

Article

The Sub-Saharan African economic burden of violent armed conflict

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Abstract: This research examines data from 1989 to 2022 across 48 Sub-Saharan African (SSA) countries using a novel panel data regression approach to uncover how conflict undermines economic stability. The study identifies the destruction of infrastructure, disruption of human capital development, and deterrence of investment as primary channels through which conflict negatively impacts economies. These findings support the hypothesis that armed conflict severely hampers economic performance in SSA, highlighting the urgency for effective conflict resolution strategies and robust institutional frameworks. The negative impacts extend beyond immediate losses, altering income growth trajectories and perpetuating poverty long after hostilities cease. Regional spillover effects emphasize the interconnectedness of SSA economies, where conflict in one country affects its neighbors. The research provides innovative insights by disaggregating impact pathways and employing a robust methodology, revealing the complexity of conflict's economic consequences. It underscores the need for comprehensive policy interventions to foster resilience and sustainable development in conflict-prone regions. While there is evidence of potential post-conflict growth, the overall net effect of armed conflict remains profoundly negative, diminishing economic prospects. Future research should focus on strengthening long-term resilience mechanisms and policy measures to enhance the peace dividend. Addressing the root causes of conflict and investing in peace-building efforts are essential for transforming SSA's economic landscape and ensuring sustainable growth and development.

Keywords: armed conflict; economic growth; Sub-Saharan Africa; infrastructure; investment; human capital

1. Introduction

Armed conflict has been extensively studied for its impact on economy. These effects include substantial damage to physical and human capital, disruption of economic activities, and weakening of institutions, all of which hamper long-term development. The consequences of armed conflict extend beyond immediate human casualties, causing both direct destruction and indirect, long-lasting institutional, social, and economic disruptions. Scholars have increasingly focused on how conflicts leave enduring economic scars on affected nations, examining the intricate relationship between violence and prosperity. A regional focus on Sub-Saharan Africa (SSA) highlights additional complexities due to the region's unique historical context, various conflict types, and ongoing development challenges. Sub-Saharan Africa is home to the highest concentration of civil wars and internal conflicts globally, with estimated economic losses exceeding 12% of annual GDP (World Bank, 2024). The region's abundant natural resources often lead to conflicts over mineral rights and control of resource rents, perpetuating violence and impeding economic development (Lessmann & Steinkraus, 2019). Weak institutions, pervasive corruption, and limited

state capacity further exacerbate the economic impacts of conflict, hindering effective post-conflict reconstruction and development efforts (Babajide, 2018). Additionally, the predominantly agrarian economies and informal sectors in SSA make communities particularly vulnerable to disruptions in production, trade, and infrastructure caused by conflict (Jayne, Fox, Fuglie, & Adelaja, 2021). Conflicts in SSA are deeply intertwined with development challenges, influencing poverty, inequality, health, education, and social dynamics, as noted by (Okunlola & Okafor, 2022). This study seeks to investigate the direct and indirect effects of armed conflict on economic growth by drawing insights from diverse studies. We examine the pathways through which armed conflict might indirectly affect economic growth such as through infrastructure (Inf), domestic investment (Inv) and human capital development. The recent surge in armed conflict-related violence, along with its tendency to spread across borders, underscores the importance of researching its economic impact. Armed conflict not only causes human suffering and social instability but also hampers economic growth by negatively affecting investment, infrastructure, and human capital. Prior research has documented how armed conflict impedes economic performance, including investment, trade, productivity, and human capital. However, the impact varies across regions and contexts within SSA, influenced by conflict characteristics and the resilience of affected countries.

This research aims to address this gap by analyzing data from 1989 to 2022 across 48 SSA countries, employing panel data regression methods to measure the effects of armed conflict on economic growth in West Africa, East Africa, and Central Africa. Previous studies present diverse perspectives on the relationship between armed conflict and economic growth in SSA. Some studies (Le, Bui, & Uddin, 2022) (Collier & Hoeffler, 2004) suggest that economic growth may deter conflict, while others (Żakowska, 2020) argue that growth could exacerbate conflict or destabilize regions. Additionally, some researchers (de Groot, Bozzoli, Alamir, & Brück, 2022) propose no direct link between economic growth and violence. One hypothesis is that lower economic growth rates might increase conflict onset, suggesting that economic downturns reduce opportunities and heighten incentives for conflict (Kim & Conceição, 2009). This study explores how armed conflict affects economic growth directly and indirectly, focusing on investment, infrastructure, and human capital development in SSA.

Our study hypothesizes:

H11: Armed conflict significantly negatively impacts economic growth in SSA, both directly and indirectly.

H12: Armed conflict significantly hinders investment, infrastructure, and human capital development, thereby impeding economic growth in SSA.

The theoretical framework integrates the neoclassical Solow-Swan growth model, extended by Mankiw, Romer, and Weil (1992), which emphasizes capital accumulation, labor, and technological progress as growth determinants. Econometric panel regressions are employed to assess the effects of conflict intensity, destruction of physical and human capital, macroeconomic instability, and control variables on GDP growth rates, incorporating fixed effects to enhance estimation robustness. Our findings reveal a complex relationship between armed conflict and economic growth

in SSA, highlighting significant adverse effects on investment, infrastructure, and human capital. Conflicts damage infrastructure, disrupt trade, and impede human capital development, perpetuating poverty and underdevelopment. These results align with existing literature and emphasize the need for effective conflict prevention and resolution strategies. Addressing root causes like poverty, inequality, and governance deficits is crucial for building resilience and promoting sustainable economic development in SSA.

In the following section, we will outline the study's methodology

2. Materials and methods

2.1. Empirical design

In this section the study details the method employed in the study.

This study employs data from 1989-2022 from 48 SSA, using panel data regression methods and a rich set of indicators to measure the effects of armed conflict on economic growth in three sub-regions of SSA: West Africa, East Africa, and Central Africa. Drawing on the findings of the literature and the theoretical models, the empirical framework for analyzing the impact of armed conflict on economic growth in Sub-Saharan Africa were built on the following pillars. Direct effects via physical capital destruction, conflict directly damages infrastructure, reducing productivity and output. Human capital depletion, loss of life, displacement, and reduced opportunities hinder skill development and labor supply. Macroeconomic instability, conflict disrupts government finances, leading to inflation, exchange rate fluctuations, and investment decline (Ujunwa, Okoyeuzu, Nkwor, & Ujunwa, 2021). Indirect effects, institutional weaknesses where conflict weakens governance, erodes property rights, and increases corruption, discouraging investment and economic activity. Reduced investment, uncertainty and risk aversion during and after conflict lead to lower domestic and foreign investment, hindering technological progress and diversification. Trade disruptions, conflict disrupts trade networks and logistics, reducing access to export markets and vital imports. Governance challenges, weak institutions and limited state capacity impede effective reconstruction and development efforts.

2.1.1. Econometric model and variable selection

Based on the theoretical framework, a suitable econometric model to estimate the impact of conflict on economic growth in Sub-Saharan Africa could be in line with established literature, like (Fang, Kothari, McLoughlin, & Yenice, 2020); (Addy, HongXing, Otchere, & Beraud, 2021) (Cerra & Saxena, 2008), and the impact of conflict on economic growth is gauged through standard growth regressions. The variables, definition, proxy, expected signs and sources used in the study are presented in **Table 1**. The model takes the form of Equation (1), while Equation (2) will be estimated to test the second hypothesis.

Table 1. Variables of the Study.

Variable	Definition	Proxy	Expected Sign	Source
Economic Growth (RGDP)	Rate of change in real GDP	-	-	World Bank, IMF, National Statistical Agencies
Conf	Total count of fatalities from armed conflicts	Number of Deaths	Negative	UCDP, ACLED, Conflict Databases
Inv	Total value of fixed capital formation	Fixed Capital Formation	Positive	National Accounts, UN National Databases
Trade (Exports)	Total value of goods and services exported	Exports	Positive	National Trade Data, WTO, International Databases
Foreign Direct Investment (FDI)	Net inflows of foreign investments	FDI	Positive	National Central Banks, UNCTAD, Investment Data
Human Capital	Composite index measuring human development	HDI, Enrolment	Positive	UNDP, UNESCO, National Education Departments
Secondary school	The secondary school enrolment rate is the percentage of the population of official secondary school age who are enrolled in secondary school.	Gross secondary school enrolment	Positive	United Nations Development Programme and World Bank.
Macroeconomic Stability	Percentage change in general price level	Inflation Rate	Negative	National Statistical Agencies, World Bank, IMF
Infrastructure	Physical structures and facilities crucial for economic activities	Air transport, registered carrier departures worldwide	Negative	World Bank
Budget Deficit	Represents the shortfall when government spending exceeds its revenue	Total annual budget deficit	Negative	National Government Financial Reports, IMF, World Bank
Military Expenditure	Total spending on defense-related activities including personnel and equipment	Total annual Military Expenditure	Negative	SIPRI, IMF, World Bank

Baseline growth equation is given below:

$$\ln y_{it} = \beta_1 \ln y_{t-1} + \beta_2 \ln C_{it} + \beta_3 \ln X_{it} + \psi_i + \theta_t + \epsilon_{it} \quad (1)$$

Where $\beta_1, \dots, \beta_n$ and $\gamma_1, \dots, \gamma_n$ represent the coefficients of the variables y_{it} signifies the log of real per-capita GDP growth in country i at time t , C_{it} is the conflict variable of interest (measured by conflict-related deaths), and X_{it} is a vector of control variables encompassing factors like military expenditure domestic investment rate, growth of export, infrastructure, human capital, foreign direct investment, and inflation. The terms ψ_i and θ_t represent country fixed effects and time fixed effects, respectively, capturing unobserved heterogeneity across countries and time-specific variations. The error term, ϵ_{it} accounts for unexplained deviations in the model.

Infrastructure, Investment, and Human Capital Equations

To test the indirect effects of conflict on infrastructure, investment, and human capital, the following equations are specified:

$$\ln Inf_{it} = \gamma_1 + \gamma_2 \ln Conf_{it} + \gamma_3 \ln Mil_Exp_{it} + \gamma_4 \ln GDP_{pc_{it}} + \gamma_5 Yg_{it} + \gamma_6 Sch_{it} + \gamma_7 Pop_{it} + \gamma_8 (Inf_{it} \times Conf_{it}) + \mu_{it} \quad (2)$$

$$\ln Inv_{i,t} = \gamma_1 + \gamma_2 \ln Conf_{i,t} + \gamma_3 \ln Mil_Exp_{i,t} + \gamma_4 GDP_{pc_{i,t}} + \gamma_5 Yg_{i,t} + \gamma_6 Sch_{i,t} + \gamma_7 Pop_{i,t} + \gamma_8 (Inv_{i,t} \times Conf_{i,t}) + \mu_{it} \quad (3)$$

$$\ln HC_{i,t} = \gamma_1 + \gamma_2 \ln Conf_{i,t} + \gamma_3 \ln Mil_Exp_{i,t} + \gamma_4 GDP_{pc_{i,t}} + \gamma_5 Yg_{i,t} + \gamma_6 Sch_{i,t} + \gamma_7 Pop_{i,t} + \gamma_8 (HC_{i,t} \times Conf_{i,t}) + \mu_{it} \quad (4)$$

Here, *Inf*, *Inv*, and *HC* denote infrastructure, investment, and human capital, respectively. These models include interaction terms to explore the compounded impact of conflict on these variables. To test the hypothesis that armed conflict significantly hinders investment, infrastructure, and human capital development, thereby impeding economic growth in Sub-Saharan Africa (SSA), the Equations (2)-(4) were estimated. These equations indicate ways through which armed conflict might indirectly affect economic growth such as through infrastructure (*Inf*), domestic investment (*Inv*) and human capital development. To further isolate the impact of armed conflicts on these variables three interactive terms were introduced one in each model.

These models aim to analyze the impact of conflict intensity, physical and human capital destruction, macroeconomic instability, and various control variables on changes in GDP growth rates across different countries over time in a panel regression framework. The inclusion of fixed effects for individual countries accounts for unobservable characteristics specific to each country, allowing for a more robust estimation of the relationship between the variables of interest. Additionally, appropriate econometric techniques were employed to address potential issues of endogeneity, omitted variables bias, and heteroskedasticity for accurate and reliable estimation results.

In addressing potential biases caused by extreme outliers, notably instances like the tragic genocide against the Tutsi in Rwanda in 1994, where approximately 8 percent of the population perished due to conflict, careful consideration is necessary. These outliers could significantly impact the regression results and thus warrant specific attention in the analysis. To enhance the robustness of the model, standard errors are clustered at the country level. This clustering approach acknowledges the potential correlation of observations within countries, thereby producing more accurate estimates and confidence intervals. Moreover, the regression models, while initially structured on existing literature, remains flexible for potential refinements or adjustments to better account for extreme instances and improve the reliability of the estimated effects of conflict on economic growth. This adaptability is crucial for ensuring the validity and robustness of the findings in such sensitive and complex analyses.

2.1.2. Estimation strategy

Estimating the model involves employing various critical estimation strategies. Endogeneity within the specified model could arise due to several factors. The potential endogeneity might stem from omitted variable bias, wherein unobserved determinants affecting both the dependent variable (real GDP growth) and the explanatory variables (conflict, *X_{it}*) are not included in the model. Additionally, reverse causality could exist, implying a bidirectional relationship between the

variables; for instance, conflicts may not only influence economic growth (y_{it}) but could also be impacted by past economic conditions (de Groot, Bozzoli, Alamir, & Brück, 2022). Moreover, measurement errors or simultaneity issues, where variables are jointly determined, may contribute to endogeneity, particularly if the included variables are not strictly exogenous. Addressing endogeneity through robust econometric techniques like instrumental variables or panel data methods becomes imperative to ensure unbiased and consistent estimates (Saeed, 2023).

To analyze the direct and indirect impacts of armed conflict on economic growth in Sub-Saharan Africa, this study employs a rigorous econometric framework tailored to address potential endogeneity issues and capture the complexities of panel data. The methodology encompasses Instrumental Variables (IV) approaches, Fixed Effects (FE) and Random Effects (RE) models, and robustness checks.

Instrumental Variables (IV) Approach:

The IV approach is essential to mitigate endogeneity concerns arising from potential bidirectional causality between armed conflict and economic growth. In our context, armed conflict (Confit) could be endogenous if its occurrence is influenced by unobserved factors affecting economic performance. The IV method helps establish consistent estimates by identifying instruments that are correlated with Confit but uncorrelated with the error term (ϵ_{it}), ensuring unbiased parameter estimates (d'Agostino, Dunne, & Pieroni., 2019)

Selection of Instruments

For the IV strategy, suitable instruments for lagged economic growth (Y_{it-1}), Confit, and control variables (Z_{it}) are identified. These instruments must satisfy the relevance and exogeneity criteria. Common instruments could include lagged values of variables, policy changes, or exogenous shocks that affect Confit but are not influenced by current economic conditions or errors.

Two-Stage Least Squares (2SLS) Estimation:

To IV estimation proceeds in two stages to address endogeneity in panel data settings:

1. First Stage: regress X_{it} on Z_{it} to obtain predicted values $\hat{X}_{it}$

$$X_{it} = \gamma_i + \delta_1 Z_{it} + u_{it}$$

Where, X_{it} is the endogenous variable (Confit), Z_{it} is the instrumental variable, γ_i captures individual fixed effects, and u_{it} is the error term.

2. Second Stage: regress Y_{it} on $\hat{X}_{it}$ and controls, estimating the impact of conflict using the predicted values

$$Y_{it} = \alpha_i + \beta_1 \hat{X}_{it} + \epsilon_{it}$$

$\hat{X}_{it}$ is the predicted value of X_{it} from the first stage, Y_{it} represents economic growth, α_i represents entity-specific fixed effects, and ϵ_{it} is the error term

The 2SLS method allows us to control for endogeneity by using instrumental variables in the first stage and then incorporating predicted values in the second stage to estimate the direct impact of armed conflict on economic growth

Indirect Impact Estimation

Panel Data Techniques - Fixed Effects and Random Effects Models:

In addition to the direct impact, we investigate the indirect effects of armed conflict on economic growth using panel data techniques. These models account for

unobserved heterogeneity and provide insights into how armed conflict influences economic outcomes over time. Given the presence of unobserved heterogeneity across Sub-Saharan African countries, both FE and RE models are considered to accommodate these variations:

Fixed Effects Model

$$Y_{it} = \beta_0 + \beta_1 C_{it} + \beta_2 Z_{it} + \alpha_i + \epsilon_{it}$$

Here, Y_{it} is the dependent variable (economic growth), C_{it} denotes armed conflict, Z_{it} represents control variables, α_i captures entity-specific fixed effects, and ϵ_{it} is the error term. The FE model controls for time-invariant unobserved heterogeneity at the entity level (countries or regions), thereby isolating the impact of armed conflict on economic growth.

Random Effects Model

$$Y_{it} = \beta_0 + \beta_1 C_{it} + \beta_2 Z_{it} + \alpha_i + \epsilon_{it}$$

Here, α_i assumed to be a random effect capturing unobserved heterogeneity across countries, assumed to be uncorrelated with the regressors. (α_i is assumed to be a random effect with $\text{Cov}(\alpha_i, \epsilon_{it}) = 0$)

Cluster-Robust Standard Errors

To address potential correlations within clusters (countries or regions), we apply cluster-robust standard errors. This adjustment enhances the accuracy of hypothesis testing and ensures robust estimation by accommodating within-cluster correlations in panel data analysis.

$$\text{Var}(\hat{\beta}) = \left(\sum_{i=1}^N \sum_{t=1}^T X_{it} X_{it}' \right)^{-1} \left(\sum_{i=1}^N \sum_{t=1}^T X_{it} \epsilon_{it}^2 X_{it}' \right) \left(\sum_{i=1}^N \sum_{t=1}^T X_{it} X_{it}' \right)^{-1}$$

Lag Structures and Lag Selection

Incorporating lag structures for variables such as lagged economic growth (Y_{it-1}) and armed conflict (Confit) is critical to capturing their dynamic effects over time. Selection of optimal lag specifications is guided by empirical testing using Bayesian Information Criterion (BIC), ensuring model fit and avoiding overfitting or underfitting issues.

2.2. Summary

By integrating these econometric methodologies tailored to panel data from Sub-Saharan Africa, this study aims to provide nuanced insights into the direct and indirect impacts of armed conflict on economic growth. Through rigorous estimation techniques and comprehensive robustness checks, the study strives to offer reliable and policy-relevant conclusions amid the complex socio-economic dynamics of the region. This framework ensures that the estimated effects of armed conflict on economic growth are robust, addressing endogeneity concerns and validating model assumptions to provide credible policy implications. Having examined the empirical design, the estimation strategy and variable description, the study details the results of the study in the next section.

3. Results and discussion

3.1. Data presentation and analysis

In this section the study details the results. **Table 2** summarizes panel data statistics for SSA countries. The average growth rate is 1.28%, ranging from -48.39% to 140.48%, reflecting diverse economic performances. Conflict levels are notably high (mean = 1038.12), with a skewed distribution (median = 0), indicating varying intensity across countries. Average military expenditure is USD 316.71 million, with a wide range (0 to 6846), underscoring differing national priorities and capabilities in defense spending relative to GDP

Table 2. Descriptive Statistics for the Baseline Model.

Variables	Mean	Median	Maximum	Minimum	Std. Dev.	Observations
Growth Rate	1.275	1.3	140.48	-48.39	6.682	1632
Conflicts	1038.122	0	772353	0	19419.63	1632
Military Expenditure	316.713	88	6846	0	704.461	1409
Inflation	41.490	5.58	23773.13	-16.86	651.953	1455
FDI	2333.558	85.5	258150	-7397	17471.08	1632
INF	9331.284	2302.5	248747	0	24353.28	1632
INVs	3027.547	516.5	62439	-39	7769.144	1632
POP	2.401	2.59	16.63	-16.88	1.506	1631
SCH	20.793	9.985	118.7	0	26.071	1632
POV	44.618	44.9	82.3	7.9	14.896	115
EXP01	5377.633	993	234970	0	17553.75	1632
HDI	0.3967	0.45	0.82	0	0.211	1632
GDP PER CAPITA	3851.193	2039	35689	0	5130.212	1632

The data shows significant macroeconomic instability with a high average inflation rate (41.49%), potentially hindering investment and growth. Foreign direct investment (FDI) is relatively low (USD 2333.56 million), suggesting limited international investment, despite some opportunities in certain countries. Population growth averages 2.40%, indicating moderate growth across observed countries. Secondary school enrollment is 20.79%, with notable disparities (SD = 26.07), highlighting unequal education access in SSA. Poverty rate averages 44.62%, indicative of widespread poverty. Export values (USD 5,377.63 million) show highly skewed distribution, reflecting diverse economic structures. Human Development Index (HDI) ranges widely (0 to 0.82), indicating disparities in development outcomes. GDP per capita averages USD 3,851.19, with significant income inequality within the region.

The correlation matrix in **Table 3** provides an overview of relationships between variables in the dataset, highlighting potential associations and dependencies. High correlations among independent variables may indicate multicollinearity, which can inflate standard errors and obscure individual variable effects in regression models. The matrix helps in deciding which variables to include in regression models by showing the strength and direction of relationships. Key findings include high correlations between Military Expenditure and both formal (0.822) and informal institutions (0.826), FDI and Exports (0.812), and Infrastructure with both Military Expenditure (0.822) and Investments (0.897). These high correlations suggest

multicollinearity, complicating the interpretation of individual effects. The researcher addresses multicollinearity by potentially excluding highly correlated variables to ensure reliable regression coefficients and align with best practices in econometrics.

Table 3. Correlation.

	Growth Rate	Conflicts	Military Expenditure	Inflation	FDI	INF	INVs	POP	SCH	POV	EXP	HDI	GDP PER CAPITA
Growth Rate	1.000	-0.077	-0.113	-0.181	-0.173	0.107	0.037	0.059	0.129	-0.054	-0.146	-0.084	-0.138
Conflicts	-0.077	1.000	0.115	0.112	0.081	-0.017	-0.093	0.147	-0.105	0.106	0.004	-0.359	-0.188
Military Expenditure	-0.113	0.116	1.000	-0.009	0.393	0.822	0.826	-0.127	0.323	0.055	0.817	0.269	0.295
Inflation	-0.181	0.112	-0.009	1.000	-0.006	-0.052	-0.043	-0.372	-0.142	0.195	-0.022	-0.013	-0.099
FDI	-0.173	0.081	0.393	-0.005	1.000	0.037	0.015	0.019	0.076	0.022	0.812	0.009	0.025
INF	0.107	-0.017	0.822	-0.051	0.037	1.000	0.897	-0.223	0.403	0.041	0.536	0.316	0.335
INVs	0.037	-0.093	0.826	-0.043	0.015	0.897	1.000	-0.147	0.365	-0.013	0.565	0.314	0.306
POP	0.059	0.147	-0.127	-0.373	0.019	-0.223	-0.147	1.000	-0.425	-0.035	-0.126	-0.434	-0.491
SCH	0.129	-0.105	0.323	0.141	0.076	0.403	0.365	-0.425	1.000	-0.062	0.301	0.440	0.482
POV	-0.054	0.106	0.055	0.195	0.022	0.041	-0.013	-0.035	-0.062	1.000	0.070	-0.432	-0.353
EXP	-0.146	0.004	0.816	-0.021	0.812	0.536	0.565	-0.126	0.301	0.070	1.000	0.204	0.243
HDI	-0.084	-0.359	0.268	-0.013	0.009	0.316	0.314	-0.434	0.440	-0.432	0.204	1.000	0.751
GDP PER CAPITA	-0.138	-0.188	0.294	-0.098	0.025	0.335	0.306	-0.491	0.482	-0.353	0.243	0.751	1.000

Source: Eviews 2012.

3.2. Baseline model: impact of armed conflict on economic growth

Table 4 examines the impact of armed conflict on economic growth for all Sub-Saharan African (SSA) countries and SSA countries in conflict, using pooled, fixed effects, and random effects estimation methods. It reports coefficients, t-statistics, standard errors, and significance levels for conflicts, military expenditure, inflation, inflation squared, foreign direct investment (FDI), and exports.

Table 4. Impact of Armed Conflict on Economic Growth.

	Model I: All SSA Countries			Model I: SSA in Conflict		
	(1)	(2)	(3)	(1)	(2)	(3)
Conflicts	-0.00807** (-2.202) [0.000]	-0.0094*** (-2.55) [0.000]	-0.0086** (-2.338) [0.000]	-0.4304*** (-3.187) [0.135]	-0.4353*** (-2.906) [0.149]	-0.422*** (-2.985) [0.141]
Military Expenditure	-0.0778*** (-2.646) [0.008]	-0.1048*** (-2.779) [0.000]	-0.092*** (-2.744) [0.000]	-0.00083 (-1.759) [0.001]	-0.00172**** (-2.905) [0.000]	-0.0013** (-2.420) [0.000]
Inflation	-0.2339*** (-3.505) [0.000]	-0.1713** (-2.485) [0.000]	-0.228*** (-3.343) [0.000]	-0.00191 (-2.470) [0.000]	-0.00205** (-2.512) [0.000]	-0.00192** (-2.427) [0.000]
INF	0.00293*** (3.803) [0.000]	0.0022** (2.148) [0.000]	0.0026** (2.965) [0.000]	0.00005 (4.327) [0.000]	0.00004** (2.425) [0.000]	0.00004** (3.259) [0.000]
FDI	0.00318** (2.225) [0.000]	0.00254 (1.097) [0.000]	0.00285 (1.577) [0.000]	0.00000 (-3.197) [0.000]	0.00000 (1.651) [0.000]	0.00000** (2.060) [0.000]
EXP	-0.00271 (-1.471)	-0.0019 (-0.712)	-0.00144 (-0.650)	-0.00007 (-2.350)	-0.00004 (-0.940)	-0.00004 (-1.232)

	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
C	1.42527 (-9.196) [0.155]	1.554 (7.522) [0.206]	1.395682 (-5.722) [0.243]	2.87089 (3.643) [0.787]	3.36496 (3.683) [0.913]	2.65630 (2.899) [0.916]
Observation	1269	1269	1269	457	457	457
Cross-sections	48	48	48	28	28	28
R ²	0.2231	0.3911	0.2930	0.3476	0.4583	0.4188
Log likelihood	-3811.578	-3664.476	-	-1431.571	-1395.125	-
Diagnostics χ^2 Hausman Test	4.3120	0.3311	0.9541	0.9310	16.210	0.0018**

Note: The values in parenthesis represent t-Statistic; the values in brackets are the standard errors; *** significance at 1%, ** significance at 5%, * significance at 10%

Key points include:

- Conflicts: Negative and significant impact on economic growth, more severe for conflict countries (-0.008 percentage points for all SSA, -0.43 for conflict countries).
- Military Expenditure: Negative and significant impact on growth, smaller for conflict countries (-0.078 percentage points for all SSA, -0.0008 for conflict countries).
- Inflation: Negative impact on growth for all SSA countries (-0.234 percentage points), positive impact for conflict countries (+0.0019 percentage points), indicating different economic dynamics based on conflict status.
- Infrastructure: Positive and significant impact on growth for all SSA countries, negative for conflict countries.
- FDI: Positive and significant impact on growth for all SSA countries (+0.003 percentage points), insignificant for conflict countries.
- Exports: Negative and insignificant impact on growth for all SSA countries, negative and significant for conflict countries.

The table shows that armed conflict directly harms economic performance more in conflict countries, while military expenditure, inflation, infrastructure, FDI, and exports have varying effects depending on the presence of conflict.

3.3. Robustness check

3.3.1 Endogeneity problem

The estimation of the model in this study incorporates rigorous strategies to address potential issues, and it is important to note that the data used does not suffer from the problem of endogeneity. Endogeneity concerns arise when independent variables are correlated with the error term in a regression model, leading to biased and inconsistent parameter estimates. In the context of this research, meticulous attention has been given to identifying and mitigating endogeneity concerns. The dataset employed is constructed with careful consideration of potential sources of endogeneity, and the econometric models utilize appropriate techniques, by adding explanatory variables that meet the relevance and exogeneity criteria to account for any remaining endogeneity. By adopting these advanced estimation strategies and

ensuring the robustness of the dataset, the study aims to produce reliable and unbiased results, enhancing the validity of the findings related to the impact of armed conflict on economic growth in Sub-Saharan Africa.

3.3.2. Instrumental variable

This section examines the impact of armed conflict on economic growth in Sub-Saharan Africa (SSA) using the Generalized Method of Moments (GMM) estimation with Instrumental Variables (IV) to address potential endogeneity issues. The instrument variables (IVs) used in this estimation include the lagged values of all the dependent variables of the models. Like in the previous results, conflict is negative and statistically significant at the 1% level as seen in **Table 5**. This suggests that armed conflict has a negative impact on economic growth in SSA. Specifically, a one percent increase in armed conflict is associated with 0.17 percent decrease in economic growth. Military expenditure is also negative and significant. This indicates that high military spending might hinder economic growth. On the other hand, inflation is negative but not statistically significant. In addition, infrastructure positively influences economic growth as shown from the result. Export shows a positive relationship with economic growth over the period under consideration. This findings under the GMM estimation are in agreement with the earlier result indicating the robustness and reliability of the findings.

Table 5. Generalized Method of Moment (GMM) Estimation.

Variables/Region	SSA
<i>Confl</i>	-0.176** (0.082) [-2.147]
<i>Mil_Exp</i>	-0.806** (0.372) [-2.011]
<i>Inflation</i>	-0.088*** (1.004) [-0.087]
<i>Inf</i>	0.049*** (0.011) [4.377]
<i>Exp</i>	0.160*** (0.033) [4.788]
<i>FDI</i>	-0.106*** (0.824) [3.600]
<i>_cons</i>	313.851*** (0.059) [56.69]
Countries	43
Instrument Rank	7
Observations	1039
R-squared	0.0597

Note: The values in parenthesis represent t-Statistic; the values in brackets are the standard errors; *** significance at 1%, ** significance at 5%, * significance at 10%. Instrument specification: C CONFLICTS(-1) MIL_EXP(-1) INFLATION(-1) INF(-1) EXP01(-1) FDI(-1)

3.3.3. Model with additional control variables

To check for the robustness of the result a model with additional dependent variables is estimated. **Table 6** provides an estimate of the previous model with the addition of domestic investment, poverty, population and human capital. The result reveals similar impact of the previously included variables with the two models above but with different magnitudes but mostly maintaining the same direction. Three of the additional variables show negative relationship with economic growth. Investment has less negative impact on economic growth in the region compared with poverty and population. Human capital has a positive impact on economic growth in the region.

Table 6. Impact of Armed Conflict on Economic growth in SSA.

<i>CONFLICTS</i>	-1.450** [0.730]
<i>MIL_EXP</i>	-2.735 [1.759]
<i>INFLATION</i>	-18.777** [9.117]
<i>INF</i>	0.032 [0.028]
<i>EXP</i>	0.417** [0.170]
<i>FDI</i>	-0.439** [0.185]
<i>INV</i>	-0.319** [0.139]
<i>POP</i>	-106.548** [52.290]
<i>POV</i>	-51.069* [30.144]
<i>HDI</i>	281.890** [380.940]
<i>C</i>	-1177.551** [352.112]
<i>Observations</i>	1140
<i>R-squared</i>	0.624
<i>Log likelihood</i>	-893.682

Note: The values in brackets are the standard errors; *** significance at 1%, ** significance at 5%, * significance at 10%.

3.3.4. Heteroskedasticity

Table 7 presents a Panel Cross-section Heteroskedasticity Likelihood Ratio (LR) Test, which is conducted to assess whether the residuals in the specified equation are homoskedastic (have constant variance) or heteroskedastic (have varying variance). The null hypothesis of the test is that residuals are homoskedastic. The equation in question includes variables such as GDP_PER_CAPITA_GROWTH, CONFLICTS, MIL_EXP (military expenditure), INFLATION, INF (inflation), FDI (foreign direct investment), EXP, and a constant term represented by C. The LR test statistic is 542.7650, and it is associated with 48 degrees of freedom. The probability value (p-value) associated with this test is 0.1023. In hypothesis testing, the p-value is

compared to the significance level (commonly 0.05) to determine whether there is enough evidence to reject the null hypothesis. In this case, the p-value is greater than 0.05, indicating that there is not enough evidence to reject the null hypothesis of homoskedasticity.

Table 7. Panel Cross-section Heteroskedasticity LR Test.

	Value	df	Probability
Likelihood ratio	542.765	48	0.1023
LR test summary			
Restricted LogL	-3811.58	1262	
Unrestricted LogL	-3540.2	1262	

Null hypothesis: Residuals are homoskedastic

The LR test summary provides additional information, including the values for the Restricted Log-Likelihood (-3811.578) and Unrestricted Log-Likelihood (-3540.195). These values are crucial for conducting the LR test. The Unrestricted Test Equation focuses on the dependent variable GDP_PER_CAPITA_GROWTH, and the method used is Panel EGLS (Generalized Least Squares) with Cross-section weights. In summary, based on the LR test results, there is insufficient evidence to reject the null hypothesis that residuals are homoskedastic in the specified equation. This suggests that the assumption of constant variance of residuals is reasonable for the given model.

In this section the study presented the results of the study. In the next section we discuss the results of the research.

4. Discussion

4.1 Hypothesis testing and result discussion

In this section we present the discussion of the study results.

“(H₁₁) Armed conflict has a significant impact on economic growth in SSA”.

The results from **Table 4** support Hypothesis (H₁₁), indicating that armed conflict has a significant negative impact, both directly and indirectly, on economic growth in Sub-Saharan Africa (SSA). In both Model I scenarios—considering all SSA countries and focusing specifically on those in conflict—the coefficient for the variable "Conflicts" is statistically significant at the 5% level. These findings affirm that armed conflict exerts a negative influence on economic growth in SSA, supporting the hypothesis that armed conflict has a significant adverse impact. The evidence suggests that the economic consequences are particularly pronounced in regions directly affected by armed conflicts. The negative coefficients underline the importance of addressing and preventing armed conflicts as crucial elements of economic development strategies in SSA. This aligns with the notion that armed conflicts can hinder economic progress, disrupt infrastructure, and contribute to a challenging environment for businesses and investments. Policymakers and stakeholders should take these findings into consideration when formulating strategies for conflict resolution and sustainable economic development in the region.

The negative impact of armed conflicts on economic growth aligns with numerous studies highlighting the disruptive effects of conflicts on economic development. The empirical evidence supports the notion that conflicts lead to resource misallocation, destruction of infrastructure, displacement of populations, and a general deterioration of economic activities (Collier & Hoeffler, 2004); (Fearon & Laitin, 2003). While the negative relationship between conflicts and economic growth is consistent with existing literature, the magnitude of the impact might vary. Some studies argue that the economic consequences of conflicts can be highly context-dependent, influenced by factors such as the duration, intensity, and geographical scope of the conflicts (Ujunwa, Okoyeuzu, Nkwor, & Ujunwa, 2021); (de Groot, Bozzoli, Alamir, & Brück, 2022) (Blattman & Miguel, 2010). The nuanced nature of conflict impacts might explain variations in effect sizes across different studies. The estimated negative impact of conflict on growth (-0.008 to -0.43) falls within the range reported in existing studies, but the specific magnitude varies depending on the methodology and data used. For instance, (Sambanis, 2001) estimates a larger negative impact (-1.5%), while (Artadi & Sala-i-Martin, 2003) find a smaller effect (-0.05). These variations highlight the importance of considering methodological choices and context-specific factors.

Furthermore, the negative association between military expenditure and economic growth is in line with the widely debated "guns versus butter" hypothesis. Increased military spending often diverts resources away from productive sectors, hindering economic growth (Clements, Gupta, & Kham, 2021). The negative association between military spending and economic growth confirms previous research by (Khalid, Okafor, & Aziz, 2019); (Dunne & Tian, N, 2013). These studies argue that resources allocated to military expenditures could be more productively invested in education, healthcare, or infrastructure, leading to higher long-term economic growth. The findings support the idea that sustained economic development requires resources to be allocated efficiently. Other studies argue that high military spending in developing countries diverts resources from productive sectors, hindering growth. (Khalid, Okafor, & Aziz, 2019); (Clements, Gupta, & Kham, 2021) found that increased military spending in conflict-affected countries does not necessarily translate into improved security, further impacting economic prospects. However,

Recent scholarly discourse examines the impact of foreign direct investment (FDI) on impoverished nations, with (Aziz & Khalid, 2019) suggesting FDI could exacerbate conflict in Sub-Saharan Africa; however, a contrasting study of (Wang, Wong, Zhuang, & Cate, 2024) utilizing global and developing country data challenges this view, demonstrating that FDI generally decreases militarization measures like military spending and armed forces size, thereby potentially enhancing societal security beyond mere absence of armed conflict.

The findings from this analysis strengthens the argument for prioritizing investments in productive sectors over military spending for sustainable development. Contrary evidence exists in some studies that argue military spending can have stimulative effects on the economy, especially in the short term, through job creation and technological advancements (Deger, 1986). The contrasting findings may underscore the need for a nuanced understanding of the economic consequences of military expenditures, considering the broader economic context.

The mixed findings regarding FDI and exports resonate with the existing literature, which often presents conflicting evidence on the relationship between these variables and economic growth. While FDI is generally considered beneficial, fostering technology transfer and job creation, its impact can be contingent on the host country's absorptive capacity and institutional environment (Alfaro, Chanda, Kalemli-Ozca, & Sayek, 2004). Similarly, the relationship between exports and economic growth is complex, influenced by factors such as trade policies, global market conditions, and domestic economic structures. The fixed and random effects models suggesting a larger negative impact of conflict compared to the pooled model align with the argument that unobserved country-specific factors can influence the relationship (Gyimah-Brempong & Corley, 2005). This emphasizes the importance of accounting for these factors when analyzing the impact of conflict on economic outcomes. Additionally, the possibility of non-linear relationships between conflict and growth, as suggested in the limitations section, is supported by studies like (Musumba, Fatema, & Kibriya, 2021) (Fearon & Laitin, 2003); (Le, Bui, & Uddin, 2022); (Khalid, Okafor, & Aziz, 2019) (Blattman & Miguel, 2010). They argue that the impact of conflict can vary depending on its intensity and duration, with low-intensity conflict potentially having less detrimental effects compared to high-intensity or prolonged conflicts.

While the findings highlight the direct devastating economic consequences of armed conflict in SSA and how managing armed conflict could lead to reduction in military spending and reallocating resources towards productive sectors could potentially boost economic growth. It is important to investigate the specific Channels Through which armed conflict hinders economic growth. Certainly, understanding the specific channels through which armed conflict hinders economic growth in Sub-Saharan Africa (SSA) is crucial for designing effective policies and interventions.

4.2. Channels through which armed conflict hinders economic growth

Table 4 investigates how armed conflict impacts economic growth in Sub-Saharan Africa (SSA) through infrastructure, investment, and human capital. It uses three panel regression models to analyze these channels. The first column focuses on infrastructure, with conflicts significantly lowering infrastructure scores, indicating that conflicts damage physical infrastructure and reduce investment incentives. Military expenditure has no significant effect on infrastructure, while GDP per capita positively affects it. Economic growth and schooling show inconsistent impacts, and population negatively affects infrastructure only in one model. The interaction term between conflicts and infrastructure is positive, suggesting that better infrastructure mitigates conflict's negative effects.

The second column examines investment. Conflicts negatively impact investment, while military expenditure and GDP per capita positively influence it. Growth rate and schooling have no significant effect on investment, while population negatively affects it. The interaction term between investment and conflicts is positive, indicating that higher investment lessens the negative impact of conflicts. The R-squared values show a substantial portion of investment variability explained by the models.

The final column continues the investment focus, reinforcing that conflicts reduce investment levels. Higher military expenditure and GDP per capita boost investment, while growth rate negatively impacts it. Education positively influences investment, whereas population growth hinders it. The interaction term between HDI and conflicts is highly significant, suggesting that human development is significantly affected by armed conflict. The models indicate that key drivers of increased investment include higher GDP per capita, education levels, and favorable human development and institutional factors.

4.3. Hypothesis testing and result discussion

“(H₁₂) Armed conflict significantly hinders investment, infrastructure, and human capital development, thereby impeding economic growth in SSA”.

The results from **Table 4** reveal a negative and statistically significant impact of armed conflict on investment in Sub-Saharan Africa (SSA). The coefficient for "ln Conflicts" is consistently negative across different models (Pooled, Fixed, Random), indicating that higher levels of armed conflict are associated with reduced investment. This finding aligns with the hypothesis that armed conflict acts as a deterrent to investment in the region. **Table 4** indicates a negative influence of armed conflict on infrastructure development in SSA. The coefficient for "ln Conflicts" is consistently negative and statistically significant across different models. This suggests that regions experiencing armed conflict face challenges in maintaining and improving infrastructure, reinforcing the hypothesis that armed conflict hinders infrastructure development. The results from **Table 4** further support the hypothesis regarding human capital development. The coefficient for "ln Conflicts" is negative and statistically significant across different models. This implies that armed conflict has a detrimental effect on human capital development in SSA. Education and health outcomes may be adversely affected during and after periods of conflict, contributing to the hindrance of human capital accumulation. Given the negative impacts of armed conflict on investment, infrastructure, and human capital development, it can be inferred that armed conflict poses a substantial barrier to economic growth in SSA. The results suggest that the consequences of conflict extend beyond the immediate socio-economic costs and contribute to a long-term impediment to overall economic development.

These regression results provide strong evidence to support the hypothesis (H2) that armed conflict significantly hinders investment, infrastructure, and human capital development, thereby impeding economic growth in SSA. They also suggest that investment, infrastructure, and human capital are potential mediators of the negative impact of armed conflict on economic growth. In conclusion, the results strongly support Hypothesis 1, suggesting that armed conflict significantly hinders investment, infrastructure, and human capital development, thereby impeding economic growth in Sub-Saharan Africa.

These findings align with existing literature that emphasizes the detrimental effects of armed conflict on economic growth (Collier & Hoeffler, 2004); (Fearon & Laitin, 2003). The negative impact on infrastructure, investment, and human capital is consistent with studies highlighting the long-term consequences of conflicts on a

country's development trajectory. The negative impact of conflict on infrastructure aligns with numerous studies (Okunlola & Okafor, 2022) (Collier, Elliot, Hegre, & Hoeffler, 2003); (Khalid, Okafor, & Aziz, 2019) (Blattman & Miguel, 2010). Physical destruction, displacement, and disrupted maintenance are well-documented consequences of conflict (Sinha & Chakrabarti, 2019); (Fagbemi & Fajingbesi, 2022); (Fiandrino, Cattuto, Paolotti, & Schifanella, 2023) (Collier & Hoeffler, 2004);

The insignificant effect is interesting. Some studies suggest military spending might protect infrastructure in specific cases however, in the context of FDI, militarization does not increase and security levels do not fall either (de Soysa, 2020), thus having the same incentives for powerful domestic actors. Excessive military expenditures in some African countries have diverted resources away from infrastructure and social development (Tian, da Silva, Béraud-Sudreau, Lianga, Scarazzato, & Assisa, 2023) (Dunne & Tian, N, 2013). while others find no clear link (Collier, Elliot, Hegre, & Hoeffler, 2003). More research is needed to understand this complex relationship. The finding that wealthier countries are more resilient is consistent with existing literature. They have better capacity for reconstruction and may be less reliant on conflict-affected infrastructure. The finding that conflict disproportionately damages existing infrastructure aligns with the "conflict trap" argument, where conflict deters further investment, leading to further deterioration. The finding that conflict exacerbates the negative impact of inflation on infrastructure is plausible as inflation can strain budgets and reduce resources for infrastructure maintenance during conflict (Ujunwa, Okoyeuzu, Nkwor, & Ujunwa, 2021) (Hegre, Nygård., & Ræder, 2017).

Additionally, the negative impact of conflict on investment aligns with numerous studies. Uncertainty, risk perception, and infrastructure damage create a disincentive for investment (Brazys, de Soysa, & Vadlamannati, 2023) (Crippa & Saaverdra-Lux, 2023). The mixed findings on military spending and investment require further investigation. Some studies suggest it can crowd out productive investment (Dunne & Tian, N, 2013), while others like (Rahman & Siddiqui, 2019) positive effects of military spending through arms export. In the latter case, for developed regions, military expenditure in the presence of arms export is regarded as an effective foreign policy tool for securing economic growth, maintaining political stability and strong rule of law: this is not the case for SSA.

(Pieroni, 2009) provides evidence that military spending can have positive effects on economic growth, particularly in economies with significant defense industries, through demand stimulation and technological advancements. Poorer countries are less resilient than wealthier countries likely due to lack of stronger institutions, financial reserves, and diversified economies (Brazys, de Soysa, & Vadlamannati, 2023). The "conflict trap" of conflict and declining investment is again supported by the finding that higher initial investment levels exacerbate the negative impact of conflict, even diverting foreign direct investment away from neighbors at peace because of perceived-risk (Hegre, Nygård., & Ræder, 2017).

Disruptions to education, healthcare, and displacement of skilled workers have long-lasting consequences (Okunlola & Okafor, 2022). The findings from the current study indicate that armed conflict has adverse effects on education, primarily due to the destruction of physical health facilities, school facilities and educational resources,

financial constraints, and heightened educational disparities. These results are consistent with previous research findings. (Singh, Kaur, Sen, Singh, & Chattu, 2021) highlight that armed conflicts typically lead to a decline in the availability of education. Similarly, according to (Frounfelker, et al., 2020), access to education is often restricted during conflicts, and there is a significant loss of school infrastructure and resources due to instability. (Mayai, 2022) observe that education faces challenges when learning venues are transformed into camps for armed groups or are completely destroyed, making it exceedingly difficult for students to continue their education.

(Agbor, Etta, & Mbua, 2022) argue that the quality of education suffers due to inadequate instruction, and returning to school during ongoing violence is impractical. To ensure that schools effectively fulfill their mandate, efforts must be intensified. Resolving the conflict remains the only long-term solution, despite the prolonged impacts it may have. Therefore, engaging regional organizations established in conflict zones becomes essential. Establishing enduring partnerships is crucial, including the formation of a permanent committee involving influential community members to advise school representatives and stakeholders.

During crises, local school administrators collaborate closely with regional education offices to make decisions on educational matters such as crisis management plans, rebuilding school infrastructure with community support, maintaining damaged facilities and resources, and supporting vulnerable students who have lost family members to conflict. Implementing these measures could potentially reduce the number of students dropping out of school.

Wealthier countries are again more resilient, likely due to better social safety nets and healthcare systems (Collier, Elliot, Hegre, & Hoeffler, 2003). The finding that existing education offers some protection aligns with studies showing education's role in mitigating conflict's negative impacts. The potential negative effect of rapid population growth on conflict-affected human capital needs further exploration. Resource constraints and competition for services might be contributing factors. The finding that countries with higher Human Development Index experience less negative impact from conflict highlights the importance of broader development efforts in conflict prevention and mitigation.

Some studies suggest that the impact of conflict on infrastructure and investment might be non-linear, with greater intensity leading to more severe consequences. This study doesn't explicitly explore non-linear relationships. The findings focus on developing countries in SSA, but the impact of conflict on economic aspects might vary depending on the specific context and regional factors. Some studies explore the long-term economic scars of conflict, which are not directly addressed in this study. Overall, the findings align well with existing literature on the negative impact of armed conflict on various economic aspects in developing countries. It highlights the importance of considering moderating factors like economic development and human capital, and the complex indirect channels through which conflict exerts its negative effects.

5. Conclusion

In conclusion, this study has provided a comprehensive analysis of the direct and indirect impacts of armed conflict on economic growth in Sub-Saharan Africa (SSA). Through a thorough review of the literature and empirical analysis, several key findings have emerged. Firstly, armed conflicts in SSA significantly hinder economic growth by causing destruction of physical and human capital, destabilizing macroeconomic conditions, and weakening institutional frameworks. These conflicts disrupt essential services such as education and healthcare, deter foreign direct investment, and create governance challenges that exacerbate corruption and hinder development. The empirical findings from our econometric model confirm the hypothesis that armed conflict has a substantial negative effect on GDP growth rates across the region. Specifically, the regression results underscore the detrimental effects on investment flows, infrastructure development, and human capital accumulation. These findings are consistent with existing literature and highlight the urgent need for targeted policy interventions to mitigate the economic consequences of armed conflicts in SSA. Looking forward, policymakers must prioritize conflict prevention and resolution efforts as foundational steps towards sustainable economic development in SSA. Strengthening institutions, improving governance, and enhancing security frameworks are critical to creating an environment conducive to investment and growth. Moreover, reallocating resources from military expenditures towards productive sectors can potentially stimulate economic activity and improve living standards in conflict-affected regions. It is crucial to acknowledge the complexity and multidimensional nature of armed conflicts in SSA, which vary widely in intensity, duration, and underlying causes. Context-specific approaches that address local dynamics and incorporate lessons learned from successful interventions will be essential in crafting effective policy responses. By focusing on these strategies, SSA can mitigate the devastating economic impacts of armed conflict and pave the way for inclusive growth and prosperity across the region.

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