**Industrialization and regional income inequality: agriculture transformation**

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**Abstract.** Industrialization and income inequality is a crucial issue in developing countries. This paper analyzes the level of income inequality in Morowali and Banggai Regencies, Central Sulawesi, Indonesia. Inequality income is proxied by Gini, Williamson and Theil (GWT) indices. The Gini coefficient was calculated based on data obtained from questionnaires distributed to 150 households. The Williamson index and Theil index were calculated by using the data of gross domestic per capita regional income. The results reveal that the regional income inequality of Morowali and Banggai Regency increased when the economic growth of both regions experienced a significant increase, when the large mining industry began to operate in both areas. The manufacturing and mining industries in have succeeded in shifting the dominance of agriculture sector. The level of income inequality among households and regional has reached a moderate level and tends to fluctuate. Meanwhile, the level of income distribution between regions within regencies is relatively low. The government should consider the impact of industrial presence in areas originally sustained by the agrarian sector in relation to income distribution. Second, the preparation of skilled and educated local workers in facing the industrialization era needs to be conducted.

1. **Introduction**

Industrialization and income inequality is a crucial issue in developing countries. The economic development of a region and the level of society's welfare is often measured from the rate of economic growth of the region, which is calculated from the rate of Gross Domestic Product (GDP) change from year to year. Based on data from the Central Bureau of Statistics, the economic growth of Indonesia as one of the developing countries is still around the single-digit level. Nevertheless, Indonesia's economic growth from 2014 until 2017 tends to increase [1], except in 2015. While Indonesia experienced a decline in economic growth in 2015, the economic growth of Central Sulawesi Province, which is part of the Unitary State of the Republic of Indonesia, increased significantly. Central Bureau of Statistics noted that the economic growth rate of Central Sulawesi Province in 2015 reached 15.50% [2]. The high economic growth rate of Central Sulawesi Province in 2015 is closely related to the influence of economic growth in several regions in Central Sulawesi Province, especially in the Morowali Regency and Banggai Regency. Morowali Regency recorded the highest economic...
growth rate in 2015 of 67.82% [3]. Meanwhile, Banggai Regency recorded the second-highest economic growth rate in Central Sulawesi Province, which was 33.70% [4].

The high economic growth rate of Morowali Regency, compared to other cities and regencies in Central Sulawesi Province, is influenced by the increasing contribution of manufacturing and mining sectors to the Gross Regional Domestic Product (PDRB) of Morowali Regency [4]. The manufacturing and mining industries in Morowali Regency have succeeded in shifting the dominance of the agriculture sector, which previously became the main contributor of the GRDP of Morowali Regency. The increasing contribution of the manufacturing and mining sector to the GRDP of Morowali Regency occurred shortly after the nickel smelter industry by PT Indonesia Morowali Industrial Park in the District of Bahodopi Morowali Regency was officially operated in 2015.

The increasing dominance of the manufacturing and mining sectors to GRDP also occurred in Banggai Regency. The high rate of growth of the manufacturing and mining sectors in the Banggai Regency in 2015 is due to the operation of PT Donggi Senoro, which is a liquefied natural gas (LNG) mining industry in Batuie District, Banggai Regency. This has resulted in a significant increase in the economic growth rate of the Banggai Regency by 2015. However, the agricultural sector is still a major contributor to Banggai Regency's GRDP.

High economic growth rates do not always reflect the real conditions. The economic growth rate tends to illustrate only the development of the economy globally and ignores the partial reality that exists. Economic growth cannot reduce poverty if it does not benefit society equally, especially in developing countries. In fact, the research results reveal that the trickledown effect theory proposing that economic growth can reduce poverty was not applicable in the 65 sample countries during the period of 1995-2011, including Indonesia.

Kuznets, a famous economist and noble recipient in 1917, assumed that the economic growth rate in the early stages could increase inequality of income distribution. Kuznets predicts that the economic growth rate of an area sustained by the agricultural sector tends to experience an increase in income distribution inequality, especially in the early stages of the industrialization era [5]. The inequality of income occurs because the majority of the population still relies on the poor agricultural sector, while some other residents have worked on the rich industrial sector [6]. Kuznets’ hypothesis has been verified by previous research. One study revealed that sustained and progressive economic growth was followed by the “U” evolution of regional income inequality in Spain [7]. Other researchers have found that the opening of employment in the non-agricultural sector actually increases income inequality in rural areas, particularly in developing countries [8]. Meanwhile, several other researchers also found that the development of the tourism industry has an impact on the significantly increasing income inequality in developing countries [9].

Income inequality occurs when the income distribution between individuals in an area is uneven [10]. The inequality of income may indicate that there has been an inequality of income and opportunity mobility in the community, which can potentially result in social jealousy, causing social conflicts and economic instability [8,11–13]. In addition, inequality income distribution can also trigger an increase in the crime rate, which also affects the economic instability of a region [14]. In fact, the research results reveal that high economic growth in a region cannot increase the happiness of people in the area due to the existence of income inequality [15].

The size of income inequality among households in a commonly used region is the Gini coefficient [16,17]. This coefficient is often used because it is sensitive in explaining the relationship between high-income population groups and other population groups [18]. Nevertheless, the Gini coefficient does not fully represent the important issues of income inequality because the measurements made for a population in an area are general [19]. Some previous studies have proposed and used other alternatives to measure income inequality, particularly the inequality of incomes between regions [20]. Another commonly used income inequality alternative is the Williamson index that can calculate regional inequality income spatially [21]. However, the income inequality index with a weighted population, such as the Williamson index, cannot serve as a sufficient inequality gauge [10]. The results of the measurement of income inequality by using the Williamson index should be reinforced
by adding the Theil index measurements into the analysis [22]. The advantage of the Theil index is that it can distinguish between regional GRDP inequalities within the region with regional GRDP disparities so that the scope of the analysis is broader [7,23]. This paper analyzes industrialization, regional income inequality and agriculture transformation.

2. Methods

2.1. Research design

This research is designed as descriptive-explorative research using a quantitative and qualitative approach. A quantitative approach is conducted through the distribution of questionnaires to households in Morowali and Banggai Regency, which are randomly selected. The total number of households in the sample was 150 households. Meanwhile, the qualitative approach is conducted by reviewing related documents obtained from the Central Bureau of Statistics and local government agencies. The distribution of questionnaires was conducted within five months, from May 2017 until September 2017. This research used per capita GRDP data of Morowali Regency, Banggai Regency, and Central Sulawesi Province, and data on the population of Morowali District, Banggai Regency and Central Sulawesi Province during the period 2011 to 2015 to calculate regional income inequality. The data are secondary data obtained through the documentation of the Central Bureau of Statistics.

2.2. Gini coefficient

The Gini coefficient measures the distribution of income inequality that occurs between individuals or between households [24]. The Lorenz curve is the most commonly used tool for graphically describing Gini coefficients as a measurement of income distribution in a population because it is simple and easy [25,26]. The Lorenz curve can describe income inequality through the relationship between the proportion of cumulative income percentage (vertical axis) and the proportion of cumulative population percentage (horizontal axis) [18].

Figure 1 shows that the AG axis is the percentage of the proportion of the population in five classes with the same percentage, while the vertical axis of the AC shows the percentage of the proportion of income in the five classes with the same percentage. The diagonal line of APQRST is an egalitarian line or line of equality that shows the same proportion of the population with income. The diagonal line of APQRST can be expressed as a reflection of the equitable income distribution. Meanwhile, the curved lines connecting the points ABCDE and F show the Lorenz curve. The field bounded by the Lorenz curve with the diagonal line is the Gini coefficient [18,26].

The income distribution is said to be perfect even if the percentage of the population receives the same amount of income. For example, point P on the curve of Figure 1 shows that 20 percent of the population receives 20 percent of revenues. When this equalization is reached, the Lorenz curve approaches the line of equality, and the Gini coefficient equals to zero. If the Lorenz curve moves away from the line of equality, for example, is the curve of AGF on the curve of Figure 1, then the income distribution is declared uneven, which means that income is received by one person only and the Gini coefficient will be equal to one. Based on the curve of Figure 1, the Gini coefficient can be calculated as follows:

\[ G = \frac{A}{A+B} = 1 - 2B \]  

If area A + area B = 0.5, then:

\[ G = 1 - 2 \int_{0}^{1} L(x)dx \]  

The discrete probability function f \( (y_i) \) with \( y_i \) where i from 1 to n, then the point is sorted from small to large with the following formula:
\[ G = 1 - \frac{\sum_{i=1}^{n} f(y_i) (S_{i-1} - S_i)}{S_n} \]  

(3)

Where:

\[ S_i = \sum_{j=1}^{i} f(y_j) \]  

(4)

In practice, the functions of \( L(x) \) and \( f(y_i) \) are not known so that there are only coordinate points in the interval. Therefore, the Gini coefficient is calculated using the following formula [27]:

\[ G_1 = 1 - \sum_{k=1}^{n} (X_k - X_{k-1})(Y_k + Y_{k-1}) \]  

(5)

Where:

- \( X_k \) = cumulative proportion of population numbers
- \( Y_k \) = cumulative proportion of income amount (sorted from small to large)
- \( G_1 \) = Estimated value of G

Gini coefficient values are between 0 and 1 [20]. The higher value of the Gini coefficient indicates higher income inequality [9]. The closer to zero, the Gini coefficient value shows the even higher distribution of income [24]. The interpretation of Gini coefficient value in this research is based on Oshima criteria where: (a) income inequality is stated low if the Gini coefficient value is less than 0.35; (b) income inequality is stated moderate if the Gini coefficient is between 0.35 to 0.5; (c) income inequality is high if the Gini coefficient value is greater than 0.5 [28]. In this research, the data used to calculate the Gini coefficient are the household data obtained from the questionnaire.

2.3. Williamson index

The Williamson Index is a weighted coefficient of variation that measures the distribution of regional per capita income levels relative to the national income averages in which each regional deviation is measured by its share in the national population [29]. The Williamson Index is an appropriate measurement of regional income inequality used to measure income inequality among regencies or cities in a province, as is this research [30]. Therefore, the Williamson index is formulated as follows:

\[ V_w = \sqrt{\bar{Y}^2 + (f_i/n)} \]  

(6)

Where:

- \( V_w \) = Williamson Index
- \( Y_i \) = GRDP per capita per regency / city
- \( Y \) = GRDP per capita of the province
- \( f_i \) = Population of each regency / city
- \( n \) = Population of the province

Perfect equalization occurs if the value of \( V_w \) obtained is equal to zero [20]. The greater the value of the Williamson index, the greater the size of the difference in geographic revenue [29]. The result of calculation of Williamson index value in this research is interpreted based on Mattola criteria (1985) where: (a) low gap if \( V_w \) value less than 0.35; (b) moderate gap if the \( V_w \) value is between 0.35 and 0.5; and (c) high gap if the value of \( V_w \) is more than 0.5 [31].

2.4. Theil index

Theil Index is the application of the concept of information theory in the measurement of income distribution [32]. Theil Index provides a complete explanation about per capita GRDP and per capita
GRDP distribution, either concentrated or dispersed in an area [23]. Theil Index comes as a solution to the international problem related to income distribution between individuals, divided into two stages: inequality between countries and inequality within countries using per capita income databases [33]. Therefore, the Theil index formula can be written as follows.

\[ I_{Theil} = I_{inter} + \sum Y_i I_{(intra)} \]  

If,

\[ I_{(inter)} = \sum Y_i \times \log(Y_i/X_i) \]  

\[ I_{(intra)} = \sum (y_j/Y_i) \log\left(\frac{y_j/Y_i}{x_j/X_i}\right) \]  

Then, the Theil index can be calculated as follows [14,33]:

\[ I_{Theil} = \sum (y_j/Y) \times \log\left(\frac{y_j/Y}{x_j/X}\right) \]  

Where:

- **I_{Theil}** = Theil Index
- **Y_j** = PDRB per capita regency/cities j
- **Y** = Provincial GRDP
- **X_j** = Population Number of districts / cities j
- **X** = Population of the province

Theil index value has no lower limit and upper limit as the Williamson index and Gini coefficient. The greater the value of the Theil index means a more uneven distribution of income and vice versa, the lower the value of the Theil index means more even income distribution [34].

3. Results and discussion

3.1. Gini coefficient

The Gini coefficients of Morowali Regency and Banggai Regency were calculated by using questionnaires that were distributed to 75 respondents randomly selected in each of the Morowali and Banggai Regency. From the calculation results using the above formula, as shown in Table 1, it is found that the value of the Gini coefficient of Morowali Regency is 0.161397. The results reflect that the level of income inequality among households in the Morowali Regency is still low, based on the criteria of Oshima. Meanwhile, the value of the Gini coefficient of the Banggai Regency is 0.344132, which means the level of income inequality among households in the Banggai Regency has reached a moderate level. Both Gini coefficient calculation results show that the level of income inequality among households in the Morowali Regency is still lower than that in Banggai Regency based on the data obtained from the household questionnaires.

The income inequality level of Morowali and Banggai Regency calculated by using the Gini coefficient is also graphically depicted using Lorenz curves in Figures 2 and 3. On the Lorenz curve of Morowali Regency (Figure 2), it appears that the Lorenz curve of Morowali Regency tends to approach the egalitarian line or evenness line. Meanwhile, the Lorenz curve of the Banggai Regency (Figure 3) tends to move away from the egalitarian line or evenness line. The Lorenz curve (Figures 2 and 3) also shows that the income distribution between households in Morowali Regency is more evenly distributed than the income distribution in Banggai Regency.
3.2. Williamson index

In this research, regional income inequality, as measured by the Williamson index, used per capita GRDP data as a database. The results of Williamson's index calculation from 2011 to 2015, as shown in Table 2 indicate that the level of regional income inequality in the Morowali Regency tends to show an upward trend. In fact, regional income inequality in 2015 in Morowali Regency reached 0.41. The figures indicate that the regional income inequality level in Morowali Regency has reached a moderate level. Meanwhile, the level of income inequality in the Banggai Regency tends to fluctuate and is still at a low level. The results of this calculation also indicate that the level of inequality of the regional income of the Morowali Regency measured by using the Williamson index is higher than the level of regional income inequality of the Banggai Regency. The calculation results in Table 2 also show a significant increase in regional income inequality level by 2015, both in Morowali Regency and Banggai Regency.

3.3. Theil index

Theil index calculation results with GRDP per capita based data, as presented in Table 3, indicate that the level of regional income inequality of Morowali Regency increased from 2011 to 2015. Table 3 also shows the inequality of local income of the Morowali Regency increased significantly in 2015 as much as 2.06 points. The regional income inequality of the Banggai Regency, as measured by the Theil index, also shows an upward trend from 2011 to 2015. Similar to Morowali Regency, the Theil index of the Banggai Regency in 2015 also increased significantly compared to previous years. Theil index calculation results reinforce the calculation results of the Williamson index.

The results of this research indicate that the level of income inequality of Morowali Regency as measured by using the Gini coefficient based on household data is still relatively low. However, the regional income inequality level of Morowali Regency calculated using GRDP data is in the medium category. The results of this research also revealed that the level of regional income inequality of Morowali Regency, both measured by using the index Williamson and Theil index, tends to show an upward trend during the period 2011 to 2015. Based on these results, it can be concluded that revenues in Morowali Regency were not distributed evenly from 2011 until 2015.

The research also reveals that at the time of the significant increase in economic growth in the Morowali Regency in 2015, there was also a significant increase in regional income inequality. By 2015, a large mining company began to operate in the Morowali Regency, which triggered a significant increase in economic growth in Morowali Regency [35]. This finding is in line with the hypothesis proposed by Kuznets and Williamson [29,36], which states that high economic growth in the transition period from agrarian to industrial areas tends to be followed by an increase in income inequality in the region [6,37]. Kuznets and Williamson also illustrate the economic growth relationship measured by per capita income and income inequality into an inverted U-shaped curve [9,38]. The Kuznets and Williamson hypothesis have been verified by a number of previous studies, both in Indonesia and outside Indonesia [7,14,39–41].

Based on data from the Central Bureau of Statistics, the main contributor to GRDP of Morowali Regency in 2015 is the manufacturing, mining, and quarrying sectors. In 2015, the distribution of GRDP from the manufacturing sector increased significantly compared to 2014, which reached 29.68%, and for the mining and quarrying industry sector also increased to 26.19% [42]. The increasing contribution of the mining and quarrying industry sector in 2015 was caused by the operation of PT Indonesia Morowali Industrial Park in Bahodopi District Morowali Regency. The operation of PT Indonesia Morowali Industrial Park had an impact on the significant increase of GRDP of Morowali Regency in 2015 [35]. It is because the operation of the large mining industry is not followed by the decrease in regional income inequality of the Morowali Regency. In fact, this research reveals an increase in economic growth in Morowali Regency in 2015, followed by a significant increase in regional income inequality in the same year.

Central Bureau of Statistics shows, the mining industry in Morowali Regency only absorbed the workforce of 3,398 in 2015. Meanwhile, the Central Bureau of Statistics data also reveals that the
agricultural sector in Morowali Regency absorbed the labor force of 22,234 in 2015. The data explained that the income distribution inequality in Morowali Regency is related to the fact that the majority of Morowali Regency's residents still worked in the agricultural sector, and other residents worked in the mining and quarrying industry sectors. Meanwhile, wages earned from the mining and quarrying industry are much higher than those earned from the agricultural sector. The wage differences increase with the emergence of technology-based industries that require skilled labor [11, 43, 44]. The difference in income between skilled and unskilled workers triggers income inequalities during the industrialization process, as described by Kuznets [45, 46]. Therefore, the income inequality in Morowali Regency is caused by only a small proportion of the population in the Morowali Regency who works in the mining sector, and the rest still work in the low-wage agricultural sector. The impact of technological advances in increasing income inequality as there is a large gap between the income of skilled and unskilled labor has also been described by previous research [12]. The previous research has even revealed that the amount of agricultural work is associated with income distribution inequality because the majority of workers with low skills work in agriculture [5]. The different sectors of employment between the agricultural and non-agricultural sectors contribute to the distribution gap [47]. The impact of agricultural sector movements through industrialization towards income inequality has been described by Kuznets in his famous paper entitled “Economic Growth and Income Inequality” [6, 48].

High unemployment rates can also increase income inequality [9]. The high regional income inequality of the Morowali Regency is also explained by the low absorption of the local workforce in the mining industry operating in the Morowali Regency. Many mining industries operating in Morowali Regency are expected to expand employment opportunities for local residents. However, the mining industry is a technology-based industry that requires an educated and skilled workforce. Meanwhile, the majority of residents of Morowali Regency only graduate from High School [49]. As a result, only a few of the local residents of Morowali Regency work in the mining industry and benefit directly from the operation of the mining industry.

Previous research has also revealed that increased migration increases spatial income inequality [46]. Massive labor migration from outside Morowali Regency and overseas reduced the proportion of local labor in the mining industry operating in the area. Labor participation rates have an impact on the per capita income gap [29]. Meanwhile, labor migration from outside the region cannot be prevented because the mining industry based on external technology requires skilled and professional labor for the operation of the technology. Meanwhile, the position cannot be filled by local workers due to their limited education and skills. Therefore, labor migration from outside the Morowali Regency increased regional income inequality in Morowali Regency because local residents only work in the low-wage agricultural sector and outsiders dominate the high-income mining sector.

The high level of income inequality of Morowali Regency measured using the Theil index in 2015 also shows that there has been inequality of income distribution between regions in the Morowali Regency. The benefits derived from inflows of foreign investment are not distributed evenly to all parts of the community. The direct benefits of increasing economic growth in the Morowali Regency due to foreign investment through the mining industry are only enjoyed by the region that became the operational place of the mining industry, Bahodopi District. Meanwhile, other sub-districts in Morowali Regency do not have direct access to the mining industry sector nor direct benefit from mining industry activities in the Bahodopi sub-district. Therefore, the GRDP of Morowali Regency is high because the large contribution from the mining and quarrying industries is not distributed evenly throughout the region in Morowali Regency. This is in line with previous research findings, which reveal that high regional income inequality in resource-rich regions is affected by the unequal distribution of immovable natural resources in the area [22, 38].

Meanwhile, the regional income inequality of the Banggai Regency during the period of 2011 to 2015 is still relatively low, although it tends to fluctuate. In 2015, the year of operation of the natural gas mining industry in the Banggai Regency, Banggai Regency, recorded a significant increase in economic growth. Similar to Morowali Regency, the increase in economic growth in Banggai
Regency is also followed by an increase in income inequality by 2015 based on the calculations of the Williamson and Theil indexes. Nevertheless, the increase in regional income inequality of the Banggai Regency in 2015 is not too significant and still in the low category. The difference in income inequality condition between Morowali Regency and Banggai Regency is caused by the difference of GRDP contribution composition in both regencies. Based on data from the Central Bureau of Statistics, the agriculture, forestry, and fishery sectors are the main contributors to the Banggai Regency's GRDP by 2015 at 31.55%. Data from the Central Bureau of Statistics also show that the mining and quarrying sectors are the second contributor to the GDRP of Banggai Regency in 2015 of 12.56%. The inequality in the distribution of regional income of the Banggai Regency in 2015 is still in the low category, although the natural gas mining industry in Batui Sub-district Banggai Regency started to operate that year because most of Banggai Regency residents still work in the agriculture sector which becomes the main contributor of GRDP. This finding is in line with previous research results, which reveal that inequality in agriculture-backed areas is lower than regional inequality in areas sustained by the industrial sector [38,50]. Nevertheless, the trend of data on the distribution of the mining sector to the Banggai Regency's GRDP tends to show an increase over the period 2010 to 2016 [4]. The result of this research reveals that the increasing contribution of the mining sector to GRDP of the Banggai Regency happened along with the increasing income inequality in Banggai Regency. This finding confirms the hypothesis of Kuznets and Williamson [29,36], which states that an increase in economic growth is followed by an increase in income inequality in the early stages of industrialization.

4. Conclusion

The results reveal that the regional income inequality (of Morowali and Banggai Regencies) increased when economic growth of both regions experienced a significant increase, especially in 2015, when the large mining industry began to operate in both areas. The manufacturing and mining industries in have succeeded in shifting the dominance of agriculture sector. The level of income inequality among households and regional has reached a moderate level and tends to fluctuate. Meanwhile, the level of income distribution between regions within regencies is relatively low. The government should consider the impact of industrial presence in areas originally sustained by the agrarian sector in relation to income distribution. Second, the preparation of skilled and educated local workers in facing the industrialization era needs to be conducted. Due to data limitations, especially postindustrial data, this research is unable to conduct complete Kuznets curve analysis. Second, this research focuses on the context of the Morowali Regency and Banggai Regency only. Therefore, further studies are suggested to examine the causal relationship between economic growth and income inequality before and after industrialization.

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