

Research article

Income inequality in SSA and its sub-regions: The role of government education spending and institutional quality

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Abstract: The persistently elevated levels of income inequality in Sub-Saharan Africa (SSA) remain a significant obstacle to achieving Sustainable Development Goal 10 (SDG 10), which seeks to reduce inequalities within and across countries. In this study, we investigated the impact of public expenditure on education and institutional quality on income inequality in SSA using the Dynamic Common Correlated Effects Instrumental Variable (DCCE-IV) estimator. Institutional quality was measured through a composite index constructed from six governance indicators using Principal Component Analysis (PCA). The empirical analysis was based on a panel of 40 SSA countries and their respective sub-regions, covering the period from 1980 to 2024. Outcomes demonstrated that institutions and education spending contribute to increased inequality, with variations across sub-regions. Institutions lead to higher inequality in West, East, and Southern-Africa. Additionally, education spending reduces inequality in Southern and West-Africa but worsens it in Central and Eastern Africa. The interaction between institutions and education spending exacerbates inequality in Southern, Eastern, and West Africa. The study underscores the need for a redistributive framework in SSA to manage education spending effectively and establish strong institutions for the welfare of all citizens, particularly low-income earners.

Keywords: institution, income inequality; government education spending; DCCE-IV; SSA countries

JEL Codes: D63, H52

1. Introduction

Since Milanovic's publication of "Global Inequality: A New Approach for the Age of Globalization" in 2016, there has been a notable surge in interest surrounding the "Lacker-Milanovic graph," also referred to as the "elephant curve," on a global scale¹. Milanovic (2016) aligned with Piketty's (2015), proposing that the widening gap between returns on capital and labor serves as the primary catalyst for contemporary income disparities. This perspective contrasts with Deaton's (2013), wherein he contended that inequalities stem from deficiencies in economic growth. Deaton's critique challenged analyses of inequality, notably Kuznets (1955) theory. The Kuznets curve suggests that as economic development advances, income inequalities should decrease. However, this assertion is under scrutiny due to the observed increase in income disparities, which undermines the notion of economically weaker nations catching up with their stronger counterparts. According to Chancel et al. (2022), the income distribution among the top 10% in various regions stands as follows: 43% in Asia, 56% in Sub-Saharan Africa (SSA), 55% in Latin America, and 48% in North America. Advanced and emerging countries have witnessed a notable increase in inequality, as noted by Xu et al. (2021), with the onset of the COVID-19 pandemic exacerbating this trend. Consequently, SSA remains one of the global regions characterized by significant levels of inequality. Remarkably, among the 19 countries worldwide with the highest levels of inequality, 10 are in Africa. At the regional level, Southern Africa comprises four of the most unequal countries on the continent.

According to the Human Capital Theory developed by Becker (1964), government spending on education can contribute to reducing income inequality. This theory emphasizes that investments in education and training promote human capital accumulation, enhance productivity, and increase individuals' earning potential. In line with this theory, public expenditure on education can reduce income disparities by providing individuals, particularly those living in poverty, with the education and skills necessary to access better-paying employment opportunities. Accordingly, government spending on education is generally expected to contribute to inequality reduction. Evidence from Sub-Saharan Africa underscores the pressing need to address high levels of income inequality. Despite progress in expanding educational opportunities, significant disparities persist in the quality of education and learning outcomes across socioeconomic groups and geographical regions. Furthermore, countries across SSA continue to face institutional deficiencies that can hinder the equitable allocation of public resources and contribute to persistent inequality (OECD, 2023).

Although public expenditure on education has contributed to reducing income inequality in some advanced economies, the persistent and substantial income disparities in SSA, often occurring in contexts characterized by weak democratic institutions, have intensified debate over the redistributive effectiveness of fiscal policy. Meltzer and Richard (1981) argued that democratic systems tend to promote redistributive policies that benefit poorer populations by enhancing their political influence over economic decisions. The rise of the New Institutional Economics has further highlighted the importance of institutions in explaining persistent inequalities, building on seminal contributions such as those by Engerman and Sokoloff (1997), which demonstrated how historical and institutional structures shape patterns of economic development and distribution. This perspective also challenges the universality of the Kuznets Curve by emphasizing that inequality depends not only on the level

¹ The Elephant Curve is a graphical representation that demonstrates the unequal income-distribution growth among people in various income groups.

and pace of economic growth but also on the nature of growth and the quality of institutions (Collier, 2007). Empirical evidence from West Africa similarly indicates that democratic governance can reduce inequality through redistributive mechanisms (Anyanwu et al., 2016). Stiglitz (2012) further argued that inequality is shaped not only by the marginal productivity of capital but also by political and institutional arrangements that determine access to economic opportunities, a view reinforced by Shimeles and Nabassaga (2018). Moreover, Bowles et al. (2006) introduced the concept of “institutional poverty traps” to explain how weak institutions can perpetuate inequality by encouraging rent-seeking and other unproductive activities. Finally, Ravallion (2009) emphasized that weak constraints on political elites may enable them to influence redistributive policies in ways that serve their own interests, thereby contributing to persistent income inequality. Collectively, these studies demonstrate that the relationship between fiscal policy, democratic governance, institutional quality, and inequality is complex and strongly dependent on the institutional context.

Moreover, the empirical literature on the effects of education expenditure and institutional quality on income inequality remains inconclusive. To the best of our knowledge, limited attention has been given to their combined effects on inequality in SSA and its sub-regions. In particular, researchers have largely overlooked the possibility that institutional quality may condition the relationship between public education expenditure and income inequality. This interaction is theoretically important because political and institutional arrangements, particularly democratic institutions, can shape the design and effectiveness of redistributive policies and, consequently, determine the extent to which education spending contributes to reducing income disparities. Despite its relevance to the political economy of redistribution, the moderating role of institutions in the education expenditure–inequality nexus remains insufficiently examined in theoretical and empirical research. In this study, we address these gaps by investigating the direct and indirect effects of public education expenditure and institutional quality on income inequality across SSA and its sub-regions. Specifically, we address four research questions: (1) Does government expenditure on education reduce income inequality in SSA? (2) Does institutional quality contribute to reducing income inequality in SSA? (3) Does institutional quality condition the effect of education expenditure on income inequality in SSA? and (4) Do the direct and indirect effects of education expenditure and institutional quality on income inequality vary across SSA sub-regions? By addressing these questions, the study contributes to the literature in several ways. First, it provides empirical evidence on the joint relationship between public education expenditure, institutional quality, and income inequality in SSA, thereby extending the existing literature that has predominantly examined these relationships separately.

SSA serves as an interesting region due to its high level of income disparity despite its low level of education spending, along with ongoing democratic experiments in various countries at different stages. Second, we enrich the literature by investigating how institution condition the impact of education spending on income disparity in SSA. This conditional impact is important as it sheds light on how education spending influences inequality differently in democratic versus autocratic countries, and it aids in understanding how political institutions influence the redistributive strategy to benefit poorer segments of society instead of concentrating them among the wealthy few. Third, considering the variation in education spending and institution across sub-regions within SSA, we refrain from assuming homogeneity in our sample. Instead, we conduct a comparative analysis to explore how the effects of education spending and institution on inequality vary among these sub-regions. Fourth, the positive and significant coefficient of the first-lag of the regressand validates the application of the dynamic-panel data approach such as DCCE-IV is validated. Fifth, this research is distinguished from

earlier studies by developing an index for institutional quality based on six governance indicators, utilizing principal component analysis (PCA). Last, our study's relevance is underscored by its timely nature, as its findings stand to significantly inform the formulation and implementation of policies aimed at addressing inequality, a key aspect of the SDG in SSA.

The remainder of this paper is structured as follows: In Section 2, we review the relevant literature, while in Section 3, we describe the methodology and data employed in the empirical analysis. In Section 4, we present and discuss the empirical findings. Finally, in Section 5, we conclude the study and provide relevant policy recommendations.

2. Literature review

A large body of empirical literature has examined the relationship between education, public education spending, and income inequality, particularly in developing regions. Early cross-country studies emphasize the redistributive role of education through human capital accumulation. De Gregorio and Lee (2002) found that educational expansion contributes to a more equal income distribution by reducing wage differentials between skilled and unskilled workers. Similarly, Castelló-Climent and Doménech (2017) demonstrated that public investment in education lowers income inequality by expanding access to schooling and reducing skill premiums, especially in low-income economies where educational gaps are pronounced. Within the context of SSA, empirical findings are more mixed and reveal important structural and institutional constraints. Anyanwu et al. (2016) using panel data for African countries, provided evidence that government education expenditure reduces income inequality by enhancing human capital accumulation, labor productivity, and inclusive growth. In line with this argument, Bhorat et al. (2017) argued that persistent inequality in Africa is partly driven by inadequate public investment in education and limited access to quality schooling, particularly among low-income households.

However, several studies suggest that increased education spending does not automatically translate into lower income inequality in SSA. Panton-Ntshona (2021) found that higher government education expenditure does not significantly reduce income inequality in a panel of 18 SSA countries. The author attributes this outcome to inefficiencies in expenditure allocation and a concentration of spending at higher education levels, where benefits tend to accrue disproportionately to higher-income groups. This evidence suggests that the effectiveness of education spending depends not only on its level but also on its composition and governance.

The theoretical foundation for understanding these empirical patterns can be traced to Human Capital Theory. Schultz (1963) emphasized that enhancing human capital through education can alleviate inequality. He argued that public investment in education is a viable strategy to reduce disparities because returns to human capital, through skills and knowledge, are more evenly distributed than income from physical assets, which is often concentrated among wealthier individuals. This implies that as education and human capital grow faster than physical capital, overall income inequality is likely to decline. Building on Schultz, the Becker-Mincer-Chiswick framework (Becker, 1964; Mincer, 1970; Becker & Chiswick, 1966) further formalizes the link between education and income inequality. The theory posits that education directly influences individual earnings and, at the aggregate level, shapes the distribution of income. While increasing educational attainment generally reduces inequality by raising the productivity of lower-skilled workers, the theory also predicts a partially positive relationship: if the average years of schooling rise faster among higher-income

groups, inequality may temporarily increase. The model assumes that rates of return to education are independent of educational levels, and over time, as unskilled workers acquire skills and join the skilled labor force, long-term income inequality should decrease.

Moreover, Knight and Sabot (1983) highlighted two mechanisms through which education affects inequality: The “Composition” effect and the “Wage Compression” effect. Initially, increases in education may favor higher-educated individuals, exacerbating inequality (Composition effect). However, as the supply of educated workers expands, the premium on education diminishes (Wage Compression effect), leading to a reduction in income inequality. These theoretical insights provide a strong foundation for interpreting empirical results in SSA, where the level, allocation, and efficiency of education spending, combined with institutional quality, determine the ultimate redistributive impact.

Empirical contributions reinforce this complexity. Voto and Ngepah (2024a) analyzed the effect of public education expenditure on income inequality in 30 SSA countries over the period 1990–2022 using FMOLS. Their results indicate that education spending increases income inequality in the long run, while its squared term exerts a negative effect, suggesting a non-linear relationship. In addition, Voto and Ngepah (2024) emphasized that cross-sectional dependence and slope heterogeneity are critical in SSA panel analyses, and failure to account for these econometric issues can bias estimates of education’s impact on inequality. Similarly, Li et al. (2024), using dynamic panel estimators for 36 SSA countries from 1995 to 2021, found that government education spending tends to increase income inequality, whereas foreign direct investment has an equalizing effect. They argued that weak institutional environments and inefficient allocation of education resources limit the redistributive impact of public spending.

These divergent findings point to the critical role of institutional quality in shaping the education–inequality nexus. Beyond education expenditure, the literature also emphasizes the broader role of digital connectivity and technological access in shaping economic development outcomes. Nsavyimana and Li (2025), examining the East African Community, showed that mobile telephone and internet penetration can contribute significantly to economic development by improving access to information, facilitating communication, expanding market opportunities, and supporting economic activities. Although they did not directly examine income inequality or public education expenditure, their findings are relevant to this analysis because digital infrastructure can complement human capital accumulation by improving access to educational resources, employment opportunities, financial services, and markets. This suggests that the redistributive effects of public education policies may also depend on the broader technological and institutional environment in which human capital is developed and utilized.

From a theoretical perspective, Acemoglu and Robinson (2012) argued that extractive institutions sustain inequality by restricting access to economic opportunities, including education, while inclusive institutions enhance the effectiveness of redistributive public policies. Empirically, Chong and Gradstein (2007) showed that weak institutions significantly reduce the inequality-reducing impact of public education spending. Likewise, Ben Mimoun and Raies (2022) found that the poverty-reducing effect of public social spending is significantly weaker in countries with poor governance, highlighting the importance of institutional quality for the effectiveness of social expenditure. Evidence from SSA confirms this importance. Bicaba et al. (2017) demonstrated that governance quality conditions the effectiveness of education policies. Similarly, Asongu and Kodila-Tedika (2018) showed that institutional quality, particularly control of corruption and rule of law, significantly influences income inequality outcomes.

Recent studies increasingly employ advanced econometric techniques and pay greater attention to institutional conditions and heterogeneity across Sub-Saharan African countries and sub-regions. Adeleye (2024) examined the relationship between human capital, institutional quality, and income inequality across 46 SSA countries and found that stronger institutional quality enhances the inequality-reducing effect of human capital. The study also provides evidence of heterogeneity across SSA sub-regions, underscoring the importance of accounting for institutional differences when assessing the distributional effects of human-capital development.

Using second-generation panel estimators, Kapingura and Tsegaye (2024) employed CS-ARDL and DCCE techniques and demonstrated that institutional quality significantly moderates the impact of education spending on income inequality in SSA, with stronger governance amplifying its redistributive effects. In addition, Voto and Ngepah (2024) highlighted that sub-regional disparities in institutional quality explain why similar levels of education spending have different effects on inequality across SSA countries.

Despite these advances, the literature remains fragmented. Most empirical studies examine education spending or institutional quality in isolation, while only a limited number explicitly analyze the institutional channel through which education spending affects income inequality, particularly at the sub-regional level in SSA. Moreover, many researchers rely on traditional estimators, such as OLS, fixed effects, or GMM, which may suffer from endogeneity, slope heterogeneity, and cross-sectional dependence; issues particularly relevant in SSA due to regional economic integration, common shocks and spillover effects. Against this background, this study contributes to the literature by jointly examining the effects of government education spending and institutional quality on income inequality in SSA and its sub-regions. By employing the DCCE-IV estimator, we explicitly account for endogeneity, slope heterogeneity, and cross-sectional dependence, thereby providing robust and policy-relevant evidence for the region (Voto and Ngepah, 2024; 2024a).

3. Methodology and data

3.1. Model

In this study, we build upon the well-known Kuznets (1955) model, which establishes the link between economic growth and income disparity, by adding variables related to institutions and government education spending. One important theoretical framework that indicates a negative correlation between inequality and economic growth is the Kuznets (1955) curve. Therefore, according to our research, the following factors determine inequality: government spending on education, institutions, economic growth, economic growth squared, and other variables that have an effect on inequality. Equation (1) is a simplified static-model that is utilized to calculate the impact of government education spending and economic growth, all within the framework of Kuznets' (1955) inequality-economic growth relationship. Here, we empirically examine how government education spending and institutions affect inequality in 40 SSA economies. Two main factors have influenced the selection of this sample: (i) The availability of data for SSA throughout a 40-year period is the primary motivator; and (ii) the reason SSA countries are selected is because they are recognized for having some of the world's lowest levels of education investment and for having some of the highest levels of inequality. The 1980–2024 time-period covered by the study is significant for two reasons: (i) The 1980s witnessed the implementation of structural adjustment programs by the World Bank and

the IMF in response to the African crisis; and (ii) this time frame includes the serious financial and economic crisis that happened between 2007 and 2020, such as the 2008 recession and the impacts of COVID-19, which had an important effect on most countries, especially on their levels of government spending and tax revenue. A static-version of Equation (1) can be described as:

$$Gini_{it} = \alpha_{it} + \beta_0 Gini_{i,t-1} + \beta_1 GDPpc_{it} + \beta_2 GDPpcSQ_{it} + \beta_3 GES_{it} + \beta_4 INST_{it} + \beta_5 (GES_{it} * INST)_{it} + \beta_6 X_{it} + \epsilon_{it} \quad (1)$$

where the Gini represents net income disparity, which was made recently made accessible by version 8.2 of the SWIID (Solt, 2019). We employ disposable Gini as it provides the net picture of income disparity in SSA. We also use the disposable Gini because it provides the net picture of inequality in SSA nations. The variable $GES*INST$ is incorporated in the vector of variables to show the interaction term between government education spending and institutions. $GDPpc$ is GDP per-capita and $GDPpcSQ$ denotes GDP per-capita Square. We use $INFLAT$ (Inflation), gender equality, ethnic fragmentation, and educational inequality as our control variable. ϵ_{it} stands for an error term. Variables are chosen according to the literature, and they are all in logarithm form except $GDPpc$.

To contribute to the field of political economy, we put forward the hypothesis that institution plays a role in shaping how government expenditure on education impact inequality. This hypothesis is based in the idea that a nation's political institutions, particularly its democratic systems, serve as a crucial mechanism for channeling government spending on education in ways that mitigate inequality. We test how institutions condition government spending on education to impact inequality in SSA. Equation (1) is the empirical model for assessing the combined impact of government education spending and institutions on income disparity. Since we consider a dynamic-version, Equation (1) adds an extra parameter, which is the lagged regressand to account for the persistence of inequality over time. We utilize Equation (1) to differentiate GINI with respect to GES to obtain Equation (2).

Thus, Equation (2) represents the marginal impact equation for determining the marginal impact of GSE on income disparity through the interaction term between GES and institution. In this study, we assess the net impact of GSE on income disparity under the conditions of maximum democracy variable values.

$$\frac{dGINI_{it}}{dGES_{it}} = \beta_4 + \beta_5 Inst_{it} \quad (2)$$

Understanding the dynamics of income inequality within SSA countries requires a comprehensive analysis of multiple economic and social factors.

- Economic growth (GDP) can impact income inequality in different ways. According to Kuznets' hypothesis, inequality initially rises and then falls as a country develops economically (Kuznets, 1955).
- Increased government spending on education generally reduces income inequality by enhancing access to education and improving human capital.
- Robust institutions, such as the rule of law, protection of property rights, and control of corruption, are associated with lower income inequality. Effective institutions ensure fair distribution of resources and equal opportunities (Acemoglu et al., 2005).
- High inflation can worsen income inequality by disproportionately reducing the purchasing power of lower-income households compared to higher-income households (Easterly & Fischer, 2001).
- Greater gender equality correlates with lower income inequality. When women have equal access to education and employment, household incomes tend to be more balanced (World Bank, 2012).

- High levels of ethnic fragmentation can increase income inequality due to potential conflicts and uneven distribution of resources among ethnic groups (Alesina et al., 1999).
- Higher educational inequality often leads to greater income inequality because it restricts access to higher-paying jobs for certain segments of the population (Coady & Dizioli, 2018).

Table 1. Source and definition of the variables.

Variable	Description	Source
Gini	Annual data on aggregate net income inequality are drawn from the Gini coefficient series provided in version 8.2 of the Standardized World Income Inequality Database (SWIID), as reported by Solt (2019). The analysis employs the disposable-income Gini coefficient, which provides a comprehensive measure of income inequality by capturing the distribution of income after taxes and transfers across countries in Sub-Saharan Africa.	SWIID
Gvt_educ_spen	Public education expenditure is measured as government spending on education expressed as a percentage of GDP. It encompasses public expenditure across primary, secondary, and tertiary education levels, as well as spending on educational research and development (R&D). The measure also includes education-related expenditures financed through transfers from international sources to the government.	WDI
Inflation	This variable is measured using the Consumer Price Index (CPI), which captures the annual percentage change in the cost of a representative basket of goods and services purchased by the average consumer. The composition of this basket may remain fixed or be periodically adjusted, typically at regular intervals such as annually, to reflect changes in consumption patterns.	World Development Indicators (WDI)
GDP per-capita	GDP per capita is incorporated into Equations (1) and (2) as a proxy for economic growth. To address its high degree of skewness and improve the distributional properties of the variable, GDP per capita is transformed using its natural logarithm.	WDI
Gender_Equality	This variable captures the extent to which a country's institutions and policies effectively promote gender equality by ensuring equitable access for men and women to education, healthcare, economic opportunities, and legal protection. A higher level of gender equality is expected to contribute to a reduction in income inequality.	World Bank
Education_level	Defined as the percentage of gross enrollment in secondary education.	WDI
Educational_Inequ	Standard_deviation of educational level	Author computation
Ethnic_Fragment	Ethnic fragmentation is captured by the ethnic fractionalization index (ethfrag), constructed from information on 650 ethnic groups in 190 countries. The measure represents the likelihood that two individuals randomly selected from a given country are members of different ethnic groups and therefore serves as an indicator of societal ethnic diversity. The index takes values between 0 and 1 (or 0 and 100), with lower values indicating greater ethnic homogeneity and higher values reflecting greater ethnic fragmentation. A value of zero corresponds to a fully homogeneous population, whereas a value of one indicates the maximum degree of ethnic diversity.	from the database of Alesina et al. (2003).
C_C	Institution index (INST) variable obtained from governance indicators. Control of Corruption	WGI_data
P_S and A_V	Political_stability and absence of violence/terrorism	WGI_data
G_E	Government_effectiveness	WGI_data
REG_QTY	Regulatory_quality	WGI_data
R_L	Rule of law	WGI_data
V_A	Voice and accountability	WGI_data

3.2. Principal component analysis

Table 2 presents the Principal Component Analysis (PCA) and correlation matrix results used to construct the institutional quality index (INST) for SSA. PCA, originally introduced by Pearson (1901) and further developed by Hotelling (1933), is a dimensionality-reduction technique that combines several correlated indicators into a smaller number of uncorrelated components while preserving the maximum amount of information contained in the original data. In this study, PCA is employed to aggregate six institutional indicators, Control of Corruption (CC), Political Stability and Absence of Violence (PS_AV), Government Effectiveness (GE), Regulatory Quality (REG_QTY), Rule of Law (RL), and Voice and Accountability (VA), into a single composite measure of institutional quality. As shown in Panel A of Table 2, the six indicators exhibit relatively strong correlations, supporting their suitability for PCA. The institutional quality index is constructed using the first principal component, which captures the largest share of the common variation among the six indicators. The corresponding PCA loadings are used as weights to obtain the composite index as follows: $INST = \beta_1 CC + \beta_2 PS_AV + \beta_3 GE + \beta_4 REG_QTY + \beta_5 RL + \beta_6 VA$, where the β coefficients represent the PCA-derived weights. The selection of the first component is further supported by the scree plot presented in Figure 1, which indicates that it contains the most relevant common information among the institutional indicators. Specifically, we choose the first component because its eigenvalue represents 2.35% of the total variation. The scree plots in Figure 1 provide additional support for our findings.

Table 2. Principal component analysis and correlation matrix results.

Panel (A): Institutional quality index variable							
Principal component results							
Compnnt	Eigenvalue	Difference	Proportion	Cumulative			
Comp 1	2.354	2.054	0.412	0.430			
Comp 2	0.124	0.109	0.032	0.430			
Comp 3	0.043	0.031	0.008	0.347			
Comp 4	0.004	0.001	0.001	0.452			
Comp 5	0.003	0.002	0.000	0.301			
Comp 6	0.001		0.003	0.912			
Principal components eigenvectors results							
Variables	Compnnt 1	Compnnt 2	Compnnt 3	Compnnt 4	Compnnt 5	Compnnt 6	Unexplained
CC	0.201	-0.089	0.079	0.110	-0.312	-0.247	0.009
PS_AV	0.162	0.241	-0.351	-0.102	0.007	0.012	0.057
GE	0.201	-0.157	-0.012	0.134	-0.121	0.341	0.021
REG_QTY	0.195	-0.121	0.149	-0.254	0.185	0.024	0.031
RL	0.143	-0.152	0.127	0.248	0.211	-0.124	0.018
V_A	0.162	0.298	-0.214	0.146	0.041	0.014	0.051
Correlation matrix results							
CC	1.000						
PS_AV	0.423*** (0.000)	1.000					
GE	0.532*** (0.000)	0.541*** (0.000)	1.000				
REG_QTY	0.851*** (0.000)	0.476*** (0.000)	0.620*** (0.000)	1.000 (0.000)			
RL	0.624*** (0.000)	0.321*** (0.000)	0.491*** (0.000)	0.534*** (0.000)	1.000		
PS_AV	0.621*** (0.000)	0.517*** (0.000)	0.432*** (0.000)	0.427*** (0.000)	0.425*** (0.000)	1.000	

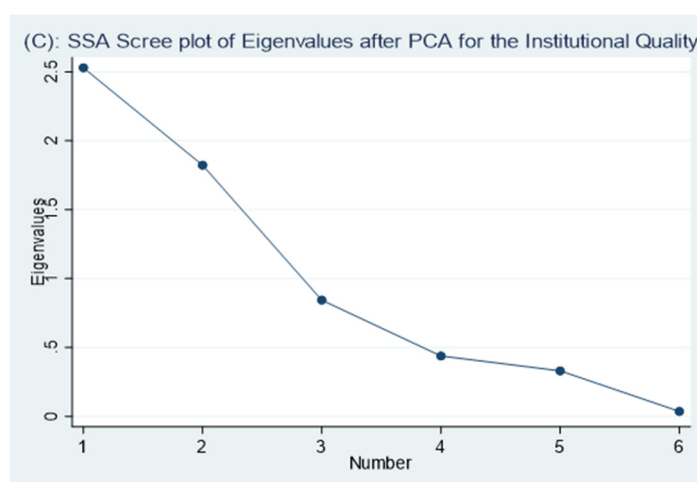


Figure 1. Scree plot of the Eigenvalue for INST.

3.3. Estimation strategy

There are two steps in the empirical examination of this study: First, we test for the presence of CSD in the variables across countries using Pesaran's (2004) CD test, where cross-sectional independence is the null hypothesis. To determine if the dependency in the errors is strong or weak under the null hypothesis of weak dependence, we also employ Pesaran's (2015) CD test. Once the strong cross-sectional dependency in the errors is established, we use the DCCE-IV method to examine the link between our variables.

3.4. DCCE-IV

Panel data is employed in this paper because it has many benefits over other techniques like microsimulation and time series. Panel data enables extra observations to be analyzed by combining time series with horizontal cross-section observations. Panel data takes into account greater sample variability and degrees of freedom than time series models (Meo et al., 2023). Because they can analyze short- and long-term results, dynamic- panel data provide an advantage over static-models (Sadorsky, 2014). Furthermore, income inequality is typically characterized by substantial persistence over time, reflecting the influence of historical and structural socio-economic conditions. Government education expenditure and institutional quality may affect inequality with a time lag rather than immediately. Therefore, a dynamic panel specification is justified as it incorporates the lagged dependent variable, enabling the model to capture the persistence of inequality and the delayed effects of policy and institutional factors. This approach is particularly suitable for a long panel dataset covering the period 1980–2024, as it accounts for the dynamic nature of inequality while exploiting the cross-country and time-series dimensions of the data.

When heterogeneity and common specific effects cannot be taken into account, panel data does have disadvantages. Researchers have mostly relied on estimating methods that were limited to homogeneous slopes and did not take cross-sectional effects into account (Meo et al., 2023). Researchers use different techniques to controls for homogeneity in panel data and time series, such as GMM, FE, RE, and OLS. These techniques assume higher degree of homogeneity as the intercept

varies between cross-sectional units. This presumption has been shown to be incorrect, and the findings are inconsistent (Ditzen, 2019). To solve this issue, we employ the DCCE estimator developed by Chudik and Pesaran (2015), a dynamic form of Common Correlated Effects developed by Pesaran (2006), to evaluate the effect of GES and institution on inequality. Lagravinesea et al. (2020), for example, used OECD data to investigate tax-buoyancy employing DCCE while Gbato (2017) employed the DCCE technique to assess the impact of taxation on economic growth in SSA. In contrast to Gbato (2017) and Lagravinesea et al. (2020), we use DCCE-IV² to evaluate the role of institution on government education spending and income disparity in SSA and its sub-regions. The advantages of using this method are: (i) It deals with slope heterogeneity; (ii) it accounts for endogeneity problems because of the existence of the lag-regressand in the model by adding the $P_T = \sqrt[3]{T}$ lags of the cross-sectional averages; and (iii) it controls for variable non-stationarity internally and deals with CSD among units.

Equation (4) is described below:

$$y_{i,t} = \alpha_i + \lambda_i y_{i,t-1} + \beta_i x_{i,t} + \sum_{i=0}^{PT} \dot{\gamma}_{i,1} \bar{z}_{t-1} + \epsilon_{i,t} \quad (4)$$

$\bar{z}_t = (\bar{y}_t, \bar{x}_t)$ by incorporating $\bar{z}_t$ in Equation (2), the estimated equation will be:

$$y_{i,t} = \alpha_i + \lambda_i y_{i,t-1} + \beta_i x_{i,t} + \sum_{i=0}^{PT} \dot{\gamma}_{i,1,y} \bar{y}_{i,t-1} + \dot{\gamma}_{i,1,x} \bar{x}_{i,t-1} + \epsilon_{i,t} \quad (5)$$

where PT is the number of lags, with the bar indicating cross-sectional averages. The symbol $\bar{z}_t$ denotes the cross-section average of all series in the model. To mitigate significant unobserved CSD, the technique of lagging the cross-sectional averages is utilized. This involves estimating individual coefficients for each unit, which are then averaged to obtain the MG estimator. Meeting specific criteria is essential for estimating DCCE using MG and PMG methods.

The utilization of four cross-sectional-averages (the independent variables, dependent variables, its lag) in this study is likely to fulfill these criteria as a significant portion of the variation in macroeconomic series may be explained by a small number of unobserved common factors. Furthermore, the number of lags ($PT = \sqrt[3]{T}$ lags of the cross-sectional averages) is adequate, and the time period (1980–2024) is sufficient to facilitate DCCE analysis. Specifically, we employ DCCE-IV to address potential endogeneity issues in the model, with the institution variable serving as an instrument variable. Institutions are a valid and theoretically robust instrument for addressing income inequality. By ensuring the protection of property rights, controlling corruption, providing inclusive economic opportunities, and shaping positive incentives, strong institutions can create a more equitable and prosperous society. This theoretical perspective is supported by extensive empirical evidence demonstrating the critical role of institutions in economic development and income distribution (Acemoglu et al., 2005; North, 1990; Mauro, 1995). These researchers have contributed significantly to the understanding of how institutions function as a critical instrument influencing economic

² Methodological limitation: Although the DCCE-IV estimator is appropriate for addressing several important econometric challenges, including cross-sectional dependence, slope heterogeneity, dynamic effects, and potential endogeneity, it is not free from limitations. Its reliability depends on the validity and relevance of the instruments and on the appropriate specification of the cross-sectional averages and their lags. Furthermore, the country-level nature of the data may mask within-country heterogeneity, while the estimator cannot completely eliminate potential omitted-variable bias or guarantee causal identification in the absence of fully exogenous instruments. Accordingly, the empirical findings should be interpreted as conditional on the validity of the model specification and identifying assumptions.

performance, development, and income inequality. To confirm the reliability of the regression and no evidence of model misspecification, we use Variance Inflation Factor (VIF) and The Ramsey RESET tests. The results show that the model specification is reliable and appropriate.

4. Results

4.1. Basic results

Prior to estimating the effects of government education expenditure and institutional quality on income inequality using the System Generalized Method of Moments (SGMM), we perform several diagnostic and preliminary analyses, including descriptive statistics, pairwise correlations, the Variance Inflation Factor (VIF), and the Ramsey RESET specification test. The descriptive statistics reported in Table 3 reveal substantial variation in the key variables across the SSA sample. The average level of income inequality is 56.4, with a standard deviation of 6.97, while the minimum and maximum values are 34 and 66.5, respectively. These figures (2 and 3) point to persistently high inequality accompanied by considerable cross-country heterogeneity. Government education expenditure averages 4.17% of GDP, with a standard deviation of 2.61, whereas the institutional quality index has a mean of 0.91 and a standard deviation of 1.38. The regional estimates further demonstrate marked differences in the distribution of inequality, education expenditure, and institutional quality. Southern Africa exhibits the highest mean level of inequality (51.1), together with average education expenditure of 5.17% of GDP and institutional quality of 0.64. East Africa records an average inequality level of 44.43, education expenditure of 4.54%, and institutional quality of 1.13. In West Africa, the average inequality level is 43.03, the education expenditure is 3.40%, and the institutional quality is 1.10, while Central Africa records averages of 48.49 for inequality, 2.34% for education expenditure, and 0.94 for institutional quality. Overall, these regional disparities underscore the heterogeneous socioeconomic and institutional conditions prevailing across SSA. The region's persistent inequality is also reflected in its disproportionate representation among countries exhibiting the highest levels of income inequality globally, particularly in Southern Africa. The correlation results presented in Table 4 indicate a negative association between both government education expenditure and institutional quality and income inequality, suggesting that improvements in these factors may be associated with more equitable income distribution. However, these bivariate relationships should be interpreted as preliminary evidence rather than causal effects. To examine whether strong correlations among the explanatory variables could distort the regression estimates, we calculate the VIF statistics. As shown in Table 5, all VIF values remain below the conventional threshold of 10, indicating that multicollinearity does not pose a significant concern. In addition, the Ramsey RESET test is employed to assess the adequacy of the model specification. The reported p-value of 0.857 is well above the 5% significance threshold, implying that the null hypothesis of no omitted variables cannot be rejected. Hence, the diagnostic results provide no evidence of substantial model misspecification and support the subsequent empirical estimation.

Table 3. Summary Statistics for SSA.

	Obs	Mean	Std. Dev	Min	Max
<i>GINI</i>	960	56.4	6.97	34	66.5
<i>GES</i>	958	4.17	2.61	.62	44.33
<i>EDINEQ</i>	960	6.24	4.35	1.4	25.3
<i>GDPPC</i>	960	1.36	4.99	−47.80	36.98
<i>INST</i>	960	0.91	1.38	1	4
<i>INFL</i>	960	11.99	18.95	−72.7	83.3
<i>ETH</i>	1080	65.7	0.456	5.9	89.7
<i>GEN</i>	1024	0.694	0.065	0.491	0.901

Note: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$. The Jarque–Bera test evaluates the null hypothesis that the data are normally distributed against the alternative hypothesis of non-normality. A statistically significant Jarque–Bera statistic leads to the rejection of the null hypothesis of normality. Source: Author's computations.

Table 4. Correlation matrix.

Variable	Gini	GES	EDINEQ	GDPPC	INST	INFL	ETH	GEN
Gini	1.000							
GES	−0.432	1.000						
	0.000							
EDINEQ	0.074	−0.068	1.000					
	0.769	0.357						
GDPPC	0.862	0.624	−0.047	1.000				
	0.000	0.000	0.571					
INST	−0.007	0.067	−0.062	0.241	1.000			
	0.753	0.008	0.035	0.003				
INFL	−0.247	−0.069	−0.357	0.073	0.243	1.000		
	0.000	0.934	0.000	0.095	0.000			
ETH	−0.086	0.049	−0.076	0.064	−0.067	−0.038	1.000	
	0.000	0.000	0.000	0.079	0.098	0.076		
GEN	−0.067	0.049	−0.079	−0.092	0.076	0.094	0.068	1.000
	0.673	0.958	0.024	0.657	0.095	0.876	0.963	

Table 5. Variance inflation factor.

Variable	VIF	1/VIF
GES	1.07	0.823
EDINEQ	1.06	0.854
GDPPC	1.12	0.972
INST	1.15	0.924
INFL	1.11	0.911
ETH	1.04	0.927
GEN	1.10	0.975
Mean VIF	1.09	0.914

The results point to a two-way causal (a bidirectional causality) relationship between government education expenditure and income inequality, indicating that the two variables mutually influence each other while unidirectional causality running from institution to inequality has been observed in SSA.³

³ To save space, the full results of panel causality test are available upon request.

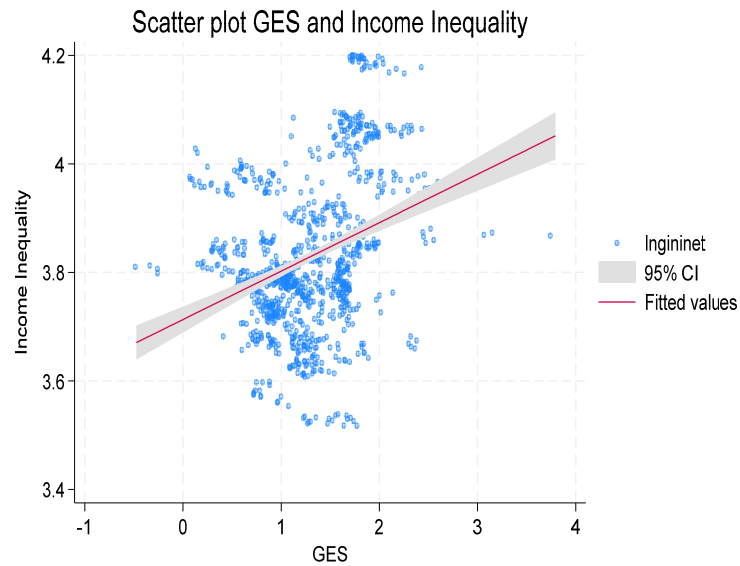


Figure 2. Scatter plot between GES and inequality for SSA.



Figure. 3 Scatter plot between institution and inequality for SSA.

4.2. CSD results

The results indicate that our data series exhibit interdependence among countries, as evidenced by p-values below the 5% significance level, leading to rejection of the null hypothesis. These findings hold true for the SSA and its sub-regions. Additionally, the analysis of CSD reveals rejection of the

null hypothesis of weak dependence in errors at the 1% significance level. This suggests a strong presence of CSD in errors for SSA and its sub-regions.⁴

4.3. DCCE-IV results

4.3.1. SGMM Results and Motivations for DCCE-IV

Table 6 presents the results of Equation (1) using the SGMM estimation methods. This table includes columns 1 to 10, with columns 1, 3, 5, 7, and 9 showing the results of the estimations without the interaction term, and columns 2, 4, 6, 8, and 10 displaying the results with the interaction term. Specifically, the SGMM results for Equation (1) indicate that GES and institutional factors are individually insignificant in reducing the income gap in SSA and most sub-regions. Even with the inclusion of the interaction term, the effect on income disparity remains insignificant in SSA and other sub-regions. This is because the SGMM method is not suitable for computing Equation (1) as it does not account for cross-sectional dependence. Given the inadequacy of the SGMM results, we focus on the DCCE-IV results to explore the relationship between government education spending, institutions, and income inequality in SSA and its sub-regions. Table 7 details the DCCE-IV results for SSA and its sub-regions. As shown in columns 1, 3, 5, 7, and 9 in Table 7, the findings indicate that government spending on education and institutions are insignificant and negative when the interaction between government spending on education and institutions is not included. However, when the interaction term is incorporated into the model, as seen in column 2 of Table 7, the significant impact on income disparity is strengthened.

Table 6. SGMM results.

Variables	SGMM1 SSA	SGMM2 SSA	Southern- Africa3	Southern- Africa4	Central- Africa5	Cental- Africa6	East- Africa7	East- Africa8	West- Africa9	West- Africa10
$GINi,t-1$	-0.078 (0.830)	0.124 (0.045)	-0.134 (0.753)	0.117 (0.051)	-0.153 (0.795)	0.181 (0.424)	-0.157 (0.684)	0.162* (0.057)	-0.195 (0.743)	0.134* (0.058)
GDP	-0.043 (0.458)	-0.083 (0.794)	0.095 (0.845)	0.074* (0.065)	-0.042 (0.684)	-0.086 (0.968)	-0.094* (0.068)	-0.054* (0.051)	-0.068 (0.951)	0.072* (0.068)
GDPSQ	-0.014 (0.725)	-0.019 (0.842)	-0.012 (0.764)	-0.021* (0.087)	-0.024 (0.697)	0.032 (0.895)	0.096* (0.054)	0.024* (0.068)	-0.023 (0.684)	-0.032* (0.094)
GES	0.057 (0.588)	0.106 (0.483)	-0.082 (0.843)	-0.086 (0.953)	0.081 (0.823)	0.075 (0.481)	0.074 (0.954)	0.084 (0.480)	-0.079 (0.960)	-0.096 (0.492)
INST	0.852 (0.496)	0.046 (0.854)	0.053 (0.574)	0.064 (0.753)	0.036 (0.172)	0.019 (0.854)	0.007 (0.214)	0.024* (0.078)	0.075 (0.141)	0.010 (0.687)
GES*INST		0.006 (0.457)		0.004 (0.352)		0.009** (0.078)		0.004 (0.352)		0.007 (0.655)
INFL	0.024 (0.752)	-0.075* (0.062)	-0.096 (0.954)	-0.068* (0.035)	0.043 (0.835)	0.068 (0.857)	0.091 (0.734)	-0.062* (0.024)	0.081 (0.935)	-0.076** (0.042)
GEN	0.024 (0.854)	0.458 (0.865)	0.867 (0.487)	0.047 (0.958)	0.072 (0.765)	0.071 (0.824)	0.071 (0.734)	0.082 (0.789)	0.047 (0.587)	0.068 (0.674)
ETH	0.074* (0.057)	0.076* (0.069)	0.076* (0.091)	0.072** (0.049)	0.048* (0.084)	0.075* (0.097)	0.084* (0.081)	0.082** (0.048)	0.043** (0.027)	0.057** (0.035)
EDINEQ	0.095* (0.068)	0.067** (0.048)	0.068* (0.085)	0.072** (0.042)	0.069* (0.071)	0.082** (0.047)	0.068* (0.057)	0.073** (0.049)	0.079* (0.068)	0.048* (0.062)
RMSE	0.001	0.002	0.002	0.001	0.001	0.002	0.001	0.001	0.002	0.002
Obs	754	754	97	97	76	76	110	110	142	134

***, ** and * demonstrate that the null is rejected at 1%, 5% and 10%, respectively.

⁴ CSD findings for SSA and sub-regions are available upon request.

Table 7. DCCE-IV results.

Variable s	DCCE - SSA1	DCCE- SSA2	Southern- Africa3	Southern- Africa4	Central- Afric5	Cental- Africa6	East- Africa7	East- Africa8	West- Africa9	West- Afri10
<i>GINI_{i,t-1}</i>	-0.078 (0.830)	0.124* (0.045)	-0.134 (0.753)	0.117* (0.051)	-0.153 (0.795)	0.181 (0.424)	-0.157 (0.684)	0.162* (0.057)	-0.195 (0.743)	0.134* (0.058)
GDP	-0.043 (0.458)	-0.083 (0.794)	0.095 (0.845)	0.074* (0.065)	-0.042 (0.684)	-0.086 (0.968)	-0.09* (0.068)	-0.054* (0.051)	-0.068 (0.951)	0.072* (0.068)
GDPSQ	-0.014 (0.725)	-0.019 (0.842)	-0.012 (0.764)	-0.021* (0.087)	-0.024 (0.697)	0.032 (0.895)	0.096* (0.054)	0.024* (0.068)	-0.023 (0.684)	-0.032* (0.094)
GES	-0.057 (0.638)	0.106* (0.073)	-0.082 (0.113)	-0.086** (0.023)	0.081 (0.143)	0.075* (0.031)	0.074 (0.214)	0.084* (0.020)	-0.079 (0.240)	-0.096* (0.052)
INST	0.852 (0.496)	0.046* (0.090)	0.053 (0.101)	0.064** (0.032)	0.036 (0.172)	0.019 (0.243)	0.007 (0.214)	0.024* (0.040)	0.075 (0.141)	0.010** (0.020)
GES*IN		0.006* (0.057)		0.004* (0.062)		0.009 (0.868)		0.004* (0.062)		0.007* (0.095)
INFL	0.024 (0.752)	-0.07* (0.062)	-0.096 (0.954)	-0.068** (0.035)	0.043 (0.835)	0.068 (0.857)	0.091 (0.734)	-0.062* (0.024)	0.081 (0.935)	-0.076* (0.042)
GEN	-0.051 (0.954)	0.351 (0.534)	0.741 (0.612)	-0.014 (0.687)	0.097 (0.835)	0.086 (0.792)	-0.092 (0.619)	0.079 (0.928)	0.083 (0.679)	0.091 (0.598)
ETH	0.043* (0.075)	0.082* (0.093)	0.043* (0.061)	0.083* (0.073)	0.075* (0.094)	0.092** (0.043)	0.073* (0.092)	0.091** (0.027)	0.068* (0.094)	0.047* (0.082)
EDINEQ	0.074* (0.043)	0.083* (0.015)	0.068* (0.091)	0.048** (0.035)	0.064* (0.049)	0.076* (0.039)	0.049* (0.047)	0.038* (0.091)	0.024* (0.047)	0.073* (0.082)
RMSE	0.001	0.002	0.002	0.001	0.001	0.002	0.001	0.001	0.002	0.002
Obs	754	754	97	97	76	76	110	110	142	134

Note: ***, ** and * demonstrate that the null is rejected at 1%, 5% and 10%, respectively.

4.3.2. DCCE-IV Results for SSA

We on the DCCE-IV results from columns 2, 4, 6, 8, and 10 to examine the link between the variables.

The root mean square error (RMSE) across all our regressions is nearly zero (0.01), indicating that cross-sectional dependence has been appropriately addressed. The findings presented in Table 6 show that most lag coefficients for inequality are significantly positive across all columns, suggesting the presence of mean reversion in inequality. In other words, inequality appears to converge toward its average level over time. Additionally, the interaction term between education spending and institutions (Inst) is significantly positive in SSA. A 1% increase in this interaction term results in a 0.006% increase in inequality.

However, education spending is positive and statistically significant in SSA. Specifically, a 1% increase in education spending raises inequality by 0.10%. As for institutions, the coefficient is positive and significant in SSA, indicating that a 1% increase in institutions (INST) leads to a 0.046% rise in inequality. Educational inequality is positive and significant in SSA, with a 1% increase in EDINEQ rising inequality by 0.083. Regarding Ethnic fragmentation, the results reveal that the relationship between ETH and inequality is positive and significant. A 1% rise in ETH increases inequality by 0.082. The results from column 2 of Table 7 reveal that the coefficients for GDP and its square are statistically insignificant in SSA. Regarding inflation, the findings show that inflation has a significantly negative effect on inequality in SSA, with a 1% rise in inflation reducing inequality by 0.075%.

4.3.3. Sub-regional heterogeneity

Sub-regional analysis reveals varying effects of education spending across the SSA sub-regions. In Southern and Western Africa, education spending is significantly negative, with a 1% increase in education spending reducing income inequality by between 0.057% and 0.096%. In contrast, education spending is significantly positive in Central and Eastern Africa, where a 1% increase in education spending raises inequality by 0.075% and 0.084%, respectively. Regarding inflation, the results indicate that inflation has a significantly negative effect on inequality in SSA, Southern Africa, Eastern Africa, and Western Africa, but is insignificant in Central Africa. A 1% increase in inflation reduces inequality by between 0.068% and 0.076% in these regions.

In terms of GDP, the findings show that it is positively and statistically significant in Southern and Western Africa, where a 1% increase in GDP raises inequality by 0.074% and 0.072%, respectively. Additionally, GDP squared is significantly negative in both regions, with a 1% increase in GDP squared raising inequality by 0.021% in Southern Africa and 0.032% in Western Africa. In Eastern Africa, GDP is significantly negative, while GDP squared is significantly positive. A 1% increase in GDP reduces inequality by 0.054%, while a 1% rise in GDP squared increases inequality by 0.024%. In Central Africa, GDP and its squared term are statistically insignificant. Furthermore, the institutional variable (INST) is positive and significant across most sub-regions, with a 1% increase in INST raising income inequality by between 0.010% and 0.064% in all regions. The interaction term between government education spending and institutions (GES*INST) is positive and significant in Southern, Eastern, and Western Africa, but insignificant in Central Africa. A 1% increase in GES*INST increases inequality by between 0.004% and 0.009% in Southern, Eastern, and Western Africa.

4.3.4. Net effect and institutional threshold analysis

Following column 2 of Table 7, the net effect of GES on income disparity is:

$$\begin{aligned}\frac{dGINI_{it}}{dGES_{it}} &= \beta_4 + \beta_5 \overline{INST}_{it} \\ &= (0.106) + [(-0.006) * (4.135)] \\ &= 0.131 \text{ score}\end{aligned}$$

where 0.006 represents the conditional impact of GES on inequality, and 0.106 is the unconditional impact of GES on inequality. However, 4.135 is the mean value of.⁵ Moreover, since the net effect is positive, we calculate the INST threshold at which the positive incidence of GES on inequality is attenuated.

4.4. Discussions

Table 7 presents an overview of the DCCE-IV estimates for the coefficients associated with GES and other independent variables across the full sample. In SSA, an increase in education spending is

⁵ Summary statistics are available upon request.

found to exacerbate inequality, which contradicts the general expectation. Education spending is typically viewed as a key driver of economic growth (Barro, 2013) and is expected to reduce income disparity.

However, the relationship between education spending and income inequality in SSA remains inconclusive. Given that education spending in the region has been historically low and has only recently increased, our findings align with the composition effect hypothesis. This hypothesis posits that an initial rise in education spending can lead to greater inequality. Securing well-paying employment tends to benefit individuals with higher levels of education, and SSA is marked by significant disparities in educational achievement, which contribute to the widening income gap (Turnovsky, 2011). Turnovsky's model illustrates that human capital, driven by education, is more heavily utilized in sectors reliant on skilled labor, thereby boosting productivity and exacerbating income inequality.

The results also show that the coefficients for GDP (as a proxy for economic growth) and its square are not statistically significant, indicating that economic growth alone does not account for income disparity in SSA. This finding is unsurprising, considering the trend over recent decades where many SSA countries have experienced growth in GDP without a proportional increase in employment and income for the majority of the population. This suggests that the economic growth observed in these countries is not benefiting the impoverished majority, thus leaving income inequality largely unaffected by growth. Moreover, the inflation variable shows significantly negative coefficients across almost all models, implying that an increase in the overall price level tends to reduce income inequality. This result might appear paradoxical, as inflation is often viewed as exacerbating inequality by diminishing the purchasing power of individuals, particularly those with lower incomes. However, the relationship between inflation and income inequality is complex and context-dependent. Some researchers characterize inflation as a regressive tax, while others argue that it is a progressive tax, or find no significant correlation with income distribution (Galli and Van Der Hoeven, 2001). The impact of inflation on income disparity can vary, with high initial inflation potentially reducing income inequality as inflation decreases, while low initial inflation may increase inequality when inflation is reduced.

Institutional variables generally show positive coefficients (Table 7). In theory, institutions, defined as systems where power is held by the people, should benefit the poor majority in SSA by improving their socioeconomic status, including income distribution. However, in SSA, democratic institutions tend to benefit primarily the educated elite with political affiliations. Bourguignon (2015) argued that the ineffective distribution of resources, often influenced by institutional deficiencies, contributes to income inequality in Africa. Insufficient resource allocation for education, healthcare, infrastructure, and social safety nets restricts opportunities for those below the poverty line, thus perpetuating income gaps. Additionally, institutional factors such as governance quality, legal structures, and public policies significantly shape income inequality in Africa.

Poor governance, corruption, and ineffective policies exacerbate income disparities by favoring specific groups or sectors over others. This view is supported by Ravallion (2009), who argued that institutions in Africa primarily benefit a small group of politicians. Corruption diverts resources to this elite, hindering economic growth and widening income inequality. The resulting inequality enables the wealthy to maintain political dominance, perpetuating corruption and making it difficult to identify the precise causes of sluggish economic growth. Ethnic fragmentation also has a significant and positive effect on income inequality, as social segregation and unequal access to resources exacerbate disparities within diverse communities (Alesina et al., 2003). Educational inequality plays a substantial role in income inequality in SSA, in line with the Skill-Biased Technological Change (SBTC) theory,

which suggests that disparities in workers' skills lead to variations in productivity and income. However, gender equality does not have a significant impact on income inequality in SSA.

4.4.1. Do the impacts of GES and DI differ among the sub-regions?

In this study, we conduct a sub-sample analysis to account for the heterogeneity among countries within the SSA region. Our primary objective is to assess whether the results differ across sub-regions. The full sample is divided into four sub-regions within SSA: Southern Africa, Central Africa, Eastern Africa, and Western Africa. Table 6 (columns 3 and 4) presents the findings for Southern Africa, while Table 7 (columns 5 and 6) shows the results for Central Africa. The findings for Eastern Africa are reported in columns 7 and 8 in Table 7, and the results for Western Africa are shown in columns 9 and 10 in Table 7.

While government expenditure on education (GES) is generally linked to increased income inequality across the SSA dataset, a closer examination through sub-sample analysis reveals notable regional variations. In the Western and Southern African sub-regions, as shown in Table 7, government education spending is associated with a reduction in income inequality, as indicated by significantly negative coefficients. This suggests that in these regions, government spending on education has been effectively utilized to mitigate income disparities. In contrast, in Eastern and Central Africa, the coefficients remain positive and statistically significant, indicating that increased education spending has been associated with greater income inequality. These findings diverge from the general SSA trend, which supports the composition effect hypothesis.

The regional analysis, however, presents distinct patterns: The results for Southern and Western Africa align with the "Wage Compression" effect hypothesis, while those for Eastern and Central Africa support the "Composition" effect hypothesis. In essence, GES reduces inequality in Southern and Western Africa, while it increases inequality in Eastern and Central Africa, as discussed in Section 2. Despite these regional differences, the impact of democracy on income inequality in the sub-samples remains consistent with the full sample results, except in Central Africa, where the coefficients become statistically insignificant (Table 6). As discussed, democracy in many African countries primarily benefits a small elite, particularly the educated and politically connected (Engerman and Sokoloff, 1997). Established institutions that favor specific groups or sectors may perpetuate income inequality over time.

Although the overall impact of economic growth on income disparity is statistically insignificant for SSA, disaggregated findings from columns 3 to 10 in Table 7 reveal that in Eastern Africa, an increase in economic growth is associated with reduced inequality, while in Central Africa, the relationship is statistically insignificant. Additionally, the squared term for economic growth is significantly positive for Eastern Africa, suggesting a non-linear relationship.

Conversely, in Western and Southern Africa, economic growth is positively associated with income inequality, while the squared term shows a negative association. This indicates that in these regions, an increase in economic growth initially leads to higher inequality, but as growth continues, inequality decreases. The findings for Western and Southern Africa align with the Kuznets hypothesis, which posits that as economies grow, income disparity initially rises, reaches a peak, and diminishes once a certain income threshold is surpassed (Kuznets, 1955). In these regions, the relationship between economic growth and income inequality follows an inverted "U-shaped" curve. In contrast, the findings for Eastern Africa suggest a "U-shaped" relationship, where inequality decreases during

the initial stages of economic growth but increases once a certain threshold is reached. The results for Central Africa, however, show that economic growth is statistically insignificant.

Regional analysis also reveals that inflation has a significantly negative impact on income inequality in almost all regions, except for Central Africa, as explained in Section 4.3. However, variables such as gender equality, ethnic fragmentation, and educational inequality remain statistically insignificant across the sub-samples.

4.4.2. Does institution condition government education expenditure to lower income disparity in SSA?

Given that the management of government education spending and the distribution of income are predominantly influenced by political factors, we investigate the interaction between institution and education spending in influencing income disparity in this section. Columns 3 to 10 in Table 6 present the regional findings, demonstrating that the interaction term between education spending and institution is significantly positive in SSA, South, West and East Africa. Furthermore, the net impact estimates based on Equation (3) indicate that at the maximum value of institution (0.131), government education spending augment income disparity by 0.006. These findings indicate that when institution increases, GES augments income inequality in SSA.

Across the SSA sample, the interacting and net effect findings suggest that education spending play a significant role in driving income disparity in highly democratic countries. Essentially, while education spending increase income disparity, this trend persists even with increased levels of democracy. These results also indicate that in democratic settings, income inequality linked to education spending tends to be higher. This phenomenon could be attributed to the fact that many SSA countries are in the early stages of their democratic journey. In these cases, democracy is in the experimental phase and has yet to fully realize its benefits. This stands in contrast to some advanced nations with centuries of democratic practice. Moreover, the transition to democracy poses significant challenges for certain SSA countries, often compounded by issues such as corruption. These challenges further exacerbate the detrimental impact of education spending on income disparity.

Regional analysis shows that in Southern Africa, the net effect results reveal that at the maximum amount of institution (4.192), GES lowers inequality by 0.102. In addition, in Central Africa, the net impact findings reveal that at the maximum amount of institution (3.975), GES increases inequality by 0.110, while in East Africa, the net effect findings reveal that at the maximum amount of institution (4.345), GES augments inequality by 0.101. Finally, in West Africa, the net impact findings demonstrate that at the maximum amount of institution (4.272), GES increases income gap by 0.125. These net impact findings indicate that the impact of education spending on income disparity conditioned by institution differs between sub regions.

5. Conclusions and policy recommendations

Researchers have explored the impact of institutions and GES on income inequality. However, these researchers have not examined how the effects of GES and institutions on inequality differ across sub-regions within SSA. Another gap in the literature is the lack of investigation into how institutional conditions mediate the relationship between government education spending and income disparity, particularly in SSA. Understanding the combined impact of institutions and education spending on inequality is crucial for comprehending how education expenditure influences inequality in democratic

contexts. We contribute to the literature by examining the direct and indirect effects of institutions and education spending on inequality, using data from 40 SSA countries spanning 1980 to 2024. To provide reliable insights and inform policy development, we employ DCCE-IV to assess the impact of institutions and education spending on inequality. Our findings can be summarized in five key points:

1. **Institutional Impact:** We find that institutions are a significant driver of rising income inequality in SSA.
2. **GES and Inequality:** Our results also indicate that GES exacerbates income inequality across SSA.
3. **Regional Variations:** Our regional analysis reveals that institutions contribute to increased income inequality in Western, Eastern, and Southern Africa, while having a neutral effect in Central Africa. Additionally, GES mitigates income inequality in Southern and Western Africa, but worsens it in Eastern and Central Africa.
4. **Interactive Effects:** We observe that institutions interact with GES to play a significant role in exacerbating income inequality in SSA.
5. **Democracy and GES:** From a regional perspective, the interaction between democracy indices and GES tends to increase income inequality in Southern, Eastern, and Western Africa, while having a negligible effect in Central Africa.

From policy and theoretical perspectives, our study contributes to the literature on the impact of institutions in SSA, highlighting how institutions tend to benefit a select group of elites, particularly those who are educated and politically connected. In SSA, institutions are expected to serve the interests of poorer households by shifting political power from the middle class to the lower-income segments, which constitute a large portion of the population. This finding is consistent with the institutional perspective developed by Bowles et al., (2006), who emphasize that social and political institutions can contribute to the persistence of poverty and economic inequality. In many SSA countries, democratic systems often enable individuals to leverage political connections to accumulate wealth from state resources. Numerous analysts have noted that many politicians in SSA prioritize personal interests over the welfare of the broader population. Our findings suggest that democratic leaders in SSA should focus on formulating and implementing policies that uplift the poor and vulnerable, thereby increasing their participation in societal affairs. This requires a shift from policies that primarily benefit politicians, such as salary increases, and toward initiatives that promote economic opportunities and empower marginalized groups.

Our research also demonstrates that GES is linked to increased income inequality in SSA. Since educational inequality contributes to income disparity, one way to ensure that education spending reduces inequality is to facilitate access to quality education for the poor. In SSA, however, access to quality education remains a significant issue. Furthermore, education spending tends to favor the elite, who often possess political influence, to the detriment of the poorer segments of society. Our analysis of interactive effects supports this view, showing that in countries with strong institutions, education spending exacerbates income inequality. This underscores the need for SSA governments to develop a distributive framework that ensures resources are managed for the benefit of all citizens, particularly low-income earners. Policymakers should consider reforms such as redistributive tax policies or strengthening social safety nets to reduce income inequality by fostering greater economic inclusivity and social equity. Stiglitz (2012) advocated for the establishment of inclusive institutions that provide equal opportunities for all individuals, regardless of socioeconomic status. These institutions should guarantee access to education, healthcare, credit, and employment for everyone. By breaking the cycle

of poverty and facilitating upward mobility, inclusive institutions contribute to reducing income inequality. Additionally, addressing ethnic fragmentation through inclusive policies and fostering dialogue among ethnic groups can build trust and promote equitable resource distribution. Reducing educational inequality by investing in education and promoting skill development, in line with the Skill-Biased Technological Change (SBTC) theory, is also crucial.

This research makes a significant contribution to academic understanding and policy implications. However, several avenues remain for future research. While we focus on the impact of institutions and government education spending on income inequality in SSA and its sub-regions, we do not explore whether the findings would differ between developed and developing regions. In future studies, researchers could conduct comparative analyses to investigate the effects of institutions and education spending on income inequality in developed and developing countries.

Author contributions

TP Voto: conceptualization, methodology, data curation, formal analysis, data analysis, literature review, and writing—original draft. Nicholas Ngepah: supervision, critical review, editing, and intellectual input. Both authors contributed to the interpretation of the results and approved the final version of the manuscript.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflict of interest

The authors declare no conflict of interest.

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