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Is there a debt-threshold effect on per capita GDP growth in South Africa? A threshold regression model

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The effect of public indebtedness on output has attracted much public attention in the aftermath of the financial crisis. The study examined the impact of public debt on per capita GDP growth of South Africa using quarterly data spanning from 1960 to 2019. This study applied the threshold regression model to find the tipping point of public debt at an aggregated level and disaggregated level, domestic and foreign debt. The findings of the threshold regression revealed a non-linear impact of total public debt; domestic debt and foreign debt on growth with a turning point – beyond which the debt-to-GDP ratio has a negative impact on long-term growth at about 34.9 percent, 30.3 percent and 4.19 percent of GDP respectively. The findings of this study rule out the policy option for excessive dependence on higher debt to stimulate economic growth for South Africa. Thus, the South African government should ensure that public debt management policies are consistent with the growth-maximizing public debt threshold.

Keywords: Per capita GDP growth, Public debt, Threshold regression model, South Africa

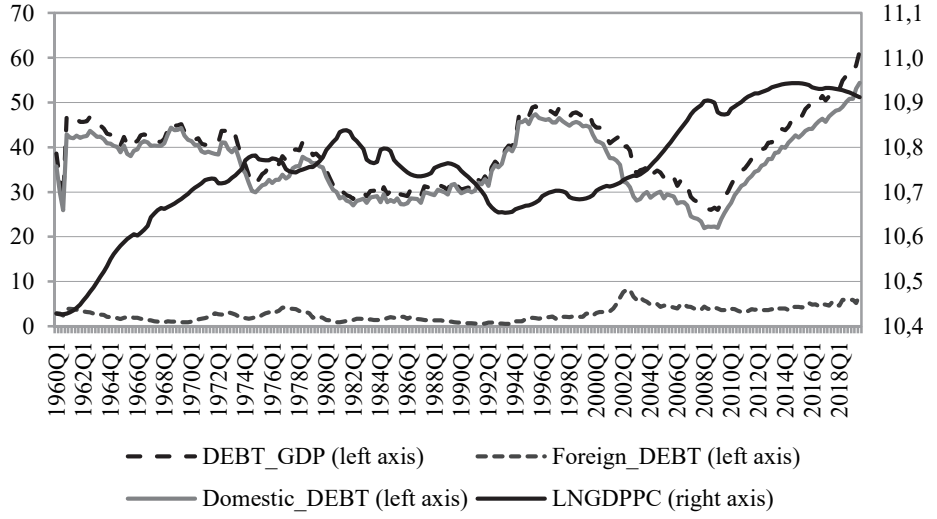
The effect of indebtedness on output attracted much public attention in the aftermath of the global financial crisis in 2008/09. The study of this relationship started in the pioneering paper of *Reinhart and Rogoff (2010)*, the authors found a threshold value of 90% to be detrimental to economic growth prospects. Their finding is supported by a considerable number of subsequent papers, such as (*Cecchetti et al., 2011; Checherita-Westphal–Rother, 2012; Baum et al., 2013* to name few), although there remains the debate regarding what the threshold value is. Apart from the above panel-data approach studies, *Hansen (2017)* adds to the literature conducting a time-series approach. There are considerable empirical justifications for why increasing the size of public debt has become a challenging

issue in recent years that has considerably dissipated the economic growth position of most developing economies, particularly when it exceeds a certain threshold. Mounting public debt will induce tax hikes and long-term sovereign yields and will create high inflation *(Kumar–Woo, 2010)*. Consequently, the rising public debt response turns out to crowd out productive public investment and reduce private investment, leading to negative effects on economic growth.

Public debt can be external and internal debt, each with distinct impacts on output. Internal debt has advantages for the home country, such as easing adverse external debt crisis and foreign exchange risk, and may assists in domestic financial market progress *(Beaugrand et al., 2002).* On the other hand, the growth-maximizing foreign debt threshold is ascribed to debt overhang *(Stylianou, 2014).* External debt may appreciate the real exchange rate, consequently hampering competitiveness and lowering investment and economic growth. Moreover, because of foreign currency denomination, additional constraints on monetary policy and management of the exchange rate might be created. South Africa's total average debt-to-GDP ratio is 38.97 percent, where 36.2 percent is internal debt-to-GDP and 2.77 percent accounts for the external debt-to-GDP ratio spanning from 1960 Q1 to 2019 Q3 (see Figure 1). However, the impact of public debt at the aggregate and disaggregate levels on economic growth in the context of South Africa has been insufficiently studied, and no consensus has been reached in the academia.

Figure 1

GDP per capita, Public debt, domestic debt and foreign debt levels of South Africa



Source: Author's calculations based on data from *South African Reserve Bank (2020).*

As the data in Figure 1 *(South Africa Reserve Bank, 2020)* show, South Africa's public debt is increasing at an alarming rate after the economic meltdown in 2008, representing 61.5% of its GDP in the third quarter of 2019 due to the various large-scale expenditure programs implemented by the government to maintain the momentum of the economy *(Kavase–Phiri, 2018)*. Consequently, South Africa's debt-to-GDP ratio and economic growth show that the degree of persistence of both series diverged after the global financial crisis, revealing that the economic growth in South Africa may vary together with the total public debt levels, which relate to the countercyclical policies and structural reforms implemented by the Government of South Africa over past periods.

In the existence of public debt-growth analysis, the studies focusing on developed nations failed to account for characteristics of emerging and developing economies mainly because they have different economic, institutional, and political structures. For instance, developed countries have a higher threshold level of public debt because they have relatively mature regulatory system, institutional support and a higher degree of internationalization of the local currency, they can, to a large extent, make use of the developed financial market to increase the marginal utility of public debt to economic growth and raise the threshold of public debt. On the other hand, developing countries have unstable access to capital markets and this leads to constrain the countries to borrow, massive infrastructural needs, and limited fiscal space to finance public spending. Due to these different characteristics, studies focusing on emerging and developing countries are required. Thus, it is vital to conduct empirical studies focusing on country specific rather than treating it as an outlier or dummy variable in studies comprising a large panel of advanced and developing countries.

As these studies *(Quintos, 1995; Panizza–Presbitero, 2014; Eberhardt–Presbitero, 2015; Baaziz et al., 2015; Chudik et al., 2017; Nganga et al., 2018; Tran, 2018)* argue, debt patterns and economic growth have an asymmetric relationship. The nonlinear relationship between public debt and economic growth becomes harmful when it surpasses the tipping point *(Tran, 2018; Chudik et al., 2017)*. Thus, it is important to compute the threshold level of public debt that helps the country achieve its highest level of economic growth. To our knowledge, very few studies have estimated and tested the effect of public debt on economic growth in South Africa, instead focused mostly on external debt, which has a low contribution to the total public debt in South Africa's indebtedness. Second, although empirical studies globally assure the nonlinear relationship between public debt and economic growth, there is limited literature on the South African economy regarding the nonlinear relationship between public debt and economic growth. Third, the existence of different growth-maximizing public debt thresholds suggests the need for country-specific ones. Hence, there is a need for further research on the recent literature by applying a nonlinear relationship

between public debt and economic growth to identify the debt threshold with the aim of ascertaining the optimum level of public debt at which economic growth will be stimulated. This study answered two research questions: When does debt go from good to bad? At what levels does the internal and/ or external debt have detrimental impact on economic growth?

The paper proceeds as follows. Section 1 provides an overview of the theoretical and empirical works on the growth-maximizing public debt threshold. The methodology and source of data are presented in Section 2. Section 3 reports the results of the threshold regression model of *Hansen (2011)* regarding the effect of public debt on economic growth. Section 4 concludes the paper.

1. Literature review

The first strand of existing theoretical literature on the potential impact of public debt on economic growth is categorized into the ""conventional analysis" hypothesis *(Elmendorf–Mankiw, 1999),* the law of increasing state activity *(Wagner, 1893)*, the debt overhang theory *(Myers, 1977)*, the "Ricardian equivalence" hypothesis *(Barro, 1974)* and the nonlinear effects of public debt on economic growth *(Reinhart–Rogoff, 2010)*. The conventional analysis" approach adopts the Keynesian view of the deficit budget in the short run, assuming that a deficit financed by government expenditures boosts economic activity, since government expenditure is a stimulant of aggregate demand. Nevertheless, in the long run, the economy adheres to the classical vision, for which higher debt can trigger higher private savings and fewer incentives to work and invest, consequently reducing capital stock and lowering productivity, ultimately reducing output. Apparently, public debt can crowd out private investment by contributing to reduced credit to the economy or by raising long-term interest rates *(Modigliani, 1961)*. The crowding out of private investment comes when a high public debt is a burden on the economy and forces the government to increase taxes in the future to service the debt. Thus, high public debt can potentially increase interest rates since the government may decide to incur more debt to service existing debt stock which in effect increases the long-term interest rate.

Apart from the conventional hypothesis, there is another theory supported by Adolf Wagner's hypothesis of the "Law of increasing state activity" and the Keynesians fiscal multiplier effect that places a positive impact of public debt on economic growth. This view argues that rising public debt induces high levels of productive public spending and that deficit-financed government spending has a

more positive multiplier effect on the economy than tax-financed government spending *(Bird, 1971; Holtfrerich, 2013; Kobayashi, 2015)*. Some empirical studies support the positive link between public debt and economic growth *(Abbas–Christensen, 2010; Greiner, 2011; Uzun et al., 2012; Owusu-Nantwi–Erickson, 2016).*

The second strand of literature purports negative effects of public debt on economic growth, explained by the debt overhang hypothesis. This view argues that the accumulation of public debt distorts the possibilities for the private sector to make optimal future investment decisions because of fiscal deterioration *(Diamond, 1965; Meade, 1958; Modigliani, 1961; Reinhart et al., 2012).* Some studies *(Mhlaba–Phiri, 2019; Gómez-Puig–Sosvilla-Rivero, 2015; Ahlborn–Schweickert, 2018; Panizza–Presbitero, 2013; Szabo, 2013; Égert, 2012; Cochrane, 2011a, 2011b; Kumar–Woo, 2010; IMF, 2005;* and *Clements et al., 2003; Iyoha, 1999)* support the negative effects of public debt on economic growth. A surge in public debt uses a portion of national savings meant for future generations. The resulting reduction in savings pushes up the interest rate, which reduces incentives to invest—lower investment results in lower capital accumulation, which drags down economic growth. Thus, Countries with a high level of debt fall into a debt overhang and with a negative effect on subsequent growth, change expectations, or bring uncertainty, change sovereign yield spreads and real interest rate to affect lower private investment.

Conversely, the third strand of literature focuses on the Ricardian equivalence hypothesis (REH) of *Barro (1974)* which states that economic growth can be unresponsive to public debt because of the assumed rational expectations of economic agents. The REH suggests that fiscal stimuli which are defined in terms of deficit-financed public spending hikes or tax cuts will have no effect on aggregate demand or on the interest rate. It stipulates that a person's consumption is determined by the lifetime present value of his after-tax income. Therefore, the REH says a government cannot stimulate consumer spending, since people assume that whatever is gained in the present will be offset by higher taxes due in the future. Thus, the underlying idea behind Ricardo's theory is that no matter how a government chooses to increase spending, whether by debt financing or tax financing, the outcome is the same and demand remains unchanged. Under this assumption, economic agents expect future taxes to offset the deficit generated by new public spending and thus reduce their expenditures *(Barro, 1976, 1989; Buchanan–Roback, 1987; Pereira–Rodrigues, 2001)*. Thus, according to the REH, fiscal policies do not affect the equilibrium level of trade balances, current account, interest rates, money demand, private consumption, investment and saving. The REH is mainly based on some strong assumptions: (a) capital markets are perfect, and the consumer does not face any borrowing constraints; (b) both the private and

public sectors have the same planning horizons; (c) taxes are non-distortionary *(Barro, 1974, 1989)*. This argument is supported by several empirical studies *(Schclarek, 2005; Kourtellos et al., 2013; Panizza–Presbitero, 2014).*

This strand of the literature argues for the existence of a nonlinear relationship between public debt and economic growth and states that below a certain threshold, public debt has a crowding-in effect that promotes economic growth, while beyond a certain threshold, the crowding-out effect outweighs the crowding-in effect; thus, public debt adversely affects economic growth *(Sachs, 1989; Poirson et al., 2002; Reinhart–Rogoff, 2010; Mupunga–Le Roux, 2015)*. Moreover, a plethora of studies argue that the growth-maximizing public debt threshold can be better explained by the debt Laffer curve – an inverted U-shaped curve. These studies state that the crowding-in effect occurs when the public debt-to-GDP ratio is below a certain threshold that dominates the crowding-out effect, and that increases in public debt are promoting economic growth. However, beyond this threshold, the crowding-out effect that outweighs the crowding-in effect leading to public debt will have a negative effect on growth. The crowding-in effect occurs when increased public sector spending replaces or drives down private sector spending, while the crowding-out effect refers to a situation where government borrowing, for the purpose of financing the deficit, reduces the quantum of loanable funds available to the private sector, thereby effectively crowding them out. The point at which public debt negatively affects growth provides information on the growth maximizing public debt threshold. Conversely, papers such as *Panizza–Presbitero, 2013, Greiner, 2012, Ferreira 2009, Toro et al. 2010* and *Schclarek, 2005*, approached the hypothesis that high debt causes reduced growth, indicating that the literature on the link between public debt and growth is not conclusive.

There are considerable empirical studies showing a nonlinear relationship between public debt and economic growth *(Reinhart–Rogoff, 2010; Herdon et al., 2014; Kumar–Woo, 2010; Cecchetti et al., 2011; Baum et al.,2013; Checherita-Westphal–Rother, 2012; Panizza–Presbitero, 2014; Eberhardt–Presbitero, 2015; Gómez-Puig–Sosvilla-Rivero, 2015; Mitze–Matz, 2015; Siddique et al., 2016; Woo–Kumar, 2015; Mupunga–Le Roux, 2015; Akram–Rath, 2019; Baharumshah et al., 2017).* The reason may be that public debt reduces savings and capital accumulation through higher interest rates in the long run and those weaken economic growth *(Modigliani, 1961; Diamond, 1965; Blanchard, 1985; Barro, 1990; Saint-Paul, 1992)*; debt has to be paid off by an upcoming reduction in public spending or distortionary taxation that impedes economic growth *(Bohn, 1998; Mendoza–Ostry, 2008; Lo–Rogoff, 2015)*; and mounting public debt deters the effectiveness of productive public spending on long-term growth *(Teles–Mussolini, 2014),* creates uncertainty or expectations of future financial repression

(Cochrane, 2011b), and could be associated with higher sovereign yield spreads *(Codogno et al., 2003)*, leading to higher real interest rates and lower private investment *(Laubach, 2009)*.

The existing empirical literature in South Africa is classified into cross-country studies and country-specific studies. This section discusses the literature gap in the list of studies on South Africa, as shown in Table 1, starting with cross-country studies. *Amoateng and Amoako-Adu (1996)* examined the nexus among economic growth, exports and external debt by taking samples from 35 African countries using *Granger's (1969)* causality test. The study revealed that there is a joint feedback effect among export revenue, external debt services and economic growth. *Fosu (1999)* discussed the effect of external debt on economic growth in sub-Saharan Africa (SSA) by taking a sample from 1980–1990 including 35 SSA countries. The study employed an augmented production function framework using the OLS method. The findings of the study suggest that external debt affects GDP growth unfavourably, while it has little or no impact on the level of investment. Another study *(Iyoha, 1999)* using annual data spanning from 1970 to1994 investigated the impact of external debt on economic growth in SSA countries; this study suggested that a 20% debt stock reduction would, on average, increase investment by 18% and increase GDP growth by 1%. *Poirson et al. (2002)* examined the nonlinear effect of external debt on economic growth from 93 developing countries by sampling annual data from 1969 to 1998. The findings of the study revealed that debt can adversely affect economic growth at approximately 160–170% of exports or 35–40% of GDP. Another study *(Hussain et al., 2015)* examined the debt-economic growth nexus in 48 countries of Sub-Saharan Africa, data spanning from 1995 to 2012, using Granger causality and Dynamic Arellano–Bond panel data estimation frameworks; the findings of this study reveals a negative relationship between debt and growth in SSA countries. *Lopes da Veiga et al. (2016)* examined the public debt, economic growth and inflation nexus from 52 African economies, between 1950 and 2012. The findings of this study for the Southern Africa Development Community countries revealed that the highest average rate of economic growth (6.8%) is achieved when the public debt/GDP ratio is below 30% of GDP, with an average inflation rate of 11%. *Akinkunmi (2017)* uncovered the external debt-growth nexus using a panel autoregressive distributed lag (PARDL) model and panel nonlinear autoregressive distributed lag (PNARDL) model from 22 SSA countries, from 1985 to 2015. Under the PARDL model, the study finds that external debt is insignificant both in the short run and long run, whereas using the PNARDL model, the lagged per capita real GDP (error correction term) is statistically significant. *Tran (2018)* sought to assess the debt threshold for fiscal sustainability from 14 emerging economies during the period 1999–2016, and this study indicates that the turning point at which the impact of public debt on growth turned negative is pegged at 35%.

Another strand of literature focuses on South African country-specific studies. *Baaziz et al. (2015)* assessed the relationship between public debt and economic growth using annual data by adopting a smooth transition regression (STR) model, confirming that the existence of a nonlinear relationship at 31.37% growth turns negative. *Mothibi (2019)* embarked on the nexus between foreign debt and government debt on economic growth in South Africa from 1980 to 2018, using an autoregressive distributive lag model (ARDL). Analysis from that study revealed a positive relationship among foreign debt, investment and economic growth, while a negative relationship was observed among government debt, expenditure and growth. *Mhlaba and Phiri (2019)*, using the ARDL model, examined the effect of public debt on economic growth, data spanning from 2002 Q1 to 2016 Q4 and concluded that debt has a deleterious effect on growth.

Table 1

List of Studies in South Africa

Studies	Countries and sampled covered	Methodology	Result
Amoateng–Amoako-Adu, 1996	35 African countries (annual: 1983 t0 1990)	Granger's causality test	Bidirectional causality
Fosu, 1999	35 SSA countries (annual: 1980 to1990)	Augmented production function using OLS method	Negative relationship
Iyoha, 1999	Sub-Saharan African countries (annual: 1970 to 1994)	Simulation methods	Negative relationship
Poirson et al., 2002	93 developing countries (annual: 1969 to 1998)	Descriptive analysis (using debt indicators)	Nonlinear relationship
Ayadi–Ayadi, 2008	Nigeria and South Africa (anual: 1980 – 2007)	ordinary least squares (OLS) and generalized least squares (GLS)	Nonlinear relationship
Baaziz et al., 2015	South Africa (annual: 1980 to 2014)	Smooth transition Regression (STR) model	Nonlinear relationship
Hussain et al., 2015	48 SSA countries (1995 to 2012)	Granger causality test	Nonlinear relationship
Lopes da Veiga et al., 2016	52 African economies (annual: 1950 to 2012)	Descriptive analysis	Nonlinear relationship
Akinkunmi, 2017	22 SSA countries (annual: 1985 to 2015)	panel autoregressive distributed lag (PARDL) model and panel non linear autoregressive distributed lag (PNARDL) models	Nonlinear relationship
Tran, 2018	14 emerging economies (annual: 1999 to2016)	Panel threshold analysis	Nonlinear relationship
Mhlaba–Phiri, 2019	South Africa (quarter: 2002:1 to 2016:4)	ARDL	Negative relationship
Mothibi, 2019	South Africa (annual: 1980 to 2018)	ARDL	positive relationship

Source: own construction based on South Africa's Studies.

The papers listed in Table 1, predominantly focus on South Africa, and applied the ARDL model, *Engle and Granger (1987)* and *Johansen* cointegration *(1991)* techniques, emphasis either on linear assumption or with only one threshold variable and have limited applications when two or more threshold variables are needed (Table 1). Second, a long frequency with a shorter span of datasets was used. Conversely, most panel data studies uncover the effect of external debt on economic growth, while South Africa's external debt is quite low. Moreover, some of the studies assume a symmetric relationship between debt and growth, while the aforementioned studies fail to consider the asymmetric relationship and country-specific heterogeneity characteristics. Thus, this paper adds to the existing debate on the impact of public debt on economic growth, giving priority to country-specific analysis, South Africa, and nonlinear relationships when two or more threshold variables are needed. Furthermore, this paper reveals the effect of public debt on economic growth at aggregated and disaggregated levels.

2. Methodology and Data

This study applied the threshold regression model of *Hansen (2011)* to examine the effect of public indebtedness on per capita GDP growth, by capturing the nonlinear dynamics between public debt and per capita GDP growth. This model is preferred over other models because linear time series models may be too restrictive to capture economically interesting asymmetries and empirically observed nonlinear dynamics.

The single threshold regression model is formulated as follows:

$$Y_t = \theta_1 X_t + \varepsilon_t \quad q_t \leq \gamma \tag{1}$$

$$Y_t = \theta_2 X_t + \varepsilon_t \quad q_t > \gamma \tag{2}$$

where Y_t represents the explained variable; X_t represents the explaining variable; q_t represents the threshold variable; γ represents the threshold quantity; and ε_t represents the residual term. The single threshold regression model is (1) when $q_t \leq \gamma$. Moreover, the single threshold regression model is (2) when $q_t > \gamma$. The indicative function $I(debt_t \leq \gamma_1)$ is then constructed. When the condition in parentheses is met, the value is 1, otherwise it is 0. Combining the above two formulas results in the following:

$$\Delta lnGDPPC_t = \theta_1 debt_t I(debt_t \leq \gamma_1) + \theta_2 debt_t I(\gamma_1 < debt_t < \gamma_2) + \theta_3 debt_t I(\gamma_2 > debt_t) + \alpha\omega_t + \mu_t$$

where γ_1 and γ_2 are the threshold values, respectively, and θs represents the slope coefficients. I(.) is the indicator function. $\Delta lnGDPPC_t$ shows the growth rate of GDP per capita and is considered the dependent variable at time t=1, 2, T. $debt_t$ measures the debt-to-GDP ratio and is taken as a regime-regressor variable. ω is the set of control variables that consist of the gross capital formation-to-GDP ratio, gross saving-to-GDP ratio, gross government consumption-to-GDP ratio, trade openness and dummy variables of structural breaks. μ represents the error term. The endogenous variable is the real GDP per capita growth rate. In this paper, we use the debt-to-GDP ratio as the threshold variable. Since this can be correlated with a range of other factors impacting growth, we also control for a broad set of other explanatory variables. In the benchmark specification, we include the gross fixed capital formation as a share of GDP, trade openness (defined as imports plus exports as a share of GDP), gross saving-to-GDP ratio, gross government consumption-to-GDP ratio and dummy variable to structural break of economic crisis.

This model tests three sequential tests. First, it tests if the null hypothesis of no threshold is accepted; second if the null hypothesis of both no threshold and single threshold is rejected. To find the threshold effect on GDP growth, this study uses a debt-to-GDP ratio as a threshold variable. Two tests are then performed, the first being a test of the significance of the threshold effect and the second involving whether the threshold estimation value equals the true value. The bootstrap method is used to construct the P value to test the significance of the threshold effect. The $LR = -2ln(1 - \sqrt{1-\propto})$ of the likelihood ratio (LR) statistic is used to test the reliability of the threshold value, and the confidence interval of the threshold estimation value is obtained. When the double threshold effect is tested, it is assumed that the first threshold is known. If the second threshold exists, the first threshold value must be verified. Based on the practice of Hansen, first, the second threshold estimation value is determined, and then the first threshold estimation value is found with the minimum sum of squared residuals. The significance and authenticity of the double threshold effect is then tested. If all tests are passed, the above steps are repeated to estimate and test the three threshold effects.

2.1 Data source

Quarterly data covering the 1960 Q1–2019 Q3 sample period were used in this paper for estimation. The data for public debt-to-GDP ratio, domestic debt-to-GDP ratio, foreign debt-to-GDP ratio and real GDP per capita were sourced from the

South African Reserve Bank.[1] In addition, control variables such as gross fixed capital formation as a share of GDP, trade openness (defined as imports plus exports as a share of GDP), gross saving-to-GDP ratio and gross government consumption-to-GDP ratio were also sourced from the South African Reserve Bank.

The control variables were selected based on previous studies such as *(Checherita-Westphal–Rother 2012; Panizza–Presbitero 2013; Wright–Grenade 2014)* and also others, considered to be statistically significant drivers of economic growth. The gross saving-to-GDP ratio is expected to have a positive impact on economic growth to help the country finance infrastructural development, even if the country fails to access additional new loans. Trade openness is expected to have a stimulant effect on economic growth, as more open economies generate trade surpluses, needed to service external debt *(Berg–Krueger 2003)*. The gross government consumption-to-GDP ratio is expected to be inversely related to economic growth *(Barro, 1999)* because the government will execute a countercyclical fiscal policy by increasing consumption in response to lower growth and reducing consumption in response to higher growth *(Megersa, 2015)*. Gross fixed capital formation as a share of GDP inversely affects economic growth due to a perceived high risk in a country by deterring further capital supply in the case of debt burden *(Malone, 2011)*.

3. Estimation and Results

3.1 Descriptive statistics

The descriptive statistics in Table 2 show that the average value of South Africa's total debt-to-GDP ratio is 38.97 percent, the internal debt-to-GDP is 36.2 percent and the external debt-to-GDP is 2.77 percent. Out of the total 38.97 percent of the public debt-to-GDP ratio, the domestic debt-to-GDP ratio accounts for 36.2 percent, which indicates the country's major source of government borrowing. Moreover, as Table 2 depicts, a sizable fraction of South Africa's public debt is dominated by its internal debt stock. Moreover, the data show high volatility in the total public debt-to-GDP ratio and domestic (internal) debt-to-GDP ratio compared to the budget balance-to-GDP ratio and external (foreign) debt-to-GDP

[1] https://www.resbank.co.za.

ratio over the period from 1960 Q1 to 2019 Q3. South Africa's government total debt-to-GDP ratio has been rising rapidly since the global financial crisis. As shown in Figure 1, historical data revealed that public debt increased during times of economic recession and slowed during the postcrisis period, although it exploded after the global economic and financial crisis.

Table 2

Descriptive statistics from 1960 Q1 to 2019 Q3, South Africa

Denomination	DEBT–GDP ratio	DD–GDP ratio	FD–GDP ratio	LnGDP	LNGDPC
Mean	38.96987	36.20377	2.766109	12.88379	10.74954
Median	39.80000	36.30000	2.300000	12.89073	10.74658
Maximum	61.50000	54.40000	8.200000	13.60434	10.94343
Minimum	26.00000	21.90000	0.500000	11.84938	10.42706
Std. Dev.	7.414324	7.152829	1.592308	0.460679	0.121236
Observations	239	239	239	239	239

Source: own calculations based on data from *South African Reserve Bank (2020).*

3.2 Unit root test

The study performs the ADF and PP unit root tests on the first differences of all observed time series, and each test is conducted with an intercept and a trend. Table 3 presents the unit root test of the variables. The stationarity test was utilized using the ADF and PP unit root. Based on the unit root test results, the debt-to-GDP ratio, internal debt-to GDP ratio, external debt-to-GDP ratio and real GDP are integrated in the order of one I (1).

Table 3

Unit root test

Variables	ADF level (C&T)	ADF 1st d/ ce (C&T)	PP level (C&T)	PP 1st d/ce (C&T)
Debt–GDP ratio	–1.21 (0.91)	–3.52(0.039)**	–0.812 (0.96)	–16.12 (0.000)***
Internal debt–GDP ratio	–1.52 (0.82)	–3.54(0.038)**	–1.116 (0.92)	–16.13 (0.000)***
External debt–GDP ratio	–1.84 (0.68)	–13.61(0.00)***	–2.16 (0.51)	–13.66 (0.000)***
Real GDP per capita	–2.19 (0.49)	–3.56 (0.036)**	–1.88 (0.66)	–6.38 (0.000)***

Note: p values are given in the parenthesis. ** and *** are 5% and 1% level of significance.
Source: own calculations based on data from *South African Reserve Bank (2020).*

3.3 Structural Break

South Africa's economy has been affected by numerous global shocks that had various effects on the South African economy. Therefore, it is not unlikely that macro data on these variables would potentially be characterized by structural breaks during the sample period. To correct possible structural breaks, this study employs structural break tests *(Bai–Perron, 2003)*, which account for a potential endogenous structural break in the dataset. The results presented in Table 4 reveal that there is one structural break identified in 1999: Q4 and 2009: Q2 for the intercept only.

Table 4

Results of structural breaks unit root test

Breaks	F-statistic	Scaled	Weighted	Critical value	Structural break
		F-statistic			
1 *	15.85063	15.85063	15.85063	8.58	2009Q2
2 *	27.57200	27.57200	32.76562	7.22	1999Q4, 2009Q2
3 *	21.19011	21.19011	30.50523	5.96	1991Q1, 1999Q4, 2009Q2
4 *	16.22596	16.22596	27.89955	4.99	1980Q1, 1991Q1, 1999Q4, 2009Q2
5 *	14.27310	14.27310	31.32050	3.91	1971Q1, 1980Q1, 1991Q1, 1999Q4, 2009Q2

Source: own calculations based on data from *South African Reserve Bank (2020).*

3.4 Non-Linearity test

This study conducted a nonlinearity test on the residuals of the variables using the argument by *Brock et al. (1987)*. The BDS primarily confirms the presence of nonlinearity in the residuals of the variables. The BDS nonlinear independence test confirms nonlinearity for all the series (Table 5). It is important that this test is done before conducting the threshold regression, whether it is linear or not.

Table 5

BDS nonlinear independence test

Dimension	Debt-GDP ratio	DD-GDP	FD-GDP ratio	LnGDP
2	0.167633*** (0.003251)	0.170045*** (0.002849)	0.168355*** (0.003977)	0.194904*** (0.003567)
3	0.280531*** (0.005136)	0.285131*** (0.004526)	0.284876*** (0.006276)	0.333616*** (0.005659)
4	0.355959*** (0.006076)	0.364060*** (0.005384)	0.360860*** (0.007417)	0.432111*** (0.006723)
5	0.407650*** (0.006290)	0.417385*** (0.005604)	0.411830*** (0.007672)	0.502576*** (0.006989)
6	0.440061*** (0.006024)	0.451203*** (0.005396)	0.443344*** (0.007341)	0.552499*** (0.006722)

S. E is given in parentheses. ***, **, and * refer to 1%, 5% and 10% levels of significance, respectively.
Source: authors' calculations based on data from *South African Reserve Bank (2020).*

3.5 Optimal growth-maximizing total public debt threshold

Proper understanding of the level where public debt is either a stimulus to or a constraint on economic growth has a vital policy implication for the economic growth of South Africa. Table 6 shows the threshold at which economic growth rates have been declining at a time when the public debt-to-GDP ratio was increasing.

Table 6

Growth-maximizing total public debt threshold

Variables	Coefficient
Θ_1 (γ< 34.9)	0.06 (0.006) ***
Θ_2 (34.9 <=γ)	−0.21 (0.12) *
Control variables	
Gross capital formation to GDP ratio	–0.18 (–3.26) *
Gross saving to GDP ratio	0.51 (0.76)
Gross government consumption to GDP ratio	−0.66 (0.08) ***
Trade openness	1.03 (2.14) **
DUMMY (1999:Q4)	–0.58 (1.11)
DUMMY (2009:Q2)	–1.25 (0.29) ***
Test for number of threshold	
LR test for threshold effect shows the number of threshold (s) estimated, and the critical values of it are produced in square brackets.	
H0: No threshold (K = 0) [critical value]	29.58 [13.98]
H0: At most one threshold (K = 1)	10.30 [15.72]
Diagnostic checking	

R-squared	*0.394640*	*Mean dependent var*	*0.002030*
Adjusted R-squared	*0.370744*	*S.D. dependent var*	*0.006647*
S.E. of regression	*0.005273*	*Akaike info criterion*	*–7.611439*
Sum squared resid	*0.006339*	*Durbin-Watson stat*	*0.947665*
Log likelihood	*915.7612*	*Normality test*	*3.78 (0.15)*
F-statistic	*16.51502*	*LM test*	*1.48(0. 15)*
Prob(F-statistic)	*0.000000*	*ARCH(2)*	*0.55 (0.46)*

Note: *, **, and *** show level of significance at the 10%, 5%, and 1% levels, respectively. The value in parenthesis are the standard errors. The model satisfies the standard diagnostic checking such as Log L, AIC, S.D. dependent var, Normality test, DW test and ARCH(2).
Source: own calculations based on data from *South African Reserve Bank (2020).*

The LR test statistic in Table 6 shows that the value for the no threshold (29.6) is greater than the critical value of the no threshold (13.98). Thus, we reject the null hypothesis of no threshold. However, the LR test statistic value of a single threshold (10.3) is lower than the critical value of a single threshold (15.72), which

suggests that we do not reject the null hypothesis of a single threshold. The result demonstrates that the existence of single thresholds indicates that the total debt to GDP ratio's upper limit should be 34.9 percent, ceteris paribus. A threshold level of the total public debt to GDP ratio above 34.9 percent led to lower economic growth, while a level below this threshold led to stimulated economic growth. These results suggest that the positive and stimulant effects of economic growth from a rise in public debt drastically decrease when the debt level is above the threshold. Hence, when the debt-to-GDP ratio is above 34.9 percent, the impact fades away, and becomes negative for a debt-to-GDP ratio above 34.9 percent. The estimated results are presented in Table 7. Focusing on the control coefficients, the gross capital formation-to-GDP ratio, the gross government consumption-to-GDP ratio and dummy 2009 Q2 (economic crisis period 2009 Q2) adversely affect economic growth, whereas trade openness spurs economic growth. The model fulfills a variety of robustness checks.

Table 7

Optimal growth-maximizing domestic debt threshold

Variables			Coefficient
Θ_1 (γ< 30.2999)			0.27 (0.09) ***
Θ_2 (30.299 <= γ)			–0.09 (0.08)
Control variables			
Gross capital formation to GDP ratio			−0.66 (0.08) ***
Gross saving to GDP ratio			–0.03 (0.02)
Gross government consumption to GDP ratio			−0.70 (0.05) ***
Trade openness			0.06 (0.01)***
DUMMY (1999: Q4)			−0.23 (0.43)
DUMMY (2009: Q2)			−0.15 (0.04) ***
Test for number of thresholds			
LR test for threshold effect shows the number of threshold (s) estimated, and the critical values of it are produced in square brackets.			
H0: No threshold (K = 0) [critical value]			36.20687 [13.98]
H0: At most one threshold (K = 1)			7.929399 [15.72]
Diagnostic checking			
R-squared	*0.408481*	*Mean dependent var*	*0.002030*
Adjusted R-squared	*0.385131*	*S.D. dependent var*	*0.006647*
S.E. of regression	*0.005212*	*Akaike info criterion*	*–7.634568*
Sum squared resid	*0.006194*	*Durbin-Watson stat*	*1.017700*
Log likelihood	*918.5136*	*Normality test*	*0.75 (0.68)*
F-statistic	*17.49423*	*LM test*	*0.99(0. 33)*
Prob(F-statistic)	*0.000000*	*ARCH (2)*	*0.08 (0.91)*

Note: *, **, and *** show level of significance at the 10%, 5%, and 1% levels, respectively. The value in parenthesis are the standard errors. The model satisfies the standard diagnostic checking such as Log L, AIC, S.D. dependent var, Normality test, DW test and ARCH (2).
Source: own calculations based on data from *South African Reserve Bank (2020).*

As the result derived from the BDS test is nonlinear and takes the larger proportion of the total public debt-to-GDP ratio and shows a steep increase, too, conducting a threshold regression for domestic debt is mandatory. The likelihood ratio statistic for the growth-maximizing domestic debt threshold favors the single threshold model with an upper limit of 30.3 percent. The turning point at which the impact of domestic public debt on economic growth turned negative is pegged at 30.3 percent, which led to lower economic growth; below this threshold, it stimulated economic growth. Focusing on the regime-dependent coefficients, the gross capital formation to GDP ratio, the economic crisis dummy 2009 Q2, and the gross government consumption to GDP ratio tended to impede economic growth, while trade openness promotedit.

Table 8

Optimal growth-maximizing foreign debt threshold

Variables			Coefficient
Θ_1 (γ< 1.399)			1.19 (2.34) **
Θ_2 (1.399 <= γ< 4.19)			0.16 (0.03) ***
Θ_3 (4.19 <=γ)			–0.10 (0.08) *
Control variables			
Gross capital formation to GDP ratio			–0.083 (0.13)
Gross saving to GDP ratio			0.00 (0.01)
Gross government consumption to GDP ratio			–0.04 (0.02)
Trade openness			0.12 (0.04) *
DUMMY (1999: Q4)			0.10 (0.07)
DUMMY (2009: Q2)			–0.26 (0.01) *
Test for number of thresholds			
LR test for threshold effect shows the number of threshold (s) estimated, and the critical values of it are produced in square brackets.			
H0: No threshold (K = 0) [critical value]			27.06945 [13.98]
H0: At most one threshold (K = 1)			19.93433 [15.72]
H0: At most two threshold (K = 2)			11.50021 [16.83]
Diagnostic checking			
R-squared	*0.403026*	*Mean dependent var*	*0.002030*
Adjusted R-squared	*0.371188*	*S.D. dependent var*	*0.006647*
S.E. of regression	*0.005271*	*Akaike info criterion*	*–7.600180*
Sum squared resid	*0.006251*	*Durbin-Watson stat*	*1.029030*
Log likelihood	*917.4214*	*LM test*	*2.11(0. 04)*
F-statistic	*12.65841*	*ARCH (2)*	*0.10 (0.76)*
Prob(F-statistic)	*0.000000*	*Normality test*	*0.24 (0.89)*

Note: *, **, and *** show level of significance at the 10%, 5%, and 1% levels, respectively. The value in parenthesis are the standard errors. The model satisfies the standard diagnostic checking such as Log L, AIC, S.D. dependent var, Normality test, DW test and ARCH(2).
Source: own calculations based on data from *South African Reserve Bank (2020).*

We carry out in this section an examination of the threshold effect of external debt on economic growth for South Africa; the result derived from the BDS test shows that foreign debt is nonlinear and has implications for interest rates in foreign currency. The results presented in Table 8 show that the LR test statistic value for no threshold (27.07) is greater than the critical value of no thresholds (13.98), and the single threshold's LR value (19.93) is greater than the critical value of single thresholds (15.72). This implies that we reject the null hypothesis of no threshold and a single threshold and indicates that the regression has more than one threshold. Furthermore, the LR test statistic value for two thresholds (11.5) is less than the critical value of no thresholds (16.83), which implies the existence of double thresholds ($1.399 <= \gamma < 4.19$). For South Africa, there is low foreign indebtedness at 2.77 percent with a possibility of swinging the ratio to 4.19 percent. However, foreign debt levels beyond 4.19 percent might have deleterious effects on economic growth and sustainable development in the country. We can infer from the total debt-to-GDP ratio, domestic debt-to-GDP ratio and foreign debt-to-GDP ratio that the South African government should cut the total public debt and domestic debt in order to achieve robust economic growth and long-run stability of fiscal stances. Moreover, the current foreign debt-to-GDP ratio in the country is at a modest level where it can be boosted by economic growth. The the threshold regression results for the control variables revealed that trade openness stimulates economic growth, while the dummy 2009 Q2 for economic crisis is found to be significant and affects economic growth negatively in the sample period under review.

In tandem, the results of the growth-maximizing public debt threshold support several empirical works *(Reinhart–Rogoff, 2010; Herdon et al., 2013; Kumar–Woo, 2010; Cecchetti et al., 2011; Baum et al.,2013; Checherita-Westphal–Rother, 2012; Eberhardt–Presbitero, 2015; Gomez et al., 2015; Mitze–Matz, 2015; Panizza–Presbitero, 2014; Siddique et al., 2016; Woo–Kumar, 2015; Mupunga–Le Roux, 2015; Akram–Rath, 2019; Baharumshah et al., 2017)*, where economic growth stimulated at lower debt levels is targeted while impeded at higher levels of debt thresholds. Furthermore, the results revealed that the fiscal policy effectiveness of the country is evaluated by the level of debt, and the South African level of debt can hamper the health of the economy if it surpasses the tipping point. Public debt levels beyond the tipping point might hinder the ability of the country to conduct countercyclical policies, and thus may increase output volatility and reduce economic growth. Therefore, the South African government should consider diverting the composition of public debt as well as reducing the level of it. Since domestic (internal) debt is beyond the turning level where domestic debt can hamper economic growth, policymakers in the country should change the composition of total public debt and increase foreign (external) debt

within the range of the threshold to stimulate economic growth. Lastly, although these findings have been explored in the South African context, they are central to the growth-maximizing public debt threshold across sub-Saharan Africa.

4. Conclusion and Policy Implications

Obtaining the debt threshold is a central task for policymakers when designing the optimal fiscal policy. This paper highlights the relationship between public debt and economic growth and examines the total public debt as domestic and foreign debt to determine the debt threshold at a disaggregate level using nonlinear econometric techniques that provide guidance for policy options. Moreover, this paper provides a clear signal to the fiscal authorities to keep the debt level below the estimated threshold. The empirical results reveal the following points. First, the growth-maximizing public debt threshold has effects where the impact becomes negative, hampering economic progress. Specifically, we observed that debt contributes positively to economic growth if it is below 34.9 percent and transitions from positive to negative if it exceeds the estimated threshold value. Beyond this tipping point, the economy begins to suffer from a debt overhang when all its distortionary effects kick in. Second, this paper checked the effects of different components of debt on economic growth, such as the domestic debt and foreign debt threshold value. Our results show that internal debt should not exceed the estimated threshold of 30.3 percent of GDP because, above this threshold, domestic debt suppresses economic growth. On the other hand, the threshold for foreign debt should not exceed 4.19 percent of GDP. With a moderate level of domestic debt and foreign debt, fiscal policy can induce economic growth. The government of South Africa should devise the public debt composition between domestic debt and foreign debt and adjust its optimal usage to the threshold levels.

It is imperative for policymakers in South Africa to understand the growth-maximizing public debt threshold in order to formulate sound macroeconomic policies for future fiscal policy and growth prospects. First, from policy perspective, the South African government should ensure that public debt management policies are consistent with the growth-maximizing public debt threshold. The findings of this study rule out the policy option for excessive dependence on higher debt to stimulate economic growth for South Africa. Second, targeting a higher total public debt level to support economic growth could lead to restraining the long-term economic growth of the country. Moreover, it is advisable for policymakers in South Africa to consider the domestic versus foreign

debt composition in deciding the optimal level of the debt threshold and reducing the level of domestic debt. Since, the domestic debt accounts for the largest share of South Africa's public debt, maintaining a prudent fiscal stance and achieving debt stabilization will, overtime, allow South Africa's government to shift resources from servicing debt to meeting national development objectives. Third, the South African government should undertake substantial fiscal consolidation measures to reduce the debt-to-GDP ratios to prudent levels. Since the existing public debt surpasses the threshold, it will have a crowding-out effect and will impair economic growth by creating instability in the macroeconomic system. Thus, the government of South Africa has to reduce its spending by restructuring state-owned businesses and reducing fuel and energy subsidies to demonstrate the fiscal health of the country and stabilize macroeconomic conditions. In addition, to reduce costs to the government, governments should also broaden their tax bases. Future research could look into the debt structure, denomination, debt-service-to-revenue ratio, residual maturity of the debt and aging.

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