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Exploring The Role of High Government Debt on Economic Growth: A Nonlinearity and Threshold Analysis for Africa's Developing Countries

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Abstract: Purpose: This paper empirically investigated the impact of high government debt on economic growth, using a panel data of 12 developing countries in Africa for the period between 1991 and 2020. Furthermore, it sought to find the existence of nonlinearity between government debt and economic growth. The study used a cross-country panel data approach estimated through the panel smooth transition regression to find the threshold effect. The results reveal a threshold of 60.5% of government debt on economic growth, suggesting an inverted U-shaped relationship between government debt and economic growth for the whole sample. After this threshold, additional government debt starts impeding economic growth. The estimated slope parameter of 18.11 supports the smoothness of government debt from a low regime to a high regime of debt. In the lower debt regime, government debt boosts economic growth; however as the level of debt growth surpasses the peak point, economic growth decreases. By implication, policymakers should have strict debt management policies in place to keep the level of government debt low, and be able to respond robustly to an economic shock. While resorting to borrowing to finance public spending, especially during economic crises, may be an imperative, it should be done in a circumspect manner so that the borrowings are kept at tolerable levels and reduced and/or repaid when there is a recovery in the economy.

Keywords: government debt; economic growth; PSTR model; Africa; developing countries

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1. Introduction

Over the years, many of Africa's low-income countries have experienced rapidly growing levels of government debt. African countries accumulate debt for different economic reasons (Rahman et al. 2019). African governments borrow in response to multi-sectoral crises, including health, financial, environmental crises, etc. They also borrow to finance investments, such as infrastructure development, educational and healthcare facilities, and investment in technology and artificial intelligence (World Economic Forum 2017). High levels of government debt have a severe and lasting impact on the economic outlook of many emerging and developing economies, through phenomena such as debt overhang and debt trap (Abdullahi et al. 2016). Furthermore, the repayment of debt is costly because it drains the already scarce financial resources. Subsequently, focus is shifted from growth opportunities to debt repayment (Pattilo et al. 2004).

To date, there is no consensus, in both the theoretical and empirical literature, on the impacts of government debt on the economy. Conventional theories such as the debt Laffer curve postulate that reasonable levels of government debt may stimulate economic growth. It is only when government debts exceed a certain, reasonable threshold that it starts impeding economic growth. According to the endogenous growth model, government debt used to acquire capital stock or to finance expenditure could pose a negative impact if not managed efficiently.

The impact of public debt on economic growth in advanced and less advanced countries is marked by a wide body of literature, such as (Agénor and Aizenman 2005; Eberhardt and Presbitero 2015; Owusu-Nantwi and Erickson 2016; Senadza et al. 2017). The study by Omotosho (2021) examined the effect of public debt on the economic growth of West Africa from 2009–2018. Panel data estimation techniques and a generalized methods of moment (GMM) model were used in the study. The study revealed that public debt and inflation pose a negative effect on economic growth in West Africa. Rahman et al. (2019) also investigated the debt–growth nexus in emerging and developing economies (EMDE). Their study concluded that there is no common threshold of 90% as previously claimed by (Reinhart and Rogoff 2010). Hence, they concluded that a relationship can take any direction. Furthermore, Brida et al. (2017) opposed the existence of a nonlinear relationship between government debt and economic growth in EMDE. They concluded that there is no relationship between government debt and economic growth by using the method of minimal spanning tree and hierarchical tree.

The present literature contradicts the notion that government debt has a direct impact on economic growth. The existing literature is vast and has yielded extensive conflicting results. Some have confirmed that debt stimulates economic growth directly (see Burhanudin et al. 2017; Maana et al. 2008). These studies conclude that there are other fundamental factors that need to be considered, including government debt size, investment on capital stock, economic size, and the robustness of debt management policies. Other studies have found a negative impact of debt on growth, see (Adom 2016; Atique and Kamran 2012; Bal and Narayan 2014). Moreover, based on existing evidence, see (Reinhart and Rogoff 2010; Karadam 2018; Ndoricimpa 2020; Baaziz et al. 2015; Baum et al. 2013), there have been varying thresholds of the effect of government debt on economic growth for different economies. According to these studies, debt is heavily impacted by factors such as economic size and the level of economic growth in that economy. Empirical evidence also suggests that the threshold in advanced economies is generally higher than in developing countries. The existing literature provides some very ambiguous and inconsistent findings on the effect of government debt on economic growth. Moreover, the contradictions in these results may result from the feasible explanation of the different results in the existing literature lying in the different model specifications, data coverage, estimation techniques and/or size of the economy being studied.

In this study, we sought to extend the existing debate on this subject matter by going back to the seminal work of Baum et al. (2013), who explored the nonlinear relationship by applying a dynamic panel threshold method for advanced economies, covering 1990–2010. Their findings revealed that debt is positive in the short run, and becomes insignificant when the ratio is about 67%. However, when the ratio grows beyond 95%, a negative impact emerges. The current study focuses on Africa's developing countries. Even with the studies carried out across African countries, the threshold effect found in these studies does not necessarily mean that it applies to highly indebted countries. Furthermore, the authors included a major macroeconomic variable: employment[1]. Low levels of employment are one of the challenges faced by many African countries (IMF 2018). Therefore, it is important to test how this variable is affected. Another variable added is gross fixed capital formation, which is the most robust and commonly used macroeconomic variable identified in the literature. Employment and gross fixed capital formation have been argued to have both direct and indirect effects on economic growth, but they were not captured in Baum et al.'s (2013) study.

Based on the inconclusive and conflicting views in the literature, this study sought to fill the gap in the literature by incorporating and examining the impact of government debt and other macroeconomic variables on economic growth in highly indebted African economies. A balanced panel of 12 highly indebted African economies covering the period 1990–2020 was employed. The countries examined in this study include Cameroon, the Central African Republic, the Republic of Côte d'Ivoire, Chad, Ghana, Madagascar, Gambia, Togo, South Africa, Uganda, Senegal, and Mali[2].

This study aimed to contribute to the ongoing debate by analyzing the nonlinear effects of government debt on economic growth using the panel smooth transition regression (PSTR) model. The PSTR method is not a new model in the African context. However, in this study, we extended Baum et al.'s (2013) debt–growth study by using the PSTR model, following Gonzalez et al.'s (2017) work. The PSTR model has various advantages. For instance, the regression coefficients can change between groups over time, based on variations in the threshold variable. Additionally, the PSTR allows a smooth transition between extreme regimes, which makes it a flexible and reliable framework. Furthermore, priority is not given to a threshold value, but it is calculated in the model. The PSTR model also provides a parametric solution to the cross-country variability and time instability of debt–growth coefficients. These features cannot be accounted for by dynamic interaction effects or by static panel techniques. Capturing nonlinearities and regime switching in this way makes PSTR a suitable model for the empirical investigation of the debt–growth relationship. Additionally, the motivation for this study originated not only from a lack of studies examining the nonlinear effect of government debt on growth in highly indebted African countries, but more generally from the fact that this relationship may differ from the one that exists in the literature due to the difference in the smoothness and level of government indebtedness. The remainder of the paper is organized as follows. A literature review is discussed in Section 2, while Section 3 gives an overview of the methodology. The findings are discussed in Section 4, and lastly, Section 5 provides concluding remarks and discusses policy implications.

2. Literature Review

2.1. Theoretical Literature Review

Sachs (2002) used the debt Laffer curve to explain the nonlinear relationship between debt and economic growth. According to this theory, there is a peak point up to which public debt stimulates economic growth, and from which any additional debt results in negative effects. This theory elucidates that as unpaid debt rises beyond a particular threshold, the country's repayment capacity begins to deteriorate (Savvides 1992). More precisely, when a country obtains debt to finance budget deficits, it makes resources more accessible for investment activities, which could stimulate growth. Borrowing beyond the peak point, however, creates debt overhang and debt service problems.

The nonlinear hypothesis was first introduced by Sachs (1998), and was used to explain debt overhang. Debt overhang occurs because of excessive government borrowing that causes inefficiencies and eventually leads to diminishing effects on economic growth (Abdullahi et al. 2016). Hence, the relationship between government debt and economic growth is nonlinear, according to this theory.

2.2. Empirical Literature

There is vast empirical evidence on the effect of debt on economic growth, with fewer studies analysing the nonlinear effects between debt and economic growth in the African context. Savvides (1992) analyzed the impact of debt overhang on the economic growth of 43 low- income countries. The study employed a two-stage limited dependent variable model which uses cross-sectional time-series data. The results revealed that a debt overhang exists, with a declining foreign capital flow having a significant negative impact on investment. Elbadawi et al. (1997) applied a quadratic model and used fixed and random effects estimations on a sample of 99 developing countries. The results uncovered that the effect of public debt on growth becomes negative when the level of debt is beyond the threshold of 97%. Meanwhile, Imbs and Romain (2005) used Kernel estimations on 87 developing economies and found that debt overhang occurs when the debt reaches 55–60% of GDP. In the same vein, Pattilo et al. (2004) also investigated the relationship between external debt and economic growth in 93 developing countries from 1969 to 1998 using the GMM method. The results suggested that, as debt ratios increase beyond a peak point (80% to 90% of GDP), debt ends up decelerating economic growth.

Furthermore, Caner et al.'s (2010) used a dynamic threshold model to explore the impact of debt on economic growth for advanced and emerging economies. Their study revealed a threshold of 77% of GDP for advanced countries and (64% of GDP) for emerging countries. A study carried by Baaziz et al. (2015) examined the nonlinear effect of public debt on economic growth in South Africa, covering 1980–2014. Their findings suggested that the effect of public debt becomes negative on economic growth when the level of debt grows beyond the threshold of 31.37% debt to GDP. Mensah et al.'s (2019) study used a panel threshold-ARDL model to explore the threshold effect of debt on economic growth in Africa. The results suggested that public debt threshold ranges between 20–80% of GDP, and as debt grows beyond 50–80% of GDP, public debt starts to adversely affect economic growth in Africa.

Ndoricimpa (2017) applied the nondynamic panel threshold regression model of Hansen (1999), and a dynamic panel threshold regression model following Kremer et al.'s (2013) study to find the threshold of debt on growth for selected African countries. The results showed a threshold of 92% for some countries, while for other countries, the threshold was found to be 102% of GDP. The findings revealed that the estimated threshold of debt is sensitive to the model applied, and to growth control variables incorporated in the estimation. Nonetheless, he contends that low debt is either neutral or enhances growth, while high government debt is consistently harmful to growth for all the countries considered. Ndoricimpa (2020) revisited the threshold effect of public debt on economic growth for middle and low-income countries and employed a PSTR technique. The findings confirmed a threshold effect averaging 62–66% for the whole sample, and 58–63% for all middle-income countries from 2012 to 2017. However, when using a dynamic panel threshold model, the results concluded a threshold of 74.3%. Furthermore, Makhoba et al. (2022) analysed the asymmetric effects of public debt on economic growth for selected emerging and frontier SADC countries. They used a symmetric transition regression model (STAR) and found an inverted-shape relationship between debt and growth in the case of South Africa. Meanwhile, for Botswana, Namibia, Zambia and Zimbabwe, they found a U-shape relationship between debt and growth.

After the 2008 global financial crisis (GFC), most studies focused on developed economies. Minea and Patric (2009) sought to establish a relationship between debt and public investment on a panel of 22 Organisation for Economic Cooperation and Development countries (OECD). They used the PSTR method for the period 1970–2006. Their findings suggested that a threshold of 50% and 90% of the debt burden would tend to reduce the positive impact of debt on public investment spending, with this impact becoming negative when the debt exceeds 120% of GDP.

Checherita-Westphal and Rother (2012) evaluated the non-linear relationship between government debt and economic growth in 12 European countries for the period 1990–2008 by employing a non-dynamic panel method on growth, expressed as a quadratic functional form of debt. The study found a non-linear effect of debt on economic growth with a threshold level of 90% to 100% of the debt to GDP ratio. These findings contradict the findings of Baum et al. (2013), who explored the same relationship using the same sample and applied the dynamic panel threshold method for the period 1990–2010. The findings revealed that debt is positively related to economic growth in the short run, but reduces to zero and becomes insignificant when the ratio is about 67%. However, the impact becomes negative for higher ratios beyond 95%.

On the other hand, Reinhart and Rogoff (2010) studied a sample of 44 advanced countries. They found a threshold of 90%, below which debt is beneficial to the economy. After that level, the average GDP falls significantly more than the median GDP, which falls by 0.1 percent; this also depends on the level of debt. However, Herndon et al. (2014) sought to confirm Reinhart and Rogoff's (2010) results by directly using their data through the threshold regression model used by Hansen (1999). After correcting the errors made by Reinhart and Rogoff (2010), their study demonstrated that countries with government debt over 90% of GDP grow by an average of 2.2 percent, not the 0.1 percent previously argued by

Reinhart and Rogoff (2010). Egert (2015) used the non-dynamic threshold model of Hansen (1999) to examine the debt–growth relationship in 20 advanced economies. The findings revealed that a negative interaction between central government debt and economic growth can set in at debt levels as little as 20% of GDP, while for general government debt, the threshold is considerably higher, at about 50%. Furthermore, finding a negative nonlinear relationship between public debt and economic growth is considerably challenging, and depends on modelling choices and data coverage (Egert 2015). Other studies have examined the effect of government debt on growth (see Eberhardt and Presbitero 2015; Ncanywa and Masoga 2018; Senadza et al. 2017; Seleteng et al. 2013; Stafania 2014; Perlo-Freeman and Webber 2009).

There are complex and different relationships between government debt and economic growth across the countries found in the literature. The debt–growth nexus should consider debt composition and countries' peculiarities that could restrict government choices and affect the economy's vulnerability to crises. Most of the literature focuses on the direct effect of debt on growth and fails to account for some of the channels explored in this study. The related literature has focused largely on developed economies, while in this study, the focus is only on African developing countries, which have been experiencing rapidly growing government debt over the years. Additionally, the existing evidence shows that the threshold level of government debt in advanced economies is higher than in developing countries.

3. Methodology and Data

We used secondary data sourced online from the World Development Indicators and International Monetary Fund. The specific control variables employed in this study include government expenditure (GE), gross fixed capital formation (GFCF), employment in industry (EMI), and employment in the service sector (EMS). The dependent variable is real GDP at constant prices (y), which serves a proxy for economic growth. Government debt (GD) is employed as an independent variable. The economic modelling of variables in the model specification is supported by theories such as the debt Laffer curve and endogenous growth theories.

We used pre-estimation techniques such as a correlation matrix and a descriptive statistics test for our data analysis, spanning 1991–2020. As mentioned earlier, the estimation technique used in this study is the PSTR model, which will allow for empirical investigation of the threshold effects of government debt on GDP. For robustness checks and sensitivity, we used the central government debt variable.

3.1. Panel Smooth Transition Regression Model (PSTR)

Following Gonzalez et al.'s (2005) study, the contemporary study used a PSTR model for Africa's developing economies to examine the nonlinear effect of government debt on economic growth. The simple case of the PSTR model, with a single transition function in two regimes illustrating the threshold effect of government debt on economic growth, is as follows[3]:

$$y_{it} = \mu_i + \lambda_t + \beta_0' X_{it} + \beta_1' X_{it} g(q_{it}; \gamma, c) + e_{it} \tag{1}$$

where y_{it} denotes a dependant variable which is a scalar. Moreover, $i = 1, \ldots, N$, and $t = 1, \ldots, T$ designates the cross-sectional and the time dimensions of the panel, correspondingly. Whereas λ_t and μ_i signify the time and fixed individual effect, correspondingly. X_{it} designates the k-dimensional vector of time-varying exogenous variables (GE, GFCF, EMI, and EMS) and the error term is represented by e_{it}. Following the work done by Granger and Teräsvirta (1993) and Gonzalez et al. (2017), the transition function in the logistic form $g(q_{it}; \gamma, c)$ is a continuous function of the transition variable q_{it} and is normalized to be bound between 0 and 1. It is the function of the threshold variable q_{it}, the slope parameter γ and the threshold parameter c. β_0 measures the effect of government debt on GDP when q_{it} is below the threshold (first extreme regime). Meanwhile, $(\beta_0 + \beta_1)$ measures the marginal effect of the threshold variable when government debt exceeds the threshold (second extreme regime). The transition function can also be expressed in a logistic function, as follows:

$$(q_{it}; \gamma,\ c) = \left(1 + \exp\left(-\gamma \prod_{j=1}^{m} (q_{it} - cj)\right)\right)^{-1} \text{ with } \gamma > 0 \text{ and } c_1 \leq c_2 \leq \ldots c_m \quad (2)$$

In Equation (2), $c_j = (c_1, \ldots, c_m)$, which is an m dimensional vector of threshold parameters. The slope parameter denoted by γ controls the smoothness of the transitions. Moreover, $\gamma > 0$ and $c_1 < \ldots < c_m$ are restrictions used for identification purposes. In practice, for $m = 1$ or $m = 2$, respectively, one or two thresholds of government debt occur, around which the impact on economic growth is nonlinear (Gonzalez et al. 2005).[4] This nonlinear effect is represented by a range of parameters between the extreme regimes. For $m = 2$, the transition function has a minimum at $(c1 + c2)/2$ and reaches a value of 1 for both the low and high values of q_{it}. Therefore, if γ tends to infinity, the model becomes a three-regime threshold model. However, it is reduced to a homogenous or linear fixed-effects panel regression when the transition function becomes constant, for instance, when γ tends to 0 (Gonzalez et al. 2005).

According to Gonzalez et al. (2017), before estimating Equation (1), three critical tests need to be undertaken. Firstly, testing for the appropriate transition variable among the set of variables included as candidates (GD, GE, GFCF, EMI, EMS). Secondly, testing for the monotonic hypothesis, and thirdly, testing for the sequence of selecting the order m of the transition function, using the LM-type test. The LM-type test consists of two groups of misspecification tests. Group 1 is the Lagrange multiplier wild (LM_χ) and Lagrange multiplier Fischer (LM_f). Group 2 is the wild bootstrap (WB) and wild-cluster bootstrap (WCB). Their F-statistic corresponding with their *p*-values will be used in the three tests mentioned in the first line of this paragraph. The theoretical reasoning behind the LM-type test is that, for all these tests, the *p*-value should be small. Note that the WB and WCB are utilized as robustness checks for linearity against the PSTR.

On the other hand, for the monotonic hypothesis between government debt and economic growth, the *p*-value of both LM_χ and LM_f should be zero; this would then justify the rejection of the H_0 of linearity between government debt and economic growth. Then, the WB and WCB will hold the argument that a nonlinearity still exists amongst the variables. Lastly, for the sequence of selecting the order m of the transition function, following Gonzalez et al. (2017), the study will check for the order $m = 3$. The sequence for selecting the order m of the transition function under the $H_0^* : \beta_3^* = \beta_2^* = \beta_1^* = 0$ is selection $m = 3$. If it is rejected, it will continue to test $H_{03}^* : \beta_3^* = 0, H_{02}^* : \beta_2^* = 0 | \beta_3^* = 0$ and $H_{01}^* : \beta_1^* = 0 | \beta_3^* = \beta_2^* = 0$, in selection $m = 2$. If it still fails, $m = 1$ will be selected as default (Teräsvirta 1994; Teräsvirta 1998).

4. Results and Discussion

4.1. Pre-Estimation Tests

It is important to run a preliminary analysis of the data series before the estimation of the model. Therefore, two classical preliminary estimation techniques have been conducted, namely, correlation matrix and descriptive statistics. The correlation matrix in Table 1 tests for collinearity of the variables. The descriptive statistics procedure in Table 2 helps researchers to understand and ascertain deviations, dispersions, and normality of the data series before the estimation of the actual model. Moreover, the panel unit root test helps to avoid a spurious model. Table 3 presents the results of the panel unit root tests.

Table 1. Correlation matrix for 12 African countries.

	GDP	GD	GE	EMI	EMS	GFCF
GDP	1.000					
	——					
GD	0.198 **	1.000				
	3.825	——				
GE	0.608 **	0.156 *	1.000			
	14.493	3.004	——			
EMI	0.257 **	−0.065 *	0.149 *	1.000		
	5.043	−1.234	2.869	——		
EMS	0.432 **	−0.052 *	0.457 *	−0.086 *	1.000	
	9.088	−0.989	9.709	−1.640	——	
GFCF	0.492 **	−0.127 *	0.129 *	0.141 **	0.040	1.000
	10.706	−2.433	2.455	2.703	0.765	——

Source(s): Authors' calculation, based on World Development Indicators (World Bank 2020). Note, GDP refers to (gross domestic product), GD (government debt) GE (government expenditure), EMI (employment in industry), EMS (employment in service), and GFCF (gross fixed capital formation). *, **, signifies the level of significance at 10%, 5% respectively.

Table 2. Descriptive statistics.

Variable	Mean	Max	Min	SD	Skewness	Kurtosis	Obs
GDP	23.11	26.51	20.42	1.44	0.35	2.87	360
GD	54.98	230.72	10.64	27.00	1.24	5.19	360
GE	12.55	22.56	3.58	3.71	0.12	2.70	360
GFCF	18.47	59.72	4.56	7.30	1.09	8.07	360
EMI	16.89	69.71	1.86	16.69	2.41	7.88	360
EMS	33.10	72.41	6.5	16.85	0.41	2.39	360

Source(s): Authors' calculation, based on WDI (2020) data.

Table 3. Panel unit root results.

Variable	Integration	Im-Pesaran-Shin	Levin-Lin-Chu	Hadri
GDP	Levels	1.21 (0.88)	−0.82 * (0.20)	7.04 *** (0.00)
	1st Δ	−11.42 *** (0.00)	−14.09 *** (0.00)	
GD	Levels	−0.78 ** (0.02)	−1.26 *** (0.01)	3.86 *** (0.00)
	1st Δ	−13.45 *** (0.00)	−13.88 *** (0.00)	
GE	Levels	−3.66 ** (0.00)	−2.25 *** (0.01)	3.68 *** (0.00)
	1st Δ	−14−43 *** (0.00)	−14.85 *** (0.00)	
EMI	Levels	1.65 (0.95)	1.61 * (0.09)	8.69 *** (0.00)
	1st Δ	−12.39 *** 0.00)	−10.78 *** (0.00)	
EMS	Levels	1.70 (0.95)	−0.21 *** (0.04)	7.82 *** (0.00)
	1st Δ	−11.17 *** (0.00)	−14.21 *** (0.00)	
GFCF	levels	−3.13 ** (0.00)	−2.46 *** (0.01)	2.51 *** (0.01)
	1st Δ	−13.71 (0.00)	−14.17 *** (0.00)	

Source: Authors' calculations, based on WDI (2020) data. Note (s): The ***, **, * denote the level of significance at 1%, 5%, and 10%, respectively. The values in parentheses denote the probability values. Δ denotes first difference.

This preliminary analysis of the dataset shows that a positive relationship between government debt and economic growth is expected in the case of Africa's developing countries. However, as previously mentioned, no conclusion can be made based on this preliminary review, since it serves as a rule of thumb.

Table 2 presents the results of the summary statistics to show whether the sample is normally distributed or there are outliers and variation of our dataset. The mean of GDP is recorded at 23.11 and for government debt at 54.98 from 1991–2020. The maximum value for GDP is recorded at 26.51, while the minimum value is 20.42. This finding may be associated with the infrastructural developments that have been taking place in many of Africa's developing countries since the 1990s. For example, the removal of the apartheid system in South Africa enabled previously disadvantaged Black South Africans to play more active roles in the economic sphere. Another contributing factor are the debt relief programmes initiated by the World Bank and International Monetary Fund (IMF) for highly indebted poor countries, some of which are included in the study. For government debt, the maximum and minimum values are recorded at 230.51 and 10.64, respectively. The preliminary data analysis shows that government debt is generally higher than GDP for the 12 African countries during the period of 1991–2020. This indeed indicates that many African countries are highly indebted. Since the 1980s, there have been internal and external shocks that have been occurring and thus putting a strain on the government. Governments have had to respond to these economic crises by acquiring debt.

According to our results, the positive values for the skewness indicate that our data are skewed rightward, or our data are positively skewed. Furthermore, when a kurtosis value is equal to 3, it means that the kurtosis is the same as normal distribution. When the kurtosis is greater than 3, it indicates that the dataset has heavier tails than a normal distribution. Each variable in this study brings 360 observations from 12 countries in the developing African region, covering a period from 1991 to 2020.

Moreover, conducting stationarity is a crucial step in order to avoid spurious estimates. However, there are cases where stationarity becomes a challenge, such as the long-time dimensions of the study. Moreover, the problem of heterogeneity is easily found in panel data across different countries, and applying the traditional unit root and cointegration tests may help solve this problem (Li et al. 2011). Nevertheless, Gonzalez et al. (2005) argued that it is invalid or inadequate to deal with the heterogeneity problem using these tests, and they proposed a new nonlinear model to deal with the problem of heterogeneity. Consequently, they came up with the PSTR model, which is a useful model in addressing the issue of heterogeneity. According to (Gonzalez et al. 2005; Wang et al. 2017; Ndoricimpa 2020; Zungu and Greyling 2022; Makhoba et al. 2022), running a unit root is not much of a concern.

Nonetheless, we carried out the panel unit root test by employing Levin, Lin and Chu (LLC) and Im-Pesaran-Shin (IPS) as the main tests for stationarity for this study (Levin et al. 2002). Meanwhile, the Hadri test is employed for a robustness check, and our dataset covers the period 1990–2020. Employing such tests will help address various problems that might exist in a panel dataset. For instance, the data may exhibit some cross-section dependency because of back-and-forth linkages that exist among variables; in such cases, the LLC test is employed. LLC forms part of the first group, which holds the assumption that cross-sections are individually and identically distributed, whereby a too restrictive assumption would posit that a potential simultaneous correlation exists among variables. On the other hand, the second group relies on the presence of structural breaks among variables, as a result of long-time dimensions, to such an extent that structural breaks could pose a possible problem in the dataset. Following Perron (1989) and Amsler and Junsoo (1995), the unit root will be partial towards a tolerant untrue unit root null hypothesis in the presence of structural breaks. Consequently, the ignorance of structural breaks is exposed to one form of statistical errors. To account for structural breaks, we employed Im et al. (2005) and Pesaran (2005). However, like other techniques, that of Im et al. (2005) has its limitations, such as the lack of power in the test when individual tests are incorporated. Hence, for robustness, we employed the Hadri test. Hadri (2000) proposed a different method for testing the unit root in panel data. The Hadri test has a null of stationary panels (the absence of a unit root) and accommodates individual specific variances as well as potential correlation.

As previously discussed, the LLC and IPS are employed using two groups. Both the LLC and IPS tests are conducted based on the null hypothesis that the data-generating process possesses a unit. If the computed test statistics value is more than the critical value, it is implied that that the null hypothesis is rejected. The results indicate that both LLC and IPS reject the null hypothesis of the existence of a unit root when GD, GE and GFCF are in levels. While GDP, EMI and EMS fail to reject the null hypothesis of unit root under IPS, because there is a contradiction between the two tests, we conclude that these variables are stationary at first difference. The reason that some variables are $I(1)$ is the possibility of structural breaks among variables. Overall, the LLC and IPS confirmed that the variables used in this study are integrated of the same order $I(0)$, except for GDP, EMI and EMS. The robustness check test (Hadri test) suggests that stationarity is rejected. We conclude by saying that all the variables are stationary when differentiated for both LLC and IPS. However, as mentioned in the first paragraph of this sub section, the problem of heterogeneity is easily found in the panel unit root; hence, Gonzalez et al. (2005) pointed out that running such tests maybe unnecessary or invalid. They came up with the PSTR model, which is effective in addressing the issue of heterogeneity. In addition, the PSTR model has the advantage of solving cross-sectional heterogeneity and time instability problems (Wang et al. 2017). We therefore conclude that it is not compulsory to differentiate data series when using the PSTR method; hence, variables are entered in their level form during the estimation method. The next section presents the results of the model estimation.

4.2. Testing for the Appropriate Transition Variable in the PSTR Model

We employed the LM-type test to identify the appropriate transition variable among the set of regressor variables (government debt, government expenditure, gross fixed capital formation, employment in industry, and employment in services) as candidates (Gonzalez et al. 2017)[5]. Table 4 presents LM-type tests of homogeneity in the panel regression of government debt on economic growth. The homogeneity test results show the marginal effect through the transition from a low-debt regime to a high-debt regime, with a common structure for all the countries.

Table 4. Results of selecting the transition variable.

Transition Variable: $GD_{i,\,t-1}$						
	LM_X		**LM_F**		**WB**	**WCB**
M	**Test**	***p*-Value**	**Test**	***p*-Value**	***p*-Value**	***p*-Value**
1	199.7	0	35.35	0	0	0
2	210.3	0	36.81	0	0	0
3	200.3	0	34.46	0	0	0

Source: Authors' calculation, based on WDI (2020) data.

The LM-type test based on the asymptotic χ^2 distributions and the F versions of the LM-type test signify that government debt is the most appropriate choice of transition variable for this study due to the *p*-values, which are smaller than all other sets of variables included as candidates. The next section reports the linearity results.

4.3. Linearity Test

One of the aims of this study was to find nonlinearity between government debt and economic growth. Therefore, in a bid to find nonlinearity, we estimated the linearity test as explained in the methodology Section 3.1. Table 5 presents the results of the linearity test which was conducted through the LM-test. The results showed that the null hypothesis of linearity was rejected, thus confirming the existence of nonlinearity between government debt and economic growth in African developing countries.

Table 5. Results of the linearity(homogeneity) test.

	LM_X		LM_F		WB	WCB
M	**Test**	***p*-Value**	**Test**	***p*-Value**	***p*-Value**	***p*-Value**
1	199.7	0	35.35	0	0	0

Note(s): H_0: linear model, H_1: PSTR model with at least one threshold.

Table 4 presents the results of selecting the appropriate transition variable. The test statistics values of LM_X and LM_F are 199.7 and 35.51, respectively, with their corresponding *p*-values of 0 and 0. Furthermore, the results were supported by the WB and WCB. These results are empirically and theoretically plausible (see Minea and Patric 2009; Caner et al. 2010). Subsequently, the result of the order m of the transition variable is reported. The next section reports the results of the sequence of the order m of the transition variable $GD_{i,\ t-1}$.

4.4. Model Evaluation

Evaluating the estimated PSTR model is another crucial step. Different types of misspecification test were employed for different reasons: (a) to test for parameter constancy over time, where the LM-type test is employed; (b) to show no remaining nonlinearity or heterogeneity (Eitrheim and Terasvirta 1996); and (c) using the WB and WCB validates the selected number of regimes in the model. For parameter constancy and no remaining nonlinearity, the *p*-value must be 0–1 (Zungu and Greyling 2022). Table 6 reports the results of the model evaluation. The findings of the LM type test under the LM_X *p*-value for parameter constancy reveal that the parameters are constant. The *p*-values (0.00 and 0.00) of the LM_X and LM_f signify the rejection of the null hypothesis of parameter constancy. The results are theoretically and empirically plausible (see Zungu and Greyling 2022; Ndoricimpa 2020; Makhoba et al. 2022). The *p*-values of the WB and WCB imply the rejection of the null hypothesis, while confirming that the estimated model with two regimes is appropriate for Africa's developing countries. The WB and WCB tests that take both heteroskedasticity and possible within-cluster dependence into consideration suggest that the estimated model with one transition is adequate.

Table 6. Parameter constancy and no remaining nonlinearity test.

	LM_X		LM_F		HAC_X		HAC_F	
M	**Test**	***p*-Value**	**Test**	***p*-Value**	**Test**	***p*-Value**	**Test**	***p*-Value**
1	37.43	0.00	3.22	0.00	11.36	0.321	0.98	0.46
WB and WCB No Remaining Nonlinearity (Heterogeneity) Test								
M	**WB *p*-Value**				**WCB *p*-Value**			
1	1				1			

Note(s): Ho: linear model: H1: model with at least one threshold.

4.5. Interpretation of the PSTR Model Results

The results suggest that the government debt is (60.5% of GDP), above which government debt diminishes economic growth in Africa's developing economies. Likewise, the estimated slope parameter (18.11) supports the smoothness of government debt from the low to the high regime. Moreover, the results show that there is an inverted U-shape relationship between government debt and economic growth for the selected African countries. These results are statistically significant and theoretically consistent with the debt Laffer curve. On the empirical level, the results are consistent with the range (62–66%) of the threshold reported by Ndoricimpa (2020) in the panel of middle-income and labor-intensive countries; they reported a debt threshold of 62–66% on a sample of 101 emerging and advanced economies. Caner et al. (2010) established a threshold of 77% of GDP for advanced countries, while for the emerging countries, the government debt threshold was (64% of GDP). The results showed that additional government debt beyond the estimated threshold reduces economic growth.

We further graphically demonstrated the variation of the 12 African developing economies between the estimated threshold and the calculated mean of government debt[6]. This enables us to understand which of the selected African countries are in the low debt regime (Below 60.5% of GDP) and which of these counties are in the high debt regime (any point above the threshold). Cote d' Ivoire and South Africa appeared to have debt levels that are above the estimated threshold (88.34 and 66% of GDP, respectively). The rest of the African countries' debt compositions fall under the low regime.

Moreover, in the low debt regime, the slope coefficient of government debt emerges with a statistically significant positive sign. This could mean that the funds that have been sourced in the form of debt have been directed to profitable public spending (Stafania 2014). The debt Laffer curve assumes a negative correlation between debt and growth. However, according to this theory, there is a peak point at which debt and growth converge to have a positive relationship, and vice versa (Sachs 2002). The results align with and substantiate this theory.

Table 7 presents the estimated results of the two-regime PSTR model, where the standard errors in brackets were attained using the cluster-robust and heteroskedasticity-consistent covariance estimator, permitting error dependency among individual countries. Government expenditure (GE) has a statistically significant impact on both regimes, showing that government expenditure in the lower regime enhances economic growth. Conversely, economic growth is reduced if government expenditure is high. The findings further reveal that, during the phase where government expenditure reduces growth, the impact factor is high (−9.42%). This shows that once government spending exceeds a certain point, it will yield a considerably negative effect on the economy. This finding is theoretically plausible and supported by Barro and Sala-i-Martin (1997), who point out that excessive government expenditure drains the most efficient investments by the private sector and impedes growth. This result is consistent with a variety of literature on economics, such as (see Perlo-Freeman and Webber 2009; Kremer et al. 2013; Seleteng et al. 2013; Ndoricimpa 2020; Makhoba et al. 2022). These studies suggested that increasing government expenditure increases growth, up to a certain peak point. Once the growth has reached its peak, the marginal productivity of private sector spending is equivalent to the marginal productivity of public spending.

Table 7. Panel smooth transition regression model estimation.

Dependent Variable: GDP (y)		
Explanatory variables	Low regime $\beta_{0j} \times 100$	High regime $(\beta_{0j} + \beta_{1j}) \times 100$
Government debt $(GD_{i,\ t-1})$	4.64 *** (1.22)	−1.05 ** (3.69)
Government expenditure $(GE_{i,\ t-1})$	4.12 ** (1.18)	−9.42 ** (3.19)
Gross fixed capital formation $(GFCF_{i,\ t-1})$	1.64 *** (5.67)	3.82 ** (1.62)
Employment in industry $(EMI_{i,\ t-1})$	1.72 *** (4,65	3.94 *** (1.56)
Employment in service $(EMI_{i,\ t-1})$	1.81 *** (3.39)	−4.18 ** (1.42)
Transition parameters		
Threshold		60.5 *** (0.02)
Slope		18.11 ** (4.22)
No. of Obs		360
No. of countries		12

Note(s): The ***/** signify the level of significance at 1 and 5%, respectively.

Various factors may cause government debt to hamper economic growth. These include high debt services, inefficient allocation of government expenditure, interest rates on loans, and exchange rate fluctuation (Agénor and Aizenman 2005). Moreover, gross fixed capital formation (GFCF) has a statistically significant and positive impact in both regimes. This perhaps may indicate that the government spending is appropriately allocated towards activities such as infrastructural investments, investing in technology and educational spending. This is in accordance with other debt–growth empirical literature (see Thanh 2015; Mijiyawa 2013), which also found that gross fixed capital formation has a significant and positive effect on growth. The control variables of employment in industry and in the services sector indicate that in the low debt regime, an increase in employment induces economic growth. This finding is plausible, as employment growth is expected to correlate with output growth. However, when transitioning to the high regime, employment in services values suggest that an increase in employment in services contracts economic growth by −4.18. This result is startling because as the number of people employed increases, a corresponding growth in output level would be expected. However, this result may be attributed to the policy choices adopted by the government. These choices include preference for high-wage labour (hence high marginal product) over low-wage unskilled or semi-skilled workers. Consequently, this means that the additional labour force is not very productive, and may cause a reduction in average productivity (Makhoba et al. 2022).

4.6. Robustness Check and Sensitivity Results

For robustness checks, we employed central government debt as a measure of debt, following the method adopted by Egert (2015). The results show that the effect of government debt on economic growth is indeed nonlinear in Africa's developing countries, regardless of whether it is general government debt or central government debt. The variables utilized in this section have the same definition as those defined in the baseline model. The results of the robustness and sensitivity analysis are reported in Table 8 for the PSTR model. Additionally, all the testing procedures for these models were followed as per Gonzalez et al.'s (2017) study[7].

Table 8. Central government debt and economic growth; robustness check model.

Dependent Variable: GDP (y)		
Explanatory variables	Low regime $\beta_{0j} \times 100$	High regime $(\beta_{0j} + \beta_{1j}) \times 100$
Central government debt $(CGD_{i,\,t-1})$	7.17 *** (3.73)	−3.05 ** (3.22)
Government expenditure $(GE_{i,\,t-1})$	8.03 ** (2.61)	−5.14 ** (1.40)
Gross fixed capital formation $(GFCF_{i,\,t-1})$	6.91 *** (3.67)	6.86 ** (0.16)
Employment in industry $(EMI_{i,\,t-1})$	2.37 *** (1.14)	1.58 *** (2.23)
Employment in service $(EMS_{i,\,t-1})$	−9.07 *** (0.53)	3.00 ** (0.53)
Transition Parameters		
Threshold		59.05 *** (0.09)
Slope		16.54 ** (0.03)
No. of Obs		360
No. of countries		12

Notes: ***/** denote the level of significance at 1% and 5%, respectively. **Source:** Authors' calculation, based on IMF (2018) data.

The authors checked the sensitivity of the findings in the baseline model by using the central government debt. This would help strengthen the findings reported in the baseline model about whether they are sensitive to variables included in the system as control variables. Estimation results demonstrate that the nonlinear effect of government debt on economic growth is not too sensitive to the variable included in the system as a control variable, or to the variable used to measure debt. Indeed, the findings are similar to those derived in the first model.

5. Recommendation and Conclusions

This study aimed to test the validity of the debt Laffer curve theory in African developing economies over the years 1991–2020. Furthermore, we explored the existence of nonlinearity between government debt and economic growth within African developing economies. This helps us to understand the level at which government debt is harmful to the economy, notwithstanding that it has been historically used as an instrument to keep the economy running.

The empirical findings of this study are that the existence of nonlinearity between government debt and economic growth in Africa's developing countries is consistent with empirical findings reported by Ndoricimpa (2020) for emerging and middle-income countries. The threshold for the selected countries is 60.5% of the GDP. Thus, our findings confirm the validity of the debt Laffer curve in Africa's developing economies, showing that when the level of government debt is low, economic growth is positively related to debt, but the relationship becomes negative as debt surpasses the optimum point.

After we established the nonlinear relationship between government debt and economic growth, this study proposed that the affected governments should respond robustly to economic shocks and debt crises, ensure the protection of jobs and spend on profitable investments. Furthermore, government should also learn from debt crises and correct structural weaknesses in the economy; this may include improving investment and developing skills. Additionally, in crisis times, having a low debt to GDP ratio could be advantageous, thus helping to reduce the impact of resultant shocks. Lastly, having a sound social security safety net that can reduce the burden of economic pressure on citizens during a crisis is essential to economic and social stability.

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Notes

1. This study used employment in industry (EMI) and employment in services (EMS) to capture employment.
2. The selection of these African developing countries is based on the availability of data.
3. The equations used in the study are based on Eitrheim and Terasvirta (1996) and Gonzalez et al. (2005; 2017).
4. Gonzalez et al. (2017) consider that it is sufficient to consider m = 1 or m = 2, as these values allow for commonly encountered types of variation in the parameters.
5. All the estimations are performed using the "PSTR" package available in R-software.
6. The graph that shows these results is not shown this paper due to space consideration. The graph is available upon request.
7. The table analyses for linearity results and appropriate transition variables are not reported in this study for space consideration, but are available upon request.

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