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Income Inequality between Provinces in Indonesia

(Ketaksamaan Pendapatan di antara Wilayah di Indonesia)

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ABSTRACT

This study aims to examine the level of income inequality between provinces and its determinants. Using Indonesian data in 2022, we use Centre of Gravity method to examine the level of inequality between eight provinces in Sumatra Island. This study further examines the determinants of income inequality based on ten provinces in Sumatra Island over 2015-2019 using balanced Panel Data Regression sourced from the Indonesian BPS-Statistics and Ministry of Environment and Forestry. It further adopted the Mediation Model to examine the effect of independent variables on income inequality through intervening variables. The Study established that only a relatively low level of inequality exist between provinces. A decrease in dependency burden on the worker can reduce income inequality through an increase in output per capita. Education has a weak effect on improving the environmental quality, but a strong effect on improving output per capita and reducing inequality. However, an increase in the dependency burden of workers can reduce output per capita but improve environmental quality. Finally, increasing environmental quality reduces inequality. Our employment of the centre of gravity method added on to the literature on income inequality. We further contribute by including workers education in explaining inequality. The role of the government is crucial in stimulating economy growth in the Aceh - North Sumatra and Jambi - South Sumatra - Lampung regions to break the concentration of inequality. In addition, the authority needs to provide an inclusive and pro-environmental development direction.

Keywords: Income inequality; centre of gravity; mediation model; panel data regression; provinces; Indonesia

ABSTRAK

Kajian ini bertujuan untuk menguji tahap ketaksamaan pendapatan di antara wilayah dan penentunya. Menggunakan data Indonesia pada tahun 2022, kajian ini menggunakan kaedah Pusat Graviti bagi menguji tahap ketaksamaan di antara 8 wilayah di Pulau Sumatera. Kajian ini selanjutnya menguji penentu ketaksamaan pendapatan berdasarkan 10 wilayah di Pulai Sumatera bagi tempoh 2015-2019 menggunakan Regresi Data Panel bersumberkan Badan Pusat Statistik dan Kementerian Alam Sekitar dan Perhutanan Indonesia. Ia seterusnya mengguna pakai Model Pengantaraan untuk mengkaji kesan pemboleh ubah tidak bersandar ke atas ketaksamaan pendapatan melalui pemboleh intervensi. Kajian mendapati hanya tahap ketaksamaan yang agak rendah wujud antara wilayah. Pengurangan beban pergantungan kepada pekerja boleh mengurangkan ketaksamaan pendapatan melalui peningkatan dalam output per kapita. Pendidikan mempunyai kesan yang lemah terhadap peningkatan kualiti alam sekitar, tetapi mempunyai kesan yang kuat terhadap peningkatan output per kapita dan mengurangkan ketaksamaan. Walau bagaimanapun, peningkatan beban pergantungan pekerja boleh mengurangkan output per kapita tetapi meningkatkan kualiti alam sekitar. Akhirnya, peningkatkan kualiti alam sekitar mengurangkan ketaksamaan. Penggunaan kaedah pusat graviti ini telah menambah kesusasteraan tentang ketaksamaan pendapatan. Kajian ini seterusnya menyumbang dengan memasukkan pendidikan pekerja dalam menjelaskan ketaksamaan. Peranan kerajaan amat penting dalam merangsang pertumbuhan ekonomi di wilayah Aceh - Sumatera Utara dan Jambi - Sumatera Selatan - Lampung untuk memecahkan

penumpuan ketaksamaan. Di samping itu, pihak berkuasa perlu menyediakan hala tuju pembangunan yang inklusif dan pro-alam sekitar.

Kata kunci: Ketaksamaan pendapatan; pusat graviti; model pengantaraan; regresi panel data; wilayah; Indonesia
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INTRODUCTION

The world is still experiencing serious income inequality which is projected to increase by 1.2% from 2017 to 2021 between countries (United Nations 2022). In Indonesia, income of the bottom 50% population was IDR 22.6 million in 2021, and IDR 285 million at the top 10% (Chancel et al. 2022)"mendeley": {"formatted Citation":"(Chancel et al. 2022. The causes of income inequality between Indonesian provinces included education, employment, economic growth (Hornok et al. 2023; Sulistyaningrum & Tjahjadi 2022; Wicaksono et al. 2017) and environmental quality (Khan et al. 2023; Wu & Id 2020). This wide disparity if left unchecked, has the potential to increase the intensity of social resentment and crime rate that may undermine trust in institutions (Dossou et al. 2023; Goh & Law 2023.

The challenges facing current sustainable development goals are increasing. The era of volatility, uncertainty, complexity, and ambiguity (VUCA) has the opportunity to create an unstable business ecosystem that may lead to complications and ambiguous decision making (Persis et al. 2021). The need for risk management in economic policy making is becoming more crucial to overcome future uncertainties, especially in responding to the dynamics of current and future challenges (Hunjra et al. 2022). Inequality in performance need to be minimised as one of the key steps towards achieving economic equality (Chu & Hoang 2020).

In addition, today's development goal also emphasizes the importance of maintaining sustainable environmental quality as a comprehensive approach towards achieving social welfare without any income inequality (Li et al. 2023; Singh & Yadav 2021). Aspects of environmental quality gain a wide space in development activities, in line with facets of improving welfare and equity, which is the mandate of the United Nation's Sustainable Development Goals or SDGs (Purvis 2019; Ranjbari et al. 2021). This mandate has been implemented in Indonesia (Presidential Regulation of the Republic of Indonesia Number 111, 2022).

However, such efforts have not translated well into market activities, which tend to reinforce inequalities at the expense of social and environmental concerns, based on a culture of privilege and false competitiveness (United Nations 2020). In addition, climate change can further negatively affect sustainable development through income inequality (Chisadza et al. 2023).

The Environment Kuznets Curve hypothesis suggests that an ascending per capita income gradually contributes to rising environmental degradation in a growing underdeveloped economy, but this will gradually reduce once high income level is achieved towards attaining a developed economy (Ali 2023; Chen et al. 2020; Grossman & Krueger 1991). This income-environment development is in line with the pattern of income inequality in the inverted U-curve. The synthesis of these two curves tends to justify the association of high per capita income with reduction in environmental degradation and income inequality. However, other studies have reported different results (Jahanger et al. 2023; Sinha 2023; Wang et al. 2023).

Human capital plays an important role in welfare outcomes, environmental quality and income distribution. Better-educated and higher-skilled workers may produce a significant impact on all three (Zhu 2023). However, the number of workers entering the labour market with appropriate qualifications has not kept pace with the growth of and demand from jobs requiring higher skills (International Labour Organization 2023). The challenges in the VUCA era closely concern human resource training, among others, especially from universities in preparing graduates with the spirit of leadership, innovation, fostering curiosity, and mastering technology (Ioniță et al. 2023).

The rapid growth of micro and small enterprises in Indonesia in the midst of the VUCA era with its demand on innovation, has the opportunity to increase the proportion of trained workers, even though their absorption of labour is much smaller compared to large-scale businesses (Ministry of Cooperatives and SMEs of the Republic of Indonesia 2023). The relationship between innovation and unemployment is described as U-shaped, where in the initial phase the presence of innovation can open up employment until the maturity phase is reached as marked by the lowest unemployment rate. And in the subsequent automation phase employment again narrows down (Sinha 2023). Increasing the proportion of workers will reduce the dependence on burden per worker and improve the distribution of accumulated income. Labour-intensive activities can reduce this worker dependence leading to reduction in the inequality gap (Antonelli & Tubiana 2023). However, labour-intensive input if not matched by the distribution of productivity, becomes the frequent cause of rising income inequality.

This study aimed at examining the level of interprovincial income inequality and its determinants. Using Indonesian data for 2022, we used the Centre of Gravity method to examine the level of inequality among the eight provinces in Sumatra Island. We then examine the determinants of income inequality based on ten provinces using balanced Panel Data Regression. Mediation tests

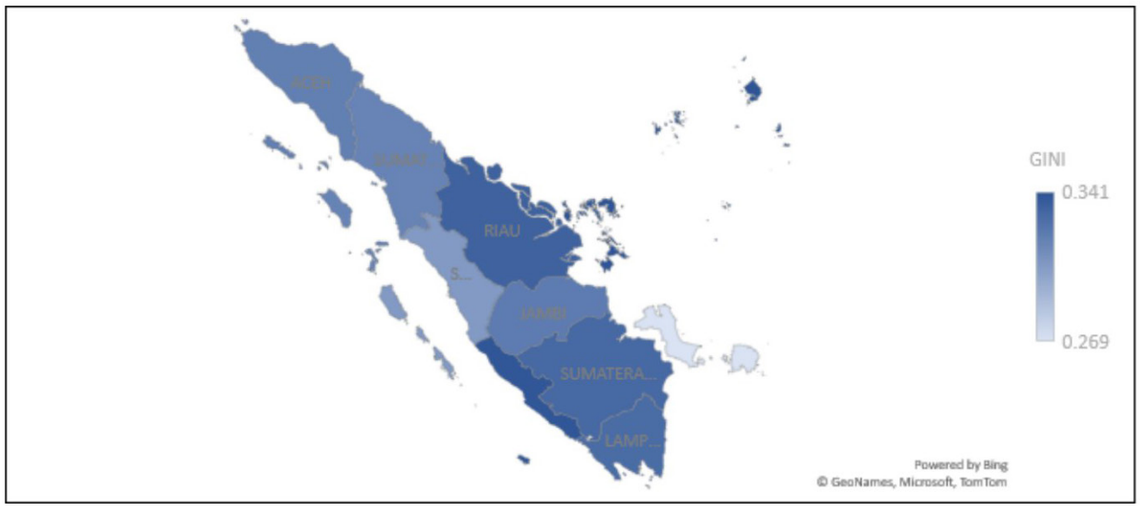
were used to examine the effect of the independent variables on inequality through their intervening variables. We discovered relatively low levels of inequality across provinces. Decreasing the dependency burden on labour can reduce income inequality through increasing output per capita. Education provided a weak contribution in improving environmental quality, but showed a strong influence in increasing output per capita and in reducing inequality. An increase in worker dependency reduced output per capita but improved environmental quality. Increasing environmental quality in consequence reduced inequality.

This study contributes to the extant literature in the area of income inequality and its determinants. Related studies on inequality in Indonesia have been conducted, among others, by Hornok et al. (2023) who discovered varying impacts that led to the increase in inequality, as attributed to the emergence of economic zones. Sulistyaningrum and Tjahjadi (2022) found that gender, years of education, and rural-urban development affect income inequality. Earlier, Wicaksono et al. (2017) showed the significant contribution of education, wealth, and wage earners to income inequality. Some of these studies addressed some common aspects, namely education, income and employment. In methodology, we used the centre of gravity method to explain the level of inequality between provinces, and the mediation test to measure the strength of the intervening variables. For the variables, we included worker education, worker dependency burden, and environmental quality to explain inequality. This study differed from Khan et al. (2023) who indicated that increasing environmental quality reduces income inequality.

BACKGROUND OF THE STUDY

Sumatra is the island with the second largest economy in Indonesia after Java. The increasing population density in Java prompted the central government to spread support for equitable development to other provinces including Sumatra. This initiative was believed to affect the dynamics of welfare and income inequality in the national population. In 2015, the provinces with relatively lowest Gini ratios (below 0.300 points) were Bangka Belitung Islands (0.283), while those increasingly above this index included Aceh (0.334), North Sumatra (0.336), West Sumatra (0.342), South Sumatra (0.36), Jambi (0.361), Riau (0.364), Riau Islands (0.364), Bengkulu (0.376) and Lampung (0.376).

The Gini ratio in 2019 for all provinces generally decreased indicating a reduction in income inequality. The three provinces with highest inequality was the Riau Islands (0.341), followed by Bengkulu (0.340) and the Riau Province (0.334). Provinces with the lowest index were Bangka Belitung (0.269), West Sumatra (0.306), and North Sumatra (0.317).



The persistent issue of inequality, and its strong relationship with income and environment prompted us to examine closely the likely roles of both factors in producing income inequality in Sumatra Island during the VUCA Era. We included workers as a proxy for development actors and as an exogenous variable. The study was expected to provide valuable information, especially for universities, on the extent of the impact of worker dependent burden on sustainable development. At the beginning of the discussion, we will identify the extreme points of highest income inequality and the best income per capita, as well as the midpoint as illustration of the ideal and factual conditions, using the centre of gravity method. These parameters should assist in providing alternative recommendations towards strengthening national development.

LITERATURE REVIEW

INCOME INEQUALITY AND REAL PER CAPITA INCOME

Concerns about income inequality surfaced following findings from Kuznets (1955). Myrdal (1957)

consequently explained the existence of negative effects that underlined the phenomena of growing inequality between emerging and wealthy countries. It was concluded that inclusive growth, which is basically labour-intensive, and the participation of citizens must be included without discrimination (Klasen 2010). Prasetiya (2021) further showed that countries with productive economic structures had smaller income inequality. In the same year, Alamanda (2021) discovered that the impact of economic growth in increasing income inequality was larger in middle-income countries relative to high-income ones. Ali et al. (2022) found an inverted Kuznets curve relationship exist in lower middle-income and upper middle-income countries.

The study by Lakner et al. (2022) suggested that reducing each country's Gini index by 1% per year has a greater impact on global poverty reduction than increasing each country's annual growth by the same rate of 1%. Taresh et al. (2021 discovered that income inequality responds positively to the impact of per capita income shocks, whereas it has a negative impact on per capita income in Indonesia.

Recent studies in Sumatra showed a convergence of real income per capita, with a trend of economic slowdown in developed areas and conversely economic acceleration in underdeveloped areas (Rahman et al. 2023). This prompted our own hypothesis that real Gross Regional Domestic Product (GRDP) per capita produces a negative effect on the Gini ratio.

ENVIRONMENTAL QUALITY

The EKC approach suggests that environmental degradation increases as GDP per capita grows in the early phase, but eventually reaches a turning point as environmental degradation begins to decline (Badunenko et al. 2023). Grossman and Krueger (1991) have studied and confirmed this phenomenon. Recent studies have also confirmed the presence of EKC in a number of G20 countries (Chen et al. 2020). However, Galeotti (2007), argued that preventing environmental degradation today is more likely motivated by saving costs rather than mitigating it in the future.

Jahanger et al. (2023) and Wang et al. (2023) established that income inequality has changed the economic growth- environmental degradation nexus from an inverted U to N-shape. A related study on European cities informed that economic growth negatively impacted environmental degradation (Rizzati et al. 2023). Sinha (2023) identified the weakness of EKC and mitigated it by replacing the income per capita axis with innovation, and linking it to unemployment as a trade-off for policy implications.

Khan et al. (2023) showed that an increase in carbon emissions in Belt and Road Initiative (BRI) countries actually reduced income inequality. Meanwhile, Ali (2023) found a reciprocal relationship between environmental degradation and inequality in 42 middle-income countries. In an earlier study in Egypt Ali (2022) argued that the relationship between income inequality and environment was not reciprocal. Xiao et al. (2023) also reported that climate policy significantly increased labour income in China.

Given that the income phase is indicative of a turning point in the reduction of income inequality, the EKC hypothesis thus also supports the easing in environmental degradation. We hypothesize that environmental degradation, measurable under the environmental quality index, shows a negative effect on the Gini ratio.

HIGHLY EDUCATED WORKERS

Becker (1964) earlier stated that income inequality is generally positively related to inequality in education and training. Wahyuni & Monika (2016) proved that education can reduce income inequality. An OECD (2021) report concluded that highly educated workers, aged 25-34, earned 38% more than workers with secondary education, and those aged 45-54, similarly earned 70% more. However, the rate of return on the productivity of highly educated labour force tends to decrease in developed countries (Hanushek & Woessmann 2021).

An Indonesian study by Hakim & Rosini (2022) suggested a positive correlation between average years of schooling and income inequality in several provinces. Another study in Indonesia concluded that there is a positive effect of labour force, who were tertiary graduates, on the Gini ratio over those from high school, both in the long and short run (Rahman et al. 2023).

Human capital also plays a role in influencing environmental quality. Wu et al. (2022) found that human capital in developing countries exacerbates environmental degradation. In contrast, human capital in China was found negatively associated with environmental degradation and positively affected sustainable development goals (Zhu 2023). Past studies have also shown that higher levels of human capital will improve the environmental performance index (Kim & Go 2020). Based on the extant literature our hypothesis is that highly educated workers exert a positive effect on real Gross Regional Domestic Product per capita and environmental quality (IKLH), but a negative impact on the Gini ratio.

WORKER DEPENDENCE' BURDEN

Piketty (2015) argued that in a market economy, firms will hire more workers as long as they earn more money than incur costs. Labour-intensive firms will grow faster than capital-intensive ones if the price of labour is lower than the price of capital, due to the effect of increasing demand. Capital-intensive business is closely related to greater technology utilization. Solow (1956) described the interaction between capital and labour, with technology as an exogenous factor. Capital intensive business requires better and more skilled workers. Technological change leads to a decrease in work sharing, intensified

routine tasks and impact on income inequality (Wacker et al. 2020; Loebbing & Acemoglu 2022). This argument is reinforced by the existence of a U-shaped relationship between innovation and unemployment, but this changes into an inverted U-shape when innovation is faced with environmental degradation (Sinha et al. 2021). However Battisti et al. (2023) found that workers in routine jobs actually moved to more skilled jobs, and that technological change did not result in significant welfare losses. A number of demographic factors are also likely to influence the rise and fall of the worker dependency burden ratio (Marois et al. 2022). This change may affect income inequality, as shown by Ali et al. (2022) who concluded that urbanization reduces inequality in upper middle-income countries.

The dominance of micro and small enterprises in Indonesia indicates that some economic movements still rely on labour-intensive patterns. The VUCA era, which opens up an increasingly accessible space for innovation, especially for businesses, makes a small exploration in its provocative use of more labour (Sinha 2023). For the lower middle-income regions of Sumatra, this is beneficial in terms of productivity and equity. On this basis, we conjecture that the burden of worker dependence negatively affects per capita real GRDP and the Gini ratio, but is still positively associated with environmental quality.

METHODOLOGY

This study examined the level of income inequality between provinces using the centre of gravity method used the midpoint of Sumatra Island as a marker for the ideal location for income equality. We then adopted the transportation cost calculation in determining the best industrial location point to be used in determining the worst inequality location point and the best income per capita. The Gini ratio data and real GRDP per capita in 2022, for eight provinces located in Sumatra, were used as weights in the calculation. Provinces with higher Gini ratios have the more power to pull the determination point closer to them. The difference between the distance of the factual point and the ideal point (midpoint) was assumed to be the gap for income inequality and income per capita. The closer the factual distance was to the ideal distance, the lower the inequality level, and vice versa. The centre of gravity method is calculated with the following formula (Chase et al. 2001):

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

where Cx is the x-coordinate and Cy the y-coordinate of the centre of gravity, dix is the x-coordinate of location, diy is the y-coordinate of location i, is Gini ratio and real GRDP per capita. The distance between provinces to the worst alternative location of inequality and the best GRDP per capita was then multiplied by the achievement of the Gini ratio and GRDP per capita of each province (as weights) to determine the closest location to the source of inequality and income dominance referred to in the study. The closest alternative location will be selected as the worst source of inequality and the best real GRDP per capita in Sumatra. Information on longitude, latitude, and distance for the centre of gravity method was sourced from Google (2023).

This study further examines the determinants of income inequality based on 10 provinces in Sumatra over 2015-2019. Information on Gini ratio, real GRDP per capita, worker dependence and highly educated workers were sourced from the BPS-Statistics Indonesia (2023a), (2023b), (2023d). At the same time, IKLH data were sourced from the Ministry of Environment and Forestry RI (2020). We use balanced panel data regression to examine the effect of highly educated workers and worker dependency burden in influencing income inequality through per capita income and environmental quality index (MacKinnon et al. 2002). There were several regression models likely to be used for analysis, namely pooled OLS model, fixed effects least-squares dummy variable, or random effects model. The equations for these three models are illustrated as follows (Gujarati & Porter 2009):

Pooled OLS Model

$$gini_{it} = \beta_1 + \beta_2 iklh_{it} + \beta_3 edu_{it} + \beta_4 percap_{it} + \beta_5 dep_{it} + u_{it} \quad (2a)$$

Fixed Effects Least-Squares Dummy Variable Model (one way)

$$gini_{it} = \beta_{1i} + \beta_2 iklh_{it} + \beta_3 edu_{it} + \beta_4 percap_{it} + \beta_5 dep_{it} + u_{it} \quad (2b)$$

Random Effects Model (with Generalized Least Square)

$$gini_{it} = \beta_1 + \beta_2 iklh_{it} + \beta_3 edu_{it} + \beta_4 percap_{it} + \beta_5 dep_{it} + w_{it} \quad (2c)$$

where $gini$ is the Gini ratio, $IKLH$ is the environmental quality index, edu is highly educated workers, $percap$ is real GRDP per capita, dep is worker dependency burden ratio, i is each province in Sumatra, t is the period 2015-2019, and w is the combined error of individual specific and idiosyncratic error. To choose the best model, two tests were carried out, the first was the restricted F test, using the following formula (Gujarati & Porter 2009):

$$F = \frac{(R^2_{fixed} - R^2_{pooled})/m}{(1-R^2_{fixed})/(n-k)} \quad (3)$$

where R^2_{fixed} is the R^2 value from the fixed effects model estimation, R^2_{pooled} is the R^2 value from the pooled OLS model, m is the number of cross sections minus 1, n is the number of observations, and k is the number of explanatory variables (including dummies and constants). If the F statistic value is greater than the F table value, then the best model is the fixed effects model. If the fixed effects model is selected, then the next step is the Hausman test to choose the best between fixed effects and random effects model. The decision is to use random effects model unless the Hausman test rejects the assumption $cov\,(x_{itj}, a_i) = 0, t = 1, 2, \ldots, T;\ j = 1, 2, \ldots, k$. The random effect estimator is much more efficient than the fixed effect estimator for time-varying regressor coefficients. However, the fixed effect model is not intended to be efficient, but to be more robust to the correlation between a_i and x_{itj} (Wooldridge 2020).

The use of OLS methods such as pooled least square and LSDV requires the assumption of the Gauss-Markov theorem, which is to have an unbiased and efficient estimator (Gujarati & Porter 2009). Panel cointegration testing is conducted to ascertain whether or not there is a long-run equilibrium relationship of the model built. Kao (1999) uses residual-based cointegration tests from the DF and ADF tests, with residuals:

$$\hat{e}_{it} = \rho \hat{e}_{it-1} + \sum_{j=1}^{P} \varphi_j \Delta \hat{e}_{it-j} + v_{itP} \quad (4)$$

Residuals are from the equation:

$$gini_{it} = \beta_{1i} + \beta_2 iklh_{it} + \beta_3 edu_{it} + \beta_4 percap_{it} + \beta_5 dep_{it} + e_{it} \quad (5)$$

with the null hypothesis that there is no cointegration, or it can be obtained from the ADF probability value. The regression analysis was subsequently divided into two stages. Firstly, we analysed from the direct effect equation model and then from the indirect effect equation model. The Sobel test was used to infer the significance of the effect of the independent variables on inequality through their intervening variables. Observations were limited to the period 2015 to 2019 in 10 provinces of Sumatra, so as to avoid bias in the results due to the influence of economic shocks during the covid-19 outbreak in 2020 and after. The equation model is as follows:

Direct Equation Model:

$$gini_{it} = c + iklh_{it} + edu_{it} + percap_{it} + dep_{it} + \varepsilon \quad (6a)$$

Indirect equation model 1:

$$iklh_{it} = c + edu_{it} + +dep_{it} + \varepsilon \quad (6b)$$

Indirect equation model 2:

$$percap_{it} = c + edu_{it} + +dep_{it} + \varepsilon \quad (6c)$$

The mediation model implies several relationships. One of them is that if the third variable acts as a cause so that the independent variable causes the third variable and the third variable causes Gini, it is thus said to be a mediator (Mackinnon 2015).

One way to test the significance of the effect of the intervening variable is by dividing its estimated effect, by its standard error (MacKinnon et al. 2002), and compare the ratio with a critical value of ± 1.96 or with the t-distribution. A ratio greater than 1.96 or smaller than -1.96 indicates that the intermediating effect exists on the intervening variable (Mackinnon 2015). The standard error formulation is as follows:

$$\sigma_{ab} = \sqrt{\alpha^2 \sigma_b^2 + b^2 \sigma_\alpha^2} \quad (7)$$

where a and b is the estimated regression coefficient, σ_α^2 and σ_b^2 the squared standard error of α and b.

VARIABLE DEFINITION

Gini Ratio

In measuring the level of inequality in each province, Statistics Indonesia uses expenditure data as a proxy for income sourced from the national socioeconomic survey (susenas). For the Gini ratio the March data was used, and the formula is as follows:

$$GR = 1 - \sum_{i=1}^{N} F_{pi}(F_{ci} + F_{ci-1}) \quad (8)$$

where F_{pi} is the frequency of population in class-i, F_{ci} is the cumulative frequency of total expenditure in class-i, and F_{ci-1} is the cumulative frequency of total expenditure in class-(i-1).

Real GRDP Per Capita

The real Gross Regional Domestic Product (GRDP) per capita used in this study was at constant 2010 prices. The value of GRDP for each year was divided by the total population in the middle of the calculation year. The formula is as follows:

$$Real\ GRDP\ per\ capita = \frac{GRDP\ Constant\ prices_t}{\Sigma\ Population\ mid-year\ of\ counting} \quad (9)$$

Environmental Quality Index (IKLH)

This index describes the condition of water quality (IKA), air quality (IKU) and land cover quality (IKTL) in 10 provinces in Sumatra. The calculation for the index can be described as follows (Ministry of Environment and Forestry RI 2020):

$$IKLH\_provinsi = (30\%\ x\ IKA) + (30\%\ x\ IKU) + (40\%\ x\ IKTL) \quad (10)$$

Worker Dependent Burden

The worker dependency burden was measured by comparing the total number of people who were not working to the total number of workers. The calculation is as follows:

$$\text{Worker Dependents Burden Ratio} = \frac{\Sigma\ population\ not\ working}{\Sigma\ working\ population} x\ 100 \quad (11)$$

Highly Educated Workers

Data on highly educated workers was based on the category of workers with a diploma level education and above. The data was then divided by the total number of workers. The calculation is as follows:

$$Proportion\ of\ highly\ educated\ workers = \frac{\Sigma\ diploma + university\ graduate\ workers}{\Sigma\ worker} x\ 100 \quad (12)$$

RESULTS AND DISCUSSION

DATA DESCRIPTION

Figure 1 shows Bangka Belitung Province as the province with the lowest average Gini ratio in 2015-2019, at 27.80 or 0.278 points. The Bengkulu Province has the highest Gini value at 35.72 points during the observation period. For the real GRDP per capita, Riau Islands Province is the region with the highest achievement, recorded at IDR 80.2 million, and the lowest is Bengkulu Province with IDR 21.8 million per year, or IDR 1.8 million per month. The worst environmental quality was in Lampung Province, and the best average quality was in Aceh Province at 75.49. The proportion of highly educated workers is higher in Aceh Province at 16.65%, while the lowest is in Lampung Province at only 8.47%. The dependency burden per worker in Bengkulu is the lowest, with 100 workers supporting 98 non-working citizens.

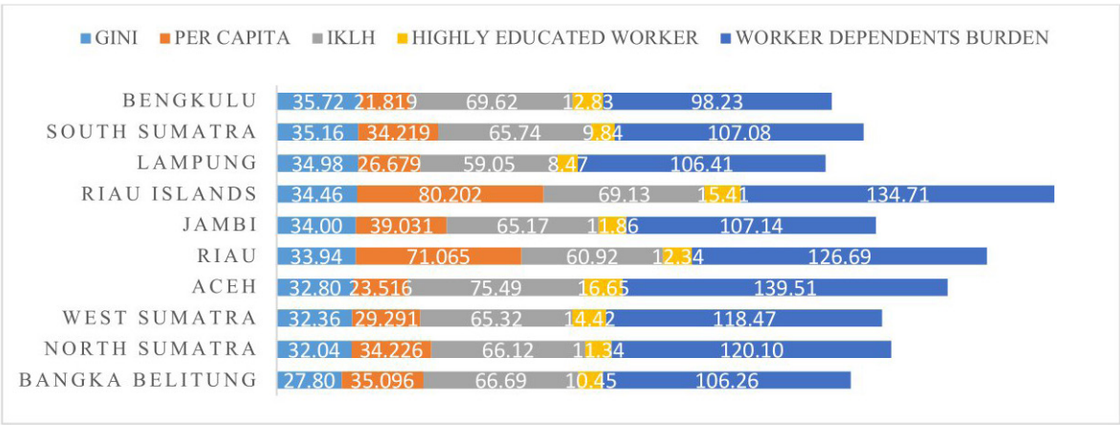


FIGURE 1. Comparison of Gini Ratio, Real GRDP per capita, Proportion of Highly Educated Workers, and Worker Dependency burden in Provinces in Sumatera Island 2015-2019

Source: Calculated by the Authors using BPS-Statistics Indonesia, 2023

MAGNET ANALYSIS OF INCOME INEQUALITY

Midpoint Location

Calculation of the midpoint location is necessary as an ideal comparison of the factual results of the worst location for the Gini ratio and the best location of real GRDP per capita. To find the midpoint, the calculation is carried out without using the weight of the Gini indicator and real GRDP per capita, or the weight is assumed to be similar for each province. The results of the midpoint calculation are as follows:

TABLE 1. Midpoint area in Sumatra Island

Best/Worst Location	Total Distance (Km)
Air Buluh, Kuantan Mudik District, Kuantan Singingi Regency, Riau	4.261

Source: Calculated in the study using Google Maps, 2023

Table 1 is the location of the closest midpoint out of the eight alternative locations that appeared on the map. The location has a total distance of 4,261 km. with the midpoint area located in Air Buluh Village, Riau Province. This area represents the point of perfect equity or without disparities in Gini and with the highest per capita income between provinces. The midpoint is located at the coordinates -0.8023695 and 101.5387362.

Gini Ratio With The Worst Location

Determination of the location for the worst Gini ratio was conducted using the centre of gravity method. The capital city of each province was set as the coordinate point, except for Aceh Province which was adjusted by using the coordinates of the Southeast Aceh Regent's Office of North Sumatra with coordinates of the Labuhanbatu regent's office. The adjustment was necessary since the positions of the two districts were directly in the middle of the province, unlike the case for Medan or Banda Aceh which are located on the edge of their respective provinces. The results are as follows:

TABLE 2. Worst location of gini ratio in Sumatera island

No	Alternative Location	Total Weighted Distance (Km)
1	Sungai Jernih, Tebo Regency, Jambi	1,398
2	Muara Kuamang, Bungo Regency, Jambi	1,392
3	Sako Makmur, Tebo Regency, Jambi	1,409
4	Rimbo Mulyo, Tebo Regency, Jambi	1,380
5	Tiumang, Tiumang District, Dharmasraya Regency, West Sumatra	1,374
6	Timpeh, Dharmasraya Regency, West Sumatera	1,401
7	Pauh Ranap, Indragiri Hulu Regency, Riau	1,417
8	Jake, Kuantan Singingi Regency, Riau	1,408

Source: Calculated by the Authors using Google Maps, 2023

Of the eight alternative locations available, it is known that the exact location point in Tiumang Village, West Sumatra has the lowest total weighted distance. In other words, if we assume the Gini ratio value as the production volume of each province's inequality and weight it to be multiplied by the distance of each province to each alternative location, then Dharmasraya Regency of West Sumatra is the location with the cheapest transportation cost to transport each province's inequality. We also assume that the inequality magnet are in the same area. The worst location leading to West Sumatra is in line with the distribution of the Gini ratio of the eight provinces studied, where the index values do not have a significant gap between each other. All provinces are in the medium inequality category, ranging from 0.30 to 0.34. The distance from Tiumang Village to the area without disparity, namely Air Buluh Riau Village, is still 43.3 km. This difference in the distance illustrates the disparity in the Gini ratio between provinces on the island of Sumatra.

FIGURE 2. Worst location of gini ratio in Sumatra Island
Source: Summarized by Author

Figure 2 indicates the the location of the worst income inequality, shaded in colored dark blue in West Sumatra, precisely the point bordering Riau Province. The location is around the midpoint of the main island of Sumatra.

Best Location Real GRDP Per Capita

The location of the best per capita real GRDP was determined using the center of gravity method. The total weighted distance is an aggregation of the results of multiplying the distance traveled by each province to each alternative location multiplied by the achievement of real GRDP per capita in 2022. The results are shown below.

TABLE 3. Best locations of GRDP per capita in Sumatera Island

No	Alternative Location	Total Weighted Distance (million Km)
1	Muara Sekalo, Tebo district, Jambi	150,342
2	Sekutur Jaya, Tebo Regency, Jambi	147,652
3	Kepayang Sari, Indragiri Hulu Regency, Riau	145,954
4	Purwo Harjo, Tebo Regency, Jambi	145,076
5	Setiang, Kuantan Singingi Regency, Riau	141,313
6	Jaya, Kuantan Singingi Regency, Riau	142,988
7	Pauh Ranap, Indragiri Hulu Regency, Riau	144,612
8	Rambahan, Logas Tanah Darat District, Kuantan Singingi Regency, Riau	140,186

Source: Calculated in the study using Google Maps, 2023.

The best location considered as the meeting point of the real GRDP per capita of Sumatra is in Riau Province, precisely in Rambahan Village. The alternative location number 8 was considered the best location as a magnet for real GRDP per capita in Sumatra since it has the shortest weighted distance to be traveled by each province. The highest real GRDP per capita value is Riau Province. This reinforces its position as the midpoint and also as the largest contributor to the real GRDP per capita generated. However, the distance from Rambahan Village to Air Buluh Village in Kuantan Mudik Sub-district is 89.9 km. which continues to reflect the income inequality of real GRDP per capita between the provinces studied.

FIGURE 3. Best Location for GRDP Per Capita in Sumatra Island
Source: Summarized by Author

The worst location for the Gini ratio and the best location for real GRDP per capita are in the province of West Sumatra and Riau, located adjacent to each other in the middle of Sumatra. The distance between location of the Gini ratio and real GRDP per capita to the midpoint are respectively 43.3 km and 89.9 km.

The worst inequality point of the Gini Ratio is towards the lower side of the midpoint whereas the location of the best real GRDP per capita is towards the upper right. Both variables are interrelated to each other, with the trend in income inequality increasing with growth in per capita income in the early phase of industrialisation (Kuznets 1955). However, with the massive economic development occuring in the provinces of Aceh, North Sumatra, West Sumatra, Bengkulu and Lampung income inequality may shift closer to the midpoint. Development that is more dominant in Aceh and North Sumatra, located on the upper side of the island, is expected to be able to attract the location of real GRDP per capita and Gini ratio to the upper left. This also aims to increase the level of real GRDP per capita and Gini ratio of the two provinces from below average value to the value of intra-island convergence. Furthermore, development on the lower left side of Sumatra, such as West Sumatra and Bengkulu, is expected to shift the previous point to lower left position. This potential outcome is in line with the achievement of real GRDP per capita and the Gini ratio of the two provinces which are still below the Sumatran average. Increased development intensity in West Sumatra and Bengkulu is expected to further increase economic growth and real GRDP per capita, which is believed to have an impact on improving the Gini ratio until the post-industrial phase. As a counterweight to the movement of points, increased growth in Lampung Province need to be prioritised since its low per capita real GRDP (Rp.28.8 million) and Gini ratio (0.329) are below the island average.

PANEL DATA REGRESSION MODEL

Selection Models

The direct equation (Gini) and two indirect equations (IKLH and percap) used data transformed into natural logarithms. The restricted F test and Hausman test on the Gini model resulted in a value below 0.050. As such, it was decided that the results of the fixed effect model will be used for analysis. The results of the IKLH and GRDP per capita models showed the probability value of the Hausman test at respectively 0.087 and 0.213 which exceeded 0.050. Thus, the random effect was considered the best model for the analysis.

TABLE 4. Panel regression model test results

Model	Cross Section F Prob.	Hausman Test Prob.	Decision
$log(gini_{it}) = c + logIKLH_{it} + log(edu_{it}) + log(percap_{it}) + log(dep_{it}) + \varepsilon$	0.000	0.000	FEM
$log(IKLH_{it}) = c + log(edu_{it}) + log(dep_{it}) + \varepsilon$	0.001	0.087	REM
$\log(percap_{it}) = c + log(edu_{it}) + log(dep_{it}) + \varepsilon$	0.000	0.213	REM

Source: Summarized by Author, 2023

Panel Cointegration Results

Based on the panel cointegration test through Kao residual cointegration test, the ADF probability value is 0.000 or below 5% alpha. This proves that the null hypothesis is rejected, or in other words, the direct equation model has a long-term equilibrium relationship between variables.

TABLE 5. Panel cointegration test results

	t-Statistic	Prob.
ADF	-6.113	0.000

Source: Secondary data output following proccesing 2023

Results of Direct Effect on Gini Ratio

The estimation results of the fixed effect model below are already in Gauss Markov conditions, where the residuals are normally distributed with a probability value. These included the Jarque-Bera value of 0.76 (above 0.05), the correlation value between variables that is below 0.5, the Durbin Watson value of 1.99, the probability value of the Pesaran CD of 0.2980, and the probability value of each independent variable on the absolute value of the residual that is greater than 0.05. The R-squared value indicates that the variation of the independent variables included in the model is able to explain the Gini ratio by 92.62%. The probability value of the F-statistic can be interpreted as indicating that at least one independent variable exerts a significant effect on the Gini ratio.

The partial test results, showed that IKLH, highly educated workers, GRDP per capita and the constant have a significant effect on the Gini ratio, as indicated by their probability values at below 5% and 1%. Meanwhile, the dependency burden of workers did not produce a significant effect and has a high probability value of 0.430 and a low t-statistic.

The coefficient value of IKLH at -0.147 indicates that an increase in its value by 1% will be followed by a decrease in the Gini ratio amounting to 0.147%. The results supported the argument of Galeotti (2007) but are relatively different from Khan et al. (2023). The results also confirmed that prevention of environmental degradation can save on development costs and bring about better economic equity compared to the cure option. Current prevention efforts such as tightening business licenses for those in high environmental risk categories, as well as the fulfillment of the AMDAL for such businesses, can be strengthened through more continuous and professional supervision. Better environmental quality can strengthen natural resource reserves which can then be utilized economically by more groups of people. Various policy efforts made by the government in improving the quality of water, air and land can create a biotic ecosystem that may provide great opportunities, especially for the low-income groups, to participate in a broader economy.

The proportion of highly educated workers has a significant negative effect on the Gini ratio which measures -0.076%. This result reinforces the findings of Wahyuni & Monika (2016), but are relatively different from those of Rahman et al. (2023). The impact of highly educated workers in reducing income inequality in Sumatra is proven to be effective, but with a lower coefficient value than the effect of IKLH. The low distribution of highly educated workers is thought to be one of the factors for the low magnitude impact of this variable. On a Sumatran scale, Aceh Province has the largest distribution, with 16.25% of its workers at the higher education level. However, this figure is still far smaller than workers with lower level education. The higher the educational level the greater is its effect in reducing inequality until the point of establishment is reached when its influence start to wane.

Real GRDP per capita has a significant negative effect on the Gini ratio at -0.569%. The coefficient value is the largest compared to other variables, meaning that the variable assumes the dominant role in reducing inequality in Sumatra Island. The higher the real output per capita produced by each person, the greater the impact in reducing inequality. Labour productivity is the main requirement in maintaining the growth momentum of this indicator, in addition to a controlled population growth rate, since population is the divisor. It is difficult to separate productivity from the quality of education, both formal and informal. This study is consistent with the findings of past studies, such as Prasetiya (2021) and Ali et al. (2022) but differs from those of Alamanda (2021).

Meanwhile, the burden of dependence on workers does not produce a significant effect on the Gini ratio in each Sumatran province. The flux in the variable, which varies substantially each year in most provinces, is suspected to be its main weakness in explaining income inequality. This may be attributed to several factors (Marois et al. 2022), including highly dynamic in-migration and out-migration among workers. The high migration dynamics among household workers also affects the flux in the unemployed population. Another possibility is the birth rate and life expectancy, which is influential on population demographics of the region.

The constant coefficient value implies that if the predictor variables are reduced to zero, the Gini ratio will increase by 9.9%. This value further reinforces the importance of the variables included in the model for reducing inequality, in line with its high R-squared value, and in addition to the dummy effect of each cross section.

TABLE 6. Fixed effect model results on the direct effect on income inequality

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGIKLH	-0.147**	0.067	-2.178	0.036
LOGPERCAP	-0.569***	0.100	-5.705	0.000
LOGEDU	-0.076**	0.035	-2.149	0.038
LOGDEP	-0.062	0.077	-0.798	0.430
C	9.900***	1.942	5.098	0.000
R-squared	0.926	Mean dependent var		-1.102
Adjusted R-squared	0.900	S.D. dependent var		0.078
S.E. of regression	0.025	Akaike info criterion		-4.338
Sum squared resid	0.022	Schwarz criterion		-3.802
Log likelihood	122.438	Hannan-Quinn criter.		-4.134
F-statistic	34.767	Durbin-Watson stat		1.998
Prob(F-statistic)	0.000			

Source: Processed secondary data output, 2023
Where: (*) is significant at (10%), (**) is significant at (5%) and (***) is significant at (1%).

Results of Indirect Effect on Environmental Quality

The indirect influence of random effect model through IKLH, showed that the proportion of highly educated workers had no significant impact on environmental quality. This finding is relatively different from Wu et al. (2022) but the direction of the relationship is similar to those in Zhu (2023) and Kim & Go (2020).

An increase in the ratio of worker dependence by 1% can significantly improve environmental quality by 0.24%. In other words, the smaller the ratio of the working population the better its contribution to reducing environmental degradation. The economy of Sumatra, partially supported by the agriculture, forestry and fisheries sectors, is considerd to still rely on conventional exploitation patterns that pay little attention to their impact on the environment. New environmentally friendly technologies are sparingly utilised in production, and the economic level is still in the middle to lower development phase, thus strengthening the allegation that the economy is mainly motivated by growth. Thus, the ongoing absorption of labour can exacerbate environmental degradation. The local highly educated workforce is not sufficiently prominent in influencing development decisions to orientate towards a more pro-environmental economy.

TABLE 7. Random effect model results on environmental quality

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGEDU	0.087	0.056	1.544	0.129
LOGDEP	0.246**	0.107	2.301	0.026
C	2.807***	0.511	5.488	0.000

Source: Processed secondary data output, 2023
Where: (*) is significant at (10%), (**) is significant at (5%) and (***) is significant at (1%).

Results of Indirect Effect on Real GRDP Per Capita

Furthermore, the indirect effect of highly educated labour and worker dependency burden on real GRDP per capita, via the the random effect model, was quite significant. The burden of worker dependence has a greater but negative level of influence, where an increase by 1% will reduce real GRDP per capita by 0.339% or vice versa. The greater proportion of the working population in Sumatra can increase real output per capita, but past track record on environmental quality reinforces current view that the economic process on the island is still moving slowly in achieving sustainable development goals.

In education, a 1% increase in the distribution of highly educated workers will increase real GRDP per capita by 0.110%. Contribution through the productivity of highly educated workers affects output per capita and provides a testimony to the quality of current universities

in producing such calibre graduates to spur economic productivity in Sumatra. This result concurs with Becker (1964) and OECD (2021) with the observation that highly educated workers earn better incomes.

TABLE 8. Random effect model results on real GRDP per capita

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGEDU	0.110**	0.054	2.021	0.049
LOGDEP	-0.339***	0.108	-3.142	0.003
C	18.737***	0.593	31.583	0.000

Source: Processed secondary data output, 2023
Where: (*) is significant at (10%), (**) is significant at (5%) and (***) is significant at (1%).

MEDIATION MODEL

The Sobel test was used to examine the mediating role of environmental quality and real GRDP per capita on the independent variables in reducing the level of inequality in Sumatra. Table 9 informs that of the four equation models formulated, only one produces a significant effect, namely Equation 4.

The model in Equation 4 indicates that a decrease in worker dependency burden ratio can reduce income inequality through an increase in per capita income. This information is obtained from the ratio value of 2.752 or higher than the critical value of 1.96. The role of GRDP per capita in equation 4 is classified as a mediator, i.e. a decrease in the worker dependency burden ratio leads to an increase in income, and an increase in real income per capita leads to a decrease in Gini, or vice versa. This supports the argument of Klasen (2010) on the role of labour-intensive development in creating inclusive growth.

Current development is thus characterised by the weak effect of highly educated workers on improving environmental quality but strong impact of increased real output per capita and reduced income inequality. This pattern is reinforced by the results of worker dependency burden ratio, which is negatively associated with productivity but positively associated with environmental quality. In other words, the larger the proportion of the working population, the higher the productivity, but consequently lowered environmental quality. This outcome however does not fully reflect the spirit of sustainable development as stated in the SDGs document. The major constraint is the relatively low GRDP per capita as a measure of the welfare of the population of Sumatra. At around 2,684 US dollars, the island is classified as lower middle income. There is no strong urge in the economy to improve the GRDP and concerns for addressing environmental issues are still wanting. The bright side however is the growth of new entrepreneurs in educated circles in the midst of the VUCA era. The tendency of labour-intensive production that are emerging has strengthened productivity and economic equity through the use of technology, but the development has barely addressed environmental quality.

TABLE 9. Mediation test results

Equation Model	Indirect effect			Ratio Value	Decision
1	Education to Gini through IKLH	-0.013	0.0102	-1.260	Not Significant
2	Dependence to Gini through IKLH	-0.036	0.023	-1.582	Not Significant
3	Education to Gini through GRDP per capita	-0.063	0.033	-1.905	Not Significant
4	Dependence to Gini through GRDP per capita	0.193	0.070	2.752	Significant

Source: Summarized by Author, 2023

CONCLUSION

This study proved the existence of a relatively low level of income inequality between provinces which is gradually reduced through efforts on environmental quality, real GRDP per capita and of highly educated workers. Improving environmental quality can also reduce inequality but the real GRDP per capita exerts the greatest influence in reducing inequality. The panel cointegration test estalished that there is a long-run equilibrium relationship between the variables. This suggests that the regression model is reliable in long-term predictions, since there is a strong relationship between the variables involved. The dependency burden of workers improves environmental quality but reduces the real GRDP per capita. This is however improved by employment of highly educated workers. The study concludes that reducing the dependency burden of worker has significant effect in decreasing income inequality through improvement in real output per capita.

The study thus suggests the need for applying economic stimulants in the Aceh-North Sumatra and Jambi-South Sumatra-Lampung regions to break the concentration of income inequality. The central government can assume the lead role in encouraging new growth centers/poles in these areas. Such stimulant

may induce strong response in strengthening provincial government policies. A further suggestion is to encourage the formulation of inclusive and pro-environmental development policies.

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