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Growth Effects of Wealth Inequality Through Transmission Channels

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Abstract: In light of the substantial rise in economic inequality in recent decades across the majority of economies, the relationship between inequality and economic growth has garnered significant attention. However, the specific impact of wealth inequality through various transmission channels on growth remains underexplored. This study underscores the limitations of relying on income inequality as a proxy for wealth disparities in growth research and emphasizes the importance of addressing nonlinearities in examining the relationship between inequality and growth. It pioneers the examination of transmission channels from wealth inequality to economic growth, employing an innovative nonlinear mediation analysis that incorporates both linear and nonlinear aspects, with the Generalized Additive Method utilized for the nonlinear part. Using the wealth Gini index as the primary measure of wealth inequality across a panel of 150 countries from 1980 to 2020, the findings indicate that inequality impedes growth via the human capital, socio-political stability, consumption, and innovation channels, while it exerts a positive influence through investment. The mediation effect of the rent-seeking channel is found to be nonsignificant. Above all, the study highlights the substantial negative impact of wealth inequality on innovation, a key driver of economic growth, underscoring the importance of addressing wealth disparities in future growth analyses and policy decisions.

Keywords: wealth inequality; economic growth; transmission channels; nonlinearity

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1. Introduction

The relationship between income inequality and economic growth has long been a significant concern in development economics and has recently re-emerged as a topic of intense debate (Topuz, 2022). Piketty (2014) notes that in many advanced economies, inequality has risen notably since 1980, mainly due to surging income shares at the top 1% or even top 0.1%. This trend of growing income inequality in both developing and developed nations has sparked renewed interest in uncovering its causes and consequences (Brueckner & Lederman, 2018; Madsen et al., 2018). Over the past three decades, most countries in the Organization for Economic Co-operation and Development (OECD) have seen the income gap between the richest and poorest segments of their populations widen (Cohen & Ladaique, 2018). For instance, the earnings ratio between the top 10% and the bottom 10% in OECD nations grew from about 7:1 in the 1980s to approximately 11:1 by 2025 (World Inequality Database, 2025).

Since fostering economic growth is a primary objective of economic policy (Mankiw, 2020), it is essential to examine how economic inequality influences this process. Historically, as highlighted by Baselgia and Foellmi (2022), many economists in the latter

half of the 20th century viewed distributional differences as less significant compared to overall economic advancement. This perspective largely stemmed from the prevailing assumption of a fundamental trade-off between growth and equality (Okun, 1975). This hypothesis needs to be examined empirically using advanced methodologies and enhanced datasets—especially by exploring the underlying transmission channels.

Romer's seminal works (Romer, 1986, 1990) on endogenous growth theory identify technological innovation, human capital accumulation, investment, and market structure as pivotal drivers of economic growth. Since then, more recent theoretical developments have expanded and refined these foundations, emphasizing the multifaceted ways in which institutions, policies, and distributional factors can shape the trajectory of long-run growth. Contemporary contributions to the literature highlight how disparities in access to education and finance can influence workforce quality, while socio-political instability and rent-seeking behaviors erode the institutional environment necessary for sustained growth (Aghion & Howitt, 2009; Acemoglu & Robinson, 2012). These newer perspectives recognize that inequality may not only affect each growth determinant in isolation but can also interact with them in nonlinear complex ways, potentially reinforcing or counteracting growth-enhancing processes.

Although there is a growing body of research exploring how inequality affects growth, the results are still contradictive. This ongoing uncertainty is understandable, considering that the connection between inequality and growth is complicated by various intermediary channels that affect growth in different directions and the often overlooked nonlinear dynamics of this relationship highlighted in several studies (Banerjee & Duflo, 2003).

Building on these insights, the aim of this research is to empirically examine the impact of wealth inequality on economic growth through transmission channels—human capital, socio-political unrest, rent-seeking, consumption, innovation, and investment—and to quantify the magnitude of each channel's effect. This paper employs a nonlinear mediation analysis, which, unlike a reduced-form approach that simply relates inequality to growth, delves deeper into the underlying mechanisms, acknowledging that some channels may promote growth while others may hinder it. Additionally, it accounts for dynamic, time-lagged effects that are difficult to capture in straightforward reduced-form regressions.

This paper contributes to the literature in three ways. The first major contribution of this study is the first-time use of nonlinear regression to analyze the transmission mechanisms from economic inequality to economic growth. Despite numerous seminal studies suggesting a nonlinear relationship between inequality and growth (Banerjee & Duflo, 2003), this issue has been ignored in the previous literature in this field when examining transmission channels. On the other hand, inequality's impact on the transmission mechanisms is considered linear in the literature (Madsen et al., 2018), and moreover inference about the significance level and direction of channel variables is only possible in a linear framework. To overcome this duality, an innovative approach was employed accounting for both linear and nonlinear aspects of the analysis. This study integrated a linear method to estimate the mediation equation from inequality to the channels and a nonlinear method for the outcome equation regressing growth on inequality and channels. In the output equation, the covariates are linearly associated with growth while inequality and mediator variables are allowed in a freeform manner to be linked with growth using the Generalized Additive Method.

Secondly, this research pioneers the examination of transmission channels from wealth inequality to economic growth, using wealth Gini as the primary measure. While theoretical discussions often focus on wealth distribution, the scarcity of data has led most empirical studies to rely on income distribution as a proxy when analyzing the impact of economic inequality on growth. Aghion et al. (1999) argue that the use of proxies is essential in

empirical research due to the lack of comprehensive data on wealth distribution across many countries. Similarly, Bénabou (1996) highlights that the sparse data on wealth distribution are problematic, as wealth distribution is the determinant of outcomes in many theories. This article addresses this issue by utilizing the World Inequality Database, which offers direct and comparable data on wealth inequality, thereby eliminating the reliance on proxies. Building on the findings of Motahar and Yahoo (2025), who identified the wealth Gini coefficient as the most significant factor among 33 measures of income inequality, wealth inequality, and poverty affecting economic growth, this study adopts the wealth Gini index as the primary indicator of inequality.

Another contributing factor of this paper is that this study is the first research that empirically examines all the well-established transmission mechanisms discussed in the literature, except for the redistribution and incentivization channels. Previous studies in this field typically investigate the role of three to four channels. Furthermore, this study utilizes very comprehensive and updated datasets from various sources for 150 countries for the period from 1980 to 2020. Additionally, even the few studies that have explored the transmission channels through which economic inequality impacts economic growth, most have typically investigated only three to four key mechanisms. In contrast, this research distinguishes itself by being the first to comprehensively consider all the well-established transmission channels. This comprehensive approach enhances the depth and generalizability of the analysis and provides more holistic understanding of the issue.

The remainder of this paper is organized as follows: Section 2 reviews the relevant literature; Section 3 describes the data and outlines the methodology; Section 4 presents the empirical results and provides a robustness check; Section 5 discusses the findings of this research in comparison with the existing literature; and finally, Section 6 concludes with reflections on the limitations of the study, policy implications, and areas for future research.

2. Literature Review

2.1. Theoretical Literature Review of Transmission Channels

Numerous transmission mechanisms linking income inequality to economic growth have been identified in the theoretical literature. Some mechanisms are found to promote growth, while others dampen it, as presented in Table 1.

Table 1. Summary of growth-promoting and growth-dampening channels of inequality.

Impact	Mechanism	Source
Growth dampening	• Human capital/Education	(Galor & Zeira, 1993)
	• Socio-political unrest/Political Stability	(Alesina & Perotti, 1996)
	• Redistributive policies/Median voter/Tax level	(Okun, 1975)
	• Rent-seeking	(Murphy et al., 1993)
	• Demand/Consumption	(Krugman, 2009)
	• Technology/Innovation	(Kaldor, 1955)
Growth promoting	• Investment	(Kaldor, 1955)
	• Incentivization	(Katz, 1986)

Source: Motahar and Yahoo (2025).

In the following paragraphs, each transmission channel will be discussed in the order presented in Table 1:

Galor and Zeira (1993) contend that economic inequality hampers growth by limiting educational opportunities for lower-income families, thus decreasing the overall accumulation of human capital within an economy. This viewpoint is bolstered by findings from Aghion et al. (1999), who observe that inequality adversely affects growth in economies

that are less developed, primarily due to the lack of educational investments among poorer segments of the population. Furthermore, Barro (2000) and De Gregorio and Lee (2002) both highlight how increased inequality slows the pace of human capital accumulation, noting that educational disparities continue to perpetuate income inequality, impede economic mobility, and obstruct long-term economic growth.

The socio-political instability posits that inequality undermines economic growth by prompting individuals to engage in non-market activities such as crime, political unrest, and revolutions (Alesina & Perotti, 1996; Bénabou, 1996; Benhabib & Rustichini, 1996; Fajnzylber et al., 2002). Such instability creates a climate of insecurity and mistrust, which discourages investment and impedes long-term economic development. Additionally, inequality can weaken the enforcement of property rights, leading to reduced investment levels (Svensson, 1998; Keefer & Knack, 2002; Glaeser et al., 2003). Rodrik (1999) further elucidates that societal divisions, intensified by external shocks, can undermine economic institutions, particularly when mechanisms for resolving conflicts are frail. The fundamental importance of economic institutions such as property rights and market functionality in promoting economic development is well recognized (Acemoglu et al., 2001, 2002; Hall & Jones, 1999).

Theoretical research often highlights a negative relationship between inequality and growth through the redistribution channel, suggesting that median voters in highly unequal societies favor wealth redistribution, leading to higher taxes that may distort economic incentives and hinder long-term growth. However, this relationship is complex and bidirectional, as changes in redistribution policies can influence inequality levels, creating endogeneity issues. Additionally, higher inequality does not necessarily result in more redistributive policies, exemplified by the United States, which despite high wealth inequality, maintains relatively low effective tax rates. Studies such as Gründler and Scheuermeyer's (2018) work find only a weak correlation between income inequality and redistribution. Furthermore, public redistribution can have positive effects by providing insurance, fostering risk taking, entrepreneurship, and innovation, which may counteract its adverse impacts on economic incentives. The measurement of redistribution is also contentious, as indirect redistribution through public goods enhances social mobility and equalizes market incomes in ways that standard measures like taxes and transfers do not fully capture. Due to these complexities and methodological challenges, this research opts not to examine the redistribution transmission channel.

Economic inequality can impede growth through rent-seeking activities and power concentration among the affluent, a common issue in highly unequal societies. As wealth distribution skews toward the wealthy, they tend to use their financial leverage to sway governmental policies in their favor, engaging in rent-seeking behaviors that diminish economic efficiency and growth (Murphy et al., 1993). This empowerment enables the wealthy to secure policies that safeguard their interests, often undermining the greater good and perpetuating income disparities, thereby hindering social mobility (Acemoglu & Robinson, 2012). Such a concentration of power not only results in resource misallocation but also stifles innovation and investment by creating barriers to entry and reducing competition (Stiglitz, 2012).

Economic inequality can also restrict growth through the consumption or demand channel. When inequality is high, income tends to accumulate disproportionately among the wealthiest, diminishing the spending power of the majority who are less affluent. This skews wealth distribution results in reduced aggregate demand since lower- and middle-income households, which generally spend a higher proportion of their earnings, have less disposable income (Krugman, 2009). As a result, when wealth is concentrated at the top, the economy experiences a consumption deficit, potentially leading to lower growth rates (Stiglitz, 2012). This reduced demand affects business operations by lowering

sales and profits and discourages investment in production capacity, further slowing economic progress.

Economic inequality adversely affects research and development (R&D) as individuals with limited wealth find it challenging to finance innovative projects. The literature shows how inequality dampens the production of ideas by narrowing the market size for innovations. According to Murphy et al. (1989), reducing economic inequality can expand market size by making innovative goods available for the less affluent, thus increasing returns to innovation and encouraging further inventive activities. This scenario posits that high inequality tends to foster demand for niche, luxury products rather than mass-produced technological goods, discouraging innovation.

From a Keynesian consumption model and classical economic theory perspective, economic inequality might positively affect growth by increasing total savings, which can be directed into investments—one of the pivotal factors in endogenous growth models. The theory suggests that wealthier individuals, possessing a higher marginal propensity to save, contribute to greater overall savings in more unequal societies (Kaldor, 1955). These accumulated savings could be then invested in productive ventures, fostering economic growth through enhanced capital accumulation (Bourguignon, 1981).

The incentivization channel suggests that economic inequality might spur growth by motivating individuals to invest in their human capital and innovate to achieve higher earnings. This theory argues that disparities in wealth and income establish a hierarchy of economic incentives, promoting entrepreneurial endeavors and enhancing efforts in education and the workplace. Mirrlees (1971) initially introduced this idea in the context of optimal labor income taxation, emphasizing how visible financial incentives could enhance productivity and lead to significant technological progress. The prospect of substantial financial rewards encourages personal and business risk taking, which can drive efficiency improvements and overall economic development, thus supporting the notion that a certain degree of inequality may be necessary to maintain economic dynamics and growth. However, the lack of a specific index in the literature to measure the incentivization channels precludes the empirical examination of this transmission mechanism in this study.

2.2. Empirical Literature Review of Inequality–Growth Nexus

Alongside theoretical studies on transmission channels, empirical studies examining the inequality–growth nexus yield widely divergent conclusions: some report positive effects, and others find negative or insignificant relationships (Baselgia & Foellmi, 2022; Mdingi & Ho, 2021). Research by Braun et al. (2020) tested the main prediction of their model regarding the impact of income inequality on growth at different levels of financial development. Utilizing pooled ordinary least squares (OLS), dynamic panel, and instrumental variable (IV) estimations on data from 150 countries between 1978 and 2012, they found that greater income inequality is associated with lower economic growth. Similarly, Royuela et al. (2018) examined the income inequality–growth relationship in over 200 regions across 15 OECD countries from 2003 to 2013. Their study revealed a generally negative association between inequality and growth within OECD regions. In a recent investigation, Breunig and Majeed (2021) re-examined the impact of inequality on economic growth in 152 countries using the Generalized Method of Moments (GMM) from 1956 to 2011, finding that inequality negatively affects growth. Similarly, Policardo and Sanchez Carrera (2024) utilize wealth inequality data for France in the period from 1970 to 2014, finding that wealth inequality negatively impacts economic growth.

Conversely, several studies have reported a positive relationship between income inequality and economic growth across multiple countries. For instance, Acheampong et al. (2023) employed the Quantile-on-Quantile Regression (QQR) method to analyze the

relationship between income inequality and economic growth. Their results reveal that income inequality has a significant positive effect on economic growth in Russia, China, and South Africa. Similarly, Scholl and Klasen (2019) built their methodology on the framework established by Forbes (2000), applying it to a dataset covering 122 countries from 1961 to 2012. Employing estimation methods like fixed effects (FE), GMM, and IV, they identified a positive relationship between inequality and growth. On the other hand, Benos and Karagiannis (2018) investigated the relationship between top income inequality and growth in the United States, considering the roles of physical and human capital accumulation. Utilizing two-stage least squares (2SLS) and GMM on annual state-level panel data from 1929 to 2013, they concluded that changes in inequality do not significantly impact growth.

A major reason for these conflicting findings is the failure to account for nonlinearity, as well as limitations stemming from data comparability and reliance on proxies. Imposing a linear specification can mask nonlinear dynamics, as shown by research revealing inverted U-shaped relationships (Banerjee & Duflo, 2003; Chen, 2003). Data limitations further complicate matters: older datasets often contain discontinuities or measurement errors, making cross-country and temporal comparisons unreliable (Atkinson & Brandolini, 2006). Finally, many studies regress growth directly on inequality, overlooking how inequality operates through transmission channels such as human capital, innovation, and socio-political stability. Addressing these shortcomings—particularly by using more reliable inequality indicators, exploring nonlinearities, and investigating mediating mechanisms—could reconcile many of the contradictory findings in this literature.

In conclusion, there are two important points to consider. First, in the examination of the mediation effects of various channels on how economic inequality impacts growth, employing wealth inequality measures rather than income distribution measures can enhance the depth and relevance of the analysis. Wealth inequality more accurately captures disparities in access to education and developmental opportunities than income inequality. Families with greater wealth can afford better educational opportunities, leading to a more stratified society where human capital development is uneven (Becker & Tomes, 1986). Additionally, wealth distribution influences investment patterns more directly than income distribution because investment decisions are typically made from existing assets rather than from flows of income (Dynan et al., 2004). In general, wealth provides a more stable measure of economic power and potential, which is crucial for analyzing the structural components of economic inequality and their broader impacts on society. Thus, studies like the works of Piketty (2014) and Saez and Zucman (2014) argue for a focus on wealth measures to fully grasp the implications of economic disparities.

Second, the moderating role of credit markets is essential in defining the relationship between economic inequality and growth. Efficient and inclusive credit markets help alleviate the negative effects of inequality by providing vital financial resources to individuals across all income levels. This access allows those from lower socio-economic backgrounds to invest in educational and entrepreneurial endeavors, thus offsetting some of the adverse effects of inequality on growth (Galor & Zeira, 1993; Banerjee & Newman, 1993).

3. Methodology

3.1. Data

In this study, panel data from 150 countries[1] are utilized covering the period from 1980 to 2020. For the wealth Gini coefficient, the primary independent variable, data from the World Inequality Database (WID), is utilized, established by Atkinson, Piketty, Alvaredo, Saez, and Zucman in 2011. WID is designed to map the distributions of income and wealth, primarily using tax statistics—a method sometimes critiqued by economists for potential under-reporting by individuals seeking to minimize tax payments. To address

these concerns and improve the accuracy of wealth distribution measurements, the creators of WID have enriched their datasets with extensive details on both capital and non-capital assets. These methodological enhancements address the typical challenges associated with tax data and allow for the inclusion of capital income in assessing income and wealth distributions.

The wealth Gini coefficient used in this research quantifies the inequality in net personal wealth distribution among adults, calculated on an equal-split basis. Net personal wealth is defined as the sum of personal non-financial assets (such as real estate and tangible goods) and personal financial assets (like stocks and savings), minus personal debt. The equal-split method assumes that wealth is shared equally among adult household members, so total household wealth is divided equally among all adults.

For selecting an indicator to proxy for innovation, the options were limited given the long time span and large sample of countries. Among domestic stock of knowledge, R&D intensity, and patent stock, the latter was chosen due to its lower incidence of missing values in the dataset.[2] Data concerning the dependent variable, real gross domestic product (GDP) per capita growth, were obtained from the World Bank. The sources and descriptions of the transmission channel variables and control variables are detailed in Tables 2 and 3, respectively.

Table 2. Description of transmission channel variables.

Index	Description or Proxy	Data Source
Human capital	Average years of education	Barro-Lee
Socio-political unrest	Political stability and absence of violence	World Bank
Rent-seeking	Power distributed by socio-economic position	World Bank
Consumption	Final consumption expenditure (% of GDP)	World Bank
Innovation	Patent application stock by residents	World Bank
Investment (%GDP)	Total value of the gross fixed capital formation and changes in inventories and acquisitions less disposals of valuables (% of GDP)	World Bank

Source: Current research.

Table 3. Description of control variables.

Index	Description or Proxy	Data Source
FDI	Foreign direct investment, net inflows (% of GDP)	World Bank
Financial Development	Private credit by deposit money banks and other financial institutions to GDP (%)	International Monetary Fund
Price Level of Investment	Price level of capital formation	Penn World Table
Inflation	Inflation, consumer prices (annual %)	World Bank
Working Age Population (%)	Population ages 15–64 (% of total population)	World Bank
Trade (%GDP)	Sum of export and import goods and services (% of GDP)	World Bank
Initial Income	Real GDP per capita with five-year lag	World Bank
Government Effectiveness	Average of the values of the following measures: perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies	World Bank

Source: Current research.

3.2. Baseline Model

This section outlines the dynamic models utilized to empirically examine the mediation effects of various transmission channels from wealth inequality to economic growth. As detailed in the basic model below, this methodology employs a linear regression for the mediation equation, consistent with previous empirical works (e.g., Gründler & Scheuermeyer, 2018; Madsen et al., 2018; Berg et al., 2018) that examined the impact of inequality on transmission mechanisms linearly. This linear examination allows us to make inferences about the significance levels in the mediation equation.

Additionally, aligning with studies that have identified a nonlinear link between inequality and growth (Banerjee & Duflo, 2003), the analysis employs a nonlinear regression for the outcome equation using spline functions for the inequality and channel variables. This method permits the independent variable and mediators to impact the target variable in a flexible, nonparametric manner. This flexible modeling approach captures the complex dynamics of this relationship while allowing us to make inferences about the sign and magnitude of the mediation effects.

Basic model:

$$\text{Mediation equation}: \ M_{it} = \alpha_i + \lambda_t + \beta W_{it} + \gamma Y_{it} + u_{it} \tag{1}$$

$$\text{Outcome equation}: \ y_{it} = \alpha_i + \lambda_t + s(W_{it-5}) + s(M_{it-5}) + \gamma Y_{it} + u_{it} \tag{2}$$

where

- M_{it}: The mediator variable (transmission channel) as brought up in Table 2.
- α_i: Country fixed effects.
- λ_t: Time-specific effects.
- W_{it}: Wealth Gini.
- Y_{it}: Initial income variable equivalent to GDP per capita of each country.
- y_{it}: Dependent variable or real GDP per capita growth.
- $s(W_{it-5})$, $s(M_{it-5})$: The smooth function of W and mediator variables indicating nonlinear effects.

Following the empirical growth literature, the initial income at the beginning of the 5-year period is used to control differences in living standards, and the 5-year average for all other variables is used to filter out business cycle fluctuations. The independent variable, wealth Gini, is integrated into all models with a five-year lag. In the basic model, the initial income is the only control variable. Consistent with the literature, the analysis incorporates the channel variables of investment, human capital, and innovation, each with a five-year lag, in the output model, while channels rent-seeking, socio-political unrest, and consumption are included without lag.

Given the dependency of inequality on the political and institutional contexts of countries, omitting growth-promoting covariates in the initial estimation model might lead to biased coefficients. To mitigate this, another model was defined, which includes several standard covariates commonly used in previous studies, excluding those that overlap with the transmission channels, as brought up in Table 2. This approach allows us to compare the outcomes from the basic growth model with those from the extended model.

Extended model:

$$\text{Mediation Equation}: \ M_{it} = \alpha_i + \lambda_t + \beta W_{it} + \gamma_1 (W_{it} \times F_{it}) + \gamma_2 F_{it} + \gamma_3 Y_{it} + u_{it} \tag{3}$$

$$\text{Outcome Equation}: \ y_{it} = \alpha_i + \lambda_t + s(W_{it-5}) + s(W_{it-5} \times F_{it}) + s(M_{it-5}) + \gamma_1 F_{it} + \gamma_2 Y_{it} + X_{it}\Gamma + u_{it} \tag{4}$$

where

- M_{it}: The mediator variable or transmission channel as brought up in Table 2.
- α_i: Country fixed effects.
- λ_t: Time-specific fixed effects.
- W_{it}: Independent variable wealth Gini.
- y_{it}: Target variable real GDP per capita growth.
- $s(W_{it-5})$: Smooth function of W_{it-5}, indicating nonlinear effects.
- $s(M_{it-5})$: Smooth function of mediator variable.
- $s(W_{it-5} \times F_{it})$: Smooth function of interaction term.
- F_{it}: Financial development.
- Y_{it}: Initial income.
- X_{it}: Control variables as brought up in Table 3.

Both models employ OLS to estimate the mediation equation and the Generalized Additive Method for the outcome equation.

3.3. Mediation Analysis Algorithm

In this study, the causal mediation analysis (Tingley et al., 2014) introduced by Imai et al. (2010) is employed. This new algorithm offers two principal advantages over the well-known mediation method introduced by Baron and Kenny (1986), which has been the common methodology utilized for mediation analysis in this field. Firstly, this method is capable of estimating nonlinear relationships. Secondly, it allows for the analysis of nonparametric models. Let $M_i(t)$ represent the potential value of a mediator of interest for unit i when the treatment status is $T_i = t$. Let $Y_i(t, m)$ represent the potential outcome that would occur if the treatment and mediating variables were set to t and m, respectively. Consider a standard experimental design in which only the treatment variable is randomized. Only one of the potential outcomes is observed, with the outcome, Yi, equal to $Y_i(T_i, M_i(T_i))$, where $M_i(T_i)$ is the observed value of the mediator Mi. In this context, the total unit treatment effect can be expressed as follows:

$$\tau_i \equiv Y_i(1, M_i(1)) - Y_i(0, M_i(0)) \tag{5}$$

This total effect can be decomposed into two components. First, the causal mediation effects are represented as

$$\delta_i(t) \equiv Y_i(t, M_i(1)) - Y_i(t, M_i(0)) \tag{6}$$

for each treatment status $t = 0, 1$. All other causal mechanisms can be represented by the direct effects of the treatment as

$$\zeta_i(t) \equiv Y_i(1, M_i(t)) - Y_i(0, M_i(t)) \tag{7}$$

for each unit i and each treatment status $t = 0, 1$. Together, they sum to the total effect,

$$\tau_i = \delta_i(t) + \zeta_i(1 - t) \tag{8}$$

for $t = 0, 1$. The Average Causal Mediation Effects (ACME) $\overline{\delta}(t)$ and the Average Direct Effects (ADE) $\overline{\zeta}(t)$ represent the population averages of these causal mediation and direct effects.

3.4. Generalized Additive Method

Generalized additive models (GAMs) expand upon standard linear regression models. In a standard linear regression model, a linear relationship is established between the dependent variable y and the predictor matrix X. This relationship is generally expressed as shown in Equation (10):

$$\mu = \beta_0 + \sum_{i=1}^{p} \beta_i X_i \quad (9)$$

where

$\mu =$ expected value of y;
$\beta_0 =$ intercept;
$\beta_i =$ coefficient of i predictor variable;
$X_i =$ value of i^{th} predictor variable;
$p =$ number of predictor variables.

These are extended to generalized linear models (GLMs), which include other types of distributions and a link function g(.) that connects the mean μ to the linear predictor variables. Consequently, the functional form of a GLM is as presented in Equation (11).

$$g(\mu) = \beta_0 + \sum_i \beta_i X_i \quad (10)$$

Generalized additive models extend GLMs by incorporating nonlinear forms of predictor variables. Essentially, they permit nonlinear functions for the predictor variables while maintaining additivity. These nonlinear predictors connect to the expected value of the response variable through an appropriate link function, and are thus expressed as

$$g(\mu) = \beta_0 + \sum_i \alpha_i f_i(X_i) \quad (11)$$

where $f_i() = i^{th}$ basis function and $\alpha_i =$ parameter for i^{th} basis function.

Typically, GAMs consist of a sum of smooth functions of the predictor variables. The shape of these functions is data-driven, thus eliminating the need for prior assumptions about the functional form of the error distribution. Various types of smooth functions, including piecewise linear smoothers, penalized regression splines, and smoothing splines, can be utilized. The standard form of a GAM using smoothing splines is

$$y = \beta_0 + \sum_{X \in A} \beta_i X_i + \sum_{X \in B} S_j(X_j) + \varepsilon \quad (12)$$

where β_0 represents the intercept; β_i are the coefficients to be estimated for the predictors ($X \in A$) modeled parametrically; and S_j are smoothing functions for covariates, shaped based on the data from predictors ($X \in B$) modeled nonparametrically. Each smoothing function S_j operates within a space known as the basis, and the functions within this space are termed basis functions. The relationship between a smoothing function and its basis functions is depicted in Equation (13).

$$S_j(x) = \sum_{k=1}^{K} b_k(x)\gamma_k \quad (13)$$

where γ_k are the coefficients that need to be estimated, and $b_k(x)$ are basis functions defined by a sequence of K knots, known as the basis dimension. The choice of basis dimension determines the maximum degrees of freedom possible for the model term. The actual effective degrees of freedom are derived from the data using smoothness selection criteria, such as Generalized Cross-Validation, but the maximum limit is $K - 1$. The effective degrees of freedom (EDFs) reflect the smoothness of the curve, which is influenced by the

smoothing parameter. The value of EDF ranges from 1 to K − 1 (or K). It would be 1 if the curve is heavily penalized to resemble a simple linear curve (Hastie & Tibshirani, 1986).

4. Results

This study seeks to answer the following research question: how does wealth inequality influence economic growth through various transmission channels—specifically human capital, socio-political unrest, rent-seeking, consumption, innovation, and investment—and to what extent does each channel impact growth?

To address the research question, the mediation function in R developed by Imai et al. (2010) is utilized. This function is specifically designed to calculate and display the direct and mediated effects, while it does not provide estimations for covariate coefficients. Furthermore, due to the adoption of a nonlinear regression method in the output model, estimating coefficients for the direct effect of inequality on growth does not yield meaningful results and, therefore, these are not reported in the findings. By incorporating fixed country and time effects, unobserved heterogeneity and temporal trends are controlled. The employment of spline functions within the output model facilitates the capture of the nonlinear impacts of inequality and mediators on economic growth. To facilitate comparability, all the independent variables were standardized to have a mean of zero and a standard deviation of one.

Before turning to the mediation analysis, it is instructive to discuss some key features of the data. The descriptive statistics in Table 4 highlight important characteristics of the variables. Wealth Gini, the main independent variable, averages 0.75 with a standard deviation of 0.08, indicating significant disparities in wealth distribution. Similarly, the wealth top 1% share averages of 29%, underscoring the concentration of wealth among the wealthiest segments of the population globally. Average years of education, the proxy of human capital, is relatively consistent across countries, with a mean of 7.15 years and a standard deviation of 3.14. Political stability, with a mean value of −0.20 and a standard deviation of 0.94, suggests variability in the socio-political climate across the sample. The rent-seeking variable shows an average of 0.49 with a standard deviation of 0.29, reflecting the uneven distribution of influence within societies. Consumption, expressed as a percentage of GDP, averages 76.65% with moderate variability. Patent stock, an indicator of innovation, exhibits a high mean of 6441.56 but also displays considerable disparity with a standard deviation of 49055.19. Finally, investment, measured as a percentage of GDP, averages 22.59%, reflecting its role as a crucial driver of economic growth, with a higher correlation with growth.

Table 4. Description of Statistics.

Variables	Mean	Min	Max	Standard Deviation	Correlation with Target Variable	No. of Observations
Real GDP per capita Growth	1.64	−31.53	35.36	4.09	1.00	5541
Wealth Gini	0.75	0.42	1.00	0.08	−0.00	3900
Wealth Top 1%	0.29	0.09	0.52	0.09	−0.03	3900
Initial Income	8164.77	34.38	117,143.71	14,244.32	−0.01	5541
FDI	3.75	−6.30	267.61	10.67	0.06	6150
Human Capital	7.15	0.34	13.9	3.14	0.13	5944

Table 4. *Cont.*

Variables	Mean	Min	Max	Standard Deviation	Correlation with Target Variable	No. of Observations
Trade Openness	78.23	0.02	510.86	51.47	0.05	4521
Investment	22.59	−4.62	107.09	9.23	0.16	5330
Working Age Population %	60.51	46.08	86.08	7.07	0.18	6150
Government Effectiveness	−0.06	−2.58	2.47	1.0	0.12	6150
Financial Development	41.88	0.00	231.23	38.42	0.05	5201
Inflation	57.92	−5.9	6424.99	305.96	−0.27	4612
Price Level of Investment	0.51	−0.09	22.11	0.67	−0.10	6150
Political Stability	−0.20	−2.83	1.68	0.94	0.11	3750
Rent-seeking	0.49	0.00	1.00	0.29	−0.04	4667
Consumption	76.65	50.00	128.04	21.83	−0.08	5415
Innovation	6441.56	0.00	1,211,265	49,055.19	0.05	3101

Source: Current research.

Having established an overview of the dataset, the subsequent analysis focuses on the mediation effect estimations. Table 5 presents the results for both the basic and extended models, illustrating how wealth inequality influences economic growth through the posited channels.

Table 5. Causal mediation estimations for basic and extended models for independent variable real GDP per capita growth and dependent variable wealth Gini.

Transmission Channel	Basic Model			Extended Model		
	Coefficient	95% CI, Lower	95% CI, Upper	Coefficient	95% CI, Lower	95% CI, Upper
Human capital	−0.005	−0.080	0.6	−0.025 ***	−0.086	−0.002
Soc-pol unrest	−0.284 ***	−0.453	−0.02	−0.291 ***	−0.422	−0.09
Rent-seeking	0.002	−0.010	0.04	−0.122	−0.377	0.40
Consumption	−0.019	−0.056	0.23	−0.110 ***	−0.359	−0.02
Innovation	−0.337 ***	−0.7359	−0.19	−0.309 ***	−0.606	−0.07
Investment	0.344 ***	0.123	0.43	0.206 ***	0.125	0.34

Note: *** $p < 0.01$.

Human capital, represented by average years of education, shows varying impacts on GDP growth across the two models. In the basic model, its impact is not statistically significant, whereas in the extended model, a significant negative effect is observed. However, the inclusion of control variables in the extended model provides more accurate regression estimations, making its results more reliable. Therefore, if the robustness check confirms the results from the extended model, it can be concluded that wealth inequality has a significant negative impact on growth through the channel of human capital. This finding would indicate that inequality hinders human capital development by denying lower-class individuals access to quality education and training, resulting in reduced long-term growth.

The significant negative coefficients for socio-political unrest in the basic and extended models suggest that inequality may also impede growth by increasing political and social instability. If inequality is coupled with low rates of social mobility, individuals might

resort to criminal activities rather than pursuing work or education (Alesina & Perotti, 1996). On the other hand, the rent-seeking indicator shows no significant impact in the basic model but displays a wide range of effects in the extended model. This underscores the complexity of how power, distributed by economic affluence, influences different economies. Since the confidence interval in both models includes zero, these findings suggest that the rent-seeking channel has no significant effect.

The consumption mediator negatively and significantly impacts real GDP per capita growth in the extended model. It can be inferred that wealth concentration at the top results in lower aggregate consumption for lower- and middle-class individuals, which weakens overall consumer demand and slows economic growth (Kumhof et al., 2015). Similarly, innovation, measured by patent stock, consistently shows a negative impact on economic growth in both models. This means that higher wealth inequality hampers the development of innovative products, ultimately leading to slower economic growth. The broad range of confidence intervals for this effect highlights the complexity of this relationship and the heterogeneity of impacts across different countries. Lastly, the investment mediation channel is the only channel in this study that demonstrates a robust positive impact on GDP growth across both models, empirically supporting the theoretical literature suggesting a positive impact from inequality on growth via investment, due to wealthier individuals having a higher propensity to save and invest (Kaldor, 1957).

Figure 1 presents the results of the mediation analysis for the transmission channels explored in this paper within the extended model. The horizontal marks indicate the estimated impacts of each transmission mechanism, while the vertical lines represent their respective confidence intervals. This study identifies significant negative effects of inequality on growth through the transmission channels of human capital, socio-political unrest, consumption, and innovation, and a positive effect through investment. The estimates for rent seeking were, however, found to be insignificant.

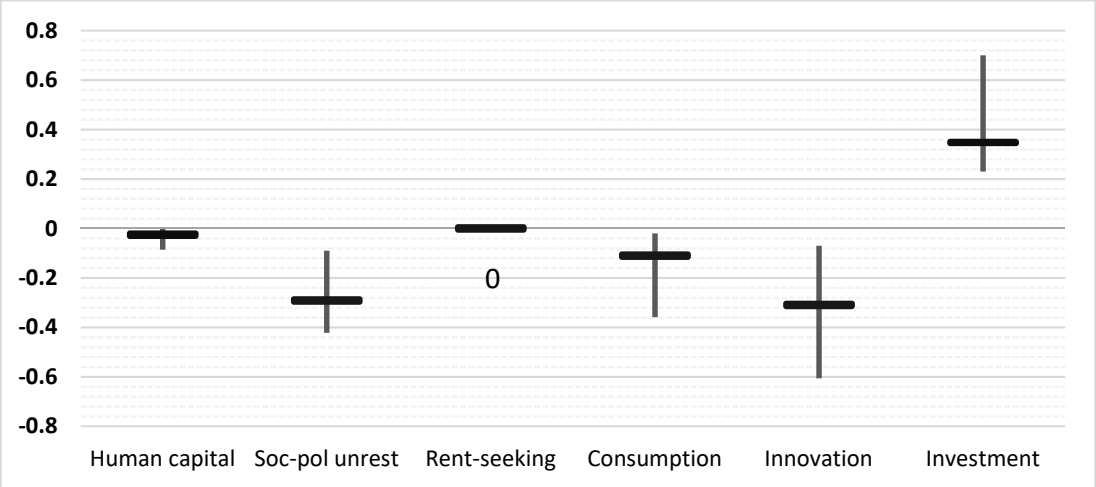


Figure 1. Causal mediation estimations of semi-specified models for independent variable real GDP per capita growth and dependent variable wealth Gini.

In this research, the innovation channel demonstrates the most substantial negative impact among the examined transmission mechanisms. This finding is crucial, as innovation is considered a fundamental driver of economic progress within economic growth theories. Theories by Aghion and Howitt (1992) emphasize that innovation leads to new technologies and productivity enhancements, which are essential for sustainable economic growth. The negative influence of wealth inequality on this channel suggests that resource concentration may restrict broad participation in innovative activities as well as shrinking the market size

for innovative goods. This likely hinders investments in high-risk, innovative ventures, which are vital for technological advancements and economic diversification (Romer, 1990).

Comparing the effects of income inequality and wealth inequality on economic growth and their transmission mechanisms, the results indicate that while both forms of inequality negatively impact growth via most of the transmission mechanisms, they do so through different channels and with varying magnitudes. Specifically, income inequality exerts a stronger negative influence on growth through human capital accumulation (Galor & Moav, 2004) and consumption (Stiglitz, 2012), suggesting that disparities in income more directly restrict access to education and reduce aggregate demand. However, the findings of this research suggest that wealth inequality has a more pronounced adverse effect on growth via innovation and socio-political stability, highlighting how concentrated wealth can hinder technological progress and exacerbate social tensions.

Robustness Check

In order to ensure the robustness of the results concerning the mediation effects of various socio-economic channels on economic growth, an additional analysis is performed by using a different wealth inequality measure, namely top 10% wealth, and performing the same estimation procedures as for the initial estimations. Top 10% wealth measures the share of net wealth of the wealthiest top 10 percent of society to the total wealth in each country. This measure is chosen following the finding of Motahar and Yahoo (2025) that wealth Gini beside top 10% wealth inequality are the most important inequality measures impacting growth across all clusters of countries. Table 5 presents the outcome of the robustness check.

The findings from the robustness check largely corroborate those of the initial analysis, underscoring the consistency of key effects across the model specifications. The robustness checks confirm the negative impact of human capital on growth, as initially observed in the extended model, with statistically significant results. The coefficient in the basic model here also becomes significant, supporting the inference of a negative relationship through this mediation channel. The results for the socio-political unrest channel remained consistent with the initial estimations in both models. The outcomes for the rent-seeking measure continue to show no significant impact. Regarding consumption, its negative effect on growth was slightly reduced here in the extended model but remained significant. In terms of innovation and investment, both maintained their negative and positive impacts on growth, respectively.

5. Discussion

Our findings examining various transmission channels in the inequality–growth nexus largely align with the empirical literature, which predominantly utilizes income inequality measures rather than wealth inequality and primarily employs linear panel regression methods.

Examining economic inequality's influence on growth through wealth inequality measures rather than the more commonly used income inequality measures provides several advantages. A major body of theoretical research underscores that wealth provides a more accurate gauge for assessing the effects of inequality on economic growth than income (Aghion et al., 1999). One key reason is that wealth—encompassing a broad range of income-generating assets—tends to be more stable than income. Additionally, because it can be inherited and accumulated over time, wealth can entrench socio-economic divisions across generations, serving as a significant transmission channel from inequality to growth. Moreover, wealth inequality has a more direct impact on investment decisions and saving behaviors than income inequality (Dynan et al., 2004). Despite theoretical arguments

suggesting that wealth inequality is a superior determinant of growth, its influence has rarely been examined empirically. To the best of our knowledge, this is the first empirical study to investigate the impact of wealth on economic growth through the transmission channels. In addition, this research extends this body of literature by employing an innovative nonlinear mediation analysis framework. This methodological advancement allows us to uncover nonlinear relationships and interaction effects that might be obscured in linear analyses. Moreover, by considering a broad panel of 150 countries over four decades, the analysis accounts for diverse economic contexts and institutional settings, providing a more comprehensive understanding of how economic disparities influence growth through various channels.

Comparing the results from the literature with those found in this study, the notion that inequality constrains economic growth by hindering human capital accumulation is broadly consistent with a diverse body of the empirical literature that employs varying measures of inequality and different econometric techniques. For instance, Madsen et al. (2018), using a panel of OECD countries and both OLS and two-stage least squares (2SLS) regressions, find that higher inequality suppresses average years of schooling and lowers GDP growth rates. Similarly, in a study by Chroufa and Chtourou (2024) examining 12 MENA countries from 2000 to 2019, inequality was found to negatively impact human capital by restricting access to essential services like education and healthcare, thereby diminishing skill development, reducing productivity, and ultimately hindering economic growth. Our extended model findings in Tables 5 and 6 similarly show a significant negative effect of wealth inequality on human capital, underscoring how concentrated wealth can undermine educational access and long-term growth.

Table 6. Causal mediation estimation; basic and extended models for independent variable real GDP per capita growth and dependent variable wealth top 10.

Transmission Channel	Basic Model			Extended Model		
	Coefficient	95% CI, Lower	95% CI, Upper	Coefficient	95% CI, Lower	95% CI, Upper
Human capital	−0.441 ***	−0.625	−0.19	−0.399 ***	−0.736	−0.11
Soc-pol unrest	−0.055 **	−0.202	−0.031	−0.060 ***	−0.225	0.17
Rent-seeking	0.150	−0.126	0.34	0.133	−0.012	0.32
Consumption	0.0580	−0.207	0.29	−0.086 ***	−0.190	−0.03
Innovation	−0.440 ***	−0.625	−0.19	−0.399 ***	−0.736	−0.11
Investment	0.094 ***	0.016	0.19	0.077 *	−0.0201	0.12

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Empirical studies also majorly support this finding that economic inequality fosters socio-political instability, thereby dampening growth. For example, Alesina and Perotti (1996) employ cross-country panel data and three-stage least squares (3SLS) regressions, using income inequality measures and political unrest indices, such as riots and coups, to illustrate how inequality destabilizes society, leading to lower growth rates. Our results in Tables 5 and 6 reinforce this conclusion, as socio-political unrest remains a significant negative channel under both wealth Gini and top 10% wealth measures. The results of this research indicate a nonsignificant effect of wealth inequality on growth via rent seeking; however, several empirical studies using varied proxies and econometric methods highlight the potentially growth-damaging role of rent seeking. Facchini et al. (2024) analyze panel data from 114 countries spanning 1990–2020 using a two-way FE technique. They demonstrate that income inequality leads to rent-seeking behaviors that divert resources

from productive investments, thereby negatively impacting economic growth. In contrast, Tables 5 and 6 in our study show no statistically significant effect for the rent-seeking channel, suggesting that such behavior might not universally emerge across different contexts.

In line with the outcomes of this research, recent empirical studies investigating the relationship between inequality and economic growth emphasize that higher levels of income inequality can negatively impact aggregate consumption and, consequently, economic growth. For instance, Ostry et al. (2014) demonstrate that greater income disparity reduces overall consumption demand, as lower-income households, which have a higher propensity to consume, are constrained in their spending, resulting in lower growth. Our extended model (Tables 5 and 6) supports this view by highlighting a negative and significant consumption channel, indicating that concentrated wealth dampens aggregate demand.

This outcome that wealth inequality hampers economic growth by restricting innovation is well supported by a range of empirical studies employing diverse methodologies and indicators. For example, Murphy et al. (1989) utilize cross-country panel data, measuring income distribution through Gini coefficients and innovation via industrialization metrics and patent registrations. Their analysis reveals that higher inequality limits the incentives and resources necessary for widespread R&D investment and technological advancement, thereby slowing growth. Similarly, Madsen et al. (2018) assess the impact of inequality on innovation, proxied by R&D expenditures and patent applications. Their results demonstrate a significant negative relationship between income inequality and innovation outputs, supporting the notion that concentrated wealth undermines the development and diffusion of new technologies. Our own findings in Tables 5 and 6 show innovation to be the strongest negative channel, confirming that high wealth inequality can stifle broad-based technological progress.

Although this study identifies the investment channel as a positive transmission mechanism, empirical evidence yields inconclusive results. Forbes (2000) employs panel regressions on a broad cross-country dataset, utilizing income-based inequality measures such as the Gini coefficient and top income shares. He identifies a positive relationship between income inequality and investment rates leading to higher growth rates. In contrast, Barro (2000) utilizes a comprehensive cross-country panel dataset with similar income inequality indicators but finds little overall relationship between income inequality and both growth and investment rates. Further complicating the empirical picture, Gründler and Scheuermeyer (2018) apply a two-step GMM approach to panel data, using the income Gini coefficient as their primary measure of inequality. Their analysis reveals a negative relationship between income inequality and investment. Similarly, Madsen et al. (2018) conduct panel OLS and IV-2SLS regressions on OECD country data, employing income Gini coefficient inequality. Their results also indicate a negative impact of wealth inequality on investment. These studies illustrate that the relationship between inequality and investment is contingent upon the methodological approaches. Nonetheless, as shown in Tables 5 and 6, our mediation analysis consistently finds a positive impact through the investment channel, suggesting that in the sampled countries, wealth concentration may stimulate savings and investment, leading to higher growth.

Overall, despite variations in methodological approaches—ranging from cross-country panel regressions and FE models to instrumental variable techniques and firm-level analyses—and differences in inequality and transmission channel indicators, the literature results are largely comparable with the findings of this study, with the exceptions of rent-seeking and investment channels. Specifically, our results indicate that wealth inequality exerts a dual effect on economic growth, operating through multiple channels. On one hand, wealth inequality is found to negatively impact growth via human capital, socio-political unrest, consumption, and innovation, with its most pronounced adverse ef-

fects observed through socio-political unrest and innovation. On the other hand, a positive effect is detected through the investment channel. In contrast, the influence of rent-seeking activities does not appear to be significant.

6. Conclusions

The impact of wealth inequality on growth through the specific transmission channels is yet to be examined empirically. This paper aims to provide insights into this issue by investigating various channels such as education, socio-political unrest, rent-seeking, consumption, innovation, and investment, utilizing a combined methodology of linear and nonlinear approaches. We compiled a panel dataset for 150 countries spanning from 1980 to 2020 and took into account the moderating influence of financial development and the lead–lag relationships among the variables. Beyond the transmission channel analysis in a nonlinear framework, another innovative aspect of this study lies in its explicit focus on wealth inequality—rather than the more commonly used income measures—to capture the enduring and accumulative nature of disparities. By adopting this focus, the study aligns more closely with theoretical arguments suggesting that wealth inequality is both more stable and a superior determinant of growth.

The results indicate that wealth inequality significantly impacts growth through all the examined channels, except for rent-seeking. This research reveals that inequality negatively affects growth via mediator channels human capital, socio-political stability, consumption, and more considerably innovation, while it exerts a positive influence through investment. One implication of these findings is that the impact of inequality is extensive and multifaceted, potentially being underestimated in most time-series studies. The findings also highlight a significant concern, as the strong negative impact of inequality on growth through innovation suggests that wealth concentration may stifle the very processes necessary for economic progress, undermining the potential for broad-based growth.

A further implication of the results suggests that addressing wealth inequality is essential for fostering sustainable economic growth. Specifically, policies that reduce disparities in wealth distribution can enhance human capital development, promote socio-political stability, and stimulate innovation—key drivers of economic progress. Targeted interventions, such as improving access to education for lower-income groups, ensuring inclusive financial systems, and mitigating socio-political unrest, can help mitigate the negative impacts of inequality. Simultaneously, policymakers must balance efforts to promote equity with maintaining investment incentives to leverage its positive contributions to growth. By focusing on wealth inequality and its multifaceted transmission channels, governments can design tailored policies that foster inclusive growth while minimizing adverse effects on economic efficiency and innovation.

While this study offers important insights into the subject, several limitations must be acknowledged to contextualize the findings appropriately. Firstly, the sample includes 150 countries with varying economic structures, institutional quality, and stages of development. While this broad coverage enhances generalizability, it also introduces heterogeneity that may obscure country-specific dynamics. The impact of wealth inequality on growth through transmission channels could differ markedly between developed and developing nations, regions with stable versus unstable political systems, or countries with varying levels of financial development. Future research might consider examining different clusters of countries with more homogeneous socio-economic characteristics, providing deeper insights into how wealth inequality impacts growth across diverse contexts.

Secondly, the wealth Gini coefficient, sourced from WID, relies primarily on tax statistics, which may under-report actual wealth due to tax evasion and avoidance strategies. Despite enhancements to include both capital and non-capital assets, some wealth may still

remain unaccounted for, potentially biasing the results. Thirdly, a key limitation of this study concerns the presence of outliers in certain variables, which can distort estimates through reliance on average values. Although winsorizing was examined as a potential mitigation strategy, it did not adequately address the outlier issue in the data. Consequently, retaining the original sample preserves genuine cross-country disparities; however, it leaves the estimations vulnerable to potential biases introduced by extreme observations.

Lastly, the study does not empirically examine the incentivization and redistribution channels due to the lack of specific indices and the complex, bidirectional nature of redistribution policies. Not including these two important channels harms the completeness of the study. Building on these observations, future studies should investigate additional transmission channels, such as incentivization and redistribution, thereby offering deeper insights into the interplay between wealth inequality and growth. Given that much of the existing literature evaluates the impact of inequality using isolated models, it is important to recognize that, in reality, policies related to income tax, wealth tax, corporate tax, or welfare packages influence the economy at an international scale, potentially resulting in capital flight or inflows, as well as brain drain or gains for countries. Therefore, future research may also benefit from expanding analyses to capture international spillovers and the broader global context. Additionally, case studies of nations that have implemented various redistribution policies in the past could provide valuable insights, shedding light on the real-world outcomes of such interventions. Ultimately, future research in this area would empower policymakers to design targeted interventions that effectively address the multifaceted impacts of inequality on economic growth.

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Informed Consent Statement: Not applicable.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

List of countries examined in this study:

Afghanistan, Albania, Algeria, Angola, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahrain, Bangladesh, Belarus, Belgium, Belize, Benin, Bhutan, Bolivia, Bosnia, Botswana, Brazil, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Central Africa, Chad, Chile, China, Colombia, Congo, Congo Dem., Costa Rica, Cote d'Ivoire, Croatia, Cyprus, Czechia, Denmark, Djibouti, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Ethiopia, Finland, France, Gabon, Gambia, Georgia, Germany, Ghana, Greece, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hungary, Iceland, India, Indonesia, Iran, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kuwait, Kyrgyzstan, Laos, Latvia, Lebanon, Liberia, Lithuania, Luxembourg, Madagascar, Malawi, Malaysia, Maldives, Mali, Malta, Mauritania, Mauritius, Mexico, Moldova,

Mongolia, Montenegro, Morocco, Mozambique, Myanmar, Namibia, Nepal, Netherlands, New Guinea, Nicaragua, Niger, Nigeria, North Macedonia, Norway, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russia, Rwanda, Saudi Arabia, Senegal, Serbia, Sierra Leone, Slovakia, Slovenia, South Korea, Spain, Sri Lanka, Sudan, Sweden, Switzerland, Syria, Tajikistan, Tanzania, Thailand, Togo, Trinidad, Tunisia, Turkey, Turkmenistan, Uganda, UK, Ukraine, United States, Uruguay, Uzbekistan, Venezuela, Vietnam, Yemen, Zambia, Zimbabwe.

Notes

[1] See Appendix A.

[2] While patent stock was chosen as the proxy for innovation largely because of its longitudinal availability and its common usage in cross-country analyses, this choice has important drawbacks that warrant acknowledgment. By focusing solely on patented inventions, it overlooks a wide range of "invisible" or non-patented innovations. In particular, service innovation, process innovation, and incremental adaptations—often undertaken by smaller firms—may not require or even benefit from formal patent protection. As Taques et al. (2021) caution, when innovation arises from tacit knowledge or customer interactions, especially in labor-intensive service sectors, patent metrics will likely underestimate the true level of novelty and creativity. In effect, low patent counts need not signal weak innovation but may instead point to a reliance on informal mechanisms of intellectual property protection or minimal feasibility of patenting in those settings. A second challenge concerns cross-national disparities in patenting infrastructures. Developed countries typically offer more cost-effective, efficient filing systems, whereas resource-scarce regions face prohibitively high application fees and weaker institutional support. These dissimilarities can bias cross-country comparisons and make it difficult to disentangle genuine differences in innovation performance from disparities in patent frameworks.

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