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# Public debt and economic growth in the West African monetary zone (WAMZ)

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## ABSTRACT

In this paper, we revisit the relationship between public debt and economic growth with a spotlight on the West African Monetary Zone (WAMZ). In the re-examination, we pursue three undertakings using both panel data and time series modelling techniques. First, we examine the linear relationship using the Autoregressive Distributed Lag (ARDL) model for time-series data and the fixed (or random) effect model for the panel data counterpart. Second, we assess the nonlinear relationship by incorporating the squared term of the debt variable as an additional explanatory variable in the models. Third, we identify the level of public debt/GDP ratio beyond which public debt becomes unsustainable using threshold regression techniques. The findings show a negative relationship across the linear models. We also establish that the debt-economic growth relationship is non-linear, and we obtain the points of inflection for the WAMZ countries. These levels are 71.9 % for Gambia, 55.8 % for Ghana, 91.5 % for Guinea, 83.7 % for Liberia, 38.45 % for Nigeria and 38.6 % for Sierra Leone. We make suggestions for the WAMZ countries to expand their economic bases by channelling funds to infrastructure development and the development of human capital in order to optimize the benefits of debt accumulation in the long run.

## Introduction

This study revisits the public debt and economic growth nexus with a focus on selected countries in the West African Monetary Zone (WAMZ)<sup>1</sup> in the West African sub-region. The study is relevant across many countries due to the rapid increase in public debt in many economies (both developed and developing) over the years, with debates about its likely impact on the macroeconomy, particularly on long-term economic growth (see [7,18,39,42,48,61]). Amongst the key arguments for public borrowing is the need for governments to bridge the resource gap to stimulate economic activities, particularly in developing and emerging economies. Nonetheless, the IMF [41] acknowledges that a moderate level of public debt, if used appropriately, is necessary to raise living standards in low-income countries; if debt levels are too high (or if mismanaged), it could be detrimental to growth, as well as other macroeconomic objectives. A question then remains: What level of debt is moderate to stimulate growth?

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<sup>1</sup> The WAMZ was established in 2000 with a Treaty adopted in 1999 by the Authority of Heads of State and Government of the Economic Community of West African States (ECOWAS) at its Summit in Togo. The major objective of the Treaty was the creation of a second monetary zone to fast track economic and monetary integration in West Africa. The WAMZ is expected to merge with the West African Economic and Monetary Union (WAEMU), to fast track the creation of a single ECOWAS monetary union.

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Theoretically, macroeconomics literature documents the relationship between public debt and economic growth, where debt accumulation could either engender or slow down economic growth. The latter occurs usually through the crowding-out of the private sector, higher inflation, and vulnerability to crisis, amongst others. The neoclassical model believes the crowding-out effect happens when government borrowing drives up interest rates, leading subsequently to reduced private investment. This also explains a situation when the country experiences debt over-hang; a situation when the country's debt burden is so heavy that a large portion of the current output accrues to foreign lenders (see [2,28,34,47,63]). The former may, however, be attributed to the Keynesians with the view that public borrowing is growth stimulating through the accelerator principle and the multiplier effect. This also explains a situation when public borrowing aids economic growth at sustainable levels when the economy is able to fulfil its present and upcoming servicing obligations without any rescheduling or accumulation of accruals (see [15,16,54]).

Reconciling the opposing perspectives on debt-growth nexus and to objectively answer the research question posed above, a new school of thought has emerged to emphasise the threshold level of debt necessary to promote economic growth, beyond which, additional debt becomes a burden to growth. Nonetheless, this line of thought is yet to be fully explored in the literature. Consequently, this study adds to the body of knowledge regarding the possibility of non-linearity in the debt-growth nexus, particularly for the WAMZ which has hitherto received little or no attention. Essentially, empirical studies on other countries/regions have mostly found the manifestation of an inverted U-shaped curve with a turning point beyond which increases in public debt impact growth negatively,<sup>2</sup> hence we have a foundation to pursue this motivation.

The motivation to further understand the debt dynamics in the WAMZ is important for several reasons. The WAMZ, which comprises The Gambia, Ghana, Guinea, Liberia, Nigeria, and Sierra Leone, provides an important case study. First, for the creation of monetary unions, long-term fiscal sustainability is critical for all the countries, as spill-over effects could spread the negative consequences from one member country to another (or others). Protracted fiscal imbalances could generate negative externalities on the whole monetary union, usually through increases in real interest rates, exchange rate misalignments, and reduction in public investment, amongst others, with resultant deterioration of growth potentials for the region. Second, the accumulation of huge and unsustainable debts could cause debt overhangs, which could undermine the ability of central banks to stabilize prices in member countries. Third, while external financing of fiscal deficits may mount excessive pressure on the exchange rate, leading to its depreciation, domestic financing could crowd out private investment, thereby hampering growth prospects. Thus, maintaining fiscal sustainability is a sine qua non for the establishment of monetary unions. Unsustainable fiscal policies may hinder the achievement and sustainability of the convergence criteria for the WAMZ, and consequently slow economic growth and monetary integration.

Given the foregoing, the study explores three research objectives, which form its contribution to the literature on debt-growth nexus. First, it examines the linear relationship between public debt and economic growth in the WAMZ countries. Second, it assesses the nonlinear relationship, and third, it determines the threshold level where public debt becomes unsustainable in the WAMZ countries. Following the introduction, the rest of the paper is structured as follows. Section 2 details the modelling frameworks and data issues. Section 3 explores the preliminary results including descriptive statistics and various pre-tests. Section 4 discusses the main results of the three objectives of the study. Section 5 completes the study with a conclusion and policy recommendations.

### Some theoretical and empirical issues on debt-growth nexus

Issues around the debt-growth relationship have a strong footing in the theoretical literature, albeit two conflicting arguments stand out in this regard. First is the conventional – Keynesians – position, which holds that a high public debt profile is necessary to stimulate aggregate income and demand and, by extension, aggregate output growth (see [25]). It is in this regard that Kassouri et al. [45] opine that this positive nexus is only significant in the short-run when countries are in their early stages of economic development and possess little amount of capital stock. Conversely, the liquidity constraint and debt overhang hypotheses – of the new-classicalists – hold that public debt influences economic growth negatively. Liquidity constraint hypothesis on the one hand posits that public debt limits the amount of funds available to businesses by raising the cost of borrowing [17,38] and thereby hampers economic growth through channels like low employment which would translate to low income, and ultimately, reduction in aggregate demand which is necessary to boost economic growth. On the other hand, the debt overhang hypothesis argues that government borrowing is tantamount to imposing a tax on future output, thus capable of crowding out investment and causing delays in economic growth [47]. Moreover, Reinhart and Rogoff [61] argue in favour of the non-linear effects of debt on growth, stating that a low level of debt can promote growth while a high level of debt is disastrous to economic growth. Hence, in the initial stages of development, borrowing is encouraged to aid productive investments. Debt accumulation, on the other hand, operates as a tax on future productivity in the long run, thus inhibiting productive private-sector investment plans and government adjustment attempts. In this sense, there is the likelihood of an inverted U-shaped relationship between debt and growth, implying that higher debt levels are associated with lower long-run growth performance [24]. Meanwhile, reasons have been alluded to these heterogeneous relationships between debt and growth (see [45]). Furthermore, a new framework on public debt proposed by Gosh et al. [32] conceptualizes 'fiscal space', which is the difference between a country's current debt level and its debt limit.<sup>3</sup> Here, an improvement in a country's structural characteristics or economic growth rate raises the debt limit, and therefore, an improvement in the performance of an economy propels public borrowing.

Overall, these theories have been tested and validated by a plethora of empirical studies (see, for example, [12,32,45,49,53];

<sup>2</sup> See for example: [7,15,18,20,26,44,54–57,67,70,73].

<sup>3</sup> Debt limit is the level of debt beyond which fiscal solvency – ability to meet long term debt obligation – fails.

amongst others). In essence, [56] find empirical evidence supporting a reversed U-shape relationship between public debt types: total public debt as a percentage of GDP, external debt, and internal debt, and economic growth in Nigeria. While a threshold level of 73.70 per cent is estimated for total public debt as percentage of GDP, 49.4 and 30.9 per cent are respectively estimated for external and internal debts. Comparatively, a review of the country's external debt profile and total debt levels revealed that the estimated threshold levels were exceeded before the debt forgiveness negotiated in 2005 and substantially within limits later. Moreover, employing a panel threshold analysis to determine debt limit for a number of emerging economies, Tran [70], demonstrates that non-Latin American economies are deemed sustainable in the short run as long as their debt stays below the threshold bounds of 40–55 % of GDP. However, the author cautions that a persistent increasing trend in debt trajectories could potentially signal long-term sustainability risk.

Akin to the above, Karadam [44] adopts a Panel Smooth Transition Regression framework to examine how debt affects growth in both industrialized and developing countries. The analysis demonstrates that, depending on the level of indebtedness, the effect of public debt on growth smoothly shifts from positive to negative. Additionally, the findings suggest that developing countries have a lower debt threshold than advanced ones. Similarly, for large levels of indebtedness, the negative effects of public long-term and short-term external debt on growth are more noticeable and severe. While the debate lingers, Egert [26] shows that a negative nonlinear relationship between the public debt-to-GDP ratio and economic growth is extremely difficult and sensitive to modelling choices and data coverage. Meanwhile, different threshold levels of debts have been estimated for various economies/regions, depending on the concerned country/region's debt structure (see [45,49,53]).

Considering the aforementioned distinct characteristics of the WAMZ (refer to Section1), we find it puzzling that little or no previous studies have looked at the threshold effect of these economies' public debt on their respective growth, hence, we opt to contribute to the growing body of literature that addresses non-linearity in the debt-growth relationship within the context of the WAMZ.

## Modelling and data issues

This study relies on a variety of econometric techniques to achieve the three stated objectives. The first set of techniques, which are directed at achieving objective one, are the Autoregressive Distributed Lag model for time series analyses and fixed (or random) effect models for panel data analyses. The Hausman test statistic assists in the decision between the fixed and random effect models. The second set is the nonlinear forms of the Autoregressive Distributed Lag model for time series analysis and fixed (or random) effect models for panel data analysis, which incorporate the squared term of the major explanatory variable (debt-to-GDP ratio) variable. The third complements the second by determining the point of inflection where the debt ratio is sustainable. The threshold regression techniques are used to evaluate the third objective, which helps to identify the public debt/GDP threshold for the WAMZ countries.

### Linear relationships

In order to analyse the impact of the debt-to-GDP ratio on economic growth in the WAMZ countries, we adopt a linear model. We specify the linear relationship (time series and panel forms) in line with Karadam [44]:

$$Growth_t = \alpha + \beta debt_t + \delta' z_t + \varepsilon_t \quad (1)$$

$$Growth_{it} = \alpha_i + \beta debt_{it} + \delta' z_{it} + \varepsilon_{it}; i = 1, 2, \dots, N; t = 1, 2, \dots, T. \quad (2)$$

where  $Growth_{it}$  is the growth rate of real gross domestic product,  $debt_{it}$  is the public debt expressed as a ratio of GDP;  $z_{it}$  captures the control variables relevant in the nexus, including trade openness (total trade as a ratio of GDP) ( $Openness_{it}$ ), gross fixed capital formation as a ratio of GDP ( $investment_{it}$ ), growth rate of labour ( $Population_{it}$ ) and inflation ( $Inflation_{it}$ );  $\alpha_{it}$  is the fixed effects which captures the differences between the WAMZ countries; while  $\varepsilon_{it}$  is the disturbance term.

Eq. [2] is a typical fixed effect model. In the case of a random effect model, the error term,  $\varepsilon_{it}$  has two components:  $\varepsilon_{it} = e_i + \zeta_{it}$ ; where the addition of the time-invariant (random) effect,  $e_i$  is to differentiate it from the fixed effect model.

We specify the Eq. [1] model in Autoregressive Distributed Lag form (based on the Pesaran and Smith [60]) to, amongst others capture the possible unit root problem in the series, the endogeneity bias due to the introduction of the lagged term in the right-hand side of the equation, and short-run and long-run dynamics, as follows:

$$\Delta Growth_t = \alpha + \theta(Growth_{t-1} - \beta_0 - \beta_1 debt_{t-1} - \delta'_0 z_{t-1}) + \delta_1 \Delta Growth_{t-1} + \delta_2 \Delta debt_{t-1} + \delta'_1 \Delta z_{t-1} + \varepsilon_t \quad (3)$$

where  $\Delta$  is the first difference operator indicating that the variable attached is captured over the short-run, hence  $\beta_1$  and  $\delta'_0$  measure the short run relationships;  $\theta$  is the coefficient of error correction which indicates long-run equilibrium or the correction of short-run deviations towards equilibrium.

Before we repose trust in the findings, we conduct relevant diagnostics tests on the disturbance term,  $\varepsilon_t$ . The relevant diagnostics help to show that the error term behaves well and that the results can be trusted for policy decisions. We explore two residual diagnostics tests: the LM test for conditional heteroscedasticity (see [29]) and the Breusch-Godfrey Serial Correlation LM test (see [10, 33]).

The LM test equation for serial correlation is based on AR(p) process for the residuals:

$$\widehat{\varepsilon}_t = \alpha_0 + \alpha_1 \widehat{\varepsilon}_{t-1} + \alpha_2 \widehat{\varepsilon}_{t-2} + \dots + \alpha_p \widehat{\varepsilon}_{t-p} + u_t \tag{4}$$

The null hypothesis of no serial correlation:  $H_0 : \alpha_1 = \alpha_2 = \dots = \alpha_p = 0$  is tested against the alternative:  $H_0 : \alpha_1 \neq \alpha_2 \neq \dots \neq \alpha_p \neq 0$  such that failure to reject the null hypothesis implies the absence of serial correlation of the residuals of any order up to  $p$ .

The test equation for conditional heteroscedasticity (ARCH effect) regresses the squared residuals on its lagged term plus a constant:

$$\widehat{\varepsilon}_t^2 = a_0 + a_1 \widehat{\varepsilon}_{t-1}^2 + a_2 \widehat{\varepsilon}_{t-2}^2 + \dots + a_p \widehat{\varepsilon}_{t-p}^2 + e_t \tag{5}$$

The null hypothesis of no ARCH effect:  $H_0 : a_1 = a_2 = \dots = a_p = 0$  is tested against the alternative:  $H_0 : a_1 \neq a_2 \neq \dots \neq a_p \neq 0$  with failure to reject the null hypothesis implying the absence of ARCH effect, in which case there is no problem of heteroscedasticity.

*Non-linear relationships*

We specify the nonlinear relationship by introducing the squared term of the debt-to-GDP ratio in Equations [1] and [2] respectively as follows:

$$Growth_t = \alpha + \beta_1 debt_t + \beta_2 debt_t^2 + \vartheta' z_t + \varepsilon_t \tag{6}$$

$$Growth_{it} = \alpha_i + \beta_1 debt_{it} + \beta_2 debt_{it}^2 + \vartheta' z_{it} + \varepsilon_{it}; i = 1, 2, \dots, N; t = 1, 2, \dots, T \tag{7}$$

where  $Growth_{it}$  is the growth rate of real gross domestic product,  $debt_{it}$  is the public debt expressed as a ratio of GDP;  $z_{it}$  captures the control variables relevant in the nexus including trade openness (total trade as a ratio of GDP), gross fixed capital formation as a ratio of GDP, growth rate of labour and inflation;  $\alpha_{it}$  is the fixed effects which captures the differences between the WAMZ countries; while  $\varepsilon_{it}$  is the disturbance term.

We specify the Eq. [6] model in Autoregressive Distributed Lag form (based on the Pesaran and Smith [60]) to amongst others capture the possible unit root problem in the series, the endogeneity bias due to the introduction of lagged term in the right hand side of the equation, and short run and long run dynamics, as follows:

$$\begin{aligned} \Delta Growth_t &= \alpha + \theta(Growth_{t-1} - \beta_0 - \beta_1 debt_{t-1} - \beta_2 debt_{t-1}^2 - \vartheta' z_{t-1}) + \\ \delta_1 \Delta Growth_{t-1} &+ \delta_2 \Delta debt_{t-1} + \delta_3 \Delta debt_{t-1}^2 + \vartheta' \Delta z_{t-1} + \varepsilon_t \end{aligned} \tag{8}$$

where  $\Delta$  is the first difference operator indicating that the variable attached is captured over short run, hence  $\beta_1, \beta_2$  and  $\vartheta_0$  measure the short run relationships; amongst the variables and  $\theta$  is the coefficient of error correction which indicates long run equilibrium or the correction of short run deviations towards equilibrium.

The modelling approach helps to explore the possibility that the relationship is non-monotonous, that is, the incidence of a certain (threshold) point where the nexus changes in sign. As employed in this study, Samargandi et al. [65] has established the use of quadratic (squared) term of the regressor (proxy for financial development) in a Panel ARDL model to explore the nonlinear relationship between financial development and economic growth (see also, [3]).

*The threshold regression model*

In other to build on the second objective of the study, we attempt to determine the threshold level of public debt at which the debt profile becomes unsustainable; that is, when public debt begins to impact negatively on economic growth in the WAMZ member countries. This is based on the threshold regression proposed in Hansen [35,36], further extended in Caner and Hansen [13], and further developed into computable Stata framework in Wang [71] for panel data analysis (see also, [64]). The Panel Threshold regression allows us to determine the point of inflection (the threshold) which divides the observation into data regimes; below or above the threshold level.

Standing on the previous specifications which identifies debt-GDP ratio as the main regressor in the predictive model for GDP growth rate, we specify the threshold model (time series and panel forms) based on the foregoing discussions as follows:

$$Growth_t = \alpha + \beta_1 debt_t(q_t < \lambda) + \beta_2 debt_t(q_t \geq \lambda) + z_t' \varpi + \xi_t \tag{9}$$

$$Growth_{it} = \alpha_i + \beta_1 debt_{it}(q_{it} < \lambda) + \beta_2 debt_{it}(q_{it} \geq \lambda) + z_{it}' \varpi + \xi_{it} \tag{10}$$

where the variables are as previously defined,  $\alpha_i = \alpha$  is the common intercept,  $z_{it}$  is the vector of other secondary regressors,  $q_{it}$  is the variable being assessed for threshold,  $\lambda$  is the threshold (value) parameter above which debt may be expected to become unsustainable (highlighted at  $\widehat{\beta}_2$ ) and  $\widehat{\beta}_1$  during which debt should still expedite economic growth.

Eqs. (9) and (10) define a single threshold model where the data is divided into two regimes by  $\widehat{\beta}_1$  and  $\widehat{\beta}_2$ . We further specify a double threshold model where the data is divided into three regimes in Eq. (11) as follows:

$$Growth_{it} = \alpha_i + \beta_1 debt_{it}(q_{it} < \lambda_1) + \beta_2 debt_{it}(\lambda_1 \leq q_{it} < \lambda_2) + \beta_3 debt_{it}(q_{it} \geq \lambda_1) + z_{it}\varpi + \xi_{it} \tag{11}$$

The threshold value(s) ( $\lambda$ 's) are determined using the least square approach, computed as:

$$\widehat{\lambda} = argmin_{\lambda} SSE_{thr}(\lambda) \tag{12}$$

A bootstrap procedure is used to obtain approximate critical value of the test statistics which allows one to perform the hypothesis test for the threshold effect. A test for threshold effect is conducted with a likelihood ratio (F) obtained from bootstrap procedure as follows:

$$F = \frac{SSE_{in} - SSE_{thr}(\widehat{\lambda})}{\widehat{\sigma}^2} = \frac{SSE_{in} - SSE_{thr}(\widehat{\lambda})}{SSE_{thr}(\widehat{\lambda})/nT} \tag{13}$$

where  $SSE_{in}$  and  $SSE_{thr}$  are the error sum of squares of the linear and threshold models respectively. The procedure tests the null of no threshold effect for which rejection supports fitting the threshold regressions.

*Unit root and Cointegration tests*

The study explores different panel data unit root tests with diverse features and null statements, namely, Harris-Tzavalis test, Breitung test, Levin-Lin-Chu test and Im-Pesaran-Shin test. The Harris and Tzavalis [37] test report the rho ( $\rho$ ) statistic. We report the lambda ( $\lambda$ ) statistics for the Breitung [9] test, the Adjusted t\* statistics for the Levin et al. [50] test, and t-bar statistics for the Im et al. [40] test. The underlying test equation for these tests is stated as follows:

$$y_{it} = \lambda_i y_{i,t-1} + \gamma_i + \epsilon_{it} \tag{14}$$

$$\Delta y_{it} = \rho_i y_{i,t-1} + \gamma_i + \epsilon_{it} \tag{15}$$

where  $y_{it}$  is the series being examined for unit root,  $\gamma_i$  represents the fixed effect. The Harris-Tzavalis, Breitung, and Levin-Lin-Chu tests assume that the autoregressive parameter is the same across the units (countries), that is,  $\lambda_i = \lambda; \forall i$ . Contrarily, the Im-Pesaran-Shin test relaxes the restriction and considers the rate of convergence to differ across the countries in the panel ( $\lambda_i \neq \lambda$  for all  $i$ ). In addition, the Levin-Lin-Chu test includes dynamics (serial correlation to the test equation as stated below:

$$\Delta y_{it} = \rho_i y_{i,t-1} + \gamma_i + \sum_{j=1}^q \theta_{ij} \Delta y_{i,t-1} + \epsilon_{it} \tag{16}$$

The foregoing test the null that the series contain unit root [ $H_0 : \lambda_i = 1$  or  $\rho_i = 0$  for all  $i$ ] against the alternative [ $H_1 : \lambda_i < 1$  or  $\rho_i < 0$  for all  $i$ ].

The time series unit root test relies on the Augmented Dickey Fuller test equation with and without the inclusion of structural breaks as follows:

$$\Delta y_t = \rho y_{t-1} + \sum_{j=1}^q \theta_j \Delta y_{t-1} + \epsilon_t \tag{17}$$

$$\Delta y_t = \rho y_{t-1} + \sum_{j=1}^q \theta_j \Delta y_{t-1} + \sum_{k=1}^5 \delta_k D_{k,t} + \epsilon_t \tag{18}$$

where  $y_t$  is the series being explored for unit root;  $D_k$  represent the breaks such that  $D_k = 1$  for  $t \geq$  break date, zero otherwise. Up to five (5) breaks are allowed in the test equation.

For the Cointegration analyses, we also explore the time series and panel Cointegration frameworks. The time series Cointegration is based on the Autoregressive Distributed Lag models (the linear and non-linear models). In the models, the behaviour of the error correction terms ( $\theta$ ) which is shown to be negative, statistically significant and less than 1 in absolute value indicate long run relationship. Formally however, we adopt the Bounds test approach to demonstrate the Cointegration more scientifically based on the Pesaran et al. [59] lower and upper bounds statistics.

The panel Cointegration is based on the use of Kao [43], Pedroni [58], and Westerlund [72] Cointegration tests can be employed to show that the error term is well behaved (that is, stationary, in which case the variables are adjudged stationary at level).

The Cointegration tests sets out from a simple regression model:

$$y_{it} = x_{it}'\beta_i + \gamma_i + \epsilon_{it} \tag{19}$$

where  $y_{it}$  is the dependent variable (real GDP growth rate),  $x_{it}$  are the covariates (debt and other intervening variables). To test whether

$y_{it}$  and the covariates are cointegrated, we obtain the residual and run ADF-type regression as follows:

$$\Delta \hat{\varepsilon}_{it} = \rho_i \hat{\varepsilon}_{i,t-1} + \gamma_i + \sum_{j=1}^q \vartheta_{ij} \Delta \hat{\varepsilon}_{i,t-1} + v_{it} \tag{20}$$

The null of no cointegration is specified as:  $H_0 : \rho_i = 0$  for all  $i$  against the alternative hypothesis:  $H_1 : \rho_i < 0$  for all  $i$ . These are captured in Kao and Pedroni ADF statistics and variance ratio for Westerlund test.

Data issues

The study uses annual data spanning 2000 to 2019 across each of the countries in the sample to make a panel (longitudinal) data structure. The entire sample entails a panel of the six (6) countries in the WAMZ region. As such, the study represents twenty (20) observations for Gambia, Ghana, Guinea, Liberia, Nigeria, and Sierra Leone, each. The study uses the real GDP growth rate (*Growth*) to represent economic growth, which functions as the dependent variable in the estimable models. Other variables include: The gross fixed capital formation (investment), the degree of trade openness, growth rate of labour, and the rate of inflation. Studies have shown that these ('other' or control) variables have the tendency to influence the debt-growth relationship, hence we control for them in our analysis to prevent omitted variable bias. The data for the study were obtained from the World Bank, the West African Monetary Institute (WAMI), and the West African Monetary Agency (WAMA) databases.

The study further complements with time series frameworks after having disaggregated the data to quarterly frequency to allow for enough observations for time series techniques. The study adopts the Chow-Lin approach (see [19]) to disaggregate the data. There are various scientific approaches to conduct the temporal disaggregation including Denton [22], Fernandez [30], Litterman [52], and Dagnum & Cholette [21] techniques for data interpolation. Sax and Steiner [66] documents these techniques in details. We adopt the

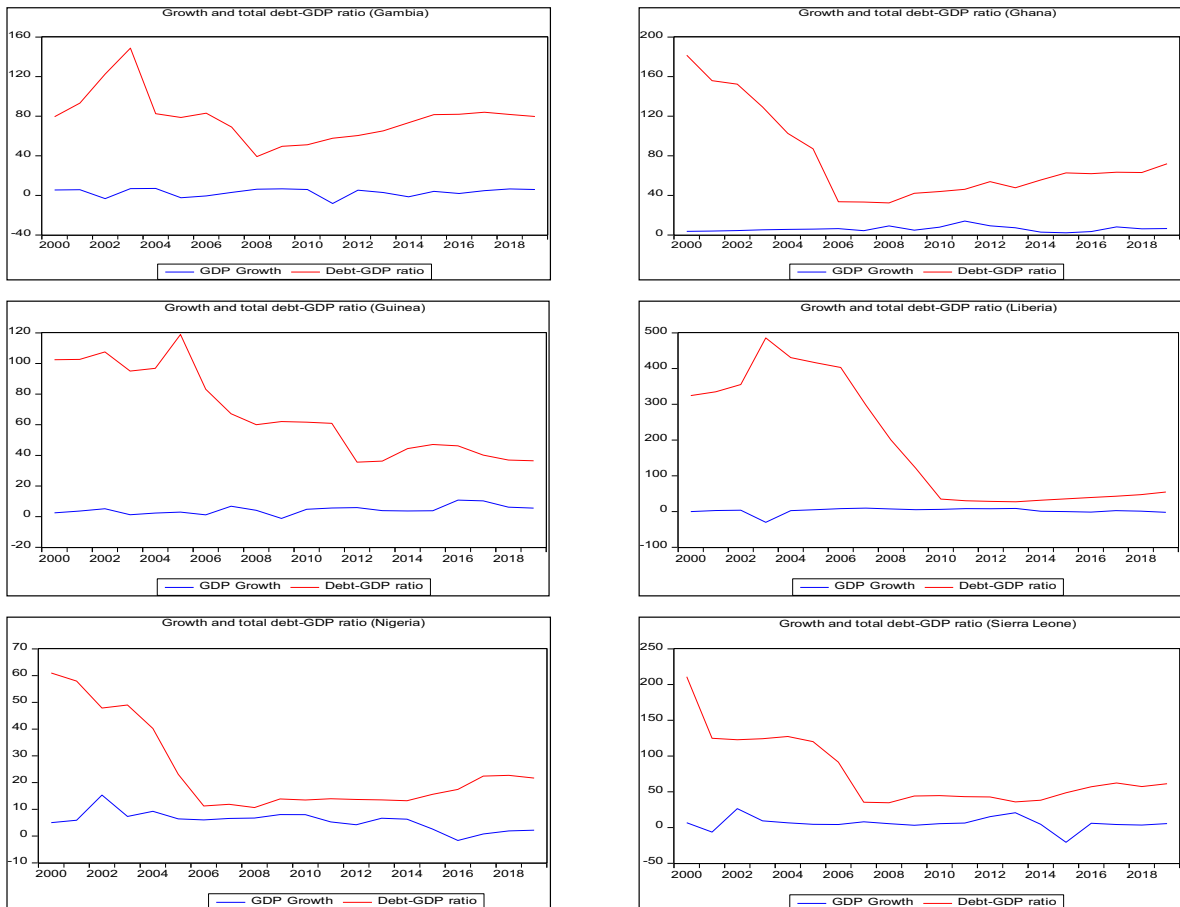


Fig. 1. Trends of growth and debt-to-GDP ratio in the WAMZ.

Note: This graph plots real growth rate of the economies against total debt (domestic plus external debt) as a ratio of GDP for each of the countries forming the WAMZ (Gambia, Ghana, Guinea, Liberia, Nigeria, and Sierra Leone). The graph for each country is arranged in the same order from left to right.

Chow-Lin approach given its suitability for stationary and cointegrated series and the results of the pre-tests on the original series in panel form which show the series are stationary and cointegrated (see the results of panel unit root and panel Cointegration tests).

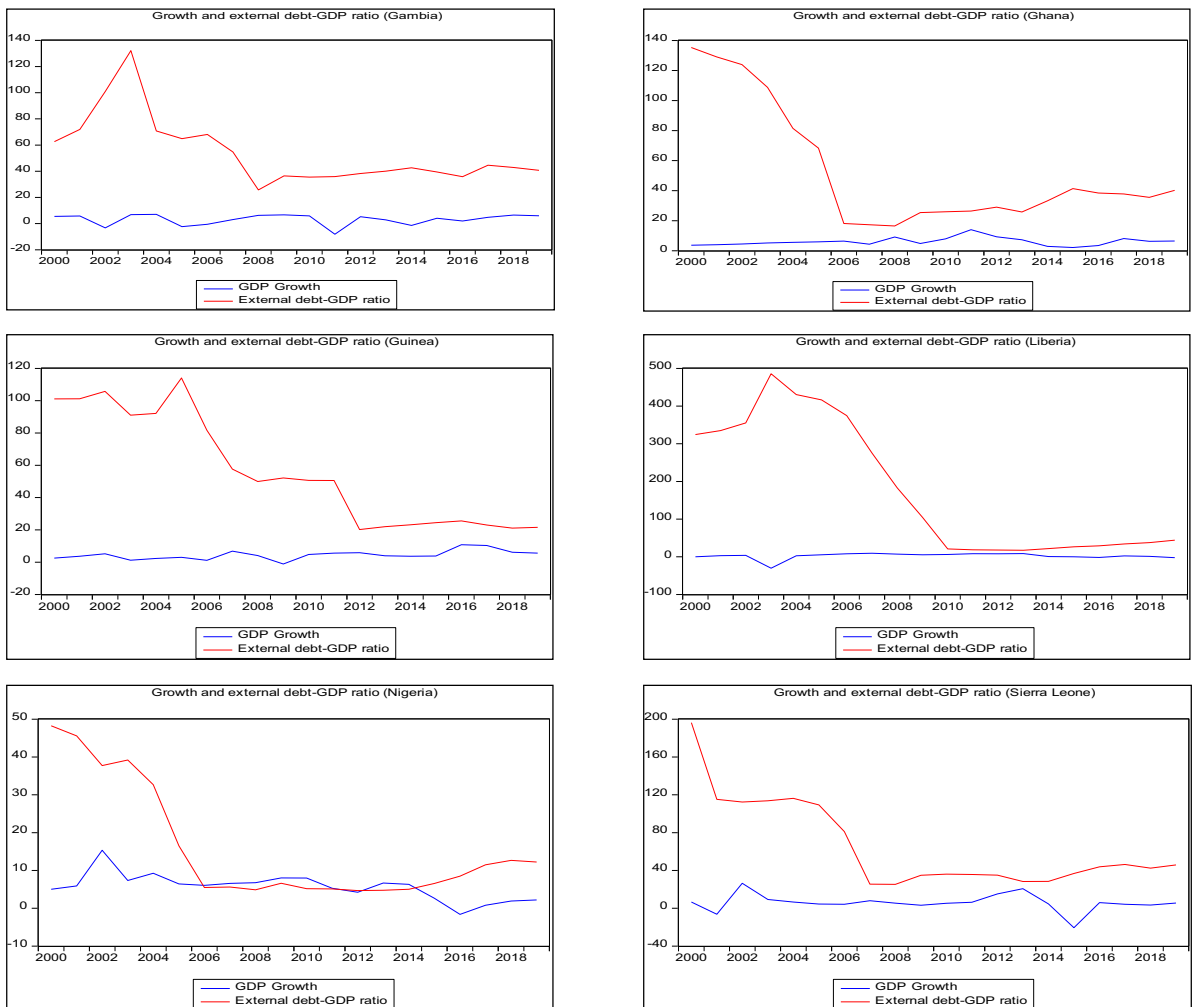
In practice, the Chow-Lin approach operates through a regression-based framework to obtain the values of a higher frequency series ( $y(t)$ ) by relating a (known) higher frequency indicator series ( $z(t)$ ) to a (benchmark) lower frequency series ( $x(t)$ ) as follows:

$$y(t) = z(t)\beta + \varepsilon(t); \varepsilon(t) = \rho\varepsilon(t-1) + v(t), |\rho| < 1 \tag{21}$$

Subject to the constraint:

$$\sum_{t=b_j}^{e_j} y(t) = x_j \tag{22}$$

where Eqs. (21) and (22) shows that the random component follow AR(1) process with zero mean and covariance matrix,  $V$ ;  $\beta$  is a vector of coefficients;  $\rho$  is the autoregressive parameter; in the absence of an indicator series, the  $z(t)$  contains a vector of 1's;  $b$  and  $e$  represent the beginning and the end observations for each period  $j$ . With the disaggregated series now in quarterly frequency, there are enough observations (80 observations) for each of the countries to permit time series (country-based) analysis.



**Fig. 2.** Trends of growth and external debt-to-GDP ratio in the WAMZ.  
**Note:** This graph plots real growth rate of the economy against external debt as a ratio of GDP for each of the countries forming the WAMZ (Gambia, Ghana, Guinea, Liberia, Nigeria, and Sierra Leone). The graph for each country is arranged in the same order from left to right.

## Preliminary results

### Descriptive statistics

This section is dedicated to graphical analysis of the trends in the variables of interest, and descriptive statistics of the variables including the mean, standard deviation, skewness, kurtosis and Jarque Bera statistics. The graphical analyses are presented in Fig. 1 to obtain preliminary information about the trends in the series over the review period and an insight into the direction of relationship between growth and debt (total debt to GDP ratio). For robustness, in Fig. 2, we explore same for external debt to GDP ratio to show that there is hardly any difference in the relationships between growth & total debt (external plus domestic debt) and growth and external debt. In Table 1, we present the descriptive statistics of the growth and debt variables (total debt to GDP ratio and total debt servicing to GDP ratio). This is followed in Table 2 with the descriptive analyses of the other macroeconomic variables included in the estimable models. The macroeconomic variables are: degree of openness (total trade as a proportion of GDP), population growth as a measure of growth of labour, inflation and gross fixed capital formation as a ratio of GDP.

There are striking features of the graphs presented in Figs. 1 and 2 that need to be highlighted. First, the two graphs are identical for the relationships depicted between growth and debt for each of the countries; Gambia, Ghana, Guinea, Liberia, Nigeria and Sierra Leone. This indicates that external debt dominates the total debt profile for the countries, hence, external debt can be employed for robustness after total debt has been used for the main analysis. Second, there appears to be visible divergence between the proxy for economic growth and those of debt variables, which may indicate expectation of negative relationship during the modelling of the debt-growth nexus. Three, there appears to be noticeable changes in the direction of the series at some turning points. This is what is technically referred to as structural shifts and may be explored with threshold regression.

Putting figures to the descriptive analyses, Ghana emerge as the country with the highest average real growth rate at 6.08 %, then Sierra Leone (5.94 %), Nigeria (5.66 %), Guinea (4.48 %), Gambia (3.14 %), and Liberia (2.29 %). The series are mixture of positive and negative skewness as well as selected cases of normal and non-normal distributions. Based on the available data, Liberia has the biggest debt burden at 187 % of gross domestic product, Gambia, 78 %, Ghana and Sierra Leone, 76 %, Guinea, 67 % and Nigeria, 24 %. There are also wide variations in the debt servicing as a ratio of GDP in the countries. Hence, in the main analysis, we may obtain divergent figures for the level debt sustainability (threshold level of debt) in the countries. The average population growth in Gambia is 3.04 %, Liberia, 3.01 %, Sierra Leone, 2.8 %, Nigeria, 2.6 %, Ghana, 2.4 %, and Guinea, 2.3 %. The average inflation figures are Ghana (15.2 %), Guinea (14.16 %), Nigeria (12.1 %), Liberia (11.3 %), Sierra Leone (8.2 %), and Gambia (6.39 %). in that order. Liberia appear as the most open economy to trade with average trade openness of 147.8 % total trade as a proportion of GDP. This figure compares with 81.7 % for Ghana, 77.1 % for Guinea, 58.4 % for Sierra Leone, 51.2 % for Gambia, and 37.3 % for Nigeria.

### Preliminary tests

Having understood the behaviour of the series and the expected relationship between economic growth and debt, we conduct relevant pre-tests before moving to the model estimations. These pre-tests help to justify the various choices of the adopted models. We

**Table 1**  
Descriptive statistics of growth and the debt variables.

Countries	Economic Growth (Real GDP growth rate)				
	Mean	SD	Skewness	Kurtosis	JB
Gambia	3.1429	4.1880	-1.2432	3.6722	5.5289*
Ghana	6.0800	2.7428	1.1523	4.6076	6.5803**
Guinea	4.4826	2.8428	0.4948	3.4700	1.0005
Liberia	2.2988	8.4455	-2.9481	12.1685	99.024***
Nigeria	5.6624	3.5449	0.4366	4.4763	2.4519
Sierra Leone	5.9376	9.2331	-0.5444	5.7157	7.1341**
<b>Total Debt as a percentage of GDP</b>					
Gambia	78.1702	24.4645	1.1968	5.0425	8.2511**
Ghana	76.0347	44.7491	1.1532	3.0656	4.4369
Guinea	67.0855	27.8819	0.4523	1.7669	1.9490
Liberia	187.115	171.502	0.4371	1.4944	2.5259
Nigeria	24.7370	16.5742	1.1600	2.8118	4.5155
Sierra Leone	76.3567	47.2236	1.2997	4.1201	6.6770**
<b>Debt servicing as a percentage of GDP</b>					
Gambia	4.9774	1.5205	0.1820	2.0402	0.8780
Ghana	6.0673	3.5075	1.1813	3.8654	5.2759*
Guinea	3.3337	1.7451	0.7689	2.7095	2.0412
Liberia	5.6893	15.499	2.6904	8.3195	47.709***
Nigeria	2.2948	1.5333	1.0172	3.0583	3.4520
Sierra Leone	3.3147	2.8082	2.2321	6.7479	28.314***
NOBS	20	20	20	20	20

**Note:** The descriptive statistics computed are the mean, standard deviation (SD), skewness, kurtosis, Jarque Bera (JB). NOBS is number of observations used in descriptive analyses (2000–2019).

**Table 2**  
Descriptive statistics of macroeconomic variables.

Countries	Gross fixed capital formation as a percentage of GDP				
	Mean	SD	Skewness	Kurtosis	JB
Gambia	13.5405	3.7284	-0.4516	3.4775	0.8699
Ghana	21.6742	5.7553	-0.2413	1.8127	1.3688
Guinea	24.2591	8.8746	2.1624	7.8430	35.132***
Liberia	20.0622	3.7044	-1.5660	8.1883	30.607***
Nigeria	20.5712	6.2104	0.6443	2.1421	1.9974
Sierra Leone	15.0646	8.8340	1.5599	5.5204	13.405***
<b>Total trade as a percentage of GDP</b>					
Gambia	51.2391	8.5990	0.5910	2.2872	1.5879
Ghana	81.7222	16.486	0.6494	2.1013	2.0789
Guinea	77.1444	21.408	0.7354	2.4984	2.0123
Liberia	147.805	76.665	1.1036	2.8704	4.0744
Nigeria	37.2788	9.4333	-0.0660	2.0776	0.7234
Sierra Leone	58.4999	18.721	0.4672	1.7885	1.9509
<b>Population growth</b>					
Gambia	3.0441	0.0852	0.6323	2.1395	1.9500
Ghana	2.4025	0.1335	-0.3768	1.8491	1.5770
Guinea	2.3046	0.2764	0.7119	2.5541	1.8554
Liberia	3.0184	0.8771	0.9144	3.6196	3.1072
Nigeria	2.6090	0.0595	-0.4205	1.8445	1.7019
Sierra Leone	2.8006	0.8689	1.0713	2.5655	3.9831
<b>Inflation</b>					
Gambia	6.3955	3.6756	1.5241	5.4447	12.723***
Ghana	15.0215	6.8186	1.1173	3.7149	4.5871
Guinea	14.1697	9.3373	0.7665	2.6703	2.0494
Liberia	11.3237	4.7647	1.3605	3.9695	6.9539**
Nigeria	12.0671	3.6642	0.0572	2.2593	0.4680
Sierra Leone	8.2121	4.8511	0.3262	2.5043	0.5594
NOBS	20	20	20	20	20

**Note:** The descriptive statistics computed are the mean, standard deviation (SD), skewness, kurtosis, Jarque Bera (JB). NOBS is number of observations used in descriptive analyses (2000–2019).

adopt the time series and panel data forms of unit root (stationarity) test and cointegration test. The panel unit root tests conducted are LLC (Levin-Lin-Chu) test, HT (Harris-Tzavalis) test, IPS (Im-Pesaran-Shin) test. For the LLC, we report the Adjusted  $t^*$  statistics; HT, the rho ( $\rho$ ) statistics; the IPS,  $t$ -bar statistics. The time series test statistics are the Augmented Dickey Fuller (ADF) test without structural breaks (ADF) and the tests with structural break in the test equation (ADF SB).

The Cointegration tests conducted are Kao, Pedroni, and Westerlund tests. All of these techniques test the null hypothesis of no Cointegration. Hence, the significance of the coefficients indicate the rejection of the null, that is, there is Cointegration between growth and debt. Kao reports Modified and Augmented Dickey-Fuller  $t$ ; Pedroni presents the (Modified) Phillips-Perron  $t$  and (Augmented) Dickey-Fuller  $t$ ; Westerlund presents Variance ratio. We explore two models; Model I is the model that has total debt as the regressor while Model II has the debt variable interchanged for external debt as the regressor. The time series Cointegration tests

**Table 3**  
The Panel Unit root tests.

Series	LLC	HT	IPS
Growth	-4.1217***	-12.8254***	-3.4085***
Total Debt	-1.7966**	0.9469	-2.2572**
External Debt	-2.1105**	1.0732	-2.0604*
Investment	-2.2254**	-5.7642***	-3.2903***
Openness	-2.2464**	-3.0908***	-2.1102**
Inflation	-3.3405***	-5.3083***	-2.7632***
Population	-8.4900***	-1.6117*	-2.9865**
Debt_Sq	-1.7799**	0.6148	-3.4002***
Ext. Debt_Sq	-2.4255***	0.6852	-3.0600***
<i>N</i>	20	20	20
<i>T</i>	6	6	6
<i>NT</i>	120	120	120

**Note:** The panel unit root tests conducted are LLC (Levin-Lin-Chu) test, HT (Harris-Tzavalis) test, IPS (Im-Pesaran-Shin) test. For the LLC, we report the Adjusted  $t^*$  statistics; HT, the rho ( $\rho$ ) statistics; the IPS,  $t$ -bar statistics. \*\*\*, \*\*, and \* represent 1 %, 5 % and 10 % statistical significance respectively.

are conducted from the (linear and non-linear forms of) Autoregressive Distributed Lag (ARDL) test equations. The reported statistics are the Bounds F-statistic using the Pesaran et al. [59] lower and upper bounds.

The panel unit root test results are contained in Table 3 with the time series counterparts in Table 4. The outcomes of the LLC and IPS panel unit root tests show that all the variables are stationary at level given by the statistical significance of the two tests. Note that the null hypothesis of the tests states that the underlying series contain unit root. The result of the HT test however contain negligible contrary evidences. Cross country (time series) unit root tests are conducted and presented in Table 4. The Augmented Dickey Fuller tests with and without structural breaks are conducted on the series at level  $I(0)$  and at first difference  $I(1)$ . The tests without structural breaks show that the series have mixed order of integration. The series only became stationary with the inclusion of structural break in the unit root test equation. The break dates are included along with the ADF statistics. This result aligns with the observations made in the descriptive (graphical) analysis.

The observed discrepancy between the panel and time series data unit root tests is not surprising. The panel counterpart is a product of the data in its original form as collected for each of the countries between 2000 and 2019. The time series tests are conducted from disaggregated data (annual data disaggregated to quarterly data via Chow-Lin approach). This point has been previously noted as one of the limitations of the study.

The results of the panel Cointegration tests (Kao, Pedroni, and Westerlund) are presented in Table 5. These are conducted for two competing models; Model I, the model that has total debt as the regressor, and Model II, the model with the debt variable interchanged for external debt as the explanatory variable. The results consistently reject the null of no Cointegration across the competing models and the three tests. While the results show Cointegration (long term) relationship between public debt and economic growth in the WAMZ countries, the results also indicate causality at least running from public debt to economic growth. Individually, the linear and non-linear variants of ARDL model (see Table 6) confirm the long run relationship between public debt and economic growth in each of the WAMZ countries. The results emanate from Bounds test obtained from F-statistic and the associated lower and upper bounds statistics as provided in Pesaran et al. [59].

## Results and discussion

### Linear relationships

The results of the Cointegration tests have cleared the air that some form of relationship does exist between debt and economic growth in the WAMZ countries individually and collectively. We then investigate the form of the nexus within the time series and panel data frameworks. The literature indicates that two forms of relationships can be expected; positive or negative nexus. The positive relationship could be observed when public borrowing stimulates investment through the accelerator principle and multiplier effect. This explains a situation when public borrowing aid economic growth at sustainable levels when the economy is able to fulfil its present and upcoming servicing obligations without any rescheduling or accumulation of accruals (see [15,16,54]). The other avenue recognises the negative relationship between growth and public debt when public borrowing potentially drives interest rates upwards and crowds out private investment and then growth.

**Table 4**  
Time series Unit root tests.

Countries	ADF $I(0)$	ADF $I(1)$	ADF_SB $I(0)$	Break date
<b>Growth</b>				
Gambia	-8.5699***	-	-10.7455***	[2011Q1]
Ghana	-3.0214**	-	-5.0581**	[2013Q1]
Guinea	-3.0536**	-	-4.8839**	[2015Q1]
Liberia	-3.3176**	-	-6.7834***	[2003Q1]
Nigeria	-1.6559	-4.1528***	-5.1739**	[2014Q3]
Sierra Leone	-8.5959***	-	-11.2995***	[2015Q1]
<b>Total Debt</b>				
Gambia	-2.4426	-3.4574***	-5.5359***	[2003Q1]
Ghana	-2.8689*	-1.4002	-5.7351***	[2002Q1]
Guinea	-1.4319	-3.4609**	-5.9816**	[2005Q1]
Liberia	-1.5853	-2.4033**	-4.9428**	[2006Q1]
Nigeria	-2.6980*	-2.1349**	-6.5822***	[2003Q1]
Sierra Leone	-1.9511	-3.7264***	-5.3989***	[2005Q1]
<b>External Debt</b>				
Gambia	-2.1595	-4.2993***	-7.0694***	[2003Q1]
Ghana	-2.9823**	-	-6.0195***	[2003Q1]
Guinea	-1.3773	-3.3578**	-5.5120***	[2005Q1]
Liberia	-1.6899	-2.3397**	-4.4161**	[2003Q1]
Nigeria	-2.5759	-2.0937**	-7.1234***	[2003Q1]
Sierra Leone	-1.9307	-3.6848***	-5.7948***	[2005Q1]

**Note:** The time series test statistics are the Augmented Dickey Fuller (ADF) test without structural breaks (ADF) and the tests with structural break in the test equation (ADF\_SB).  $I(0)$  is the test conducted at level while  $I(1)$  is the test conducted at first difference. Values in square brackets “[...]” are the structural break dates obtained from the ADF\_SB test. \*\*\*, \*\*, and \* represent 1 %, 5 % and 10 % statistical significance respectively.

**Table 5**  
Panel Cointegration tests.

Test type	Model (I) Total Debt	Model (II) External Debt
Kao test	-6.4573*** -5.0371***	-6.4439*** -5.0800***
Pedroni test	-2.4051*** -5.7706***	-2.4309*** -5.8959***
Westerlund test	-2.7369***	-2.7781***
<i>N</i>	6	6
<i>T</i>	20	20
<i>NT</i>	120	120

**Note:** The Cointegration tests conducted are Kao, Pedroni, and Westerlund tests. All of them test the null hypothesis of No Cointegration. Hence, the significance of the coefficients indicate the rejection of the null, that is, there is Cointegration between growth and debt. Kao reports Modified and Augmented Dickey-Fuller t; Pedroni presents the (Modified) Phillips-Perron t and (Augmented) Dickey-Fuller t; Westerlund presents Variance ratio. Model I is the model that has total debt as the regressor while Model II has the debt variable interchanged for external debt as the regressor. \*\*\*, \*\*, and \* represent 1 %, 5 % and 10 % statistical significance respectively.

**Table 6**  
Time series Cointegration tests.

Country	Linear model	Nonlinear model
Gambia	16.4951***	21.763***
Ghana	5.1244***	3.9766**
Guinea	4.4927***	3.7522**
Liberia	9.8866***	4.6306***
Nigeria	5.8348***	4.3848***
Sierra Leone	15.1232***	4.7217***

**Note:** The time series Cointegration tests are conducted from the Autoregressive Distributed Lag (ARDL) test equation. The reported statistics are the Bounds F-statistic using the Pesaran et al. [59] lower and upper bounds. \*\*\*, \*\*, and \* represent 1 %, 5 % and 10 % statistical significance respectively.

**Table 7**  
Linear economic growth - debt nexus (without control variables).

Linear model	Model (I) Total Debt	Model (II) External Debt
Debt	-0.0161*** (0.00582)	-0.0162*** (0.00572)
Constant	5.972*** (0.718)	5.744*** (0.658)
<b>Model diagnostic</b>		
Hausman test	0.34	0.23
<i>N</i>	6	6
<i>T</i>	20	20
<i>NT</i>	120	120

**Note:** The panel analyses are conducted using either the fixed effect (FE) or random effect (RE) models. Standard errors are in round parenthesis "(...)". The decision on the choice of either FE or RE is reached via the Hausman test statistics. The statistical significance of the Hausman test indicate the choice of fixed effect model while its insignificance indicates the choice of random effect model. Model I is the model that has total debt as the regressor while Model II has the debt variable interchanged for external debt as the regressor. *N* is the number of cross section units (i.e. countries) and *T* is the number of time periods. \*\*\*, \*\*, and \* represent 1 %, 5 % and 10 % statistical significance respectively.

We present the results for the linear relationships in Tables 7-9. Table 7 documents the results of fixed effect and random effect models adjudged by the Hausman test for two models, Model I, the model that has total debt as the regressor, and Model II, the model with the debt variable interchanged for external debt as the explanatory variable. Table 8 improves on Table 7 by incorporating other macroeconomic variables into the model to show that the coefficients do not change markedly with the inclusion of additional regressors. In both results, negative relationship is observed for the debt-growth nexus. The negative relationship is confirmed for the two model variants (the models with total debt and external debt) and the models with and without additional regressors. In addition to that, trade openness and growth of labour have positive and statistically significant impact on economic growth in the WAMZ. The positive and negative impacts observed for investment and inflation respectively are not statistically significant.

The negative nexus between public debt and economic growth can be attributed to several factors one of which is spending without saving or borrowing against future revenues which can expose the economy to debt sustainability risks (see [24]). Another instance is in high indebted countries where creditors ask for higher interest rates (that could constrain investment) due to incessant default (see [2,34,47]). In such highly indebted countries (HICs), revenue resources and earnings generated from exports are used for debt servicing as a replacement for being utilised for health, education, population welfare, investments, growth of economy or for scientific research and development (see [4,16]). There are several evidences in the literature suggesting inverse relationship between public debt and economic growth of highly indebted countries due to the fact that debt servicing and repayment are usually financed through the budget (see also [1,6,51]). These occur when the country experiences debt over hang; a situation when the country's debt burden is so heavy that a large portion of the current output accrues to foreign lenders and consequently creates disincentive to investment (see [28,47,63]).

Cross country evidences (in Table 9) based on based on (time series) Autoregressive Distributed Lag model also confirm the wide spread negative impact of public debt on economic growth in Gambia, Ghana, Liberia and Guinea (the negative relationship is however not significant in Guinea). The results of the negative nexus rank amongst host of others which appear to agree that there is negative impact debt on growth especially in high indebted developing countries (see [8,11,14,23,24,27,31,46,48,61,62,68]). Positive relationship is only obtained in Nigeria and Sierra Leone (although the positive relationship is not significant in Nigeria). These findings are consistent over the short and long run horizons. The models that produce these results are well-behaved with the error correction terms being negative, statistically significant and less than one (1) in absolute value, as expected. These consistent behaviours of the error correction terms (speed of adjustment to long run equilibrium) confirm the results of Cointegration tests earlier reported.

### Non- Linear Relationships

There are extensive evidences in the literature suggesting that the relationship between debt and growth is positive up to a certain (point) threshold beyond which it exerts negative impact (example include, [15,18,20,54-57,67,73]). A number of these studies suggest that this nonlinear relationship is a reality in both advanced and developing countries although this threshold is lower for the latter group of countries than the latter (see also [44]).

**Table 8**  
Linear economic growth - debt nexus (with control variables).

Linear model	Model (I) Debt	Model (II) External Debt
Debt	-0.0250*** (0.00660)	-0.0238*** (0.00647)
Investment	0.0399 (0.0754)	0.0367 (0.0757)
Openness	0.0637*** (0.0148)	0.0614*** (0.0147)
Inflation	-0.0533 (0.0817)	-0.0554 (0.0819)
Labour	3.972*** (0.938)	3.899*** (0.939)
Constant	-8.975** (3.438)	-8.966** (3.450)
<b>Model diagnostic</b>		
Hausman test	15.93***	15.55***
<i>N</i>	6	6
<i>T</i>	20	20
<i>NT</i>	120	120

**Note:** The panel analyses are conducted using either the fixed effect (FE) or random effect (RE) models. Standard errors are in round parenthesis "(...)". The decision on the choice of either FE or RE is reached via the Hausman test statistics. The statistical significance of the Hausman test indicate the choice of fixed effect model while its insignificance indicates the choice of random effect model. Model I is the model that has total debt as the regressor while Model II has the debt variable interchanged for external debt as the regressor. *N* is the number of cross section units (i.e. countries) and *T* is the number of time periods. \*\*\*, \*\*, and \* represent 1 %, 5 % and 10 % statistical significance respectively.

**Table 9**  
Linear economic growth - debt nexus (Time series analysis).

Country	Gambia	Ghana	Guinea	Liberia	Nigeria	S. Leone
Short run	-0.0464* (0.0260)	-0.0130*** (0.0035)	-0.00075 (0.0021)	-0.0376*** (0.0074)	0.0027 (0.0061)	0.0291** (0.0109)
ECT(-1)	-0.9913*** (0.1061)	-0.2233*** (0.0429)	-0.2144*** (0.0439)	-0.4929*** (0.0681)	-0.1619*** (0.0290)	-0.9853*** (0.1101)
Long run	-0.0454** (0.0206)	-0.0585*** (0.0102)	-0.0035 (0.0090)	-0.0763*** (0.0224)	0.0171 (0.0409)	0.0295** (0.0126)
<b>Diagnostics</b>						
Serial LM (2)	0.1067	0.0680	0.1337	1.4927	0.2037	0.1315
Serial LM (4)	0.5454	1.6357	1.2646	1.2023	0.2623	0.0759
Hetero	0.2571	1.2761	1.0461	1.0880	4.4006**	0.8178

**Note:** The time series analyses are conducted using the Autoregressive Distributed Lag models. The short run and long run coefficients are presented with the coefficient of error correction (ECT(-1)). Standard errors are in round parenthesis "(...)". \*\*\*, \*\*, and \* represent 1 %, 5 % and 10 % statistical significance respectively. The diagnostics tests are the serial correlation LM tests across lags 2 and 4 and the test for heteroscedasticity.

In [Table 10](#), we produce the results for the non-linear forms of the fixed and random effect models (under panel data framework) also for two models; Model I is the model that has total debt as the regressor while Model II has the debt variable interchanged for external debt as the regressor. In both models, we include the squared term of the debt variable in the right-hand-side as an additional explanatory variable. We obtain convincing evidence for the nonlinear debt-economic growth relationship across the two models with positive (and significant) impact of the debt variable as well as the negative (and significant) impact of the squared debt variable (debt\_sq). The implication of this finding is that there is indeed a point of inflection for which debt accumulation leads to negative consequences in the WAMZ countries. This point at which debt becomes unsustainable needs to be determined and this is the subject of the next section.

We seek country specific evidences in [Table 11](#) with time series estimations across the six WAMZ countries. The error correction terms (speed of adjustment) show consistency by being negative, statistically significant and less than one (1) in absolute value across the country models. The results are also consistent for the debt and its squared counterparts across the short and long run horizons. As obtained for the panel data regressions, the results indicate positive (and significant) impacts of the debt variables as well as negative and statistically significant impacts of the squared terms. The (negligible) exception is found in Nigeria where the signs are consistent but the magnitudes are insignificant. We therefore produce findings along others such as Siddique et al. [69], Baharumshah et al. [5] that also find that there exist a turning point where the impacts of debt on economic growth turns negative.

### Threshold analysis

In this section, we further build on the non-linear nexus explored in the previous section by adopting the panel data and time series threshold regressions. First the panel data threshold regressions. These analyses are conducted for two model variants (see [Table 12](#)); Model I, the model that has total debt as the regressor and Model II has the debt variable interchanged for external debt as the explanatory variable. The threshold regression divides the data sample into two (given single threshold) and hence produce two coefficients ( $\hat{\beta}_1$  and  $\hat{\beta}_2$ ), where the former is expected to be positive and the former, negative to confirm the earlier results of non-linear public debt-economic growth nexus. Further for robustness, we produce results in [Table 13](#) where we demonstrate that the results are consistent with the exclusion of outliers like Nigeria and Ghana from the sample.

The null hypotheses of no threshold effects are consistently rejected across the various model variants. The coefficients are positive (although statistically insignificant) at lower data samples ( $\hat{\beta}_1$ ), while as expected, the coefficients at higher data samples ( $\hat{\beta}_2$ ) are negative and as well statistically significant to lend credence to the non-linear relationship extensively reported in the previous section. While investment is used as the threshold variable, the impacts of the other macroeconomic variables are consistent with what was earlier reported with the fixed effect and random effect model estimations. While the impacts of trade openness and growth of labour (population) are positive and statistically significant, the effect of inflation remain negative although statistically insignificant.

The panel threshold analysis may not be suitable to obtain the inflection points – the points where debt accumulation become inimical to growth. This is better obtained from the time series counterparts to produce the threshold values ( $\lambda$ ) for each of the countries. We explore this [Table 14](#). With the  $\hat{\beta}_2$  coefficients consistently negative in all the countries, we obtain the threshold levels at which debt becomes unsustainable for each of the countries: Gambia (71.9 %), Ghana (55.8 %), Guinea (91.5 %), Liberia (83.7 %), Nigeria (38.45 %), and Sierra Leone (38.6 %). These figures compare amongst the earlier findings for example: debt to GDP proportion of about 90 % found in Reinhart and Rogoff [61], 60–80 % in Muhanji and Ojah [54] for Africa, 90–100 % in Checherita-Westphal and Rother [18], 61 % in Wright and Grenade [73] for Caribbean countries, around 60 % in Égert [26], 88 % in Karadam [44] for developing countries, and about 40–55 % debt-GDP ratio found in Tran [70].

### Conclusion and policy recommendations

The study seeks to understand the nexus between public debt and economic growth in the WAMZ countries. The study explores the linear relationships using linear panel and time series models, the non-linear relationships using non-linear forms of the panel and time

**Table 10**  
Nonlinear economic growth - debt nexus.

Non-linear model	Model (I) Total Debt	Model (II) External Debt
Debt	0.0444** (0.0224)	0.0319* (0.0187)
Debt_Sq	-0.000144*** (0.000052)	-0.000121*** (0.000045)
Constant	3.025** (1.268)	3.959*** (0.966)
<b>Diagnostic test</b>		
Hausman test	1.69	1.00
<i>N</i>	6	6
<i>T</i>	20	20
<i>NT</i>	120	120

**Note:** The panel analyses are conducted using either the fixed effect (FE) or random effect (RE) models. Standard errors are in round parenthesis “(...)”. The decision on the choice of either FE or RE is reached via the Hausman test statistics. The statistical significance of the Hausman test indicate the choice of fixed effect model while its insignificance indicates the choice of random effect model. Model I is the model that has total debt as the regressor while Model II has the debt variable interchanged for external debt as the regressor. Debt\_Sq is the square of the respective debt series. *N* is the number of cross section units (i.e. countries) and *T* is the number of time periods. \*\*\*, \*\*, and \* represent 1 %, 5 % and 10 % statistical significance respectively.

**Table 11**  
Nonlinear economic growth - debt nexus (Time series).

	Gambia	Ghana	Guinea	Liberia	Nigeria	S. Leone
<b>Short run</b>						
Debt	0.0650*** (0.0138)	0.0369*** (0.0125)	0.0201*** (0.0068)	0.0273** (0.0106)	0.0248 (0.0462)	0.1361*** (0.0434)
Debt_Sq	-0.0003*** (0.0001)	-0.0002*** (0.00006)	-0.0002** (0.00006)	-0.00007** (0.00002)	-0.00019 (0.00064)	-0.00076** (0.0003)
ECT(-1)	-0.9559*** (0.1167)	-0.0969*** (0.0276)	-0.1077*** (0.0316)	-0.3499*** (0.0925)	-0.2515*** (0.0472)	-0.8355*** (0.2187)
<b>Long run</b>						
Debt	0.0680*** (0.0114)	0.3805*** (0.0949)	0.1868*** (0.0360)	0.0780*** (0.0197)	0.0988 (0.1829)	0.1629*** (0.0288)
Debt_Sq	-0.0003*** (0.00011)	-0.0019*** (0.00047)	-0.0015*** (0.0004)	-0.0002*** (0.00004)	-0.00076 (0.0027)	-0.0009*** (0.0002)
<b>Diagnostics</b>						
Serial LM (2)	0.1300	0.0443	0.1165	0.8768	1.1103	1.2389
Serial LM (4)	0.9166	1.3025	0.6548	1.6218	1.2235	1.4705
Hetero	0.2325	3.5706*	2.1609*	3.0861*	2.8498*	0.2206

**Note:** The time series analyses are conducted using the Autoregressive Distributed Lag models. The short run and long run coefficients are presented with the coefficient of error correction (ECT(-1)). Debt\_Sq is the square of the respective debt series. Standard errors are in round parenthesis “(...)”. \*\*\*, \*\*, and \* represent 1 %, 5 % and 10 % statistical significance respectively. The diagnostics tests are the serial correlation LM tests across lags 2 and 4 and the test for heteroscedasticity.

series models that incorporates the squared term of the debt variable as an additional explanatory variable, and the determination of threshold level beyond which public debt becomes unsustainable in the WAMZ countries.

The first objective is confronted with the linear form of Autoregressive Distributed Lag (ARDL) model for the time series data while the fixed effect or random effect models are employed for the panel data counterpart. We deal with the second objective using the nonlinear form of Autoregressive Distributed Lag (ARDL) model that contain the squared term of the debt variable as an additional explanatory variable for the time series data and same for the fixed effect or random effect models are employed for the panel data counterpart. The panel and time series threshold regression techniques were used to evaluate the third objective which helps to identify the public debt/GDP threshold for the WAMZ countries.

The findings obtain negative relationship across the linear models. We also establish the debt-economic growth relationship is nonlinear and we obtain the points of inflection for which debt accumulation leads to negative consequences in the WAMZ countries. In the end, we conclude that the relationship is largely negative in the WAMZ countries and that Gambia and Ghana are high risk countries given that their average debt to GDP profiles have either reached or exceeded the unsustainable threshold levels

There are lessons for the WAMZ countries as a group and individually from the findings of this study. Individually, some of the countries (and the others in the near future) may have to review their sources of financing public investments away from public debt accumulation given that the average debt to GDP profile have reached or exceeded the unsustainable threshold levels. These countries have average debt-to-GDP values (threshold values) as follows: Gambia with 78.17 % average value (and 71.9 % threshold value) and

**Table 12**  
Threshold regression analysis.

Threshold model	Model (I) Total Debt	Model (II) External Debt
Constant	-4.897 (3.485)	-5.973* (3.423)
$\hat{\beta}_1$	0.0418 (0.0740)	0.0298 (0.0741)
$\hat{\beta}_2$	-0.650*** (0.181)	-0.646*** (0.178)
Threshold ( $F$ )	17.10***	17.10***
Threshold effect?	Yes	Yes
<b>Other regressors:</b>		
Openness	0.0635*** (0.0144)	0.0762*** (0.0154)
Inflation	-0.118 (0.0801)	-0.128 (0.0801)
Population	2.075** (0.972)	2.279** (0.954)
$F(u_i) = 0$	4.37***	5.12***
$N$	6	6
$T$	20	20
$NT$	120	120

**Note:** The panel threshold analyses are conducted using the Hansen [36] model under the Wang [71] framework. Standard errors are in round parenthesis "(...)".  $N$  is the number of cross section units (i.e. countries) and  $T$  is the number of time periods. \*\*\*, \*\*, and \* represent 1 %, 5 % and 10 % statistical significance respectively.

**Table 13**  
Further threshold regression analysis.

Threshold model	Without Nigeria	Without Ghana
Constant	-4.016 (3.784)	-6.821* (3.954)
$\hat{\beta}_1$	0.0235 (0.0836)	0.109 (0.0837)
$\hat{\beta}_2$	-0.776*** (0.203)	-0.680*** (0.205)
Threshold ( $F$ )	16.93***	16.10***
Threshold effect?	Yes	Yes
$F(u_i) = 0$	3.69***	3.77***
$N$	5	5
$T$	20	20
$NT$	100	100

**Note:** The panel threshold analyses are conducted using the Hansen [36] model under the Wang [71] framework. Standard errors are in round parenthesis "(...)". The analyses considers robustness by excluding economies like Nigeria or Ghana from the sample.  $N$  is the number of cross section units (i.e. countries) and  $T$  is the number of time periods. \*\*\*, \*\*, and \* represent 1 %, 5 % and 10 % statistical significance respectively.

Ghana with 76.03 % average value (and 55.8 % threshold value). These countries should rather pay more attention to taxes as alternative means of sustaining government programmes. In the light of this, the WAMZ countries in general should seek to expand their economic bases by channelling funds to infrastructures development and development of human capital that will help optimize the benefit of debt accumulation in the long run.

#### CRediT authorship contribution statement

**Dinci Jessica Penzin:** Conceptualization, Methodology, Data curation, Software, Writing – original draft, Writing – review & editing. **Benedict Ndujisi Akanegbu:** Visualization, Validation, Writing – original draft, Writing – review & editing.

#### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to

**Table 14**  
Time series threshold regression analysis.

Threshold model	Gambia	Ghana	Guinea	Liberia	Nigeria	S. Leone
$\hat{\beta}_1$	0.0575 (0.0409)	0.0026 (0.1259)	0.0836*** (0.0289)	0.0942*** (0.0207)	0.1687** (0.0672)	-0.2100 (0.2735)
$\hat{\beta}_2$	-0.1233*** (0.0350)	-0.0460*** (0.0084)	-0.0463** (0.0223)	-0.0640*** (0.0109)	-0.5640*** (0.1161)	-4.7470*** (0.7483)
$\lambda$	71.9 %	55.8 %	91.5 %	83.7 %	38.45 %	38.6 %
<b>Diagnostics</b>						
$R^2$	0.58	0.75	0.86	0.85	0.78	0.43
$F - test$	4.00***	35.94***	40.64***	43.78***	36.40***	8.74***

**Note:** The time series threshold analyses are conducted using the Hansen [36] modelling framework. Standard errors are in round parenthesis "(...)". \*\*\*, \*\*, and \* represent 1 %, 5 % and 10 % statistical significance respectively.

influence the work reported in this paper.

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