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Economic Development and Convergence In Sumatra Island, Indonesia

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Abstract: Economic Development and Convergence In Sumatra Island, Indonesia

The island of Sumatra, one of the largest contributors to the Indonesian economy, has experienced increased economic growth from time to time, but the acceleration of growth from each province has a different pace. This study aims to analyze the development and convergence of real per capita income that occurred on the island of Sumatra from 2011-2020, using panel data from 10 provinces in it. The novelty of this study incorporates Klassen's analysis as an effort to provide more concrete recommendations as well as the calculation of the half-life value per province which illustrates the convergence speed of each region. This can support the strength of the recommendation. We also divide the two observation periods, namely during normal conditions, and include 2020 as the year the economic shock occurred to compare changes in the convergence rate. Klassen's typology of economic development on the island of Sumatra for the 2016-2020 period shows a shift in the Riau Island Province towards being depressed and Bangka Belitung in the lagging zone. Meanwhile, Aceh Province is getting closer to the potential zone line. The level of inequality from the average value of the Williamson index is classified as moderate and during the year of observation shows an increase in value indicating convergence. The Covid-19 pandemic has reduced inequality, But on the other hand, the pandemic has also caused a decrease in real income in all the provinces observed, which means that welfare has decreased. The half-time value of each province implies economic stagnation that will occur in depressed developed regions and opens up opportunities for underdeveloped regions to spur growth in their real per capita income. In measuring the convergence itself, there was a convergence of real income per capita on the island of Sumatra. In other words, the conditional convergence model has a relatively higher convergence speed than the absolute convergence model. As an implication of the study, efforts to equalize per

capita income on the island of Sumatra can be accelerated by spurring economic growth, HDI, and the distribution of gross fixed capital in areas that are in quadrants 3 and 4. Policies in eradicating poverty are a booster in accelerating the convergence process.

Keywords: Convergence; Inequality; Real Income Percapita; Covid-19; Poverty

INTRODUCTION

Reducing inequality is one of the 17 goals agreed upon in the 2030 sustainable development agenda (Bappenas, 2019). Economic development that continues to roll is expected to spur high economic growth accompanied by reduced income inequality between communities. However, it seems that all parties have to accept the bitter initial effects, that rapid economic growth in one region in the initial phase will cause disparities with other regions. Up to a certain point, the gap will decrease. Like what was said by Kuznets (1955), one can assume a long-swinging curve on the inequality characteristics of the income structure, widens in the early phases of economic growth, becomes stable for a time, and narrows in the later phases. This concept is reinforced by the growth model Solow (1956), where technology is assumed to be an exogenous factor, poor countries/regions will grow faster than rich countries due to higher marginal products. There are several arguments why income is not closely related to well-being. The focus of attention in the growth literature is on the difference between, per capita income, income per worker, and hourly income. Jones (1997) suggests that real GDP per capita is a better measure of welfare, while real GDP per worker is a better measure of productivity (Isaac, 2017).

It is logical to think that a steady-state distribution of per capita income would take place if all economies across regions grew at the same rate. Referring to the neoclassical model, this condition requires that the exogenous growth rate of technology is the same in the long run for all countries. Model from Eaton & Kortum (1994) concludes several things, first, that capital is not a driving force for growth, which only moves endogenously to benefit from technological improvements. Second, technology spreads much more slowly between countries than within countries, and even large countries derive a substantial part of their growth from abroad. Then, the study Jones (1997), assumed a steady state of per capita income distribution in the 1990 period, it was that groups of countries with high-income distribution have a catch-up effect and some countries will even overtake the United States. Conversely, a group of countries with low incomes will remain very close to their relative income levels in 1990. Furthermore, R. Barro &

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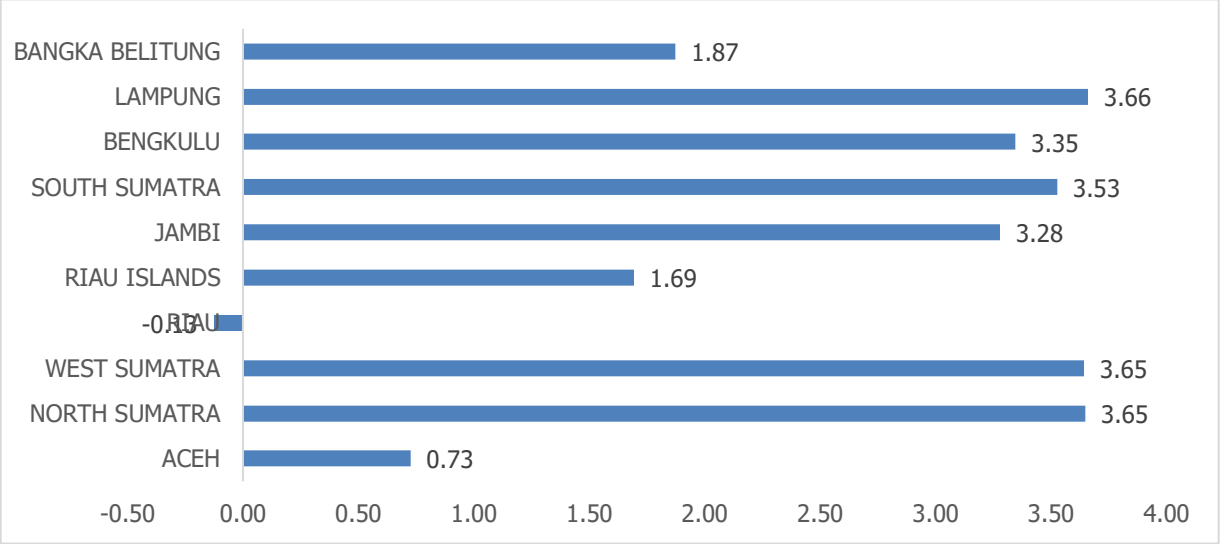
Sala-i_martin (1997) construct a model that combines elements of endogenous growth with the convergence implications of the neoclassical growth model. The results illustrate that in the long term, the world's growth rate is driven by inventions from technology-leading countries. The cost-increasing trend of the participating country will reduce its growth rate and produce a conditional convergence pattern. Poorly defined intellectual property rights deprive the leading nation of sufficient incentives to invent, whereas the following has excessive incentives to copy technologys.

Figure 1. Average Real GDP Growth per Capita Between Province On The Island of Sumatera 2011-2020



Source: Indonesian Central Bureau of Statistics, data processed, (2023)

Sumatra Island is one of the growing clusters in Indonesia with the second largest economic distribution after Java. The emergence of growth centers in several strategic areas of Sumatra Island will create two conditions, namely the lagging effect and the catch-up effect by poor regions to established regions. This condition should be explored more deeply to see the performance of the ongoing economic convergence/divergence. We use real income per capita as an observation variable, in line with the opinion of Jones (1997), which states that this indicator is a better reflection of welfare. In Figure 1 below, it is known that based on the average real income growth per capita from 2011-2020, each region has relatively different intensities. This difference can be seen especially in the provinces of Aceh, Riau, Bangka Belitung, and Riau Islands with other provinces. Some of these provinces include areas with the highest per capita income with depressed growth rates. One of them is Riau, with an average growth rate of -0.13 percent during the year of observation. Meanwhile, the provinces of North Sumatra, West Sumatra, and Lampung have the highest average growth.

In previous research, Zulham et al. (2019) conducted a study on the convergence of economic growth on the east coast of North Sumatra. The results of the study conclude that the regional disparity between districts/cities in the East Coast of North Sumatra Province for the period 2003-2015 shows that some areas tend to increase and other areas tend to decrease. The independent variables (working population, number of poor people, and average length of schooling) have a major influence in increasing the speed of convergence of economic growth on the East Coast of North Sumatra.

In another study, Hartmann et al. (2017) prove that countries that export complex products have lower levels of income inequality than countries that export simpler products. In addition, another finding is that a country's productive structure can limit its range of income inequality. Akram & Rath (2020) examine the role of export diversification in the convergence of per capita income (output). By using a panel dataset using the Generalized Method of Moment (GMM) technique in 95 countries, the results prove that there has been an absolute and conditional divergence between the overall sample and subsample based on income and region. The findings show that although high export diversification increases per capita income (output), it does not significantly reduce the per capita income (output) gap between rich and poor countries.

Research conducted by Zulham, et al. (2020) explores the supply chain strategy of fiscal decentralization and its effect on regional performance proxied to per capita income. The focus of the study was on 3 districts and cities in the area of North Sumatra Province from 2011-2015. Based on the results of the study, it is known that the Williamson index for the General Allocation Fund per capita shows an unstable distribution. Meanwhile, the distribution of the Williamson index for per capita income is in the medium category. Subsequent results show that Regional Original Income and balancing funds have a positive influence on per capita income in North Sumatra.

Gross Regional Domestic Product is a commonly used measuring tool to describe the strength of the economy in a region. However, this measurement tool still has weaknesses in providing a comprehensive picture of development developments that are oriented towards reducing poverty and increasing the welfare of the population. In this case, the Human Development Index is often used to complete development information in terms of human development, especially from the health and education dimensions. Study Mihaela & Georgiana (2015) in their conclusion states that economic growth focuses on income generation, but human development implies the consolidation of all possibilities, whether economic, social,

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cultural, al or political. Income is a means of human development, but it is not the only one. The Human Development Index is an innovative construct, highly arbitrary, yet interesting, and over time it has proven very useful for disseminating information, analysis, and guidelines for public policy at global and national levels.

Besides human capital, development also requires physical capital as a determinant of productivity. Mankiw (2016) in his book describes four factors that cause big differences in living standards, one of which is the factor of physical capital per worker. Physical capital is an important part of producing other production factors, where this capital becomes the input of a production process which is the output of a previous production process. By default, the term physical capital can be reflected in the amount of gross fixed capital formation which is one of the elements forming the value of GRDP.

The convergence model informs that if developed regions (high real income per capita) experience slowing growth balanced by a fairly high growth rate in underdeveloped regions, it can be strongly suspected that economic dispersion will occur. However, if what happens is the opposite, then the condition that occurs is a divergence. The analysis begins with the Klassen typology technique to see the distribution of economic power between provinces and their economic performance. Then, to see the trend and the magnitude of the welfare disparity that occurs, we use the Williamson index to analyze it. Proof of convergence that takes place between provinces on the island of Sumatra using the Sigma convergence model and beta convergence with the help of panel data regression. This study includes HDI, gross fixed capital formation, and the number of poor people as predictor variables on beta convergence, in looking at the effect empirically on the island of Sumatra.

Previously, the same research on the island of Sumatra was conducted by Budiman et al., (2018) which shows the convergence of sigma and beta in 2012-2017. We reconfirmed and added quadrant mapping in two different periods to see the shifts from each province in the two observation periods. We use this tool as an effort to provide recommendations, especially for provinces that need more specific interventions to catch up with provinces that are classified as advanced. The calculation of the half-life value for each province can strengthen the results from the quadrant division shown. Then, we also divide the regression calculation into two periods, namely 2011-2019 and 2011-2020. We want to compare the changes in the coefficients over a range of normal conditions with a timeframe that includes periods of economic shocks. Some of these aspects are expected to be the novelty of the study and complement what has been proven before.

LITERATURE REVIEW

Neoclassical economic theory argues that the economy will move towards a steady state or steady state (Todaro, 2006). When an economy is in a steady state, the increase in per capita income will only occur at the level of technology (Valdes, 2003). When an economy is below its steady state, the per capita income growth will be greater than the technological level. Convergence is the process of economic growth in different countries or regions in such a way as to reduce the gap in income, productivity, wage levels, and various other economic indicators. This can mean reduced differences or gaps in GDP per capita between regions, and productivity (Abramovitz, 1986), or the existence of economic growth in poor countries that are so impressive that it tends for these poor countries to catch up with rich countries. (J. R. Barro & Martin, 2004).

Within the scope of the analysis of economic growth, it cannot be separated from the problem of income inequality that occurs between regions. Along with the increase in growth, it will affect income inequality. An increase or decrease in investment that is interconnected with economic growth is one of the factors that trigger income inequality between regions. In addition, the causes of income inequality in Indonesia which are summarized by Tambunan, (2003) include the concentration of regional economic activities, an area that has a high concentration of economic activity that will grow faster. This can cause labor, capital, and trading activities to move to more developed areas. Then, the investment allocation is concentrated in a certain area. This causes a low level of income per capita in areas with minimal investment. Furthermore, the factors of population growth, education, and health are considered to play an important role in contributing to people's income. The inequality that occurs in an area will affect the level of community welfare in the region. The human development index and income inequality have an interrelated relationship. HDI harms inequality, and the role of formal education in supporting economic growth states that the higher the formal education obtained, the higher labor productivity will be (Becker, 1962).

Convergence is a decrease in the difference in per capita income of a poor country or region with a rich or poor country based on their very fast economic growth, this is based on the fact that the economy of a region leads to a steady state condition if the region or region is already in a steady state condition. the economy will then slow down. This statement is supported by research (Kumo, 2011; Li & Zhou, 2011; Brandt et al, 2014; Kaitila, 2013).

Unlike the previous statement, research conducted by Yuslinaini et al., (2015) with the

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same research area, namely the island of Sumatra, shows that in the 2002-2014 observation period, there was a divergence of economic growth in the observation area. Yulisningrum & Setyastuti (2012) who conducted research in Indonesia from 1992 to 2012 also stated that convergence of economic growth did not occur. Economic growth in poor areas was relatively slow compared to rich areas. The convergence process of a region shows a dynamic condition. This can be seen from the findings of Amos & Ireland, (2015) which showed that there was a pattern of transition in Oklahoma from convergence to divergence during the study period.

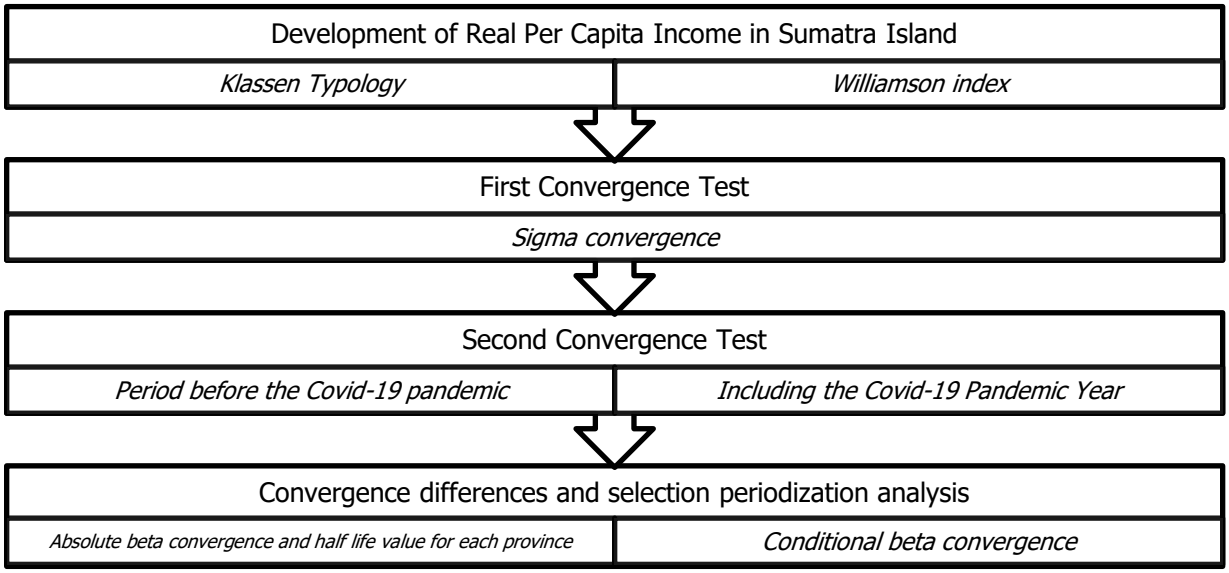
Barro & Martin (2004) explain that convergence can be calculated based on two concepts, namely sigma convergence and beta convergence. Sigma convergence is measured through the level of dispersion of the log of income per capita of each region. If the income dispersion continues over time, it can be said that the gap between provinces is decreasing or there is sigma convergence. Meanwhile, the procedure for testing beta convergence is to first find out whether there is unconditional convergence or absolute convergence, and then test the explained convergence (explained convergence) or conditional convergence (conditional convergence). Absolute convergence is done by estimating the econometric model in which the initial conditional dependent variable is the only explanatory variable. While conditional convergence is done by including several explanatory variables in the test other than the dependent variable at the beginning of the period.

METHODS

This section type of this research is descriptive research with a quantitative approach. The focus research observations were carried out on the island of Sumatra with an analysis period from 2011 - 2020. As a comparison, we also carried out regressions for the 2011-2019 period, to see trends in the direction of convergence or divergence that occurred between normal economic times and periods of addition to pandemic conditions. The provinces to be studied were Aceh, North Sumatra, West Sumatra, Riau, Riau Islands, Jambi, South Sumatra, Bengkulu, Lampung, and Bangka Belitung.

The type of data used is panel data or a collection of data which is a combination of time series and cross-section. The data studied include those categorized as economic variables, namely the growth of Gross Regional Domestic Product (GRDP), GRDP per capita, and gross fixed capital formation (GFCF). Meanwhile, what are categorized as social variables are the human development index (HDI) and the number of poor people.

Figure 2. Research Framework



Klassen Typology

This method is a classification to describe the pattern and structure of economic growth in a region. Dividing regions based on two main indicators, namely regional economic growth and regional per capita income (Nur Hidayah & Tallo, 2020).

Williamson Index

This index is used to measure the level of economic inequality between regions and is used to explain the condition of development in an area. The basis for calculating this indicator is to use per capita income which is linked to the number of residents per region. The value of this index ranges from zero to one. A value of zero indicates that the inequality of income distribution between districts/cities in province X is low. On the other hand, if this index is close to 1, it can be interpreted that the inequality of income distribution between districts/cities in province X is high (Andhiani et al., 2018).

Convergence Measurement

R. J. Barro & Sala-I-Martin (1991) stated that the convergence theory is derived from the assumption of constant return to scale of the Cobb-Douglas function with the following equation:

$$Y_t = K_t^{\alpha} \, (A_t \, L_t \,)^{1-\alpha} \text{ , } 0 < \propto < 1$$

As for the convergence measurement, it can be divided into two parts, namely sigma convergence and beta convergence. Sigma convergence (σ-convergence) is measured through the level of dispersion of GRDP per capita, namely through the calculation of the standard deviation of the logarithm of GRDP per capita. If there is a tendency to decrease the dispersion

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between economies in the study period, it can be concluded that the economy is convergent. Beta convergence (β-convergence) has two stages of analysis, namely absolute convergence analysis and conditional convergence. Conditional convergence can only be determined after first testing absolute convergence in the economy. To determine whether or not absolute convergence occurs in the study area and period

The study model was built from the Solow-Swan neoclassical growth model, which was later developed by Mankiw, Romer, and Weil (Neycheva, 2018) with the following equation:

$$Y_{it} = A_{it} K_{it}^{\propto} H_{it}\, \beta L_{it}^{1-\alpha-\beta} \qquad (2)$$

Where Y_{it} is economic growth of a country I in the period t , A_{it} is the technological level of a country I in the period t, K_{it} is a capital accumulation of a country i in the period t , H_{it} is the human capital accumulation of a country i in the period t, and L_{it} is total labor force a country i in the period t. The assumption built into this model is a constant return to scale.

The idea of β-convergence is derived from the Solow-Swan model. Beta convergence explains does not mean that countries will reach the same steady state, as implied by sigma convergence. Barro & Sala I Martin (1990, 1992) give the form of the β-convergence equation as follows:

$$\frac{\ln Y_{i.T} - \ln Y_{i.t-1}}{T} = \alpha + \beta \ln Y_{i.t-1} + \mu_{i,t} \qquad (3)$$

Where , $\ln Y_{i.T}$ is Gross Regional Domestic Income per capita in period t, while , $\ln Y_{i.t-1}$ is Gross Regional Domestic Income per capita in the period before t. If -1 < < 0, it can be concluded that there is a convergence of economic growth in the research area and period. On the other hand, absolute convergence does not occur if the value of β < -1 or β > 0.

Conditional convergence can only be calculated after absolute convergence has been calculated. Conditional convergence is calculated by adding several control variables to the absolute convergence model. The control variables (variables other than economic growth and GRDP per capita) used in this study are the human development index (HDI), gross fixed capital formation (GFCF), and the number of poor people, then panel data regression was performed on these variables. The conditional convergence model is as follows:

$$\ln GRDP_{i.t}\ \alpha + \beta 1 \ln GRDP_{i.t-1} + \beta 2 \ln HDI_{i.t} + \beta 3 \ln GFCF_{i.t} + \beta 4 \ln POOR_{i.t} + \mu_{i,t} \qquad (4)$$

Where :

$GRDP_{i.t}$ = GRDP per capita of province i in year t

$GRDP_{i.t-1}$ = GRDP per capita of province i in the year before t

$HDI_{i.t}$ = Human Development Index in province i in year t

$GFCF_{i.t}$ = Gross Fixed Capital Formation of province i in year t

$POOR_{i.t}$ = Number of Poor Population of province i in year t

$\mu_{i,t}$ = Error term

From the models mentioned above, the most appropriate model will be determined to estimate the panel data regression model which includes the general effects model, fixed effect model, and random effects model. The next step is to look at the speed of convergence, to analyze the rate or speed of convergence that occurs, it is necessary to identify whether absolute convergence occurs in an economy. The value of is used to determine whether or not absolute convergence occurs and at the same time indicates the speed of the ongoing convergence process. If the value is getting closer to -1, then the speed of convergence is getting higher. On the other hand, if the value of the absolute convergence model is close to 0, then the convergence speed will be lower. convergence speed can be calculated via:

Convergence speed = coefficient β x 100% (5)

Meanwhile, to see the length of time used to eliminate half of the economic inequality that occurs, the half-life value can be used. The half-life value of convergence can be determined using the following formula:

$$t = \frac{-\ln(0.5)}{\beta} \text{ or } t = \frac{Ln\ (2)}{\beta} \quad (6)$$

According to R. J. Barro & Sala-I-Martin, (1991) It is important to know the speed of convergence because when there is a faster convergence, it indicates that the economy is getting closer to a steady-state condition. On the other hand, if the convergence is very slow, the economy will move further away from the steady-state condition.

RESULT AND DISCUSSION

Based on the picture below, the average value of the four observational variables in 10 provinces of Sumatra Island can be seen. For graphical visualization purposes, the four observational data in the image are transformed in the form of natural logarithms. It is known that the highest per capita real income is in the Riau Archipelago Province with an average value of Rp. 76.9 million followed by North Sumatra Province with Rp. 71.1 million. Bengkulu Province is the region with the lowest per capita income, which is only Rp. 20.5 million, followed by Aceh province of Rp. 23.3 million. The average per capita real income of Sumatra Island during 2011-2020 was Rp. 37.9 million.

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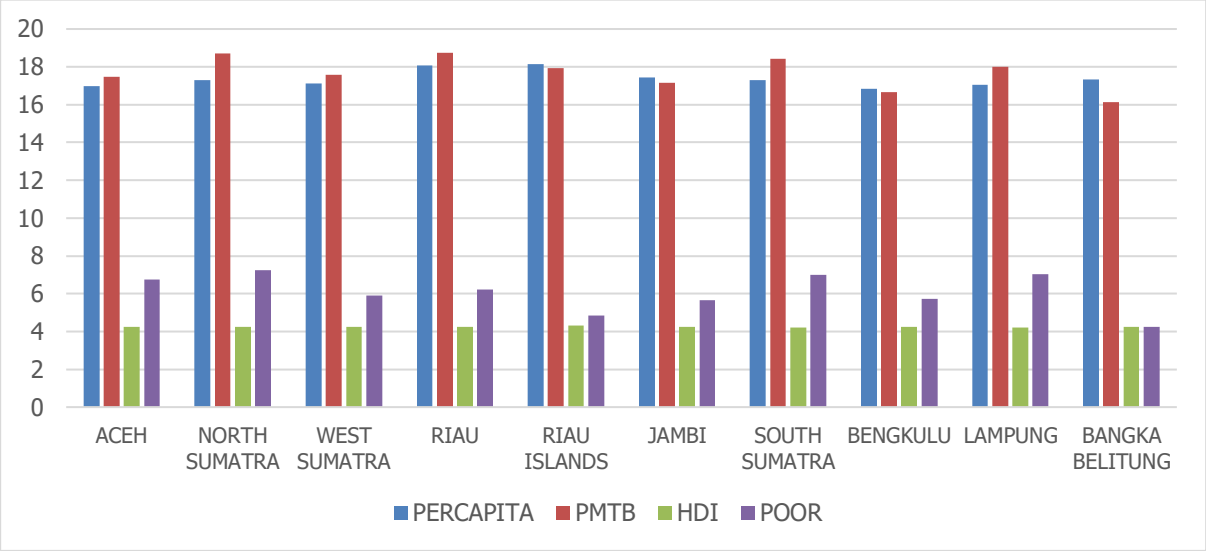
Figure 3. Average Per Capita Real Income, PMTB, HDI, and Number of Poor Population in the Province of Sumatra Island in 2011-2020



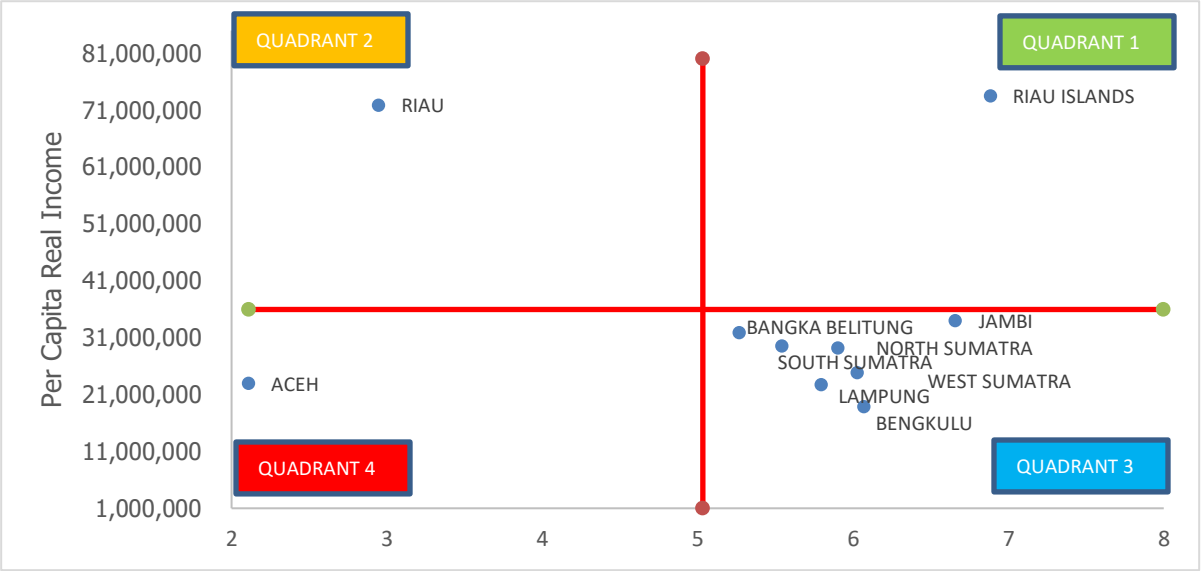
Source: Indonesian Central Bureau of Statistics, data processed, (2023b)

The highest gross fixed capital formation is in Riau Province, with an average value of Rp. 139.5 trillion per year. While the lowest was in Bangka Belitung Province of Rp. 10.2 trillion. The highest Human Development Index is in Riau Archipelago Province with an index value of 73.71, and the lowest HDI is in Lampung with 67.24 points. Meanwhile, North Sumatra Province is the region with the largest number of poor people, namely 1.3 million people whose lives are still below the poverty line. This is in line with the population of North Sumatra which is the largest compared to the other nine provinces.

Welfare Performance and Disparity

This study uses the Klassen Typology technique to map the economic position of each province on the island of Sumatra. The mapping here uses economic growth and real per capita income as benchmarks for the economic performance of each region. We divide it into two time periods to see changes in the distribution of economic performance. The first period is from 2011-2015, and the second period is from 2016-2020. Klassen's typology divides performance conditions into 4 quadrants, where quadrant 1 is a province that is classified as developed and growing rapidly. Quadrant 2 describes the province experiences high real per capita income accompanied by low economic growth. Furthermore, Quadrant 3 is a province that is classified as potential and can develop rapidly. Meanwhile, provinces in Quadrant 4 are categorized as relatively underdeveloped regions.

Figure 4. Klassen Typology of Per Capita Real Income and Economic Growth Sumatra Island 2011-2015



Source: Secondary data output after processing, 2022; (Rahman, 2022)

The picture above shows that there is only one province in quadrant 1, namely the Riau Islands Province, this province has had an economic performance above the average of other regions, where the economic growth of the Riau Islands is on average above 5.03 percent, and real income per capita is on average above 35.95 million rupiahs. Unlike the case of Riau Province, which has a per capita income above the average, its economic growth performance is below average. Quadrant 3 is filled with many regions, including the provinces of North Sumatra, West Sumatra, Jambi, Bengkulu, South Sumatra, Lampung, and Bangka Belitung. Some of the provinces mentioned above are areas that have the potential to develop more rapidly. Aceh Province is the only region that is relatively underdeveloped. The province has an average economic growth of only 2.11 percent and a real income per capita of 22.93 million rupiahs.

Klassen's typology of economic performance on the island of Sumatra for the 2016-2020 period shows a shift in the two provinces out of the previous quadrant. The area in question is the Province of the Riau Islands which moved from Quadrant 1 to Quadrant 2 and the Province of Bangka Belitung which in this period was in Quadrant 4 and was previously classified as a potential province. the effects of the 2020 pandemic at least contributed to the economic slowdown in all provinces, especially provinces in quadrants 1 and 2. previous findings regarding the effects of the pandemic on income inequality were quite varied. Furceri et al. (2021) found that the distributional effect of the pandemic among countries varied considerably, depending

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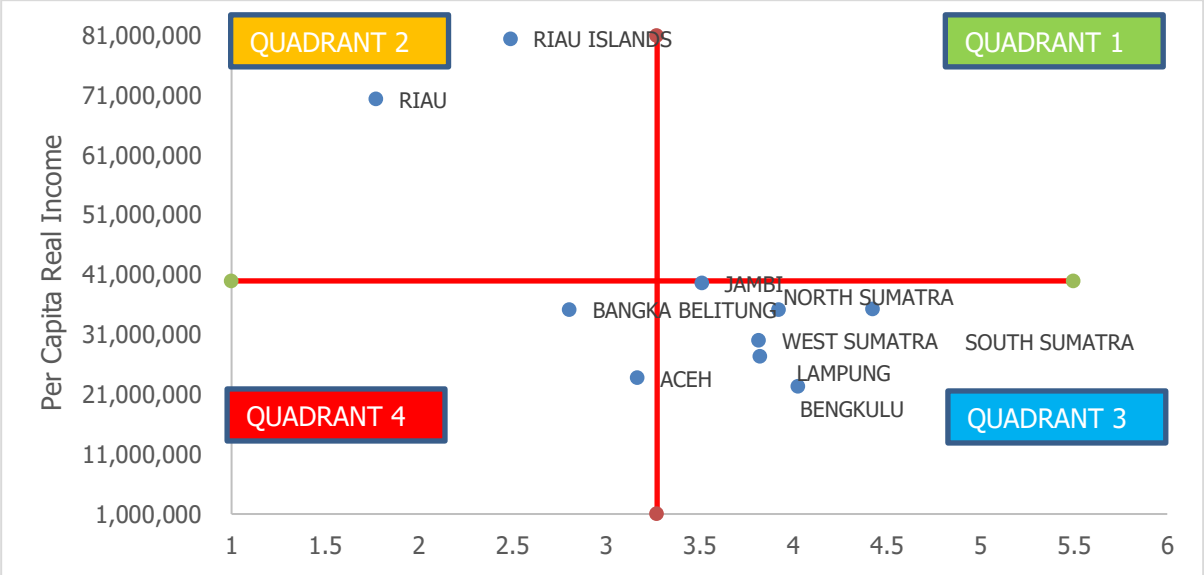
on the characteristics of the country, initial income distribution, and policy response. Meanwhile, Sayed & Peng (2021) show that the pandemic that occurred over the past 100 years contributed to a decrease in income inequality in the years following the pandemic. Differences in the characteristics and policy mix of each country also have an impact on the results of inequality that vary between expenditure groups (Acheampong et al., 2023).

Figure 5. Klassen Typology of Per Capita Real Income and Economic Growth Sumatra Island 2016-2020

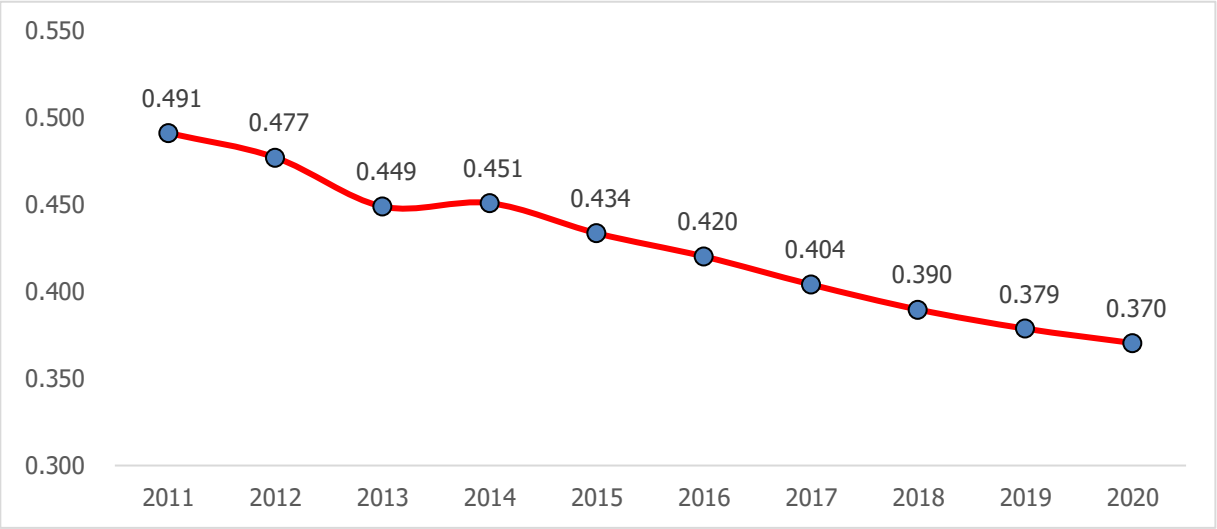


Source: Secondary data output after processing, 2022; (Rahman, 2022)

The picture above also shows the movement of several provinces to move out of the previous quadrant line, such as Aceh Province, which had quite good economic development in this period, which was marked by the approach of the Aceh region to enter quadrant 3. The economic growth performance of South Sumatra Province on average was still better. well during the second period, which is characterized by a shift of the point to the right. Jambi Province's real income per capita performed better than other regions but was followed by a slowdown in economic growth. This slowdown was also experienced by all regions, where the COVID-19 pandemic in 2020 had an impact on the average rate of economic growth for each province which tends to be depressed. This also affects the average rate of real income per capita of each region but with a smaller proportion. This condition has not clearly demonstrated the phenomenon put forward by Jones (1997) that regions with high income distribution have a catch-up effect and conversely, groups of regions with low incomes will actually remain very close to their relative income levels. The movement of Aceh towards quadrant 3 and the shifting of the Riau Archipelago and the stagnation experienced by Riau Province show a more dynamic

pattern of development, with other factors such as differences in the level of institutional change which are thought to also affect the distribution pattern of the above quadrants.

Figure 6. Williamson Index of Real Income Per Capita of Sumatra Island 2011-2020



Source: Secondary data output after processing, 2022; (Rahman, 2022)

Furthermore, in measuring the degree of inequality, this study uses the Williamson index as a measuring tool for detection. The variable used to see the performance of equity is the real income per capita. Based on the picture below, it can be seen that there has been a decline in the index number from 2011 to 2020. The index at the beginning of the observation year was 0.491, which consistently decreased until 2013 at 0.449. In 2014, there was an increase in the index value of 0.451 but it fell back steadily until 2020 when reached 0.370. This picture indicates an earlier economic convergence that occurred on the island of Sumatra.

Sigma Convergence

Convergence analysis is carried out by two approaches, namely sigma convergence and beta convergence. The results of the sigma convergence indicate that there has been a convergence of real income per capita between provinces on the island of Sumatra. This condition can be seen in the figure below, which shows the movement of the standard deviation of real income per capita between regions of the Sumatra Islands which has consistently fallen. This is clarified by the situation at the beginning of the observation year (2011) which had a deviation of 0.453, then decreased in the following year to 0.446. A consistent decline of around 0.06 - 0.13 points lasted throughout the year of observation. The COVID-19 pandemic has also not changed this dispersion effect. The dispersion of real income per capita is a large window into seeing the condition of income convergence in a deeper review.

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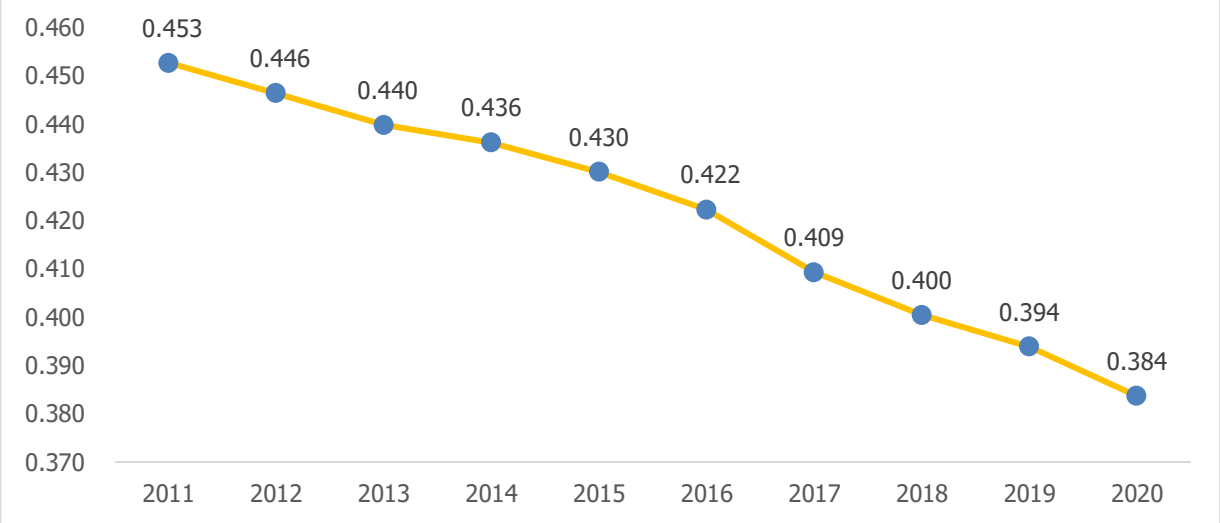
Figure 7. Standard Deviation in Real Income Per capita
Inter-Province Island of Sumatra 2011-2020



Source: Secondary data output after processing, 2022; (Rahman, 2022)

The next step is to perform absolute beta convergence testing. Our goal is to confirm previous findings on the island of Sumatra which illustrate the convergence of per capita income. We carry out regressions in two ranges of observations, first, limiting observational data to 2019, due to the outbreak of Covid-19 in 2020 which caused an economic shock and is feared to bring biased results. Second, we try to compare the results by including 2020 as an additional observation period. If the essence of the results is not much different, then we will use a longer period in discussing the study.

Beta Convergence (Before Covid-19)

The results of the Chow test and Hausman test from the 2011-2019 period are as follows:

Table 1. Chow Test and Hausman Test Absolute Beta Convergence 2011-2019

Chow Test Probability Value	Hausman Test Probability Value
0,0000	0,0019

Source: Secondary data output after processing, 2022; (Rahman, 2022)

The results from the table above indicate that the fixed effect model will be used as material for the analysis of the study. This is supported by the probability value of the Chow test and Hausman test which is lower than 0.05, where the fixed effect model is concluded as the best model to use. The absolute beta convergence results from the fixed effect model can be seen in the table below.

Table 2. Fixed Effect Model Estimation Results on Absolute Beta Convergence in 2011-2019

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.921730	0.210336	4.382187	0.0000
GRDP_1	0.948519	0.012150	78.06964	0.0000

Source: Secondary data output after processing, 2022; (Rahman, 2022)

The results above show a value of (1+β) of 0.9485. In determining the occurrence of convergence, it is necessary to have a β value below zero and above -1. The value of β which is between 0 and 1 indicates the convergence of real income per capita on the island of Sumatra. The value (1+β) of 0.9485 informs that the value of β is -0.0515, this value means that absolute convergence has a speed of 5.15%. This means that to calculate the half-life, using the formula $t = \frac{-LN(0.5)}{0,0515}$, the value is 13.45, in other words, it takes around 13.5 years to cover half of the total inequality. , and to cover all inequality takes about 27 years. Thus, through a β value of -0.0515, it can be concluded that there is a process of convergence of real income per capita between provinces on the island of Sumatra which leads to a meeting point in normal economic times.

After carrying out absolute convergence, the next step is to estimate conditional convergence which aims to determine whether or not there is an influence of other variables on real income per capita in the Sumatra region. In addition, this step can also provide information about changes in the speed of convergence upon the inclusion of these predictor variables. The dependent variables in this study include the previous year's per capita income, the Human Development Index (HDI), gross fixed capital formation (GFCF), and the number of poor people. The data is converted in the form of natural logarithms before processing. The absolute beta convergence results before covid-19 with the fixed effect model are as follows

Table 3. Fixed Effect Model Results on Conditional Convergence in 2011-2019

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.738093	0.318994	5.448669	0.0000
GRDP_1	0.935889	0.024065	38.88935	0.0000
GFCF	-0.001660	0.006603	-0.251353	0.8022
HDI	-0.019538	0.101718	-0.192076	0.8482
POOR	-0.080139	0.023616	-3.393398	0.0011

Source: Secondary data output after processing, 2022; (Rahman, 2022)

The results above show that in the 2011-2019 period or during the entire period with a

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normal economy, there has been a conditional convergence in real per capita income between provinces on the island of Sumatra. This is shown from the previous per capita income coefficient value which was below 1 or 0.9358. Furthermore, of the three variables that were tested for influence, only the number of poor people had a significant negative effect, while GFCF and HDI had no significant effect on real income per capita.

Beta Convergence (Including the Covid-19 Pandemic Year)

Next, we added 2020 as the observation period whose results will be compared with the 2011-2019 period. The starting step is to perform absolute beta convergence testing from 2011-2020. To choose which model is the best in panel data regression, several tests are carried out. Chow test is used to test the best model between common effect and fixed effect. The prob chi-square value is less than 0.05, in other words, the best model is the fixed effect.

Table 4. Absolute Beta Convergence Chow test and Hausman Test 2011-2020

Chow Test Probability Value	Hausman Test Probability Value
0,0000	0,0000

Source: Secondary data output after processing, 2022; (Rahman, 2022)

Then a selection is made between a fixed effect model with a random effect. The test is carried out using the Hausman test. The results show that the prob chi-square value is less than 0.05, which means that the best model is the fixed effect model.

The regression results below show an R-squared value that is close to 100 or 99.84 percent of real income per capita for the current year explained by real income per capita in the previous year. Next, the predictor variable coefficient value of 0.8731 (below 1) indicates a convergence effect experienced by real per capita income for each province on the island of Sumatra. This coefficient value can be interpreted if the real income per capita in the previous year increased by 1 percent, it will have an impact on the increase in real income per capita for the current year by 0.87 percent.

The estimation results above show the value (1+β) of 0.8731. In determining the occurrence of convergence, it is necessary to have a value of below zero and above -1. The value of which is between 0 and 1 indicates the convergence of real income per capita on the island of Sumatra. The value (1+β) of 0.8731 informs that the value is -0.1269. Thus, through the value of -0.1269, it can be determined that there is a process of convergence of real income per capita between provinces on the island of Sumatra which leads to a convergence point (convergence).

The result of the fixed effect estimation above describes the β value of -0.1269, which

means that absolute convergence has a convergence speed of 12.69%. The next step is to calculate the middle time (half-life), by entering the formula $t = \frac{-LN(0.5)}{0{,}1269}$ it is known that the value is 5.4621, in other words, it takes about 5.5 years to cover half of the total inequality, and to cover the entire inequality it takes about 11 years.

Table 5. Fixed Effect Estimation Results of Absolute Beta Convergence Model 2011-2020

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.222764	0.324534	6.849102	0.0000
GRDP_1	0.873134	0.018731	46.61537	0.0000
	Effects Specification			
Cross-section fixed (dummy variables)				
R-squared	0.998476	Mean dependent var		17.35080
Adjusted R-squared	0.998304	S.D. dependent var		0.430592
S.E. of regression	0.017731	Akaike info criterion		-5.123562
Sum squared resid	0.027980	Schwarz criterion		-4.836994
Log-likelihood	267.1781	Hannan-Quinn criteria.		-5.007583
F-statistic	5829.740	Durbin-Watson stat		1.622346
Prob(F-statistic)	0.000000			

Source: Secondary data output after processing, 2022; (Rahman, 2022)

When compared with observations up to 2019, the convergence between 2011 and 2020 is much faster. The economic shock in 2020 implies a stronger economic slowdown in developed regions so that the per capita income of each province is moving faster towards a common ground. The stronger economic slowdown in developed regions is understandable because developed regions have more dominant economic interactions with their partner regions so that developed regions experience the highest impact of limiting social activities. In line with the findings of Brussevich et al. (2022) which showed that the covid-19 crisis resulted in a temporary acceleration of the convergence of per capita income in 2020. This study also supports the findings of Deaton (2021), where the covid-19 pandemic has reduced global income inequality, and reduced per capita income is higher in rich countries.

Using the least square dummy variable (LSDV) all coefficients vary across individuals, Gujarati N. Damodar (2009), in addition to the overall coefficient value, it is also known the coefficient value of each province as a step in obtaining the middle time value of each province towards a catch-up point. The equation is as follows:

$$\ln GRDP_{i.t} == a_1 + a_n D_{ni} + \beta 2 \ln GRDP - 1_{i.t} + \gamma_n (D_2 \ln GRDP - 1_{i.t}) + \mu_{i,t}$$

Where, $\ln GRDP_{i.t}$ is the real income per capita of each province, a_1 is the intercept of

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the province of Aceh, $a_n D_{ni}$ is the differential intercept of each other province in the dummy of each province, $\beta 2 \ln GRDP - 1_{i.t}$ is the regression coefficient of the real income per capita of the previous year Aceh Province, γ_n is the differential coefficient for each other province.

Aceh Province is a province that becomes the basis for adjustment of the differential intercept and differential slope coefficient from 9 other provinces. The results of data processing using Stata.14 assistance are as follows:

Table 6. The Value of Each Province's Half-Life To Go to Catch Up Point

No.	Province	Differential Intercept	Intercept	Differential Slope Coefficient	Coefficient	B-Value	Half-Life Value
1	Aceh	3.649904	3.649904	0.785199	0.785199	0.214801	3.23
2	North Sumatra	-1.8152	1.834705	0.110489	0.895688	0.104312	6.64
3	West Sumatra	-1.74197	1.907937	0.105224	0.890423	0.109577	6.33
4	Riau	7.055001	10.70491	-0.37732	0.407883	0.592117	1.17
5	Riau Islands	0.918048	4.567952	-0.0361	0.749102	0.250898	2.76
6	Jambi	-0.8416	2.808303	0.055112	0.840311	0.159689	4.34
7	South Sumatra	-2.27315	1.376752	0.137009	0.922208	0.077792	8.91
8	Bengkulu	-1.80636	1.843543	0.107033	0.892232	0.107768	6.43
9	Lampung	-1.78638	1.86352	0.107255	0.892454	0.107546	6.45
10	Bangka Belitung	0.232367	3.882271	-0.00843	0.776766	0.223234	3.11

Source: Secondary data output after processing, 2022; (Rahman, 2022)

Based on the results of the half-life values of each province above, it is known that based on the development of the existing real income per capita of Riau Province, in the future it will have the fastest middle time to reach a meeting point with real per capita income in other provinces. This province requires a median period of 1.2 years. Meanwhile, South Sumatra Province took at least 9 years to cover half of the inequality on the island of Sumatra. Regions categorized as underdeveloped provinces in the previous Klassen typology such as Aceh and Bangka Belitung have half-life values that are not much different, which are 3.23 and 3.11, respectively. This means that these two provinces need at least 3.2 years to close half the real income inequality on the island of Sumatra. However, areas that are in the category of potential to develop require a longer time with a range of 4 years to 9 years. This result further implies that the economic slowdown in provinces that are classified as depressed, such as Riau Province and Riau Islands, is offset by an acceleration in underdeveloped areas such as Aceh and Bangka Belitung, shows that the theory put forward by Kuznets (1955) and Solow (1956) who argues that inequality will occur in the initial phase of growth, stabilize for a while, and narrow in the

next phase where lagging regions will grow faster than developed regions due to higher marginal product. Results Economic stagnation is predicted to occur in depressed developed regions and opens opportunities for underdeveloped regions to spur growth in real per capita income. The next step is to perform a conditional beta convergence test. The result is as follows:

Table 7. Fixed Effect Model Results on Conditional Convergence 2011-2020

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.809294	0.456056	8.352694	0.0000
GRDP_1	0.867541	0.036386	23.84273	0.0000
GFCF	0.004018	0.011232	0.357713	0.7214
HDI	-0.129008	0.162847	-0.792205	0.4304
POOR	-0.167193	0.036759	-4.548359	0.0000
Effects Specification				
Cross-section fixed (dummy variables)				
R-squared	0.998779	Mean dependent var		17.35080
Adjusted R-squared	0.998595	S.D. dependent var		0.430592
S.E. of regression	0.016141	Akaike info criterion		-5.285757
Sum squared resid	0.022405	Schwarz criterion		-4.921033
Log-likelihood	278.2878	Hannan-Quinn criteria.		-5.138147
F-statistic	5413.077	Durbin-Watson stat		1.472917
Prob(F-statistic)	0.000000			

Source: Secondary data output after processing, 2022; (Rahman, 2022)

The results of the 2011-2020 observations also show conditions with the same substance as observations in 2011-2019, or during normal economic times, where there is still a convergence of GRDP per capita, but at a higher speed. This can be seen from the value of the coefficient GRDP_1 which is further away from number 1. The estimation of the fixed effect model above produces an R-squared value of 0.9987 or 99.87 percent of the proportion of variations in real income per capita can be explained by the model. The F-statistic probability value of 0.0000 indicates that the predictor variables used in the model simultaneously have a significant effect on real per capita income. The results above also show that the coefficient of real income per capita has changed slightly from the previous 0.8731 to 0.8675. By using this value, the value of β is -0.1325, between -1 and 0, it can be determined that there is a conditional convergence process in real income per capita between provinces on Sumatra Island. The value of β indicates the speed of the convergence process in the research area of 13.25 percent. The conditional convergence model has a relatively higher convergence speed than the absolute convergence model. In other words, conditional convergence will occur faster

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than absolute convergence.

This finding can also be interpreted that with the influence of other independent variables, namely GFCF, HDI, and the number of poor people, the convergence process can take place more quickly. These results support the findings of Zulham et al. (2019) who states that there has been a convergence process of economic growth on the east coast of North Sumatra, where the conditional convergence model has a higher speed than the absolute convergence.

Partially, the number of poor people has a significant negative effect on real per capita income. This condition is indicated by the probability value of 0.0000 or below the 5 percent error degree. The magnitude of the effect is that when the number of poor people decreases by 1 percent, it will increase real income per capita by about 0.17 percent. These results further reinforce the importance of support in the form of targeted poverty alleviation policies, conducting regular monitoring and evaluation of existing poverty alleviation programs, and encouraging the poor to be directly connected to development activities.

Other results inform that GFCF and HDI have no statistically significant effect on real per capita income. This result is shown from the probability value of both which are quite high with values of 0.7214 and 0.4304, respectively, or above 5 percent alpha. The role of GFCF which has not been able to contribute more dominantly to the real income per capita of the people of Sumatra is an indication of a reflection of inefficiency in its use and has not been able to create added value that is proportional to the amount of capital spent. Another assumption is that the return on capital expenditure will require a time lag in the next several periods. This situation is a logical reason for the low level of significance of the influence of GFCF.

Likewise, the HDI has no significant effect on real per capita income. This index was recorded 40 times having an opposite relationship during the observation period in all provinces, where when per capita income experienced a lower growth rate, HDI growth moved higher, and vice versa. It is necessary to improve the quality of the three dimensions incorporated in the HDI so that an increase in life expectancy, RLS, HLS, and per capita expenditure in quantity can provide a stronger impetus for increasing real output per Sumatran population. The results of this study are different from the findings of Nurlaili & Cahyadin (2020) which show that there is a significant and positive effect of HDI on per capita income in Indonesia. The emergence of differences in these findings can also be caused by differences in the calculation of the per capita income in question. In this study, per capita, GRDP is used based on constant prices, and it is relatively difficult to find an equivalent comparison of the results obtained.

CONCLUSION

The results of the classsen analysis show that the Riau Islands is shifting towards being depressed and Bangka Belitung is moving towards the underdeveloped zone. Meanwhile, Aceh Province is getting closer to the potential zone line. The Williamson index is known to have experienced a relatively stable decline in index numbers from 2011 to 2020. In other words, there has been a decrease in the real per capita income disparity between regions on the island of Sumatra. The results of the sigma convergence test show strongly that there has been a convergence of real per capita income between provinces on the island of Sumatra. The absolute beta convergence estimation results prove that there is a convergence effect experienced by the real per capita income of each province on the island of Sumatra. The conditional convergence test proves that the inclusion of PMTB, HDI, and the number of poor people as predictor variables can speed up the ongoing convergence process.

The convergence in the 2011-2020 range has a higher speed than the 2011-2019 normal conditions range. This shows that the Covid-19 pandemic has reduced inequality, where regions that are more developed and more connected to global markets are experiencing a more massive economic slowdown. However, on the other hand, the Covid-19 pandemic has also caused a decrease in real income in all observed provinces, which means that welfare has decreased.

The implication is that it is necessary to solve development concentrations that are more directed to areas in underdeveloped areas. The hope is to stimulate the emergence of new growth centers around the area. In this context, the central government can maximize its role in accelerating connectivity between these regions. Meanwhile, local governments, especially quadrants 3 and 4 can contribute more in encouraging superior products in their regions to be more competitive. Policies in eradicating poverty are a booster in accelerating the convergence process. This study has not captured the various characteristics between regions and variations in response to government policies in encouraging an increase in people's income, including responses in the face of a pandemic. Longer observations in the aftermath of the pandemic can further emphasize the effects of economic shocks on inequality through more specific methods.

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