


RESEARCH ARTICLE



The impact of climate change, inflation, and foreign direct investment on income inequality in ASEAN-4

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ABSTRACT

This study examines the effects of climate change, inflation, and foreign direct investment (FDI) on income inequality in ASEAN-4 countries (Indonesia, Thailand, Malaysia, and the Philippines), with economic growth and corruption control as moderating variables. Utilizing annual data from 2002 to 2023 sourced from the World Bank, this research employs panel regression analysis to assess the relationships among variables. The findings provide empirical evidence that climate change and FDI have a positive impact on income inequality, whereas inflation has a negative effect. These results highlight the urgency of addressing inequality in the region. Mitigating climate change is essential to reduce the risks associated with rising CO₂ emissions. Governments must also ensure stable inflation to help narrow income gaps. Furthermore, policies promoting the equitable distribution of FDI across regions are necessary to enhance labor absorption, particularly among low-skilled workers.

KEYWORDS

Income inequality; climate change; CO₂ emissions; inflation; foreign direct investment

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1. Introduction

Income inequality remains one of the most persistent challenges across both developed and developing countries. Over the past few decades, policymakers have increasingly turned their attention to issues surrounding economic growth and the equitable distribution of income. In recent years, income inequality has emerged as a critical concern, particularly in developing nations, many of which are experiencing widening income gaps (Yuldashev et al., 2023).

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Recognizing the adverse implications of inequality, governments and international organizations have intensified their focus on inclusive development. The World Bank, through the Sustainable Development Goals (SDGs) launched in 2015, identified reducing inequality as one of its 17 global targets. Extensive studies have shown that inequality can serve as a catalyst for social and political unrest, economic inefficiencies, and declining social cohesion (Singer, 2018). Todaro (2013) emphasizes that extreme disparities in income distribution weaken the foundations of sustainable economic development.

The International Monetary Fund (IMF) also underscores the importance of addressing income inequality, noting that an increase in the income share of the richest 20 percent may, paradoxically, suppress GDP growth in the medium term (Norris et al., 2015). This suggests that income gains are not always distributed evenly across segments of society.

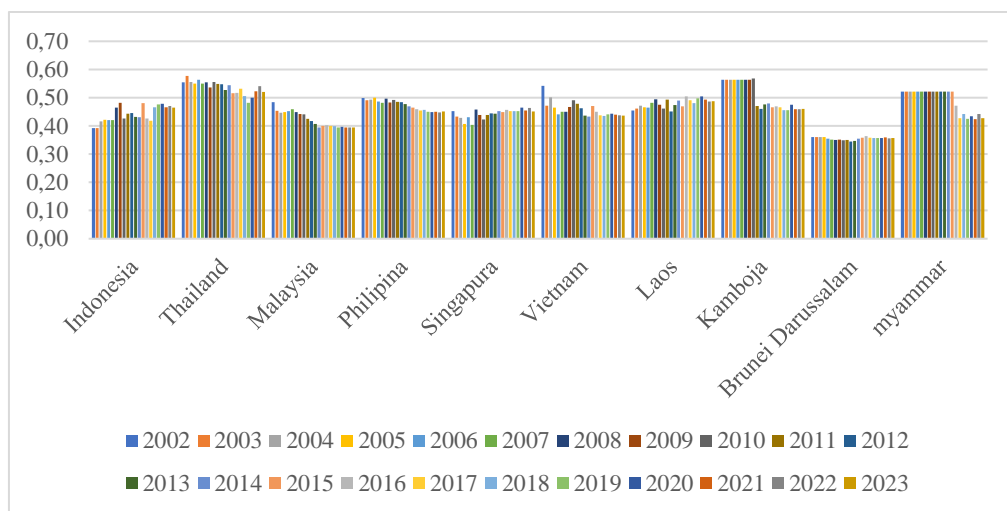


Figure 1. Gini ratio trends in ASEAN countries. *Source:* World Inequality Database (2025)

In the context of Southeast Asia, the ASEAN region—comprising mainly developing economies—has not been immune to the problem of income inequality. Data from the World Inequality Database reveal that income inequality in ASEAN countries remains relatively high, with Gini coefficients exceeding 0.40 in several nations. This is further illustrated by Figure 1, which presents the development of income inequality in ASEAN from 2002 to 2023. The average Gini ratio across ASEAN during this period is 0.46, with Indonesia exhibiting the highest average at 0.54,

followed by Cambodia at 0.51. In contrast, Brunei Darussalam recorded the lowest average Gini ratio of 0.36.

The persistence of inequality in ASEAN is often attributed to uneven economic development. While some regions within countries experience rapid economic growth, others lag behind. Moreover, the lack of adequate human capital and skill disparities contribute to the widening income gap (Violin & Lutfi, 2022).

Within ASEAN, four countries—Indonesia, Thailand, Malaysia, and the Philippines—are categorized by the World Bank as upper-middle-income economies, with per capita income ranging from US\$4,466 to US\$13,845. These ASEAN-4 countries represent key case studies in understanding income inequality in the region.

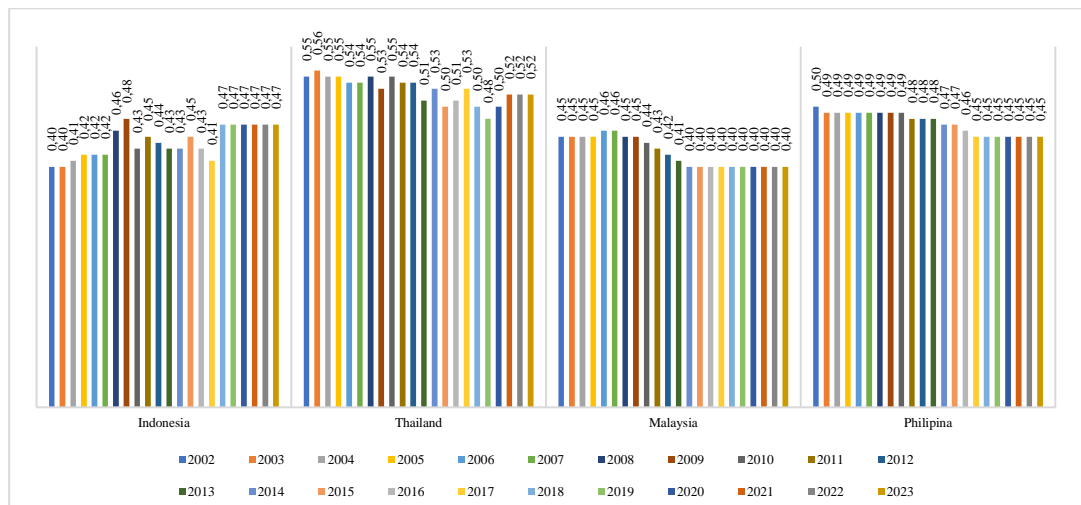


Figure 2. Trends in the Gini ratio in Indonesia, Thailand, Malaysia, and Philippines, 2002–2023. *Source:* World Inequality Database (2025).

According to the World Inequality Database, income inequality in ASEAN-4 countries has shown significant fluctuations from 2002 to 2023. As shown in Figure 2, Thailand recorded the highest Gini ratio in the group at 0.52 in 2023, followed by the Philippines with an average of 0.47. Malaysia had the lowest average inequality level at 0.42 during the same period. These disparities highlight the pressing nature of inequality, particularly as it relates to macroeconomic indicators such as foreign direct investment (FDI), inflation, and economic growth.

Recent research has begun to examine the complex interconnections between inequality and broader environmental and economic issues. Oanh & Ha (2023)

found that rising income inequality exacerbates environmental degradation in Asian countries. Similarly, Cevik & Jalles (2023) reported that developing countries are more vulnerable to the adverse effects of climate change, which in turn intensifies income inequality. In contrast, studies such as Kalaichelvi & Navaratnam (2018) suggest that FDI may contribute to reducing inequality over the long term. Febriani et al. (2022) also showed that economic growth significantly influences income distribution.

Given these findings, this study aims to investigate the impact of climate change, inflation, and foreign direct investment on income inequality in ASEAN-4 countries. Understanding these dynamics is essential for policymakers seeking to design effective strategies to promote inclusive and sustainable economic development in the region.

2. Literature review

2.1. Income inequality

Income inequality refers to the unequal distribution of income within a country or region. It arises due to disparities in economic prosperity among communities, often influenced by differences in resource availability, geographical conditions, and production factors. These disparities lead to uneven development and income distribution, ultimately resulting in welfare gaps across regions (Kuncoro, 2013).

According to Todaro & Smith (2011), income inequality can be measured using several indicators:

a. Size distribution

The size of the distribution can be calculated by comparing the level of income inequality can be seen from how much percentage of income is received by the poorest 40 percent of the population compared to the richest 20 percent of the population. This size of the distribution is used to classify the level of income inequality, namely:

1. High inequality occurs when the poorest 40 percent of the population only receives <12 percent of the total national income.
2. Moderate inequality occurs if the group receives between 12 and 17 percent of national income.
3. Low inequality occurs when the poorest 40 percent of the population earns more than 17 percent of total national income.

b. Lorenz curve

The Lorenz curve shows the quantitative relationship between the percentage of population and the percentage of income in a year. If the curve moves further away from the diagonal line, it indicates that the level of inequality experienced by the population in the country is getting higher (Figure 3).

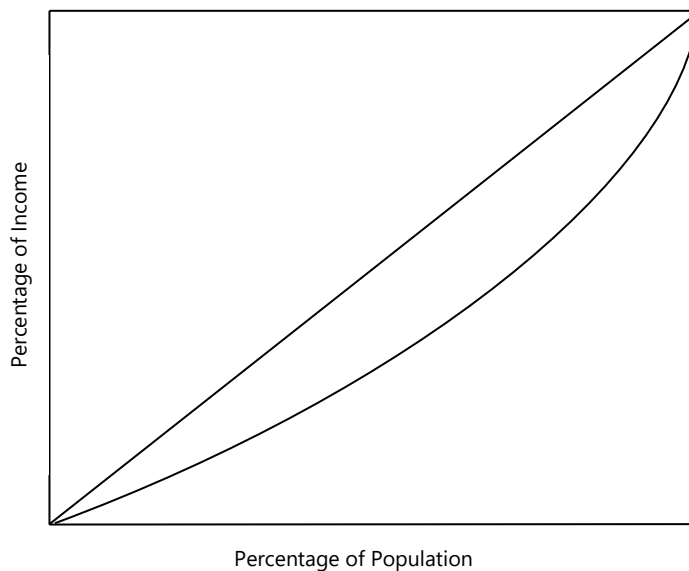


Figure 3. Lorenz curve. *Source:* Todaro (2013)

The horizontal axis shows the cumulative percentage of the population, while the vertical axis shows the total percentage of income received by each percentage of the population. The closer the Lorenz Curve is to the diagonal line, the more even the distribution of income.

c. Gini index

The Gini index or Gini ratio is one way to measure the level of income inequality. The Gini index is obtained from calculating the ratio of the area between the diagonal and the Lorenz curve. The higher the coefficient value, the higher the level of income inequality. In mathematical form, the formula for calculating the Gini coefficient can be stated as follows:

$$GR = 1 - \sum_{i=1}^n fpiX (Fci + Fci - 1) \quad (1)$$

Where GR is the Gini ratio, fpi represents the proportion of the population in the i -th expenditure class, Fci is the cumulative proportion of total expenditure up to the i -th class, and $Fci-1$ is the cumulative proportion of total expenditure up to the $(i-1)$ -th class.

2.2. Climate change

Climate change refers to alterations in climate patterns over a specific period, driven by both natural factors and human activities. It has impacted various physical and biological systems globally (Balasubramanian, 2017; Subair, 2015). According to Balasubramania (2017), several indicators of climate change include:

1. Greenhouse effect

Increased concentration of Carbon Dioxide (CO₂) and other gases in the atmosphere. This increase is caused by increased burning of coal and other organic fuels. Increased concentration of CO₂ and other gases in the atmosphere causes an increase in heat waves reflected by the earth and absorbed by the atmosphere.

2. Global and regional surface temperatures

Surface temperature or temperature is a measure of the environment for the level of heat of a particular object. Temperature is always changing and the distribution of temperature in the atmosphere is very fast.

3. CO₂ emissions

CO₂ emissions from fossils include all emissions from fossil fuel consumption including burning of coal, oil, gas and other combustion (Aswadi et al., 2024). In addition, direct industrial emissions from cement. These emissions do not include emissions from land use change.

2.3. Inflation

Inflation is the rate of increase in the prices of goods or services in general and continuously over a certain period. Inflation is measured by the rate of change in

the general price level. Inflation is caused by excess demand caused by the increase in the amount of money circulating in the community. The level of inflation can have positive and negative impacts on a country's economy depending on the degree of inflation itself. Excessive inflation can put serious pressure on economic stability and has the potential to cause bankruptcy in a number of companies (Hartono, 2016).

Inflation can be measured by looking at the price changes of various basic necessities of the community that apply in the market. The Consumer Price Index (CPI) is a measurement by looking at the level of price changes (inflation/deflation) (BPS, 2024s). The inflation (or deflation) rate is calculated as:

$$Inflation = \frac{CPI_n - CPI_{(n-1)}}{CPI_{(n-1)}} \times 100 \quad (1)$$

Where inflation is the inflation/deflation rate in month n , CPI_n is the Consumer Price Index for the current month, $CPI_{(n-1)}$ is the Consumer Price Index for the previous month.

2.4. FDI

FDI refers to long-term investments by foreign entities into domestic business sectors. FDI plays a significant role in boosting economic development and generating employment opportunities (Aprianto et al., 2018). FDI consists of two types of investment, namely inward and outward (OECD, 2022).

1. Inward FDI

Foreign direct investment in the country, where the total level of FDI in the economy is reported at the end of the period by industry sector. Inward Foreign Direct Investment is measured in millions of USD as a share of total Inward FDI.

2. Outward FDI

Investment from within the country to other countries, the total level of direct investment from the reported economy at the end of the period by destination country. This measure is expressed in millions of USD and as a share of total Outward FDI.

3. Methods

3.1. Data

This study uses annual panel data, namely by combining cross-section data in ASEAN 4 (Indonesia, Malaysia, Thailand, and the Philippines) and time series for the period 2002-2023 so that the number of observations is 88 observations (see [Table 1](#)).

Table 1. Operational definitions of variables and data sources

Variable	Information	Definition	Source
INC	Income Inequality	The difference in economic prosperity between the rich and the poor is reflected in the difference in income (Index).	World Inequality Database
CC	Climate Change	Increased atmospheric temperature change (US\$ of GDP).	World Bank
INF	Inflation	The average percentage increase in the overall prices of goods, commodities, and services over a period of time (Percentage).	World Bank
FDI	Foreign Direct Investment	Long-term investment made directly by foreign investment in the business sector of domestic citizens (Percentage).	World Bank

3.2. Data analysis

The model used in this study is illustrated in the following equation:

$$INC_{it} = \alpha + \beta_1 CC_{it} + \beta_2 INF_{it} + \beta_3 FDI_{it} + e_{it} \quad (2)$$

This model is then transformed into its logarithmic form:

$$\text{Log}(INC_{it}) = \alpha + \beta_1 \text{Log}(CC_{it}) + \beta_2 \text{Log}(INF_{it}) + \beta_3 \text{Log}(FDI_{it}) + e_{it} \quad (3)$$

Where Log is the natural logarithm, INC_{it} is the income inequality variable, α is the constant, β is the regression coefficient of the independent variable, CC_{it} is represents climate change (measured by CO₂ emissions), INF_{it} is the inflation rate, FDI_{it} is foreign direct investment, e is the error term, i is the object and t is the time. The data were analyzed using EViews 10 software to perform panel regression analysis.

4. Results

4.1. Results of model selection

Table 2 shows the results of the selection of the best model, namely the effect of climate change, inflation and FDI on income inequality. Obtained a probability value in the Cross-section Chisquare smaller than alpha (α) ($0.0000 < 0.05$) in each estimation model, both in the chow test and the hausman test, it was found that the best model was the Fixed Effect Model (FEM).

Table 2. Results of the Chow test and Hausman test

Model		Effects Test	Statistics	Prob.	Decision
Model I	Chow Test	Cross-section F	99.4887	0.0000***	FEM
		Cross-section Chi-square	135.8998	0.0000***	
	Hausman test	Random cross section	298.4662	0.0000***	FEM

4.2. Results of static panel data regression

Table 3 shows that climate change has a positive effect on income inequality in Indonesia, Thailand, Malaysia, and the Philippines. The coefficient value for the climate change variable is 0.17 with a probability of 0.00, which means it is less than 0.05. The coefficient of 0.17 states that a one percentage point increase in climate vulnerability is associated with a 17.39 percent increase in income inequality. This finding is in line with research by Malpede & Percoco (2021), Cevik & Jalles (2023) explaining that the impact of a one percentage point increase in climate vulnerability will cause an increase in income inequality. The impact of climate change can increase economic inequality and will indirectly affect the poor, both globally and in developing countries (Majeau et al, 2024). However, according to research by Otrachshenko & Popova (2021), exposure to extreme temperatures does not affect income inequality.

Inflation affects income inequality. The inflation coefficient of -0.0056 with a significance level of 0.02, which is less than 0.05, indicates that inflation has a negative and significant effect on income inequality. This means that if inflation increases by 1 percent, it will reduce the level of inequality by 0.0039 percent. This confirms that inflation and income inequality have a U-shaped relationship between inflation and income inequality. This study is in line with research conducted by Zheng et al. (2020) who stated that there is a U-shaped relationship between

inflation and income inequality in OECD countries and the United States. Walsh & Yu (2012) showed that food inflation does not have a negative impact on low-income groups or this group can be offset by increased income obtained by other groups.

Table 3. Panel data regression results on income inequality

Variable	Coefficient	Std. Error	t-Statistic	Prob
C	-0.6812	0.0300	-2,2686	0.0000***
CC	0.1739	0.0490	3,5460	0.0007***
INF	-0.0056	0.0024	-2,3283	0.0224***
FDI	0.0089	0.0045	1,9721	0.0520**
R-squared	0.8041		F-statistic	55,4228
Adjusted R-squared	0.7896		Prob(F-statistic)	0.0000

Note: The dependent variable is Income Inequality

The effect of FDI on income inequality. The FDI coefficient of 0.008 indicates a positive relationship with income inequality. This shows that a 1 percent increase in FDI will increase income inequality. An increase in FDI that is not evenly distributed will increase income inequality from one region to another. The uneven distribution of FDI causes the level of income inequality to increase. Where FDI is only distributed in certain regions or areas, so that there is demand that will drive income and demand which will then increase investment. While in other regions, low FDI development will trigger a higher level of inequality. This is because the level of investment in the area is low. Suanes (2016) research shows that there is a positive effect of FDI on income inequality in Latin America. Figini & Görg (2011), Le et al. (2021) found a nonlinear effect of FDI on income inequality in developing countries. Meanwhile, Chen & Wu (2019) research found that an increase in FDI can result in a reduction in the Gini coefficient of 0.01.

5. Discussion

The results of this study are consistent with prior research by Malpede & Percoco (2021) and Cevik & Jalles (2023), which found that a one percentage point increase in climate vulnerability is associated with a rise in income inequality. Climate change tends to disproportionately affect poorer communities, thereby exacerbating economic disparities both globally and in developing countries (Aswadi et al., 2024;

Gam et al., 2023; Majeau et al., 2024). However, contrasting evidence is presented by Otrachshenko & Popova (2021), who argue that exposure to extreme temperatures does not significantly affect income inequality, highlighting the need for further context-specific studies.

The findings also reveal that inflation has a negative and statistically significant effect on income inequality. The inflation coefficient is -0.0056 with a significance level of 0.02 ($p < 0.05$), indicating that a 1% increase in inflation reduces income inequality by approximately 0.0039%. This supports the hypothesis of a U-shaped relationship between inflation and income inequality, where moderate inflation may help narrow income gaps. This result aligns with the study by Glawe & Wagner (2024) and Zheng et al. (2020), which identified a U-shaped relationship in OECD countries and the United States. Walsh & Yu (2012) similarly noted that food inflation does not adversely affect low-income groups, as the impact can be offset by increased income in other segments of the population.

Regarding FDI, the study finds a positive relationship with income inequality. The coefficient of 0.008 indicates that a 1% increase in FDI is associated with a rise in income inequality. This implies that uneven distribution of FDI across regions can exacerbate income gaps. In areas where FDI is concentrated, investment-driven growth leads to increased income and demand, while regions with limited FDI remain economically stagnant, widening regional disparities. Suanes (2016) observed similar outcomes in Latin America, noting a positive link between FDI and inequality. Meanwhile, Figini & Görg (2011) and Le & Nguyen (2021) suggest a nonlinear relationship between FDI and inequality in developing countries. Contrarily, Chen & Wu (2019) found that an increase in FDI could reduce the Gini coefficient by 0.01, indicating the potential for FDI to reduce inequality when properly managed and distributed.

6. Conclusion

Based on the results of the panel regression analysis using the FEM, this study concludes that climate change and foreign direct investment have a positive effect on income inequality in ASEAN-4 countries, while inflation has a negative effect. Furthermore, economic growth serves as a moderating variable that strengthens the negative relationship between FDI and income inequality, suggesting that higher economic growth can mitigate the inequality-widening effects of FDI.

These findings underscore the importance of inclusive and sustainable economic policies. Governments in ASEAN-4 countries should prioritize climate change mitigation strategies, ensure stable inflation to support equitable income distribution, and promote policies that encourage balanced FDI across regions. Such measures can help reduce structural income inequality and foster more inclusive development.

Conflict of interest

The authors declare that there are no conflicts of interest regarding this publication.

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