Received: 16 December 2024 | Revised: 13 May 2025 | Accepted: 22 May 2025 | Published online: 17 June 2025

RESEARCH ARTICLE

Journal of Comprehensive Business Administration Research
2025, Vol. 00(00) 1–17
DOI: 10.47852/bonviewJCBAR52025028

BON VIEW PUBLISHING

Kuznets Revisited: An Econometric Exploration of Growth and Inequality Across 39 Economies

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Abstract: Using World Bank panel data and Kuznets' theory, this study examines the connection between economic growth and income inequality in 39 nations between 2004 and 2019. Three econometric models are used in the analysis: fixed effects, quadratic regression, and linear regression. The results show a complex and nonlinear relationship. In the overall sample, the linear model reveals a weak but significant positive correlation between gross domestic product and inequality; in lower-middle-income countries, however, the relationship is strongly negative, suggesting that economic growth can mitigate inequality. A U-shaped dynamic, in which inequality initially decreases with growth before increasing once more above a threshold country income level (281.8 billion USD), is confirmed by the quadratic and fixed effects models. This study is significant because it takes a modern, disaggregated approach that improves "Kuznets" theory in the context of globalization and provides valuable policy insights. It highlights the need for development-stage-specific measures—such as progressive taxation, equitable access to education, and rural investment—to ensure that growth leads to inclusive and sustainable outcomes, particularly in lower-middle-income countries.

Keywords: economic development, income inequalities, GDP, Gini, Kuznets theory, econometric analysis, fixed effect model

1. Introduction

The nexus between economic growth and income inequality constitutes a persistent enigma in economic discourse. Existing studies, across diverse methodological and temporal frameworks, often yield contradictory findings. Anchored in Kuznets' [1] seminal hypothesis, this study applies empirical analysis to a sample of 39 economies, exploring how economic expansion reshapes the stratification of income and socioeconomic equilibrium. Understanding this interplay between gross domestic product (GDP) and inequality is crucial for designing policies that foster inclusive development and social justice.

GDP represents the total value of goods and services produced within a nation over a specific period. It is a standard metric for tracking economic performance over time and between regions [2]. The GDP (constant LCU) index used in this study reflects the sum of gross value added by resident producers, adjusted for taxes and subsidies. However, GDP alone does not account for wealth distribution or individual well-being [3].

Economic inequality, typically measured by the Gini index, assesses income distribution disparities. A Gini score of zero reflects perfect equality, whereas a score of 100 indicates extreme inequality [4]. Notably, income inequality rose globally during the latter 20th century but has stabilized or declined in some regions post-2000 due to factors like globalization, labor markets, and state policies [5].

The relationship between economic growth and inequality is complex. Some argue that growth reduces inequality by creating jobs and opportunities, benefiting all societal segments, particularly the poorest [6]. Others suggest growth exacerbates inequality by favoring the wealthy [7]. A third perspective posits no inherent correlation between the two variables [8].

Historically, income inequality increased as some countries developed faster than others. However, since 2000, many developing countries have experienced higher growth rates, reducing global income inequality. This shift is attributed to demographic changes, improved institutions, and increased human capital in developing nations [9]. Kavya and Shijin [10] support that there is no clear evidence to support the proposition that economic development and financial growth together reduce income inequality, and most advanced high-income countries do not benefit from financial development.

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Additionally, geographic considerations can affect inequality measures, as regional patterns differ from national aggregates [11]. According to Panzera and Postiglione [12], the anonymity condition suggests that traditional inequality indices are invariant to offsets; that is, very different spatial patterns can lead to the same inequality index.

The originality of this study lies in its disaggregated and multidimensional econometric approach, analyzing the dynamics between growth and inequality across heterogeneous income groups, following the World Bank classification. This study provides a modern investigation of inequality dynamics by focusing on a large dataset and a recent time period (2004–2019) from 39 economies. In order to capture latent country-specific heterogeneity and validate the polymorphic and context-dependent structure of the growth–inequality nexus, it uses linear regression, quadratic regression, and a fixed effects model. This study validates the descending phase of Kuznets' hypothesis by showing that, in contrast to previous research, GDP growth can significantly reduce disparities in lower-middle-income countries while potentially exacerbating inequality in higher-income contexts. These findings underscore the imperative for differentiated, context-sensitive policy architectures to ensure that economic expansion fosters inclusive and sustainable development.

The findings contribute significantly to economics and policymaking by validating Kuznets' hypothesis in modern contexts and identifying the potential for targeted social welfare and fiscal policies to balance growth and inequality. This evidence serves as a crucial resource for policymakers addressing income disparities.

1.1. Research question and hypotheses

This study investigates the core question: "How does economic growth affect the level of income inequality?" Drawing on existing literature, the research examines several hypotheses to explore the relationship between GDP and income inequality:

H0: Income inequality is not affected by GDP, indicating no relationship between economic growth and income distribution.

H1: GDP influences income inequality, which may increase or decrease depending on the societal context.

H2: Economic growth positively affects income inequality, consistent with the first phase of the Kuznets curve, where growth leads to a widening income gap.

H3: Economic growth is negatively associated with income inequality, consistent with the second phase of the Kuznets inverted-U curve, during which continued development leads to a gradual decline in inequality.

H4: In lower-middle-income countries, economic growth is negatively associated with income inequality, reflecting the descending segment of the Kuznets inverted-U curve, wherein continued economic development leads to a reduction in inequality as structural transformation and redistributive mechanisms take effect.

Existing studies on GDP and inequality often exhibit conceptual fragmentation, frequently overlooking income group heterogeneity or obscuring the direct nexus between growth and inequality within a multitude of control variables. Addressing these lacunae, this study provides an updated and parsimonious analysis of 39 countries (2004–2019), isolating GDP and Gini as the core variables. It elucidates how growth affects inequality asymmetrically across income strata—validating Kuznets' hypothesis within a contemporary, globalized framework—and offers granular insights for income-specific policy design.

The research is structured as follows: in Chapter 2, the literature review is presented. Then, the methodological framework of the research and the results are presented in Chapter 3; Chapter 4 discusses the results. Finally, Chapter 5 presents the conclusions and lists policy recommendations, suggestions for future research, and the limitations of the research.

2. Literature Review

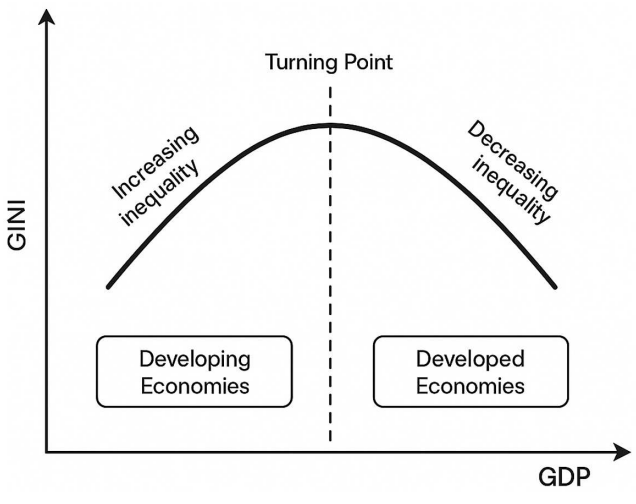
This study is grounded on recent literature, with over 60% of references published between 2020 and 2025. This contemporary focus ensures analytical relevance and reflects current developments in the inequality-growth debate. Classic works, such as Kuznets [1] and Piketty [13], are retained for theoretical consistency.

There have been many studies linking economic growth to the emergence of income inequality. One of the first studies on the relationship between economic growth and inequality was presented by Kuznets [1], who described that there is an inverted U-shaped relationship between economic growth and income inequality, concluding that as economies grow, inequality first increases and then begins to decline. Kuznets was surprised by these findings, noting that *"Long-term stability, let alone a reduction in inequality... is a puzzle"* [14].

This quotation from Kuznets emphasizes the difficulty and complexities involved in managing social justice and economic development. Kuznets voiced his concern about how social and economic forces can be balanced to lessen inequality and preserve economic stability. His use of the word "puzzles" emphasizes how difficult and complicated it is to accomplish these objectives. Economic growth initiatives frequently result in increased inequality; reversing this trend calls for careful planning, social reforms, and perhaps adjustments to how opportunities and resources are distributed. Reducing inequality and attaining long-term stability are difficult tasks that frequently encounter obstacles and contradictions, as Kuznets acknowledged.

Figure 1 illustrates the conceptual scheme of the Kuznets curve, where the x-axis denotes economic growth (GDP) and the y-axis denotes income inequality (Gini coefficient). Despite its initial prominence, the Kuznets hypothesis has attracted critique regarding its empirical validity and applicability across diverse socioeconomic contexts. Evidence remains inconclusive, particularly in advanced economies where inequality often persists or intensifies despite growth. Scholars such as Glomm [15] argue that the original

Figure 1
Kuznets curve



framework inadequately captures contemporary dynamics shaped by automation, globalization, and structural shifts beyond industrialization. Nonetheless, the Kuznets curve retains heuristic value, offering a conceptual archetype for exploring the evolving nexus between growth and inequality.

Research by Lin et al. [16] on a large sample of countries concludes that income inequality first increases and then decreases with economic growth, supporting Kuznets' hypothesis. The Kuznets hypothesis is robustly verified using modern data, with inequality following a sinusoid form rather than a concave curve, and world trade has a significant impact on inequality [17]. The inverted U-shaped Kuznets curve of economic development and income inequality is confirmed in the context of the Asian continent [18]. Alamanda's [19] research finds that economic growth has a significant positive impact on income inequality, meaning that the higher the economic growth, the larger the gap between the rich and the poor. As for the US economy, a recent study showed that the share of wealth held by the top 1%increased from just under 30% in 1989 to almost 39% in 2016 [20].

Greece, which got the biggest bailout package in the world during the sovereign debt crisis, is a unique case in contemporary economic history. Income and wealth disparity increased despite significant financial assistance and adjustment initiatives, especially after 2009. Fasianos and Tsoukalis [21] demonstrate that real assets were the primary driver of the notable increase in wealth inequality. Karountzos et al. [22] found that unemployment during austerity exacerbated the strong positive correlation between GDP growth and inequality. Furthermore, Kotsios [23] exposed substantial tax distortions that disproportionately affect lower-income groups. These results challenge the Kuznets hypothesis and emphasize the crucial role of labor market conditions and fiscal policy by showing that growth without efficient redistribution mechanisms fuels inequality.

Dorofeev [24] concludes that the level of income inequality determines the direction of its effect on economic growth. Increasing income inequality in countries with low levels of inequality in most cases enhances economic growth, and the reverse is also true. Also, the correlation between economic growth and income inequality is certainly more negative for countries with low per capita income and more positive in countries with high per capita income. In a study conducted by Soava et al. [25] for the European Union (EU), two trends appear between the developed and less developed regions of the Union: in the less developed EU countries, income inequality has an increasing trend with positive economic growth, while in the highly developed EU countries, the situation appears completely opposite, as economic growth leads to a decrease in income inequality. According to the research of Jianu et al. [26], income inequality positively impacts economic growth in developed EU member states, while it hinders growth in developing EU countries, highlighting the need for an optimal level of income inequality.

Beyond structural factors, economic policies—particularly taxation and investment—play a critical role in shaping income distribution. Recent literature suggests that income inequality is not only a consequence of growth but may also act as a constraint on it. High inequality can undermine GDP growth by fostering social instability, eroding trust in institutions, and limiting human capital development, thereby affecting long-term economic performance [27]. Economic growth remains the main driver of nations' prosperity and the sustainability of their political systems. However, nations' growth trajectories face unexpected challenges in the wake of the recent COVID-19 pandemic. This calls for a re-examination of the determinants of economic development, particularly with regard to the factors associated with the current situation [28].

Leightner and Zhang [29] claim that the use of tax policy to compensate for social inequality promotes economic growth (GDP). Indeed, they point out that the best taxes to increase GDP are corporate and property taxes, while the best taxes to decrease GDP are sales and personal income taxes. According to Wan's [30] findings, income inequality decreases as the age of the population, gross savings rate, and tax revenue ratio increase, while income inequality increases as the poverty rate, level of advanced education, and GDP per capita increase.

Another parameter that needs to be investigated is the degree of financialization of the economy. Financialization is the shift from allocation of capital to productive uses, which results in the transfer of wealth from others to finance manipulators, exacerbating income inequality of wealth [31]. Financialization has increased income inequality in Organisation for Economic Co-operation and Development countries, but the relationship is complex and requires further research [32]. The study by Brei et al. [33] empirically examines the link between financial structure and income inequality, analyzing data from 97 countries for the period 1989–2012, and concludes that this relationship is not linear but has a bend as follows: increased finance reduces income inequality up to a point, but market-based finance increases it beyond that point, while bank lending does not.

Financialization increases income inequality by concentrating income between the rich and the wealthy, while also harming the middle class and the poor, with the incomes of the poor being more vulnerable to financialization [34]. According to Hyde et al. [35], in rich capitalist democracies, financialization exacerbates market- and state-mediated income inequality, while financial crises exacerbate redistribution.

Economic growth is a tool for measuring the development and progress of countries, while technological innovation is one of the factors affecting economic growth and contributing to the development and modernization of production methods. Therefore, technological innovation is the main driver of economic growth and human progress.

Higher gross domestic expenditure on research and development tends to increase income inequalities [36]. Spending on innovation, research and development, and investment in innovation supports competition and progress. Consequently, sustainable economic growth is achieved. This ensures the preservation of resources for future generations and the achievement of economic and social growth. In addition, a sustainable level of workforce education, investment in research, creation of new products, and investor access to markets for innovative products will be ensured through public and private sector development and improvement of people's living conditions.

Technological change and innovation can affect inequality and GDP through the creation or destruction of jobs, the restructuring of labor markets, and increased productivity. Innovation is positively correlated with top income inequality [37]. In a study conducted by Hausken and Moxnes [38] studying 127 countries on factors affecting innovation, they conclude that inequality (Gini) causes tensions and potentially disruptions that suppress innovation; thus, innovation is positively related to GDP per capita and negatively related to the Gini index.

Education and skills can affect both economic inequality and GDP by ensuring equal access to educational opportunities and the skills needed to participate in the labor market. In a study conducted by Czelleng and Losoncz [39], they conclude that rising inequality reduces the rate of GDP growth. The most effective tool for generating economic growth and stability is to improve education as education intensifies and promotes competition and enhances skills; therefore, income inequality can be mitigated, and social

mobility can be enhanced in a way that the two key drivers of capitalism—competition and innovation—are not weakened.

According to Tang and Wang [40], educational mismatch significantly affects income inequality among highly educated workers and suggest policy interventions aimed at improving the education match rate, signaling and reducing market frictions that potentially reduce wage inequality. For instance, income inequality in the USA is driven by the growth in labor earnings inequality, with education playing a significant role, while in large European economies, inequality is growing fast in Germany, Italy, and the UK, but not in France [41]. Highly educated individuals in unequal societies are more accepting of inequality than less educated individuals, with meritocratic values being a key driver in more equal societies [42].

Due to new forms of inequality that are affecting younger generations, such as the digital divide, residential status, and spatial segregation, educational inequality in Europe is becoming more varied and entrenched [43]. Education plays a major role in creating social inequality in both the Global South and the North, but interventions related to education can help combat this inequality [44]. By comparing the USA and the UK and concentrating on the connection between GDP and income inequality (as determined by the Gini index), Karountzos et al. [45] contribute to this expanding corpus of work. According to their research, there is a substantial positive relationship between GDP and inequality in the USA, indicating that higher-income groups gain disproportionately from economic expansion. The UK, on the other hand, exhibits a weaker correlation, underscoring the role that social welfare and redistributive policies play in mitigating this effect. This study provides empirical insights for customizing policy interventions to address disparities in advanced economies and emphasizes the crucial role that national policy frameworks play in influencing the relationship between growth and inequality.

Emerging economies frequently exhibit strong economic growth coupled with rising income inequality, where the wealthiest segments capture a disproportionate share of national income—as seen in Brazil, India, and South Africa [46]. Key structural and demographic drivers such as aging populations, female labor participation, unemployment, and pronounced urban-rural divides—where cities gain more from globalization and technology—further exacerbate inequality [47]. To counter these trends, governments are encouraged to implement progressive taxation, strengthen social safety nets, and invest in education and healthcare [46–48].

3. Research Methodology

Previous empirical studies on the relationship between economic growth and income inequality have often treated countries as a homogeneous group, applying uniform models without differentiating by income classification. This approach overlooks the structural, institutional, and policy heterogeneity that characterizes economies at different development stages. Consequently, aggregated analyses may obscure critical dynamics that are only observable within specific income categories, particularly the turning point predicted by the Kuznets hypothesis.

Moreover, many studies incorporate a wide range of explanatory variables—such as education, trade openness, or labor market indicators—thus diluting the direct link between economic growth and inequality. In contrast, the present study focuses exclusively on the relationship between GDP and income inequality (measured by the Gini index), applying a parsimonious but targeted framework. It employs three complementary econometric perspectives: linear regression to identify overall trends, quadratic regression to capture potential nonlinearities consistent with Kuznets' curve, and fixed effects modeling to account for country-specific, time-invariant factors. By conducting subgroup analyses across high-, upper-middle-, and lower-middle-income countries, the study provides a more precise and development-sensitive understanding of how economic growth influences inequality.

This study focused on a sample of 39 countries from 2004 to 2019 and used World Bank (2024) data on GDP and Gini index (see Table 1). Based on the World Bank's 2022 per capita gross national income (GNI) classification, the sample was chosen to guarantee representation from all income levels (lower middle, upper middle, and high income).

To analyze the heterogeneity in the growth–inequality relationship, countries in the sample were grouped according to the World Bank's official income classification system, which is based on GNI per capita using the Atlas method. This classification, updated annually, divides countries into low, lower-middle, upper-middle, and high-income groups. Although low-income countries were excluded due to limited data availability, the remaining 39 countries were allocated to three income categories: lower middle, upper middle, and high income. This grouping approach is widely used in cross-country empirical research to capture development-stage-specific economic dynamics and is particularly relevant when testing nonlinear hypotheses like the Kuznets curve, which assumes different inequality trajectories across stages of development. Grouping by income enables more meaningful statistical interpretation and policy relevance, as the impact of economic growth on inequality is known to differ substantially between lower- and higher-income economies. This stratified analysis allows the study to go beyond aggregate effects and to assess whether the relationship observed aligns with theoretical expectations across distinct economic contexts.

The maximization of representativeness and coverage across income groups and geographic regions served as the guiding principle for the selection of 39 countries. The sample covers a range of economic systems, including market-driven, mixed, and transitioning economies, and includes economies from Europe, Asia, Latin America, and North America. These nations were chosen to ensure methodological robustness while preserving regional and developmental diversity because they had complete and consistent time-series data on GDP and the Gini index for the 2004–2019 period. This deliberate sample design improves the findings' external validity and provides generalizable insights into trends in income inequality in relation to global economic expansion.

Regarding data preprocessing, the sample of 39 countries was selected based on the availability of complete and simultaneous annual data for both the Gini and GDP indices across the full timeframe. Therefore, no imputation or casewise deletion was necessary. GDP values were transformed using the natural logarithm (LOGGDP) to address scale disparities and mitigate heteroscedasticity, while the Gini index was used in its original form given its normalized and bounded nature.

The dataset was regarded as a short time series due to its 15-year duration. Since the short timeframe reduces nonstationary effects and enables the analysis to concentrate on trends and relationships rather than long-term behavior, stationarity tests were not conducted.

Even though macroeconomic panel data frequently show nonstationary behavior, this study did not use stationarity tests like the Phillips-Perron or Augmented Dickey-Fuller because of the dataset's short time span (15 years, 2004–2019). Formal stationarity tests are less reliable and powerful when time horizons are short, and test results may be further distorted by structural disruptions like crises. Rather, the analysis concentrated on short-panel

Table 1
Study's sample of countries from three income groups for the years 2004–2019

Increasing number	Country name	Country income group
1	Armenia	Upper middle income
2	Austria	High income
3	Belgium	High income
4	Belarus	Upper middle income
5	Canada	High income
6	Costa Rica	Upper middle income
7	Cyprus	High income
8	Czechia	High income
9	Germany	High income
10	Denmark	High income
11	Dominican Republic	Upper middle income
12	Ecuador	Upper middle income
13	Spain	High income
14	Estonia	High income
15	Finland	High income
16	France	High income
17	United Kingdom	High income
18	Georgia	Upper middle income
19	Greece	High income
20	Honduras	Lower middle income
21	Hungary	High income
22	Indonesia	Upper middle income
23	Ireland	High income
24	Italy	High income
25	Lithuania	High income
26	Luxembourg	High income
27	Latvia	High income
28	Peru	Upper middle income
29	Poland	High income
30	Portugal	High income
31	Paraguay	Upper middle income
32	Russian Federation	Upper middle income
33	El Salvador	Upper middle income
34	Slovak Republic	High income
35	Slovenia	High income
36	Sweden	High income
37	Turkiye	Upper middle income
38	Ukraine	Lower middle income
39	United States	High income

and cross-sectional variation, where stationarity assumptions are less important, especially when using pooled ordinary least squares (OLS) estimation.

We are aware of possible endogeneity issues, especially the two-way causal relationship between GDP and income inequality. Job creation and redistribution are two ways that economic growth can impact inequality, whereas high inequality can have an impact on political stability and the accumulation of human capital, both of which can influence growth paths. Furthermore, unobserved elements like political institutions, fiscal policies, demographic changes, or technological advancements may contribute to omitted variable bias. Although this study uses a reduced-form framework, future research could benefit from using dynamic panel estimators Generalized Method of Moments (like GMM), structural modeling, or instrumental variable techniques to explicitly address endogeneity and control for latent confounders.

The data were statistically processed using SPSS, with GDP values transformed logarithmically (LOGGDP) to handle scale differences. The analysis involved:

1) Correlation Analysis: Establishing the relationship between Gini and the three income categories above, in order to establish whether there is a correlation between the income level of each country and the level of inequality.
2) Linear Regression: Using the model $Gini_{it} = \beta 0 + \beta 1 LOGGDP_{it} + \varepsilon_{it}$, where LOGGDP was the independent variable and Gini the dependent variable, to assess the impact of economic growth on income inequality.

The nations were further divided into three income brackets: upper middle, lower middle, and high. Within each group, regression and correlation analyses were performed to assess the relationship between GDP and inequality at various income levels, offering a more nuanced understanding of the dynamics than could be obtained from the sample as a whole.

Due to significant data limitations pertaining to GDP and Gini indices from 2004 to 2019, low-income countries were not included in the analysis, jeopardizing the validity of panel estimations. The robustness of the results is protected by this exclusion, even though it limits the findings' applicability to low-income contexts where informal economies, institutional fragility, and data volatility are prevalent. Future research may address this lacuna through alternative datasets or qualitative approaches. However, since lower-middle, upper-middle, and high-income economies account for the majority of the world's population and output, the study still has broad applicability.

To empirically assess the Kuznets hypothesis, the analysis proceeded to a second step. In order to capture potential nonlinearities consistent with the inverted-U shape proposed by Kuznets, a quadratic specification was employed. This involved augmenting the model with a squared term of the log-transformed GDP variable ($LOGGDP^2$). The functional form of the model was as follows:

$$GINI_{it} = \beta_0 + \beta_1 LOGGDP_{it} + \beta_2 (LOGGDP_{it})^2 + \varepsilon_{it}$$

This approach allows for a direct test of the presence and direction of curvature in the growth–inequality relationship. The turning point of the curve was calculated as $-\beta_1/2\beta_2$, providing an estimate of the income level at which inequality shifts direction. Multicollinearity diagnostics were conducted to assess potential redundancy between the linear and squared terms. All models were estimated using OLS with robust standard errors.

A general linear model (GLM) with country dummy variables was used to implement a fixed effects framework in light of the possible autocorrelation in residuals (Durbin–Watson <2). This method allows for more reliable estimation of within-country variation while accounting for unobserved, time-invariant heterogeneity across nations. The validity of the model assumptions was also evaluated through diagnostic tests for heteroskedasticity and multicollinearity.

3.1. Research results

3.1.1. 1st linear regression between all countries

Table 2 indicates a weak relationship between the variables, with $R = 0.153$ and $R^2 = 0.023$, meaning only 2.3% of the variation in the Gini index is explained by LOG(GDP). The adjusted R^2 is slightly lower, and the standard error of the estimate is 7.3822, reflecting the spread of Gini values around the regression line. The Durbin–Watson statistic (0.150) suggests potential positive autocorrelation in the residuals, as values closer to 0 indicate stronger positive autocorrelation.

Table 2
Model summary, 2004–2019

R	*R* square	Adjusted *R* square	Std. error of the estimate	Durbin–Watson
0.153	0.023	0.022	7.3822	0.150

Table 3 presents the linear regression coefficients for the model that determines the Gini index based on LOGGDP. The coefficient of constant is about 23.931, with a standard deviation of about 2.913, and has a significance of $p < 0.001$. The coefficient of LOG(GDP) is about 0.937, with a standard deviation of about 0.243, and has a significance of $p < 0.001$. The standardized coefficient (beta) is about 0.153, indicating the relative contribution of LOG(GDP) to the prediction of Gini. The linear regression model identifying the Gini index based on LOGGDP is **GINI = 23.931 + 0.937 × LOGGDP.**

An analysis of variance (ANOVA) is then conducted to examine the statistical significance of the regression model (see Table 4).

The *F*-value is approximately 14.826, and significance (Sig.) is approximately 0.000. Based on these results, we see that the *F*-value is significantly high, with a *p*-value (Sig.) well below the 0.05 significance level. This indicates that the regression model is statistically significant.

The regression line in Figure 2 illustrates a moderate positive relationship between Gini (dependent variable) and LOGGDP (independent variable). As LOGGDP increases, Gini also increases, suggesting that economic growth is associated with rising income inequality. The upward slope of the line reflects a moderate impact of GDP growth on inequality levels.

3.1.2. Correlation between Gini and income level category (1, 2, 3) for all countries, years 2004–2019

To capture potential nonlinear effects that may differ across development stages, countries were grouped according to the World Bank income classification. This allows the model to reflect differentiated growth–inequality dynamics across income levels.

In this phase, a correlation analysis between the Gini and the three income categories (1 = high income, 2 = upper middle income, and 3 = lower middle income) is carried out in order to establish the existence of a correlation between the income category of each country and the level of inequality.

The above correlation table shows the correlations between the Gini variable and the INCOME GROUP variable income category 1, 2, 3 (see Table 5). From the results, it is observed that the correlation between Gini and INCOME GROUP variables is statistically significant at the 0.01 level of significance. This means that there is a strong positive correlation between the two variables: as the Gini index increases, so does the income group, and vice versa.

Kendall's tau_b and Spearman's rho correlation coefficients are non-parametric measures of correlation used to analyze correlations between noncontinuous variables. Kendall's tau_b and Spearman's rho correlations are both statistically significant at the 0.01 level of significance. Both Kendall's tau_b and Spearman's rho show a positive correlation between the Gini variable and the INCOME GROUP variable (see Table 6). This indicates that there is a significant positive relationship between income inequality and income group.

Table 3
Coefficients, 2004–2019

	Unstandardized coefficients		Standardized coefficients		
	B	Std. Error	Beta	*t*	Sig.
Constant	23.931	2.913		8.216	0.000
LOGGDP	0.937	0.243	0.153	3.850	0.000

Table 4
ANOVA, 2004–2019

	Sum of squares	Mean square	*F*	Sig.
Regression	807.942	807.942	14.826	0.000
Residual	33896.795	54.496		
Total	34704.737			

Figure 2
The regression line of the GINI model, 2004–2019

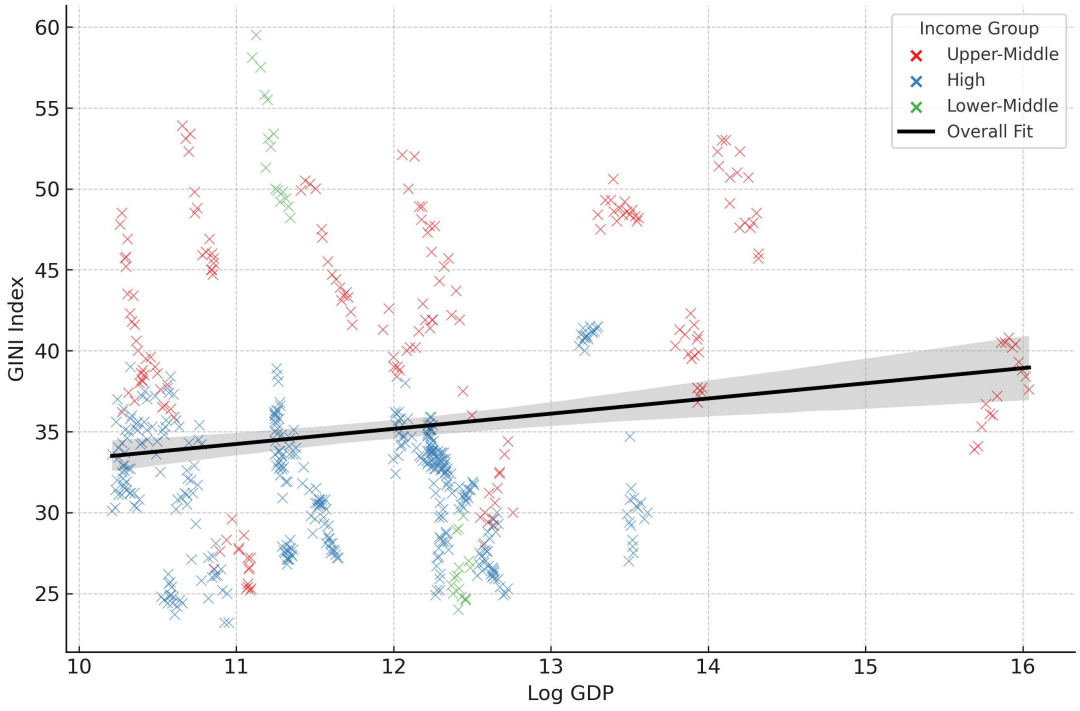


Table 5
Correlations between GINI and income category 1, 2, 3, years 2004–2019

		GINI	Income Group
GINI	Pearson correlation	1	0.543
	Sig. (2-tailed)		0.000
	Sum of squares and Cross-products	34704.737	1482.554
	Covariance	55.706	2.380
Income Group	Pearson correlation	0.543	1
	Sig. (2-tailed)	0.000	
	Sum of squares and cross-products	1482.554	214.974
	Covariance	2.380	0.345

Table 6
Kendall's tau_b and Spearman's rho correlation coefficients between GINI and income category 1, 2, 3, years 2004–2019

			GINI	Income Group
Kendall's tau_b	GINI	Correlation coefficient	1.000	0.422
	Income Group	Correlation coefficient	0.422	1.000
Spearman's rho	GINI	Correlation coefficient	1.000	0.504
	Income Group	Correlation coefficient	0.504	1.000

3.1.3. 2nd linear regression between Gini and LOGGDP for each income level category (1, 2, 3), years 2004–2019

Countries were separated into different income groups in accordance with the World Bank's income group classification in order to investigate whether the relationship between GDP and inequality varies systematically across various levels of development.

The final step of statistical processing involves three linear regressions. For each income level category, a linear regression is specifically conducted using the Gini index as the dependent variable and the LOGGDP index as the independent variable. In line with the World Bank's income group classification, countries were divided into distinct income categories to explore whether the GDP–inequality relationship varies systematically across different development levels.

Three linear regressions are conducted in the last stage of statistical processing. Specifically, a linear regression is run for each income level category with the Gini index as the dependent variable and the LOGGDP index as the independent variable, as follows.

1) 1st linear regression for the sample of countries in category 1 (high income)

In Table 7, we observe that the model does not explain the variation in the Gini index very well, as the R square value is very close to zero. This means that our model is not able to effectively explain the variation of the Gini index based on the LOGGDP variable.

Table 7
Model summary category 1, 2004–2019

R	Adjusted R square	Std. error of the estimate	Durbin–Watson
0.034	–0.001	3.9572	0.149

In Table 8, we observe:

F-test: the *F*-value is 0.469, indicating that the model is not statistically significant. Sig: The *p*-value is 0.494, which is high, indicating that the probability of the model occurring by chance is high. Based on these results, we conclude that the model is not statistically significant in predicting the Gini index.

2) 2nd linear regression for the sample of countries in category 2 (upper middle income)

Table 9 shows that the model poorly explains Gini variation (R^2 = 0.008), with LOGGDP adding little value. The high standard error and low Durbin–Watson statistic (0.165) indicate weak predictive power and autocorrelation, making the model unreliable for upper-middle-income countries.

Table 8
ANOVA category 1, 2004–2019

	F	Sig.
Regression	0.469	0.494

Table 9
Model summary category 2, 2004–2019

R	*R* square	Adjusted *R* square	Std. error of the estimate	Durbin–Watson
0.092	0.008	0.003	7.1912	0.165

Table 10 demonstrates that the model is not statistically significant, with an F-value of 1.622 and a *p*-value of 0.204. The high *p*-value suggests a high likelihood that the observed relationship is random. Thus, the model does not provide a reliable prediction of the Gini index for upper-middle-income countries using LOGGDP as a predictor.

Table 10
ANOVA category 2, 2004–2019

	F	Sig.
Regression	1.622	0.204

3) 3rd linear regression for the sample of category 3 countries (lower middle income)

Table 11 indicates a strong predictive power of the model for lower-middle-income countries, with R^2 = 97.7%, suggesting that the model explains nearly all the variance in GINI. The adjusted R^2 is similarly high, confirming that the inclusion of LOGGDP does not diminish the model's fit. However, the significant error estimate and the Durbin–Watson statistic highlight potential issues with autocorrelation in the residuals.

The linear regression model's remarkably high R^2 value (97.7%) for lower-middle-income nations raises serious questions about how reliable the findings are. Although the Kuznets curve's theoretical predictions are supported by the strong negative

Table 11
Model summary category 3, 2004–2019

R	*R* square	Adjusted *R* square	Sig. F change	Durbin-Watson
0.989	0.977	0.977	0.000	0.621

correlation between GDP and income inequality, this nearly perfect explanatory power is unusual for macroeconomic panel data and could be a sign of underlying data limitations or model sensitivity to outliers. The model might have unintentionally captured peculiar country-specific trends or structural breaks that skew generalizability as a result of the smaller number of countries in this subgroup and the potential for limited variance in both GDP and Gini index values over time. Furthermore, the regression result may be disproportionately impacted by potential outliers, which are nations that are undergoing fast structural change or that are dealing with measurement anomalies.

Table 12
ANOVA category 3, 2004–2019

	F	Sig.
Regression	1298.148	0.00

Based on the results shown in Table 12, we conclude that the model is statistically significant for predicting the Gini index for lower-middle-income countries using log GDP (LOGGDP) as a predictor.

Table 13 shows:

1) Constant: The constant is 303.052 with a standard error of 7.327 and a *t*-value of 41.360. The *p*-value is < 0.001, indicating that the constant is statistically significant.
2) LOGGDP: The coefficient for log GDP is −22.291 with a standard error of 0.619 and a *t*-value of −36.030. The *p*-value is < 0.001, indicating that the contribution of log GDP is statistically significant.

Based on these results, and having the ANOVA table, we can conclude that both variables are significant for the model and have a negative correlation with the Gini index.

The next plot represents the negative relationship between the Gini index and the LOGGDP variable for countries below medium size (category 3) for the years 2004–2019. There is also a concentration of observations at the ends of the line (see Figure 3).

3.1.4. Quadratic regression model

A quadratic regression model was estimated in order to investigate the possible nonlinear relationship between economic growth and income inequality. The goal was to evaluate the empirical viability of the Kuznets hypothesis, which postulates an inverse U-shaped relationship between inequality and income. To account for curvature effects, the model specification contained both a linear (LOGGDP) and a squared (LOGGDP²) term. Table 14 presents the findings.

The coefficient for LOGGDP was negative and statistically significant (β = –10.724, p = 0.001), indicating that at lower levels of income, economic growth tends to reduce income inequality. In contrast, the coefficient for the squared term, LOGGDP², was positive and highly significant (β = 0.468, p < 0.001), suggesting that inequality begins to rise again at higher levels of income. This pattern implies a U-shaped relationship between growth and inequality, rather than the classic inverted-U curve originally suggested by Kuznets.

Calculated as $-\beta 1/2\beta 2$, the estimated turning point is roughly LOGGDP ≈ 11.45, or an income level of roughly USD 281.8 billion. This suggests that while growth is linked to a decrease in inequality for nations below this threshold, it may worsen disparities for those above it.

With an R^2 of just 0.043, the model's explanatory power is still restricted even though it is statistically significant ($F(2, 621)$ = 13.94, p < 0.001). Strong multicollinearity between the linear and squared terms was further confirmed by collinearity diagnostics, which showed very high variance inflation factors (VIF ≈ 184) and a maximum condition index of 283.25. With standardized residuals ranging from –1.54 to +3.44, residual diagnostics also indicated the presence of outliers and mild heteroscedasticity.

Unlike the traditional inverted-U hypothesis proposed by Kuznets, the resulting curve in Figure 4 shows a U-shaped relationship between log-transformed GDP and income inequality. Although inequality first declines as income rises, it starts to increase once more after a certain point (LOGGDP ≈ 11.45), indicating that high-income economies might see a resurgence of inequalities.

These results imply that there is more nuance to the relationship between inequality and income than the conventional Kuznets curve would indicate. High income inequality may be a result of structural changes like global capital mobility, weakened redistributive institutions, or technological concentration. Because of this, the U-shaped relationship that this analysis revealed emphasizes how crucial it is to review growth-inequality dynamics in light of current economic circumstances.

3.1.5. Fixed effect model

A GLM with country-specific dummy variables was used in a fixed effects approach to address possible autocorrelation problems uncovered by the Durbin–Watson statistic and to account for unobserved, time-invariant heterogeneity across nations. In order to account for nonlinear dynamics in the income–inequality relationship, the model included the log of GDP (LOGGDP) and its squared term (LOGGDP²) as covariates, while maintaining the Gini index as the dependent variable.

As shown in Table 15, both explanatory variables were statistically significant at the 1% level. The coefficient for LOGGDP

Table 13
Coefficients category 3, 2004–2019

	Unstandardized coefficients		Standardized coefficients	
	B	Std. error	Beta	Sig.
(Constant)	303.052	7.327		0.000
LOGGDP	–22.291	0.619	–0.989	0.000

Figure 3
Relationship between the GINI index and the LOGGDP variable for lower-middle size countries (category 3), 2004–2019

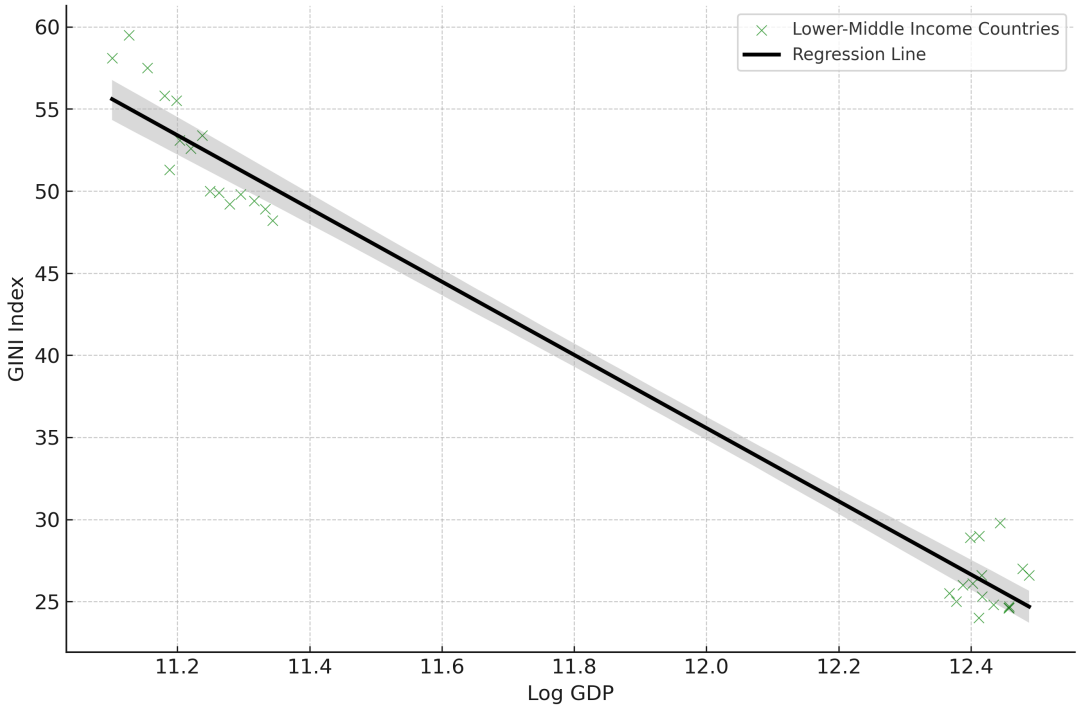


Table 14
Key statistics from the quadratic regression model

Statistic	Value	Interpretation
R	0.207	Weak positive correlation between predicted and observed GINI values
R^2	0.043	Only 4.3% of variance in inequality is explained by the model
Adjusted R^2	0.040	Adjusted for the number of predictors
F-statistic (ANOVA)	13.939	Indicates overall model significance
p-value (ANOVA)	< 0.001	The model is statistically significant
Durbin–Watson	0.150	Very low; indicates potential autocorrelation in residuals
Coefficient (LOGGDP)	–10.724 (p = 0.001)	Negative and significant: inequality falls with rising income initially
Coefficient (LOGGDP^2)	0.468 (p < 0.001)	Positive and significant: inequality rises again beyond a threshold (U-shape)
Turning point (LOGGDP)	≈ 11.45	Corresponds to GDP ≈ 281.8 billion USD (reversal point in the curve)
VIF (LOGGDP and LOGGDP^2)	184.145	Extremely high → strong multicollinearity
Condition index (Max)	283.253	Confirms multicollinearity between predictors
Residual std. dev.	7.30	Dispersion of residuals; mild heteroscedasticity suspected
Residual range	–11.24 to +25.14	Presence of large prediction errors and possible outliers

was negative (β = –10.724, p = 0.001), while the coefficient for LOGGDP^2 was positive (β = 0.468, p < 0.001), confirming the presence of a U-shaped relationship. This implies that inequality tends to decline at lower-income levels but begins to rise again beyond a certain income threshold. These findings align with the modified version of the Kuznets curve, suggesting a re-emergence of inequality in more developed economies.

The fixed effects specification is validated by the significance of country dummy variables, which also show significant differences in inequality levels between countries. Levene's test, however, showed significant heteroskedasticity (F = 105.14, p < 0.001), indicating that the variance of residuals varies by nation. Although the GLM framework provides some degree of robustness, panel-corrected estimation methods or robust standard errors might be useful for subsequent research.

Figure 5 shows the fixed effects quadratic model and a basic OLS regression (GINI ~ LOGGDP) to compare the linear and nonlinear interpretations. The fixed effects model shows a U-shaped curve, suggesting that inequality reemerges at higher-income levels—a nuance that the linear approach misses. The linear model predicts a uniform decline in inequality with rising income.

Figure 5 uses both linear and quadratic specifications to show the relationship between income (log-transformed GDP) and

Figure 4
The quadratic regression curve of the GINI model

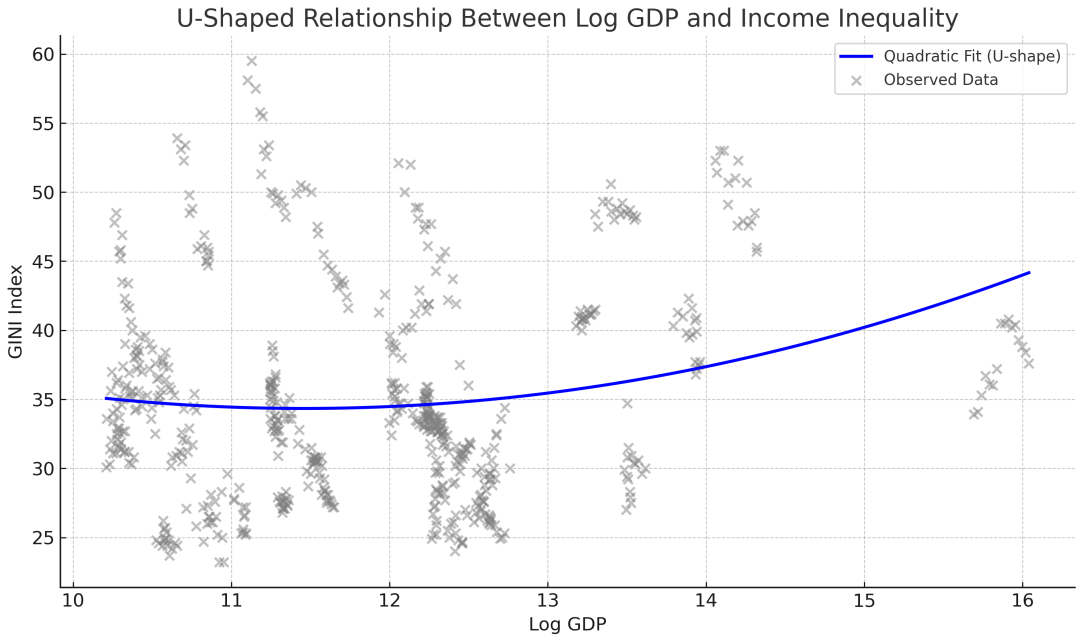


Table 15
Parameter estimates from fixed effects GLM model

Parameter	B	Std. error	t	*p*-value
Intercept	95.772	20.309	4.716	0.000
LOGGDP	–10.724	3.272	–3.278	0.001
SQLOGGDP	0.468	0.131	3.574	0.000

income inequality (Gini index). The linear fit obtained from OLS is represented by the dashed green line, which shows a modest upward trend. A U-shaped relationship is revealed by the quadratic fit estimated using a fixed effects model, which is represented by the solid blue curve. This implies that, in line with a modified Kuznets hypothesis, inequality first decreases or stays constant with income growth before starting to increase once more after a particular point.

Income and inequality have a nonlinear relationship, as shown by the U-shaped curve obtained from the fixed effects model. A more complex pattern is revealed by the fixed effects specification, whereas the linear trend calculated using simple OLS indicates a consistent decrease in inequality as income rises. In particular, the model captures an initial decline in inequality followed by a reversal beyond a certain income threshold by combining both LOGGDP and LOGGDP². This curvature, which would not have been detected under a strictly linear specification, represents the shifting dynamics of distribution in the later stages of development. The fixed effects approach provides a more accurate and policy-relevant representation of the growth–inequality relationship by controlling for time-invariant country-specific factors and concentrating on within-country variation.

3.2. Synopsis of statistical results

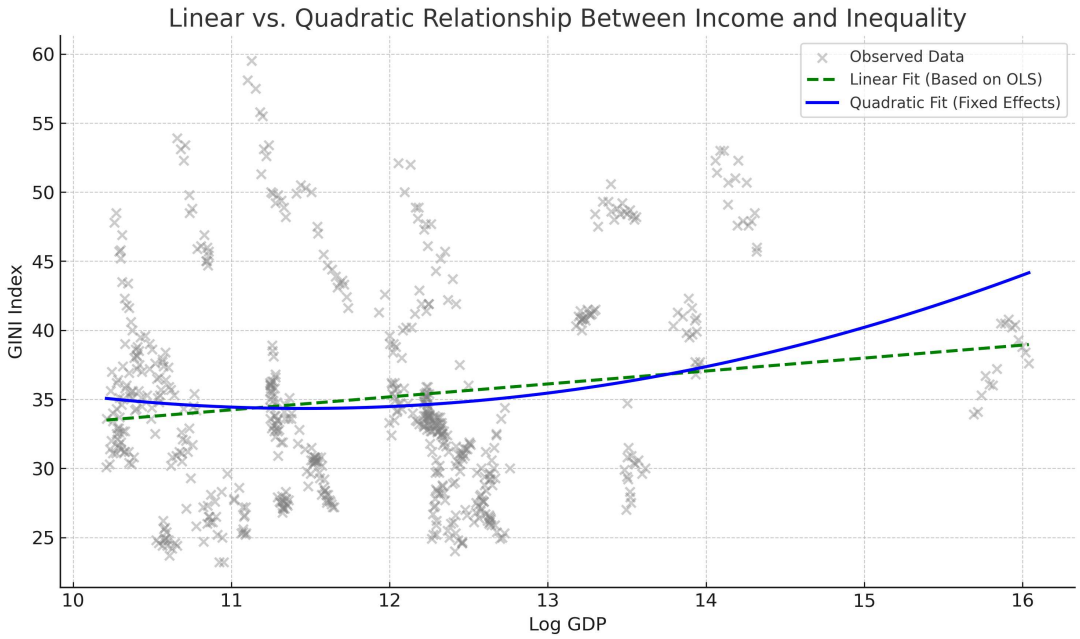
From the overall analysis of the statistical tables presented above, we can conclude the following:

1) Statistical Significance of the Model: The linear regression model across the sample countries is statistically significant as the F-value is highly significant ($p < 0.05$). This means that at least one of the independent variables significantly explains the changes in the dependent variable.
2) Correlation of Variables: The LOGGDP variable is positively correlated with the Gini index as shown in the correlation matrix. This suggests that as GDP increases, income inequality also increases.
3) Effect of Variables: The coefficient of the variable LOGGDP is statistically significant ($p < 0.05$), indicating that this variable has a significant effect on the Gini index. The coefficient estimate ($\beta = 0.937$) indicates that for every unit increase in the log of GDP, the Gini index is expected to increase by about 0.937 points. The constant coefficient, that is, the other factors, which are assumed to be constant without including the effect of GDP, leads to a Gini level of almost 24 points.
4) Correlation by Income Category: this correlation shows a positive and statistically significant relationship between the Gini and the income category of each country.

Linear regression by income group: the models obtained from the linear regression separately for each country's income category show the following:

1) For high-income countries (high-income-category 1), the model is not statistically significant.
2) For upper-middle-income countries (upper-middle-income-category 2), the model is not statistically significant.
3) The correlation between the Gini index and the LOGGDP variable is negative, and the model is statistically significant for

Figure 5
The linear and quadratic regression curve of the GINI model



lower-middle-income countries (lower-middle-income-category 3). This implies that income inequality falls as GDP rises.

Economic growth and income inequality have a significant but complicated relationship, according to the statistical analysis. A weak but statistically significant positive correlation between log-transformed GDP and the Gini index was found by the linear regression model, indicating that, generally speaking, higher-income levels are linked to marginally higher levels of inequality. A quadratic regression was used to check for nonlinearity. With a negative coefficient for the linear term and a positive coefficient for the squared term, the results showed a U-shaped relationship. According to this, inequality first decreases as income rises, but it then starts to increase once more after a particular income threshold (LOGGDP ≈ 11.45). Both the linear and quadratic models were statistically significant ($p < 0.001$), despite the models' modest overall explanatory power ($R^2 \approx 4\%$). Diagnostic checks highlighted strong multicollinearity between predictors and mild heteroscedasticity, which should be considered when interpreting the results. These findings point to structural asymmetries in the growth–inequality dynamic, particularly in higher-income contexts, and underscore the relevance of adopting nonlinear frameworks in inequality analysis.

Results from the fixed effects model, which was applied using a general linear model with country dummies, were statistically significant. A U-shaped relationship between income and inequality was indicated by the significant values of both LOGGDP and its squared term ($p < 0.01$). This implies that while inequality first declines as the economy grows, it then starts to increase once more after a particular income level. The findings' internal validity was improved by the use of fixed effects, which adjusted for unobserved, time-invariant variations between nations. The model was able to concentrate on within-country variation over time thanks to the fixed effects approach, which produced a more accurate evaluation of the growth–inequality relationship despite having a modest explanatory power ($R^2 \approx 4.3\%$).

3.3. Examination of the research hypotheses based on the findings

The null hypothesis (H0), which posits that "income inequality is not affected by GDP," is clearly rejected across all model specifications. In the linear regression model, where LOGGDP is the sole explanatory variable, the relationship with the Gini index is statistically significant ($p < 0.01$), with a negative regression coefficient. This suggests that, on average, higher-income levels are associated with lower inequality. The ANOVA confirms the statistical significance of the model ($F = 27.13$, $p < 0.001$), supporting the H1 hypothesis that GDP does indeed affect income inequality.

Hypothesis H2, which claims that "income inequality is positively affected by GDP," is not supported by the linear model, as the direction of the relationship is negative. Instead, the linear model lends support to an inverse association, suggesting that as GDP increases, inequality tends to decrease. Therefore, we reject H2 and tentatively accept H3, which implies a negative relationship between income and inequality at the aggregate level.

However, the results shift when moving to the quadratic model. The inclusion of the squared LOGGDP term reveals a U-shaped relationship: the coefficient for LOGGDP is negative, while the coefficient for LOGGDP² is positive—both statistically significant. This implies that inequality initially decreases with GDP growth but starts rising again beyond a certain income threshold (LOGGDP ≈ 11.45). This challenges the linear view and points toward a more complex, nonlinear dynamic. Thus, H3 is only partially supported.

Additionally, the presence of a statistically significant U-shaped pattern is reinforced, while model robustness is increased by the fixed effects analysis, which accounts for unobserved heterogeneity across nations. This model demonstrates that the GDP-inequality relationship's strength and direction change over time and across income levels.

Lastly, there is evidence to support hypothesis H4, which claims that "in lower-middle-income countries, GDP has a negative effect on inequality." In this income category, LOGGDP and

the Gini index have a significantly negative correlation, which is confirmed by subgroup analysis. This result is in line with the first stage of the Kuznets hypothesis and the downward portion of the U-shaped relationship.

4. Discussion

Proposed by Kuznets [1] in the 1950s, the Kuznets hypothesis postulates a nonlinear relationship between economic growth and income inequality. In its canonical form, inequality rises in the early stages of development—driven by urbanization, labor market disparities, and unequal access to resources—and subsequently declines as prosperity expands and redistributive policies emerge. Empirically, the regression model of this study (GINI = 23.931 + 0.937 × LOGGDP) captures this dynamic, indicating that GDP growth initially amplifies inequality, consistent with the ascending phase of the Kuznets curve.

The models obtained from the linear and quadratic regression are displayed in Figure 6, which also displays the regression lines' slope on a fictitious Kuznets curve.

The hypothetical Kuznets curve, which was positioned to symbolize the traditional inverted-U relationship between income and inequality, is above both the linear and quadratic empirical models, according to the graphical comparison. Both deviate from the conventional Kuznets formulation, although the fixed effects quadratic model displays a U-shaped curve and the linear fit records a downward trend. This implies that the dynamics of inequality in modern economies might be higher than those predicted by the original theory. The empirical curves' "touch" or surpassing of the fictitious Kuznets curve suggests that contemporary factors like globalization, technological inequality, and weakened redistribution may be amplifying inequality beyond what classical growth-based models predicted. Thus, the observed patterns call for a reassessment of the conventional growth–inequality paradigm.

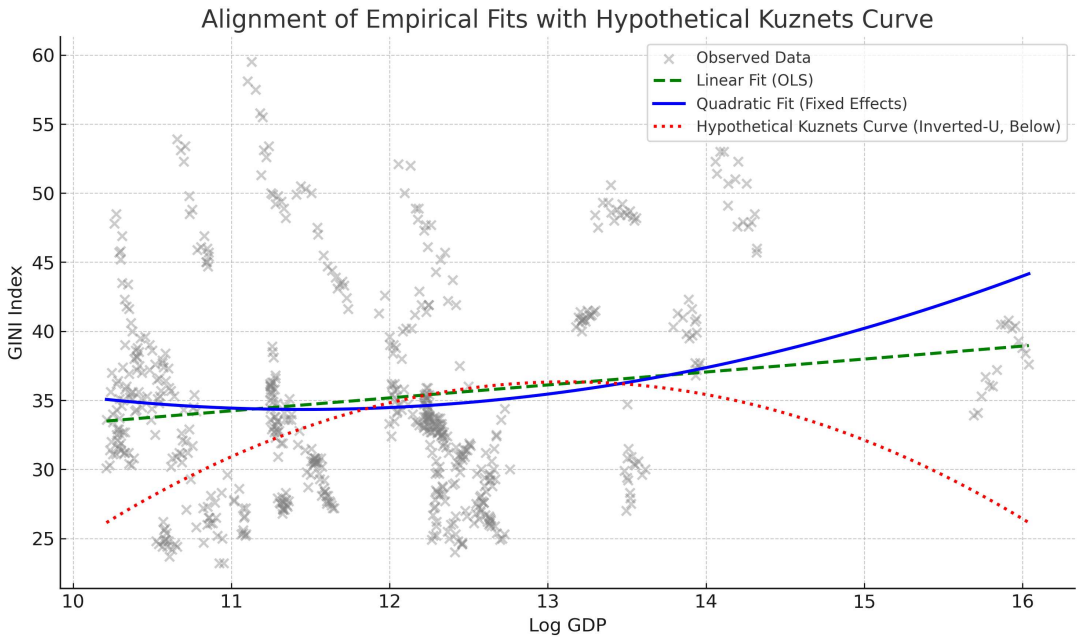
However, it remains important to further examine the mechanisms that shape the relationship between GDP and income inequality in order to better understand the trajectory of income inequality in modern society. Nonetheless, the findings of the research are partly consistent with Kuznets' theory and agree with Huynh's [18] research, which concludes that income inequality and economic growth show a U-shaped relationship, rejecting the inverted-U or monotonic hypothesis.

The present study identified a significant variation in the relationship between economic growth and income inequality across income groups. Specifically, it revealed a strong negative correlation between LOGGDP and the Gini index in lower-middle-income countries, reinforcing the validity of the declining phase of the Kuznets curve. However, when analyzing the full sample and particularly high-income countries, the relationship between GDP and inequality proved either weak or statistically insignificant, raising questions about the general applicability of Kuznets' hypothesis in contemporary economic contexts. The quadratic regression model further revealed a U-shaped relationship, where inequality initially decreases with income growth but begins to rise again beyond a certain income threshold (GDP ≈ 281.8 billion USD). This aligns with recent studies by Doğan and Can [49], showing that globalization tends to exacerbate inequality in advanced economies, thereby challenging the linear expectations of the Kuznets model.

While Kuznets' theory associated the reduction of inequality with structural transformation from agriculture to industry and services, contemporary research highlights a more complex reality. Modern patterns of income distribution are increasingly shaped not only by economic growth but also by factors such as human development, protection of property rights, taxation systems, and the allocation of resources to social welfare programs [50]. These parameters form an integral part of a country's socioeconomic architecture, influencing inequality dynamics beyond the classic growth-centered framework.

As highlighted in the literature, globalization alters the nature of structural change, reinforcing wage disparities, skill-biased technological diffusion, and capital concentration—factors that disproportionately benefit high-skilled workers and wealth holders [34, 51]. The finding in this study that inequality rises again in high-income economies reflects the insights of Baymul and Sen [52],

Figure 6
Linear regression and quadratic models on Kuznets curve



who argue that globalization can lock countries into "high inequality equilibria," especially when institutions fail to redistribute effectively. Therefore, while the analysis confirms the declining segment of the Kuznets curve in lower-income settings, it also supports calls to revise or extend Kuznets' framework to reflect the complexities of a globalized and financialized world economy according to Alexiou et al. [32] and Aghion et al. [37].

The descending phase of the Kuznets curve may initially seem to be supported by the strong negative correlation between GDP and income inequality in lower-middle-income nations, indicating that economic growth in these settings directly reduces inequality. However, care should be taken when interpreting this pattern. The findings might not support a general "new Kuznets curve," but rather particular contextual elements that define lower-middle-income economies in the years after 2000. These nations frequently experience fast structural change, which includes targeted poverty reduction initiatives, labor formalization, rural development, and the expansion of basic education—all of which have a direct impact on income distribution.

Global aid flows, remittance-driven consumption, or sectoral booms (such as in agriculture or light manufacturing) have also disproportionately raised the incomes of lower earners in many lower-middle-income countries. The Kuznets hypothesis may be momentarily supported by these context-sensitive dynamics, but they are not always suggestive of a broad or predictable developmental trajectory. Therefore, rather than assuming a revived or revalidated Kuznets trajectory, the interpretation of the statistically robust negative association should take institutional, policy-driven, and regional particularities into consideration.

The classical Kuznets hypothesis, which holds that there is an inverted-U relationship between economic growth and income inequality, is called into question by the quadratic regression's findings. The empirical data from this study point to the opposite trajectory from Kuznets' theory, which predicted that as economies industrialize and mature, inequality would first increase before declining. Inequality tends to decrease in the early phases of growth, especially in lower-income environments, but resurfaces at higher-income levels, according to the observed U-shaped relationship. This reversal might be a reflection of modern structural dynamics that Kuznets' original framework did not take into consideration, like the waning power of redistributive institutions in developed economies, the expansion of capital-intensive technologies, and financial globalization. The results suggest that inequality may resurface as opposed to supporting the conventional "inequality peaks and then falls" paradigm. The findings imply that inequality may re-emerge as a second-order effect of growth once a certain income threshold is surpassed. These results echo more recent empirical studies that question the universality of the Kuznets curve and support a more context-dependent understanding of the growth–inequality nexus.

By separating within-country variation over time, the fixed effects analysis offered a more nuanced understanding of the connection between inequality and income. The inclusion of LOGGDP and its squared term revealed a significant U-shaped pattern, which raises the possibility that the traditional Kuznets hypothesis may no longer adequately capture the complexity of the growth–inequality dynamic in modern economies. The findings suggest that inequality may initially decrease with income growth but eventually reappear in more developed contexts, despite the original theory's prediction of an inverted-U curve. The fixed effects model strengthens this conclusion by taking into consideration time-invariant country-specific factors, demonstrating that the observed pattern cannot be fully explained by the structural features unique to each nation. Rather, transnational factors like globalization, technological advancement, and the breakdown of redistributive mechanisms may be the cause of the increasing trend in inequality at higher-income levels. These results highlight the necessity of unique policy approaches that go beyond income growth.

Despite being fundamental, the classical Kuznets hypothesis may not be enough to adequately explain the complexity of contemporary inequality dynamics in light of these findings. According to the U-shaped relationship found in this study, equality in advanced stages of development is not always the result of economic growth. Rather, structural, institutional, or financial factors that were not taken into account in Kuznets' original model may cause inequality to reappear or continue.

In this regard, Piketty's [13] well-known $r > g$ hypothesis provides a strong counterargument: wealth tends to concentrate when the rate of return on capital exceeds economic growth, escalating inequality unless intentional policy measures are taken to counteract it. Piketty contends that inequality is a political and institutional result rather than an inevitable byproduct of growth, in contrast to Kuznets, who predicted that inequality would naturally decrease with industrial and social advancement. This more comprehensive theoretical framework puts the empirical trends seen here in context and implies that proactive structural reforms—rather than growth alone—are necessary for long-term decreases in inequality.

5. Conclusion

The purpose of this study was to investigate, using a scientific methodology, the connection between GDP and income inequality as measured by the Gini index. The Gini index and log-transformed GDP were the main variables used in this study, which looked at the relationship between economic growth and income inequality in 39 countries between 2004 and 2019. The objective was to investigate whether income growth is consistently linked to decreases or increases in inequality across various income groups and to empirically assess the viability of Kuznets' hypothesis.

The linear regression analysis revealed a weak but statistically significant positive relationship between GDP and income inequality across the full sample, suggesting that economic growth is, on average, associated with slight increases in inequality. However, disaggregated analysis by income group revealed important differences: while the model was statistically insignificant for high- and upper-middle-income countries, it showed a strong and significant negative relationship in lower-middle-income countries, indicating that economic growth can reduce inequality in less advanced economies—consistent with the descending segment of the Kuznets curve.

A quadratic regression model was used to account for nonlinear dynamics, and the results showed a U-shaped relationship between GDP and income inequality. Inequality initially decreases as income rises, but it starts to increase once more after a certain point (GDP $\approx$ 281.8 billion USD). This pivotal moment raises the possibility that further economic expansion in developed nations could result in greater inequality, most likely as a result of structural changes, the effects of globalization, and dwindling redistributive power.

Lastly, to account for unobserved, time-invariant heterogeneity across nations, a fixed effects model was used. The outcomes improved internal validity while confirming the U-shaped relationship and supporting the quadratic model's conclusions. Inequality was statistically predicted by both LOGGDP and LOGGDP^2. This model demonstrated the limitations of assuming a consistent trajectory across all economies by emphasizing the nonlinear and nation-specific nature of the growth–inequality relationship.

In summary, the study offers some evidence in favor of the Kuznets hypothesis, especially when it comes to lower-income situations. It also implies that the relationship between inequality and growth is more complicated—possibly reversing direction—in more developed economies. To guarantee that economic growth translates into inclusive and sustainable development, these findings urge distinctive, context-sensitive policy approaches that are adapted to the income level and institutional makeup of each nation.

5.1. Policy proposals

Governments can reduce income inequality by funding social welfare programs like poverty benefits or those that give subsidies to the less fortunate, since GDP and income inequality are positively connected.

The policy proposal for implementing social welfare policies focuses on creating programs that aim to reduce income inequality by providing financial and social support to disadvantaged groups in society. Social welfare programs include things like poverty grants, financial assistance for basic needs like food and housing, and social protection programs like health care and education.

Our research on income levels shows a negative relationship between GDP growth and inequality in low-income countries. It is recommended to focus on these countries because growth benefits them much more than it does in both developed and developing countries.

The policy should aim to achieve balanced and equitable growth that lowers inequality and creates a more prosperous and cohesive society.

The empirical findings of the study lend credence to the notion that the effects of economic growth on inequality vary depending on the income group. In lower-middle-income countries where growth significantly reduces inequality, policy should prioritize investments in education, digital skills, and rural infrastructure to enhance human capital and labor market access. However, by supporting progressive taxation and expanding healthcare services, redistribution can be reinforced without limiting growth. Supporting small businesses, particularly those in rural and agricultural areas, is crucial to creating jobs outside of cities.

On the other hand, in higher-income economies where growth may worsen inequality, fiscal policies that focus on labor market protections, social safety nets, and wealth concentration become essential. To ensure that growth has inclusive and long-lasting effects, specific and targeted policy frameworks that are adapted to each country's developmental stage are ultimately needed.

5.2. Suggestions for future research

It is proposed to carry out a long-term study focusing on the evolution of income inequalities in different countries and over different time periods. This study will focus on the availability of data on the Gini index and will analyze the evolution of income inequality in relation to GDP in different countries. As the Gini index is not available for all countries and for long periods of time, this study will have to take these limitations into account and consider alternative inequality indicators or look for data from official and non-official sources. The results of this research could provide important insights into the evolution of income inequality and confirm or revise Kuznets' theory.

5.3. Limitations

Due to data consistency and availability for both GDP and the Gini index across the 39 countries that were chosen, the study's focus is on the years 2004–2019. This temporal scope guarantees data integrity, comparability, and methodological rigor, but it also restricts long-term inferences. Crucially, this 15-year period encompasses significant worldwide economic changes, making the analysis current and pertinent to current policy discussions.

Even though the empirical design was robust, it is important to recognize some statistical limitations. The low Durbin–Watson statistic (≈0.15) suggests autocorrelation, while the low R^2 values show that GDP alone cannot fully account for inequality variation. Furthermore, the interpretation of coefficients is complicated by the multicollinearity between GDP and GDP² (VIF ≈ 184). These limitations are consistent with Kuznets' original hypothesis and reflect the study's frugal focus on GDP and Gini. The growth–inequality relationship could be further refined in future studies by adding more sophisticated estimation methods and broader socioeconomic variables to the analytical framework.

Ethical Statement

This study does not contain any studies with human or animal subjects performed by any of the authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

Data Availability Statement

The data that support the findings of this study are openly available in the Mendeley database at https://doi.org/10.17632/mby2hxrggr.1.

Author Contribution Statement

Panagiotis Karountzos: Conceptualization, Methodology, Validation, Resources, Data curation, Writing – original draft, writing – review & editing, Visualization, Project administration, Funding acquisition. **Ioannis Gerogiannis:** Data curation, Software, Validation, Formal Analysis, Resources, Writing – original draft, Visualization, Funding acquisition. **Ioannis Douridas:** Data curation, Software, Validation, Formal analysis, Resources, Writing – original draft, Visualization, Funding acquisition. **Nikolaos Kapsimallis:** Writing – original draft, Software, Validation, Formal analysis, Resources, Data curation. **Ioannis Koukos:** Resources, Data curation, Software, Validation, Formal analysis, Writing – original draft, Visualization, Funding acquisition. **Paraskevi Filka:** Data curation, Software, Validation, Formal analysis, Resources, Writing – original draft, Visualization.

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How to Cite: Karountzos, P., Gerogiannis, I., Douridas, I., Kapsimallis, N., Koukos, I., & Filka, P. (2025). Kuznets Revisited: An Econometric Exploration of Growth and Inequality Across 39 Economies. *Journal of Comprehensive Business Administration Research*. https://doi.org/10.47852/bonviewJCBAR52025028