The Nonlinear Relationship Between Income Inequality and Economic Growth: A Panel Data Analysis

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Abstract

Disparity in income levels tends to be directly proportional to the rate of growth of the economy. The Kuznets hypothesis gave this intuition its most familiar form. As economies undergo development, inequality will increase during the phase of structural transformation and subsequently will fall as industrialization and education, as well as broader economic participation, become more widespread. The findings suggest that there may not be one stable inequality-growth relationship that applies equally across countries and stages of development.

Keywords: Income inequality; Economic growth; Kuznets hypothesis; Gini index; Panel data; Fixed effects; World Bank data

Introduction:

Disparity in income levels tends to be directly proportional to the rate of growth of the economy. The Kuznets hypothesis gave this intuition its most familiar form. As economies undergo development, inequality will increase during the phase of structural transformation and subsequently will fall as industrialization and education, as well as broader economic participation, become more widespread. This story sounds interesting. However, real data has never really cooperated that well. The empirical literature indicates that there may either be a positive or negative relationship between inequality and growth.

According to Forbes (2000), there is no doubt about an estimated panel in Banerjee and Duflo (2003). The authors argue that the introduction of a non-linear specification to the multivariate model can help in elaborating the estimations. More recent work keeps the picture unsettled. Balcilar et al. (2021) found an inverted-U relationship in a semi-parametric analysis of 63 countries, but their estimated turning point was conditional on the sample and model used. Shen and Zhao (2023) likewise found that the effect of inequality on growth differs across income levels, with the negative effect concentrated more strongly at lower income levels. These findings suggest that there may not be one stable inequality-growth relationship that applies equally across countries and stages of development.

This paper returns to the question using a deliberately smaller and fully traceable dataset rather than preserving the much larger observation count in the earlier manuscript. The data come directly from two World Bank indicators. The decision has a practical consequence: the original hypothesis may or may not survive the new sample. In fact, it does not.

Research Question:

Is there a statistically significant linear and/or nonlinear association between income inequality and yearly economic growth in a ten-country panel observed 2004-2024?

Hypotheses of Research

H_0: The relationship between economic growth and income inequality is nonlinear and statistically significant.

H_1: The data do not support the existence of an inverted-U relationship between the Gini index and annual GDP growth

The researcher wanted to see whether the familiar Kuznets pattern actually appears when recent World Bank data are put through a few reasonable panel models. The analysis compares pooled and within-country estimates and then checks whether the result changes when one country at a time is removed. The researcher does not recommend treating the results as a universal rule about inequality and growth.

Literature Review:

The Kuznets Hypothesis: Kuznets (1955) proposed that inequality might initially increase and later decline as an economy moves from agriculture toward industry and more advanced forms of production. The argument was partly historical and descriptive rather than a fully specified econometric model. Later empirical work turned the idea into the familiar inverted-U test. The challenge is one of interpretation. A future astronomical detection might seem to fulfill religion's hopes. Inequality and growth may be affected simultaneously by education, access to credit, institutions, technology, labour markets, demographic changes and more.

Alternative Views: According to Galor and Zeira (1993), investment in human capital is affected by credit market imperfections. A country's growth process can be hampered when poorer households borrow to pay for schooling or for investment in some productive activity. Unlike Krugman, Forbes (2000) found positive panel estimates consistent with the idea that the short- and medium-run relationship need not look like the classical Kuznets curve. Banerjee and Duflo (2003) are especially relevant here since they show how imposing a simple functional form can be misleading. Their analysis suggests that nonlinearities matter, but it also cautions against reading a statistical curve as a complete explanation of the underlying process.

Recent evidence also shows that inequality measures and functional form are harder to ignore. Blotevogel et al. (2022) show that estimated relationships can change depending on whether inequality is measured with different Gini concepts or top-income shares. That matters for the present study because the analysis relies on the World Bank Gini index rather than a measure of top-end income concentration. Tuominen (2024) uses top 1% income shares for 137 countries, and the inequality-growth relationship varies with both the time horizon and the level of development. Their findings don't fit a single linear or quadratic narrative conveniently.

Country-specific and regional studies reach similarly mixed conclusions. Ali et al. (2024) and others investigate six South Asian nations; the relationships are S-shaped, N-shaped rather than simply inverted-U. By contrast, other recent panel evidence continues to find an inverted-U under particular specifications. The point is not that one side has finally won the debate. Rather, recent research suggests that sample selection, development level, the measure of inequality, and the time horizon can all change what the regression appears to say.

The debate is still alive in 2026. Galbraith et al (2026) interrogate seven decades of Kuznets-inspired research and argue that the curve remains a useful way of thinking about structural transformation and political economy. They also emphasize how much the empirical literature has moved on. According to Tomaskovic-Devey and Lin (2011) review, it would be beneficial to approach our paper in such a manner: rather than assuming that a Kuznets curve would appear in the data, nonetheless treat it as a hypothesis to test.

Limitations:

The present analysis is narrower than the large cross-country literature. It does not attempt to settle the theoretical debate. Instead, it asks a simpler question: when two World Bank indicators are placed together in a recent 2004–2024 panel, do the data themselves produce the inverted-U pattern predicted by the quadratic model? The answer in this sample is no.

Research Methodology:

Data Sources: To measure income inequality, we will stick to the Gini Index (World Bank indicator SI.POV.GINI), while the measure of economic growth will be annual GDP growth (World Bank indicator NY.GDP.MKTP.KD.ZG) (World Bank, n.d.). The Gini index measures inequality on a 0-100 scale, where higher values mean more inequality between a group of people (World Bank, n.d.). GDP growth is the annual percentage growth rate of GDP at market prices based on constant local currency. The two files were merged by country code and year.

Sample Construction: The study examines the time span of 2004-2024. Ten nations were retained because, across the 21 years in the downloaded files (World Bank, n.d.), they have complete paired observations for both variables. Armenia, Costa Rica, Dominican Republic, Ecuador, Georgia, Indonesia, Paraguay, Peru, Uruguay, United States. This produces exactly.

The countries were not selected because they produced a preferred statistical result. The selection was based on data completeness, which makes the sample construction reproducible. The trade-off is clear: the resulting panel is small and should not be described as globally representative. It is a deliberately transparent sample for an undergraduate empirical analysis.

Table 1: Variables

Variable	Definition	Source
GDP growth	Annual percentage growth in GDP	World Bank, NY.GDP.MKTP.KD.ZG
Gini	Gini index, 0–100 scale	World Bank, SI.POV.GINI
Gini²	Squared Gini index	Calculated from Gini
Year effects	Annual time indicators	Calculated from year

Econometric Specification: The linear pooled model is:

$$\mathbf{Growth}_{it} = \alpha + \beta_1 \mathbf{Gini}_{it} + \gamma_t + \varepsilon_{it}$$

The nonlinear specification is:

$$\boldsymbol{Growth}_{it} = \alpha + \beta_1 \boldsymbol{Gini}_{it} + \beta_2 \boldsymbol{Gini}_{it}^2 + \gamma_t + \varepsilon_{it}$$

An inverted-U requires $\beta_1 > 0$ and $\beta_2 < 0$, with a turning point inside the observed range. The turning point is calculated as $Gini^* = -\beta_1/(2\beta_2)$. A statistically significant squared term is not sufficient by itself. The signs, statistical uncertainty, and location of the turning point all matter.

Estimation and Inference: Pooled OLS is estimated with year controls. Country fixed effects are then added to absorb time-invariant differences across countries. Standard errors are clustered by country in the reported models. This choice is conservative given the repeated observations within each country. Because there are only 10 clusters, the clustered standard errors should still be interpreted cautiously. The estimates are useful for inference within this sample, but they are not equivalent to evidence from a large-N cross-country panel.

Robustness Check: A leave-one-country-out analysis re-estimates the quadratic pooled model ten times, removing each country in turn. This is useful here because one or two countries with unusual inequality or growth patterns could otherwise drive the fitted curve.

Results:

Table 2: Descriptive Statistics

Statistic	Gini	GDP growth (%)
N	210	210
Mean	41.95	4.23
SD	6.41	4.04
Minimum	25.10	−14.10
Median	41.80	4.63
Maximum	53.90	14.01

The average Gini index in the sample is 41.95, while mean annual GDP growth is 4.23 percent. Growth is considerably more volatile than the inequality measure. Essentially, the link between the Gini and a GDP growth is approximately –0.038 (close to zero before the controls come).

Table 3: Pooled Linear Model

Variable	Coefficient	Clustered SE	p-value
Gini	−0.0660	0.0298	0.027
Year effects	Yes	—	—
R^2	0.534	—	—
Observations	210	—	—

The linear model generates a tiny negative Gini coefficient that is statistically significant at the 5 percent level. This should not be interpreted as cause and effect. The Kuznets hypothesis, which is basically non-linear, is not even proved.

Table 4: Pooled Quadratic Model

Variable	Coefficient	Clustered SE	p-value
Gini	−0.2314	0.6369	0.716
$tGini^2$	0.00205	0.00802	0.799
Year effects	Yes	—	—
R^2	0.535	—	—

Observations	210	—	—

The quadratic model is the key test of the original hypothesis. It does not support an inverted-U. The linear Gini coefficient is negative and the squared term is positive. Moreover, each coefficient is statistically insignificant. Because the estimated squared coefficient is positive, the fitted quadratic is technically U-shaped. Also, its coefficients are too unreliable to consider that curvature as an empirical relationship. It can therefore be concluded that the sample does not provide any statistically convincing evidence of a Kuznets curve.

Table 5: Country Fixed Effects

Variable	Coefficient	Clustered SE	p-value
Gini	0.9668	0.5939	0.104
Gini²	−0.00973	0.00665	0.143
Country effects	Yes	—	—
Year effects	Yes	—	—
R^2	0.607	—	—
Observations	210	—	—

The fixed-effects estimates move in the direction associated with an inverted-U: the Gini coefficient. The coefficient is positive, and the squared coefficient is negative. But neither coefficient is. It is the scientist which is statistically significant. It is not the case at a 10 percent level. The apparent curvature therefore cannot be treated as evidence supporting H_0.

This contrast between pooled and fixed-effects results is useful. The relationship looks different when the model asks a different question. Pooled OLS partly reflects differences between countries, whereas fixed effects focus on changes within countries over time. With these data, the within-country evidence remains too uncertain to support a Kuznets interpretation.

Table 6: Leave-One-Country-Out Analysis

Country removed	Gini coefficient	p	Gini² coefficient	p
Armenia	−1.396	0.120	0.0157	0.139
Costa Rica	−0.192	0.777	0.0015	0.864
Dominican Republic	−0.264	0.690	0.0023	0.781
Ecuador	−0.339	0.616	0.0036	0.674
Georgia	−0.319	0.620	0.0034	0.680
Indonesia	−0.302	0.640	0.0029	0.725
Paraguay	−0.228	0.742	0.0020	0.817
Peru	−0.214	0.749	0.0018	0.832
Uruguay	−0.124	0.869	0.0007	0.944
United States	0.321	0.398	−0.0049	0.303

The exercise will not resolve the debate for each country. The significance of German contributions to the dispute about the timing of the transition is not resolved, as this (positive) coefficient does not become insignificant after removing any one country. Removing Armenia produces a negative linear coefficient with a positive squared term. Overall, the evidence is not stable enough to support the original hypothesis.

Discussion:

The result is different from what the earlier version of the paper suggested. Once I rebuilt the sample directly from the World Bank files, the inverted-U was no longer there. That was not something I wanted to force either way. The data simply gave a different answer.

There are several ways to read this. The first is simply that the Kuznets curve may not describe this particular group of countries during this period. Another possibility is that annual GDP growth is too noisy a measure to reveal a longer-run relationship between inequality and development. A third is that the Gini index captures only one dimension of distribution and may not line up closely with the mechanisms emphasized in the theoretical literature.

The fixed-effects model adds another layer. Its coefficients have the signs associated with an inverted-U, but the uncertainty is large. That suggests that within-country changes in inequality do not provide a clean enough signal in this sample. The pooled result and fixed-effects result are therefore not contradictory so much as answers to different empirical questions.

None of this means that inequality does not affect growth. The models here are fairly lean. They do not account for investment, human capital, institutions, trade, inflation, demographic changes, or financial development. Any of those factors could be related to both inequality and growth, so omitted variables remain a real concern.

Likewise, the negative linear coefficient in the pooled model should not be turned into a policy claim that reducing inequality will automatically increase GDP growth. The study identifies an association in a small selected panel. It does not identify a causal intervention.

The KZ hypothesis is unsupported when outliers are present, and conclusions of robustness should be regarded as questionable. That is a much smaller claim than saying the hypothesis is wrong in general. A different set of countries, a longer period, another measure of inequality, or a different model could give a different result.

In that sense, the null result is useful. It pushes the discussion away from treating an inverted-U as something that should appear whenever inequality and growth are placed in the same regression.

The first limitation is sample size. Ten countries and 210 observations are enough for a transparent panel exercise, but not enough to make broad global claims. The country selection is also based on complete data coverage, which may itself introduce selection into the sample.
Second, Gini observations are based on household survey information and can differ in survey concepts and comparability across countries. The annual GDP growth rate is volatile and may be impacted seriously by temporary shocks. The third story may tell a different story on longer-run growth measurement.

Additionally, since there are only ten country clusters used, cluster-robust inference must be treated with caution. Moreover, the quadratic specification is a single functional form only. By using a spline, threshold model, or semiparametric approach, one may find a shape that a single squared term cannot. Fifthly, the article does not prove causality.

Conclusion:

The question behind the paper was simple enough: does inequality rise and then fall as growth increases, as the Kuznets hypothesis suggests? In the ten-country panel used here, I cannot find convincing statistical evidence that it does.

The pooled quadratic model indicates that the linear Gini coefficient is negative while the quadratic term remains positive. Either of these two statements is statistically insignificant. The

fixed effects model gives us coefficients with opposite signs that are more consistent with an inverted U, but these coefficients also fail to achieve conventional significance. A leave-one-country-out test does not save the original hypothesis.

The findings call for some caution. Inequality and growth are shaped by far more than one variable, and a quadratic equation cannot capture all of those moving parts. A useful next step would be to work with a larger panel, more comparable inequality measures, additional controls, and perhaps lagged relationships so that the longer-run side of the question is easier to see.

The empirical analysis in this revised manuscript was reconstructed from the two World Bank files supplied for the study: SI.POV.GINI (Gini index) and NY.GDP.MKTP.KD.ZG (GDP growth, annual %). The sample was created by merging the indicators on country code and year, restricting the period to 2004–2024, and retaining the ten countries with complete paired observations for every year in that period.

The reported regressions were recalculated from those supplied files. No observations, coefficients, or p-values were invented to obtain a desired conclusion. The main empirical result is actually contrary to the original hypothesis, which is why the manuscript has been rewritten around the observed evidence.

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