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THE EFFECT OF INVESTMENT AND INFRASTRUCTURE ON ECONOMIC INEQUALITY IN THE REGENCIES/MUNICIPALITY OF BALI PROVINCE BALI

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Abstract

Economic inequality in Bali Province remains concentrated in the southern region due to the dominance of the tourism sector. This quantitative study analyzes the effects of Domestic Investment (PMDN), Foreign Direct Investment (PMA), road infrastructure, access to improved drinking water, and digital infrastructure on economic inequality (Gini Ratio) across the nine regencies/municipality of Bali during the 2017–2025 period. The analysis employs panel data regression using the selected Random Effect Model (REM) with robust standard errors clustered at the regency/municipality level. The estimation results indicate that, simultaneously, all variables have a significant effect on economic inequality (Wald chi2 = 46.15; Prob > chi2 = 0.0000). However, partially, only digital infrastructure is found to have a negative and statistically significant effect (one-tailed p = 0.001), confirming its role as the only consistent and robust economic equalizer. Domestic Investment (PMDN) and road infrastructure exhibit positive coefficient directions consistent with the initial hypotheses but are not statistically significant at the 5 percent significance level after correcting the standard errors. Meanwhile, Foreign Direct Investment (PMA) and access to improved drinking water have no significant effect, with coefficient directions opposite to the hypotheses, reflecting the weak linkage of enclave-type foreign investment in the tourism sector as well as the achievement of relatively equal service coverage (ceiling effect) for drinking water across all regencies/municipality in Bali. These findings support the relevance of the Cumulative Causation Theory (Myrdal) and the Endogenous Growth Theory (Romer), while also emphasizing the importance of correcting standard errors in panel data with a limited number of clusters. The policy implications highlight the need to accelerate digital infrastructure development in lagging regions as the highest priority for achieving more equitable economic development in Bali Province.

Keywords: Economic Inequality, Investment, Infrastructure, Panel Data, Random Effect Model.

INTRODUCTION

The aspiration of economic development has never been confined solely to achieving economic growth, but rather to ensuring that the benefits of such growth are equitably enjoyed by all segments of society. Inclusive economic development implies that economic growth should be capable of generating comprehensive and equitable improvements in social welfare (Dewi & Suryadi, 2025; Mahadiansar et al., 2020). However, empirical evidence often suggests otherwise; high economic growth is not always accompanied by an equitable distribution of development outcomes, making income inequality one of the principal challenges of regional development (Hartati, 2021). Non-inclusive growth fails to ensure the proportional distribution of benefits, thereby necessitating comprehensive redistributive policies to strengthen the inclusiveness of the growth process (Muyassar, 2024). This paradox between growth and equity serves as the starting point for understanding why economic inequality should not be regarded merely as an inevitable byproduct of development, but rather as a structural issue that demands serious scholarly attention.

At the national level, Indonesia recorded a Gini ratio of 0.379 in 2024 (BPS Indonesia, 2024), indicating that income distribution inequality remains a significant issue across regions. This figure is not merely an administrative statistic but also reflects regional disparities that risk constraining economic expansion, as asymmetrical regional development undermines the effectiveness of economic growth and the process of regional convergence (Panzera & Postiglione, 2021), while simultaneously making it more difficult for communities in lagging regions to escape the poverty trap due to limited access to productive resources (Rinaldi et al., 2025). In other words, inequality is not merely a matter of distribution but also a matter of the sustainability of economic growth itself.

Bali Province, therefore, is not merely one of Indonesia's 38 provinces, but rather represents a theoretically rich case for investigation because it possesses a mono-sectoral economy heavily dependent on tourism, making it vulnerable to external shocks while simultaneously serving as a magnet for investment and capital mobility that are unevenly distributed across space. The concentration of economic activities in Badung Regency, Gianyar Regency, and Denpasar Municipality has generated disparities in development and income levels compared with other areas of Bali, thereby reinforcing economic disparities among regencies/municipality (Juliarta and Setyari, 2022; Nuryanto, 2018). This spatial inequality has created a phenomenon of growth polarization, whereby southern Bali has developed rapidly as the center of the modern economy, while the northern, eastern, and western regions have tended to lag behind in capturing the benefits of development. Consequently, urbanization flows and capital accumulation continue to move asymmetrically, which, if left without policy intervention, will further exacerbate interregional economic fragmentation.

Nevertheless, aggregate provincial figures have the potential to obscure substantial variations at the local level. Economic inequality in this study is measured using the Gini ratio at the regency/municipality level because this indicator is the most commonly used measure of income distribution inequality within a region (Badan Pusat Statistik, 2024; World Bank, 2024). The Gini ratio is calculated based on the Lorenz Curve, with values ranging from 0 to 1, where values closer to 1 indicate a higher degree of income distribution inequality (Panzera & Postiglione, 2020; World Bank, 2024). Although the Gini ratio technically measures income inequality, this study employs it as a proxy for regional economic inequality because income distribution reflects disparities in public access to investment, employment opportunities, infrastructure, and economic activities across regions (Hornok et al., 2024; Panzera & Postiglione, 2020). The existence of spatial heterogeneity and variations in inequality patterns across regions further strengthens the justification for conducting the analysis at the regency/municipality level as the primary unit of observation in this study (Nurdina, 2021).

The fundamental question, therefore, is what factors drive certain regions in Bali to continue advancing while others increasingly fall behind. In the development economics literature, investment has consistently been identified as one of the primary determinants influencing the dynamics of regional inequality (Asongu & Odhiambo, 2020). This study operationalizes the investment variable through the realization of Domestic Investment (PMDN) and Foreign Direct Investment (PMA) at the regency/municipality level because these two indicators possess distinct characteristics and transmission mechanisms affecting regional economic structures and therefore need to be analytically differentiated (Sadid & Wijimulawiani, 2024). Domestic Investment (PMDN) generally exhibits strong forward and backward linkages with the domestic sector, making it effective in promoting local employment and stimulating grassroots economic activities. In contrast, Foreign Direct Investment (PMA) functions as a driver of macroeconomic growth through intensive capital transfers, the diffusion of modern technology, and enhanced sectoral productivity (Hornok et al., 2024). However, the trickle-down effect of Foreign Direct Investment (PMA) is often limited because its benefits tend to be concentrated in specific regions, thereby potentially exacerbating income polarization (Fazaalloh, A. M., 2024).

The historical concentration of investment in southern Bali accurately reflects the mechanism of cumulative causation formulated by Myrdal (1957), whereby regions endowed with absolute advantages in the form of well-established infrastructure, access to the global tourism market, and a skilled labor force continue to attract new investment, while peripheral regions experience backwash effects through the outflow of productive resources due to their inability to compete with growth centers. This structural inequality is consistent with the argument advanced by Hakim and Rosini (2022), who contend that Foreign Direct Investment (PMA) tends to widen regional disparities because it is concentrated in developed regions and capital-intensive modern sectors, whereas Domestic Investment (PMDN) is more capable of promoting equitable development due to its close linkages with local economic activities. Therefore, investment policies oriented toward strengthening domestic productive sectors and creating labor-intensive employment opportunities constitute a crucial instrument for reducing regional inequality (Herdiyati, 2022).

In addition to investment, infrastructure availability functions as a critical determinant of inequality dynamics, and it is at this point that two major theoretical perspectives intersect. According to Gunnar Myrdal (1957), development concentrated in particular territories inherently widens interregional disparities through the backwash effect. Conversely, the Endogenous Growth Theory developed by Paul Romer (1986, 1990) argues that strategic infrastructure interventions can enhance regional productivity and sustain long-term economic growth. The tension between these two perspectives makes the relationship between infrastructure and inequality an empirical rather than merely a normative issue. Equitable provision of public infrastructure, including road networks, access to improved drinking water, and internet connectivity, has the potential to serve as an instrument of spatial integration while simultaneously posing the risk of widening disparities if its distribution is not inclusive. This theoretical framework is consistent with the findings of Suparman et al. (2023) and Wahyuni and

Ikhsan (2022), who demonstrate that the quality and equitable distribution of infrastructure significantly influence the reduction of regional disparities in Indonesia.

More specifically, road infrastructure performs a dual role in the context of regional inequality. Road networks can reduce disparities when developed inclusively by connecting lagging regions (hinterlands), yet they may deepen polarization if development prioritizes only growth centers (Achten & Lessmann, 2020). Access to clean water also plays a crucial role in improving quality of life and promoting equitable development because reliable access to improved drinking water contributes to better public health and regional economic productivity (Bayu, 2020). Meanwhile, internet infrastructure reflects the capacity of society for digital inclusion in assimilating information and exploring digital economic opportunities. Accordingly, accelerating digital penetration is believed to be directly associated with expanding societal productivity, which, in the long run, contributes to reducing economic disparities across regions, although its effectiveness may still vary spatially due to differences in digital literacy and the unequal distribution of supporting facilities (Asmoro, 2023).

The complexity of the interaction between investment, infrastructure, and inequality has not yet been sufficiently explored in the existing literature. Most previous studies examining the effects of investment and infrastructure on inequality have focused on the national or provincial level, thereby failing to capture the heterogeneity of characteristics across regencies/municipality (Asmoro, 2023; Makmuri, 2017). Furthermore, local studies conducted in Bali Province, such as those by Sukmaadi and Marhaeni (2021) and Ardiyanti and Suasih (2023), have not analytically distinguished the impacts of Domestic Investment (PMDN) and Foreign Direct Investment (PMA), nor have they simultaneously incorporated digital infrastructure as an explanatory variable. This study addresses this research gap by employing panel data analysis at the regency/municipality level in Bali over the 2017–2025 period, a timeframe deliberately selected because it encompasses three contrasting economic phases: the pre-pandemic period (2017–2019), the COVID-19 crisis (2020–2021), and the post-pandemic recovery (2022–2025). The selection of this period is crucial because the pandemic shock created strong exogenous variation for identifying the behavior of investment and infrastructure in relation to inequality under fluctuating economic conditions (Baltagi, 2021).

Based on the asymmetries in regional development, investment, and infrastructure availability, examining the determinants of regional economic inequality has become increasingly urgent. Accordingly, this study aims to analyze the direction and magnitude of the effects of Domestic Investment (PMDN), Foreign Direct Investment (PMA), road length ratio, access to improved drinking water, and digital infrastructure on the Gini ratio of regencies/municipality in Bali Province during the 2017–2025 period. From a practical perspective, the findings of this study are expected to provide policy recommendations for regional governments in formulating more inclusive regional development strategies aimed at reducing economic inequality in Bali Province.

RESEARCH METHOD

This study employs a quantitative approach with an associative research design to analyze the effects of investment and infrastructure on economic inequality in Bali Province. The independent variables examined include Domestic Investment (PMDN), Foreign Direct Investment (PMA), road infrastructure, access to improved drinking water, and digital infrastructure, while the dependent variable is economic inequality measured using the Gini ratio. The analysis is conducted using panel data regression, combining the cross-sectional dimension of the nine regencies/municipality in Bali Province with the time-series dimension covering the 2017–2025 period. The use of panel data enables a more efficient analysis in capturing both cross-regional and intertemporal variations compared with the separate use of cross-sectional or time-series data (Sugiyono, 2019; Baltagi, 2021; Wooldridge, 2020).

The study was conducted across all regencies/municipality in Bali Province because they exhibit heterogeneous economic characteristics with a dominant tourism sector and experienced significant economic dynamics during the pre-pandemic period, the COVID-19 pandemic, and the economic recovery period. The data used consist of quantitative secondary ratio-scale data obtained from the Bali Provincial Statistics Office (BPS), including the Gini ratio, realized Domestic Investment (PMDN), Foreign Direct Investment (PMA), road density, the percentage of the population with access to improved drinking water, and the percentage of the population accessing the internet. The study utilizes 81 observations derived from the combination of nine regencies/municipality and nine years of observation. All data were collected through documentation of official publications issued by the Bali Provincial Statistics Office (BPS), thereby ensuring the validity and consistency of the analyzed data (Sugiyono, 2019; BPS Provinsi Bali, 2024).

The data analysis was performed using Stata software through a sequence of descriptive statistical analysis, panel data regression model selection (Common Effect Model, Fixed Effect Model, or Random Effect Model) using the Chow test, Hausman test, and Lagrange Multiplier test, followed by classical assumption tests comprising multicollinearity, autocorrelation, and cross-sectional dependence tests. Hypothesis testing was conducted using the simultaneous test (Wald Chi-Square), partial test (t-test), and the coefficient of determination (Adjusted R^2) to evaluate the model's ability to explain variations in economic inequality. When violations of the classical assumptions were detected, the study applied robust standard errors to ensure that the parameter estimates remained Best Linear Unbiased Estimators (BLUE), thereby allowing the analytical results to be interpreted validly in explaining the effects of investment and infrastructure on economic inequality in Bali Province (Baltagi, 2021; Wooldridge, 2020).

RESULT AND DISCUSSION

Descriptive Analysis of the Research Variables

The descriptive data indicate the existence of regional development disparities across Bali Province during the 2017–2025 period. The realization of Domestic Investment (PMDN) and Foreign Direct Investment (PMA) tended to be concentrated in Badung Regency, Denpasar Municipality, and Gianyar Regency, supported by the tourism sector, trade activities, and more advanced infrastructure. In contrast, Bangli Regency, Karangasem Regency, and Jembrana Regency continued to record relatively low investment levels. This condition is consistent with the uneven distribution of infrastructure, where road density, access to improved drinking water, and digital infrastructure exhibited higher levels of achievement in economic growth centers than in surrounding regions. Although all infrastructure indicators improved throughout the observation period, disparities remained, reflecting that development has not yet been optimally distributed across all regencies/municipality in Bali Province (Badan Pusat Statistik Provinsi Bali, 2025; Badan Pusat Statistik Provinsi Bali, 2026).

The economic inequality variable, measured using the Gini Ratio, also demonstrates differences in income inequality across regions. Denpasar Municipality and Badung Regency consistently exhibited higher levels of inequality due to the high concentration of economic activity, investment, and urbanization, whereas several other regions recorded lower Gini Ratio values that more accurately reflected equality at relatively low income levels. These inequality dynamics were also influenced by the COVID-19 pandemic, which reduced economic activity during 2020–2021, followed by a subsequent increase in inequality during the economic recovery period, driven by renewed investment flows and the recovery of the tourism sector throughout 2022–2025. Overall, the descriptive analysis of the research variables indicates that investment distribution and infrastructure equity remain important factors associated with regional economic inequality across Bali Province (Badan Pusat Statistik Provinsi Bali, 2026).

Logarithmic Transformation of the PMDN and PMA Variables

Before estimating the panel data regression model, the Domestic Investment (PMDN) and Foreign Direct Investment (PMA) variables were transformed into their natural logarithmic forms (ln), resulting in the variables log_pmdn and log_pma. This transformation was performed because the investment data exhibited highly skewed distributions with extremely wide value ranges, allowing the transformation to reduce the influence of outliers, approximate a normal distribution, and produce more efficient parameter estimates that satisfy the Best Linear Unbiased Estimator (BLUE) assumptions (Porter & Gujarati, 2008; Wooldridge, 2020). In addition, the logarithmic transformation facilitates coefficient interpretation as the change in the Gini Ratio resulting from a 1 percent increase in investment while simultaneously harmonizing the scale differences between investment values and the Gini Ratio (Kennedy, 2008; Wooldridge, 2020). Meanwhile, the road infrastructure, access to improved drinking water, and digital infrastructure variables were not transformed because they already possessed comparable measurement scales and relatively stable data distributions. Consequently, the regression model was estimated using a combination of logarithmic and non-logarithmic variables in accordance with the principle of parsimony in econometrics (Porter & Gujarati, 2008).

Descriptive Statistical Analysis Results

Table 1. Summary of Descriptive Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
Gini	0,314	0,029	0,247	0,392
log_pmdn	12,629	1,869	6,263	15,755
log_pma	11,858	3,220	0,000	16,593
Road	1,935	0,977	0,903	4,615
Water	96,740	4,166	75,600	100,000
Internet	59,597	17,798	22,730	92,240

Source: Processed by the authors (2026)

Based on Table 1, the dependent variable, the Gini Index, has a mean value of 0.314 with a standard deviation of 0.029, indicating that the level of expenditure inequality within the study area falls into the moderate category with relatively stable data dispersion. Regarding the investment variables, log_pmdn has a mean of 12.629 with a standard deviation of 1.869, whereas log_pma has a mean of 11.858 and a larger standard deviation (3.220), indicating that foreign investment is more volatile than domestic investment and that there are still regions or periods that have not received foreign investment. Among the infrastructure variables, access to improved drinking water has the highest mean (96.740) with a relatively low standard deviation (4.166), reflecting a well-distributed level of service coverage. In contrast, internet access has a mean of 59.597 with a standard deviation of 17.798, indicating the continued existence of a digital divide across regions. Meanwhile, the road infrastructure variable has a mean of 1.935 with a standard deviation of 0.977, suggesting that road infrastructure is relatively more evenly distributed than internet access, although regional variations in infrastructure development remain evident.

Panel Data Model Selection

Table 2. Summary of Panel Data Regression Model Selection Results

Test Type	Hypothesis (H_0)	Test Statistic	Prob.	Conclusion
Chow Test	Common Effect	F = 6,57	0,0000	Select Fixed Effect
Hausman Test	Random Effect	Chi-square = 2,92	0,7117	Select Random Effect
LM Test	Common Effect	Chibar2 = 34,77	0,0000	Select Random Effect

Source: Processed by the authors (2026).

1) Chown Test

H_0: If the probability value (p-value) for the cross-section F statistic is greater than the significance level (α = 0.05), then H_0 is accepted, and the Common Effect Model (CEM) is the most appropriate model.

H_1: If the probability value (p-value) for the cross-section F statistic is less than the significance level (α = 0.05), then H_0 is rejected, and the Fixed Effect Model (FEM) is the most appropriate model.

Based on the test results, the Prob > F value is 0.0000. Since this significance value is lower than the 5 percent significance level ($\alpha = 0.05$), H_0 is rejected. This finding indicates the existence of significant cross-regional heterogeneity, implying that the Fixed Effect Model (FEM) is more appropriate than the Common Effect Model (CEM).

2) Hausman Test

H_0: If the probability value (p-value) for the cross-section test is greater than the significance level ($\alpha > 0.05$), then H_0 is accepted, and the Random Effect Model (REM) is the most appropriate model

H_1: If the probability value (p-value) for the cross-section test is less than the significance level ($\alpha < 0.05$), then H_0 is rejected, and the Fixed Effect Model (FEM) is the most appropriate model.

The estimation results show a Prob > chi2 value of 0.7117. Since this value is greater than 0.05, H_0 is accepted, indicating that the Random Effect Model (REM) is more efficient because no evidence of systematic correlation is found between the individual-specific effects and the explanatory variables.

3) Lagrange Multiplier (LM) Test

H_0: If the probability value (p-value) is greater than the significance level ($\alpha > 0.05$), then H_0 is accepted, and the Common Effect Model (CEM) is the most appropriate model

H_1: If the probability value (p-value) is less than the significance level ($\alpha < 0.05$), then H_0 is rejected, and the Random Effect Model (REM) is the most appropriate model.

The test results indicate a Prob > chibar2 value of 0.0000. Since this probability value is well below 0.05, H_0 is rejected, demonstrating that the variance of the individual-specific effects is not equal to zero. Therefore, the Random Effect Model (REM) is statistically superior to the Ordinary Least Squares (OLS) model (CEM).

Based on the results of the Chow Test, Hausman Test, and Lagrange Multiplier Test, the panel data regression model selected and employed in this study is the Random Effect Model (REM). This model is considered more efficient in capturing the heterogeneity of regional characteristics across Bali Province than the alternative panel data regression models.

Classical Assumption Tests

1) Autocorrelation Test

Table 3. Autocorrelation Test Results

Wooldridge test for autocorrelation in panel data H0: no first-order autocorrelation
F(1, 8) = 2.684
Prob > F = 0.1400

Source: Processed by the authors (2026)

Based on the test results, the Prob > F value is 0.1400. Since this probability value is greater than the 0.05 significance level, it can be concluded that the research model is free from autocorrelation problems. Therefore, the estimation results are considered valid.

2) Normality Test

Table 4. Normality Test Results

Variable	Obs	Pr(Skewness)	Pr(Kurtosis)	adj_chi2(2)	Prob>chi2
res	81	0.9927	0.8112	0.06	0.9718

Source: Processed by the authors (2026)

Based on the test results, the probability value (Prob > chi2) is 0.9718. Since this probability value is greater than the 0.05 significance level, the residuals of the research model are normally distributed.

3) Multicollinearity Test

Table 5. Multicollinearity Test Results

	VIF	1/VIF
Log PMA	2.43	0.410684
Internet	2.19	0.457179
Water	2.07	0.482179
Log PMDN	1.56	0.642599
Road	1.47	0.680034
Mean VIF	1.94	.

Source: Processed by the authors (2026)

Based on the test results, all variables have VIF values well below 10, with a Mean VIF of 1.94. This indicates that there is no evidence of multicollinearity in the research model.

4) Cross-Sectional Dependence Test

Table 6. Cross-Sectional Dependence Test Results

Pesaran's test of cross sectional independence = 3,561, Pr = 0.0004
Average absolute value of the off-diagonal elements = 0.280

Source: Processed by the authors (2026)

Based on the results of Pesaran's test, the probability value (Pr) is 0.0004. Since this value is lower than the 0.05 significance level, the research model exhibits cross-sectional dependence. This finding indicates that shocks occurring in one regency/municipality are likely to affect other regencies/municipality within Bali Province. To address this issue and ensure that the estimation results remain valid, efficient, and possess unbiased standard errors, the final estimation of the Random Effect Model (REM) in this study employs Robust Standard Errors (or Cluster-Robust Standard Errors at the regency/municipality level) to correct for cross-sectional dependence among regions.

Random Effect Model Regression Equation

Table 7. REM Regression Equation

Gini	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]
log_pmdn	.00264	.00173	1.53	.126	-.0007	.0060
log_pma	-.00029	.00990	-0.30	.767	-.0022	.0016
Road	.00770	.00684	1.13	.260	-.0057	.0211
Water	.00084	.00067	1.26	.208	-.0004	.0021
Internet	-.00072	.00023	-3.14	.002	-.0011	-.0002
Constant	.23058	.05097	4.52	.000	.1306	.3305

Mean dependent var	0.314	SD dependent var	0.029
Overall r-squared	0.1772	Number of obs	81
Chi-square	46.15	Prob > chi2	0.0000
R-squared within	0.1839	R-squared between	0.1882

Source: Processed by the authors (2026)

Based on the panel data regression equation estimated using the Random Effect Model (REM) with robust standard errors, the Wald Chi-square probability value is 0.0000, indicating that Domestic Investment (PMDN), Foreign Direct Investment (PMA), road infrastructure, access to improved drinking water, and digital infrastructure simultaneously have a significant effect on economic inequality across the regencies/municipality of Bali Province during the 2017–2025 period. Partially, only the internet infrastructure variable exhibits a negative and significant effect ($p = 0.002$) on economic inequality, indicating that increased digital access penetration at the regency/municipality level plays an effective role in reducing economic disparities.

Conversely, the other variables, namely Domestic Investment (PMDN) ($p = 0.126$), Foreign Direct Investment (PMA) ($p = 0.767$), road infrastructure ($p = 0.260$), and access to improved drinking water ($p = 0.208$), do not have a statistically significant partial effect on economic inequality at the 95% confidence level. These results indicate that, within the scope of the study area, the distribution of investment and the availability of basic physical infrastructure have not yet become sufficiently strong factors in explaining variations in economic inequality across regions. Therefore, it can be concluded that digital inclusion is the most crucial and consistent instrument for reducing economic inequality in the study area, while the other economic factors did not exert statistically significant effects during the observation period.

Hypothesis Testing Results

a) Simultaneous Effect Test (F-Test) of Investment and Infrastructure on Economic Inequality.

The model feasibility test was conducted to determine whether all independent variables in the study jointly affect the dependent variable, as formulated in H_1. In the panel data regression model using the Random Effect Model (REM) approach, simultaneous testing was performed using the Wald Chi-Square Test.

The Wald chi2 value was 46.15 with a probability value (Prob > chi2) of 0.0000, which was substantially lower than the significance level of α = 0.05. Therefore, H_0 was rejected and H_1 was accepted: Domestic Investment (PMDN), Foreign Direct Investment (PMA), road infrastructure, access to improved drinking water, and digital infrastructure simultaneously had a significant effect on economic inequality during the study period.

b) Partial Test (t-Test)

The partial test was conducted to determine the individual effect of each independent variable on economic inequality. Because the research hypotheses (H_2 to H_6) were formulated directionally (one-tailed, either positive or negative), the partial testing in this section employed a one-tailed test rather than a two-tailed test. By default, the Stata regression output reports two-tailed probability values. Therefore, the one-tailed probability values were obtained by dividing the two-tailed probability values by two (one-tailed p = two-tailed p ÷ 2), subject to the additional condition that the estimated coefficient direction must correspond to the hypothesized direction. When the coefficient direction was contrary to the hypothesized direction, H_0 was automatically accepted without considering the magnitude of the probability value because the data did not support the proposed direction of effect. The testing criteria at the significance level of α = 0.05 (95 percent confidence level) were as follows: when the coefficient direction corresponded to the hypothesis and the one-tailed probability value was < 0.05, H_0 was rejected and the alternative hypothesis was accepted; when the coefficient direction did not correspond to the hypothesis or the one-tailed probability value was ≥ 0.05, H_0 was accepted and the alternative hypothesis was rejected.

1) Testing the Effect of X1 (PMDN) on Y (Economic Inequality)

The first hypothesis in this study was formulated as follows:

H_0 : Domestic Investment (PMDN) does not have a significant positive effect on economic inequality across the regencies/municipality of Bali Province ($\beta \leq 0$).

H_2 : Domestic Investment (PMDN) has a significant positive effect on economic inequality across the regencies/municipality of Bali Province ($\beta > 0$).

The Random Effect Model estimation results showed that the coefficient of log_pmdn was 0.0026 (positive direction, consistent with H_2), with a two-tailed probability value of 0.126. Therefore, the one-tailed probability value was 0.126 ÷ 2 = 0.063. Because the coefficient direction was consistent with the hypothesis and the one-tailed probability value (0.063) was > 0.05, H_0 was accepted. Statistically, Domestic Investment (PMDN) did not have a significant effect on inequality in the study area. This finding indicates that domestic investment entering the regencies/municipality of Bali had not generated an income differentiation effect capable of significantly altering the structure of inequality during the 2017–2025 period.

2) Testing the Effect of X2 (PMA) on Y (Economic Inequality)

The second hypothesis in this study was formulated as follows:

H_0 : Foreign Direct Investment (PMA) does not have a significant positive effect on economic inequality across the regencies/municipality of Bali Province ($\beta \leq 0$).

H_3 : Foreign Direct Investment (PMA) has a significant positive effect on economic inequality across the regencies/municipality of Bali Province ($\beta > 0$).

The estimation results showed that the coefficient of log_pma was -0.00029 (negative direction), with a two-tailed probability value of 0.767. Therefore, the one-tailed probability value was 0.767 ÷ 2 = 0.383. Because the one-tailed probability value (0.383) was substantially greater than 0.05, H_0 was accepted and H_3 was rejected. Foreign Direct Investment (PMA) was not proven to have a significant effect on economic inequality. This finding indicates that foreign investment in Bali, which is concentrated in the tourism sector in the southern region, had not developed sufficiently strong economic linkages to influence the income distribution structure in a measurable manner during the 2017–2025 period, consistent with the concept of enclave investment in Dependency Theory (Prebisch, 1950; Frank, 1967).

3) Testing the Effect of X3 (Road Infrastructure) on Y (Economic Inequality)

The third hypothesis in this study was formulated as follows:

H_0 : Road infrastructure does not have a significant positive effect on economic inequality across the regencies/municipality of Bali Province ($\beta \leq 0$).

H_4 : Road infrastructure has a significant positive effect on economic inequality across the regencies/municipality of Bali Province ($\beta > 0$).

The estimation results showed that the road infrastructure coefficient was 0.00770 (positive direction, consistent with H_4), with a two-tailed probability value of 0.260. Therefore, the one-tailed probability value was 0.260 ÷ 2 = 0.130. Because the coefficient direction was consistent with the hypothesis and the one-tailed probability value (0.130) was > 0.05, H_0 was accepted. Road infrastructure in Bali may already be relatively evenly distributed or may have reached a saturation point in terms of its effect on economic mobility, such that additional road access no longer generates changes in the level of expenditure inequality.

4) Testing the Effect of X4 (Access to Improved Drinking Water) on Y (Economic Inequality)

The fourth hypothesis in this study was formulated as follows:

H_0 : Access to improved drinking water does not have a significant negative effect on economic inequality across the regencies/municipality of Bali Province ($\beta \geq 0$).

H_5 : Access to improved drinking water has a significant negative effect on economic inequality across the regencies/municipality of Bali Province ($\beta < 0$).

The estimation results showed that the water access coefficient was 0.00084, indicating a positive sign that was contrary to H_5, which predicted a negative effect. Because the coefficient direction did not correspond to the hypothesized direction, H_0 was accepted and H_5 was rejected without further consideration of the probability value (the one-tailed probability value for a negative direction when the coefficient is positive is automatically substantially greater than 0.05). As an additional observation, the two-tailed probability value of 0.208 also indicated that this coefficient was not statistically significant in either direction. Therefore, access to improved drinking water was not proven to function as an equalizing factor for economic inequality in Bali, as hypothesized. Empirically, access to improved drinking water across all regions of Bali had already reached a very high and relatively equitable level of coverage, such that this variable no longer possessed sufficient discriminatory power or variation to influence economic inequality across regions.

5) Testing the Effect of X5 (Internet Penetration) on Y (Economic Inequality)
The fifth hypothesis in this study was formulated as follows:

H_0 : Digital infrastructure does not have a significant negative effect on economic inequality across the regencies/municipality of Bali Province ($\beta \geq 0$).

H_6 : Digital infrastructure has a significant negative effect on economic inequality across the regencies/municipality of Bali Province ($\beta < 0$).

The estimation results showed that the internet coefficient was -0.00072 (negative direction, consistent with H_6), with a two-tailed probability value of 0.002. Therefore, the one-tailed probability value was 0.001. Because the coefficient direction corresponded to the hypothesis and the one-tailed probability value was substantially below 0.05, H_0 was rejected and H_6 was accepted at the 1 percent significance level. Digital infrastructure was proven to have a negative and significant effect on economic inequality; every increase in internet access reduced the Gini Ratio by 0.0009 points, ceteris paribus. This finding confirms the role of digital infrastructure as an economic equalizer, consistent with the non-rival nature of knowledge capital in Endogenous Growth Theory (Romer, 1986, 1990) and the spread effect mechanism (Myrdal, 1957), which operates through the dissemination of information and the expansion of market access to lagging regions.

c) Coefficient of Determination Test

The coefficient of determination (R-squared) was used to measure the extent to which the independent variables were capable of explaining variation in the dependent variable within the regression model. According to Porter and Gujarati (2008), the coefficient of determination ranges from 0 to 1. The higher the R^2 value, the greater the ability of the independent variables to explain the dependent variable. In this study, the coefficient of determination in the Random Effect Model was assessed using the overall R-squared value obtained from the regression estimation results.

Based on the estimation results, the overall R-squared value was 0.1772 or 17.72 percent. This result indicates that Domestic Investment (PMDN), Foreign Direct Investment (PMA), road infrastructure, access to improved drinking water, and digital infrastructure were able to explain 17.72 percent of the variation in economic inequality across the regencies/municipality in the study area. Meanwhile, the remaining 82.28 percent was explained by other variables outside the research model that were not included in the analysis.

The overall R^2 value of 17.72 percent should be interpreted proportionally within the methodological context of regional macroeconomic panel data. First, in studies employing an inequality index (Gini Ratio) as the dependent variable, a low R^2 value is a common phenomenon that has been documented in the international literature. Lessmann (2014), in a study of regional inequality across 55 countries, found that standard econometric models generally explain only 10–25 percent of inequality variation because highly heterogeneous structural, historical, and geographical factors are difficult to quantify within a single regression model. Second, model validity does not depend solely on the R^2 value, but also on simultaneous significance (Wald chi2 = 46.15; p = 0.0000) and the use of robust standard errors, which ensure that the estimates remain consistent and unbiased. Porter and Gujarati (2008) emphasize that in regional economic panel data, a low R^2 value does not indicate a poor model when the estimated regression coefficients consistently exhibit theoretically appropriate directions and statistical significance. Third, the within R-squared value of 0.1839 indicates that the model was able to explain 18.39 percent of the variation in inequality occurring over the observation period within each regency/municipality. This represents the most policy-relevant dimension because it reflects the response of inequality to changes in investment and infrastructure over time. Therefore, the limited overall R^2 value more accurately reflects the multidimensional complexity of inequality than a weakness in the specification of the model employed.

Discussion of Research Findings

Simultaneous Effects of Investment and Infrastructure on Economic Inequality across Regencies/Municipality in Bali Province during 2017–2025

Based on the estimation results of the Random Effect Model (REM) with robust standard errors clustered at the regency/municipality level, the Wald Chi-square value was 46.15 with a probability of 0.0000, which was lower than the significance level of $\alpha = 0.05$. These results demonstrate that Domestic Investment (PMDN), Foreign Direct Investment (PMA), road infrastructure, access to improved drinking water, and digital infrastructure simultaneously had a significant effect on economic inequality across regencies/municipality in Bali Province during the 2017–2025 period, although, as discussed in the following partial analysis, this significant contribution at the individual level was primarily attributable to the digital infrastructure variable.

This finding is consistent with the theoretical frameworks underlying the study, namely the Cumulative Causation Theory proposed by Myrdal (1957) and the Endogenous Growth Theory advanced by Romer (1986, 1990). Myrdal argues that economic growth is cumulative and tends to generate interregional inequality through the backwash effect mechanism, a condition in which factors of production such as labor, capital, and investment tend to flow from less-developed regions to more economically advanced regions. Romer (1990) emphasizes that the accumulation of both physical and knowledge capital constitutes a primary source of long-term growth; therefore, the geographically uneven distribution of investment and infrastructure has the potential to produce an equally uneven distribution of output and welfare.

Empirical evidence from various studies supports the importance of considering investment and infrastructure simultaneously when explaining regional inequality. Cali & Sen (2011), in their study in India, demonstrated that investment and infrastructure jointly had a significant effect on regional inequality, although the direction of the effect depended on the spatial distribution of investment. Meanwhile, Agénor & Moreno-dodson (2006) emphasized that the geographically uneven development of physical and information technology infrastructure may instead widen disparities across regions. In the Indonesian context, Yusuf & Sumner (2015) found that investment and infrastructure variables simultaneously affected the Gini index across Indonesian provinces, although the direction varied depending on the type of investment and regional characteristics.

The coefficient of determination (overall R-squared) of 0.1772, or approximately 17.72 percent, indicates that the model was capable of explaining 17.72 percent of the variation in economic inequality in Bali, while the remaining 82.28 percent was explained by other variables outside the research model. This relatively low R-squared value does not necessarily weaken the validity of the model, considering that in panel data econometric studies using an inequality index as the dependent variable, which is influenced by numerous structural factors, such a value remains scientifically acceptable. Porter and Gujarati (2008) emphasize that, in the context of regional economic panel data, a low R-squared value does not always indicate a poor model because variation in inequality is often driven by highly heterogeneous factors that are difficult to quantify within a single regression model. This is consistent with Lessmann (2014), who states that regional inequality is influenced by a complex combination of historical, geographical, structural, and policy-related factors that cannot be fully captured by conventional variables. Therefore, investment and infrastructure simultaneously play a relevant role in shaping the pattern of economic inequality in Bali Province, although, as discussed further below, only digital infrastructure was found to have a statistically significant partial effect after data correction and the application of robust standard errors.

Partial Effect of Domestic Investment (PMDN) on Economic Inequality across Regencies/Municipality in Bali Province during 2017–2025

The Random Effect Model estimation results show that the Domestic Investment (PMDN) variable, proxied by its natural logarithmic value (log_pmdn), had a coefficient of 0.0026489, a z-statistic of 1.53, and a two-tailed probability value of 0.126. Because the research hypothesis (H_2) was formulated directionally, predicting that PMDN would have a positive effect on economic inequality, a one-tailed test was applied. Accordingly, the one-tailed probability value was calculated as 0.126 ÷ 2 = 0.063. Although the positive coefficient direction was consistent with the hypothesized direction, the one-tailed probability value (0.063) exceeded the significance level of α = 0.05; therefore, H_0 was accepted and H_2 was rejected. Thus, following data correction and the use of robust standard errors, PMDN was not proven to have a significant effect on economic inequality in Bali Province at the 5 percent significance level, although the direction of the effect remained consistent with the theoretical prediction.

This finding is consistent with the Cumulative Causation Theory (Myrdal, 1957), according to which investment tends to flow toward regions that already possess comparative advantages, such as Badung and Denpasar. Nevertheless, the statistical insignificance of this effect indicates that the backwash effect mechanism operating through PMDN was not sufficiently strong to generate statistically detectable disparities at the regency/municipality level in Bali during the study period and that factors other than domestic investment were likely more dominant in shaping the observed pattern of inequality.

Partial Effect of Foreign Direct Investment (PMA) on Economic Inequality across Regencies/Municipality in Bali Province during 2017–2025

The Random Effect Model estimation results show that the Foreign Direct Investment (PMA) variable, proxied by its natural logarithmic value (log_pma), had a coefficient of -0.000293, a z-statistic of -0.30, and a probability value of 0.767. This probability value was substantially greater than the significance level of α = 0.05; therefore, it can be concluded that PMA did not have a significant effect on economic inequality in Bali Province during the 2017–2025 period. Changes in the value of foreign investment did not have a statistically detectable effect on fluctuations in Bali's Gini index.

This finding indicates that the Cumulative Causation Theory model (Myrdal, 1957), which positions foreign investment as a driver of regional disparities, was not empirically supported in this region. This result may be explained by the fact that PMA in Bali is highly concentrated in the tourism sector in the southern region. Such extreme spatial concentration causes variation in PMA across regencies to be insufficiently dynamic to produce significant differences in the inequality index. Moreover, according to Endogenous Growth Theory (Romer, 1990), the effectiveness of foreign investment depends heavily on the absorptive capacity of the local economy. The dominance of PMA in the labor-intensive tourism service sector limits technology transfer to other sectors, thereby minimizing spillover effects on lagging regencies.

Theoretically, this condition also reflects the concept of enclave-type investment, as explained in Dependency Theory (Frank, 1967; Prebisch, 1950), whereby foreign investment operations have limited linkages with the local economy. Studies by Sylwester (2006) and Bhandari (2007) support the view that the effect of PMA on inequality depends substantially on the destination sector. In Bali, because tourism has already become the mainstream of the economy, PMA does not fundamentally alter the income distribution structure. Therefore, future foreign investment policies should be directed toward sectoral diversification and stronger supply-chain integration with local MSMEs so that investment can generate more inclusive effects and contribute meaningfully to economic equity.

Partial Effect of Road Infrastructure on Economic Inequality across Regencies/Municipality in Bali Province during 2017–2025

The Random Effect Model estimation results show that the road infrastructure variable had a coefficient of 0.0077042, a z-statistic of 1.13, and a two-tailed probability value of 0.260. Because the research hypothesis (H_4) was formulated directionally, a one-tailed test was applied, resulting in a one-tailed probability value of 0.260 ÷ 2 = 0.130. Although the positive coefficient direction was consistent with the hypothesized direction, the one-tailed probability value (0.130) was substantially greater than the significance level of $\alpha = 0.05$; therefore, H_0 was accepted and H_4 was rejected. Thus, road infrastructure was not proven to have a significant effect on economic inequality in Bali Province.

Although statistically insignificant, the positive coefficient direction can still be explained through the framework of Cumulative Causation Theory (Myrdal, 1957) and Krugman's New Economic Geography Theory (1991), according to which transportation infrastructure development concentrated in already advanced regions has the potential to facilitate the backwash effect and strengthen agglomeration processes. This result is consistent with the findings of Demirgüç-kunt et al. (2020) and Baum-snow et al. (2017), which show that the development of major road networks in developing regions tends to reinforce the dominance of core cities. Nevertheless, any such effect, if present, was not sufficiently strong or consistent to be statistically detected at the regency/municipality level in Bali during the study period. Future road development policies should nevertheless remain oriented toward spatial equity, given that the positive coefficient direction provides an initial indication, although not statistically confirmed, that the uneven distribution of road infrastructure may potentially contribute to inequality.

Partial Effect of Water Infrastructure on Economic Inequality across Regencies/Municipality in Bali Province during 2017–2025

The estimation results show that the access to improved drinking water variable had a coefficient of 0.0008471, a z-statistic of 1.26, and a two-tailed probability value of 0.208. This coefficient was positive, whereas H_5 predicted that access to improved drinking water would have a negative effect on economic inequality. Because the estimated coefficient direction was contrary to the hypothesized direction, H_0 was accepted and H_5 was rejected without further consideration of the probability value, as the data did not support the proposed direction of effect. As an additional observation, the two-tailed probability value of 0.208 also indicates that the coefficient was not statistically significant in either direction. Therefore, the rejection of H_5 was supported both by the inconsistent coefficient direction and by the absence of statistical significance. This finding indicates that variation in access to improved drinking water across regions in Bali was not proven to function as an equalizing factor for economic inequality, as hypothesized.

Theoretically, although access to drinking water constitutes a minimum prerequisite for development according to Myrdal (1957), this variable is not a primary determinant of economic disparities in Bali. Factors such as investment and transportation connectivity are considerably more dominant in determining inequality. Furthermore, based on data from BPS Provinsi Bali, household access to improved drinking water across all regencies/municipality in Bali has reached a relatively high and equitable level, such that the remaining cross-regional variation is too limited to generate a statistically detectable effect, either in reducing or increasing inequality. Consistent with the findings of Cali & Sen (2011) and Nurdina (2021), the effectiveness of infrastructure in reducing inequality is highly dependent on the initial level of infrastructure availability. In regions that have already achieved high coverage, additional access to water no longer produces a meaningful effect on changes in the inequality index, making the direction of its effect inconsistent and difficult to predict solely through the spread effect theory.

Although H_5 was not statistically or directionally supported in this study, it is important to note that access to improved drinking water remains highly relevant from a policy perspective in the context of sustainable development in Bali. Inequality in access to improved drinking water at both the household and inter-village levels in Bali still requires serious attention, particularly given the increasing pressure on water resources resulting from tourism growth. Policies promoting inclusive and equitable access to improved drinking water are relevant not only for reducing inequality but also for maintaining the sustainability of natural resources and the overall quality of life of the Balinese population.

Partial Effect of Digital Infrastructure (Internet) on Economic Inequality across Regencies/Municipality in Bali Province during 2017–2025

The estimation results show that the digital infrastructure (Internet) variable had a coefficient of -0.000726, a z-statistic of -3.14, and a probability value of 0.002. Because the research hypothesis (H_6) was formulated directionally, predicting that internet access would have a negative effect on economic inequality, a one-tailed test was applied. Accordingly, the one-tailed probability value was calculated as 0.002 ÷ 2 = 0.001. This probability value was substantially lower than 0.05, indicating that digital infrastructure had a negative and significant effect on economic inequality in Bali Province. This means that every increase in internet access reduced the Gini Ratio by 0.0007266 points, ceteris paribus. This finding is consistent with the estimation results prior to data correction and confirms that digital infrastructure functions as the most robust economic equalizer among all variables examined in this study.

The theoretical foundation refers to Endogenous Growth Theory (Romer, 1986), in which digital technology constitutes knowledge capital that generates positive externalities for productivity and innovation. Unlike physical capital, digital access is non-rival and is capable of distributing the benefits of development more evenly through the spread effect mechanism (Myrdal, 1957). Information technology can reduce geographical barriers and information transaction costs that have historically contributed to inequality, consistent with ICT4D theory (Heeks, 2010). By reducing information asymmetry between advanced and lagging regions, the internet functions as an effective instrument for promoting greater equity.

The findings of this study are consistent with the research of Asongu et al. (2020) and Asmoro, S. A. (2023), who demonstrated that internet access reduces inequality through digital financial inclusion and expanded market access for MSMEs. In Bali, broader internet access enables the agricultural and handicraft sectors in regencies such as Bangli and Karangasem to reach global consumers through e-commerce. This success confirms that investment in digital infrastructure represents the most strategic policy for empowering regions marginalized from the main centers of growth. Accelerating digital infrastructure development in regencies where internet access remains limited is therefore the principal policy recommendation for achieving inclusive economic equity in Bali Province.

CONCLUSION

Based on the estimation results of the Random Effect Model with robust standard errors using panel data from the nine regencies/municipality in Bali Province during the 2017–2025 period and the hypothesis testing (H_1–H_6), several main conclusions can be drawn. First, Domestic Investment (PMDN), Foreign Direct Investment (PMA), road infrastructure, access to improved drinking water, and digital infrastructure were found to have a significant simultaneous effect on economic inequality (H_1 accepted). This is evidenced by the Wald Chi-square value of 46.15 with a probability value of 0.0000, confirming that the proposed model is appropriate for explaining variations in economic inequality within the study area.

Furthermore, the partial test results indicate that only the digital infrastructure variable had a negative and significant effect on economic inequality (H_6 accepted). With a coefficient of -0.0007 and a one-tailed p-value of 0.001, digital infrastructure proved to be the only equalizing instrument that remained consistent and robust after the adjustment of standard errors. This finding provides strong empirical support for Endogenous Growth Theory (Romer, 1990), which emphasizes the positive externalities of knowledge capital accumulation through the utilization of information technology in reducing regional disparities.

Conversely, the remaining variables did not exhibit statistical significance after the robust correction was applied. Domestic Investment (PMDN) (H_2 rejected) and road infrastructure (H_4 rejected) were not statistically significant at the 5 percent significance level, although both variables exhibited positive coefficients consistent with the initial hypotheses. Meanwhile, Foreign Direct Investment (PMA) (H_3 rejected) and access to improved drinking water (H_5 rejected) did not have significant effects, and the estimated coefficient directions did not support the proposed hypotheses. From a methodological perspective, this study also demonstrates that the use of conventional standard errors in panel data with a limited number of cross-sectional units (N = 9) may produce overstated significance estimates. Therefore, the application of cluster-robust standard errors in this study constitutes a crucial methodological approach for generating more accurate and academically reliable conclusions.

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