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Kuznets Curve for the US: A Reconsideration Using Cosummability

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Abstract

The relationship between long-run economic growth and income inequality has gained a growing attention in economic research for over decades. This study employed advanced time series techniques to examine the existence of an inverted U-shaped long-run relationship between economic growth and income inequality. Using long-span and very recent data for the United States, for the periods 1917 to 2012, and the concept of summability, balancedness and co-summability, which was advanced to analyze nonlinear long-run relations among stochastic processes. The empirical results find no evidence in support of nonlinear long-run (inverted U-shaped) relationship for the US, but findings from vocal set of economists strongly lends the basis upon which conclusions are drawn in this study.

JEL Codes: C22, E62, F34

Keywords: Income inequality, economic growth, summability, balancedness, co-summability.

1. Introduction

A study conducted by Kuznets in 1955 is continuously referenced by most of the researches evaluating the possible relationship that flows from economic growth to income inequality and/or vice versa. Simon Kuznets carried out the study on three great industrialized economies of United States, Germany and United Kingdom, whose empirical findings was based on the hypothesis that income inequality rose at the wake of industrialization process and later declined

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as development process increased (inverted U-curve). Interestingly, Kuznets neither gave sufficient empirical evidence for testing this assumption of a long temporal change in income inequality, nor can the stages be explicitly dated. Anand and Kanbur (1993)[1] in their analysis, provided a valid explanation for this swing in income inequality for developing countries. Hence, it becomes expedient to consistently take a closer look at Kuznets study while taking caution when analyzing the relationship between income inequality and growth.

The relation between income inequality and economic growth has long been a subject of discussion among economists. Tracing this back to the 1960s, President John F. Kennedy once qualified the relationship between inequality and growth as a rising tide that lifts all boats to illustrate the idea that economic growth is beneficial to both the poor and rich in the society. In spite of this, whether the poor can access the gains of growth equally as the rich poses debatable questions. The conflicting experience in the aftermath of the Second World War between the East Asia and Latin America cannot be over-emphasized. During this period, Latin America experienced high level of income inequality and moderate growth, while the reverse was the case with East Asia, where there was a moderate level of income inequality and glowing economic growth. This however steamed up the admiration to reporting an inverse relationship between economic growth and income inequality.

Based on existing literature, there are studies conducted primarily on economic growth-income inequality relationship, which have reported extensive conflicting outcomes. These several empirical cross-country surveys chiefly include but is not limited to Alesina and Rodrik (1994), Persson and Tabellini (1994) and other studies (see Wan, Lu, and Chen, 2006; Sukiassyan, 2007; Majumdar and Partridge, 2009; Ogus Binatli, 2012; Wahiba and El Weriemmi, 2014; Hender, Qian and Wang, 2015; Tuominen 2015; 2016a, b; Babu, Bhaskaran and Venkatesh, 2016) all of which have confirmed the negative relationship. Lately, many research endeavors have found direct (positive) relationship between growth and income inequality (see Li and Zou, 1998; Forbes, 2000; Partridge, 2007; Frank, 2009; Muinelo and Roca, 2013; Chan, Zhou and Pan, 2014; Cingano, 2014; Fang, Miller and Yeh, 2015; Nahum, 2015; Rubin and Segal, 2015; Saari

[1] For interested reader see the work of Kuznets, S. (1955). Economic growth and income inequality. *The American Economic Review*, 45(1), 1-28; and Anand, S., & Kanbur, S. R. (1993). The Kuznets process and the inequality—development relationship. *Journal of Development Economics*, *40*(1), 25-52.

and Dietzenbacher, 2015; Ward and Charles, 2015). While Barro (2000) posits that the relationship between the variables is inconclusive, others found mixed relationship between economic growth and income inequality (see Chen, 2003; Voitchovsky, 2005; Shin, 2012). Notably, the empirical difference in existing datasets, estimation techniques and/or model specifications have been proposed as possible reasons for the differing results from previous studies.

The positive relationship between economic growth and income inequality is illustrated as follows. It is expected that, in a developed economies, the saving habit of the few rich (privileged) should be higher than that of the poor masses (less privileged). Thus, income re-distribution from the few rich to poor masses would automatically lower the aggregate saving rate or habit of the entire economy and by implication cause a decrease in economic growth. On the other hand, income redistribution could possibly decline incentive for the few rich to work hard, which could also cause a decrease in the level of economic growth. On this premise, it is hypothesized that income inequality at a particular time can negatively influence economic growth and other times positively influence economic growth.

In addition, the inverse relationship that has been widely assumed to exist between economic growth and income inequality can be likened to the following illustration. In most developing countries, the less privileged are not considered credit worthy, and so they do not have access to capital. Thus, this scenario incapacitates investment opportunities for the poor, while those who are extremely poor can hardly actively participate in production, thereby resulting to what is obviously an inequality gap. Hence, a decline in the level of economic growth is occasioned by income inequality which leads to social-economic and political instability. To augment this claim, Tuominen (2016a) while reassessing the relationship between economic growth and top-end inequality for 25 countries (developing and developed countries) between the periods 1920 to 2000, exploits the top 1% income distribution and addresses issues regarding nonlinearity, found that, there exist a significant negative relationship between the top 1% income distribution and economic growth, especially in developed economies, though this relationship become weaker as the quest for economic development rises. Though, there is a tendency for a positive relationship between the observed variables at the subsequent phases of development (Tuominen, 2015). Thus, it is hypothesized that income inequality at a particular time can negatively influence economic growth and at other times positively influence economic growth[2].

To the best of authors knowledge, there exist only few studies (see Robinson, 1976; Braulke, 1983; Ram, 1991; Fosu, 1993; Hsing and Smyth, 1994; Nielsen and Alderson, 1997; Jacobsen and Giles, 1998; Banerjee and Duflo, 2000; Chen, 2003; Huang, 2004; Lin and Weng, 2006; Lin, 2007; Lin, Suen and Yeh, 2007; Kim, Huang and Lin, 2011; Huang, Lin and Yeh, 2012; Lessmann, 2014), which have specifically investigated the inverted U-shaped relationship between economic growth and income inequality. Using non-parametric estimation techniques in the US for the period from 1947 to 1991, Jacobsen and Giles (1998) could not find evidence in support of Kuznets inverted U-shaped relationship between economic growth and income inequality. On the other hand, Banerjee and Duflo (2000) revealed through their cross-country analysis that economic growth is an inverted U-shaped function of income inequality. Chen (2003) documented an inverted U-shaped relationship, using Gini coefficient to proxy for income inequality and real gross domestic product (GDP) to proxy for economic growth for a panel countries 54 countries, by employing the Barro-type model over a 22 year period from 1970 to 1992. Huang (2004) employs flexible nonlinear inference method as advanced by Hamilton (2001, 2003) to examine the validity of the Kuznets hypothesis in a cross-country analysis, found an evidence in support of nonlinearity and inverted U-shaped relation between GDP per capita and inequality, thus, confirming the Kuznets hypothesis.

In contrast to the conventional parametric quadratic methods for examining Kuznets hypothesis, Lin, Huang and Weng (2006) employ semi-parametric to examine existence of an inverted U-shaped relationship between inequality and GDP per capita in a cross-country analysis and document evidence in support of Kuznets hypothesis, similarly Huang (2007) in a cross-country analysis, found that, Kuznets hypothesis only exist in countries with moderate income inequality, however, and not in countries with extremely low or extremely high income inequality. Furthermore, Huang and Lin (2007) in their empirical investigation to validate Kuznets hypothesis for 75 countries, using the data obtained from Iradian (2005) unlike the previous studies, found asymmetric relationship between GDP per capita and income inequality.

[2] There are many reasons why income inequality would negatively or positively influence economic growth. For more details see Weil (2005) and Tachibanaki (2005).

Lessmann (2014) found a strong evidence in support of an inverted U-shaped relationship between spatial inequality and economic development using the same econometric approach for 56 countries for the period from 1980 to 2009, through parametric and semi-parametric regression.

Kim, Huang and Lin (2011) using the pooled mean group (PMG) estimator as advanced by Pesaran, Shin and Smith (1999) observed a long-run equilibrium relationship between real GDP per capita and inequality for the United States. According to their findings, the relationship between inequality and per capita GDP is U-shaped rather than the conventional inverted U-shaped proposed by Kuznets hypothesis. This resonate with the findings of Huang, Lin and Yeh (2012) on the Kuznets hypothesis for the United States. Patriarca and Vona (2013) examined an inverted U-shaped relationship between structural change and income distribution, and found that in an economy where technology and preference adjust over time, several long-term growth are mostly occur due to various distributive rules controlling the task of innovative rents between entrepreneurs and workers.

It is against this backdrop that current study seeks to revisit the inverted U-shaped nexus between economic growth and income inequality for United States. Primarily, the focus of this study is to extend the work of Hsing and Smyth (1994) and Jacobsen and Giles (1998) in three ways. First of all, this study unlike the others, employed a long and relatively more recent dataset on income inequality and economic growth for the period from 1917 to 2012 using 96 observations. For a study like this, long-span data is required and will be sufficient for evaluating the inverted U-shaped relationship as it incorporates the transition processes in the economy of United States from certain stages of economic growth to its recent economic status. Secondly, other studies made use of Gini coefficient to proxy for income inequality, but current study employed six (6) measures of income distribution (Gini, Theil, Atkinson, Rmeandev, Top 10% and Top 1%) to proxy and measure income inequality. This is considered more suitable to capture the inherent existing relationships between economic growth and income inequality, at different levels of income distribution/inequality. Thirdly, to improve on the quadratic econometric techniques of Hsing and Smyth (1994), Jacobsen and Giles (1998), and other existing findings, this study evaluated Kuznets inverted U-shaped relationship using the idea of co-summability. The econometric framework behind co-summability is explained below. To examine linear relationships among continuous economic non-stationary time series data, the cointegration techniques is no doubt a perfect framework. However, the intrinsic linearity in the framework of integration and co-integration makes it inappropriate to evaluate nonlinear long-run relations among non-stationary processes, which is the case when evaluating Kuznets inverted U-curve.

In this study, the concept of co-summability proposed by Berenguer-Rico and Gonzalo (2013) is employed. The order of summability, which was introduced by Berenguer-Rico and Gonzalo (2014) to deal with nonlinear transformations of non-stationary processes. Hypothetically, it is assumed that, a co-summable relationship is balanced, when the variables under observation exhibit same order of summability and portray a long-run equilibrium relationship that are nonlinear, considering that the errors have least order of summability. Based on our knowledge, this study is the first to use the idea of co-summability to investigate and examine inverted U-shaped relationship for the United States, using a long-span and very recent time series data. Also, this study is the only one known to make use of the nonlinear econometric technique proposed by Berenguer-Rico and Gonzalo (2013) to evaluate the inverted U-shaped relationship between economic growth and income inequality. The novelty of this study lies in the application of sound, reliable and new time series econometric methods.

Basically, the analysis of this study is focused on whether there exists nonlinearity in the long-run growth-inequality relationship, without considering any issues related to direction of causality, which have no statistical soundness and validity of our research outcomes. Thus, in case of the inability to find possible evidence in support of nonlinear long-run relations between economic growth and income inequality, then conventional empirical specifications in the existing literatures adopting polynomial or threshold functions are basically misspecified. This is coupled with the fact that the causality interpretation made on those studies are probably not sound and reliable. Considering the fact that most sound academic protagonist of Kuznets inverted U-shaped hypothesis have argued that these time series providing valid evidence in support for nonlinearities in the growth-inequality nexus, empirical findings have crucial policy implications. However, the results of current study finds evidence in support for long-run relationship between income inequality and economic growth in the linear specifications for United States and not nonlinear specifications as previously claimed. It is based upon these existing empirical findings that the researchers are able to make conclusions. The findings for this study concert to the obvious consensus in the pool of existing literature that there exists a nonlinear relationship between economic growth and income inequality. However, the caution is to policymakers against undertaking any severity measures to shrink the income inequality gap in the fear of enhancing exclusion in the economy.

This study is organized in four other sections. The second section considers a detail discussion on the concept of summability, balancedness and co-summability. This is followed by the data and the empirical model used in this study. In section four, the results and empirical findings are discussed, while conclusion is drawn in the last section.

2. Methodology

In this section, the concept of summability, balancedness and co-summability method employed in our empirical analysis is explained as follows.

2.1 Summability

The idea of summability was conceived in Gonzalo and Pitarakis (2006), and recently expounded upon by Berenguer-Rico and Gonzalo (2013, 2014). According to scholars, a random process $\left(y_t\right)$ will be summable of order β, represented as $S\left(\beta\right)$, if and only if, non-random sequence $\left(m_t\right)$ exist in such a way that,

$$S_T = \frac{1}{T^{1/2+\beta}} L(T) \sum_{t=1}^{T} \left(y_t - m_t\right) = O_P(1) \text{ as T} \rightarrow \infty, \tag{1}$$

where, β denotes the least real number such that S_T is stochastically bounded, and $L(T)$ represents a slowly ranging function.

This concept generalizes the idea of integration in linear form and gives room for establishing order of summability for several nonlinear models. As expected, if a linear $\left(y_t\right)$ time series is *I*(*d*), thus, it will be summable of order *d*, that is, $S\left(d\right)$. In a situation, where time series $\left(y_t\right)$ is a nonlinear transformation, this demands the use of the concept of summability. In this empirical application, the focus is to evaluate the order of summability of the variables of interest to be incorporated in the polynomial specifications or framework.

2.2 Balancedness

Once the assumption regarding the concept of summability is established, then the balance specification or requirement of the empirical relationship that exist between the variables is then evaluated. That is, evaluating whether both parts of the empirical equation of the model maintain a matching order of summability. The empirical equation specified for the model is given as: $y_t = f(x_t, \theta)$ where y_t is assumed to be balanced, if $y_t \sim S(\beta_y)$; $f(x_t, \theta) \sim S(\delta_f)$ and $(\beta_y = \beta_f)$ Therefore, we specified the null and alternative hypothesis of balancedness as:

$$H_0 : \beta_y - \beta_f = 0$$
$$H_1 : \beta_y - \beta_f \neq 0$$

It is pertinent to observe that, under the null hypothesis of balancedness, the related confidence interval includes zero. Therefore, evaluating the variables for balancedness is crucial for the soundness and credibility of the empirical specification in this study.

2.3 Co-summability

Co-summability is a crucial pre-estimation test that should be conducted, to evaluate the validity of an empirical model specified for use along with the balancedness test. Besides, two summable random processes $x_t \sim S(\beta_x)$ and $y_t \sim S(\beta_y)$ are assumed to be co-summable, if and only if, $f(x_t, \theta_f) \sim S(\beta_y)$ in such a way that $u_t = y_t - f(x_t, \theta_f)$ is $S(\beta_u)$, where $\beta_u = \beta_y - \beta$, β is greater than zero and $(y_t, x_t) \sim CS(\beta_y, \beta)$.

However, the parametric function of $f(\cdot, \theta_f)$ can be substituted with a conventional nonlinear function. While β, β_y and β_x are unknown in application, Berenguer-Rico and Gonzalo (2014) introduced a consistent and more reliable estimator with slow convergence rate of $\frac{1}{\ln(T)}$. Considering that, the strong co-summability will indicate that, the order of summability β_u of u_t is statistically not different from zero. It is worth noticing that under the null hypothesis, we specified that, the confidence interval contains zero.

3. Data and empirical model

In this section, the data, sources of data and empirical model considered in this study are discussed. Using the assertion by Berenguer-Rico and Gonzalo (2013), the relationship between economic growth and income inequality in a polynomial form is given as:

$$y_t = \beta_0 + \beta_1 z_t + \beta_2 z_t^2 + \cdots + \beta_k z_t^k \qquad (2)$$

where, z_t is a measure of economic growth and y_t measures different levels of income distribution. It is crucial to emphasize the following points associated with equation (2) above. First, with regards to the measures chosen for z_t, the most commonly used measure of economic growth is the real gross domestic product per capita i.e. real GDP per capita. In this study, the real GDP per capita is employed to measure the level of economic growth based on data availability for the period from 1917 to 2012. Although reliable data of the real GDP is available until 2015, the data for income distribution is available up to 2012, which is probably the latest data on income distribution. Secondly, for analyzing the relationship between GDP per capita and income inequality, the order of polynomial previously used in the existing literature has either been quadratic or cubic. For quadratic (see Robinson, 1976; Banerjee and Duflo, 2000; Chen, 2003; Patriarca and Vona, 2013) and cubic (see Lessmann, 2014). In our analysis, following the methodology of Berenguer-Rico and Gonzalo (2013), we use polynomials of up to 4th order, i.e. k = 4. Thirdly, y_t and z_t are often used in their level forms (see Banerjee and Duflo, 2000; Chen, 2003; Rubin and Segal, 2015) or at times in natural logarithms forms (see Lessmann, 2014), while in other cases, they are compared both in levels and natural logarithmic transformation forms (see Muinelo-Gallo and Roca-Sagalés, 2013; Babu *et al*, 2016). Note that equation (2) allows for testing the various forms of the relationship between inequality and GDP per capita; (1) $\beta_1 > 0$ and $\beta_i = 0$, for $i > 1$, suggests a monotonically increasing linear relationship, meaning that rising incomes are accompanied by rising levels of inequality; (2) $\beta_1 < 0$ and $\beta_i = 0$, for $i > 1$, presents a monotonically decreasing linear relationship; (3) $\beta_1 > 0$, $\beta_2 < 0$ and $\beta_i = 0$, for $i > 2$, reveals an inverted-U quadratic relationship between inequality and GDP per capita, indicating that high levels of income are associated with decreasing levels of inequality once a certain level of income is reached. The peak of this quadratic curve is reached at the turning point where $z = -\beta_1/2\beta_2$; (4) $\beta_1 < 0,\ \beta_2 > 0$ and $\beta_i = 0$, for $i > 2$, suggests a quadratic relationship in U pattern; (5) $\beta_1 > 0,\ \beta_2 < 0,\ \beta_3 > 0$ and $\beta_i = 0$, for $i > 3$, indicates a cubic polynomial, representing the N-shaped pattern, where the inverted-U hypothesis occurs up to a certain point, from which inequality increases again. (6) $\beta_1 < 0,\ \beta_2 > 0,\ \beta_3 < 0$ and $\beta_i = 0$, for $i > 3$, reveals a cubic polynomial, representing the inverted-N shape.

Therefore, evaluating the inverted U-shaped relationship between economic growth and income inequality for the raw data (levels) and natural logarithm forms of real GDP per capita is done at constant 2009 US dollar values, while measuring different levels of income distribution for income inequality. The data was sought for income distribution from the work of Frank (2009)[3], inequality measures for Gini, Artkin05, RMeanDev and Theil, Top 10% and Top 1% as put together for World Wealth and Income Database (WWID), while data on real GDP per capita was obtained from Global Financial Database (GFD).

4. Results and empirical discussion

This section contains the results and discussion on the empirical findings from several estimations carried out. In order to achieve the research objective of investigating the inverted U-shaped relationship between economic growth and income inequality in United States, the idea of co-summability was adopted to choose the suitable model specification for the study data. The co-summability technique is built on two distinct tests of summability and balancedness as earlier discussed. Based on the idea of summability, an evaluation of balancedness was carried out i.e. the test for the order of summability of our dependent variable (income inequality) in a hypothesized model specification, is not different from that of the exogenous variables. On the other hand, if balancedness of the variables are confirmed, then it is not out of place to evaluate for co-summability i.e. to test whether the random term of the hypothesized model specification

[3] For an exposition on the estimation of this series and file including percentile threshold see Frank, Sommeiller-Price and Saez. Interested reader for further explanation on estimation of other measures of income share or distribution should see Frank, Mark. W. 2009 "Inequality and Growth in the United States: Evidence from a New State-Level Panel of Income Inequality Measure" *Economic Inquiry*, Volume 47, Issue 1, Pages 55-68:

is of a lower order of summability. It is crucial to bear in mind that the model specifications confirming the balancedness and co-summability existence are probably most suitable for the data.

<Insert Table 1 here>

In Table 1, the result for the order of summability is clearly captured. This result shows that the estimates are matching 95 percent confidence intervals of the order of summability over the coverage period for specified model in equation (2) for k = 4. Interestingly, the confidence intervals for the tests on real GDP per capita and on two measures of income distribution (Top 10% and Top 1%) in levels, does not include zero, thus, rejecting the null hypothesis of summability of order zero. However, the estimated orders of summability for Atkin05, Gini, Rmeandev and Theil are in contrast very close to zero. Therefore, the null hypothesis that these income distribution measures are $S(0)$ cannot be rejected. These results are almost identical to when log forms are used, with the exception of the linear term $(\ln GDP)$ which is $S(0)$ in this case. These empirical findings give prominence to the crucial persistence of the data and presents a strong incentive for the analysis over time series properties earlier posited to be of ultimate significance when evaluating the economic growth and income inequality relationships. In relation to the integrated data, there is possibility of having spurious results, if there is failure to confirm that the specified empirical models are balanced and co-summable.

<Insert Table 2 here>

<Insert Table 3 here>

In Table 2, the results of balancedness tests are contained for both levels and natural logarithms for the coverage periods in this study. For the sampled periods, results reveal that balancedness is only confirmed when data are taken in logarithms, but with a maximum polynomial order that differs from one variable to another; until k = 3 for Atkin05, that is, under linear, quadratic and cubic polynomial specifications, since zero is included in the corresponding confidence intervals; until k = 2 for Theil and Top 1%; k = 1 for Gini, Rmeandev and Top 10%. Consequently, based on these results, it is of no use to further consider the data in levels (raw data). In a nutshell, the null hypothesis of balanced specifications cannot be rejected for the specified models.

In addition, Table 3 reports the results for co-summability tests of the variables taken in natural logarithms form. Note that this table shows only the regressions for which the balancedness is achieved. For the log-transformed data, results show that co-summability is not rejected for all considered specifications except the linear form for some variables; the rejection is observed only for Theil in the case of linear form with deterministic trend and for Top 10% and Top 1% in the case of a linear form both with and without deterministic trend.

Based solely on balancedness and co-summability results, there is some ambiguity about the adequate form to use for each variable. Indeed, there exists more than one potential specification for some variables; linear, quadratic or cubic form for Atkin05; linear or quadratic form for Theil. For Top 1%, quadratic form seems to be the most appropriate (see Tuominen, 2016b) while the linear form is adequate for Gini and Rmeandev. For Top 10%, Co-summability is however rejected. In order to select, for each inequality measure, the most appropriate specification among those for which both balancedness and co-summability are achieved, we use three fitness tests for model selection; Akaike information criteria (AIC), Schwarz information criteria (BIC) and the Likelihood Ratio Test (LRT). As for the comparison between AIC and BIC, we observe that the selection results of BIC are identical with AIC, with the exception for Atkin05 inequality measure. In the case of Atkin05, despite the fact that cubic form with deterministic trend is selected by the AIC criterion, the likelihood ratio test confirms the result of the BIC criterion by not rejecting the null hypothesis of quadratic form without deterministic trend at conventional 5% level. To summarize, our results indicate that the relationship between income and inequality has generally either linear or quadratic form. Indeed, out of six measures of inequality used in this study, three among them give evidence to a quadratic relationship; quadratic form without deterministic trend for Atkin05; and quadratic form with deterministic trend for Theil and Top 1%. The measures of inequality providing evidence in favor of linear relationship with deterministic trend are Gini and Rmeandev. In addition, by analyzing the signs of the coefficient estimates for the selected quadratic regressions we found that $\beta_1 < 0$ and $\beta_2 > 0$, which implies a quadratic relationship in U pattern. Hence, there is no evidence of an inverted U-shaped relationship between income and inequality in United States.

Consequently, based on the empirical results and current findings, the researchers conclude as in Hsing and Smyth (1994) and Jacobsen and Giles (1998) that the Kuznets inverted U-shaped hypothesis is not applicable to United States. This implies that relative to Hsing and Smyth (1994) and Jacobsen and Giles (1998), using long and very recent data with advanced econometric techniques that capture nonlinearity in the long-run relationship between income inequality and economic growth, does not help with evidence in support of the inverted U-shaped curve theory.

5. Conclusion

This study employed more sophisticated econometric techniques to investigate the existence of the popular Kuznets inverted U-shaped hypothesis in the long-run equilibrium relationship between economic growth and income inequality at various measures for United States. Motivated by the plethora of controversial arguments and differing conclusions regarding the relationship between growth and inequality levels, this study employed long and very recent data to capture transformation processes of the sampled country, using the idea of co-summability, which is proposed to analyze nonlinear long-run relations among stochastic processes. The empirical results and findings, however, present no evidence in support of the Kuznets inverted U-shape for United States,

The findings challenge some of the prevailing conclusions regarding the existence of an inverted U-shaped relationship between economic growth and income inequality in the United States. However, this is not a claim that high income inequality level should not bother the policymakers or that income inequality in the short-run may not be harmful to growth. Alternatively, emphasis is placed on the absence of evidence for nonlinear methodology for the relationship between economic growth and income inequality. If the long-run relationship between economic growth and income inequality implies causality, then current empirical findings have policy implications, such that a country with negligible income inequality can influence its growth by broadening its income inequality level, while one with a high income inequality can enhance its growth by lowering its income inequality level. However, since this model did not capture a relationship of causality, then such policy recommendations should be taken with cautiousness.

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Table 1: Estimated Order of Summability

Variables	$\hat{\delta}$	I_{low}	I_{up}
Raw data			
Atkin05	0.317	-0.156	0.791
Gini	0.298	-0.118	0.714
Rmeandev	0.327	-0.182	0.837
Theil	0.314	-0.128	0.756
Top10	1.072	0.473	1.671
Top1	0.603	0.156	1.051
GDP	0.824	0.396	1.252
$(GDP)^2$	1.055	0.522	1.587
$(GDP)^3$	1.287	0.641	1.934
$(GDP)^4$	1.520	0.741	2.299

Log-transformed data

Ln(Atkin05)	0.356	-0.274	0.985
Ln(Gini)	0.291	-0.150	0.731
Ln(Rmeandev)	0.360	-0.184	0.905
Ln(Theil)	0.396	-0.033	0.826
Ln(Top10)	1.069	0.489	1.649
Ln(Top1)	0.634	0.067	1.202
Ln(GDP)	0.526	-0.026	1.079
$Ln(GDP)^2$	0.570	0.024	1.117
$Ln(GDP)^3$	0.608	0.210	1.007
$Ln(GDP)^4$	0.643	0.275	1.010

Note: $\hat{\delta}$ represents the estimated order of summability while I_{low} and I_{up} denotes lower and upper bounds of the corresponding 95 percent confidence intervals.

Table 2: Test for Balancedness

Dependent Variables	Exogenous Variables	β_T	I_{low}	I_{up}
Atkin05	GDP	-3.043	-5.235	-0.852
Atkin05	$(GDP)^2$	-5.770	-9.361	-2.179
Atkin05	$(GDP)^3$	-8.424	-13.489	-3.358
Atkin05	$(GDP)^4$	-11.047	-17.755	-4.339
Gini	GDP	-3.028	-5.004	-1.051
Gini	$(GDP)^2$	-5.755	-9.223	-2.286
Gini	$(GDP)^3$	-8.409	-13.497	-3.320
Gini	$(GDP)^4$	-11.032	-17.777	-4.286
Rmeandev	GDP	-2.802	-4.629	-0.976
Rmeandev	$(GDP)^2$	-5.529	-8.900	-2.158
Rmeandev	$(GDP)^3$	-8.183	-13.231	-3.134
Rmeandev	$(GDP)^4$	-10.806	-17.512	-4.100
Theil	GDP	-2.709	-4.529	-0.889

Theil	$(GDP)^2$	-5.436	-8.705	-2.166
Theil	$(GDP)^3$	-8.090	-12.919	-3.261
Theil	$(GDP)^4$	-10.713	-17.163	-4.263
Top10_p	GDP	-2.941	-5.015	-0.866
Top10_p	$(GDP)^2$	-5.667	-9.371	-1.964
Top10_p	$(GDP)^3$	-8.321	-13.546	-3.097
Top10_p	$(GDP)^4$	-10.944	-17.670	-4.219
Top1_ps	GDP	-3.078	-5.266	-0.890
Top1_ps	$(GDP)^2$	-5.805	-9.589	-2.021
Top1_ps	$(GDP)^3$	-8.459	-13.767	-3.151
Top1_ps	$(GDP)^4$	-11.082	-17.902	-4.262
LAtkin05	L(GDP)	**0.006**	**-0.901**	**0.913**
LAtkin05	$L(GDP)^2$	**-0.803**	**-2.035**	**0.429**
LAtkin05	$L(GDP)^3$	**-1.523**	**-3.130**	**0.083**
LAtkin05	$L(GDP)^4$	-2.207	-4.170	-0.243
LGini	L(GDP)	**-0.224**	**-1.021**	**0.572**
LGini	$L(GDP)^2$	-1.034	-1.998	-0.069
LGini	$L(GDP)^3$	-1.754	-3.093	-0.415
LGini	$L(GDP)^4$	-2.437	-4.133	-0.741
LRmeandev	L(GDP)	**-0.066**	**-0.875**	**0.743**
LRmeandev	$L(GDP)^2$	-0.875	-1.708	-0.042
LRmeandev	$L(GDP)^3$	-1.595	-2.797	-0.393
LRmeandev	$L(GDP)^4$	-2.279	-3.833	-0.724
LTheil	L(GDP)	**0.076**	**-0.872**	**1.024**
LTheil	$L(GDP)^2$	**-0.733**	**-1.650**	**0.184**
LTheil	$L(GDP)^3$	-1.453	-2.643	-0.264
LTheil	$L(GDP)^4$	-2.137	-3.700	-0.574
LTop10_p	L(GDP)	**-0.093**	**-0.836**	**0.650**
LTop10_p	$L(GDP)^2$	-0.902	-1.696	-0.108
LTop10_p	$L(GDP)^3$	-1.623	-2.760	-0.485
LTop10_p	$L(GDP)^4$	-2.306	-3.850	-0.762
LTop1_ps	L(GDP)	**0.034**	**-0.873**	**0.941**
LTop1_ps	$L(GDP)^2$	**-0.775**	**-1.652**	**0.102**
LTop1_ps	$L(GDP)^3$	-1.495	-2.738	-0.253
LTop1_ps	$L(GDP)^4$	-2.179	-3.854	-0.503

Note: $\beta_T = \delta_y - \delta_f$, δ_y and δ_f represent the estimated order of summability of the endogenous variable and the sum of the explanatory variables respectively. I_{low} and I_{up} represents lower and upper bounds of the corresponding 95 percent confidence intervals.

Table 3: Test for Co-summability

Dep. Var.	L(Atkin05)	L(Atkin05)	L(Atkin05)	L(Atkin05)	L(Atkin05)	L(Atkin05)	L(Gini)	L(Gini)	L(Rmeandev)	L(Rmeandev)
1	-3.453***	2.541*	38.306***	40.842***	-90.003	-75.259	-2.123***	1.191*	-1.756***	2.199**
T	.	0.016***	.	-0.006*	.	-0.005	.	0.009***	.	0.011***
L(GDP)	0.193***	-0.501***	-8.453***	-9.167***	31.366	26.856	0.145***	-0.239***	0.142***	-0.316***
$L(GDP)^2$	.	.	0.446***	0.495***	-3.663	-3.219	.	.	.	.
$L(GDP)^3$	.	.	.	.	0.141*	0.127	.	.	.	.
$\hat{\delta}_{\varepsilon}$	0.329	0.414	-0.070	-0.479	-0.087	-0.416	0.307	0.396	0.283	0.378
I_{low}	-0.361	-0.014	-0.933	-1.559	-0.814	-1.269	-0.297	-0.117	-0.430	-0.133

I_{up}	1.020	0.843	0.794	0.601	0.639	0.437	0.912	0.909	0.996	0.888
AIC	-0.359	-0.516	-1.296	-1.307	-1.311	**-1.315**	-1.794	**-2.008**	-1.319	**-1.503**
BIC	-0.305	-0.435	**-1.216**	-1.200	-1.204	-1.182	-1.740	**-1.927**	-1.266	**-1.423**
LRT_1		17.057***	91.984***	94.993***	95.403***	97.819***		22.508***		19.652***
LRT_2				3.009*	3.419*	5.835*				

Dep. Var.	L(Theil)	L(Theil)	L(Theil)	L(Theil)	L(Top10)	L(Top10)	L(Top1)	L(Top1)	L(Top1)	L(Top1)
1	-2.355***	7.509***	72.253***	78.479***	-0.918***	5.465***	-1.826***	6.963***	61.463***	65.898***
T	.	0.027***	.	-0.014***	.	0.017***	.	0.024***	.	-0.010**
L(GDP)	0.179***	-0.963***	-15.268***	-17.020***	-0.002	-0.741***	-0.015	-1.033***	-13.119***	-14.367***
$L(GDP)^2$			0.796***	0.917***					0.675***	0.761***
$L(GDP)^3$										
$\hat{\delta}_\varepsilon$	0.408	0.536	0.022	-0.075	1.082	0.625	0.656	1.722	0.446	0.645
I_{low}	-0.159	0.108	-0.734	-0.892	0.440	0.244	0.050	0.832	-0.241	-0.122
I_{up}	0.975	0.964	0.777	0.742	1.724	1.006	1.262	2.612	1.133	1.412
AIC	0.661	0.509	-0.555	**-0.627**	-1.053	**-1.494**	0.343	0.174	-0.845	**-0.886**
BIC	0.714	0.589	-0.475	**-0.520**	-1.000	**-1.414**	0.397	0.254	-0.765	**-0.779**
LRT_1		16.62***	118.74***	127.65***		44.30***		18.29***	116.10***	122.05***
LRT_2				8.910***						5.953**

Note: $\hat{\delta}_\varepsilon$ represents the estimated order of summability of the residual calculated from the regression $y_t = f(x_{t,}\theta_f) + \varepsilon$ as proposed by Berenguer-Rico & Gonzalo (2013), while I_{low} and I_{up} represents lower and upper bounds of the corresponding 95 percent confidence intervals. LRT_1 and LRT_2 are the likelihood ratio tests of the null hypotheses of linear and quadratic forms (without trend), respectively. ***, ** and * represent significance at the 1, 5 and 10 percent levels respectively.