estimator employed (Pesaran & Smith, 1995; Pesaran, Shin, & Smith, 1999).

The Error Correction Model (ECM) representation of the Panel ARDL employed in this study can be expressed as follows:

$$\Delta POVi_t = \phi_i (POVi_{t-1} - \beta_{1i} HDI_{i,t-1} - \beta_{2i} OUR_{i,t-1} - \beta_{3i} GRDP_{i,t-1}) + \sum_j \lambda_{ij} \Delta POVi_{t-j} \\ + \sum_j \delta_{1ij} \Delta HDI_{i,t-j} + \sum_j \delta_{2ij} \Delta OUR_{i,t-j} + \sum_j \delta_{3ij} \Delta GRDP_{i,t-j} + \varepsilon_{it}$$

where  $\Delta$  denotes the first difference. The parameter  $\phi_i$  represents the Error Correction Term (ECT), which indicates the speed of adjustment when deviations from the long-run equilibrium occur. The coefficient  $\lambda_{ij}$  captures the lagged dynamics of the dependent variable, while  $\delta_{1ij}$ ,  $\delta_{2ij}$ , and  $\delta_{3ij}$  represent the short-run dynamics of HDI, OUR, and GRDP per capita, respectively.

A negative and statistically significant ECT indicates an adjustment mechanism toward the long-run equilibrium. Thus, the approach allows the study to examine not only whether the development indicators are associated with poverty, but also whether such relationships occur in the short or long run and how deviations from equilibrium are corrected over time (Pesaran, Shin, & Smith, 1999).

### Preliminary Tests

Before estimating the Panel ARDL model, several preliminary tests were conducted to examine the characteristics of the data and assess the suitability of the selected approach.

First, a Cross-Sectional Dependence (CSD) Test was conducted to identify the possibility of interdependence across regencies and municipalities. For the POV variable, the analysis employed the Breusch–Pagan LM, Pesaran Scaled LM, Bias-Corrected Scaled LM, and Pesaran CD tests. All tests produced probabilities of 0.0000, indicating the presence of cross-sectional dependence in the poverty rate. Testing for cross-sectional dependence is important in panel analysis because interdependence across units may affect the validity of procedures that assume cross-sectional independence (Pesaran, 2004; Pesaran, 2007).

Second, panel unit root tests were conducted to determine the integration properties of each variable. The analysis employed the Pesaran CIPS approach and was complemented by the Levin–Lin–Chu (LLC) and Im–Pesaran–Shin (IPS) tests. The use of the CIPS test is particularly relevant because it allows for cross-sectional dependence among panel units (Pesaran, 2007). These tests were conducted to ensure that the variables included in the model were not integrated of order two,  $I(2)$ , as required for the application of the Panel ARDL framework.

The CIPS results indicate that POV and HDI are stationary at level. POV has a CIPS statistic of  $-2.26553$ , while HDI has a statistic of  $-2.37951$ , both satisfying their respective significance criteria. For OUR, the results also indicate stationarity at level. Meanwhile, GRDP per capita exhibits non-stationary behavior at level and becomes stationary after first differencing based on the LLC and IPS tests used in the analysis.

### Panel Cointegration Test

After examining the integration characteristics of the variables, the existence of a long-run relationship among the variables was tested using the Kao Residual Cointegration Test. The test was conducted with 23 cross-sections

and 368 observations covering the period 2010–2025. The null hypothesis of the Kao test states that there is no cointegration.

The Kao test is a residual-based panel cointegration procedure designed to test the null hypothesis of no cointegration in panel data (Kao, 1999).

The test produced an ADF t-statistic of  $-5.029934$  with a probability of  $0.0000$ . Therefore, the null hypothesis was rejected. This result indicates the existence of a long-run cointegrating relationship among POV, HDI, OUR, and GRDP per capita across the regencies and municipalities of Aceh.

### PMG and MG Estimation

After establishing the existence of a cointegrating relationship, the Panel ARDL estimation was conducted using two alternative estimators, namely the Pooled Mean Group (PMG) and Mean Group (MG) estimators.

The PMG estimator assumes that the long-run coefficients are homogeneous across panel units, while allowing short-run dynamics to differ across units. In contrast, the MG estimator allows both long-run and short-run coefficients to differ across regions. This distinction is important in the present study because the development characteristics, economic structures, and socioeconomic conditions of regencies and municipalities in Aceh are not completely homogeneous.

Methodologically, the PMG estimator imposes homogeneity on the long-run coefficients while allowing short-run coefficients to vary across units. The MG estimator estimates the relationship separately for each individual unit and subsequently obtains the average coefficients across units. The PMG framework follows the formulation developed by Pesaran, Shin, and Smith (1999), while the MG approach is grounded in the dynamic heterogeneous panel framework of Pesaran and Smith (1995).

The lag structure was determined using the Akaike Information Criterion (AIC) through an automatic lag-selection procedure. The maximum lag for both the dependent and independent variables was set at two periods. The procedure evaluated 54 model specifications and selected the ARDL(2,2,2,2) specification. The effective estimation sample consists of 322 observations covering 2012–2025.

### Hausman Test and Final Estimator

The final estimator was selected using the Hausman test. This test was employed to determine whether the differences between the PMG and MG estimators were systematic.

The Hausman test produced a statistic of  $17.405477$ , with 4 degrees of freedom and a probability value of  $0.0016$ . Since the probability value is lower than  $0.05$ , the null hypothesis was rejected. This result indicates systematic differences between the PMG and MG estimators. Therefore, the Mean Group (MG) estimator was selected as the final estimator for the analysis.

The selection of the MG estimator is also consistent with the objective of accounting for regional heterogeneity. Under this estimator, long-run relationships are not constrained to have identical coefficients across all regencies and municipalities, allowing differences in regional development characteristics to be reflected in the estimated relationships (Pesaran & Smith, 1995).

All estimations were performed using EViews 13.

## Results and Discussion

### 4.1 Statistik Deskriptif

Table 1 presents the descriptive statistics of the research variables covering 23 regencies and municipalities in Aceh Province over the 2010–2025 period. The statistics include the mean, median, minimum, maximum, standard deviation, and number of observations. Each variable contains 368 observations, reflecting a balanced panel structure across the cross-sectional units and observation periods.

*Tabel 1. Statistik Deskriptif Variabel Penelitian*

| Variabel | Mean     | Median | Minimum | Maximum | Std. Dev. | Obs. |
|----------|----------|--------|---------|---------|-----------|------|
| POV      | 16.64209 | 16.94  | 5.45    | 26.22   | 4.114034  | 368  |

|                 |           |           |           |           |           |     |
|-----------------|-----------|-----------|-----------|-----------|-----------|-----|
| IPM             | 70.01245  | 69.5      | 58.97     | 89.55     | 5.35244   | 368 |
| TPT             | 6.760571  | 6.88      | 0.37      | 17.97     | 3.034768  | 368 |
| PDRB per kapita | 24,401.35 | 20,947.50 | 11,730.00 | 70,766.00 | 10,407.21 | 368 |

Source: Processed data based on BPS publications, 2010–2025.

The poverty rate (POV) has a mean of 16.64 percent, with a minimum of 5.45 percent and a maximum of 26.22 percent. The standard deviation of 4.11 indicates variation in poverty rates across regions and observation periods. The difference between the minimum and maximum values also indicates that poverty conditions are not uniform across the regencies and municipalities of Aceh.

The Human Development Index (HDI) has a mean value of 70.01, with a minimum of 58.97 and a maximum of 89.55. This range indicates differences in human development outcomes across the observed regencies and municipalities. The variation in HDI is relevant to the analysis because differences in human development may be associated with differences in poverty conditions across regions.

The Open Unemployment Rate (OUR) has a mean of 6.76 percent, with a minimum of 0.37 percent and a maximum of 17.97 percent. The relatively wide range indicates differences in labor-market conditions across regencies and municipalities and over the observation period.

GRDP per capita exhibits relatively large variation compared with the other variables, with a mean of 24,401.35 and values ranging from 11,730.00 to 70,766.00. Its standard deviation of 10,407.21 indicates substantial differences in per-capita economic capacity across the regencies and municipalities. This variation is relevant to the present study because the economic characteristics and development structures of regions in Aceh are not completely homogeneous.

Overall, the descriptive statistics indicate substantial variation in poverty, human development, labor-market conditions, and regional economic capacity across regions and over time. These variations provide an empirical basis for considering cross-sectional heterogeneity in the subsequent dynamic panel analysis.

#### 4.2 Cross-Sectional Dependence Test

Before conducting the stationarity tests and estimating the model, this study examines the possibility of cross-sectional dependence across regencies and municipalities. This test is important in panel data analysis because the economic and social conditions of one region may be related to developments in other regions. In the context of Aceh, the regencies and municipalities operate within an interconnected regional economic and policy environment; therefore, changes occurring in one region may be associated with developments in other regions.

The cross-sectional dependence test is applied to the poverty rate (POV) using four statistics: the Breusch–Pagan LM, Pesaran Scaled LM, Bias-corrected Scaled LM, and Pesaran CD tests. The results show that all four statistics produce a probability value of 0.0000. The Breusch–Pagan LM test produces a statistic of 3,425.121 with 253 degrees of freedom, while the Pesaran Scaled LM and Bias-corrected Scaled LM tests produce statistics of 141.0180 and 140.2513, respectively. Meanwhile, the Pesaran CD statistic is 55.99058. All tests have probability values below 0.05.

Based on these results, the null hypothesis of no cross-sectional dependence is rejected. Thus, there is evidence of cross-sectional dependence in the poverty rate across the regencies and municipalities included in the panel. This finding indicates that poverty dynamics in an individual regency or municipality cannot be considered entirely independent of developments in other regions.

The presence of cross-sectional dependence also has methodological implications for the subsequent stages of the analysis. It indicates the importance of employing panel procedures that account for possible interdependence among cross-sectional units. Therefore, the subsequent stationarity analysis is complemented by the Cross-sectionally Augmented IPS (CIPS) approach, which was developed for panel unit-root testing in the presence of cross-sectional dependence (Pesaran, 2007).

*Table 2. Cross-Sectional Dependence Test for Poverty Rate*

| Test                     | Statistic | df  | Probability |
|--------------------------|-----------|-----|-------------|
| Breusch–Pagan LM         | 3425.121  | 253 | 0.0000      |
| Pesaran Scaled LM        | 141.018   | —   | 0.0000      |
| Bias-corrected Scaled LM | 140.2513  | —   | 0.0000      |
| Pesaran CD               | 55.99058  | —   | 0.0000      |

Source: EViews estimation results.

#### 4.3 Panel Unit Root / Stationarity Test

Stationarity testing was conducted before estimating the Panel ARDL model to identify the integration properties of each variable in the panel. Because the cross-sectional dependence test for the poverty rate indicated interdependence across regions, the initial stationarity assessment employed the Cross-sectionally Augmented IPS (CIPS) approach. The CIPS approach was developed for panel unit-root testing while accounting for cross-sectional dependence (Pesaran, 2007).

The CIPS results indicate that the poverty rate (POV), Human Development Index (HDI), and Open Unemployment Rate (OUR) are stationary at level. In contrast, GRDP per capita does not exhibit stationarity at level based on the CIPS test.

For POV, the CIPS statistic is  $-2.26553$ , compared with a 5 percent critical value of  $-2.21$ , leading to rejection of the null hypothesis of a unit root at the 5 percent level. HDI produces a similar result, with a CIPS statistic of  $-2.37951$ , which is lower than the 5 percent critical value of  $-2.21$ . Meanwhile, OUR has a CIPS statistic of  $-2.95343$ , leading to rejection of the unit-root null hypothesis even at the 1 percent significance level. Thus, POV, HDI, and OUR can be classified as stationary at level, or  $I(0)$ .

In contrast, GRDP per capita has a CIPS statistic of  $-1.20722$  at level with a probability value of  $\geq 0.10$ . This result is insufficient to reject the null hypothesis of a unit root. The CIPS test for the first difference of GRDP also produces a statistic of  $-1.68047$  with a probability value of  $\geq 0.10$ . Therefore, based on the CIPS test alone, stationarity of GRDP at first difference cannot be confirmed. An alternative test using a logarithmic transformation also does not provide evidence of stationarity based on CIPS.

To obtain additional evidence regarding the integration properties of GRDP, further tests were conducted using the Levin, Lin and Chu (LLC) and Im, Pesaran and Shin (IPS) approaches. At level, the LLC test produces a statistic of  $-0.79734$  with a probability value of  $0.2126$ , while the IPS test produces a statistic of  $-0.85272$  with a probability value of  $0.1969$ . Both results indicate that GRDP is not stationary at level. At first difference, the LLC test produces a statistic of  $-8.22277$  with a probability value of  $0.0000$ , while the IPS test produces a statistic of  $-5.15914$  with a probability value of  $0.0000$ . These results provide additional evidence that GRDP becomes stationary after first differencing (Levin, Lin, & Chu, 2002; Im, Pesaran, & Shin, 2003).

Taken together, the results indicate different stationarity properties across the variables. POV, HDI, and OUR exhibit  $I(0)$  behavior based on the CIPS test, whereas GRDP is non-stationary at level and receives support for  $I(1)$  behavior based on the LLC and IPS tests at first difference. The differences across testing procedures, particularly for GRDP, indicate that its integration order should be reported cautiously rather than being determined from a single test. These results nevertheless provide a basis for applying the Panel ARDL framework, which accommodates variables with different integration orders, provided that none of the variables is integrated of order two or higher (Pesaran, Shin, & Smith, 1999).

*Table 3. Panel Unit Root Test Results*

| Variable | Test | Statistic | Probability | Stationarity Decision |
|----------|------|-----------|-------------|-----------------------|
|----------|------|-----------|-------------|-----------------------|

|               |      |          |             |                |
|---------------|------|----------|-------------|----------------|
| POV           | CIPS | -2.26553 | < 0.05      | I(0)           |
| IPM           | CIPS | -2.37951 | < 0.05      | I(0)           |
| TPT           | CIPS | -2.95343 | < 0.01      | I(0)           |
| PDRB          | CIPS | -1.20722 | $\geq 0.10$ | Non-stationary |
| $\Delta$ PDRB | CIPS | -1.68047 | $\geq 0.10$ | Non-stationary |
| PDRB          | LLC  | -0.79734 | 0.2126      | Non-stationary |
| $\Delta$ PDRB | LLC  | -8.22277 | 0.0000      | Stationary     |
| PDRB          | IPS  | -0.85272 | 0.1969      | Non-stationary |
| $\Delta$ PDRB | IPS  | -5.15914 | 0.0000      | Stationary     |

Source: EViews estimation results.

#### 4.4 Panel Cointegration Test - Kao

After identifying the stationarity characteristics of each variable, the study proceeds to test for the existence of long-run relationships among the variables using the Kao Residual Cointegration Test. The test is conducted to determine whether the poverty rate (POV), Human Development Index (HDI), Open Unemployment Rate (OUR), and GRDP per capita exhibit a long-run equilibrium relationship across the regencies and municipalities of Aceh Province. The Kao test is a residual-based panel cointegration procedure used to test the null hypothesis of no cointegration among variables in panel data (Kao, 1999).

The Kao test produces an ADF t-statistic of  $-5.029934$  with a probability value of 0.0000. The test covers 23 regencies and municipalities over the 2010–2025 observation period, resulting in 368 observations. The test specification employs no deterministic trend with a lag length of 1.

Since the probability value of 0.0000 is lower than the 5 percent significance level, the null hypothesis of no cointegration is rejected. Therefore, the results provide evidence of a long-run cointegrating relationship among POV, HDI, OUR, and GRDP per capita across the regencies and municipalities of Aceh.

This finding indicates that although the individual variables may change over time and exhibit different stationarity characteristics, there is a long-run equilibrium relationship linking the variables. In other words, changes in human development, labor-market conditions, and regional economic capacity occur within a system of relationships that exhibits a tendency toward long-run equilibrium with the poverty rate.

The cointegration result provides an empirical basis for applying the Panel Autoregressive Distributed Lag (Panel ARDL) approach in the subsequent estimation stage. The existence of a long-run relationship allows the subsequent analysis to distinguish short-run dynamics from long-run relationships and to identify the adjustment mechanism when deviations from long-run equilibrium occur (Kao, 1999; Pesaran, Shin, & Smith, 1999).

**Table 4. Kao Panel Cointegration Test**

| Test            | Statistic | Probability |
|-----------------|-----------|-------------|
| ADF t-statistic | -5.029934 | 0.0000      |

Panel specification: 23 cross-sections; 2010–2025; 368 observations; no deterministic trend; lag length = 1.

Source: EViews estimation results.

#### 4.5 Panel ARDL Estimation

##### 4.5.1 Lag Selection and Model Specification

Following the cointegration test indicating the existence of a long-run relationship among the poverty rate, Human Development Index (HDI), Open Unemployment Rate (OUR), and GRDP per capita, the next stage involved estimating the model using the Panel Autoregressive Distributed Lag (Panel ARDL) approach. The lag structure was selected automatically based on the Akaike Information Criterion (AIC), with a maximum of two lags specified for both the dependent variable and the explanatory variables. The use of the ARDL framework in dynamic panel analysis allows short-run and long-run relationships to be examined within a unified framework while accounting for dynamic adjustment and cross-sectional heterogeneity (Pesaran & Smith, 1995; Pesaran, Shin, & Smith, 1999).

The model selection procedure identified ARDL (2,2,2,2) as the specification used for estimation. The procedure evaluated 54 alternative model specifications, with the AIC serving as the model selection criterion. Accordingly, the selected specification allows the poverty rate and each explanatory variable to incorporate dynamics of up to two lagged periods.

The use of the lag structure is important because the relationship between regional development conditions and poverty does not necessarily occur immediately within the same period. Changes in HDI, labor-market conditions, and regional economic capacity may require time before being reflected in changes in the poverty rate. Therefore, the ARDL specification enables the study to capture these dynamics through both short-run components and long-run relationships within the same framework (Pesaran, Shin, & Smith, 1999).

The subsequent estimation was conducted using two approaches, namely the Pooled Mean Group (PMG) and Mean Group (MG) estimators. PMG allows short-run dynamics to differ across regions while imposing homogeneity on the long-run coefficients across cross-sectional units. In contrast, MG allows both short-run and long-run coefficients to differ across regencies and municipalities. The two estimators were subsequently compared using the Hausman Test to determine the estimator most consistent with the characteristics of the panel data (Pesaran & Smith, 1995; Pesaran, Shin, & Smith, 1999).

*Table 5. Panel ARDL Model Specification*

| Specification                    | Value          |
|----------------------------------|----------------|
| Selected ARDL model              | ARDL (2,2,2,2) |
| Maximum lag – dependent variable | 2              |
| Maximum lag – regressors         | 2              |
| Lag selection criterion          | AIC            |
| Number of models evaluated       | 54             |
| Cross-sections                   | 23             |
| Estimation period                | 2010–2025      |
| Effective estimation sample      | 2012–2025      |
| Effective observations           | 322            |

Source: EViews estimation results.

#### 4.5.2 PMG and MG Estimation Results

The Panel ARDL model was estimated using two estimators, namely the Pooled Mean Group (PMG) and Mean Group (MG) estimators. The use of these two estimators aims to provide evidence on the long-run relationship between poverty and regional development indicators while accounting for cross-sectional dynamics. The PMG and MG estimates were subsequently compared using the Hausman Test to determine whether the homogeneity restriction imposed on the long-run coefficients under the PMG specification could be maintained. The distinction between the PMG and MG estimators follows the dynamic heterogeneous panel framework developed by Pesaran and Smith (1995) and the PMG formulation proposed by Pesaran, Shin, and Smith (1999).

The PMG estimation results show that HDI has a long-run coefficient of  $-0.433825$  with a probability value of  $0.0000$ . This coefficient indicates a negative and statistically significant relationship between HDI and the poverty rate in the long run under the PMG specification. OUR has a coefficient of  $0.083413$  with a probability value of  $0.0001$ , while GRDP per capita has a coefficient of  $0.000247$  with a probability value of  $0.0000$ . Thus, all three variables exhibit statistically significant relationships in the PMG long-run estimation.

However, the PMG results are not used as the primary basis for the final conclusions of the study. This is because the PMG estimator assumes that the long-run coefficients are homogeneous across cross-sectional units (Pesaran, Shin, & Smith, 1999). In the context of this study, Aceh's regencies and municipalities have different development characteristics, economic structures, and socioeconomic conditions. Therefore, the validity of the homogeneity assumption needs to be assessed empirically by comparing the PMG estimates with the MG estimates.

Meanwhile, the MG estimation results indicate differences in the long-run coefficients compared with the PMG estimates. The HDI coefficient under the MG specification is  $-1.384952$  with a probability value of  $0.0000$ , while the OUR coefficient is  $-0.465141$  with a probability value of  $0.1053$ , and the GRDP per capita coefficient is  $0.001126$  with a probability value of  $0.1992$ . These differences between the PMG and MG estimates provide an important basis for conducting the Hausman test before determining the estimator to be used as the final model. The MG approach allows cross-sectional heterogeneity in the coefficients to remain reflected in the estimates, consistent with the dynamic heterogeneous panel framework of Pesaran and Smith (1995).

**Table 6. Panel ARDL Estimation Results: PMG and MG**

| Variabel        | PMG Coefficient | PMG Prob. | MG Coefficient | MG Prob. |
|-----------------|-----------------|-----------|----------------|----------|
| HDI             | $-0.433825$     | $0.0000$  | $-1.384952$    | $0.0000$ |
| OUR             | $0.083413$      | $0.0001$  | $-0.465141$    | $0.1053$ |
| GRDP per capita | $0.000247$      | $0.0000$  | $0.001126$     | $0.1992$ |
| C               | $39.787402$     | $0.0000$  | $97.280442$    | $0.0000$ |

Source: EViews estimation results.

#### 4.5.2 Hausman Test and Estimator Selection

To determine the most appropriate estimator between the Pooled Mean Group (PMG) and Mean Group (MG) approaches, the study subsequently employs the Hausman Test. The test is used to examine whether systematic differences exist between the PMG and MG estimates. The null hypothesis states that the MG and PMG estimates do not differ systematically, implying that the homogeneity restriction imposed on the long-run coefficients under the PMG specification remains acceptable. Conversely, rejection of the null hypothesis indicates that the differences between the two estimators are systematic, making the MG approach more appropriate (Hausman, 1978).

The Hausman Test produces a statistic of  $17.405477$ , with 4 degrees of freedom (df) and a probability value of  $0.0016$ . Since the probability value is lower than the 5 percent significance level, the null hypothesis is rejected. This result indicates systematic differences between the PMG and MG estimates, suggesting that the assumption

of homogeneous long-run coefficients across the regencies and municipalities does not receive sufficient empirical support in the research model.

Based on this result, the Mean Group (MG) estimator is selected as the final estimator for the study. The selection of MG allows both long-run relationships and short-run dynamics to reflect differences across the regencies and municipalities of Aceh. This choice is relevant to the characteristics of the study area, which consists of regions with diverse development conditions, economic structures, and labor-market conditions (Pesaran & Smith, 1995).

Accordingly, the interpretation of the results in the subsequent sections is based on the MG estimates as the final model, while the PMG estimates are retained as a comparison in the estimator-selection process. This selection further supports the analytical approach of treating regional heterogeneity as an important consideration in understanding poverty dynamics in Aceh.

**Table 7. Hausman Test for Estimator Selection**

| Test         | Statistic | df | Probability | Keputusan  |
|--------------|-----------|----|-------------|------------|
| Hausman Test | 17.405477 | 4  | 0.0016      | MG dipilih |

Source: EViews Estimation Results.

Note:  $H_0$  = there is no systematic difference between the MG and PMG estimators.

#### 4.6 Long-Run Estimation Results of the Mean Group (MG) Model

Following the Hausman Test, which indicates systematic differences between the PMG and MG estimators, the Mean Group (MG) model is employed as the final estimator. The long-run MG estimates indicate that the relationships between regional development indicators and the poverty rate differ in both direction and statistical significance. Among the three explanatory variables, only the Human Development Index (HDI) exhibits a negative and statistically significant relationship with the poverty rate in the long run. Meanwhile, OUR and GRDP per capita have statistically insignificant coefficients.

**Table 8. Long-Run Estimation Results of the MG Model**

| Variabel        | Koefisien | Std. Error | t-Statistic | Probabilitas |
|-----------------|-----------|------------|-------------|--------------|
| HDI             | -1.384952 | 0.278272   | -4.976967   | 0.0000       |
| OUR             | -0.465141 | 0.286352   | -1.624371   | 0.1053       |
| GRDP per capita | 0.001126  | 0.000876   | 1.284697    | 0.1992       |
| Constant        | 97.28044  | 15.13942   | 6.42564     | 0.0000       |

Source: EViews estimation results.

##### 4.6.1 HDI and Poverty in the Long Run

The HDI variable has a coefficient of  $-1.384952$  with a probability value of 0.0000, making it statistically significant at the 1 percent level. The negative coefficient indicates a long-run relationship between higher HDI and a lower poverty rate in the MG model.

The coefficient indicates that, holding the other variables constant, a one-point increase in HDI is associated with an approximately 1.38 percentage-point decrease in the poverty rate in the long run. This interpretation should be considered in the context of HDI as an indicator encompassing health, education, and living-standard dimensions. Thus, the negative relationship is consistent with the human development perspective, which places the expansion of human capabilities as an important component of poverty reduction (Sen, 1999; Alkire & Foster, 2011).

The finding also reveals a difference between short-run and long-run dynamics. In the short run, changes in HDI do not exhibit a statistically significant relationship with changes in poverty, whereas the long-run relationship is negative and statistically significant. This indicates that the relationship between human development and poverty in the study data is more apparent over a longer time horizon than through immediate inter-period changes. The short-run results are discussed further in the subsequent section.

#### 4.6.2 OUR and Poverty in the Long Run

OUR has a coefficient of  $-0.465141$  with a probability value of  $0.1053$ . Although the coefficient is negative, the probability value is greater than the 10 percent significance level. Therefore, there is insufficient statistical evidence to establish a significant long-run relationship between OUR and the poverty rate in the MG model.

The negative coefficient should not be interpreted as evidence that an increase in unemployment reduces poverty. Because the coefficient is not statistically significant, the more appropriate empirical interpretation is that OUR does not exhibit a statistically significant long-run relationship with the poverty rate in the research model.

This finding suggests that the relationship between open unemployment and poverty at the regency and municipality level cannot be explained solely by changes in the OUR. Labor-market structure, the prevalence of informal employment, household characteristics, and sources of income in individual regions may provide relevant context for understanding this relationship. However, these factors are beyond the variables directly examined in the research model.

#### 4.6.3 GRDP per Capita and Poverty in the Long Run

GRDP per capita has a coefficient of  $0.001126$  with a probability value of  $0.1992$ . Although the coefficient is positive, it is not statistically significant. Therefore, the study does not find sufficient statistical evidence of a long-run relationship between GRDP per capita and the poverty rate in the MG model.

This result should be interpreted cautiously. A positive but statistically insignificant coefficient cannot be interpreted as evidence that an increase in GRDP per capita causes an increase in poverty. The empirical finding is that changes in GRDP per capita do not exhibit a statistically significant long-run relationship with the poverty rate over the observation period and across the units of analysis.

Substantively, this finding indicates that increases in average regional economic capacity do not, in statistical terms, demonstrate a clear long-run relationship with changes in the poverty rate within the model. The literature on growth and poverty also indicates that this relationship may depend on how the benefits of economic activity are distributed across population groups (Bhattacharyya & Resosudarmo, 2015; Rini & Tambunan, 2021). However, the distribution mechanism is not directly tested in this study. Therefore, an interpretation concerning the inclusiveness of growth should be treated as a possible explanation rather than as a causal conclusion from the estimated model.

#### 4.7 Short-Run Estimation Results of the MG Model

The short-run estimation results from the Mean Group (MG) model indicate that not all changes in regional development indicators are immediately reflected in changes in the poverty rate within the same period. Among all short-run variables estimated, the change in GRDP per capita in the previous period is the only variable that exhibits a statistically significant relationship with changes in the poverty rate. Meanwhile, changes in HDI, OUR, current-period GRDP per capita, as well as lagged changes in HDI and OUR, do not show statistically significant relationships.

**Table 9. Short-Run Estimation Results of the MG Model**

| Variable   | Coefficient | Std. Error | t-Statistic | Probability |
|------------|-------------|------------|-------------|-------------|
| D(POV(-1)) | 0.017757    | 0.199098   | 0.089188    | 0.929       |
| D(HDI)     | -0.119316   | 0.32888    | -0.362794   | 0.717       |
| D(HDI(-1)) | 0.159518    | 0.414324   | 0.385008    | 0.7005      |

|                        |            |           |           |        |
|------------------------|------------|-----------|-----------|--------|
| D(OUR)                 | 0.056294   | 0.079411  | 0.708891  | 0.4789 |
| D(OUR(-1))             | 0.011385   | 0.055318  | 0.205809  | 0.8371 |
| D(GRDP per capita)     | -0.0000233 | 0.000128  | -0.182479 | 0.8553 |
| D(GRDP per capita(-1)) | -0.000299  | 0.0000942 | -3.171399 | 0.0017 |

Source: EViews estimation results.

#### 4.7.1 Short-Run Dynamics of HDI

The change in HDI in the current period has a coefficient of  $-0.119316$  with a probability value of  $0.7170$ , while the change in HDI in the previous period has a coefficient of  $0.159518$  with a probability value of  $0.7005$ . Neither coefficient is statistically significant.

Therefore, the estimation results do not provide sufficient statistical evidence that changes in HDI, either in the current period or in the previous period, are associated with changes in the poverty rate in the short run.

This finding differs from the long-run relationship obtained previously, in which HDI exhibits a negative and statistically significant coefficient. This difference indicates that the relationship between human development and poverty in the estimated model is more evident over the long-run horizon than through changes in HDI from one period to the next. This interpretation is consistent with the human development perspective, which views improvements in capabilities as a process whose welfare implications may emerge gradually over time (Sen, 1999; Alkire & Foster, 2011).

This interpretation should nevertheless be considered within the limits of the empirical results. The model indicates different patterns across the short- and long-run horizons, but the specific transmission mechanisms underlying these differences are not directly tested in this study.

#### 4.7.2 Short-Run Dynamics of the Open Unemployment Rate

The change in the OUR in the current period has a coefficient of  $0.056294$  with a probability value of  $0.4789$ , while the change in the OUR in the previous period has a coefficient of  $0.011385$  with a probability value of  $0.8371$ . Neither coefficient is statistically significant.

These results indicate that changes in the OUR do not have a statistically significant relationship with changes in the poverty rate in the short run, either in the current period or through a one-period lag.

The finding suggests that short-run changes in open unemployment conditions do not exhibit a clear statistical relationship with changes in poverty among the observed regencies and municipality. As with the long-run results, the direction of a coefficient alone is not used as a basis for inferring a substantive relationship when the coefficient is not statistically significant.

Accordingly, the short-run OUR results should be distinguished from potential relationships that may emerge over a longer horizon. In the present study, the empirical evidence does not indicate a statistically significant short-run relationship between changes in OUR and changes in the poverty rate.

#### 4.7.3 Short-Run Dynamics of GRDP per Capita

The change in GRDP per capita in the current period has a coefficient of  $-2.33 \times 10^{-5}$  with a probability value of  $0.8553$ , indicating that it is not statistically significant. In contrast, the change in GRDP per capita in the previous period has a coefficient of  $-0.000299$  with a probability value of  $0.0017$ , making it statistically significant at the 1 percent level.

These results indicate the presence of a lagged relationship in the short-run dynamics. The current-period change in GRDP per capita does not exhibit a statistically significant relationship with changes in poverty, whereas the change in GRDP per capita in the previous period has a negative and statistically significant relationship with changes in the poverty rate.

In other words, within the estimated model, changes in regional economic capacity are not fully reflected in changes in poverty within the same period. The statistically significant relationship instead appears in the change in GRDP per capita one period earlier. This finding provides an indication of a time lag in the relationship between changes in regional economic conditions and changes in the poverty rate.

This pattern is consistent with the literature suggesting that the relationship between economic growth and poverty reduction may vary according to the characteristics of growth and the extent to which the benefits of growth are distributed throughout the economy (Bhattacharyya & Resosudarmo, 2015; Rini & Tambunan, 2021). However, in this study, the result represents a statistical relationship and is not interpreted as evidence of a causal relationship.

Because GRDP per capita is measured on a different scale from HDI and OUR, the magnitude of the coefficient  $-0.000299$  should not be directly compared with the coefficients of the other variables to determine the relative “strength” of each variable.

#### 4.7.4 Persistence of Changes in Poverty

The variable  $D(POV(-1))$  has a coefficient of  $0.017757$  with a probability value of  $0.9290$ , indicating that it is not statistically significant.

This result indicates that changes in the poverty rate in the previous period do not exhibit a statistically significant relationship with changes in the poverty rate in the current period after accounting for the other variables in the short-run model.

Thus, there is insufficient statistical evidence of persistence in changes in poverty from one period to the next within the short-run specification of the estimated MG model.

Overall, the short-run dynamics of the MG model reveal two main empirical patterns. First, changes in HDI and OUR, both in the current period and in the previous period, do not exhibit statistically significant relationships with changes in the poverty rate. Second, the change in GRDP per capita in the previous period has a negative and statistically significant relationship with changes in the poverty rate, whereas the current-period change in GRDP per capita is not statistically significant. These patterns indicate that the relationship between regional development indicators and poverty does not necessarily emerge simultaneously within the same period, highlighting the importance of the time dimension in understanding poverty dynamics across regencies and municipalities in Aceh.

#### 4.8 Error Correction Term (ECT) and Adjustment Mechanism

The estimation results of the Mean Group (MG) model show that the Error Correction Term (ECT), reported as COINTEQ in the EViews output, is  $-0.789703$ , with a standard error of  $0.249598$ , a  $t$ -statistic of  $-3.163895$ , and a probability value of  $0.0017$ . The coefficient is negative and statistically significant at the 1 percent level.

*Table 10. Error Correction Term of the MG Model*

| Variable      | Coefficient | Std. Error | t-Statistic | Probability |
|---------------|-------------|------------|-------------|-------------|
| COINTEQ / ECT | $-0.789703$ | $0.249598$ | $-3.163895$ | $0.0017$    |

Source: EViews estimation results.

The negative and statistically significant ECT coefficient indicates the presence of an adjustment mechanism toward the long-run equilibrium following deviations from that equilibrium relationship. Thus, short-run changes in the poverty rate and regional development variables are not entirely independent of the long-run relationship identified through the cointegration analysis.

The absolute value of the ECT coefficient,  $0.789703$ , indicates that approximately 78.97 percent of the deviation from the long-run equilibrium is corrected within one period. Since the study uses annual data, one period represents approximately one year. Therefore, when a deviation from the long-run equilibrium occurs, a substantial portion of that deviation is estimated to be adjusted in the following period.

The magnitude of the adjustment coefficient also indicates that the return toward equilibrium follows a direction consistent with the error correction mechanism. However, the value of 78.97 percent should be understood as a model adjustment parameter, rather than as a measure of the “speed” of development or the effectiveness of a particular policy. The coefficient indicates the proportion of the deviation from the long-run equilibrium that is corrected by the system in the subsequent period.

The ECT finding further supports the preceding cointegration results. The Kao Test indicates the existence of a long-run relationship among POV, HDI, OUR, and GRDP per capita, while the negative and statistically significant ECT indicates that the model contains an adjustment mechanism when deviations from this equilibrium relationship occur. Accordingly, the Panel ARDL results suggest that the relationship between regional development and poverty operates through a combination of short-run dynamics, long-run relationships, and an adjustment process toward equilibrium.

#### **4.9 Discussion**

The Mean Group (MG) estimation results indicate that the relationship between regional development and poverty in Aceh differs between the short-run and long-run horizons. In the long run, HDI exhibits a negative and statistically significant relationship with the poverty rate, whereas OUR and GRDP per capita do not show statistically significant relationships. In the short run, most changes in the variables do not exhibit statistically significant relationships with changes in poverty, except for the change in GRDP per capita in the previous period, which is negatively and significantly associated with changes in the poverty rate. In addition, the negative and statistically significant error correction term (ECT) indicates the existence of an adjustment mechanism toward long-run equilibrium. These findings suggest that changes in regional development conditions are not necessarily translated immediately into changes in poverty within the same period, with some relationships emerging over a longer horizon.

First, the negative and statistically significant long-run relationship between HDI and poverty highlights the importance of the human development dimension in the poverty reduction process in Aceh. The HDI coefficient of  $-1.384952$  indicates that a one-point increase in HDI is associated with an approximately 1.38 percentage-point reduction in the poverty rate in the long run, holding the other variables in the model constant. This finding is consistent with Sen's (1999) capability approach, which views development as a process of expanding people's substantive capabilities and opportunities to live lives they have reason to value. From this perspective, poverty is not solely associated with low income but also with limitations in access to education, health, employment opportunities, and other social opportunities. A multidimensional perspective on poverty similarly emphasizes that well-being cannot be fully represented by a single economic dimension (Alkire & Foster, 2011).

Accordingly, the negative relationship between HDI and poverty can be understood as an indication that improvements in human quality are more consistently associated with poverty reduction than aggregate economic indicators alone. Improvements in education and health, for example, may conceptually expand individuals' capabilities to obtain better employment and income opportunities. However, this mechanism represents a conceptual explanation rather than a causal relationship directly established by the present model.

This finding is also consistent with Ferayanti et al. (2023), who examined 23 regencies and municipalities in Aceh over 2011–2019 and found a negative and statistically significant relationship between HDI and poverty. Hardianti et al. (2026), using the same 23 regencies and municipalities in Aceh but covering 2020–2024, also found a negative and statistically significant relationship between HDI and poverty. The consistency in the direction of these findings provides an indication that human development is a relatively consistent dimension associated with poverty conditions in Aceh, although the studies differ in observation periods and estimation approaches.

Second, the negative but statistically insignificant OUR coefficient in the long run indicates that the relationship between open unemployment and poverty in Aceh is not sufficiently strong statistically within the model specification. The coefficient of  $-0.465141$  cannot be interpreted as evidence that an increase in unemployment reduces poverty. Rather, its statistical insignificance indicates that the study does not provide sufficient evidence of a systematic long-run relationship between OUR and the poverty rate after accounting for HDI, GRDP per capita, time dynamics, and regional heterogeneity.

This result differs from Ferayanti et al. (2023), who found a negative and statistically significant relationship between OUR and poverty in Aceh. The difference may be associated with differences in the observation period, model specification, and estimation approach. The Panel ARDL framework used in this study specifically allows short-run dynamics and long-run relationships to be examined separately. Thus, the difference in findings does not necessarily indicate a substantive contradiction but may reflect differences in empirical context and the dynamic structure captured by the respective models.

The finding is also relevant to national-level evidence. Wibowo and Ridha (2021) found that the unemployment rate was not statistically significant in explaining poverty in a panel analysis of four Indonesian provinces with the highest poverty rates. Meanwhile, ARDL-based evidence in the Indonesian context may produce different patterns

depending on the observation period and model specification. These differences highlight the importance of regional context, observation period, and econometric approach when examining the relationship between labor-market conditions and poverty.

Third, GRDP per capita does not exhibit a statistically significant relationship with poverty in the long run, whereas the change in GRDP per capita in the previous period has a negative and statistically significant relationship with changes in poverty in the short run. The long-run result is represented by a GRDP coefficient of 0.001126 with a probability value of 0.1992. Therefore, there is insufficient statistical evidence to establish a long-run relationship between GRDP per capita and the poverty rate in the final model.

This finding should be clearly distinguished from an interpretation that an increase in GRDP per capita causes an increase in poverty. The positive coefficient is statistically insignificant, and therefore the study does not provide sufficient evidence for such a relationship. This result is consistent with Hardianti et al. (2026) in Aceh, who found that GRDP per capita did not have a statistically significant relationship with poverty.

However, the short-run results reveal a different pattern. The coefficient of  $\Delta\text{GRDP}(-1)$  of  $-0.000299$  with a probability value of 0.0017 indicates a negative and statistically significant relationship between the change in GRDP per capita in the previous period and the change in the poverty rate in the current period. Because the statistically significant term is the lagged GRDP, rather than the contemporaneous change in GRDP, this finding indicates a possible time lag in the relationship between changes in economic activity and changes in poverty. It also underscores the relevance of a dynamic approach because the relationship between economic development and poverty does not necessarily emerge simultaneously within the same period. The literature on growth and poverty similarly indicates that this relationship may depend on the characteristics of growth and the distribution of its benefits across population groups (Bhattacharyya & Resosudarmo, 2015; Rini & Tambunan, 2021).

In the context of Aceh, this pattern can also be interpreted cautiously in relation to heterogeneity in regional economic structures. Increases in economic output may occur through sectors with different capacities to absorb labor. Consequently, an increase in GRDP per capita in a given period may not necessarily be translated immediately into lower poverty in the same period. Hardianti et al. (2026) likewise highlight differences in economic structure and labor-absorption capacity as relevant contextual factors in understanding the relationship between economic growth and poverty in Aceh.

Fourth, the statistical insignificance of most short-run variables indicates that changes in poverty in Aceh do not necessarily respond immediately to changes in regional development indicators. Changes in HDI, OUR, and GRDP per capita in the current period are statistically insignificant in the MG model. This differs from the significant long-run relationship between HDI and poverty and the significant lagged relationship involving GRDP. The difference suggests that changes in human development and economic conditions may require time before becoming reflected in poverty outcomes.

This finding provides an important rationale for the use of the Panel ARDL framework in this study. The approach allows dynamic relationships to be distinguished between short-run responses and long-run relationships (Pesaran & Smith, 1995; Pesaran, Shin, & Smith, 1999). Therefore, the statistical insignificance of a variable in the short run does not necessarily imply that the variable is irrelevant to poverty over the overall adjustment horizon. In the case of HDI, for example, the results instead indicate a strong and statistically significant long-run relationship.

Fifth, the ECT coefficient of  $-0.789703$ , which is statistically significant at the 1 percent level, indicates the presence of an adjustment mechanism toward long-run equilibrium. The absolute value of the coefficient indicates that approximately 78.97 percent of the disequilibrium from the previous period is corrected in the following period. Since the data are annual, this adjustment can be interpreted within an annual time frame. The finding indicates that when deviations occur from the long-run relationship among poverty, HDI, OUR, and GRDP per capita, the system exhibits an adjustment mechanism toward equilibrium.

The ECT result also reinforces the preceding Kao cointegration test, which indicates the existence of cointegration among the variables. Thus, the empirical evidence reveals three complementary layers of dynamics: a long-run equilibrium relationship, short-run changes that are largely not immediately statistically significant, and an adjustment mechanism following deviations from long-run equilibrium. This framework is consistent with the characteristics of heterogeneous dynamic panel models, which distinguish short-run adjustment processes from long-run relationships across panel units (Pesaran & Smith, 1995; Pesaran, Shin, & Smith, 1999).

Overall, the findings indicate that human development is the dimension most consistently associated with poverty in the long-run relationship, whereas the relationships between poverty and labor-market conditions and

regional economic capacity are more complex and are not statistically significant across every time horizon. The findings further indicate that the relationship between regional development and poverty in Aceh needs to be understood by considering both the time dimension and regional heterogeneity rather than relying solely on static relationships among indicators.

From a regional development perspective, the findings indicate that poverty reduction cannot be understood simply as an automatic consequence of increased economic activity. Improvements in human quality, particularly through the dimensions reflected in HDI, exhibit a clearer long-run association with lower poverty in the estimated model. Meanwhile, the lagged relationship involving GRDP suggests that changes in economic conditions may require time before being reflected in poverty outcomes. Therefore, assessments of regional development performance need to consider not only changes in indicators within a single period but also the continuity of the development process and the adjustment mechanisms operating across periods.

#### **4.10 Regional Heterogeneity and Policy Interpretation**

The estimator selection results indicate that the Mean Group (MG) estimator is more appropriate than the Pooled Mean Group (PMG) estimator for this study. The Hausman test produces a statistic of 17.405477 with a probability value of 0.0016, leading to rejection of the null hypothesis. This finding indicates that the homogeneity restriction on long-run relationships imposed by the PMG estimator does not receive sufficient empirical support. Therefore, the MG estimator provides greater scope for accommodating the characteristics of individual regencies and municipalities in explaining the relationship between regional development and poverty.

Such heterogeneity is important in the context of Aceh because its 23 regencies and municipalities differ in terms of social and economic characteristics, geography, production structures, and labor-market conditions. Consequently, changes in HDI, OUR, or GRDP per capita do not necessarily generate identical poverty responses across regions. From a regional development perspective, the findings indicate that the relationship between development indicators and poverty should be understood as potentially varying according to regional characteristics rather than as a completely uniform relationship across Aceh.

These findings also help explain why the results of this study do not always coincide with previous research. Ferayanti et al. (2023), for example, used data from 23 regencies and municipalities in Aceh over 2011–2019 and employed a Random Effect Model, finding negative and statistically significant relationships between both HDI and OUR and poverty. Meanwhile, Hardianti et al. (2026), using the 2020–2024 period and a Random Effect Model, found that HDI was negatively and significantly associated with poverty, OUR also exhibited a negative and significant relationship, whereas GRDP per capita was statistically insignificant. These differences do not necessarily indicate contradictory findings, as the studies differ in observation periods and estimation approaches.

In this context, the study by Yusnuri and Abubakar (2023) also provides an important reference point. Their study used Indonesian data for 2006–2021 and examined the relationships among HDI, unemployment, poverty, and economic growth. The results indicated a statistically significant simultaneous relationship among these variables, although the direction and significance of individual relationships varied according to the model specification. Their study used economic growth as the dependent variable, whereas the present study places poverty as the dependent variable and employs Panel ARDL to distinguish short-run dynamics from long-run relationships. Thus, the present study extends the previous research context through a regional focus and a dynamic analytical approach.

Regional heterogeneity also has implications for policy interpretation. The findings do not support an approach that assumes that a given change in a development indicator will generate an identical poverty response across all regencies and municipalities. Instead, poverty-reduction policies need to consider initial human development conditions, economic structure, labor-market characteristics, and the economic capacity of individual regions.

In terms of human development, the finding that HDI has a negative and statistically significant long-run relationship with poverty provides empirical support for sustained attention to education, health, and living-standard dimensions. However, this result does not imply that policies aimed at improving HDI will automatically produce lower poverty in the short run. The statistical insignificance of changes in HDI in the short run instead indicates that the benefits of human development for poverty reduction may require time and sustained processes to emerge.

Meanwhile, the statistical insignificance of OUR in the long run indicates that labor-market policies need to consider more than changes in the open unemployment rate alone. Informal employment structures, job quality, household income, and labor-force characteristics may be relevant in explaining why changes in OUR are not always

accompanied by significant changes in poverty. This also suggests that unemployment indicators should be interpreted together with other welfare indicators.

On the other hand, the negative and statistically significant relationship between the change in GRDP per capita in the previous period and the change in poverty indicates a time dimension in the relationship between economic activity and welfare. This finding suggests that developments in regional economic activity may require time before being reflected in poverty indicators. However, because the study is observational, the result is more appropriately interpreted as a dynamic relationship rather than as evidence that an increase in GRDP per capita directly causes a reduction in poverty.

Thus, the main policy implication of this study is not that there is a single development instrument that uniformly determines changes in poverty across Aceh. Rather, the findings highlight the importance of sustained human development, an understanding of labor-market characteristics, and stronger linkages between economic activity and societal welfare, while taking into account the characteristics of individual regions. This approach is more consistent with the empirical evidence that the relationship between regional development and poverty is dynamic and heterogeneous across regions.

#### **4.11 Regional Development Implications**

The findings indicate that the relationship between regional development performance and poverty in Aceh operates through interconnected dimensions and across different time horizons. The finding that HDI has a negative and statistically significant relationship with poverty in the long run indicates that human development represents an important dimension in the poverty reduction process. At the same time, the statistical insignificance of OUR and GRDP per capita in the long run indicates that improvements in particular economic indicators do not automatically translate into statistically observable changes in the poverty rate over the long run. Therefore, regional development performance needs to be interpreted from a multidimensional perspective.

The first implication concerns the sustainability of human development. The negative and statistically significant long-run relationship between HDI and poverty provides empirical support for sustained attention to improvements in education, health, and living standards. From the perspective of the capability approach, human development is not only an outcome of development but also a process that expands people's capabilities to access economic and social opportunities (Sen, 1999). Since changes in HDI do not exhibit a statistically significant relationship with poverty in the short run, human development policies should also be understood as long-term investments whose benefits may not be immediately reflected in poverty indicators.

The second implication concerns labor-market policy. The study does not find a statistically significant long-run relationship between OUR and poverty. This finding suggests that the assessment of labor-market conditions should not rely solely on changes in the open unemployment rate. Other aspects, such as job quality, income levels, informal employment, productivity, working hours, and employment stability, may be important in understanding household welfare. Accordingly, regional labor-market policies need to consider both employment opportunities and the quality of available employment.

The third implication concerns the relationship between economic activity and societal welfare. The statistical insignificance of GRDP per capita in the long run indicates that an increase in regional economic capacity cannot be statistically linked directly to changes in poverty within the model. However, the statistically significant relationship involving the change in GRDP per capita in the previous period in the short run indicates a time dimension in this relationship. Therefore, assessments of regional economic development should not rely solely on changes in output in the current year but should also consider how economic developments are translated into employment opportunities, household income, and welfare in subsequent periods.

The fourth implication concerns regional heterogeneity. The selection of the MG estimator based on the Hausman test indicates that the long-run relationship should not be treated as completely homogeneous across all regencies and municipalities. Consequently, poverty-reduction policies in Aceh need to allow for adaptation according to the characteristics of individual regions. Strategies implemented in regions with different economic structures, fiscal capacities, labor-market characteristics, and levels of human development do not necessarily need to have identical forms of implementation.

The fifth implication concerns the time dimension of regional development planning. The ECT coefficient of  $-0.789703$  indicates that approximately 78.97 percent of the deviation from long-run equilibrium is adjusted in the following period. This finding indicates that changes in development conditions and poverty need to be viewed as

a dynamic process. Policy evaluation based solely on annual changes in indicators may overlook adjustment processes that take place gradually over time.

Accordingly, the findings provide a basis for a regional development approach that combines human development, labor-market quality, stronger linkages between economic activity and welfare, and sensitivity to regional characteristics. This does not mean that every regency or municipality must adopt entirely different policies; rather, policy implementation needs to consider initial conditions and the development mechanisms operating within each region.

In the context of poverty reduction, the findings also highlight the importance of policy continuity. The long-run relationship between HDI and poverty, together with the adjustment mechanism toward equilibrium, indicates that development outcomes cannot always be assessed solely through short-run changes. Therefore, consistency in development programs, sustained investment in human quality, and regular monitoring of welfare indicators are relevant components of regional development planning and evaluation.

The findings also provide opportunities for future research to extend the analysis by incorporating variables that capture job quality, income distribution, sectoral economic structure, local government expenditure, and regional socioeconomic characteristics. Incorporating these dimensions could provide further insight into why the relationship between regional development and poverty varies across regions and over time.

## Conclusion

This study analyzes the dynamic relationship between human development, labor-market conditions, regional economic capacity, and poverty across 23 regencies and municipalities in Aceh Province over the period 2010–2025 using the Panel Autoregressive Distributed Lag (Panel ARDL) approach. The Kao cointegration test indicates the existence of a long-run equilibrium relationship among the poverty rate, HDI, OUR, and GRDP per capita. Furthermore, the Hausman test indicates that the Mean Group (MG) estimator is more appropriate than the Pooled Mean Group (PMG) estimator, implying that regional heterogeneity in long-run relationships needs to be considered when interpreting the results.

The MG estimation results indicate that HDI has a negative and statistically significant relationship with the poverty rate in the long run. The coefficient of  $-1.384952$  indicates that a one-point increase in HDI is associated with an approximately 1.38 percentage-point reduction in the poverty rate in the long run, holding the other variables in the model constant. In contrast, OUR has a negative but statistically insignificant coefficient, while GRDP per capita has a positive but also statistically insignificant coefficient in the long run. Thus, the study does not find sufficient statistical evidence of a long-run relationship between either OUR or GRDP per capita and the poverty rate in the final model specification.

In the short run, changes in HDI and OUR do not exhibit statistically significant relationships with changes in poverty. The current-period change in GRDP per capita is also statistically insignificant, whereas the change in GRDP per capita in the previous period has a negative and statistically significant relationship with changes in the poverty rate. This finding indicates that the relationship between economic activity and poverty may involve a time lag and does not necessarily emerge immediately within the same period. In addition, the ECT coefficient of  $-0.789703$  is statistically significant and indicates an adjustment mechanism toward long-run equilibrium, with approximately 78.97 percent of the deviation from the previous equilibrium being corrected in the following period.

Scientifically, this study contributes to the literature on regional development and poverty in Aceh by extending relatively static panel approaches into a dynamic framework that distinguishes short-run relationships, long-run relationships, and adjustment mechanisms. The use of the MG estimator following the Hausman test also allows the analysis to account for heterogeneity across regencies and municipalities, rather than imposing uniform relationships between development indicators and poverty across all regions. In this context, the study contributes to a broader understanding of poverty as a dynamic development phenomenon associated with human development processes, economic conditions, and regional characteristics.

This study has several limitations. First, the analysis covers a relatively limited number of regencies and municipalities, while the annual observation period results in a shorter effective time dimension after accounting for the lag structure of the Panel ARDL model. Second, the variables included in the model do not capture all dimensions potentially associated with poverty, such as job quality, income distribution, sectoral economic structure, local government expenditure, and other socioeconomic characteristics. Third, the study is observational in nature; therefore, the statistical relationships identified cannot be directly interpreted as causal relationships. In addition,

certain characteristics of regional data, including limitations in the availability of particular indicators, may constrain the scope of the analysis.

Given these limitations, future research could extend the analysis by incorporating indicators of job quality, income inequality, sectoral economic structure, local government expenditure, and more detailed socioeconomic characteristics. Future studies could also employ approaches that allow regional heterogeneity to be examined more extensively, including the exploration of differences in development mechanisms across regions. Longer observation periods and richer datasets may further provide a more comprehensive understanding of regional development dynamics and poverty reduction in Aceh.

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