



The relationship of economic growth, income inequality and poverty: a study on developing countries

A relação entre crescimento econômico, desigualdade de renda e pobreza: um estudo sobre os países em desenvolvimento

Firat Cem Doğan¹

Mehmet Hanifi Aslan²

Abstract

This study aims to examine the relationship between income inequality, poverty and economic growth in selected eight developing countries determined by the World Bank's Atlas method between 2000 and 2020. The problem of the study is the increasing and deepening income inequality and poverty in developing countries in recent years. In this context, panel data analysis was chosen to reveal the relationship between income inequality, poverty and economic growth in developing countries, and a wide data set such as gini coefficient, head number index, per capita national income, democracy index, human development index and misery index was used. Income inequality, poverty and economic growth were analyzed with three different models) and compared with each other. Considering the results of the analysis, the Durbin-Hausman cointegration test was conducted to reveal the existence of a long-term relationship between the variables, and the existence of a long-term cointegration relationship between the variables was determined. According to the results of Dumitrescu Hurlin causality test, a bidirectional causality relationship was found between the variables. According to panel regression analysis, it was determined that while per capita increases in national income

¹ Doctor in Economics, Hasan Kalyoncu University - Faculty of Economics, Administrative and Social Sciences, Havaalanı Yolu Üzeri 8. km, 27010 Şahinbey/Gaziantep, Turkey, Turquia. E-mail: fcem.dogan@hku.edu.tr
Orcid: <https://orcid.org/0000-0002-2398-1484>

² Doctor in Economics, Hasan Kalyoncu University - Faculty of Economics, Administrative and Social Sciences, Havaalanı Yolu Üzeri 8. km, 27010 Şahinbey/Gaziantep, Turkey, Turquia. E-mail: mhanifiaslan@hku.edu.tr
Orcid: <https://orcid.org/0000-0002-6970-7480>

increase income inequalities, increases in democracy and per capita income reduce poverty, and increases in democracy index increase per capita income. According to the results, various social, economic and political policies have been proposed to reduce income inequality and poverty and increase economic growth.

Keywords: Income Inequality. Poverty. Economic Growth. Poverty Reducing Growth. Panel Data.

Resumo

Este estudo visa examinar a relação entre desigualdade de renda, pobreza e crescimento econômico em oito países em desenvolvimento selecionados, determinados pelo método Atlas do Banco Mundial entre 2000 e 2020. O problema do estudo é o aumento e o aprofundamento da desigualdade de renda e da pobreza nos países em desenvolvimento nos últimos anos. Neste contexto, a análise de dados do painel foi escolhida para revelar a relação entre desigualdade de renda, pobreza e crescimento econômico nos países em desenvolvimento, e um amplo conjunto de dados, como coeficiente de gini, índice de número da cabeça, rendimento nacional per capita, índice de democracia, índice de desenvolvimento humano e índice de miséria, foi utilizado. A desigualdade de rendimentos, a pobreza e o crescimento econômico foram analisados com três modelos diferentes) e comparados entre si. Considerando os resultados da análise, o teste de cointegração de Durbin-Hausman foi realizado para revelar a existência de uma relação de longo prazo entre as variáveis, e a existência de uma relação de cointegração de longo prazo entre as variáveis foi determinada. De acordo com os resultados do teste de causalidade Dumitrescu Hurlin, foi encontrada uma relação de causalidade bidirecional entre as variáveis. De acordo com a análise de regressão de painel, foi determinado que, enquanto os aumentos per capita no rendimento nacional aumentam as desigualdades de rendimento, os aumentos na democracia e no rendimento per capita reduzem a pobreza e os aumentos no índice de democracia aumentam o rendimento per capita. De acordo com os resultados, várias políticas sociais, econômicas e políticas foram propostas para reduzir a desigualdade de renda e a pobreza e aumentar o crescimento econômico.

Palavras-chave: Income Inequality. Pobreza. Crescimento Econômico. Pobreza Reduzindo o Crescimento. Dados do Painel.

Introduction

The concept of income distribution pertains to the division of income generated in an economy during a specific period (typically a year) among production factors, individuals, sectors, regions, societies, and countries. It also reveals how income is distributed among different segments of society, the extent of income disparities between the poor and the rich, and how these disparities change over time. The unequal distribution of income among individuals, regions, and countries is a widespread issue observed in developed, developing, and low-income countries alike (Alfranca ve Galindo, 2003: 134; Ocampo and Martin, 2003: 99).

Income distribution is typically analyzed using a set of statistical indicators and measures. These measures include average income, median income, the Gini coefficient, the Lorenz curve, and the Pareto distribution. These indicators are used to quantitatively assess income distribution, measure inequality levels, and illustrate differences among income groups. Income distribution is closely related to concepts such as social justice, economic opportunity equality, and social mobility. The way income is distributed in a society can impact a country's level of prosperity, the risk of poverty, social exclusion, and economic stability. In a society with high income inequality, low-income individuals and households may face economic hardships, while high-income individuals have more opportunities. Research on income distribution is a significant topic of discussion among economists, sociologists, and policymakers (Atkinson and Bourguignon, 2000: 1-58).

Income inequality, as a concept, refers to the unfair distribution of national income among individuals, households, regions, social groups, or owners of production factors within a country during a specific period. These disparities in income distribution have been the focus of attention for policymakers and economists for many years. Particularly in the 20th century, when income inequality experienced what can be described as an "explosion" worldwide, economists dedicated their efforts to studying this issue. The observed increase in income inequality primarily stems from a significant rise in inequality between different regions or countries across the globe (Bourguignon and Morrisson, 1999: 17-18).

If we look at the historical perspective of the income inequality problem, we need to start with the views of T. Malthus, who expressed his ideas on poverty and inequality in the 17th century. Malthus believed that excessive population growth would pose a significant threat to poverty and inequality. It is evident that Malthus was heavily influenced by the writings of the British agricultural scientist Arthur Young in forming these views. According to Young's work, which described his impressions of the late 17th century, France was one of the most

densely populated countries in Europe. While France's population was around 20 million in the early 1800s, it had reached nearly 30 million by the end of the 1800s. Malthus argued that the resulting population growth posed a risk of leading humanity into poverty and misery, emphasizing the need for strict birth control among the poor to mitigate this risk (Piketty, 2015: 5).

Thomas Robert Malthus, David Ricardo, Karl Marx, and other classical economists have conducted detailed analyses on income distribution and inequalities at different periods without necessarily presenting a specific method or source that would allow for a comprehensive comparison of different assumptions. However, Simon Kuznets' book on inequality and distribution, published in 1955, brought clarity to the subject as much as possible by providing transparent methods and source (Piketty, 2015: 19).

The following subheadings will explain the theories of Kuznets' Inverted-U Hypothesis and the Bourguignon Triangle, which empirically and theoretically examine the relationships between income inequality, poverty, and economic growth in the economic literature.

2.1 Kuznets' Inverted-U Hypothesis

Simon Kuznets, in his article titled "Economic Growth and Income Inequality" published in 1955, introduced his own theory known as Kuznets' Inverted U Hypothesis, which explores the relationship between economic growth and income inequality. Kuznets argued that income inequality increases during the early stages of economic development, but later on, it diminishes, resulting in an inverted U-shaped pattern. Changes in income distribution over time are observed when per capita income increases, as indicated by research utilizing the Gini coefficient (Kuznets, 1955: 4).

Kuznets' Inverted U Hypothesis, which demonstrates the relationship between economic growth and income inequality during the period of rapid growth following World War II and the subsequent industrialization process, is illustrated in Figure 1.

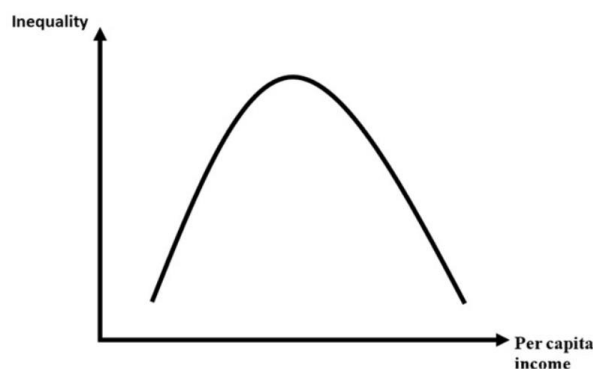


Figure 1: Kuznets' Inverted-U Hypothesis

Source: The depicted Kuznets' Inverted U Hypothesis was created by the author.

According to Figure 1, per capita income is represented on the horizontal axis, while the Inequality is represented on the vertical axis. It can be observed that during the initial stages of economic development, inequalities increase, while in later stages, they decrease. The relationship between income inequality and economic growth can be explained by two factors up to income level: the savings intensity of higher-income groups and the industrial structure of income distribution. The savings intensity of higher-income groups, under fixed conditions, leads to an imbalance in savings levels, resulting in the accumulation of income-generating assets in the hands of the upper-income groups. The industrial structure of income distribution, on the other hand, arises due to urbanization and industrialization. As the population shifts from the agriculture sector, where income inequality is relatively lower, to the industrial sector, income inequalities further increase. However, the adverse effects arising from savings in the later stages of economic growth are mitigated by redistributive policies implemented by the government and policymakers. The problems and negative effects associated with industrialization can be addressed by allowing the establishment of younger industries in developing countries, where personal freedoms are enhanced. Additionally, another factor that reduces income inequality is the movement of laborers supplying their labor from low-income industrial establishments to higher-income ones (Gallo, 2002: 18-19).

2.2 Bourguignon Triangle

Poverty, Inequality, and Growth Conference held in Paris on November 13, 2003, François Bourguignon, the Chief Economist of the World Bank, examined the relationship between poverty, growth, and inequality in his work, which he named after himself and is known in the literature as the "Bourguignon Triangle" or "The Poverty, Growth, and Inequality Triangle." Bourguignon addressed the question of which aspect, poverty, growth, or inequality, should form the basis of a country's development strategies. He argued that in order for an

economy to develop on solid foundations, it is essential to prioritize the reduction of absolute poverty. Bourguignon emphasized that without efforts to reduce inequality and achieve economic growth, sustainable economic development cannot be achieved. He presented a triangular model illustrating the relationships among poverty, growth, and inequality, highlighting the need for policies that address all three dimensions (Bourguignon, 2003: 2).

According to Bourguignon's model, which emphasizes the mutual interaction between growth and inequality and their impacts on poverty, long-term growth is effective in reducing poverty levels. However, due to limited development levels and poverty reduction policies in countries, an increase in income inequality can further exacerbate poverty despite economic growth (Bourguignon, 2004: 3).

Bourguignon's triangular model depicting the relationship between poverty, growth, and inequality is shown in Figure 2.

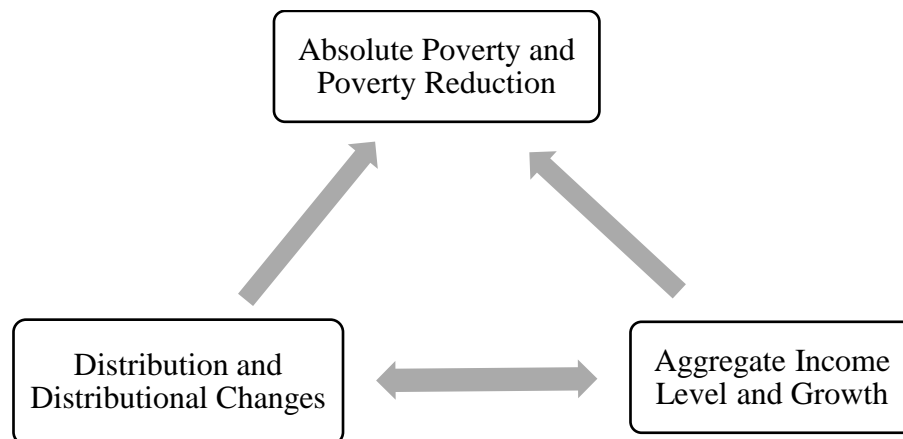


Figure 2: Bourguignon's Triangle of Poverty, Growth, and Inequality

Source: Bourguignon's Triangle theory was created by the author

According to the Bourguignon's triangle model shown in Figure 2, at the top, there is absolute poverty and poverty reduction, representing the population below the poverty line. On the bottom right of the triangle, there is total income level and growth, representing changes in income within the population. On the bottom left, there is "inequality" and "distribution," representing income disparities within the population. The arrows in the triangle of poverty, inequality, and growth indicate the cause and effect relationship between absolute poverty, inequality, and growth. In the model, growth and inequality influence each other, and both of them impact absolute poverty.

Literature Review

When examining the results of research conducted on income inequality, poverty, and economic growth in the economic literature, it is clear that there is no consensus on these issues. The divergence in theoretical and empirical research findings has further increased interest in the topic in recent years. Based on the gap mentioned in the literature, it was decided to conduct this research.

In this section, studies conducted on the relationship between income inequality, poverty, and economic growth are presented chronologically from old to new. According to this:

Blank and Card (1993), in their causal analysis study for the United States, stated that poverty is relatively less responsive to economic growth. Therefore, they emphasized the need for different policies to reduce poverty, suggesting that it would be a wise decision to pursue alternative approaches.

Persson and Tabellini (1994) conducted a panel data analysis study for Austria, Denmark, Finland, Germany, Netherlands, Norway, Sweden, the United States, and the United Kingdom. In their research, they proposed a theory that as income inequality increases, economic growth decreases. They analyzed this theory using two different data sets and panel data. The model was divided into two periods: 1830-1850 and 1970-1985. The estimations for these data sets revealed a negative relationship between economic growth and income inequality.

Clarke (1995), conducted a study applying the Barro-type growth model in Sub-Saharan African countries, North Africa, Middle Eastern countries, and OECD countries. In their research, they proposed a theory that as income inequality increases, economic growth decreases. They analyzed this theory using two different data sets and panel data. The model was divided into two periods: 1830-1850 and 1970-1985. The estimations for these data sets revealed a negative relationship between economic growth and income inequality.

Birdsall et al. (1995) conducted a panel data analysis for selected East Asian economies. Their study revealed that despite high growth and low inequality rates in East Asia, low growth and high inequality were observed in Latin American countries. This finding suggested that income inequality serves as a contributing factor in explaining low growth rates. The relationship between income inequality and growth was examined in various periods by incorporating other determinants of economic growth, such as average annual assassination rates, government expenditure, and educational participation rates, into the model. The findings confirmed the positive impact of low income inequality on economic growth.

De Janvry and Sadoulet (1996) conducted a panel data analysis on income inequality, growth rates, and poverty in selected Latin American countries during the period of 1970-1994. According to the test results, the Gini coefficient, which represents income inequality, was found to be significantly influenced by the headcount ratio. When poverty was measured by the number of poor people, it was affected by income inequality, but no conclusive evidence was found regarding the impact of inequality on poverty.

Partridge (1997) conducted a panel data analysis for United States of America, examining the relationship between income inequality measured by the Gini coefficient and economic growth during the period of 1960-1990. The findings of the analysis indicated a positive relationship between the variables. Similarly, when the share of income received by the top 20% was considered instead of the Gini coefficient in the model, a positive relationship between economic growth and income inequality was observed.

Bruno et al. (1998) examined the relationship between income inequality, growth rates, and poverty in selected Latin American countries during the period of 1970-1994 through panel data analysis. According to the test findings, it was revealed that the Gini coefficient, which represents income inequality, was significantly affected by the headcount ratio. When poverty was measured by the number of poor people, it was found to be influenced by income inequality. However, no conclusive evidence was found regarding the impact of inequality on poverty.

Li et al. (2000) conducted a panel data analysis in selected Asian, OECD, and Latin American countries to examine the effects of corruption on income using the Gini coefficient as a measure of inequality. The findings indicated that corruption increased income inequality. Countries with moderate levels of corruption had higher Gini coefficients. Furthermore, they concluded that corruption negatively affected the Gini coefficient through public expenditure. However, they did not find evidence of economic growth affecting the Gini coefficient.

Banerjee and Duflo (2003) conducted a panel data analysis for 45 selected countries. The study found a non-linear relationship between growth and inequality. It was observed that more egalitarian societies experienced higher growth, particularly in the presence of high initial levels of inequality. Changes in inequality were found to result in lower levels of economic growth in the short term.

Ravallion (2004) investigated the relationship between absolute poverty and income inequality in 70 selected developing countries using panel data analysis for the 1990s. The findings of the analysis did not reveal a systematic relationship between inequality and poverty. This result was attributed to the relatively weak link between income inequality and economic growth.

De Sousa-Brown and Gebremedhin (2004) examined the relationship between income inequality and poverty in 38 rural counties of West Virginia, USA, during the period of 1980-1990 using OLS and 2SLS cross-sectional data analysis. The test results indicated that income inequality and poverty occur simultaneously, and poverty is found to be the underlying cause of income inequality. It was concluded that as per capita income increases, poverty decreases.

Jalilian and Kirkpatrick (2005) conducted an Engle-Granger causality analysis in selected developing countries to examine the effects of financial development on poverty. The relationship between the growth of the financial sector and poverty reduction was analyzed using the Engle-Granger causality test. The results of the study revealed that up to a certain level, the growth of the financial sector contributes to both economic growth and poverty reduction.

Kraay (2006) conducted a panel data analysis for selected 80 developing countries to examine whether there is poverty-reducing economic growth between the 1980s and 1990s. According to the study, for economic growth to have a poverty-reducing effect, it needs to have three sources. These sources are stated as follows: poverty being excessively sensitive to economic growth in average income, a significant growth in average income, and growth in relative income that reduces poverty.

Lonnie and David (2008) conducted a study using the Vector Error Correction Model (VEC) for the United States, investigating the relationship between economic growth and poverty from 1959 to 2004. The analysis findings revealed that economic growth plays a significant role in reducing poverty, as indicated by the obtained results.

Matins-Bekat and Kulkarni (2009) conducted a panel data analysis for Brazil, examining the relationship between income inequality and economic growth during the period of 1980-2005. According to their study, Brazil ranked as the second highest country in terms of Gini coefficient, with a global average of 0.625 in 1989, indicating significant levels of income inequality and lack of equal opportunities. Interestingly, during the period known as the "Brazilian miracle" in the 1960s-1970s, when the economy experienced an average annual growth rate of 10%, income inequality actually increased.

Lin et al. (2009) examined the relationship between inequality and growth for a selected group of 83 countries using threshold analysis. According to the findings, a significant income threshold was identified in the relationship between growth and inequality. It was found that the impact of income inequality on economic growth is strong and negative below the critical development level. Therefore, the test results indicate that redistribution policies aimed at reducing income inequality, such as transfer expenditures and progressive taxation, would

facilitate economic growth in low-income economies but hinder economic growth in high-income economies.

Malinen (2012) conducted a panel data analysis to examine the relationship between economic growth and income inequality for a selected group of 53 countries. Unit root tests were conducted, which indicated that the variables were stationary. However, cointegration tests were performed for the variables, and the Perdoni test revealed a cointegrating relationship between income inequality and per capita income.

Ravallion (2012) utilized household surveys in selected 90 countries and employed the EKK method to estimate the impacts of poverty, economic growth, and income inequality. According to the OLS estimation results, there were negative effects between poverty and economic growth, while no relationship was found between income inequality and economic growth or poverty.

Atif et al. (2012) analyzed the impact of globalization on income inequality in 68 developing countries during the period of 1990-2010 using panel data analysis. According to the analysis findings, globalization increases income inequality in developing countries.

Ncube et al. (2013) analyzed how income inequality affects both poverty and economic growth in MENA (Middle East and North Africa) countries during the period of 1985-2009 using the EKK method. The test results provide evidence that high levels of inequality in this group of countries lead to a slowdown in economic growth and an increase in poverty.

Cingano (2014) conducted a panel data analysis to examine the relationship between average annual economic growth and income inequality in a selected group of 31 OECD countries for the period 1970-2010. The test results revealed the presence of a negative impact of income inequality on economic growth.

Chang and Fru (2015) tested the impact of income inequality on growth in the Southern African Development Community (SADC) countries during the period 1995-2010 using panel data analysis. The variables used in the model were the Gini coefficient as a measure of income inequality and per capita GDP data as a measure of growth. The test results showed that exchange rate fluctuations and income inequality have a significant and negative impact.

Akıncı and Akıncı (2016) conducted cointegration analysis and Toda-Yamamoto causality analysis to reveal the relationships between financial development, economic growth, and income inequality variables in Turkey during the period of 1960-2014. According to the test results, economic growth reduces income inequality. The inverse U-shaped hypothesis of Kuznets is valid for Turkey.

Yang and Greaney (2017) conducted an Engle-Granger causality and regression model study in China, Japan, South Korea, and the United States to examine the short and long-term

relationships between income inequality, economic growth, and redistribution during the period of 1960-2014. According to the test results, increasing income inequality stimulates economic growth.

Serven and Marrero (2018) examined the relationship between economic growth and poverty in Mexico during the period of 1960-2016 using cointegration analysis. According to the study's findings, it was concluded that in order to reduce poverty rates in Mexico, economic growth needs to be strengthened.

Permadi A.Y (2018) examined whether Indonesia's economic growth performance between 2005 and 2013 was pro-poor or not using the Growth Incidence Curve (GIC) and Pro-Poor Growth Index (PPGI) methods. According to the test results, it was revealed that Indonesia's economic growth between 2005 and 2013 was not poverty-inducing.

Tridico (2018) analyzed the determinants of income inequality in selected 25 high-income OECD countries during the period of 1990-2013 using regression-correlation variation models. According to the test results, it was found that income inequality has been increasing rapidly in both developed and developing countries over the past 20 years.

Evcim et al. (2019) conducted a panel data analysis to examine the economic determinants of poverty in 7 MENA countries and Turkey during the period of 1990-2013. According to the test results, it was found that the most important factors in reducing poverty are women's labor force participation and economic growth.

Model, Dataset and Method

In this subsection, firstly, the selected countries from the group of developing countries and the econometric models to be used in the empirical analysis will be introduced. Then, the description of the dataset to be used in the study and the explanation of the applied analysis methods will be provided.

The countries included in the scope of the research from the groups of developing countries have been selected based on the World Bank's Atlas method. The countries are shown in the following Table 1.

Developing Countries							
Turkey	Brazil	Poland	Mexico	Argentina	Indonesia	China	Russia

Table 1: Groups of Developing Countries

Source: Developing countries were selected according to the World Bank's Atlas method.

Nine (N=9) countries have been selected in the group of developing countries, as shown in Table 1. The models used in the research are as follows.

Model 1

$$GINI = \beta_1 + GROW + \beta_2 POV + B_i X_c$$

In the first model, the dependent variable is *GINI*, measured as the Gini coefficient representing income inequality. The independent variables in this model are per capita GDP *GROW* as a measure of economic growth and the *POV* variable representing poverty. The control variables in this model are the Human Development Index (HDI), the Misery Index (MI), and the Democracy Index (DI). The term $B_i X_c$ in the model represents the control variable.

Model 2

$$POV = \beta_1 + GROW + \beta_2 GINI + B_i X_c$$

In the second model, the dependent variable is *POV*, measured as the poverty index representing poverty as defined in the first model. The independent variables in this model are *GROW* for economic growth and *GINI* for income inequality, as defined in the first model. The control variables in this model are the Human Development Index (HDI), the Misery Index (MI), and the Democracy Index (DI). The term $B_i X_c$ in the model represents the control variable.

Model 3

$$GROW = \beta_1 + GINI + \beta_2 POV + B_i X_c$$

In the third model, the dependent variable is *GROW*, representing economic growth, and the independent variables are *GINI* and *POV*. The control variables in this model are again the Human Development Index (HDI), the Misery Index (MI), and the Democracy Index (DI). The term $B_i X_c$ in the model represents the control variable.

The variables used in the study and their sources are presented in Table 2.

Variables	Explanation	Source
GINI	Gini Coefficient	World Bank
		(Standardized World Income Inequality Database-SWIID)
GROW	Per capita Income	(World Bank)
POV	It represents the percentage of individuals in a country who earn \$3.20 per day at Purchasing Power Parity, relative to the total population.	United Nations Development Program (UNDP)
HDI	Human Development Index (HDI)	United Nations Development Program (UNDP)
MI	Arthur Okun's Misery Index (Inflation+Unemployment)	(World Bank)
DI	Democracy Index	The Economist Intelligence Unit (EIU)

Table 2. Variables and Sources

Source: The dependent and independent variables above were chosen by the authors according to the literature on income distribution, poverty and economics.

In the 1st Model, where the Gini coefficient is the dependent variable, the independent variables are GROW and POV, and the control variables are the Human Development Index (HDI), Misery Index (MI), and Democracy Index (DI). In the 2nd Model, where POV is the dependent variable, the independent variables are Gini and GROW, and the control variables are HDI, MI, and DI. In the 3rd Model, where GROW is the dependent variable, the independent variables are Gini and POV, and the control variables are HDI, MI, and DI. In the study, variables that are not stationary at their own levels but become stationary when taking the first difference are denoted by the letter D.

The test statistics and their significance levels are provided in the evaluation of the empirical analysis findings. The significance levels for the test results are set at 1%, 5%, and 10%. R-Project software was used for the analysis (Croissant ve Millo, 2018: 1-43; Zeileis and Hothorn, 2002: 7-10).

During the analysis of the thesis, E-Views, STATA 13, and R-Project econometric and statistical software programs were utilized. In this context, the descriptive statistics of the variables were presented in the initial stage of the econometric analysis. Since the panel data structure is $T > N$, the presence of cross-sectional dependence in the established models and research variables was assessed using the Lagrange-Multiplier (LM) test developed by Breusch and Pagan (1980). To test the stationarity of the variables under cross-sectional dependence, the CIPS method, which is a second-generation unit root test, was employed (De Hoyos and Sarafidis, 2006: 482; Pesaran, 2007: 265-312).

Cross-sectional independence assumes that the impact of a shock affecting any unit within the panel is the same for all countries, and that the occurrence of a macroeconomic shock in one country does not affect the other countries in the panel. Therefore, the cross-sectional

dependence and stationarity levels of the variables in the country groups included in the panel have been examined. If variables that have been found to have unit roots at their own levels become stationary when their first differences are taken, panel cointegration tests can be applied to examine long-term relationships. According to our findings, there is cross-sectional dependence among the units. Therefore, the variables have been made stationary by taking their first differences (Şahbaz et al., 2014: 53).

In practice, in cases where there is cross-sectional dependence, autocorrelation, or heteroscedasticity, the robust Driscoll-Kraay (2008) covariance estimators were used to estimate the panel regression model in the final stage (Hoechle, 2007: 281-312).

During the construction of panel regression analysis models, selection was made among pooled least squares (PLS), random effects, and fixed effects types. These selections were performed using F-test, Breusch-Pagan LM test, and Hausman test. After conducting tests for the selection of the type of effects, the presence of heteroscedasticity and autocorrelation problems among variables was examined. In the panel regression analysis stage, the Breusch-Pagan (BP) test was used to test for heteroscedasticity, and the Breusch-Godfrey (BG) test was used to test for autocorrelation (Torres-Reyna, 2010: 1-28).

Based on these findings, the Durbin-Hausman (2008) cointegration test was conducted to determine the long-term relationship among variables. In the Durbin-H method by Westerlund (2008), the presence of cointegration relationship is tested separately for group and panel dimensions. The Westerlund (2008) Durbin-H group test allows for variations in autoregressive parameters across cross-sections. Rejecting the null hypothesis in this test indicates the presence of cointegration relationship at least for some cross-sections (Di Iorio and Fachin, 2008: 1-8).

In the final part of the empirical analysis, the causal relationships among variables were examined. For this purpose, the Dumitrescu and Hurlin (2012) panel causality test, which can be applied to heterogeneous panels, was employed.

3.1 Tests, Findings, and Discussion of the Models

In this subsection, panel data graphs for variables in each model, descriptive statistics for the models and variables, tests for cross-sectional dependence, CIPS and stationarity tests, F-test, Breusch-Pagan LM test, and Hausman test, Autocorrelation and Heteroskedasticity, Panel Regression Results, Durbin-Hausman Cointegration Test, and Dumitrescu-Hurlin Causality Test will be conducted for each model in sequence. Subsequently, the obtained findings regarding the models will be discussed.

3.1.1 Panel data plots for variables

The panel data plots of the variables used in the models are shown in Figure 3 below.

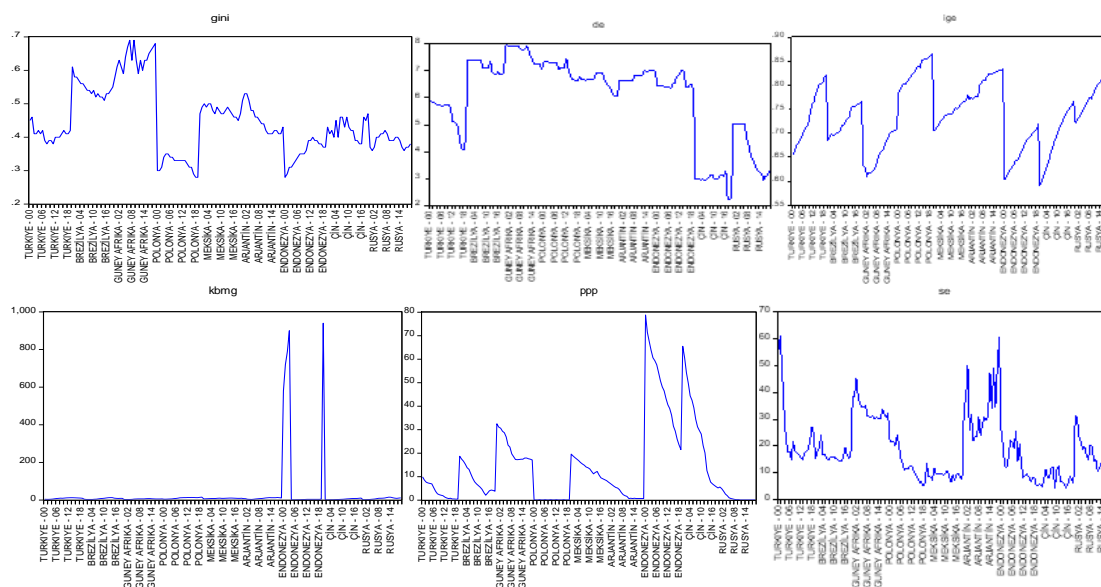


Figure 3. Panel Data Plots for Dependent and Independent Variables Used in the Models

3.1.2 Descriptive statistics for variables

The table below presents descriptive statistics for the relevant variables in developing countries.

In Table 3, descriptive statistics for variables in developing countries are presented. The first column of the table displays the means of the variables.

Variable	Mean	SD	Min	Max	Skew	Kurt.
Gini	0.450	0.100	0.280	0.690	0.640	-0.230
GROW	29.050	130.160	1.000	940.000	5.930	34.150
POV	14.230	17.500	0.100	78.800	1.600	1.970
HDI	0.740	0.070	0.590	0.860	-0.140	-0.890
MI	19.210	11.740	4.490	61.300	1.200	1.290
DI	6.020	1.560	2.260	7.940	-0.990	-0.330

Table 3: Descriptive Statistics for Variables in Developing Countries

Mean: Average, SD: Standart deviation, Min: Minimum, Max: Maximum, Skew: Skewness, Kurt: Kurtosis

3.1.3 Cross-section dependence results

The table below presents the results of the LM test for cross-section dependence of variables in developing countries.

Table 4 displays the results of the LM test for cross-section dependence among variables in developing countries. The hypotheses of this test are as follows:

H₀: There is no cross-section dependence among variables.

H₁: There is cross-section dependence among variables.

	LM Test	Probability Value *
Gini	1496.900	0.000***
GROW	1010.600	0.000***
HDI	1559.400	0.000***
MI	1077.300	0.000***
DI	1583.500	0.000***
POV	1495.300	0.000***

Note: *p<0.10, **p<0.05, ***p<0.01

Table 4: Cross-Section Dependence Test Results for Developing Countries

According to the test results presented in Table 4, when examining the data for variables in the group of developing countries, the probability values of the panel dependence tests are less than 0.001. Therefore, the null hypothesis "There is no cross-sectional dependence among the variables" is rejected, and the alternative hypothesis "There is cross-sectional dependence among the variables" is accepted. Since there is cross-sectional dependence in the research data, the CIPS test, which is a second-generation unit root test under cross-sectional dependence, has been used in the stationarity stage.

3.1.4 CIPS unit root and stationarity test results

The table below presents the results of the CIPS test and stationary analysis for the variables in developing countries.

Variables	CIPS Test (Level)				CIPS Test (First Difference)			
	Constant	Probability Value*	Constant+Trend	Probability Value*	Constant	Probability Value*	Constant+Trend	Probability Value*
Gini	-2.926	0.000***	-2.306	0.288	-4.261	0.000***	-4.663	0.000***
GROW	-3.907	0.000***	-3.085	0.038**	-3.392	0.000***	-2.888	0.081*
HDI	-2.467	0.026**	-2.397	0.321	-3.538	0.000***	-3.777	0.000***
MI	-2.730	0.000***	-3.793	0.000***	-5.060	0.000***	-4.890	0.000***
DI	-1.756	0.336	-2.262	0.477	-3.166	0.000***	-3.317	0.028**
POV	-1.514	0.369	-2.676	0.293	-3.544	0.000***	-3.228	0.000***

Note: *p<0.10, **p<0.05, ***p<0.01

Table 5: Results of Stationarity Analysis using CIPS Test for Developing Countries

The results of the stationary analysis for variables related to developing countries are presented in Table 5. From the table, it can be understood that the variables GROW and MI are stationary at their own levels, while the variables Gini and HDI are stationary according to the model that includes a constant term but not according to the model that includes both a constant and a trend term. On the other hand, the other variables are not stationary at their own levels. After taking the first differences of the non-stationary variables, it is observed that they become stationary according to both the model with a constant term and the model with both a constant and a trend term. Based on these findings, the variables GROW and MI are left at their own levels, while the first differences of the other variables are taken for further analysis.

3.1.5 Panel regression test results

Table 6 shows the results of the panel regression application to reveal the effect of the factors affecting the Gini coefficient chosen as the dependent variable. The hypotheses of this test are as follows:

H₀: The variable DGROW has no effect on DGini.

H₁: The variable DGROW has a significant effect on DGini in the same direction.

H₀: The variable DHDI has no effect on DGini.

H₁: The variable DHDI has a significant negative effect on DGini.

H₀: The variable DDI has no effect on DGini.

H₁: The variable DDI has a significant negative effect on DGini.

Variable	Coefficient	z-statistic	Probability Value*
GROW	1.1185	4.649	0.000***
DPOV	-3.05E-04	-0.916	0.492
DHDI	-0.361	-1.466	0.000***
MI	4.61E-05	0.635	0.430
DDI	-0.547	-1.242	0.000***
R2	0.029		
RSS	0.062		
TRSS	0.064		

Note: *p<0.10, **p<0.05, ***p<0.01, RSS: Error sum of squares, TRSS: Overall error sum of squares, R2: Determination coefficient

Table 6: Panel Regression Statistics for Factors Influencing the DGini Variable in Developing Countries

When examining the regression results in Table 6, it can be observed that the variables GROW, DHDI, and DDI significantly affect the Gini coefficient. The p-value for the coefficient of the GROW variable is less than 0.001, and since the GROW regression coefficient is positive, the null hypothesis H_0 , stating no effect of GROW on the Gini coefficient, is rejected in favor of the alternative hypothesis H_1 , which states that "GROW variable has a positive effect on the Gini coefficient." Similarly, the p-values for the coefficients of the DHDI and DDI variables are less than 0.001, and since the regression coefficients of DHDI and DDI are negative, the null hypothesis H_0 , stating no effect of DHDI and DDI on the Gini coefficient, is rejected in favor of the alternative hypotheses stating that "DHDI and DDI variables have a negative effect on the Gini coefficient." Accordingly, an increase of one unit in the DHDI and DDI variables leads to a decrease of 0.361 and 0.547 units, respectively, in the Gini coefficient, while an increase of one unit in the GROW variable increases income inequality by 1.1185 units. On the other hand, the variables DPOV and MI don't significantly affect the Gini coefficient. From these findings, it can be concluded that in developing countries, an increase in the Human Development Index and Democracy Index is associated with a decrease in the Gini coefficient, and an increase in per capita income serves as a driving force in reducing income inequality.

Tablo 7 displays the panel regression results that reveal the factors influencing the dependent variable DPOV. The hypotheses for this test are as follows:

H_0 : The variable DGROW has no effect on DPOV.

H_1 : The variable DGROW has a negative effect on DPOV.

H_0 : The variable DDI has no effect on DPOV.

H_1 : The variable DDI has a negative effect on DPOV.

Variable	Coefficient	z-statistic	Probability Value*
GROW	-1.674	-8.408	0.000***
DGini	-1.465	-0.832	0.402
DHDI	-67.388	-1.586	0.205
MI	0.021	1.098	0.299
DDI	-1.190	-2.476	0.000***
R2	0.203		
RSS	296.240		
TRSS	371.890		

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, RSS: Error sum of squares, TRSS: Overall error sum of squares, R2: Determination coefficient

Tablo 7: Panel Regression Results for Factors Influencing DPOV Variable in Developing Countries

According to the panel regression results in Table 7, the probability values of the coefficients are less than 0.001, indicating that the GROW and DDI variables significantly affect the DPOV variable. Therefore, the null hypotheses H_0 , stating that there is no effect of

GROW and DDI variables on DPOV, are rejected, and the alternative hypotheses H_1 , stating that GROW and DDI variables have a negative effect on DPOV, are accepted. The regression coefficients of GROW and DDI variables are negative, indicating an inverse relationship between them and the DPOV variable. Based on these findings, an increase of one unit in the GROW variable leads to a decrease of approximately -1.674 units in the DPOV variable. Similarly, an increase of one unit in the DDI variable results in a decrease of approximately 1.190 units in the DPOV variable. On the other hand, it is observed that DGini, DHDI, and MI variables do not significantly affect the DPOV variable. In light of this information, it can be concluded that in developing countries, an increase in the democracy index is associated with a reduction in poverty, and increases in per capita income act as a driving force in reducing poverty.

Tablo 8, the panel regression results aiming to reveal the effects of factors on the coefficient of DGROW, which is selected as the dependent variable. The hypotheses of this test are as follows:

H_0 : The DDI variable has no effect on DGROW

H_1 : The DDI variable has a positive effect on DGROW

H_0 : The DMI variable has no effect on DGROW

H_1 : The DMI variable has a negative effect on DGROW

Variable	Coefficient	z-statistic	Probability Value*
DGini	302.035	1.292	0.233
DPOV	-24.386	-1.626	0.198
DHDI	-1253.721	-1.206	0.304
MI	-0.644	0.183	0.000***
DDI	1.248	-2.165	0.000***
R2	0.113		
RSS	1.67E+06		
TRSS	1.89E+06		

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, RSS: Error sum of squares, TRSS: Overall error sum of squares, R2: Determination coefficient

Tablo 8: Panel Regression Results for Factors Influencing GROW Variable in Developing Countries

When examining the panel regression results given in Table 8, it can be observed that the p-values of the coefficients for the DDI variable are less than 0.001. Therefore, the null hypotheses (H_0) are rejected, and the alternative hypotheses (H_1) "DDI variable has a positive effect on GROW" and "DMI variable has a negative effect on GROW" are accepted. Since the regression coefficient of the DDI variable is positive, it indicates a positive relationship with the GROW variable. On the other hand, the regression coefficient of the DMI variable is negative, indicating an inverse relationship with the GROW variable. Accordingly, a one-unit

increase in the DDI variable leads to an approximate increase of 1.248 units in the GROW variable, while a one-unit increase in the DMI variable results in a decrease of 0.644 units in the GROW variable. However, it is observed that the DGini, DPOV, and DHDI variables do not significantly influence the GROW outcome. In summary, in developing countries, an increase in democracy index is associated with an increase in per capita income, while an increase in the poverty index is associated with a decrease in per capita income.

3.1.6 Durbin-Hausman panel cointegration test

The Durbin-Hausman panel cointegration test was conducted to examine the presence of long-term relationships in the data of developed, developing, and low-income countries under both the assumption of homogeneity and heterogeneity. The results of the Durbin-Hausman panel cointegration test are presented in the tables below.

H_0 : There is no evidence of long-term relationship among the variables.

H_1 : There is evidence of a long-term relationship among the variables.

Test Statistic	T Statistic	Probability Value*
Durbin-H Group Statistic	9.781	0.000***
Durbin-H Panel Statistic	3.627	0.000***

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9. Durbin-Hausman Cointegration Test Results for Developing Countries

According to Table 9, the probability value of the Durbin-H Group and Panel statistic is less than 0.01 (specifically 0.000 and 0.000, respectively). Therefore, the null hypothesis H_0 , which states that there is no long-term relationship among the variables, is rejected, and the alternative hypothesis H_1 , which states that there is a long-term relationship among the variables, is accepted.

3.1.7 Dumitrescu-Hurlin nedensellik testi sonuçları

The table below presents the results of the Dumitrescu-Hurlin causality test to determine the presence of causal relationships between dependent and independent variables in developing countries.

The results of the Dumitrescu-Hurlin Panel Causality Test, conducted to determine the presence of causal relationships between variables, are shown in Table 10. The hypotheses for this test are as follows:

H_0 : There is no one-way causality between the variables.

H₁: There is a one-way causality relationship between the variables.

Hypothesis	W-bar Statistic	Z-bar Statistic	Probability Value *
DGROW \Rightarrow DGini	0.523	1.662	0.000***
DGini \Rightarrow DGROW	1.677	0.482	0.637
DPOV \Rightarrow DGini	0.421	0.588	0.935
DGini \Rightarrow DPOV	0.322	0.841	0.423
DHDI \Rightarrow DGini	1.451	-1.037	0.341
DGini \Rightarrow DHDI	0.689	-1.487	0.000***
MI \Rightarrow DGini	2.226	2.601	0.000***
DGini \Rightarrow MI	1.698	0.448	0.589
DDI \Rightarrow DGini	0.574	-0.903	0.482
DGini \Rightarrow DDI	0.637	-1.224	0.782

Note: *p<0.10, **p<0.05, ***p<0.01

Table 11: Dumitrescu-Hurlin Panel Causality Test Results for Variables Used in Models in Developing Countries

Table 11 presents the results of the Dumitrescu-Hurlin panel causality test for the variable DGini as the dependent variable in developing countries. The results of the Dumitrescu-Hurlin panel causality test show that the probability values for the statistics of the variables GROW, DHDI, and MI are less than 0.001 (0.000, 0.000, 0.000) Therefore, the null hypothesis H₀, which states that there is no one-way causality relationship between the variables, is rejected, and the alternative hypothesis H₁, which states that there is a one-way causality relationship between the variables, is accepted. The presence of a one-way causality relationship is found from DGini to DHDI, from DGini to DGROW, and from DGini to MI. However, no causality relationship is found between the variable DGini and DDI or DPOV.

Table 12 presents the results of the Dumitrescu-Hurlin causality test to determine the presence of causal relationships among the relevant variables. The hypotheses for this test are as follows:

H₀: There is no bidirectional causality relationship between the variables.

H₁: There is a bidirectional causality relationship between the variables.

Hypothesis	W-bar Statistic	Z-bar Statistic	Probability Value *
DGROW \Rightarrow DPOV	0.367	1.387	0.000***
DPOV \Rightarrow DGROW	0.352	1.678	0.000***
DGini \Rightarrow DPOV	1.387	0.642	0.852
DPOV \Rightarrow DGini	2.369	1.023	0.565
DHDI \Rightarrow DPOV	0.982	1.040	0.000***
DPOV \Rightarrow DHDI	1.973	0.298	0.000***
MI \Rightarrow DPOV	2.156	0.234	0.722
DPOV \Rightarrow MI	1.973	-0.040	0.832
DDI \Rightarrow DPOV	2.499	0.749	0.560
DPOV \Rightarrow DDI	1.973	-0.040	0.832

Note: *p<0.10, **p<0.05, ***p<0.01

Table 12: Dumitrescu-Hurlin Panel Causality Test Results for Variables Used in Models in Developing Countries

Table 12 presents the results of the Dumitrescu-Hurlin panel causality test for the variable DPOV as the dependent variable in developing countries. The results of the Dumitrescu-Hurlin panel causality test show that the probability values for the variables DGROW and DHDI are less than 0.001 (0.000, 0.000), indicating that the null hypothesis H_0 , which states that there is no bidirectional causality relationship between the variables, is rejected. Therefore, the alternative hypothesis H_1 , which states that there is a bidirectional causality relationship between the variables, is accepted. The presence of a bidirectional causality relationship is found from DGROW and DHDI to DPOV, as well as from DPOV to DGROW and DHDI. However, no causality relationship is found between the variables MI, DDI, and DGini with DPOV.

Tablo 13. Dumitrescu-Hurlin Test Results for Determining Causality Relationship Among Variables.

H_0 : There is no one-way causality relationship between the variables.

H_1 : There is a one-way causality relationship between the variables.

Hypothesis	W-bar Statistic	Z-bar Statistic	Probability Value *
DGini \nrightarrow GROW	2.888	1.368	0.577
GROW \nrightarrow DGini	1.689	0.632	0.882
DPOV \nrightarrow GRPW	0.367	0.547	0.985
GROW \nrightarrow DPOV	0.741	0.884	0.544
DHDI \nrightarrow GROW	7.345	3.548	0.000***
GROW \nrightarrow DHDI	1.398	0.897	0.539
MI \nrightarrow GROW	4.680	4.021	0.000***
GROW \nrightarrow MI	0.691	2.698	0.233
DDI \nrightarrow GROW	8.702	4.987	0.000***
GROW \nrightarrow DDI	2.377	0.398	0.891

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 13. Dumitrescu-Hurlin Panel Causality Test Results for Selected Variables in Developing Countries

Table 13 presents the results of the Dumitrescu-Hurlin panel causality test for developing countries, with GROW variable as the dependent variable. According to the test results, the probabilities for DHDI, MI, and DDI variables are smaller than 0.001 (0.000, 0.000, 0.000), leading to the rejection of the null hypothesis (H_0) and acceptance of the alternative hypothesis (H_1) that there is evidence of a causality relationship between the variables. Specifically, a one-way causality relationship is observed from DHDI to GROW, from MI to GROW, and from DDI to GROW. However, no causality relationship is found between DGini and DPOV variables with DGROW variable.

Conclusion and Recommendations

Throughout history, humanity has faced the problem of inequality and poverty. This issue has been one of the fundamental macroeconomic topics in the field of economics and has consistently attracted the attention of economists. Income inequality enriches those who receive a larger share of the national income while further impoverishing those who receive less. This problem particularly affects developing countries. In recent years, income inequality and poverty have become significant and deepening issues in developing countries.

In this study, which examines the relationship between income inequality, poverty, and economic growth in developing countries selected according to the World Bank's Atlas method, the panel regression test results applied indicate that in the 1st Model where Gini is the dependent variable, increases in per capita national income lead to an increase in income inequality. This result supports Kuznets' Inverted-U hypothesis, which is the first study examining the relationship between income inequality and economic growth in the economic literature. It is found that the democracy index reduces income inequality in developing countries, while the Human Development Index also reduces income inequality. On the other hand, it is concluded that if developing countries establish a solid legal system based on law and democracy, income inequality will decrease.

In the 2nd Model, where poverty is the dependent variable, it is found that democracy and increases in per capita national income reduce the level of poverty. In short, increases in democracy and per capita national income play an important role in reducing poverty.

In the 3rd Model, where per capita national income is the dependent variable, it is found that the misery index reduces per capita national income, while increases in the democracy index increase per capita national income. Developing countries will increase their per capita national income if they reduce inflation and unemployment, which are components of the misery index. Additionally, possible increases in the democracy index will also increase per capita national income.

According to the results of the Durbin-Hausman Cointegration test conducted to reveal the presence of a long-term relationship between variables in developing countries, the existence of a long-term cointegration relationship between dependent and independent variables has been detected.

Furthermore, according to the results of the Dumitrescu Hurlin causality test, in Model 1, Model 2, and Model 3, where the dependent variables are Gini, GROW, and POV, bidirectional causality relationships have been identified between the dependent and independent variables.

In light of these findings, developing countries should implement policies that reduce inflation and unemployment in order to decrease income inequality and poverty. Additionally, developing countries should strive to establish a strong and transparent legal system based on solid principles, uphold the rule of law and democracy, and implement these principles in all institutions without compromise. This will promote justice and legal order in various aspects, ultimately reducing income inequality and poverty.

Furthermore, potential increases in per capita income and improvements in the human development index will also contribute to the reduction of poverty and income inequality. On the other hand, to alleviate poverty, it is necessary to reduce inflation and unemployment, which are components of the poverty index. To increase per capita income, efforts should focus on reducing the poverty index and developing policies that enhance the human development index.

Potential increases in the human development index and the implementation of policies that combat inflation and unemployment through public measures will help reduce the level of poverty.

The findings of this study, which examines the theoretical and empirical relationship between income inequality, poverty, and economic growth in developing countries, are consistent with and similar to the results of previous research conducted by Blank and Card (1993), Persson and Tabellini (1994), Clarke (1995), Partridge (1997), Bruno et al. (1998), Li et al. (2000), Banerjee and Duflo (2003), Ravallion (2004), Kraay (2006), Lonnie and David (2008), Martins-Bekat and Kulkarni (2009), Lin et al. (2009), Malinen (2012), Ravallion (2012), Ncube et al. (2013), Cingano (2014), Akinci and Akinci (2016), Yang and Greaney (2017), Serven and Marrero (2018), Permadi A.Y (2018), Tridico (2018), and Evcim et al. (2019). These studies have provided supporting evidence and similar findings regarding the relationship between income inequality, poverty, and economic growth in developing countries.

References

- Alfranca, O. and Galindo, M. A. (2003). Public Expenditure, Income Distribution, and Growth in OECD Countries. *International Advances in Economic Research*, 9(2), 133-139.
- Atkinson, A. B. & F. Bourguignon (2000). *Introduction: Income Distribution and Economics, Handbook of Income Distribution*. Eds. A. B. Atkinson & F. Bourguignon, Amsterdam, Elviesier.
- Bourguignon, F. and Morrison, C. (1999). The Size Distribution of Income Among World Citizens: 1820-1990, *Worldbank Papers*, 13243, 1-36.
- Bourguignon, F. (2003). The Poverty, Growth, Inequality Triangle Conference on Poverty, Inequality and Growth, *EU Development Network*.

- Bourguignon, F. (2004). The Poverty-Growth-Inequality Triangle. *The World Bank Policy Research Working Paper*, 28102.
- Croissant, Y and Millo, G. (2008). Panel Data Econometrics in R: The Plm Package. *Journal of Statistical Software*, 27(2), 1-43.
- De Hoyos, R. E. and Sarafidis, V. (2006). Testing for Cross-Sectional Dependence in Panel-Data Models. *Stata Journal*, 6(4), 482.
- Di Iorio, F. and Fachin, S. (2008), A Note on the Estimation of Long-run Relationships in Dependent Cointegrated Panels. *Munich Personal RePEc Archive (MPRA) 12053, University Library of Munich*, 1-8.
- Gallo, C. (2002). Economic Growth and Income Inequality: Theoretical Background And Empirical Evidence. *Development Planning Unit University of College London Working Paper 119*, 1-34.
- Hoechle, D. (2007). Robust Standard Errors for Panel Regressions with Cross-Sectional Dependence. *The Stata Journal*, 7(3), 281-312.
- Kuznets, S. (1955). Economic Growth And Income Inequality. *The American Economic Review*, 45 (1), 1-28.
- Ocampo, J. and Martin, A. J. (2003). Globalization and Development: A Latin American and Caribbean Perspective. *Stanford, CA: Stanford University Press*. DOI:10.1596/0-8213-5501-5
- Pesaran, M. H. (2007). A Simple Panel Unit Root Test in The Presence of CrossSection Dependence. *Journal of Applied Econometrics*, 22(2), 265-312.
- Piketty, T. (2015). *Capital in the Twenty-First Century* (Translated by Hande Koçak) (2nd Edition). Istanbul: Türkiye İş Bankası Kültür Yayınları.
- Şahbaz, A., Yanar, R., and Adıgüzel, U. (2014). The Relationship between R&D Expenditures and High-Technology Goods Exports: Panel Causality Analysis. *Çukurova University Journal of Social Sciences Institute*, 23(1), 47-60.
- Torres-Reyna, O. (2010). Getting Started in Fixed/Random Effects Models Using R/Studio *Statistical Services Princeton University*, 1-28.
- The Economist Intelligence Unit (EIU). <https://www.eiu.com> (Democracy Index)
- The World Bank Indicator (WB). <https://data.worldbank.org/indicator> (Economic Growth Data).
- United Nations Development Programme (UNDP). <http://hdr.undp.org/en/indicators> (Work poor (% of total employment) at PPP \$3.20 per day. (Poverty Data)
- United Nations Development Programme (UNDP). <http://hdr.undp.org/en/data> (Human Development Index)
- World Bank Indicator (WB). <https://data.worldbank.org/indicator> ([Arthur Okun's Misery Index was calculated mathematically by the author by taking the ratio of inflation and unemployment data taken from the World Bank Indicator Database](#))

World Bank Atlas Method. <https://datahelpdesk.worldbank.org/knowledgebase/articles/378832-what-is-the-world-bank-atlas-method>

Zeileis, A. and Hothorn, T. (2002). Diagnostic Checking in Regression Relationships. *R News* 2(3), 7-10. <https://CRAN.R-project.org/doc/Rnews/>

Submetido em: 28.08.2023

Aceito em: 27.09.2023