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Soaring inflation in sub-Saharan Africa: A fiscal root?

Olumide O. Olaoye[1] · O. J. Omokanmi[1] · Mosab I. Tabash[2] · S. O. Olofinlade[1] · M. O. Ojelade[3]

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Abstract
The study investigates the effect of fiscal policy on the inflation rate in a panel of 44 sub-Saharan African (SSA) countries over the period 2003–2020 using a non-linear system generalized method of moments (system GMM) and the dynamic panel threshold estimation techniques. The results show that the recent increase in inflation rate has a fiscal nature and that monetary policy alone may not provide an effective response. Specifically, the results indicate that a positive shock to fiscal policy (captured by public debts) has a positive and statistically significant effect on inflation, while a negative shock to public debt has a statistically non-significant impact on the inflation rate. Also, money supply exerted a positive and insignificant impact on inflation, indicating that the current inflation rate in the region may not be induced by money supply. However, the joint effect of public debts and money supply shows that public debts aid the effect of money supply on the inflation rate, albeit, not in the proportion predicted by the quantity theory of money. Further, the results also found a public debt threshold point of 60.59% of GDP. This implies the current inflationary pressure may be rooted in fiscal policy and that further accumulation of public debts beyond the benchmark established in the study would worsen the inflationary pressure in SSA. Importantly, the study found that for fiscal policy to spur growth and reduce inflationary pressure in SSA, the inflation rate should be managed and brought within a single-digit framework of 4%. The research and policy implications are discussed.

Keywords Asymmetry · Inflation rate · Threshold · Fiscal policy · Money supply · Non-linear estimation · SSA

1 Introduction

Following the COVID 19 pandemic, governments across the globe, and in sub-Sahara in particular, deployed fiscal policy to cushion the negative effects of the pandemic and propped up economies (Hole 2022). Specifically, across the globe, governments have embarked on a new wave of borrowing to cushion the effect of the pandemic. The increase in public debts coincides with the rapid increase in domestic prices across the globe, and particularly in the world's poorest continent—sub-Saharan Africa (SSA, hereafter) (see Olaoye et al. 2020a, b). For example, in the region's biggest economy—Nigeria—inflation has soared to a 17-year high of 21.34% (Central Bank of Nigeria(CBN) 2022). Likewise, in

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the region's second biggest economy—South Africa—inflation rate reached a 13-year high of 7.5% since 2009 (Statistics South Africa(Stats SA) 2022). Similarly, in Ghana, inflation rose for the 11th consecutive month to a record high of 31.7%—its highest level since November 2003 to mention just a few. In general, the mean inflation rate for SSA stands at over 8%, while the global lenders—the World Bank and IMF—warned that an inflation rate of more than 12% is expected for SSA over the next 12 months.

The implications of a rising level of public debts for domestic prices has elicited serious concerns among academics and policymakers, and thus, bring the debate on the macroeconomic implications of high levels of public debts to the fore of international agenda, and dominated and fiscal policy debates. This is understandable since a surge in domestic prices may strain external and fiscal balances, particularly, in the commodity-importing countries, which have increased food security concerns in the region. Besides, a high inflation rate erodes the confidence of investors, and this in turn increases interest rate and the level of uncertainty in the economy, lowers the level of capital investment, slows down economic development, thereby pushing more people into poverty (Hossein and Emmanuel 2018; World Bank 2022). In the same vein, the International Monetary Fund (IMF) in its 2022 report warned that Nigeria and other countries in SSA risk social and political instability and worsening food insecurity because of rising inflation.

Similarly, several scholars (see Khan and Senhadji 2001; Azam and Khan 2020) have suggested that high and persistent inflation may be inimical to economic growth since inflation increases the level of uncertainty in the economy, which in turn lowers the level of capital investment, slows down economic growth. For example, Azam and Khan (2020) examined the threshold effect of inflation on economic growth in a panel of 27 countries over the period 1975–2018. The authors found that threshold levels of 12.23% and 5.36% for developing and developed countries respectively, beyond which inflation impedes economic growth. Likewise, Khan and Senhadji (2001) found threshold levels of between 1–3% and 11–12% for industrialized and developing countries respectively.

Consequently, in line with the primary objectives of the monetary authorities—which is to ensure a low and stable rate of aggregate price inflation (i.e. price stability) as measured by commonly accepted measures such as the consumer price index—central banks across emerging markets are making big rate increases. For example, the Central Bank of Nigeria (CBN) in February 2023 increased the monetary policy rate (MPR) by 100 basis points to 17.5%. In a similar vein, the South African reserve bank (SARB) increased interest rate by 75 basis points, taking the repo rate to 5.5% and the prime lending rate to 9% (the biggest increase in nearly 20 years) (Statistics South Africa(Stats SA) 2022), while Ghana's central bank raised interest rates by 300 basis points to 22%, its largest increase since 2002. The move by the monetary authorities is consistent with several empirical studies in monetary economics literature (see Saunders 1997; Boyd and Smith 2006; Asongu 2014; Cioran 2014; Iddrisua and Alagidedea 2019; Umar et al. 2019; Bhattacharya and Jain 2019; Ida 2020; Khieu 2021) that monetary policy tools such as the interest rate might be an effective policy tool to reduce soaring inflation.

However, in recent literature, some authors (see Omekara et al., 2016; Boyo 2012; Hole 2022; Boesler 2022; IMF 2020) have argued that the current inflation trend may have fiscal roots as the rise in inflation rate coincides with increase in public debts, particularly, following the COVID-19 pandemic (see Fig. 1); and that monetary authorities may fail in their bid to control soaring inflation and could end up pushing price growth higher unless it is supported by appropriate fiscal policy. Further, they note that when inflation has a fiscal nature, monetary policy alone may not provide an effective response and that raising interest rates may have fundamental implications for the economy (i.e. household, firms

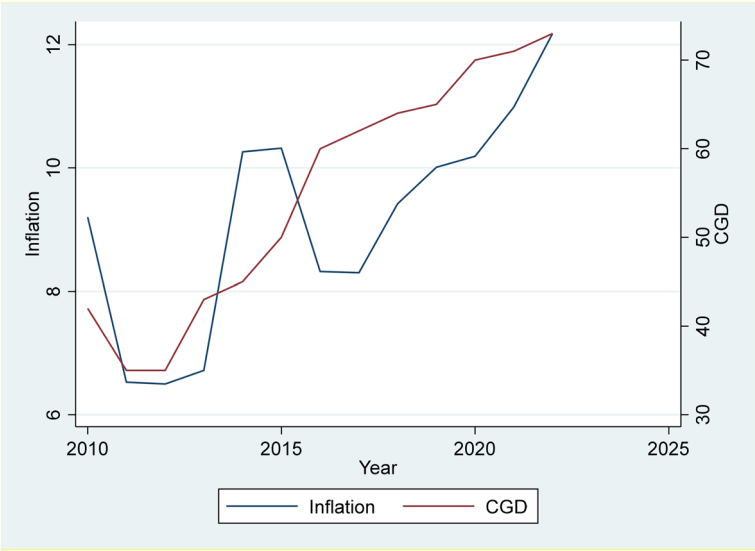

Fig. 1 Trends of public debts (captured by Central Government Debts) and Inflation in sub-Saharan Africa. Note: For developing countries, the Central Government Debt (CGD) is typically better recorded, and thus, widely adopted

and government). For instance, Omekara et al. (2016) argue that the cost of capital (interest rate) influences the availability of credit, which in turn affects the level of investment in an economy and slow down economic development. Boyo (2012) notes that there is a causative link between inflation and cost of funds and that inflation pushes cost of funds (interest rate) upwards. Thus, if inflation is high, then the cost of funds (interest rate) has to be over the rate of inflation, which increases interest rate further and may likely slow down investment. In contributing to the debate, Hole (2022) argued that raising interest rates may lead to a vicious circle of rising nominal rates, rising inflation, economic stagnation, and a worsening debt situation. Similarly, the International Monetary Fund (IMF) has warned central banks against raising interest rates in a hurry as it may jeopardize economic recovery. This implies to control inflation, fiscal policy must be deployed in tandem[1] with monetary policy.

Consequently, some scholars (see Akanbi 2015; Klein and Linnemann 2020; Ferrara et al. 2021; Olaoye 2022; Hole 2022; Boesler 2022; Maitra and Mondal 2022) have investigated the effect of fiscal policy on inflation in both developed and developing economies (see Table 1 for summary of literature).

1.1 Gaps in the literature

Most of the existing studies on the link between fiscal policy and inflation are characterized by some significant shortcomings. Precisely, most of the previous studies work on

[1] Sargent and Wallace (1981) argue that the effectiveness of monetary policy in controlling inflation critically depends on its coordination with fiscal policy. Similarly, the fiscal theory of the price level, FTPL (See Sims 1994; Woodford 2001) note that price level is determined by fiscal policy instruments, such as debt and deficit.

Table 1 Summary of review of literature on fiscal policy

Authors	Topics and period covered	Methods/estimation technique
Fiscal policy and economic growth		
Gómez-Puig et al. (2022)	On the heterogeneous link between public debt and economic growth (1995–2016)	The grouped fixed effect (GFE) estimator and a multinomial logit
Kassouri et al. (2021)	New insights on the debt-growth nexus: a combination of the interactive fixed effects and panel threshold approach (2000–2018)	Interactive fixed effects and dynamic panel threshold methods
Law et al. (2021)	Public debt and economic growth in developing countries: nonlinearity and threshold analysis (1984–2015)	Dynamic panel threshold
Olaoye et al. (2021)	Re-examining the government expenditure–growth nexus in ECOWAS countries (2005–2017)	Driscoll and Kraay's nonparametric covariance matrix estimator
Olaoye et al. (2021)	Government spending and economic growth in ECOWAS: an asymmetric analysis (2005–2017)	Dynamic panel threshold
Olaoye et al. (2020a, b)	Government spending and economic growth: a trivariate causality test (2008–2017)	PVAR and system GMM
Djimeu (2018)	The impact of the heavily indebted poor countries initiative on growth and investment in Africa (1996–2014)	A fifth-order polynomial
Dalena and Magazzino (2012)	Government expenditure and revenue in Italy (1862–1993)	Co-integration and causality techniques
Forte and Magazzino (2016)	Government size and economic growth in Italy: a time-series analysis	Threshold analysis
Forte and Magazzino (2013)	Twin deficits in the European countries	GMM
Fiscal policy and other macroeconomic indicators		
Maitra and Mondal (2022)	Potency of fiscal variables in inflation variations in Sri Lanka (1977–2018)	VAR
Olaoye et al. (2022)	Macroeconomic implications of rising stock of public debts: evidence from sub-Saharan African countries	Driscoll-Kraay non-parametric covariance matrix estimator and dynamic panel threshold
Olaoye (2022)	Sub-Saharan Africa's rising public debt stock: before another debt relief	System GMM
Ferrara et al. (2021)	Questioning the puzzle: Fiscal policy, real exchange rate and inflation	proxy-SVAR

Table 1 (continued)

Authors	Topics and period covered	Methods/estimation technique
Klein & Linnemann (2020)	The time-varying effect of fiscal policy on inflation: evidence from historical US data	Time-varying parameter VARs
Mustapha and Prizzon, (2018)	Africa's rising debt: how to avoid a new crisis	A Review
Hossein and Emmanuel (2018)	Forecasting UK consumer price inflation using inflation forecasts	Multivariate singular spectrum analysis (MSSA)
Akanbi (2015)	Sustainability of fiscal policy in an oil-rich economy: the case of Nigeria (1970–2011)	Johansen estimation technique
Baharumshah et al. (2016)	Fiscal sustainability in an emerging market economy: When does public debt turn bad? (1980–2014)	Markov-switching
Teles and Mussolini (2014)	Public debt and the limits of fiscal policy to increase economic growth	OLS, GMM, and mean group methods
Baldacci and Kumar (2012)	Fiscal deficits, public debt, and sovereign bond yields (1980–2008)	Instrumental variable approach
Inflation and economic growth		
Azam and Khan (2020)	Threshold effects in the relationship between inflation and economic growth: further empirical evidence from the developed and developing world (1975–2018)	Fixed effects and feasible generalized least squares (FGLS)
Azam and Rashid (2015)	The monetarist hypothesis of inflation in Pakistan—a critique (1972–2011)	Ordinary least squares (OLS)
Khan and Senhadji (2001)	Threshold effects in the relationship between inflation and growth (1960–1998)	TAR, 2SLS, GLS
Money supply and inflation		
Azam and Rashid (2020)	Monetary facts or Monetarist facts? A re-examination	
Omanukwue (2010)	The quantity theory of money: evidence from Nigeria (1990Q1–2008Q4)	Engle-granger two-stage test

Table 2 Descriptive statistics of variable

Summary statistics	INF	RGDP	CGD	EXC.RATE	MS	CORRUP
Mean	9.04	17.9	65.9	102.70	17.25	1.98
Median	5.33	18.1	48.6	98.04	14.04	2.00
Max	513.9	22.1	547.7	538.04	485.54	4.00
Min	− 9.61	14.3	0.48	58.54	− 8.17	0.00
Std. dev	27.2	1.6	63.6	45.80	24.77	0.77
Skewness	13.4	0.2	3.4	6.58	10.33	− 0.05
Kurtosis	213.9	3.1	19.8	58.0	18.15	3.27
Observations	773	788	790	362	755	642

the assumption that the relationship between fiscal policy and inflation is symmetric. But recent evidence suggests that there is an asymmetric structure in government fiscal policy (see Hung and Lee 2010; Olaoye et al. 2020a, b; Olaoye and Olomola 2022). Moreover, these scholars have found possible inconsistencies with the standard linear estimation techniques, which informed the application of nonlinear estimation techniques. Further, it has been affirmed that the response of macroeconomic indicators (such as inflation) to positive and negative shocks in fiscal policy may differ in absolute terms and magnitude (see Olaoye et al. 2020a, b).

There are other reasons why the potential asymmetric phenomenon in public debt series should not be ignored. One, available evidence shows that the public debt profile exhibits asymmetric behaviour (see Combes et al. 2017). Two, fiscal variables such as government spending and public debts are subject to a wide range of shocks (particularly, following the COVID-19 pandemic) thereby creating breaks in the time series (see Eller and Urvova 2012; Neaime and Gaysset 2017). Thus, if the fiscal evolution process is asymmetric, then the symmetric process implicitly assumed in previous studies (see Table 2) is restrictive and might be indicative of a model misspecification.

Two, the existing studies have not considered the joint significance of high level of public debts and money supply on inflation rate. This is important because if public debt magnifies the effect of money supply on inflation, then, it implies that both monetary and fiscal authorities must work in tandem to curb the rising inflation rate in SSA.

The study contributes to the existing literature in the following significant ways:

One, the study extends the literature on fiscal policy beyond the fiscal-growth nexus by examining the link between fiscal policy and inflation rate. This is crucial because inflation rate is a key economic indicator and a significant determinant of a country's growth process.

Two, the study adopts two main non-linear methodological approaches:

First, the study follows the footsteps of Hatemi-J (2012) and Granger and Yoon (2002) to separate positive shocks in fiscal policy from the negative shocks. There are various reasons for this choice. One, it is shown that the separation of positive shocks from negative shocks helps to better reveal the asymmetric structure in the data Hatemi-J (2012). Further, the method allows us to investigate whether the response of inflation rate to positive shocks differs from its response to negative shocks to fiscal policy.

Second, the study also adopts the innovative and robust dynamic panel threshold technique by Seo and Shin (2016) to account for the potential asymmetric structure in fiscal policy process and to control for endogenous threshold variable and regressors. A major advantage of the dynamic panel threshold estimation is that it is appropriate for empirical investigation where

the threshold effect focuses on one variable, without a discontinuous regression response at the threshold. More importantly, the dynamic panel threshold produces a robust inference regardless of the existence of a kink (a false jump) in the model, since the asymptotic normality holds true irrespective of whether the regression function is continuous or not (Seo and Shin 2016).

Three, the study also investigated the interactive of public debts and money supply on inflation rate in SSA.

Four, in addition to investigating the threshold level of fiscal policy for price stability, the study also investigates the optimal inflation rate for macroeconomic stability. This is important since it has been established that fiscal policy instruments such as public debts can be used without harmful economic effects only in circumstances of low inflation and interest rates (see Modern Monetary Theory under the theoretical literature review section for details).

The study found that a positive shock to fiscal policy (captured by public debts) has a positive and statistically significant effect on inflation, while a negative shock to public debt has a statistically not-significant impact on inflation rate. To be more specific, the results show that when public debt exceeds 60.59% of GDP, further accumulation of public debts worsens the inflation rate in SSA. This implies that further accumulation of public debts beyond the benchmark established in this study would lead to the increase in inflationary pressure in SSA. Importantly, the study found that for fiscal policy to spur growth in SSA, inflation rate should be within the single digit framework of 4%.

The rest of the paper is structured as follows. Section 2 presents the review of literature, Sect. 3 presents the theoretical framework, data and methodology; Sect. 4 presents the empirical analysis and discussion of results; and Sect. 5 presents the conclusions and implications for policy.

2 Review of literature

2.1 Theoretical review

The theoretical literature on fiscal policy—inflation nexus is mixed. The study highlights the main arguments in the literature. One line of theoretical insight is the fiscal theory of price level (FTPL), following, Sargent and Wallace (1981). The proponents of the FTPL argue that the price level is determined by fiscal policy instruments, such as debt, deficit and the present as well as the future tax-spending arrangement of people. They offered that fiscal policy may determine the price level even in an inflation-targeting monetary policy setting. The theory recognizes the 'wealth effect' of government debt as an additional channel of fiscal policy to affect the price level or inflation in the long run. According to them, since prices are sticky in the short run, a rise in the level of public debt rises leads to higher spending by consumers. The increase in the demand for goods and services, in turn, increases output and employment in the short run. However, in the long-run, a rise in the level of public debts leads to an increase in inflation growth rate. Precisely, the increase marginal propensity to consume relative to the marginal propensity to save leads to a fall in private savings, and consequently, a rise in the real interest rate, which in turn, decreases private investment and leads to smaller output growth, and thus causes a rise in the price level.

Another line of theoretical insight is the Modern Monetary Theory (MMT) was pioneered by the American Economist, Warren Mosler in his book "The 7 Deadly Innocent

Frauds of Economic Policy" (see Mosler 2010), and championed by Stephanie Kelton. The MMT argues that public debts can be used without harmful economic effects. According to them, inadequate government spending (deficit spending/borrowing) can be extremely harmful and cause a recession since deficit spending is what builds people's savings. The essential message of the MMT is that debt is simply money that the government put into the economy and didn't tax back, and that there is no financial constraint on government borrowing in circumstances of low inflation and interest rates. Although the proponents of the modern monetary theory acknowledge that inflation is theoretically a possible outcome from excessive government spending (debts), they concluded that it is highly unlikely and such resulting inflation can be fought with policy decisions in the future if required.

There is also the Quantity Theory of Money popularized by Milton Friedman and Anna Schwartz in their book, "A Monetary History of the United States", 1867–1960. The theory posits that the general price level of goods and services is proportional to the money supply in an economy. According to the quantity theory of money, if the amount of money in an economy doubles, ceteris paribus, price levels will also double. This implies there is a close one to one relationship between money supply and consumer prices, which results in a rise in the inflation rate.

2.1.1 Empirical review

2.1.1.1 Review of literature on asymmetric structure in fiscal policy It is now widely recognized that fiscal policy indicators such as public debt may not follow a linear path (see Gomez-Puig and Sosvilla-Rivero 2017; Çulha 2017; Bökemeier and Stoian 2018; Olaoye and Olomola 2022) and thus, the symmetric process assumed in extant studies might not be appropriate. These authors asserted that the symmetric estimation techniques are likely to be too restrictive to adequately capture the asymmetries that may exist in the debt series. Further, it is argued that there is an asymmetric information phenomenon in government fiscal policies and a potential asymmetric structure regarding the fiscal sustainability framework. For example, Hung and Lee (2010) found that the presence of asymmetric information intensifies the negative effect of government spending (debts) on economic growth. Specifically, the study notes that the optimal share of government spending (debts) in the presence of asymmetric information is less than the output elasticity of public debt. In support of the asymmetric structure phenomenon in public debts, Eller and Urvova (2012) affirm that the projection of debt paths is subject to a wide range of possible macroeconomic and fiscal shocks.

There are other reasons why the asymmetry phenomenon in fiscal policy analysis should not be ignored. First, there is a possibility of a non-linear relationship in fiscal policy—macroeconomic indicators nexus (see Chen 2014; Beqiraj et al. 2018). Second, there is uncertainty and lack of transparency in government fiscal policy making (Hughes et al. 2003) especially in developing countries where the institutional policy framework is weak. According to Hughes et al. (2003), government fiscal policy is often characterized by rigidities, bureaucracy, lack of credibility and transparency and weak governance. Third and most notably, available empirical evidence shows that business cycle indicators, such as public debts exhibit asymmetric behavior (via automatic fiscal stabilizers and/or discretionary fiscal measures) (see Combes et al. 2017), indicating that economic cycle asymmetries could transmit into the fiscal policy evolution process.

Although few studies have examined the asymmetry phenomenon in the evolution of government debt (Hung and Lee 2010; Gomez-Puig and Sosvilla-Rivero 2017; Bökemeier and Stoian 2018), most of these studies merely adopt a dummy variable to test the presence of asymmetric structure in the fiscal policy process (Hung and Lee 2010; Gomez-Puig and Sosvilla-Rivero 2017). One major shortcoming of the dummy variable approach is that it requires that the break date is known and this approach cannot adequately capture the asymmetric process (Olaoye et al. 2020a, b). Other studies have explored the non-linearity in fiscal policy using the static non-linear techniques. The methods adopt either the quadratic fiscal response method, where the non-linearity is specified by simple inclusion of a squared debt stock term (Bohn 2008) or the cubic fiscal response method [by the simple inclusion of a cubic debt stock term (Ghosh et al. 2013; Checherita-Westphal and Ždarek 2017; Bökemeier and Stoian 2018)]. These traditional static non-linear estimation techniques have been severely criticized in the literature for its limitation and inability to adequately capture the asymmetric structure in fiscal policy (see Olaoye and Olomola 2022).

3 Theoretical framework

The study is anchored on the Fiscal Theory of the Price Level (FTPL), following Sargent and Wallace (1981). The authors argue that the effectiveness of monetary policy in controlling inflation critically depends on its coordination with fiscal policy. According to the theory, the price level is determined by fiscal policy instruments, such as debt, deficit and the present as well as the future tax-spending arrangement of people (see Sims 1994). More specifically, the theory recognises the 'wealth effect' of government debt a dominant channel for inflation. For instance, in the short run, the theory notes that when public debt rises, consumers resort to higher spending, and they become profligate and consume more with the increased inflow of government borrowing. The increase in the demand for goods and services increases output and employment in the short run, as prices are sticky in the short run. However, since the marginal propensity to consume is higher than the marginal propensity to save, the private savings fall, and consequently, the real interest rate rises. A higher interest rate in the long run keeps away private investment, and leads to a decline in output, and thus, a rise in the price level in the long run.

3.1 Data and methodology

This study adopts an (unbalanced) panel data set of 44 sub-Saharan African countries. The data spanned year 2003–2020 (see Table 7 in the Appendix for the list of countries). The study made use of annual secondary data.[2] The study used public debts to capture fiscal policy. This helps us to accommodate the effect of the pandemic on government resources. See Table 8 in the Appendix for the list of variables and data sources.

[2] Note: The study reported the variables in terms of GDP ratios. This is because several authors (Magazzino et al. 2019) affirm that analysis based on GDP-ratios provide more credible information about the fiscal series than the raw and real data. We exempt control of corruption index which is already standardized and other variables such as interest rate and inflation rates which are already in rate.

3.1.1 Model specification for the asymmetric effect of public debt on inflation

$$\pi_{it} = \alpha_0 + \delta\pi_{i,t-1} + \rho d_{i,t-1} + \phi MS_{i,t} + \sum_{k=0}^{1} \theta gap_{i,t-k} + \lambda cor_{i,t} + X_{i,t}\beta + \varepsilon_{i,t} \quad t = 1, ..., \mathrm{T} \tag{1}$$

where π_t is the inflation rate in year t, d_{t-1} denotes public debt at the end of the previous year, π_{t-1} is the lagged inflation rate,$\varepsilon_t \sim iid(0, \sigma_\varepsilon^2)$, MS denotes money supply, (this is to capture the monetarist's view that inflation is a monetary phenomenon. The monetarists argue that excessive supply of money relative to demand for real balances causes inflation (see Inim et al. 2020 and Ndikumana et al. 2021), gap is the outputgap to capture structural factor affecting inflation (see Ndikumana et al. 2021), cor denotes corruption. It is firmly established in the literature that in an environment where the level of corruption is high, citizens will evade tax, and there will be increase in capital flight which reduces the fiscal space for productive activities in the country, and increases domestic prices (see Sassi and Gasmi 2017; Alzahrani 2018; Elkamel 2019). X_t is a vector of control variables (growth rate of GDP, and exchange rate). Equation 1 forms the basis of estimation. In line with the FTPL, we expect that a rise in public debts would lead to an increase in the inflation rate, and as such, the estimated coefficient of public debts is expected to be positive.

Following the recent development in the econometric literature on asymmetric structure in fiscal policies (see Çulha 2017; Bökemeier and Stoian 2018; Olaoye and Olomola 2022), this study controls for the asymmetric structure in public debt process. Asymmetry implies that a positive shock to public debt may have a differing impact on inflation rate, as would a negative shock to public debt. Hence, Eq. (1) is re-specified to include the integrated debt variable:

$$d_t = d_{t-1} + \varepsilon_{1,t} = d_{1,0} + \sum_{j}^{t} \varepsilon_{1,j}, \tag{2}$$

for $t = 1, 2, \ldots \mathrm{T}$

The initial value is denoted by constant term $d_{1,0}$ is the initial value while $\varepsilon_{1,j}$ is the error term.$\varepsilon_{1,t}^{+} = max(\varepsilon_{1,t}, 0)$ and $\varepsilon_{1,t}^{-} = min(\varepsilon_{1,t}, 0)$ are the positive and negative shocks respectively. Therefore, $\varepsilon_{1,t} = \varepsilon_{1,t}^{+} + \varepsilon_{1,t}^{-}$. The partial cumulative sum of the shocks is shown:

$$d_{1,t}^{+} = d_{1,0}^{+} + \varepsilon_{1,t}^{+} = d_{1,0} + \sum_{j=1}^{t} \varepsilon_{1,t}^{+}, \tag{3}$$

for $t = 1, 2, \ldots \mathrm{T}$,

$$d_{1,t}^{-} = d_{1,0}^{-} + \varepsilon_{1,t}^{-} = d_{1,0} + \sum_{j=1}^{t} \varepsilon_{1,t}^{-}, \tag{4}$$

for $t = 1, 2, \ldots \mathrm{T}$,

In a partial cumulative form, the positive and negative shocks to public debt is expressed in Eq. 5:

$$d_{1,t}^{t} = \sum_{j=1}^{t} \varepsilon_{1,j}^{+} \quad and \quad d_{1,t}^{-} = \sum_{j=1}^{t} \varepsilon_{1,j}^{-} \tag{5}$$

for $t = 1, 2, \ldots T$,

The re-estimated model is then expressed as follows:

$$\pi_{i,t} = \alpha_0 + \delta\pi_{i,t-1} + \rho d^{-}_{i,t-1} + \rho d^{+}_{i,t-1} + \phi MS_{i,t} + \sum\nolimits_{k=0}^{1} \theta gap_{i,t-k} + \lambda cor_{i,t} + X_{i,t}\beta + \varepsilon_{i,t} \tag{6}$$

where π_t is the inflation rate in year t, d^{+}_{t-1} and d^{-}_{t-1} are positive and negative shocks to public debt, π_{t-1} is the lagged inflation rate, *MS* denotes money supply, gap is outputgap, *cor* denotes corruption, X_t is a vector of control variables (economic growth (GDP), and exchange rate) and $\varepsilon_t \sim iid(0, \sigma^2_{\varepsilon})$.

3.1.2 Model specification for the threshold level of public debt

3.1.2.1 Dynamic panel threshold Following Seo and Shin (2016), the study adopted the dynamic panel threshold regression model shown in Eq. 7:

$$\pi_{i,t} = \left(1, x^{'}_{i,t}\right)\phi_1 1\left(q_{i,t} \le \gamma\right) + \left(1, x^{'}_{i,t}\right)\phi_2 1\left(q_{i,t} > \gamma\right) + \varepsilon_{i,t}, \quad i = 1, \ldots, n; t = 1, \ldots, T, \tag{7}$$

Equation 7 can be expressed explicitly as:

$$\pi_{i,t} = (1, \pi_{i,t-1})\phi_1 1(CGD_{i,t} \le \gamma) + (1, \pi_{i,t-1})\phi_2 1(CGD_{i,t} > \gamma) + \varepsilon_{i,t}, \quad i = 1, \ldots, n; t = 1, \ldots T, \tag{8}$$

where π_{it} is inflation rate, $\pi_{i,t-1}$ is the lagged dependent variable, 1(.) is the indicator function, CGD is the debt-to-GDP ratio and the regime-dependent variable, γ is the threshold parameter, ϕ_1 and ϕ_2 are the slope parameters associated with different regimes. ε_{it} consists of the error components:

$$\varepsilon_{i,t} = \alpha_i + \upsilon_{i,t}, \tag{9}$$

where α_i is a fixed effect term and υ_{it} is a zero-mean random disturbance.

3.1.2.2 Kink model The dynamic panel threshold also controls for the possibility of a kink (i.e., a false jump) in the model. A kink is confirmed if $\left(1, x^{'}_{it}\right)\delta = \kappa\left(q_{it} - \gamma\right)$ for some κ (see Eq. 10) is taken into account. This happens when one element of x_{it} is q_{it} with the coefficient κ and the first element of δ equals to $-\gamma\kappa$ under some certain restrictions.

In the restricted model with a kink, Eq. 10 is derived:

$$y_{i,t} = x^{'}_{i,t}\beta + \kappa(q_{i,t} - \gamma)1\left\{q_{i,t} > \gamma\right\} + \alpha_i + \varepsilon_{i,t}, \quad i = 1, \ldots, n; t = 1, \ldots, T. \tag{10}$$

In this milieu, Seo and Shin (2016) show that the asymptotic distribution of the GMM estimator remains valid even when the model is a kink one. This is in contrast to the least-squares estimator for the linear regression which shows the presence of the cube root phenomenon.

3.1.2.3 Estimation technique *System generalized method of moments (SGMM)* The baseline estimation technique is the system Generalized Method of Moment (SYS GMM) (see Blundell and Bond 1998). Specifically, the study adopts the SYS-GMM. The estimation technique helps us to control for possible endogeneity and simultaneity bias due the inclusion of the lagged dependent variable among the independent variables since the lagged

Table 3 Result of the panel unit root tests (individual effects and linear trends). *Source*: Authors' computations, 2020

Variables	LLC	Breitung	IPS	PP-fisher	ADF-fisher	Order
CGD	− 16.62***	4.18	− 9.03***	146.61***	114.83***	I(0)
INF	− 178.35***	0.75	− 51.20***	244.44***	171.33***	I(0)
ΔMS	− 3.41*	− 3.52**	− 3.94***	10.61***	11.21***	I(1)
RGDP	− 4.218***	2.02534	1.37	55.92	75.41	I(0)
pcapGDP	− 12.73***	5.435	− 2.93***	156.75***	101.09**	I(0)
ΔREER	− 73.69***	− 0.698	− 4.73***	63.64***	108.66***	I(1)

Table 2 shows the results of unit root tests under individual and linear trends. INF, CGD, REER, pcapGDP, MS, RGDP, inflation, government debt, real effective exchange rate, per capital GDP (growth rate), money supply, and real gross domestic product respectively. Δ denotes first difference operation

dependent variable might be correlated with the error term, and this breaks down the static model approach. The method is an efficient estimation to remove the time-invariant heterogeneity. This suggests that regression estimates from static approach might be unreliable and biased.

The SYS-GMM identifies variables as predetermined variables, while treating all the control variables as endogenous. The SYS-GMM addresses the possibility of simultaneity bias and the serial correlation by using lagged values of the dependent variables as instruments. The consistency of the S-GMM estimator rests on the assumption that the error terms are not correlated, the instruments used are valid, and the changes with additional instruments are uncorrelated with country fixed effects. As instrument, the study uses the mean debt of all the countries in the sample.

3.1.2.4 The dynamic panel threshold regression For the threshold estimation, the study adopts the dynamic panel threshold technique, following Seo and Shin (2016). The method controls for nonlinear asymmetric dynamics and cross-sectional heterogeneity, simultaneously in the dynamic threshold panel data framework. Importantly, the dynamic panel threshold method controls for endogeneity of both the threshold variable and regressors. Further, in the dynamic panel threshold, the lagged dependent variable and endogenous covariates are also allowed to be endogenous.

4 Empirical analysis and discussion of results

4.1 Descriptive statistics

The results presented in Table 3 shows that the standard deviation is low which means the data are clustered around the mean and has fewer extreme values. This indicates that the sample mean is close to the true mean of the overall population, indicating that the mean is a true representation of the actual data.

4.2 Unit root tests

The test for the stationarity properties of the variables is conducted. It is important to test for stationarity properties to determine the appropriateness of the methodology adopted in this study.

As can be seen in Table 3, the results indicate that the variables are integrated of order 0, i.e., I(0) or at first difference [I(1)]. This also confirms that the Generalized Method of Moments (GMM) technique adopted in this study is appropriate.

The basic estimation technique is the Dynamic System GMM, which accounts for simultaneity and endogeneity problems inherent in dynamic panel modelling. The results presented in Table 4 are robust across all specifications. The Sargan test of over-identifying restrictions is used to confirm the validity of the instruments. The test reveals that the instruments used in this study are not correlated with the error term, and thus, valid. The robustness of the results from the empirical analysis is also confirmed by the AR(2). The result shows that the model does not suffer from problem of serial autocorrelation. Also, the F-statistic supports the reliability of the model, which indicates that the estimates are robust and reliable.

The result shows that a positive shock to public debt has a positive and statistically significant effect on the inflation rate, while a negative shock to public debt has a statistically not-significant impact on the inflation rate. This implies that further accumulation of public debts in SSA would lead to increase in inflationary pressure in the region. This finding is consistent with the submission of the IMF and the World Bank that warned that following the rise in public debts, an inflation rate of more than 12% is expected for SSA. The result is also supported by Maitra and Mondal (2022) who investigated the inflationary impacts of public debt, budget deficit and public expenditure for Sri Lanka, and found that fiscal policy instruments are, in general, inflationary.

In the same vein, the result shows that money supply exerted a positive and statistically insignificant effect on inflation. This indicates that the current inflation in the region is not influenced by money supply. However, the joint effect of public debt (denoted by CGD) and money supply indicates that the increase in public debts influences the effect of money supply on inflation rate, albeit, the impact is weak (the result does not support the one to one relationship between money supply and consumer prices as predicted by the QTM). This might not be unconnected with the rise in the financing of government debts by monetary authorities. For example, in the region's biggest economy—Nigeria—around 55% of annual budget shortfalls has been financed by the CBN in the last 6 years (representing about 45% of the total money supply). This result is also consistent with the result of Azam and Rashid (2020) who found that though there is a positive relationship between money supply growth and inflation but not a proportionate correlation as predicted by the Quantity Theory. Similarly, Omanukwue (2010) also noted that there is a positive and statistically significant relationship, albeit, a weakening relationship between money supply and prices in Nigeria.

Further, the result indicates that corruption is a major determinant of the inflation rate in SSA. This result is supported by Sassi and Gasmi (2017), Alzahrani (2018) and Elkamel (2019).[3]

[3] These authors asserted that in an environment where the level of corruption is high, citizens will evade tax, and there will be increase in capital flight which reduces the fiscal space for productive activities in the country which leads to a rise in domestic prices.

Table 4 Dynamic panel estimates (system GMM) estimates

Inflation	System GMM				
	Total debt	Negative shock	Positive shock	Money supply	Joint effect
	(1)	(2)	(3)		
Inflation (−1)	0.414*** (0.020)	0.426 (0.019)***	0.416 (0.020)***	0.428*** (0.020)	0.413*** (0.020)
CGD−	–	–	–	–	–
CGD^{+}	–	0.022 (0.683)	0.046*** (0.021)	–	–
CGD	0.053*** (0.026)	–	–	–	–
MS	–	–	–	0.020 (0.029)	–
MS*CGD	–	–	–	–	0.001*** (0.0003)
LRGDP	−4.190** (2.13)	−5.132*** (2.074)	−4.84*** (2.065)	−5.670*** (2.09)	−4.983*** (2.051)
CORRUP	0.021** (0.0043)	0.024 (2.83)	−0.202 (0.100)	–	–
EXCH	−1.74** (0.85)	−1.02 (0.47)	−1.93* (1.21)		
HP (Cycle)	−0.271 (4.825)	−2.18 (4.83)	−1.14 (4.74)	−1.574 (4.839)	−0.989 (4.675)
Constant	76.18** (38.83)	95.79*** (37.33)	94.75*** (36.98)	105.41*** (37.51)	92.54** (36.84)
Significant levels (*p* values)					
F-statistics	42.20	22.05	42.70	73.20	102.40
Prob (F-statistics)	0.0000	0.0000	0.0000	0.0000	0.0000
Sargan	0.1236	0.4210	0.7440	0.3220	0.4505
AR (1)	0.1074	0.0654	0.0310	0.0996	0.0438
AR (2)	0.1740	0.1510	0.4335	0.3900	0.3856

CGD denotes Central Government Debt and is typically better recorded, and thus, adopted in this study. MS is real money supply, LRDGP is the natural logarithm of real gross domestic product, CORRUP is control of corruption. EXCH is the real exchange rate, and HP (Cycle) is theoutputgap

*, **,***denote 10, 5 and 1% levels of significance respectively. The values in parenthesis are the standard errors

Table 5 Threshold estimate of public debt using the dynamic panel threshold with a kink. *Source*: Authors computation

Panel Var: COUNTRID	
Time Var: YEAR	
Number of moment conditions: 320	
Bootstrap p value for linearity test = 0	
Dependent variable	(INFLATION)
Lag_y_b (−1))	
CORRUP	−0.5561
CGD	0.0666***
Kink_slope	−0.0862***
r	60.5901***
Public Debt (CGD)	(INFLATION)
Bootstrap p value	0.0000
Threshold estimate	60.5901
	Lower regime (δ) <
Dependent variable	(INFLATION)
CGD	0.0400**
CORRUP	6.5253
	Upper regime (δ1) >
CGD	0.3789***
CORRUP	1.5090

The bootstrap algorithm to test for the presence of the threshold effect is set under the null hypothesis $H_0 : \delta_0 = 0$. Notes: Lag_y_b denotes the endogenous independent variable ((−1)), CORRUP denotes control of corruption, CGD is public debt

*, **,***denote 10, 5 and 1% levels of significance respectively

The study also adopts the dynamic panel threshold technique to account for the potential asymmetric phenomenon in public debt process. The aim is to investigate the threshold level beyond which public debt worsens inflation rate in SSA. The result is presented in Table 5. The results show that the estimated threshold level splits the observations into two regimes. The test for linearity rejects the null hypothesis of linearity in public debt series. Specifically, the results show a public debt threshold point of 60.59% of GDP beyond which inflation rate worsens. This indicates that further accumulation of public debt (i.e., a higher public debt-to-GDP ratio) will worsen inflation rate in SSA countries. This is tenable since increased public borrowing limits fiscal space for human and physical capital investment which might inhibit growth and productivity, thereby leading to a rise in domestic prices across SSA.

The study also estimated the optimal inflation rate for macroeconomic stability. This is important since it is suggested in the theoretical literature (see the Modern Monetary Theory) that public debt can help to spur economic growth and engender macroeconomic stability, only in an environment of low inflation and interest rates. The result as presented in Table 6 shows that the optimal inflation rate for sustainable growth and macroeconomic stability is approximately 4%. This suggests that for public debt to spur economic growth and engender macroeconomic stability in SSA, the prevailing inflation rate must not exceed 4%.

Table 6 Threshold estimate of inflation rate using the dynamic panel threshold with a kink. *Source*: Authors computation

Panel Var: COUNTRID	
Time Var: YEAR	
Number of moment conditions: 336	
Bootstrap p value for linearity test = 0	
Dependent variable	(RGDP)
Lag_y_b (− 1))	0.7326
CORRUP	− 0.0002
CGD	− 0.0008***
INF	− 0.0377***
Kink_slop0e	0.0365***
r	3.9968***
Public debt (CGD)	(RGDP)
Bootstrap p value	0.0000
Threshold estimate	3.9968

The bootstrap algorithm to test for the presence of the threshold effect is set under the null hypothesis $H_0 : \delta_0 = 0$. Notes: Lag_y_b denotes the endogenous independent variable ((− 1)), CORRUP denotes control of corruption, CGD is public debt, INF is inflation rate

*, **,***denote 10, 5 and 1% levels of significance respectively

5 Conclusions and policy recommendations

The study examined the effects of fiscal policy on inflation rate in sub-Saharan Africa, while accounting for the potential asymmetric structure in fiscal policy. The findings indicate that there is an asymmetric impact of public debts on inflation rate in SSA. The result shows that beyond a certain threshold, public debts exacerbate the inflation rate. Specifically, the study found that when public debt exceeds 60.59% of GDP, further accumulation of public debts worsens inflation rate in SSA. This implies that further accumulation of public debts beyond this benchmark established in this study would lead to increase in inflationary pressure in SSA.

Importantly, the study found a threshold value inflation rate of 4%.

Following the empirical findings, the study makes the following.

The study recommends that to reduce the inflation rate in sub-Saharan Africa, governments must adhere strictly to the debts limit of 60.59% of GDP established in this study. Otherwise, further accumulation of public debts in the region will "crowd out" available economic resources—due to huge debt repayment and high debt service cost associated with high public debt level—thereby, stifling economic growth and productivity which might worsen inflation.

In a similar vein, for public debts to reduce inflationary pressure, spur growth and engender macroeconomic stability, the study recommends that the governments, policymakers and monetary authorities in SSA should work in tandem and put in place measures to bring down the soaring inflation rate to within 4%. In this regard, policymakers (such as the monetary authorities) should reduce its financing of government debts

to within the maximum limits stipulated by law, since the consequence of the central banks' excessive financing of government deficits is the distortion or surge in monetary base which might lead to the deterioration of domestic prices and exchange rate.

Similarly, the monetary authorities should consider halting the increase in interest rates since the current inflationary pressure might be rooted in fiscal policy. This implies a further rise in the interest rates could end up pushing price growth higher and may have fundamental implications for the economy (i.e. household, firms and government).

Lastly, the study recommends that SSA governments must develop economic and political institutions that promotes transparency, reduce the level corruption and holds governments accountable. That is, governments must strengthen the quality of institutions to reduce economic and political corruption to the barest minimum so that the intended economic benefits of government's policies may ensue.

Appendix

See Tables 7 and 8.

Table 7 List of 44 sub-Saharan African Countries used in the study

Countries	CGD (2018)
Nigeria	18.87
Angola	64.98
Botswana	14.33
Cape Verde	125.83
Congo Republic	130.79
Congo Dem. Republic	18.10
Gambia	88.03
Ghana	71.83
Sao Tome and Principe	88.36
Malawi	54.80
Seychelles	63.63
South Africa	53.03
Sudan	121.59
Ethiopia	54.19
Equitoral Guinea	37.40
Kenya	54.21
Namibia	41.99
Zambia	63.10
Zimbabwe	82.25
Burkina Faso	15.92
Liberia	34.44
Cote D'ivoire	46.95
Mali	35.44
Mozambique	102.07
Benin	54.55
Burundi	51.71
Cameroon	34.55
Central African Republic	52.85
Chad	52.49
Comoros	32.37
Gabon	62.68
Guinea	37.94
Guinea Bissau	53.87
Lesotho	33.68
Madagascar	35.96
Mauritania	96.57
Mauritius	65.33
Niger	45.25
Rwanda	40.45
Senegal	48.33
Sierra Leone	63.93
Tazania	36.97
Togo	75.72
Uganda	40.03

Table 8 Data, sources and measurements of key variables. *Source*: World Development Indicators (2019), Global Database (2019), International Country Risk Guide (2019), Author's computation (2021)

Variables	Definition	Measurement	Source
Public debt (CGD)	This consists of all government debts. For developing countries. The Central government debt (CGD) is typically better recorded, and thus widely adopted	Central government debt (% of GDP)	Global Database (2020)
Gross domestic product (GDP)	This is the productive capacity of an economy. The real domestic product is the nominal value of the GDP deflated by consumer price index based on current US dollars	Current $ US	WDI (2021)
Inflation rate	Inflation, as measured by the annual growth rate of the GDP implicit deflator, shows the rate of price change in the economy as a whole. The GDP implicit deflator is the ratio of GDP in current local currency to GDPin constant local currency	Inflation, GDP deflator (annual %)	WDI (2021)
Output gap	This is an economic measure of the difference between the actual output of an economy and its potential output. It is a measure of structural factor that influences inflation	The study used the Hodrick–Prescott technique for separating the short from the long term	Authors calculation
Money supply	This is the amount of cash or currency circulating in the economy	This is measured by the broad money (M3) in real form	WDI (2021)
Institutional quality (control of corruption)	This indicator measures the extent to which public power is exercised for private gain, including both petty and grand from of corruption, as well as capture of state by elites and private interests. It also measures the strength and effectiveness of a country's policy and institutional framework to prevent and combat corruption	The control of corruption index is measured by no corruption	ICRG (2021)

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Authors and Affiliations

Olumide O. Olaoye[1] · O. J. Omokanmi[1] · Mosab I. Tabash[2] · S. O. Olofinlade[1] · M. O. Ojelade[3]

✉ Olumide O. Olaoye
oluweds34@gmail.com

O. J. Omokanmi
kanmilatunde@gmail.com

Mosab I. Tabash
Mosab.tabash@aau.ac.ae

S. O. Olofinlade
olofin73@gmail.com

M. O. Ojelade
mathewojelade30@gmail.com

[1] Thomas Adewumi University, Oko, Nigeria

[2] College of Business, Al Ain University, Al Ain, UAE

[3] Koladaisi University, Ibadan, Nigeria