Mineral rents, conflict, population and economic growth in selected economies: empirical focus on Sub-Saharan Africa

Temitope Abraham Ajayi
Teesside University International Business School, Middlesbrough, UK

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Abstract

Purpose – This study aims to investigate the effects of mineral rents, conflict and population growth on countries' growth, with a specific interest in 13 selected economies in Sub-Saharan Africa.

Design/methodology/approach – This paper uses a combination of research methods: the pooled ordinary least squares (OLS), the fixed effect and the system generalized method of moment (GMM). The consistent estimator (system GMM), which provides the paper's empirical findings, remedies the inherent endogeneity bias in the model formulation. The utilized panel dataset for the study spans from 1980 to 2022.

Findings – The study suggests that mineral rents positively affect countries' growth by about 0.407 percentage points in the short run. The study further demonstrates the long-run negative impacts of population growth rates and prevalence of civil war on economic growth. The empirical work of the study reveals that an increase in the number of international borders within the group promotes mineral conflicts, which impedes economic growth. Evidence from the specification tests performed in the study confirmed the validity of the empirical results.

Social implications – Mineral rents, if well managed and conditioned on good institutions, are a blessing to an economy, contrary to the assumptions that mineral resources are a curse. The utilization of mineral rents in Sub-Saharan Africa for economic growth depends on several factors, notably the level of mineral conflicts, population growth rates, institutional factors and the ability to contain civil war, among others.

Originality/value – This study is the first attempt in the post-coronavirus disease 2019 (COVID-19) era to revisit the investigation of the impacts of mineral rents, conflict and population growth rates on the countries' growth while controlling for the potential implications of the qualities of institutions. One of the significant contributions of the study is the identification of high population growth rates as one of the primary drivers of mineral conflicts that impede economic growth in the states with enormous mineral deposits in Sub-Saharan Africa. The crucial inference drawn from the study is that mineral rents positively impact countries' growth, even with inherent institutional challenges, although the results could be better with good institutions.

Keywords GDP, Institutions, Conflict, Population, Resource curse, Mineral rents

Paper type Research paper

1. Introduction

The existence of geo-political conflict in virtually all the mineral-rich economies in Sub-Saharan Africa has led to a mix of propositions about the implications of mineral resources in an economy (Collier and Hoeffler, 2004; Kazuyo, 2021; Ross, 2004; Oliver *et al.*, 2022; Miguel and Shanker, 2011). Specifically, in Sub-Saharan Africa, mineral rents and resource-induced conflicts pervade most of her mineral-rich economies, with the existence of Niger Delta rebels in Nigeria, M23 groups in the Democratic Republic of the Congo, the Darfur-based Sudan

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Liberation Movement or Sudan People's Liberation Movement-North, the UNITA (In Portuguese *União Nacional para a Independência Total de Angola,* translating to *"The National Union for the Total Independence of Angola"*) rebels in Angola and those in the Sahel regions of Chad, Niger and Burkina Faso, among others. The central agitation among the above-listed geo-political conflict sponsors or mineral rebel groups is rent-seeking through resource conflict. Interestingly, some of the economies mentioned above consist of states with large population sizes. For instance, in 2021, Nigeria's population was 213 million, followed by the Democratic Republic of the Congo with 95.9 million people, Angola with about 34.5 million people, Burkina Faso with about 22.1 million people and Ethiopia with 120.2 million people (World Development, 2022). Nevertheless, as mentioned above, those economies are characterized by slow growth and a high poverty rate,

The rationales of this study are twofold: first, to examine the effects of mineral rents on the economic growth of mineral-conflict economies and determine whether high population growth is linked with the prevalence of mineral-induced conflicts. Second, the study aims to assess the transmission channels of geo-political conflicts that hamper the growth of Sub-Saharan economies with substantial mineral deposits. The *greed and grievance proposition* is a pointer to the second rationale (Murshed and Tadjoeddin, 2009; Collier and Hoeffler, 2004; Fearon and Laitin, 2003; Ross, 2004, 2006; Burgess *et al.*, 2015). The "*greed theorem*" of mineral resources suggests that the primary motivating factor of violent conflict is people's attempts to improve their economic situation, with the presumption that the reward (benefit) of rebellion outweighs the associated costs. Similarly, scholars like Miguel and Shanker (2011) and Hsiang *et al.* (2013) argued that variations in climatic conditions, especially in the Global South could potentially drive civil conflict. A notable implication of the greed and grievance proposition, especially for most mineral-producing states in the Global South, is its transmutation into a resource curse. Evidence in the literature suggests multiple transmission channels of mineral-induced conflict and civil war (Murshed and Tadjoeddin, 2009). However, some previous scholastic works on the relationship between mineral conflict and economic growth needed to account for the impact of demographic indicators like population growth or size as a potential channel of transmission of mineral conflicts noticeably in the Global South. Meanwhile, this study adds value to the existing body of knowledge in four crucial routes:

First, many of the previous empirical works failed to control for the potential role of the population surge among the developing mineral-producing states in the Global South (e.g. Lujala, 2010; Berman *et al.*, 2017). Anecdotal evidence indicates that developing mineral-producing economies with large population sizes will likely have high poverty rates, severe unemployment problems, ethnic divisions and governance challenges driven primarily by large population sizes. The United Nations population projection is that two-thirds of the predicted growth in the world population between 2020 and 2050 will occur in Sub-Saharan Africa. Interestingly, many of the economies in our sample would be the main drivers of such population explosion.

Second, from the sample size perspective, this study is the first attempt in the literature to deliberately focus an empirical searchlight on those mineral-rich economies in the Global South with sustained violent conflict occasioned by resource conflict. Our strategy categorizes economies with similar and potential characteristics as a group, emphasizing mineral-rich economies with mineral-induced challenges. Our sample economies fit this picture, and we overcome the external validity problem of studies like Kazuyo (2021), which focused primarily on the economy of the Democratic Republic of the Congo to examine minerals and conflict; Patrick *et al.* (2022) with empirical work on conflict and mineral, but mainly on the quarry sector; Farzanegan *et al.* (2018) with the scope of coverage of 1984–2004 to investigate mineral rents and internal conflicts; Nina and Christana (2021) with primary interest only on the Sierra Leone economy among others. Our sample size is more robust and relevant to the research postulations about the impacts of mineral rents, conflict and

population dynamism on economic growth, given the grouping of 13 economies in the Global South with common mineral conflict characteristics.

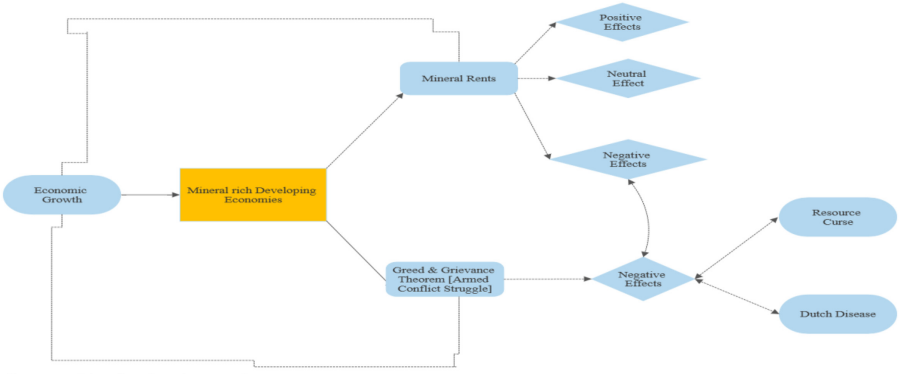
Third, this study is timely given the upsurge in violence in the Global South occasioned by resource conflicts, especially in countries like Nigeria, the Democratic Republic of the Congo, Sierra Leone, Burkina Faso, Equatorial Guinea, the Central African Republic, Angola, Sudan and others within the last decade.

Fourth, from the perspective of explanatory variables, this study applies the totality of mineral resources as a percentage of gross domestic product (GDP) sourced from the World Development (2022) to proxy mineral rents as opposed to the previous works with the usage of oil rents or a specific mineral like diamond to denote mineral rents.

By aggregating all mineral resources, we guaranteed external validity, given the disparate endowment of mineral resources in our sample economies. The structure of the remainder of this paper goes as follows: Section 2 provides the theoretical foundation of the study, with an empirical literature survey in Section 3; data and research methodology are crafted in Section 4, followed by the empirical results and discussion of findings in Section 5. Our robustness test in Section 6 and Section 7 concludes the work with the policy implications encoded in it.

2. Brief theoretical perspective

The theoretical foundation of this study rests on two pillars: the resource curse proposition and the Dutch disease hypothesis. Further, this study takes additional theoretical clues from an abridged version of the Solow model. Solow (1956) argued that population growth is an exogenous growth determinant and determines the steady state level of output growth in conjunction with aggregate savings. Further, variations exist in the cross-country steady state for the heterogeneity conditions among economies. By implication, an increase in population growth rate lowers a nation's output. Empirical evidence from Mankiw *et al.* (1992) attests to the validity of the Solow model, even with the augmentation of physical capital. In this study, the physical capital represents the available minerals in the sample countries, with the rents of such minerals being the main attractions of those countries. Significantly, many of the countries in our sample consist of high-population growth economies with the potential for a population explosion, increasing the burden of poor growth in the affected countries. In essence, there has been no consensus in the literature as to the impact of mineral rents on an economy, leading this study to categorize the likely effects of mineral rents as three under the conceptual framework: positive, negative and neutral effects of mineral rents in an economy (See Figure 1, the conceptual framework).



Source(s): Author's work

Figure 1.
The conceptual framework chart

3. Survey of empirical literature

An enormous amount of literature exists about the effects of mineral rents and/or conflict on a country's growth (Rustad and Binningsbø, 2012; Murshed and Tadjoeddin, 2009; Ross, 2004; Jammeh and Ping, 2011; Berman *et al.*, 2017; Collier and Dominic, 2008; Brunnschweiler and Bulte, 2009; Fearon and Laitin, 2003) with seemingly mixed outcomes. In dissecting those conflicting empirical positions, we observe that most of the research outcomes about the inverse implications of mineral rents on economic growth while controlling for conflict are rooted in developing resource-producing economies (Nina and Christina, 2021; Lessman and Seidel, 2017; Collier and Hoeffler, 2005; Patrick *et al.*, 2022; Diemel and Hilhorst, 2019). By extension, many of the negative assumptions about the impacts of mineral rents on economic growth have led to the resource curse debate and/or Dutch disease hypothesis in the literature (Jinxuan *et al.*, 2021; Burcu *et al.*, 2023; Tamás *et al.*, 2020; Oliver *et al.*, 2022; Sidiki and Nell, 2021). Subjecting resource curse or Dutch disease to further evaluation has shown some form of disputation about the validity of those propositions, notably concerning the economies of developed resource-rich countries. In this study, the primary interest is on the economies of developing mineral-rich states, which dictate the propensity to examine how mineral rents, conflict and population dynamism impact growth in those economies.

The preponderance of mineral-induced violent conflicts in the Global South to impact economic growth has opened a new discourse in the literature (Lujala, 2010; Diemel and Hilhorst, 2019), especially the rebel-greed hypothesis, whereby the violent rebel groups control and share a significant amount of minerals in their domain, leading to conflict minerals or conflict resources (Kazuyo, 2021). These violent rebel groups further maintain control over the territorial parts of the country, using the acquired illegal rents to obtain destructive weapons, like in the case of Boko Haram in the north-eastern part of Nigeria and militants in the Niger Delta areas of Nigeria, Mai Mai groups in Congo, funding of civil war by warring groups in Sierra Leone, in Angola and of late in the Darfur region of Sudan and South Sudan (Fanthorpe and Maconachie, 2010; Diemel and Hilhorst, 2019) with large holds on their controlled territories. The logical deduction from the pervading conflicts in the mineral-rich economies of the Global South is that there may be a likelihood of a nexus between violent conflict and economic growth while controlling for mineral rents. The business operating environment is a significant determinant of a country's growth in the literature. An unsafe or hostile business operating environment, especially those ravaged by mineral rebels, would likely experience slow growth or reduce the interest of investors and foreign direct income in those states.

Evidence in the literature indicates that the presumptions that greed and grievance drive conflict in mineral-rich economies, particularly in developing economies, are susceptible to empirical rebuttals from scholars. For instance, Murshed and Tadjoeddin (2009) argued that institutional problems or *social contract failure* are the leading cause of mineral-induced conflicts instead of greed and grievance. This study concurs in part with the propositions of Murshed and Tadjoeddin (2009), given that institutional challenges in Sub-Saharan Africa have a significant nexus with low income per capita, poverty, poor health conditions and failure of governance, the aggregate of which potentially culminates in the grievance of the population and, by extension, a fertile ground for the growth of rebellion groups that see the appropriation of minerals in their domain as the panacea to their impoverished conditions. Empirical evidence suggests that many developing economies with weak institutions are mineral-dependent states, which tends to support Mavrotas *et al.*'s (2009) position about *point-source resources*. Point-source [1] resources include minerals like oil and gas, with their presence in developing economies leading to institutional problems, particularly in governance (democracy), and hindering the growth of those countries mainly due to the mismanagement of the rents from those point-source resources.

The mineral extractions in the Global South are volatile in the context of the perceived "free money" that the mismanagement of mineral rents promotes. As such, violent conflicts in the Global South can be linked with mineral extraction in all its ramifications.

4. Data and research methodology

4.1 Data analysis

In this study, we utilize a panel dataset spanning 1980 to 2022 for the 13 carefully selected economies in Sub-Saharan Africa. The two main justifications for the chosen economies are data availability and research focus on the Global South, particularly on the economies of volatile developing mineral-rich states with many resource-induced violence conflicts and the potential for high population growth rates. Table 1 below presents the definitions of variables, measurements and sources.

The dependent variable is the per capita rate of real GDP growth sourced from the World Development (2022). Authors have used several variables in the past to denote mineral rents. We observe that many of the recent works on resource allocation and economic growth use oil rents. This study observed that oil is not the only mineral available in the sample economies. Our primary explanatory variable is the total natural resource rents, which consist of virtually all the mineral rents in the selected economies. The total natural resources rents and population growth rate data were sourced from the World Development (2022).

Our control variables for the impact of violent conflict on the economic growth of the mineral-rich states in the Global South are the prevalence of civil war and the number of neighboring states sharing a border with the identified countries in our sample. For the prevalence of civil war, the variable measures the number of internal armed conflicts in a particular year. Evidence in the literature suggests that the bulk of armed struggle or conflict within the economies of mineral-rich developing states impacts the growth rate. Therefore, we utilize the number of civil wars per year as one of the control variables to proxy conflict in our model development. The civil war score ranges from 1 as the lowest to 10 as the highest numerical value. In addition, we extract datasets on civil war and conflict using the Uppsala model in carrying out the robustness experiment to improve the efficacy of our findings on the relationships between civil war and countries' growth in mineral-producing economies. Within Uppsala, using data on civil war and conflict, the study created a dummy variable to observe the varying severity of civil war, ranging from minor conflict (0) to major civil war (1). Our second control variable for armed conflict is the number of neighboring states sharing a border with the countries in our sample. Anecdotal evidence shows that an economy's security depends on its conflict dynamics and immediate proximity to neighboring countries. In furtherance to that position, we argue in this study to include the number of countries sharing borders with countries in our sample to measure the degree or likelihood of external aggression against the countries in our group as the second control variable for conflict. Both control variables were sourced from the Polity IV Index of Regime Change, Centre for Systemic Peace (2021). The descriptive statistics are shown in Table 2 below.

The qualities of institutions are the democratic institutional quality developed from the Polity IV index of regime change (2022) with an index of 10 as the fully democratized state and strongest democratic institution to 1 as an autocratic or weak democratic institution. The indices can also be converted into percentage values. The effectiveness of governance institution quality is the second control variable for the institution, which the study developed from the World Development (2022), with ranges of the index from −2.5 as poor quality of institution to +2.5 as strong or good effectiveness of governance institution. The third control variable for the quality of the institution is the accountability institution. Political economy literature demonstrates the need for government to be accountable and transparent. This study sourced data for the quality of accountability institutions (QAISs) from World

Variable	Definition	Measurements	Time period	Source
GROW	Per capita growth rate of real GDP, which represents economic growth	Percentage	1980–2022	World Development (2022)
MINE	Mineral rents share in the GDP [Total natural resources rents as a percentage of GDP]	Percentage	1980–2022	World Development (2022)
POPR	Population growth rate	Percentage	1980–2022	World Development (2022)
CIVI	Prevalent of civil war	Numerical or Point value	1980–2022	Polity IV Index of Regime Change, Centre for Systemic Peace (2021)
BORD	Number of countries sharing borders with the country	Numerical or Point value	1980–2022	Polity IV Index of Regime Change, Centre for Systemic Peace (2021)
PGCW	Population growth rate * prevalent of civil war [composite variable]	Percentage	1980–2022	World Development (2022) and Polity IV Index of Regime Change, Centre for Systemic Peace (2021)
MRWC	Mineral rents * prevalent of civil war [composite variable]	Percentage	1980–2022	World Development (2022) and Polity IV Index of Regime Change, Centre for Systemic Peace (2021)
DEMO	Democratic institution quality	Numerical or Point value	1980–2022	Polity IV Index of regime change-Centre for Systemic Peace (2021)
EFGI*	Effectiveness of governance institutional quality	Numerical or Point value	1980–2022	World Governance Indicators, Kaufmann *et al.* (2010) In World Development (2022)
QAIS*	Quality of accountability institution	Numerical or Point value	1980–2022	World Governance Indicators, Kaufmann *et al.* (2010) In World Development (2022)
ICWU	Intensity of civil war (Uppsala Model)	Numerical or Point value	1980–2022	Violent Political Protest: Introducing a New Uppsala Conflict Data Program Data set on Organized Violence, Svensson *et al.* (2022)
DVSW	Dummy variable for severity of civil war (Uppsala Model)	Numerical or Point value	1980–2022	Author's estimation derived from: data on Violent Political Protest: Introducing a New Uppsala Conflict Data Program Data set on Organized Violence, Svensson *et al.* (2022)

Note(s): ** The two variables consist of data with availability from 2001. This study uses multiple imputation commands (See Colin and Pravin, 2012, pp. 47–48) in Stata 17 to input the missing values for the series. Moreover, the two variables were not used as part of the study's empirical result but only utilized to compute our robustness test to augment other governance indicators or qualities of institutions used, like the democratic quality of institutions with complete series
Source(s): Author's compilations

Table 1.
Variable description and source

Development (2022) in its voice and accountability variable, ranging from −2.5 as a weak institution to +2.5 as a strong institution.

Variable [Notation]	Mean	SD	Min	Max	Observation
GDP per capita [GROW]	0.83	10.74	−47.9	140.48	527
Mineral rents share of GDP [MINE]	18.45	14.98	1.85	88.59	559
Population growth rate [POPR]	2.85	0.97	−5.28	6.44	559
Prevalent of civil war [CIVI]	0.72	1.67	0	6	559
Number of countries sharing borders [BORD]	4.35	2.07	0	8	559
Population growth rate * Prevalent of civil war [PGCW]	1.99	5.32	−14.38	21.70	559
Mineral rents * Prevalent of civil war [MRWC]	16.87	47.37	0	354.855	524
Democratic institution quality [DEMO]	−5.70	24.06	−8	8	559
Effectiveness of governance institutional quality [EFGI]	5.67	24.02	−8.844	97.285	559
Quality of accountability institution [QAIS]	5.66	23.50	−7.988	92.868	559
Intensity of civil war (Uppsala Model) [ICWU]	1.38	1.15	−2.5	2	559
Dummy variable for severity of civil war (Uppsala Model) [DVSW]	0.023	0.151	0	1	559

Source(s): Author's computations

Table 2.
Descriptive statistics

4.2 Research method

4.2.1 Model specification. This study follows the assumptions of the augmented Solow model (See Solow, 1956) as enshrined in the work of Mankiw *et al.* (1992) about the potential impacts of physical capital [2] (mineral resources in this study) and population growth rate on national output. The basic assumptions of the Solow model entail an aggregate production function whereby:

$$\mathrm{Y(t)} = \mathrm{F[k(t), L(t), A(t)]} \tag{1}$$

where Y(t) is the total output produced in an economy at time t, k(t) represents the stock of capital, L implies the labor or aggregate employment and A(t) is the technology at the time t. Functionally, the output produced in an economy is a function of the three variables: capital, labor and existing technology. In developing the study's model, the primary emphasis is on the impacts of mineral rents, conflicts and population on economic growth while controlling for other potential growth drivers like the qualities of institutions. The multiple-regression equation model for this study is specified as follows:

$$GROW = \alpha_i + \beta_1 MINE + \beta_2 POPR + \beta_3 CIVI + \beta_4 BORD + \beta_5 PGCW + \beta_6 MRMC + \beta_7 DEMO + \beta_8 GROW_{-1} + \varepsilon \tag{2}$$

The dependent variable from equation (1) above is *GROW*, the GDP per capita growth rate. For the right-hand-side explanatory variables, *MINE* denotes mineral rents as a percentage of GDP; *POPR* is the population growth rate; *CIVI* implies the prevalence of civil war; *BORD* is the border proximity of the country to its neighbors and *PGCW* represents the composite variable created from the interaction of population growth rate and the prevalence of civil war. *MRMC* is another composite variable derived from the interaction of mineral rents as a percentage of GDP and the prevalence of civil war. *DEMO* is the quality of the democratic institution and is the lag one of the per capita growth rate of GDP. Including the lagged value of a dependent variable following the econometric theory reduces the instances of autocorrelation in the model development (see Keele and Kelly, 2006; Wooldridge, 2012). In the context of this study, the lagged value of the per capita GDP growth rate curtails the incidence of autocorrelation in the model development process.

The α_i is the intercept, the βs is the parameter to be estimated and ε is the stochastic error term. The *ith* in equation (1) represents the countries in the group, where $i = 1, 2, N = 13$ and t is the time factor, $t = 1, 2, T = 42$ years.

The study adopts the GMM estimation procedure for the dynamic panel regression model above to examine the implications of mineral rents, conflict and population dynamism on economic growth. Following the work of Arellano and Bond (1991), the GMM model for the study is given as follows:

$$Z = \pi + \varphi Z_{-1} + \beta G + \Omega_t + M + \varepsilon \tag{3}$$

where i = 1, ... N; t = 1,2, . . .T.

Z is the economic growth (grow) i at time, Z_{-1} is the lag one of economic growth. G denotes the vector of explanatory variables across the 13 selected economies and over time, M_i is an unobserved country-specific effect, Ω_t is the time effect and ε is the error term. The subscripts *"t"* and *"i"* represent the time period and country, respectively.

In order to eliminate the individual country-specific effects, M_i in equation (2) above, we take the first difference, which leads to:

$$\Delta Z = \varphi * \Delta Z_{-1} + \beta \Delta G + \varepsilon \tag{4}$$

One of the best practices in the model estimation procedure is to begin with the pooled ordinary least squares (OLS). Applying an OLS approach to equation (4) above would yield inconsistent estimates and biased results given the unobserved panel-fixed effect and/or endogeneity issues. To derive a consistent estimate, Arellano and Bond (1991) proposed the generalized method of moments (GMM) using the lag of the dependent variable as an instrument to correct the endogeneity issues whereby $\Delta Z - 1 \varepsilon \neq 0$. The GMM is a generic method for constructing estimators analogous to maximum likelihood (ML). GMM uses assumptions about specific moments of the random variables instead of assumptions about the entire distribution, which makes GMM more robust than ML at the cost of some efficiency. These assumptions are called moment conditions. These moment conditions are functions of the model parameters, including the data, with the assumption of zeros at the parameters' true values.

4.2.2 The justifications for the system GMM application and endogeneity discussion. In econometric parlance, endogeneity happens if there is a correlation among variables in a regression model, say, one or more independent variables and the error component. If unchecked, endogeneity problems lead to inconsistent or biased estimates in the regression equations. Among the notable causes of endogeneity are omitted variable bias, measurement error, reverse causation and simultaneity (e.g. Baltagi, 2013). In this study, the dependent variable is the per capita growth rate of GDP. The key explanatory variable is the total mineral rents as a percentage of GDP. By deduction, cross-country variations exist in the computation or estimations of the mineral rents.

Further, other crucial regressors with the potential for an endogeneity bias are the qualities of institutions. Given the heterogeneity conditions across the 13 selected economies, disparities prevail in the estimations of the identified variables above. As such, a likelihood exists in our model for the measurement error of mineral rents, the prevalence of civil war and the qualities of institutions utilized in our regression equation. The main advantages of GMM are as follows: first, the GMM is particularly useful for dynamic panel data with many observations; second, the GMM [3] controls for endogeneity issues like measurement error, as we have in this study, omitted variable bias, unobserved panel heterogeneity, reverse causation and simultaneity; third, the GMM model is designed for models with heteroscedasticity and autocorrelation within panels or groups (see Blundell and Steve, 1998). The cumulative merits of the GMM present it as an appropriate method to apply in this

study. There are two variants of GMM: the difference GMM (Arellano and Bond, 1991) and the system GMM (Blundell and Steve, 1998). Both approaches would correct the endogeneity issues. The difference GMM transforms all the explanatory variables via the first difference and removes the fixed effects. The system GMM, on the other hand, overcomes the perceived shortcomings by introducing more instruments to secure efficiency gains. Using more instruments in the system, GMM transforms them by making them exogenous (uncorrelated) with a fixed effect. Specifically, the system GMM uses two regression equations: the initial, or original, and the transformed. Above all, the system GMM deducts the average of all future available observations of a variable, meaning orthogonal deviations, which averts and reduces data loss. Given the merits of the system GMM as a generic estimation procedure for dynamic panel data, this study applies it as our consistent estimation approach. The GMM utilizes either the Hansen J test (Hansen, 1982) or the Sargan test of over-identifying restrictions to determine the instruments' validity.

5. The result and discussion of findings

Table 3 presents our empirical results for this study. Therein, we show the preliminary estimation procedures, pooled OLS and fixed-effect estimators in columns 1 and 2 of Table 3, followed by the estimates of the panel instrumental variable technique in Column 3 – a consistent estimator on its own. Panel IV [4] uses three instruments. However, our consistent estimator results with the system GMM are presented in Column 4. For the parameter estimate of the share of mineral rents in GDP in Column 4, we have 0.407* in the short run and 0.413* in the long run. By implication, an increase in the mineral rents among our sample population by

Dependent variable: per capita growth rate of GDP [grow]

Variable [Notation]	Pooled OLS model	Fixed effect model	Panel IV model	System GMM model
Share of mineral rents of GDP[MINE]	0.185*** (5.80)	0.432*** (8.35)	0.341*** (4.42)	0.407* (2.72)
Population growth rate [POPR]	−2.660*** (−4.55)	−4.620*** (−6.58)	−4.575*** (−6.54)	−4.108* (−2.04)
Border proximity [BORD]	−0.221 (−0.98)	0.841 (0.82)	0.871 (0.85)	0.608* (0.72)
Prevalence of civil war [CIVI]	−5.229*** (−4.86)	−5.994*** (−5.40)	−6.291*** (−5.61)	−5.844* (−2.36)
Population growth rate * Civil war [PGCW]	1.757*** (5.69)	2.365*** (7.56)	2.344*** (7.52)	2.340** (2.86)
Mineral rents * Civil war [MRWC]	−0.0187 (−0.91)	−0.0491* (−2.37)	−0.0348 (−1.55)	−0.0482* (−1.82)
Democratic institution quality [DEMO]	0.0264 (1.34)	0.0291 (1.48)	0.0297 (1.52)	0.0276 (1.01)
Lag one of dependent variable	0.154*** (3.58)	0.0812 (1.95)	0.101* (2.35)	0.0150 (0.13)
Constant	6.431** (2.99)	2.817 (0.58)		−78.37 (−0.59)
N	498	498	497	484
Countries	13	13	13	13
Fixed effect		Y	Y	Y
Time dummy variable	Y		Y	Y
Arellano bond 2 [AR_2]				0.2048

Note(s): t statistics in parentheses * $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$
Source(s): Author's computations

Table 3.
The empirical results

one unit promotes the countries' growth by about 0.407% points in the short run, at a 5% significance level. Substantial proofs in the literature exist as per the positive effects of mineral rents on economic growth. A quick observation of the estimated parameter of the share of mineral rents in the GDP with the panel instrumental variable in Column 3 of Table 3 shows a positive outcome with about 0.341% points, similar to the system GMM estimate.

Given the above outcome, this study aligns with such positive resource schools of thought positions in the literature as Yanıkkaya and Turan (2018), Chandan and Sudharshan (2022), Haseeb *et al.* (2021) and Sala-i-Martin and Subramanian (2013), among others. Significantly, over 50% of the national income of many of the economies in our sample emanates from mineral rents (US Energy Information and Administration, 2022). Despite the instabilities in the mineral price regime, mineral rents have remained an important growth driver in many developing mineral-producing states, given the seemingly mono-economy practice in their domestic economies, which has placed tremendous responsibilities and determination of their national budget on mineral rents.

The population growth's parameter estimate, as observed from Column 4 of Table 3, is −4.108*. By interpretation, an increase in the population growth rate in our sample signals a negative effect on countries' growth by about −4.108% points in the short run and −4.170 points in the long run, at a 5% significance level. The population growth rate is one of the crucial demographic variables that has far-reaching implications for the growth of an economy. Scholars have argued in the literature that the Global South's prevailing population explosion could mar those economies' growth strategies (see Peterson, 2017; Dao, 2013).

The optimum population growth rate is desirable, but most of the population growth rates in developing states have not been stabilized at the optimum population thresholds. The significant implication of the rise in population growth in our sample indicates the inability of the mineral rents to meet the per-head demands of the population, leading an economy to macroeconomic problems. Countries like Nigeria, with about 215 million people and an annual population growth rate of 2.44% in 2020, have faced various economic challenges despite the huge mineral rents, possibly confirming the nexus between the rapid population growth rate and economic growth. That assertion is true for countries like the Democratic Republic of the Congo, among others in the Global South.

5.1 The long-run equilibrium solution

Below is the long-run equilibrium solution of the system GMM:

$$\text{Grow} = 0.413[\text{MINE}] - 4.170[\text{POPR}] + 0.618\,[\text{BORD}] - 5.933[\text{CIVI}] + 2.376[\text{PGCW}] - 0.049\,[\text{MRWC}] + 0.028[\text{DEMO}]$$

The parameter estimates of border proximity in column 4 of Table 3 show 0.608*. That implies that, on average, an increase in the number of countries that have an immediate border with countries in our sample by one, the higher the rate of economic growth by about 0.608% points in the short run and 0.618% points in the long run, at the 5% level of significance. The finding on border proximity negates our *a priori* expectation. Potentially, border proximity may facilitate trade, productivity and other economic activities among countries. That may be the factor that our econometric experiment is picking up. In the context of mineral conflict, however, anecdotal evidence suggests that the porous borders of some of the states in the mineral-rich economies in the Global South have hugely contributed to the inflation of mineral conflicts and deprived such economies of an enormous mineral rent due largely to the activities of mineral rebels (Ross, 2012, 2015). For instance, the hitherto operations of Boko Haram in the north-eastern part of Nigeria have changed dramatically into unlawful exploitation of agricultural minerals in the Lake Chad regions and extra-judicial

activities given the proximity of the Nigeria border in the northern parts to countries like Chad, Niger, Cameron and Libya, among others.

As observed in column 4 of Table 3, the parameter estimate of the civil war's prevalence is −5.844*. It means that an increase in the prevalence of civil war by one in our sample economies decreases the country's growth rate by about −5.844% points in the short run and −5.933% points in the long run. Well-documented evidence in the literature shows that the prevalence of war is a massive impediment to economic growth. No nation can flourish in the atmosphere of war and conflict. Given the political upheaval between Ukraine and Russia, a vivid example of this can be observed in Ukraine's economy. As such, this study agrees with the position in the literature about the negative impacts of conflict in the form of civil war on economic growth (Ross, 2015, 2018; Brunnschweiler and Bulte, 2009; Hodler, 2006). Further, one of the factors that have held down the growth of economies like the Democratic Republic of the Congo, Sierra Leone, Cote d'Ivoire and Liberia, among others, is the prevalence of civil war in those economies, which has led to a significant loss in Foreign Direct Investment (FDI), a loss of investors' interest in those economies and making the mineral rents becoming valuable tools in the hands of various mineral rebels who controlled parts of those states in the past and, in some cases, till now.

For our first composite variable, the interaction of population growth rate and civil war, the estimated parameter, as observed in column 4 of Table 3, is 2.340** in the short run and 2.376* in the long run. This outcome is striking because our *a priori* expectation is that the parameter sign would be negative. However, civil war indirectly checks or reduces the sample economies' population growth rates, thereby improving the countries' growth. That may be the potential factor that our econometric work is picking up. Realistically, there would be some loss of lives and properties during the civil war as observed in the literature. As such, our econometric experiment may be picking up all of these factors. Our second composite variable, the interaction variable between the share of mineral rents in GDP and civil war, as observed in column 4 of Table 3, has a parameter estimate of −0.0482* in the short run and −0.049* in the long run. The interpretation of the above is that mineral rents could positively affect countries' growth as identified earlier. However, when interacting with the prevalence of civil war, the effect of such an interaction becomes a negative impact. Logically speaking, the finding here about the interaction of mineral rents and civil war being damaging is justified, given the previous finding on the effect of civil war prevalence.

The specification test, the Arellano–Bond serial autocorrelation test, shows that our model does not suffer from autocorrelation problems. Our AR2 result is 0.2048, meaning that at a 5% significance level, we cannot reject our sample's null hypothesis of no autocorrelation. Our econometric model development for this study uses robust standard error estimates for our system GMM. By implication, the Hansen or Sargan test is not required given the application of robust standard error (see Cameron and Pravin, 2010, p. 301). Interestingly, evidence from an alternate or supplementary consistent estimator (Panel IV) utilized in Table 3 shows that all the estimated signs of parameter coefficients with the panel instrumental variable estimator in Column 3 are the same as our primary consistent estimator – the system GMM. That outcome is good news for our model and proof of its validity.

6. The robustness test

We carried out a specific robustness test to validate our empirical findings, as outlined in Table 4. Table 4 contains seven sets of regression equations with the application of a consistent estimator, the system GMM. In Column 1 of Table 4, we reran the regression equation in Column 4 of Table 3 and introduced another explanatory variable, the foreign direct investment net inflow as a percentage of GDP. Despite adjusting our model

Table 4.
Robustness test with system GMM

Dependent variable: per capita growth rate of GDP [grow]							
Variables [Notations]	Robust system GMM 1	Robust system GMM 2	Robust system GMM 3	Robust system GMM 4	Robust system GMM 5	Robust system GMM 6	Robust system GMM 7
Share of mineral rents of GDP [MINE]	0.377** (2.63)	0.309* (2.42)	0.312* (2.46)	0.307* (2.35)	0.333* (2.43)	0.333* (2.43)	0.328* (2.38)
Population growth rate [POPR]	−4.303 (−1.94)	−4.473* (−1.97)	−4.553* (−1.97)	−4.603* (−2.07)	−4.630* (−1.96)	−4.630* (−1.96)	−4.611* (−1.96)
Border proximity [BORD]	0.520 (0.72)	0.696 (0.87)	0.626 (0.76)	0.628 (0.79)	0.615 (0.77)	0.615 (0.77)	0.610 (0.74)
Prevalence of civil war [CIVI]	−5.881* (−2.28)	−6.458* (−2.36)	−6.561* (−2.38)	−6.467* (−2.35)	−6.320* (−2.38)	−6.320* (−2.38)	−6.282* (−2.38)
Population growth rate * Civil war [PGCW	2.386** (2.71)	2.510** (2.71)	2.579** (2.71)	2.593** (2.79)	2.572** (2.79)	2.572** (2.79)	2.570** (2.79)
Mineral rents * Civil war [MRWC]	−0.0553* (−2.04)	−0.0451* (−2.00)	−0.0422 (−1.88)	−0.0452* (−2.03)	−0.0485* (−2.00)	−0.0485* (−2.00)	−0.0520* (−2.10)
Democratic institution quality [DEMO]	0.0331 (1.39)	0.0391 (1.76)	0.0398 (1.78)	−0.0567 (−0.27)	−0.631 (−1.23)	−0.631 (−1.23)	−0.623 (−1.22)
Lag one of dependent variable	0.0334 (0.35)	0.0319 (0.33)	0.0326 (0.35)	0.0344 (0.37)	0.0313 (0.33)	0.0313 (0.33)	0.0309 (0.32)
FDI net inflow of GDP [FDIN]	0.0270 (0.89)	−0.292 (−1.73)	−0.277 (−1.65)	−0.270 (−1.64)	−0.256 (−1.63)	−0.256 (−1.63)	−0.268 (−1.71)
Mineral rents* FDI [DFIM]		0.006* (2.40)	0.007* (2.35)	0.005* (2.35)	0.005* (2.40)	0.005* (2.40)	0.006* (2.49)
Civil violence prevalence [VOCI]			−2.572 (−1.21)	−3.019 (−1.48)	−3.020 (−1.44)	−3.020 (−1.44)	−2.743 (−1.29)
Effectiveness of governance institutional quality [EFGI]				−0.0982 (−0.43)	−0.158 (−0.83)	−0.158 (−1.83)	−0.169 (−0.90)
Quality of accountability institution [QAIS]					−0.522 (−0.97)	−0.522 (−0.97)	−0.500 (−1.94)
Intensity of civil war (Uppsala Model) [ICWU]						2.468* (2.33)	2.479* (2.33)
Dummy variable for severity of civil war (Uppsala Model) [DVSW]							2.552* (2.48)
Constant	36.35 (0.28)	−12.97 (−0.11)	18.43 (0.14)	41.28 (0.34)	34.67 (0.28)	−459.2* (−2.03)	−469.3* (−2.07)
N	483	483	483	483	483	483	483
Countries	13	13	13	13	13	13	13
Fixed effect	Y	Y	Y	Y	Y	Y	Y
Time dummy variable	Y	Y	Y	Y	Y	Y	Y
Arellano bond two [AR_2]	0.2188	0.7101	0.6898	0.6968	0.6130	0.6130	0.6067

Note(s): t statistics in parentheses * $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$

Source(s): Author's computations

formulation, we can observe that our parameter estimate for mineral rent is positive, with a magnitude of about 0.377*.

The population growth rate sign remains negative at about −4.303*; the border proximity parameter estimate remains negative at 0.520; the prevalence of civil war is still a negative parameter at about −5.881* and the signs of our two composite variables remain the same with what we obtained in Column 3 of Table 3, our empirical finding. In Column 2 of Table 4, we introduced another variable into Column 1, a composite variable via the interaction of mineral rents and FDI. Despite the adjustment, all the signs of our parameter estimates remain the same. In Column 3 of Table 4, we introduced another variable, VOCI – the prevalence of violent conflict, into our regression equation in Column 2 of Table 4. However, all the signs of our estimated parameters are the same, with no apparent changes in signs except for minor adjustments in the levels of magnitude. In Column 4 of Table 4, the quality of governance effectiveness (EFGI) is introduced, with no change to the parameter signs. In Column 5 of Table 4, another institutional quality, QAIS, is introduced without altering our parameter signs for crucial variables. For Column 6 of Table 4, we further revise the dynamics of the measurement of civil war with the Uppsala model of civil war intensity (ICWU).

Nevertheless, the parameter signs of our variables of interest did not change. Finally, in Column 7 of Table 4, we introduced a dummy variable formed from the Uppsala Civil War model to determine the severity of civil war, ranging from a minor conflict of 0 to a major civil war of 1. However, all the signs of our estimated parameters remain the same. All the AR2 outcomes from Columns 1 to 7 of Table 4 indicate no autocorrelation among the system of regression equations. Therefore, the robustness tests imply that, having subjected our findings to various modifications, this study's empirical findings remain strong and internally valid. As such, the findings of this study have a strong tendency for external validity, which is suitable for our research study.

7. Conclusion and policy implications

This study investigates the effects of mineral rents, conflict and population growth on the growth of 13 selected Sub-Saharan African countries. The study's findings suggest that mineral rents positively affect countries' growth. By extrapolation, mineral rents are a blessing to an economy, contrary to the assumptions of the resource curse. Further, the empirical findings in the study lend credence to the potential adverse effects of a high population growth rate on the countries' growth, notably the rich mineral-deposit countries in Sub-Saharan Africa.

The study demonstrates that some of the mineral-conflict economies in Sub-Saharan Africa also have large populations. The rising population may contribute to mineral conflict and, by extension, the slow growth in Sub-Saharan Africa. Moreover, the study indicates that greater the number of national borders within the conflict-prone Sub-Saharan African states with significant mineral deposits, the lower their growth rates. Hence, the prevalence of civil war significantly reduces growth (see Brunnschweiler and Bulte, 2009; Collier and Hoeffler, 2012; Hodler, 2006). A shred of evidence from countries like the Democratic Republic of the Congo, Sierra Leone, Burkina Faso, Liberia, Sudan, Angola and the Central African Republic are notable examples.

The study's policy implications are: first, mineral rents are an economic blessing if well managed (Sarmadi *et al.*, 2014; Kropf, 2010; Chandan and Sudharshan, 2022; Acemoglu and Robinson, 2012). Second, institutional reforms are crucial for conflict-prone economies in the Sub-Saharan economies for economic growth with mineral rents. Third, conscious population growth control policies may be needed to address the likelihood of population explosion-induced stagnation in the Sub-Saharan African economies. Fourth, robust border control actions may be necessary to reduce the influx of mineral conflicts from country to country. Finally, there may be a need to peacefully address some of the rebel groups' "*legitimate*" agitations or grievances, given their propensity to sustain violent economic sabotage.

Notes

1. According to Mavrotas *et al.* (2009), point-source resources "exhibit concentrated and capturable revenue patterns". By implication, resources like oil and minerals have their revenue concentrated given the production and demand patterns of such commodities, in contrast to many agricultural products with a more dispersed or diffused revenue flow. The concentrated nature of the point-source minerals exposes them to resource dependence syndrome and other institutional vices.
2. There are variants of physical capital like FDI net inflows (see Muhammad, 2020, p. 458). However, mineral rents as seen in the literature potentially attract FDI net inflows given the technical transfer of exploration and large returns on its investment.
3. The three instruments utilized include lag one of the mineral rents of GDP, lag one of ethnic war and lag one of annual rainfall (precipitation), with the estimates of our system GMM and panel instrumental variable estimator showing similarities.
4. The study uses three instruments: the lag one of mineral rents of GDP, the lag one of ethnic war and the lag one of annual rainfall. The three instruments were statistically confirmed to be strong and valid instruments of choice. The inclusion of lag one of annual rainfall confirms the assumptions of Miguel *et al.* (2004), Miguel and Shanker (2011) about the applicability of variations in rainfall as an IV when investigating drivers of civil conflict, particularly in the Global South.

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Corresponding author

Temitope Abraham Ajayi can be contacted at: topijay@yahoo.com