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Gravity of Income Inequality and Spatial Model in Java-Bali, Indonesia
(*Graviti Ketidaksamaan Pendapatan dan Model Spatial di Jawa–Bali, Indonesia*)

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ABSTRACT

This study analyses the level of income inequality in the Java-Bali region from 2015 to 2022, examining the direct, spillover, and mediating effects of key determinants using centre-of-gravity, spatial and mediation analysis. Results indicate that overall income inequality is relatively low although welfare distribution across provinces remains uneven. Spatial estimates show that higher real GRDP per capita reduces individual income inequality, while a larger share of highly-educated workers is associated with greater inequality. Higher population density increases income levels but also exacerbates inequality. Other factors including environmental quality, labour dependency ratios, regional expenditure, and democratic conditions do not exhibit statistically significant effects on inequality. GRDP gap analysis reveals that higher real GRDP per capita and greater labour dependency widen the GRDP gap between Java-Bali and other islands. Conversely, higher education attainment, increased population density, and stronger democratic conditions contribute to narrowing the inter-island gap, with significant regional spillover effects. Mediation results indicate that real GRDP per capita does not mediate the effects of exogenous variables on the Gini coefficient, but it does mediate the effects of population density and regional expenditure on the GRDP gap. Overall, the study provides a comprehensive assessment of inequality combining Gini coefficients and GRDP gap measures. The findings highlight the importance of enhancing productivity through improving human capital, strengthening regional growth nodes, improving the effectiveness of public expenditure, and strengthening democratic institutions to achieve more equitable welfare outcomes.

Keywords: Income inequality; education; population density; centre of gravity; spatial; mediation

ABSTRAK

Kajian ini menganalisis tahap ketidaksamaan pendapatan serta kesan langsung, limpahan dan pengantara pembolehubah penentu di Pulau Jawa-Bali sepanjang 2015-2022. Kajian menggunakan pusat graviti, pemodelan spatial dan analisis pengantaraan. Menggunakan kaedah pusat graviti, kami mendapati bahawa jurang ketidaksamaan pendapatan relatif adalah rendah, tetapi tahap kebajikan antara wilayah adalah tidak sekata. Berdasarkan keputusan model spatial menunjukkan bahawa peningkatan dalam KDNK sebenar per kapita mengurangkan ketidaksamaan dalam kalangan individu di wilayah yang diperhatikan. Peningkatan pekerja berpendidikan tinggi meningkatkan ketidaksamaan. Peningkatan kepadatan penduduk meningkatkan pendapatan tetapi juga meningkatkan ketidaksamaan di rantau ini. Sementara itu, kualiti alam sekitar, beban pergantungan pekerja, perbelanjaan wilayah, dan demokrasi tidak mempunyai kesan yang ketara. Sebaliknya, peningkatan dalam GRDP per kapita dan pergantungan pekerja akan meningkatkan jurang GRDP. Pada masa yang sama, pendidikan, kepadatan penduduk, dan demokrasi dapat mengurangkan jurang pendapatan wilayah antara Jawa-Bali dan pulau-pulau lain. Terdapat kesan limpahan yang ketara. GRDP sebenar per kapita tidak mengantara kesan pembolehubah eksogen pada Gini, tetapi boleh menjadi pengantara kepadatan penduduk dan perbelanjaan serantau pada jurang GRDP. Kajian itu menggunakan model pusat graviti dan spatial skala pulau untuk menjelaskan ketidaksamaan pendapatan melalui perbandingan jurang Gini dan GRDP. Penemuan ini membayangkan *kepentingan mengukuhkan produktiviti melalui pekerja berpendidikan, membangunkan wilayah nodal, keberkesanan perbelanjaan, dan demokrasi untuk memupuk kebajikan yang lebih saksama.*

Kata kunci: Ketidaksamaan pendapatan; pendidikan; kepadatan penduduk; Pusat graviti; spatial; pengantaraan

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INTRODUCTION

Since the Covid-19 pandemic, income inequality has gained greater attention (World Bank 2023), as it is influenced by democracy, environmental conditions, and income levels (Acheampong et al. 2023; Rahman, et al. 2023; Zhang et al. 2023). In Indonesia, disparities across provinces are shaped by education, employment opportunities, and regional government expenditure (Anderson et al. 2016; Hornok et al. 2023; Sulistyaningrum & Tjahjadi 2022; Wicaksono et al. 2017).

Current development emphasizes not only equity and economic growth but also environmental sustainability, with the aim of achieving well-being without widening disparities (Li et al. 2023a; Singh & Yadav 2021; Presidential Regulation of the Republic of Indonesia Number 111 2022). However, market activities and climate change often exacerbate inequality (United Nations 2020; Chisadza et al. 2023), although appropriately designed sustainable policies may mitigate these effects (Li et al. 2023).

Human capital and institutions also play a critical role in shaping income distribution. While higher income and education are associated with lower inequality and improved environmental outcomes (Zhu 2023; Ali 2023; Grossman & Krueger 1991), the supply of skilled labour nevertheless often lags behind demand (International Labour Organization 2023). Democratic governance influences decision-making and equitable outcomes (Acemoglu et al. 2015), while effective government expenditure can reduce inequality and improve welfare among low-income groups (Dhital et al. 2023; Zulkarnaen (2017).

Spatial and spillover analyses further highlight the dynamics of inequality across regions (Almuazam & Sirait 2022; Mahadi et al. 2022; J. Wang et al. 2022). In Indonesia, the Gini ratio rose from 32.2 in 1998 to 38.3 in 2023, indicating persistent inequality despite a brief decline during 2015–2019 before rising again following the Covid-19 pandemic.

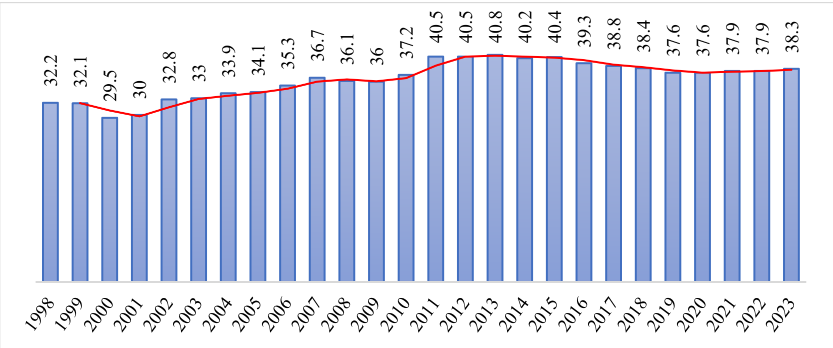

FIGURE 1. Development of Gini Ratio in Indonesia 1998-2023
Source: World Bank (2024)

Infrastructure development initially contributed to inequality reduction up to 2019, but this trend was reversed during the Covid-19 pandemic. By 2022, inequality had increased in West Java, Yogyakarta, DKI Jakarta, and Central Java, while only Banten and Bali recorded lower inequality levels than in 2019.

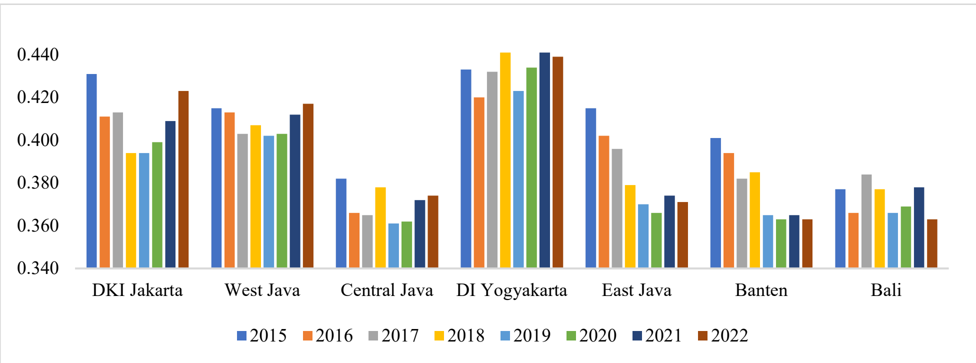

FIGURE 2. Development of Gini ratio in Java-Bali, 2015-2022
Source: BPS-Statistics Indonesia (2023)

Figure 3 shows GRDP distribution in Java–Bali relative to national GDP. From 2015 to 2019, the GRDP shares for all provinces increased, but these declined during the Covid-19 pandemic. By 2022, only Central Java and Bali recorded lower shares than in 2015, while other regions, especially Sumatra, experienced increases partly due to the resilient agricultural sector.

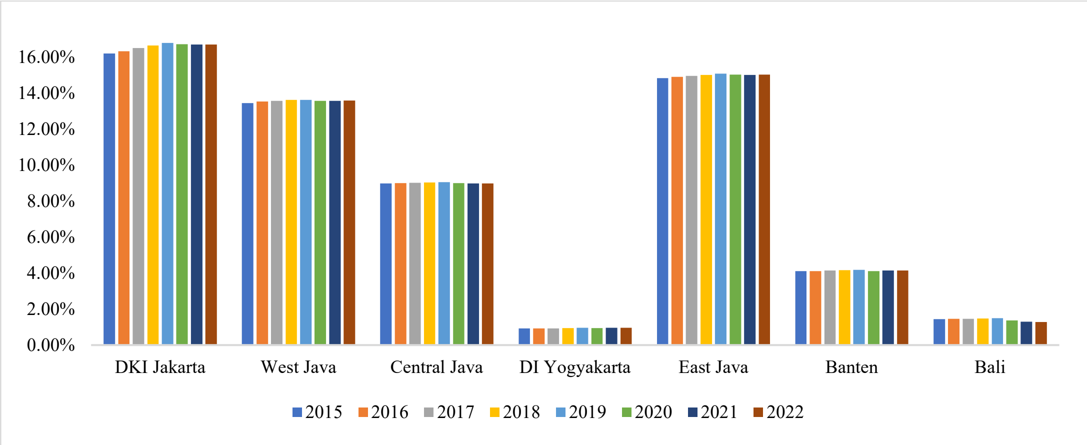

FIGURE 3. Development of GRDP gap of provinces in Java-Bali relative to the national average GDP
Source: BPS-Statistics Indonesia (2023)

This study analyses income inequality from multiple perspectives. First, it identifies regions with the highest inequality, the highest GRDP per capita, and the largest GRDP gap relative to the regional midpoint in Java-Bali. Second, it examines the direct spillover effects of key determinants using spatial econometric techniques. Third, it tests the mediating role of selected intervening variables affecting inequality.

Previous studies in Indonesia (Hornok et al. 2023; Sulistyaningrum & Tjahjadi 2022; Wicaksono et al. 2017) have largely focused on education, income, and employment. In contrast, this study differs in terms of variable selection, modelling, and regional scope.

This study contributes to the literature and policy discourse on income inequality and its determining factors. Methodologically, it introduces a centre-of-gravity approach to measure interprovincial inequality. Furthermore, mediation analysis is employed to examine how factors such as worker education, dependency burden, environmental quality, population density, democracy, and per capita regional expenditure influence inequality. It applies island-scale spatial regression to capture both direct and spillover effects comprehensively.

LITERATURE REVIEW

INCOME INEQUALITY AND DISPARITY OF ECONOMIC DEVELOPMENT

Income inequality undermines social welfare through economic inefficiencies, low savings, rent-seeking behavior, and excessive investment in higher education (Todaro & Smith 2020). In capitalist economies, where returns to capital exceed output growth, disparities may widen further (Piketty 2014). While Kuznets (1955) hypothesized that inequality rises and then falls with economic maturity, Myrdal (1957) argued that this pattern does not hold in developing countries, highlighting the importance of inclusive, labour-intensive growth strategies (Klasen 2010). Historical declines in inequality reflect political and economic shocks, rather than natural processes (Piketty 2014). Given the complex links between inequality, environmental pressures, and social conditions, balanced development is essential (Purvis 2019; Ranjbari et al. 2021). This study thus examines income inequality in Java–Bali, a high-output region characterized by persistent disparities, using a multi-dimensional framework.

RELATIONSHIP BETWEEN REAL PER CAPITA INCOME AND INCOME INEQUALITY

Recent evidence indicates that economic growth tends to increases inequality more strongly in middle-income than in high-income countries (Alamanda 2021). An inverted Kuznets curve has been observed in lower- and upper-middle-income economies (Ali et al. 2022). Given that Java–Bali is Indonesia's largest economic hub, this study hypothesizes that higher real GRDP per capita reduces the Gini ratio while widening the interregional GRDP gap.

RELATIONSHIP BETWEEN ENVIRONMENTAL QUALITY AND INCOME INEQUALITY

Industrialization, energy use, and lifestyle changes have worsened environmental degradation, often at the expense of economic equity (Maryam et al. 2017; Phimphanthavong 2013). Air pollution has been shown to increase income inequality, with significant spatial spillover effects (Wu & Id 2020), while higher carbon emissions in some countries have reduced inequality (Khan et al. 2023). In Java–Bali, this study hypothesizes that improved environmental quality reduces the Gini ratio and widens the GRDP gap.

RELATIONSHIP BETWEEN WORKER EDUCATION AND INCOME INEQUALITY

Human capital is central to sustainable development and inequality reduction, as income disparities are closely linked to differences in education and skill training (Becker 1964). Although highly educated workers typically earn higher wages, returns to education may diminish in more developed regions (Hanushek & Woessmann 2021). Evidence from Indonesia remains mixed, with some studies linking higher education attainment with rising inequality (Hakim & Rosini 2022; Rahman et al. 2023). This study hypothesizes that a more even distribution of highly educated workers reduces both Gini ratio and the GRDP gap.

RELATIONSHIP BETWEEN WORKER DEPENDENCY BURDEN AND INCOME INEQUALITY

According to Piketty (2015), rising wages in market economies may encourage capital-intensive production, reducing employment opportunities while increasing labour's income share. Technological changes further affect routine occupations, with both very low and very high levels of innovation linked to higher unemployment (Loebbing & Acemoglu 2022; Wacker et al. 2020; Sinha et al. 2021), although some workers transition into skilled positions (Battisti et al. 2023). Demographic factors also influence the worker dependency ratios (Marois et al. 2022). This study hypothesizes that a higher dependency burden increases both Gini ratio and the GRDP gap.

RELATIONSHIP BETWEEN GOVERNMENT SPENDING AND INCOME INEQUALITY, ENVIRONMENT, AND PER CAPITA OUTPUT

Government expenditure influences development outcomes and sustainability (Purvis 2019; Ranjbari et al. 2021). Expansionary fiscal policies can benefit low-income households (Dhital et al. 2023), while social protection and health expenditure tend to reduce inequality more effectively than spending on education and housing (Martinez-Vazquez et al. 2012). Accordingly, this study hypothesizes that higher per capita local government spending reduces the Gini ratio and the GRDP gap.

RELATIONSHIP BETWEEN DEMOCRACY AND INCOME INEQUALITY

Income inequality is influenced by political dynamics. Empirical studies show mixed effects: Gu & Wang (2022) associate inequality with global political polarization; Novokmet et al. (2017) find sharper increases in inequality in Russia than in China; and Acheampong et al. (2023) find that democracy increases inequality in parts of Africa but has neutral effects in East Africa. In the context of Java-Bali, this study hypothesizes that a higher democracy index reduces both the Gini ratio and the GRDP gap.

METHODOLOGY

This study examines seven provinces in Java Bali, namely Banten, DKI Jakarta, West Java, East Java, Central Java, Yogyakarta, and Bali, using 2023 data on the Gini ratio, real GRDP per capita, and the GRDP gap. The centre-of-gravity method is employed to capture current patterns of income disparities.

For the spatial panel regression analysis, annual data for the period 2015-2022 were obtained from BPS covering the Gini ratio, real GRDP per capita, the share of highly educated workers, worker `dependency burden, population density, and the democracy index. Data on environmental quality were sourced from the Ministry of Environment, while data on regional government expenditure per capita were obtained from the Ministry of Finance. Geographic coordinates and inter-provincial distances were derived from Google Maps.

VARIABLE OPERATIONAL DEFINITION

The study employs a total of nine variables. The following section presents their operational definitions, data sources, calculation methods, and measurement units:

TABLE 1. Operational definition of variables

Variable	Definition	Indicator	Unit
Gini ratio	Sourced from Statistics Indonesia, measures income inequality based on expenditure disparities. Values close to 0 indicate greater equality, while those close to 1 indicate greater inequality. The data are transformed into natural logarithms.	$$GR = 1 - \sum_{i=1}^{N} F_{pi}(F_{ci} + F_{ci-1})$$ GR denotes the Gini ratio. F_{pi} represents the cumulative proportion of the population in the i-expenditure class, while F_{ci} denotes the cumulative proportion of expenditure in class-*i*.	%

Variable	Definition	Indicator	Unit
GRDP gap	Under the centre-of- gravity method, the GRDP gap captures income disparities among Java-Bali provinces. In the regression model, it reflects differences between Java-Bali and other islands, representing each province's GRDP relative to the national average. Data from Statistics Indonesia are transformed into natural logarithms.	$\frac{GRDP\ at\ constant\ prices\ of\ the\ province}{National\ Gross\ Domestic\ Product\ at\ constant\ prices/34\ provinces}$ $(national\ average\ GDP)$	%
Environmental quality (IKLH)*	This index measures water, air, and land quality across seven Java–Bali provinces. Data from the Ministry of Environment are transformed into natural logarithms.	$IKLH = (30\%\ x\ IKA) + (30\%\ x\ IKU) + (40\%\ x\ IKTL)$	%
Real GRDP per capita	The GRDP at constant prices divided by the mid-year population. Data from Statistics Indonesia are transformed into natural logarithms.	$Real\ GRDP\ per\ capita = \frac{GRDP\ at\ constant\ prices}{total\ population}$	%
Highly educated workers	The proportion of highly educated workers relative to total workers by province, sourced from Statistics Indonesia and transformed into natural logarithms.	$\frac{number\ of\ highly\ educated\ workers}{total\ workers}$x100	%
Worker dependency burden ratio	Measures the dependency burden by comparing the population without income to the population with income. Data are sourced from Statistics Indonesia, and transformed into natural logarithms.	$\frac{number\ of\ people\ who\ are\ not\ working}{total\ workers}$x100	%
Population density	Defined as the number of people per unit area, sourced from Statistics Indonesia and transformed into natural logarithms.	$\frac{total\ population\ of\ the\ province}{area\ of\ the\ province}$	%
Regional spending per capita	The average regional expenditure per resident in each province. Data from the Indonesian Ministry of Finance are transformed into natural logarithms.	$\frac{total\ regional\ spending}{total\ population\ of\ the\ province}$	%
Democracy index	Measures democratic development based on political rights, civil liberties, and democratic institutions. Higher scores indicate stronger democratic performance. Data from Statistics Indonesia are transformed into natural logarithms.	The method integrates quantitative and qualitative approaches, with calculations designed for cross-validation. Weights of aspect, variable, and indicators were determined using the Analytical Hierarchy Process involving academics, researchers, practitioners, government officials, NGOs, and the media.	%
Longitude and latitude	Geographical coordinates identifying the location of each province. In the centre-of-gravity method, they are used to measure distance to the midpoint, while in spatial regression, they define neighbouring provinces for the spatial weight matrix using RStudio. Data are sourced from Google Maps.	The distance between one observation point to another.	degree (°)

Source: BPS-Statistics Indonesia, (2023), Ministry of Environment and Forestry RI, (2020)

METHODS AND ANALYTICAL MODEL

CENTRE OF GRAVITY

The centre-of-gravity method, commonly used to determine optimal industrial locations based on distance and cost efficiency, is adapted in this study to identify provinces exhibiting the highest income inequality and the highest real GRDP per capita in Java-Bali.

The centre-of-gravity method is calculated using the following formula (Chase et al. 2001):

$$Cx = \frac{\Sigma dixWi}{\Sigma Wi} \qquad (1)$$
$$Cy = \frac{\Sigma diyWi}{\Sigma Wi}$$

The above method is adjusted to suit the objectives of this study, where Cx is x-coordinate of the centre of gravity, Cy is y-coordinate of the centre of gravity, dix is x-coordinate of location i, diy is y-coordinate of location i, Wi denotes the level of income and output inequality per capita associated through the Gini ratio, real GRDP per capita, and GRDP gap.

PANEL DATA REGRESSION

Panel data regression is first employed to test for spatial dependence. This is followed by the Hausman test to determine the most appropriate model specification, either fixed effects or random effects, for subsequent spatial modelling. The baseline panel regression equation is specified as follows (Gujarati & Porter 2009):

Fixed Effects Least-Squares Dummy Variable Model:

$$gini_{it} = \alpha_i + \beta_1 percapita + \beta_2 iklh_{it} + \beta_3 education_{it} + \beta_4 dep_{it} + \beta_5 density_{it} + \beta_6 spending_{it} + \beta_7 democracy_{it} + u_{it} \quad (2a)$$

$$GRDPgap_{it} = \alpha_i + \beta_1 percapita + \beta_2 iklh_{it} + \beta_3 education_{it} + \beta_4 dep_{it} + \beta_5 density_{it} + \beta_6 spending_{it} + \beta_7 democracy_{it} + u_{it} \quad (2b)$$

Random Effects Model (with Generalized Least Square):

$$gini_{it} = \alpha + \beta_1 percapita + \beta_2 iklh_{it} + \beta_3 education_{it} + \beta_4 dep_{it} + \beta_5 density_{it} + \beta_6 spending_{it} + \beta_7 democracy_{it} + w_{it} \quad (2c)$$

$$GRDPgap_{it} = \alpha + \beta_1 percapita + \beta_2 iklh_{it} + \beta_3 education_{it} + \beta_4 dep_{it} + \beta_5 density_{it} + \beta_6 spending_{it} + \beta_7 democracy_{it} + w_{it} \quad (2d)$$

In this specification, $gini$ denotes the Gini ratio; $GRDPgap$ represents the Gross Regional Domestic Product gap; $percapita$ refers to real GRDP per capita; $iklh$ is the environmental quality index; $education$ denotes the proportion of highly educated workers; dep is the burden ratio of worker dependents; $density$ represents population density; $spending$ refers to local expenditure per capita; and $democracy$ is the provincial democracy index. The subscript i denotes each province in Java-Bali, while t refers to the period 2015-2022. The parameter α is intercept, β represents the slope coefficients, and w denotes the composite error term, which combines individual-specific and idiosyncratic errors.

SPATIAL PANEL DATA MODEL

The modelling procedure begins with the selection of the most appropriate panel data specification using the F-test and the Hausman test. Spatial correlation is then examined using the Pesaran and Breusch-Pagan LM tests. Where cross-section dependence is detected, a K-Nearest Neighbours (KNN) spatial weight matrix is constructed. The optimal number of neighbours is determined based on Moran's I test, spatial model significance, and AIC values (Anselin 2007; Anselin & Rey 2010; M. Firdaus et al. 2024).

The Moran's I test is used to identify the presence or absence of spatial effects in the data by incorporating spatial weights into the calculation. The formula is as follows (Anselin & Rey 2010):

$$I = \frac{n \sum \sum W_{ij}(x_i - \bar{x})(x_j - \bar{x})}{W \sum (x_i - \bar{x})} \quad (3)$$

where I is Moran's I; n is number of provinces; x_i is value in province i, x_j is value in province j; $\bar{x}$ is average value of x_i across all provinces; and W_{ij} is the standardized spatial weight between provinces i and j. Moran's I test computed using R studio (Anselin 2007). The inverse-distance spatial weight matrix is constructed as follows:

$$w_{ij} = \frac{w_{ij^*}}{\sum_j w_{ij^*}} \quad (4)$$

where $w_{ij}*$ is the inverse value of the spatial distance between provinces i and j (d_{ij}), such that $w_{ij}* = 1/d_{ij}\alpha$, with α taking values of 1, 2, ..., n. Model selection is guided by Akaike's Information Criterion (AIC), which is derived from the maximum likelihood framework and expressed in logarithmic form as follows:

$$AIC = e^{2k/2} \frac{SSR}{n} \quad (5)$$

Where k is the number of estimated parameters, n is number of observations, e = 2.718, and SSR is $\sum(gini_i - \widehat{gini})^2$ or $\left(grdpgap_i - \widehat{grdpgap}\right)^2$, with the smallest AIC value considered as the best model (Widarjono 2018).

The spatial-autoregressive (SAR) model captures the interaction effects among spatial units by allowing the dependent variable to be influenced by its spatial lag. The SARAR model extends this framework by incorporating spatial dependence in both the dependent variable and error term. Accordingly, several spatial specifications are considered in this study (Drukker & Prucha 2013).

Spatial-Autoregressive (SAR):

$$gini_{it} = \delta \sum_{j=1}^{N} W_{ij} gini_{jt} + \alpha_n + percapita_{it}\beta + iklh_{it}\beta + education_{it}\beta + dep_{it}\beta + density_{it}\beta + spending_{it}\beta + democracy_{it}\beta + \varepsilon_{it} \quad (6a)$$

$$GRDPgap_{it} = \delta \sum_{j=1}^{N} W_{ij} GRDPgap_{jt} + \alpha_n + percapita_{it}\beta + iklh_{it}\beta + education_{it}\beta + dep_{it}\beta + density_{it}\beta + spending_{it}\beta + democracy_{it}\beta + \varepsilon_{it} \quad (6b)$$

Spatial-Autoregressive Disturbance (SARAR):

$$gini_{it} = \delta \sum_{j=1}^{N} W_{ij} gini_{jt} + \alpha_n + percapita_{it}\beta + iklh_{it}\beta + education_{it}\beta + dep_{it}\beta + density_{it}\beta + spending_{it}\beta + democracy_{it}\beta + u_{it}, u_{it} = \lambda \sum_{j=1}^{N} W_{ij} u_{jt} + \varepsilon_{it} \quad (7a)$$

$$GRDPgap_{it} = \delta \sum_{j=1}^{N} W_{ij} GRDPgap_{jt} + \alpha_n + percapita_{it}\beta + iklh_{it}\beta + education_{it}\beta + dep_{it}\beta + density_{it}\beta + spending_{it}\beta + democracy_{it}\beta + u_{it}, u_{it} = \lambda \sum_{j=1}^{N} W_{ij} u_{jt} + \varepsilon_{it} \quad (7b)$$

In these spatial models w_{ij} denotes the standardized spatial weight (row i, column j); $gini$ is the Gini ratio; $GRDPgap$ is the Gross Regional Domestic Product gap; $percap$ is real GRDP per capita; $iklh$ is the environmental quality index; $education$ is the proportion of highly educated workers; dep is worker dependency burden; $density$ is population density; $spending$ is local government expenditure per capita,; and $democracy$ is the provincial democracy index. The parameter β represents the coefficients of independent variables, δ is the spatial lag coefficient, ε is the error vector, u captures spatial dependence in the error term, and λ is the spatial error coefficient.

MEDIATION MODEL

The mediation model employs coefficients and standard errors derived from the selected spatial models (Equations 6a–7b) to test mediation effects. When real GRDP per capita or environmental quality significantly explains inequality, an indirect spatial regression model is estimated, allowing for spatial dependence. The Sobel test is then applied to assess the significance of the indirect effect. The indirect effect model equation is specified as follows:

Indirect model 1 with SAR model:

$$iklh_{it} = \delta \sum_{j=1}^{N} W_{ij} iklh_{jt} + \alpha_n + education_{it}\beta + dep_{it}\beta + density_{it}\beta + spending_{it}\beta + democracy_{it}\beta + \varepsilon_{it} \quad (8a)$$

Indirect model 1 with SARAR model:

$$iklh_{it} = \delta \sum_{j=1}^{N} W_{ij} iklh_{jt} + \alpha_n + education_{it}\beta + dep_{it}\beta + density_{it}\beta + spending_{it}\beta + democracy_{it}\beta + u_{it} \quad (8b)$$

Indirect model 2 with SAR model:

$$percapita_{it} = \delta \sum_{j=1}^{N} W_{ij} iklh_{jt} + \alpha_n + education_{it}\beta + dep_{it}\beta + density_{it}\beta + spending_{it}\beta + democracy_{it}\beta + \varepsilon_{it} \quad (9a)$$

Indirect model 2 with SARAR model:

$$percapita_{it} = \delta \sum_{j=1}^{N} W_{ij} iklh_{jt} + \alpha_n + education_{it}\beta + dep_{it}\beta + density_{it}\beta + spending_{it}\beta + democracy_{it}\beta + u_{it} \quad (9b)$$

A mediation model examines how an intervening variable influences the relationship between two variables. Depending on its function, the intervening variable may act as a disturbance, covariate, moderator, or mediator (Mackinnon 2015).

The mediation effect is assessed by dividing the indirect effect, ab (the coefficient from Equation 1 multiplied by the coefficient from Equation 2), by its standard error (MacKinnon et al. 2002). A ratio greater than ±1.96 indicates a statistically significant mediation effect (Mackinnon 2015). The standard error of the indirect effect is computed as follows:

$$\sigma_{\alpha b}=\sqrt{\alpha^2\sigma_b^2+b^2\sigma_\alpha^2} \quad (10)$$

Where α and b are estimated regression coefficients, σ_α^2 and σ_b^2 are squared standard errors of α and b, respectively.

RESULT AND DISCUSSION

INCOME INEQUALITY GAP AND REAL GRDP PER CAPITA IN JAVA-BALI USING THE CENTER OF GRAVITY METHOD

Centre-of-gravity method is applied to identify the relative positions of the Gini ratio, real GRDP per capita, and the GRDP gap across Java-Bali. Provinces with higher values exert a stronger pull on the calculated location. To assess disparities, a midpoint representing equal conditions across provinces (assigned a value of 1 for each province) is calculated. The distance between each indicator's point and this midpoint reflects the degree of inequality or imbalance in distribution.

MIDPOINT LOCATION

The midpoint serves as a benchmark against which the positions associated with the worst Gini ratio, highest real GRDP per capita, and GRDP gap are compared. This point represents perfect convergence, where all provinces have equal Gini or GRDP gap values. The midpoint is calculated without applying weights to the Gini ratio, real GRDP per capita, or GRDP gap, assuming equal weights for all provinces. The results of the midpoint location calculation for Java–Bali are as follows:

TABLE 2. Java–Bali central point area results

Midpoint Location	Total Distance (Km)
Wonokerso, Kendal Regency, Central Java	2,574

Source: Data processing results through Google Maps, 2024

Of the seven alternative locations, Wonokerso, Central Java, is the closest to the inequality midpoint, with an aggregated distance of 2,574 km and coordinates of -7.176143607 and 110.2908858.

WORST LOCATION GINI RATIO

The coordinates of the seven provincial capitals in Java–Bali were first determined. The 2023 Gini ratio was then used as a weight, with total weighted distances calculated by multiplying each province's distance to alternative locations by its Gini ratio. The final results are as follows:

TABLE 3. Worst Gini Ratio location, Java–Bali

No	Alternative Location	Total Weighted Distance (Km)
1	Klepon Poncol, Semarang Regency, Central Java	1,030
2	Tempuran, Semarang Regency, Central Java	1,037
3	Yosorejo, Pekalongan Regency, Central Java	1,086
4	Karangmoncol, Pemalang Regency, Central Java	1,077
5	Dermanganti, Kendal Regency, Central Java	1,029
6	Kedung Kebo, Pekalongan Regency, Central Java	1,063
7	Sigentong, Brebes Regency, Central Java	1,078

Source: Data processing results through Google Maps, 2024

Of the seven alternative locations, Dermanganti, Kendal, Central Java yields the lowest total weighted distance of 1,029 km. This aligns with the relatively small variation in Gini indices across provinces, with three values exceeding 0.4, and a highest–lowest gap of only 0.087. The 11 km distance between Dermanganti and the midpoint in Wonokerso indicates that the greatest inequality is located near the geographical Centre of Java–Bali.

FIGURE 4. Distance from Worst Gini Location to Midpoint, Java–Bali 2023
Source: Data processing results through Google Maps, 2024

BEST LOCATION OF REAL GRDP PER CAPITA

To identify the optimal location for real GRDP per capita, 2023 provincial GRDP per capita values for each Java-Bali province, are used as weights, reflecting welfare levels. Total weighted distances are calculated accordingly. Using the centre-of-gravity method, the results are as follows:

TABLE 4. Best GRDP Per Capita Locations, Java–Bali

No	Alternative Location	Total Weighted Distance (Million Km)
1	Kalikamal, Kedunguter, Brebes Regency, Central Java	143,23
2	Danau Rw. Pening, Semarang Regency, Central Java	170,11
3	Kanci Kulon, Cirebon Regency, West Java	136,50
4	Gandawesi, Majalengka Regency, West Java	130,87
5	Limbangan, Brebes Regency, Central Java	141,66
6	Jatimerta, Cirebon Regency, West Java	131,79
7	Mekarmulya, Majalengka Regency, West Java	130,85

Source: Data processing results through Google Maps, 2024

The results indicate that the best location for real GRDP per capita in Java–Bali is Mekarmulya, West Java Province, yielding the lowest total weighted distance of 130.85 million km. This location deviates from the Java–Bali midpoint in Central Java due to the dominant influence of the DKI Jakarta's high GRDP per capita, which shifts the equilibrium westwards. The distance of 303 km between Mekarmulya and the midpoint in Wonokerso reflects the extent of income disparity across provinces. Thus, the optimal income location lies in West Java, adjacent to Jakarta, influenced by its significantly higher real GRDP per capita.

FIGURE 4. Distance from Best GRDP per Capita Locations to Midpoint, Java–Bali 2023
Source: Data processing results through Google Maps, 2024

LOCATION OF GRDP GAP TO NATIONAL AVERAGE GDP

Income disparities between provinces in Java-Bali are further illustrated by using the real GRDP gap, defined as each province's real GRDP relative to the national average. This measure is used as the calculation weight. Of the seven alternative locations, the results are narrowed to Central Java and West Java, with Indramayu, West Java, recording the lowest total weighted distance of 6,331 km.

TABLE 5. GRDP gap locations, Java–Bali

No	Alternative Location	Total Weighted Distance (Million Km)
1	Kedunguter, Brebes Regency, Central Java	6,599
2	Kalibareng, Kendal Regency, Central Java	6,949
3	Sawojajar, Brebes Regency, Central Java	6,504
4	Cikawung, Indramayu Regency, West Java	6,331
5	Wonokerto Kulon, Pekalongan Regency, Central Java	6,599
6	Dampyak, Tegal Regency, Central Java	6,422
7	Kaliwlingi, Brebes Regency, Central Java	6,641

Source: Data processing results through Google Maps, 2024

The distance between Indramayu and the midpoint is approximately 310 km, indicating a high degree of income inequality among the Java-Bali provinces. This finding is consistent with the results for the real GRDP per capita, highlighting substantial welfare gaps across the region.

FIGURE 5. Distance of GRDP Gap to the Midpoint, Java-Bali
Source: Data processing results through Google Maps, 2024

DIRECT AND SPILLOVER EFFECTS

PANEL COINTEGRATION TEST

Prior to spatial regression, panel cointegration tests are conducted to verify the long-run equilibrium of the Java-Bali models. The Kao residual test reports ADF probabilities of 0.006 for the Gini model and 0.000 for the GDP gap model, both below the 5% significance level, confirming long-run equilibrium and supporting the model's suitability for long-term analysis.

TABLE 6. Kao residual cointegration test results

Tests	Gini Model	GRDP gap model
T-statistic ADF	-2.492	-3.519
P-value ADF	0.006	0.000

Source: Data processing results, 2024

SPATIAL ECONOMETRICS IN JAVA-BALI ISLAND

The Breusch-Pagan LM test indicates spatial dependence in both Gini and GRDP gap models, with p-values of 0.030 and 0.003, respectively. The Pesaran CD test further confirms spatial dependence in the Gini model ($p < 0.05$), but not in the GRDP gap model ($p = 0.773$).

TABLE 7. Spatial dependence test results with fixed effect model, Java-Bali

Tests	Gini Model		GRDP Gap Model	
	P-value	Decision	P-value	Decision
Normality test	0,447	Residuals are normally distributed	0.238	Residuals are normally distributed
Cross-section dependence (Breusch-Pagan LM test)	0.030	There are spatial dependencies	0.003	There are spatial dependencies
Cross-section dependence (Pesaran CD test)	0.030	There are spatial dependencies	0.773	There are no spatial dependencies

Source: Data processing results, 2024

The Moran test confirms spatial dependence in the Gini model using the *K*- Nearest Neighbor (KNN) approach with one to four neighbors, with p-values from 0.000 to 1.849e-10. Among the spatial models tested, the SAR model is significant under KNN-4 ($p = 0.048$), while SARAR model is significant at KNN-3 ($p = 1.569e-13$). Given the instability of the SARAR model when additional neighbors are included, the SAR model is selected to explain direct and spillover effects on income inequality in Java-Bali. For the GRDP gap model, the SARAR specification with the nearest neighbor is preferred, as it yields a lower AIC, despite KNN-2 yielding a significant lambda.

TABLE 8. Selection of spatial model of Gini ratio

Tests	P-value KNN-1	P-value KNN-2	P-value KNN-3	P-value KNN-4	KNN-1 Decision	KNN-2 Decision	KNN-3 Decision	KNN-4 Decision
Moran test	0.000	9.112e-06	7.433e-09	1.849e-10	There are spatial dependencies	There are spatial dependencies	There are spatial dependencies	There are spatial dependencies
SAR Model								
Hausman test	0.190	0.160	0.233	0.216	Random Effects	Random Effects	Random Effects	Random Effects
Lambda	0.137	0.053	0.100	0.048*	Not significant	Not significant	Significant	Significant
AIC	-	-	-	-204.333	-	-	-	
SARAR Model								
Hausman test	0.217	0.001	0.004	0.075	Random Effects	Fixed Effects	Random Effects	Random Effects
Lambda	0.465	0.981	1.569e-13 ***	0.770	Not significant	Significant	Significant	Not significant
AIC	-	-	-212.943	-	-	-	-	-

Note: * = p<.1, ** = p<.05, and *** = p<.01
Source: Data processing results, 2024

TABLE 9. Selection of spatial model of GRDP gap

Tests	P-value KNN-1	P-value KNN-2	P-value KNN-3	P-value KNN-4	KNN-1 Decision	KNN-2 Decision	KNN-3 Decision	KNN-4 Decision
Moran test	1.893e-05	4.879e-07	6.596e-12	1.54e-15	There are spatial dependencies	There are spatial dependencies	There are spatial dependencies	There are spatial dependencies
SAR Model								
Hausman test	1	0.968	0.987	0.988	Random Effects	Random Effects	Random Effects	Random Effects
Lambda	0.8519	0.738	0.511	0.073	not significant	Not significant	Not significant	Not significant
AIC	-	-	-	-	-	-	-	-
SARAR Model								
Hausman test	1.394e-15	4.73e-06	0.786	0.845	Fixed Effects	Fixed Effects	Random Effects	Random Effects
Lambda	2.2e-16 ***	0.000***	0.159	0.115	Significant	Significant	Not significant	Not significant
AIC	-247.00	-231.3987	-	-	AIC value is smaller than KNN-2	AIC value is higher than KNN-1	-	-

Note: * = p<.1, ** = p<.05, and *** = p<.01
Source: Data processing results, 2024

Information on lambda value, standard error, and p-value of the SAR KNN-4 random effects model given below:

TABLE 10. Coefficients of SAR KNN-4 random effects model

Model	Lambda	Rho	Std.error	P-value
Gini	0.325	-	0.164	0.048 **
GRDP Gap	0.729	-0.884	0.032	2.2e-16 ***

Note: ** = p<.05, and *** = p<.01
Source: Data processing results, 2024

Based on information in Table 10, Table 11, and Table 12, the SAR and SARAR model equations for the Gini and GRDP gap model can be constructed as follows:

$$Gini_{it} = 0.325 \sum_{j=4}^{7} w_{ij} Gini_{jt} + 0.026 iklh_{it} - 0.121 percapita_{it} + 0.103 education_{it} + 0.019 dep_{it} + 0.103 density_{it} - 0.053 spending_{it} - 0.014 democracy_{it} \quad (11)$$

$$GRDPgap_{it} = 0.729 \sum_{j=1}^{7} w_{ij} GRDPgap_{jt} + 0.005 iklh_{it} + 0.238 percapita_{it} - 0.039 education_{it} + 0{,}026 dep_{it} - 0.532 density_{it} - 0.018 spending_{it} - 0.0674 democracy_{it} - 0.884 Wu \quad (12)$$

The lambda (δ) value of 0.325 and 0.729 in the Gini and GRDP gap models indicate positive spatial dependence. This implies that the Gini ratio in the four nearest provinces and the GRDP gap in the nearest province increase by 0.325 and 0.729 times, respectively, of the observed province's average value (Yasin et al. 2020). By contrast, the rho (λ) of -0.884 in the GRDP gap model indicates negative spatial autocorrelation, whereby errors in neighbouring provinces decline by 0.884 times those of the observed province (M. Firdaus et al. 2024; Yasin et al. 2020).

The SAR model with a four-nearest-neighbour weighting matrix (KNN-4) shows that real GRDP per capita, the share of highly educated workers, and population density significantly influence income inequality in Java–Bali. Real GRDP per capita and the share of highly educated workers exhibit significant direct effects, while population density shows a significant total effect. Other variables, namely environmental quality, dependency ratio, regional expenditure per capita, and democracy are not statistically significant.

A 1% increase in real GRDP per capita reduces income inequality in the same province by 0.121%, indicating that higher economic productivity tends to narrow inequality, albeit with weak spillover effects. However, during 2021–2022, the Covid-19 shock disrupted this relationship, as inequality increased alongside rising GRDP per capita in large provinces such as Jakarta, West Java, and Bali.

The share of highly educated workers increases inequality, where a 1% rise in their proportion raises the Gini ratio by 0.103%. This finding is consistent with Hanushek and Woessmann (2021), Hakim and Rosini (2022), and Rahman et al. (2023) who reveal that returns to education are uneven across advanced regions. In Java-Bali, higher productivity and wages of highly educated workers disproportionately benefit the upper-income groups, while low-educated workers experience stagnant income, thus further widening the wage gap. Over-education and skill mismatch further limit wage growth, weakening equality-enhancing benefits.

Population density also widens inequality. With an average density of 3,185 people per km², peaking at 16,200 in Jakarta, the concentration of economic activity and limited land availability intensify competition for employment and services. Technological progress and automation further aggravate inequality by reducing labour demand while benefiting capital-intensive sectors, as consistent with studies by Loebbing and Acemoglu (2022) and Wacker et al. (2020).

Although environmental quality is not statistically significant, the dense and highly industrialized nature of Java-Bali implies substantial environmental costs. Efforts to transition towards a greener economy may reduce output and business profits, creating trade-off between sustainability and equality. Similarly, the dependency ratio shows a positive but insignificant effect, suggesting that a higher burden on workers may increase inequality, especially amid shrinking labour demand and limited job creation.

Regional expenditure per capita shows a negative but insignificant coefficient, implying limited redistributive effectiveness. Likewise, the democracy index shows a negative but insignificant relationship, reflecting a largely procedural form of democracy with limited impact on equality. Overall, the SAR results highlight that productivity growth can reduce inequality within provinces, but structural constraints, such as education gaps, high population density, and weak fiscal-democratic performance, continue to impede equitable development across Java-Bali.

TABLE 11. Results of direct and spillover effect on Gini Ratio (SAR Random Effects, KNN-4)

Variable	Direct Effect	Spillover Effect	Total Effect
log(iklh)			
coefficient	0.026	0.012	0.038
p-value	(0.403)	(0.547)	(0.547)
standard error	0.033	0.024	0.054
log(percapita)			
coefficient	-0.121*	-0.053	-0.175
p-value	(0.069)	(0.319)	(0.122)
standard error	0.072	0.071	0.130
log(education)			
coefficient	0.103***	0.046	0.149
p-value	(0.007)	(0.274)	(0.274)
standard error	0.039	0.051	0.079
log(dep)			
coefficient	0.019	0.008	0.0272
p-value	(0.804)	(0.833)	(0.808)
standard error	0.046	0.029	0.073
log(density)			
coefficient	0.103***	0.045	0.148**
p-value	(0.007)	(0.254)	(0.041)
standard error	0.039	0.049	0.079
log(spending)			
coefficient	-0.053	-0.023	-0.077
p-value	(0.243)	(0.463)	(0.298)
standard error	0.042	0.038	0.074
log(democracy)			
coefficient	-0.014	-0.006	-0.020
p-value	(0.858)	(0.852)	(0.851)
standard error	0.071	0.044	0.112

Note: * = p<.1, ** = p<.05, and *** = p<.01
Source: Data processing results, 2024

In the GRDP gap model, five explanatory variables, namely real GRDP per capita, education, worker dependency burden, population density, and democracy, show significant direct, spillover, and total effects. A 1% increase in real GRDP per capita in province *i* raises its economic share relative to national average by 0.238%, with a spillover of 0.296 to neighbouring provinces *j*. This strengthens the Java–Bali's economic dominance, thereby widening the national GDP gap by 0.534%, reflecting the region's superior infrastructure and economic base.

In contrast, a 1% increase in the proportion of highly educated workers reduces the GRDP gap by 0.039% in province *i* and 0.048% in neighbouring province j. This reflects the diffusion of knowledge investment, and productive activity beyond Java–Bali, resulting in a more balanced spatial distribution of economic growth. However, the same increase raises the Gini ratio, indicating that interregional convergence is accompanied by interregional divergence.

The worker dependency burden widens the GRDP gap, with direct, spillover, and total effects of 0.026%, 0.032%, and 0.058%, respectively. Automation and the relocation of higher-paid workers and their families constrain labour absorption in Java–Bali and weaken economic connectivity with other regions, reinforcing inter-regional disparities.

Higher population density reduces the GRDP gap by 0.532% in province *i* and 0.660% in neighbouring province *j*, yielding a total effect of 1.192%. This implies that increased population density in Java–Bali lowers its relative economic dominance while stimulating growth in other regions, indicating gradual national rebalancing of economic activity across Indonesia. However, as shown in the Gini model, higher density simultaneously increases intraregional inequality, implying convergence between regions but divergence within them

Improvements in democracy index reduce the GRDP gap, with direct, spillover, and total effects of 0.067%, 0.083% and 0.149% respectively. if democratic practices strengthen nationwide. Stronger democratic institutions facilitate inclusive decision-making and equitable resource distribution, enabling provinces outside Java–Bali to narrow down the GRDP gap.

Overall the findings emphasize the dual role of economic productivity and institutional quality. While real GRDP growth consolidates Java–Bali's dominance, the strategic allocation of educated labour and stronger democratic governance can mitigate regional disparities, underscoring the importance of coordinated regional development policies to achieve more balanced economic growth in Indonesia.

TABLE 12. Direct and spillover effects of GRDP gap (SARAR Fixed Effects, KNN-1)

Variable	Direct Effect	Spillover Effect	Total Effect
log(iklh)			
coefficient	0.005	0.006	0.011
p-value	(0.474)	(0.477)	(0.475)
standard error	0.008	0.010	0.018
log(percapita)			
coefficient	0.238***	0.296***	0.534***

Variable	Direct Effect	Spillover Effect	Total Effect
p-value	(0.000)	(0.000)	(0.000)
standard error	0.044	0.070	0.112
log(education)			
coefficient	-0.039***	-0.048***	-0.088***
p-value	(0.000)	(0.001)	(0.000)
standard error	0.011	0.015	0.026
log(dep)			
coefficient	0.026**	0.032*	0.058*
p-value	(0.046)	0.056	(0.051)
standard error	0.013	0.017	0.031
log(density)			
coefficient	-0.532***	-0.660***	-1.192***
p-value	(0.000)	0.000	(0.000)
standard error	0.118	0.179	0.294
log(spending)			
coefficient	-0.0184	-0.023	-0.041
p-value	(0.126)	(0.133)	(0.129)
standard error	0.012	0.015	0.026
log(democracy)			
coefficient	-0.067***	-0.083***	-0.149***
p-value	(0.000)	(0.001)	(0.001)
standard error	0.020	0.027	0.046

Note: * = p<.1, ** = p<.05, and *** = p<.01

Source: Data processing results, 2024

MEDIATION EFFECT

Both the Gini and GRDP gap models indicate that only real GRDP per capita significantly reduces inequality. In consequence, the quality of life index (IKLH) is excluded from the mediation test for Java–Bali, and only real GRDP per capita is tested as a potential mediator.

RESULTS OF THE INDIRECT EFFECT OF REAL GRDP PER CAPITA

To obtain unbiased estimates, the same spatial specifications as the direct models are applied. The Hausman test (p = 0.006) supports the fixed-effects specification. The Breusch-Godfrey/Wooldridge test (p = 0.411) indicates no serial correlation, while the Breusch-Pagan LM test (p = 0.009) confirms spatial dependence. Although the Pesaran CD test shows no spatial effects, the Moran test is conducted for further verification.

TABLE 13. Results of panel model selection, autocorrelation and spatial dependence test on real GRDP per capita model

Tests	P-value	Decision
Best Panel Model (Hausman test)	0,006	Fixed effect model
Serial corelation (Breusch-Godfrey/Wooldridge test)	0,411	No spatial correlation
Cross-section dependence (Breusch-Pagan LM test)	0,009	There are spatial dependencies
Cross-section dependence (Pesaran CD test)	0,635	No spatial dependencies

Source: Data processing results, 2024

The Moran test with four nearest neighbours yields a value of 1.849e-10, confirming significant spatial dependence in the real GRDP per capita model. SAR random-effects estimation under KNN-4 yields a lambda of 4.803e-05, while SARAR KNN-4 produces a lambda of 3.437e-12, both significant at the 5% level. Although SARAR has the lowest AIC, it is primarily used to obtain direct effect estimates for mediation analysis.

TABLE 14. Selection of KNN-4 spatial model on real GRDP per capita model

Tests	P-value	Decision
Moran test	1.849e-10	There are spatial dependencies
	SAR Model	
Hausman test	0.331	Random Effects
Lambda	4.803e-05 ***	Significant
AIC	-164.0151	2
	SARAR Model	
Hausman test	0.908	Random Effects
Lambda	3.437e-12 ***	Significant
AIC	-172.0717	1

Note: * = p<.1, ** = p<.05, and *** = p<.01

Source: Data processing results, 2024

Based on SARAR random effects KNN-4 model, population density, regional expenditure per capita, and democracy, significantly affect real GRDP per capita, with p-values of 0.000, 0.000, and 0.059, respectively. A 1% increase in population density raises real GRDP per capita by 0.697%, reflecting market expansion and efficiency gains. A1% increase in regional expenditure per capita and the democracy index raises real GRDP per capita by 0.168% and 0.114%, respectively. Meanwhile, the share of highly educated workers and the dependency ratio are not significant. The results highlight population density as the main driver of economic development, whereas democracy enhances welfare through institutional mechanisms such as the effective use of village funds.

TABLE 15. Real GRDP per capita regression results (SARAR Random Effects, KNN-4)

Variable	Direct Effect	Standard Error	P-value
log(education)	-0.092	0.055	0.100
log(dep)	-0.032	0.044	0.363
log(density)***	0.697	0.107	7.485e-11***
log(spending)***	0.168	0.028	8.034e-10***
log(democracy)*	0.114	0.063	0.059*

Note: * = p<.1, ** = p<.05, and *** = p<.01
Source: Data processing results, 2024

MEDIATION EFFECT ON GINI MODEL

Mediation is tested by comparing ratio statistic with its critical value. The ratio is calculated as ab divided by the value of $\sqrt{b^2SE_a^2 + a^2SE_b^2}$, with a 5% critical level of 2.008 (56 observations minus five explanatory variables). The results show that all ratios in the Gini model fail to exceed the critical value, indicating that real GRDP per capita does not mediate the effects of exogenous variables on income inequality in Java-Bali.

TABLE 16. Mediation test results on Gini Model

Model	Indirect Effect	ab	$\sqrt{b^2SE_a^2 + a^2SE_b^2}$	Ratio	Decision
1	Education to Gini through real GRDP per capita	0.011	0.009	1.187	Not significant
2	Dependents to Gini through GRDP per capita	0.004	0.006	0.669	Not significant
3	Population Density to Gini through real GRDP per capita	-0.085	0.052	-1.640	Not significant
4	Local spending per capita to Gini through real GRDP per capita	-0.020	0.013	-1.631	Not significant
5	Democracy to Gini through real GRDP per capita	-0.014	0.011	-1.238	Not significant

Source: Data processing results, 2024

MEDIATION EFFECT ON GRDP GAP MODEL

The GRDP gap model yields two significant mediation effects, with ratios of 4.154 and 4.013, both exceeding the critical value of 2.008. In model 3, higher population density continues to reduce the GRDP gap through real GRDP per capita, but the effect is weakened: the direct effect of -0.532 is partially offset by a mediated effect of 0.166, resulting in a net effect of -0.366. In model 4, higher local expenditure per capita increases real GRDP per capita, which in turn widens the GRDP gap between Java–Bali and the national average. This indicates that while regional spending simultaneously boosts regional output, it can also exacerbate inter-island disparities, underscoring the need to enhance spending effectiveness outside Java–Bali to achieve balanced national growth.

Table 17. Mediation test results on GRDP gap model

Model	Indirect Effect	ab	$\sqrt{b^2SE_a^2 + a^2SE_b^2}$	Ratio	Decision
1	Education to GRDP Gap through real GRDP per capita	-0.022	0.014	-1.589	Not significant
2	Dependents to GRDP Gap through GRDP per capita	-0.008	0.010	-0.721	Not significant
3	Population Density to GRDP Gap through real GRDP per capita	0.166	0.040	4.154	Significant
4	local spending per capita to GRDP Gap through real GRDP per capita	0.040	0.010	4.013	Significant
5	Democracy to GRDP Gap through real GRDP per capita	0.027	0.016	1.718	Not significant

Source: Data processing results, 2024

CONCLUSION

Using the centre-of-gravity method, the analysis indicates that income inequality is relatively low overall, but welfare is unevenly distributed across provinces. The spatial regression of the Gini model shows that an increase in real GRDP per capita reduces income inequality within provinces, whereas a higher proportion of highly educated workers and greater population density tend to increase inequality. The effect of population density is widespread across the Java-Bali region. All determinants show a weak spillover effect on neighbouring provinces.

Results from the GRDP gap model indicate that increases in real GRDP per capita and labour dependency ratios widen the economic gap between Java–Bali and other islands. Conversely, higher shares of highly educated workers, population density, and stronger democratic conditions reduce the inter-island GRDP gap, with significant spillover effects on neighbouring provinces.

The real GRDP per capita model shows that population density and regional expenditure per capita significantly increase real GRDP per capita in Java–Bali, while a more democratic environment also carries a positive effect. Mediation tests show that GRDP per capita does not significantly mediate the effect on the Gini ratio. However, in the GRDP gap model, higher population density continues to reduce the gap, albeit with a diminished effect, while increased local expenditure widens the GRDP gap through its positive impact on GRDP per capita.

These findings highlight the income concentration in DKI Jakarta, and underscore the need for targeted interventions to stimulate development in the DIY, Central Java, West Java, and Banten. Establishing new growth nodes in these regions would help balance welfare distribution and reduce inequality. Promoting the development of smaller cities and rural growth centres could generate new economic hubs, raise local welfare, and gradually enhance income convergence while reducing regional disparities.

The effectiveness of regional expenditure, the strengthening of substantive democracy, and productivity gains by a more educated and skilled workforce are important factors, in promoting equitable growth, alongside the encouragement of more environmentally sustainable economic activities. Enhancing inter-island economic cooperation and connectivity can further strengthen spillover effects and support more balanced national development, ensuring that the prosperity of Java–Bali benefits Indonesia as a whole.

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