Investigating the Non-linear Effect of Public Debt on Economic Growth in SADC Region

Abstract

The study examined the non-linear effect of public debt on economic growth in Southern African Developing Communities (SADC) region for the period 2000-2018. The study estimated a Panel Smooth Transition Regression (PSTR) model to analyse the magnitude of a threshold and transition function of public debt impact to growth in SADC. The findings of the study shows that public debt has a significant non-linear effect on economic growth among SADC countries. The results reveal the threshold level of 60% at which public debt start to deter economic growth in SADC region. Hence, the study propose that policymakers in SADC ought to effectively formulate debt management policies that seeks to keep debt target within the threshold of 60% of GDP directed towards investment in productive sectors such as infrastructural development, education and training, and technological advancement which all aims at boosting long-term economic growth through active fiscal policy measures.

JEL Codes: E62, H630

Key words: Public Debt, Fiscal Policy, Growth and Panel Smooth Transition Regression

Author(s): Bongumusa Prince Makhoba, *makhobabp@gmail.com*; and **Irrshad Kaseeram**, *kaseerami@unizulu.ac.za* University of Zululand, KwaDlangezwa Campus, Faculty of Commerce, Administration and Law (FCAL), Department of Economics.

1. Introduction

A number of different countries over the years' has proven that higher level of public debt is detrimental to economic growth prospects despite their level of development. However, this has proved to hit hard the most in several developing countries where growth and development is very stagnant. The majority of SADC member states are characterised by discouraging investment climate, and low level of economic growth and development, and thus it becomes compelling for these countries to borrow even more funds from external sources to finance their economic activities towards growth and development. Generally, the government raises its revenues through printing money, collecting taxes and borrowings to maintain sustainable economic growth. The difference between government expenditure and tax revenues (budget deficit) normally forces the government to borrow in order to keep up with its obligation of fulfilling public needs and development objectives.

Numerous studies (Reinhart and Rogoff, 2010; Teles and Mussolini, 2014 and Baaziz *et al*., 2015) suggested that increasing public debt poses a negative impact on long-term economic growth. Empirical studies shows that examining the nonlinear effect of public debt and economic growth has gained popularity among different global scholars. Moreover, the significance of the study is to shade more light on existing collective scientific literature on the nonlinear relationship between public debt and growth from the context of Southern African Developing Communities (SADC).

The current study examine the impact of growing level of public debt on economic growth among SADC economies using the annual time series data ranging from 2000-2018. The study contributes to literature through assessing the non-linear effect of public debt on economic growth using fixed and time-varying threshold models. The study estimate the Panel Smooth Transition Regression (PSTR) model to investigate the non-linear relationship and threshold level at which public debt stifle economic growth, with time series data extracted from the World Development Indicators (WDI) and Quantic data. The estimation process is carried out using R Studio and Eviews 10 statistical computing software.

2. Review of Theoretical and Empirical Literature

2.1 Theoretical Literature

Romer (1986) and Lucas (1988), and Barro's (1990) pioneered the endogenous growth theory suggesting that public debt could have a positive effect on economic growth depending on the kinds of public investments financed by public debt. A certain level of public debt directed towards productive sectors and sustainable public goods could spur economic growth (Checherita-Westphal and Rother, 2012). Conversely, Barro's (1990) asserted that public debt has a negative long-run impact on economic growth through crowding-out effect. The negative impact of high public debt expose the country to macroeconomic illness, sovereign risk and affect the effectiveness of public expenditure (Teles and Cesar Mussolini, 2014).

The neoclassical theory regard fiscal policy as sustainable if public debt to GDP ratio of the country is stable for a long-term period. The neoclassical prescriptions suggest that if the country has the real economic growth rate that is below real interest rate, and with a budget deficit, this implies that fiscal policy is unsustainable to stimulate long-term economic growth (Fourie and Burger, 2003). A majority of SADC member states operate under economic conditions where real interest rate exceed real GDP growth rate, and with substantial budget deficit, hence according to the neoclassical principles, this fiscal policy stance is unsustainable to promote long-term economic growth.

2.2 Empirical Perspectives

A study carried out by Reinhart and Rogoff (2010) examine the role of public debt on economic growth among 20 advanced economies for the period 1946-2009. The study found a negative correlation between government debt and economic growth. They suggest that effect fade away when public debt falls below the debt threshold of 90% of GDP. This study became the first study to discover the threshold effect of public debt to growth. Moreover, Reinhart and Rogoff (2010) was later criticised by Herndon et al. (2013) on the accuracy of 90% debt threshold level. Herndon et al. (2013) corrected for a number of methodological errors and applied different weighting data methods. The study suggest that debt level of 90% of GDP cannot be defended that they consistently reduce a country's economic growth.

Taylor *et al*, (2011) studied the effect of fiscal deficits and government debt on economic growth in the USA using a VAR model for a period 1961-2011. The study found a strong positive effect primary deficit on economic growth. The study suggest that in order to achieve low fiscal deficit and high growth, the government ought to focus more on improving economic activities through fiscal policy. A study conducted by Ghosh *et al.*, (2013) assess fiscal fatigue, fiscal space and debt sustainability in 23 advanced economies with panel data fixed effect over the period 1970-2007. The results show a strong evidence of fiscal fatigue and the marginal response of primary balance to debt is non-linear. This relationship becomes positive at moderate debt level but start to decrease when debt level approach about 90-100% of GDP, and start to become negative as the debt ratio reach 150% of GDP.

Another study conducted by Checherita-Westphal and Rother (2012) scrutinise a non-linear effect of public debt on economic growth among 12 European countries for the period 1990-2008, employing a non-dynamic panel method on growth expressed as a quadratic functional form of debt. The study found a non-linear effect of debt on economic growth with a threshold level of 90% to 100% of debt-GDP ratio. Baum et al. (2013) studied similar relationship using same set of countries applying dynamic panel threshold method for the period 1990-2010. The results reveal a significant positive impact of public debt on growth for debt-to-GDP ratio below the threshold of 67%. Furthermore, a significant negative effect of debt-to-GDP ratio above the 95% threshold level (Antonakakis, 2014).

The work of Checherita-Westphal *et al*., (2014) used a panel data for OECD and European countries to investigate fiscal sustainability utilising growth-maximizing debt target, which comprise of public debt target that government ought to maintain in order to be successful in maximising output level. The findings of the study propose that euro area ought to target debt level of 50% of GDP if member states have a common public debt target. A study carried out by Teles and Mussolini (2014) examine how the size of the debt-to-GDP ratio affect long-term economic growth. The study estimated the GMM and OLS model using unbalanced panel data of 74 countries for the period 1972-2004. They proposed a theoretical endogenous growth model in which the government use public debt to improve productive expenditure. The study found a negative impact of the public debt-to-GDP ratio to the effect of fiscal policy on long-term economic growth. The results reveal that an increase in government expenditure lead to a rise in output, however a negative effect was also observed through a rise in tax burden on consumers and government indebtedness as necessary measures to finance the public spending.

A study carried out by Baaziz *et al*., (2015) assessed the relationship between accumulating public debt and real GDP in South Africa for the period 1980-2014. Their study discovered that public debt becomes negative to economic growth if public debt to GDP reaches the 31.37% threshold. Jacobo and Jalile (2017) investigated the effect of government debt on economic growth in 16 Latin American economies. The study used a panel fixed-effect estimation technique for a period 1960-2015. They found a positive effect of debt on GDP growth in the short-run, however, the findings also shows that this effect decreases almost to zero at the threshold between 64% and 71% of debt-to-GDP ratios.

3. Research Methodology

As previously mentioned, study examine the nonlinear effect of public debt on economic growth in SADC. The study employed the panel data of 14 SADC countries, namely, Angola, Botswana, Congo (DRC), Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland, Seychelles, Tanzania, Zambia and Zimbabwe, covering the period 2000-2018. The study used GDP as an endogenous variable, and explanatory variables include public debt (PD), squared public debt (PD^2), gross fixed capital formation (GFCF) and government expenditure (GOE). A proposed model specification of the study is expressed as follows:

$$lnGDP = \alpha_0 + \beta_1 PD + \beta_2 PD_t^2 + \beta_3 lnGFCF + \beta_4 GOE + \varepsilon_t \qquad (1)$$

In the above equation, we transform GDP and GOE into natural logarithmic form since these two variables are in monetary values. This process allows us to interpret $\beta_{1,2,3\ldots}$ as elasticities and to and also to mitigate heteroscedasticity in our model. Our supporting models (PDOLS and PFMOLS) require all variables to be stationarity before estimating the model. Hence, testing for stationarity is very paramount, this also allows us to avoid estimating spurious regression if the data series is non-stationary. The study employed the Im-Pesaran-Shin (IPS), Levin and Lin (1993), and Fisher-type Choi (2001) to test for the unit root among variables.

3.1 Panel Smooth Transition Regression (PSTR) Model

The study adopt a PSTR model proposed by González et al. (2005) to ascertain the potential non-linear effect of public debt on economic growth among SADC countries. A PSTR model is an extended version of the panel threshold regression (PTR) model developed by Hansen (1999). This panel data model allow regression coefficients to vary over time and across cross-sectional units or individuals. The PSTR generalises the PTR by allowing the regression coefficients to change smoothly when moving from one extreme regime to another (Gonzalez *et al*, 2017). Therefore, we express the PSTR with threshold of two extreme regimes and a single transition function to illustrate relationship between public debt and growth. According to González *et al.*, (2017), the basic PSTR with two extreme regimes and a single transition function can be written as follows:

$$Y_{it} = \alpha_i + \lambda_t + \beta'_0 X_{it} + \beta'_1 X_{it} g(q_{it}; \gamma, c) + \varepsilon_{it} \tag{2}$$

Where the endogenous variable $\boldsymbol{Y_{it}}$(GDP) is a scalar, $\boldsymbol{X_{it}}$ is a vector of time-varying exogenous variables (PD, PD^2, GOE and GFCF). $i = 1 \ldots, N, t = 1 \ldots, T$, and N and T represent the cross-section and time dimension of the panel, respectively. $\boldsymbol{\alpha_i}$ and $\boldsymbol{\lambda_t}$ denote fixed individual effects and time effects, respectively, and $\boldsymbol{\varepsilon_{it}}$ are error terms in the system. The transition function $\boldsymbol{g}(\boldsymbol{q_{it}}; \boldsymbol{\gamma}, \boldsymbol{c})$ in (1) is a continuous function of the observable threshold variable $\boldsymbol{q_{it}}$ (public debt) and is normalised to be bounded between zero and one. $\boldsymbol{\gamma}$ represent the slope parameter that denotes the smoothness of the transition from one regime to the other, and $\boldsymbol{c}$ is the threshold parameter (public debt-GDP threshold). The value of transition variable $\boldsymbol{q_{it}}$ determines the value of $\boldsymbol{g}(\boldsymbol{q_{it}}; \boldsymbol{\gamma}, \boldsymbol{c})$ and thus effective regression coefficients $\boldsymbol{\beta_0} + \boldsymbol{\beta_1} \boldsymbol{g}(\boldsymbol{q_{it}}; \boldsymbol{\gamma}, \boldsymbol{c})$ for individual at time (Gonzalez *et al*, 2017).

In line with González et al. (2005), following the work of Granger and Teräsvirta (1993), Teräsvirta (1994), and Teräsvirta et al. (2010), the logistic transition function for the time series STAR models can be represented as follows:

$$g(q_{it}; \gamma, c) = \left(1 + exp\left(-\lambda \prod_{j=1}^{m} (q_{it} - c_j)\right)\right)^{-1} \quad with\, \gamma > 0 \;and\; c_1 < c_2 < \cdots < c_m \tag{3}$$

Where $c = (c_1 \ldots \ldots, c_m)$ is an m-dimensional vector of location parameters, and the slope parameter γ determines the smoothness of the transition. A PSTR can be generalised into an additive model with more than two different regimes as follows:

$$y_{it} = \mu_i + \lambda_i + \beta'_0 x_{it} + \sum_{j=1}^{r} \beta'_j x_{it} g_j\left(q_{it}^{(j)}; \gamma_j, c_j\right) + \varepsilon_{it} \tag{4}$$

Where the transition function $g_j\left(q_{it}^{(j)};\gamma_j,c_j\right)$, $j=1\ldots,r$ depend on the slop parameters γ_j and on location parameters c_j. If $r=1, q_{it}^{(j)}=q_{it}$, and $\gamma_j\to\infty$ for all $j=1\ldots,r$, the transition function becomes an indicator function, then the above model (3) becomes a PTR model with $r+1$ regimes. Hence, PSTR can be viewed as generalised PTR with multiple regimes in Hansen (1999).

According to González et al. (2005), a PSTR ought to follow the following specification procedure which include testing for the linearity against the PSTR model, parameter output estimation; and testing for number of transition function.

3.1.1 Testing for linearity

González et al. (2005) assert that testing for linearity in a PSTR model test the null hypothesis of $H_0{:}\,\beta_1=0$. However, Hansen (1999) suggest that this test is non-standard because under this null hypothesis, the PSTR model contains unidentified nuisance parameters. Hence, González et al. (2005) adopt a possible solution by replacing $(q_{it};\gamma,c)$ in equation (1) with its first-order Taylor expansion round $\gamma=0$ and test the linearity hypothesis of $H_0{:}\,\gamma=0$, obtain the following auxiliary regression:

$$y_{it}=\mu_i+\beta_1'^{*}x_{it}+\beta_2'^{*}x_{it}q_{it}+\cdots\beta_m'^{*}x_{it}q_{it}^{m}+\varepsilon_{it}'^{*} \quad (5)$$

Where $\beta_1'^{*}\ldots,\beta_m'^{*}$ are vectors of parameters which are multiples of γ an

d $\varepsilon_{it}^{*}=\varepsilon_{it}+R_m\beta_1^{*}x_{it}$, where R_m is the remainder of the Taylor expansion. Hence, testing for $H_0{:}\,\gamma=0$ in equation (1) is equivalent to testing the $H_0^{*}{:}\,\beta_1'^{*}+\cdots+\beta_m'^{*}=0$ in equation (4). Thus, this null hypothesis can tested using a Wald and Likelihood ratio tests. The Wald LM test can be written as follows:

$$LM_W=\frac{NT(SSR_0-SSR_1)}{SSR_0} \quad (6)$$

Meanwhile, the Fischer LM test can be written as follows:

$$LM_F=\frac{NT(SSR_0-SSR_1)/mk}{SSR_0/(TN-N-mk)} \quad (7)$$

Moreover, the Likelihood ratio test can be presented in the following equation:

$$LR = -1[\log(SSR_1) - log(SSR_0)] \tag{8}$$

Where SSR_0 is the panel sum of squared residuals under H_0 (linear panel model with individual effects) and SSR_1 is the panel of sum of squared residuals under H_1 (PSTR model with m regimes).

3.1.2 Parameter estimation

The estimation of parameters $(\beta_0', \beta_1', \gamma, c)$ within a PSTR in equation (1) involves the fixed-affects estimator and nonlinear least squares (NLS). This is done by first eliminating the individual effects by removing individual-specific means, and then we apply NLS to the transformed data. The NLS is applied to determine the values of these parameters that minimise the concentrated sum of squared errors (Thanh, 2015 and González et al., 2017).

3.1.3 Testing for the Number of Transition Functions

Testing for a number of transition functions within a PSTR framework test the null hypotheses of no remaining non-linearity in the transition function. When testing for the number of transition functions, we assume that the linearity hypothesis is rejected (González et al., 2005). Furthermore, we test whether there is one transition function $H_0: r = 1$ or two transition functions $H_0: r = 2$. Consider an auxiliary regression model with $r = 2$ regimes:

$$y_{it} = \mu_i + \beta_0'^{*} x_{it} + \beta_1'^{*} x_{it} g_1(q_{it}^1; \gamma_1, c_1) + \beta_2'^{*} x_{it} g_2(q_{it}^2; \gamma_2, c_2) + \varepsilon_{it}^{*} \tag{9}$$

The null hypothesis stating that there is no remaining heterogeneity in an estimated three-regime PSTR model can be expressed as $H_0: \gamma_2 = 0$. We replace the transition function, $g_2(q_{it}^2; \gamma_2, c_2)$ by the Taylor expansion around $\gamma_2 = 2$ and then in testing linear constraints on the parameters. Therefore, the above equation (8) can be expressed as follows:

$$y_{it} = \mu_i + \beta_0'^{*} x_{it} + \beta_1'^{*} x_{it} g_1(q_{it}^1; \gamma_1, c_1) + \theta x_{it} q_{it} + \varepsilon_{it}^{*} \tag{10}$$

Testing for no remaining nonlinearity is expressed as $H_0: \theta = 0$. SSR_0 denote the panel sum of squared residuals under H_0, while SSR_1 represent the sum of squared residuals of the transformed model in a PSTR model with one transition function. Given a PSTR model with

$r = r^*$, the null hypothesis $H_0: r = r^*$ is tested against the alternative $H_1: r = r^* + 1$. If H_0 is not rejected, this procedure cannot proceed. Otherwise the null hypothesis $H_0: r = r^* + 1$ is tested against $H_1: r = r^* + 2$. This procedure continue until we accept the null hypothesis on no remaining heterogeneity.

4. Empirical Results

4.1 Formal Panel Unit Root Tests

This part report the results of the formal unit root tests to ascertain stationarity among variables. As mentioned earlier, the study employed the Im, Pesaran, and Shin (2003) (IPS), Levin, Lin and Chu (2002) (LLC) and Fisher-type Choi (2001) (FSR) to test for unit root among the variables within a panel framework. These tests are conducted the based on the null hypothesis stating that the series has a unit root. Therefore, we reject the null hypothesis if t-statistic is greater than the critical value, implying that there is no unit root. Conversely, if the t-statistic is smaller than the critical value, we accept the null hypothesis.

Table 1: Unit Root Test Results

TESTS	GDP	PD	PD^2	GFCF	GOE
IPS W-stat					
Levels	-2.6255***	-4.9280***	-5.1632***	-3.9733***	-4.5807***
[*P-value*]	[0.0043]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Differences	-9.8360***	-11.5512***	-11.5512***	-11.4062***	-11.7349***
[*P-value*]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
LLC t*-stat					
Levels	-2.0135**	-1.4878*	-1.4645*	-2.579038***	-2.9099***
[*P-value*]	[0.0220]	[0.0684]	[0.0715]	[0.0050]	[0.0018]
Differences	-7.8538***	-5.4588***	-5.5575***	-7.1996***	-7.1254***
[*P-value*]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Fisher-type					
Levels	0.3474	6.2621***	7.9593***	3.4984***	3.6704***
[*P-value*]	[0.3641]	[0.0000]	[0.0000]	[0.0003]	[0.0001]
Differences	29.3239***	53.6777***	53.9926***	48.6736***	52.9641***
[*P-value*]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]

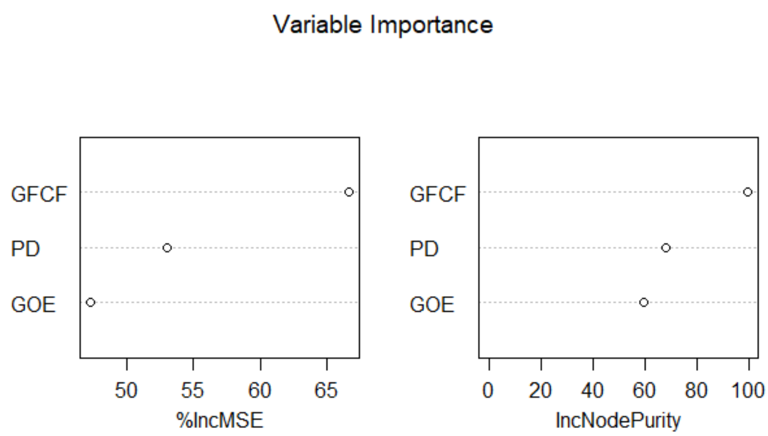
Notes: Asterisks ***, ** and * denotes the statistical level of significance at 1%, 5%, and 10%, respectively. The [*p*-values] are shown in parenthesis.

Source: Researcher's Estimations.

The above results of unit root test clearly shows that all variable are stationary in their level form. The IPS is chosen as the main test over LLC, simply because the LLC does not account for heterogeneity bias in a panel framework. The LLC and FSR test ought to complement and confirm the IPS findings. The IPS test indicate that all variables are stationary in levels at 1% level of significance. The LLC also shows that all variables are I(0). The FSR shows that GDP is I(1) while other variables are I(0). The conclusion on the order of integration is drawn upon the IPS test results, i.e. all variables are I(0).

Figure 1: Determining the Variable of Importance

Figure 2 below allows us to determine the variable of importance when ordering our variable for model specification of a panel data model.



Author's own estimation using R Studio.

The above diagram shows the importance of each of the variable included in the model specification for model estimation. The exogenous variables that were tested include GFCF, PD and GOE, on GDP as an endogenous variable. The results shows that gross fixed capital formation (GFCF) is the most exogenous variable contributing to economic growth in SADC region, followed by public debt (PD) and government spending (GOE), respectively.

4.2 Panel Smooth Transition Regression Model

4.2.1. Results of Linearity Test

Table 4.1 reports the linearity tests results which indicate that the null hypothesis stating that the model is linear is rejected by all applicable tests, thus implying that the relationship between public debt and economic growth in the SADC region is indeed nonlinear.

Table 4.1: Linearity Tests

Test	m = 1		m = 2	
	Statistic	p-value	Statistic	p-value
Lagrange Multiplier – Wald (LM_W)	12.29	0.006***	19.73	0.003***
Lagrange Multiplier – Fischer (LM_F)	3.199	0.024**	2.530	0.022**

Note: (***), (**) and (*) denote significance level at 1%, 5% and, respectively.
H_0: Linear model, and H_1: PSTR model with m = 1 or m = 2.
Author's own estimation using R Studio.

Testing homogeneity of the coefficients of these country-specific variables, implies that we assume that macroeconomic effects on growth do not differ across countries. The linearity test helps to determine whether the order m is one or two. The result of linearity shows the p-value of Lagrange multiplier test for the null hypothesis of linearity against the alternative of logistic (m=1) or exponent (m = 2) PSTR specification. The results indicate that the null hypothesis of linearity under LM_W test is strongly rejected at the 1% level of significance, and LM_F is rejected at 5% significance level. Furthermore, the rejection of linearity is stronger when m = 1, hence, the logistic specification (m = 1) is preferred to exponential specification (m = 2). The wild bootstrap (WB) test also identified a specific transition variable with p-values that are practically equal to zero. This finding implies that there is a non-linear relationship between public debt and growth in the SADC region. Hence, the study proceed with the estimation of the PSTR model in order to test the non-linear effect, the transition function and the threshold of public debt on growth among SADC countries.

4.2.2. Sequence of homogeneity tests for selecting order m of transition function

Table 4.2: Homogeneity tests for selecting order m of transition function

```
Sequence of homogeneity tests for selecting number of switches 'm':
------------------------------------------------------------------------------------
LM tests based on transition variable 'PD'
  m   LM_X        PV  LM_F        PV HAC_X     PV  HAC_F     PV WB_PV WCB_PV
  1 12.290 6.449e-03 3.199 2.442e-02 2.831 0.4184 0.7368 0.5312   0.0   1.00
  2  7.811 5.009e-02 2.003 1.148e-01 1.824 0.6098 0.4676 0.7052   0.5   0.25
  ----------------------------------------------------------------------------------
```

Author's own estimation using R Studio.

The above table present the sequence of homogeneity tests for selecting the order m of the logistic transition function in a PSTR model for growth with public debt (PD), gross fixed capital formation (GFCF) and government expenditure (GOE) for a balanced panel of 14 SADC countries over the period 2000 - 2018. The results provide the sequence test for PD only as a transition variable due to brevity, however, the results for other variables are available upon request. Table 4.2 report the results of the specification test sequence for all variables in order to determine the order m of the logistic transition function. The LM, HAC and WCB test indicate that m=1 is the best choice, while WB is not informative as its p-value is equal to zero. Therefore, the study proceed with estimation of the following PSTR model:

$$\begin{aligned} LGDP_{it} &= \mu_i + \lambda_i + \beta_{11}PD_{i,t-1} + \beta_{12}LGFCF_{i,t-1} + \beta_{13}GOE_{i,t-1} \\ &\quad + \left(\beta_{21}PD_{i,t-1} + \beta_{22}LGFCF_{i,t-1} + \beta_{23}GOE_{i,t-1}\right)g\left(PD_{i,t-1};\gamma,c\right) + \varepsilon_{it} \end{aligned} \quad (4.4)$$

Where λ_i represent the fixed time effects, and

$$g\left(PD_{i,t-1};\gamma,c\right) = \left(1 + \exp\left(-\gamma\left(PD_{i,t-1} - c\right)\right)\right)^{-1}, with\ \gamma > 0. \quad (4.5)$$

4.2.3. Results of No Remaining Non-Linearity

Table 4.3: No remaining nonlinearity tests

```
No remaining nonlinearity (heterogeneity) test
  m  LM_X       PV  LM_F     PV HAC_X     PV  HAC_F     PV
  1 52.66 0.008919 1.124 0.3115    26 0.7213 0.5549 0.9727
-----------------------------------------------------------------
WB and WCB no remaining nonlinearity (heterogeneity) test
  m WB_PV WCB_PV
  1     1      1

*****************************************************************
```

H_0: PSTR with one threshold; and H_1: PSTR with at least two thresholds.
Author’s own estimation using R Studio.

Estimating the PSTR requires one to test for no remaining nonlinearity. Table 4.3 presents the result of no remaining non-linearity test after assuming that the PSTR has two regimes. The study provide a strong evidence of that the null hypothesis of no remaining nonlinearity (r = 1) cannot be rejected by all tests, except LM_X test. However, the LM_F, HAC, WB and WCB reject this null hypothesis, thus implying that the PSTR model has one threshold and two regimes in the context of the SADC region. On the other hand, null hypothesis without threshold (r = 0) and the one with at least two thresholds (r = 2) are both rejected by all of these tests. This result implies that there is only one threshold level of public debt which separates the low debt regime from the high debt regime in SADC region. The study further estimate the PSTR which applies the nonlinear least squares to data that is free from individual effects.

4.4. Parameter consistency test

Table 4.4: Parameter consistency

Parameter constancy test

m	LM_X	PV	LM_F	PV	HAC_X	PV	HAC_F	PV
1	64.46	0.0003893	1.376	0.1041	26	0.7213	0.5548	0.9727

Author's own estimation using R Studio.

The study further tests the adequacy of the two-regime PSTR model by applying the misspecification tests of parameter constancy. The above Table 4.4 report the results of parameter constancy which indicate that the estimated PSTR model with one threshold on two regimes is adequate. Moreover, the findings also shows that the WB and WCB tests which take into account both heteroscedasticity and possible within-cluster dependence suggest that the estimated PSTR model with a single transition and two regimes is adequate, however, this result is not displayed due to brevity but available upon request.

4.5. Results of a two-regime PSTR model

Table 4.5: PSTR estimates

Panel smooth transition regression (PSTR) model		
Endogenous variable : GDP		
Explanatory variables	**Low regime** $\beta_{0j} \times 100$	**High regime** $(\beta_{0j} + \beta_{0j}) \times 100$
Public debt(PD)	**0.07** (0.005)	**-0.18**** (0.0009)
Gross capital formation(GFCF)	**-1.02***** (0.006)	**0.016** (0.004)
Government expenditure(GOE)	**1.34**** (0.007)	**2.10***** (0.008)
Dummy variable (Dummy)	**0.39** (2.36)	**2.23*** (0.41)
Transition Parameters		
Threshold (c)		**60.38***** (0.08)
Slope (γ)		**18.41***** (3.91)
# of obs.		**280**
# of countries		**14**

Author's own estimation using R Studio.

Table 4.5 presents the estimated parameters for a PSTR model with a single transition function and two regimes. As mentioned earlier, one of the requirements for estimating a PSTR is to test for no remaining linearity in the model. The nonlinear relationship between public debt and economic growth in the SADC region has only one threshold or two regimes as displayed in Table 4.3 for no remaining non-linearity. Hence, the study estimate the PSTR by applying nonlinear least squares to a panel data eliminated for the individual effects.

Table 4.5 report the results of the PSTR for 14 SADC member states for the period 2000-2018. The findings reveal that public debt has a nonlinear relationship with economic growth in SADC region. Consistent with the expectations, the public debt threshold level is found to be 60% for the SADC region, which is not significantly different from the finding of Baum et al. (2013) studied the nonlinear effect of public debt on growth in 12 European countries and found the debt threshold target of 67%. Checherita-Westphal *et al.*, (2014) also investigated the effect of public debt on growth and found a debt threshold level of 50% among OECD and European countries.

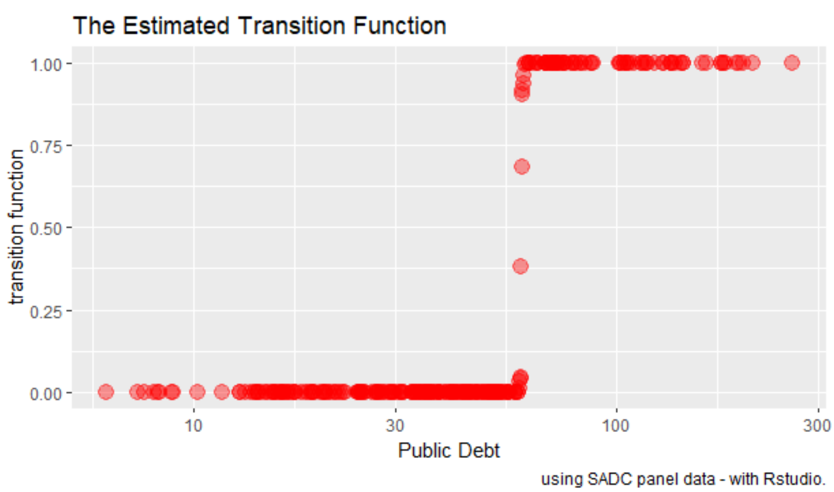
The estimated debt threshold level for SADC region is significantly higher than the 31.37% threshold level found by Baaziz *et al.*, (2015) for South Africa. The intuitive logic for this huge margin may be the fact that South Africa is the most developed country among other member states of the entire SADC region and to a certain extent pursues more advanced macroeconomic policies than other developing SADC member states. Moreover, the estimated threshold level is lower than the findings reported by Reinhart and Rogoff (2010), and Checherita-Westphal and Rother (2012), where both studies reported a threshold level of 90% of debt to GDP ratio for advanced. The findings of the study is theoretically plausible since developed countries have more capacity in term of efficiency, capacity and growth level to borrow and repay its long-term debt as compared to developing countries.

Furthermore, SADC member states are classified as non-industrialised, low/middle income, or developing countries and thus share same economic characteristics and pursue similar macroeconomic policies as other developing regions around the world, hence the economic conditions may be different from developed regions, such as Euro zone and United Kingdom. Hence some macroeconomic conditions in the SADC region may be similar to the economic conditions of other developing countries elsewhere such as Asian countries and South America. Therefore, the estimated debt threshold of 60% in the SADC region is considered to be at a reasonable level for a region that is consists of only developing countries.

The coefficients of all variables, except for the coefficient of GFCF, are statistically significant in the high debt regime. The signs of coefficients for all the variables are theoretically plausible and in line with several scientific literature conducted on the effect of public debt on economic growth across different countries. Under a low debt regime, the coefficient of public debt is found to be 0.7 but statistically insignificant. On the other hand, for high debt regime, public debt coefficient is estimated to be -0.18 and statistically significant at 1%. This finding implies that the effect of government debt on growth is positive and not strong when debt level is below the threshold of 60%, but the effect becomes negative and severe when debt level reach and goes beyond the estimated the threshold level of 60%.

The coefficient of gross fixed capital formation is positive and statistically significant at 1% in the low regime as suggested by the Solow growth model. This findings is also in line with prior empirical studies carried out by Vinayagathasan (2013), and Thanh (2015). A significant positive sign of gross fixed capital formation suggests that fiscal policymakers of SADC member countries can stimulate economic growth by promoting both domestic and foreign investment. However, a negative sign of GFCF in the high debt regime is not plausible and unexpected since economic theory as advocated by Solow growth model postulates that investment project enhance long-term economic growth. Moreover, the unexpected sign of the GFCF coefficient in the high debt regime may be attributable to the issue of data quality in the SADC region. Government spending is found to have a positive impact on growth in both low and high regime, however for a low regime, the effect is insignificant, and for a high regime the impact is statistically significant at 1% significance level. This finding is theoretically plausible since it is consistent with the theoretical framework proposed by Keynes (1936) in his theory of economic development.

Figure 1: Estimated transition function of the PSTR model.



Author's own estimation using R Studio.

Figure 1 above shows the transition function plotted against the threshold of public debt. As previously mentioned, the results reveal that the relationship between public debt and economic growth in SADC region has only one threshold or two regimes. The estimated transition plot in figure 1 provide strong evidence that the change from a low public debt regime to a high debt regime is smooth but relatively gradual. This is shown by the estimated low transition parameter of 18.41. This estimated low transition parameter suggests that fiscal policymakers in the SADC region need to act with caution when the government debt level reaches the estimated threshold level. The results shows that the transition function with respect to public debt as a transition variable has a threshold value c = 60.38 and transition parameter $\boldsymbol{\gamma} = 18.41$.

5. Conclusion and Policy Prescriptions

The investigation of a nonlinear effect of public debt on economic growth has not receive much attention in the context of African developing countries, particularly in SADC region. Fiscal policymakers in both advanced and developing countries normally resort to government borrowings from financial institution such as International Monetary Fund (IMF), World Bank (WB) or other countries in order to bridge the gap between excessive government spending and low revenue, or to advance a certain macroeconomic objective of the country. As mentioned earlier, the current study examined the nonlinear relationship between public debt and economic growth for a panel of SADC countries by applying a PSTR model which precisely determines the debt threshold level endogenously. The study employed a panel data for SADC countries over the period 2000-2018. The study estimated the threshold value and the coefficient of the slope through the use of endogenous regressors which include GDP per capita, public debt, gross fixed capital formation (investment) and government expenditure. The major advantage of the PSTR is that this model is a relatively new panel data econometric estimation technique which has the ability of estimating the smoothness of the function that links the low regime with the high regime.

The findings of the study provide strong evidence of a nonlinear relationship between public debt and economic growth in SADC region. The debt threshold level for SADC region is estimated to be 60%, above which public debt is detrimental for growth, and statistically at the 1% level of significance. Moreover, the coefficients of all variables estimated through the PSTR model are consistent with prior empirical studies. The speed of transition from low to high regime is relatively smooth but gradual. This suggests that there is no strong pressure for fiscal policymakers in SADC to engage in government borrowings as a mechanism to restore long-term growth when public debt reach the estimated threshold level. The results postulates that fiscal policymakers ought to be cautious and curb public debt when it approaches or goes beyond the estimated threshold value to enhance economic growth in the region. The study propose that SADC fiscal policymakers should consider the level of public debt below the threshold of 60% to promote sustainable economic stability, development and growth. The findings reveal that SADC member states ought to target the threshold level of 60% debt to GDP in order to achieve desired macroeconomic objectives.

References

Aizenman, J., Kletzer K. and Pinto B. (2007). Economic Growth with Constraints on Tax Revenues and Public Debt: Implications for Fiscal Policy and Cross-Country Differences. NBER Working Paper No. 12750.

Antonakakis, N., (2014). Sovereign debt and economic growth revisited: The role of (non) sustainable debt thresholds.

Baaziz, Y., Guesmi, K., Heller, D. and Lahiani, A, (2015). Does public debt matter for economic growth? Evidence from South Africa. *Journal of Applied Business Research*, *31*(6), pp.2187-2196.

Barro, R. (1990). Government Spending in a Simple Model of Endogenous Growth. *The Journal of Political Economy*, 98 (5): S103 - S125.

Baum, A., Checherita-Westphal, C. and Rother, P. (2013). Debt and growth: New evidence for the euro area. Journal of International Money and Finance, 32: 809-821.

Checherita, C., Rother, P. (2012). The Impact of high Government Debt on Economic Growth and its Channels. *European Economic Review*, 56 (7): 1392–1405.

Checherita-Westphal, C., Hallett, A.H. and Philipp, R., (2014). Fiscal sustainability using growth-maximizing debt targets. *Applied Economics*. Vol. 46 (6): 638-647.

Fourie, F.C. and Burger, P., (2003). Fiscal sustainability and the South African transformation challenge. *South African Journal of Economics.* Vol. 71(4): 806-829.

Ghosh, A.R., Kim, J.I., Mendoza, E.G., Ostry, J.D. and Qureshi, M.S. (2013). Fiscal fatigue, fiscal space and debt sustainability in advanced economies. *The Economic Journal*, 123 (566).

Herndon, T., Ash, M., Pollin, R., (2013). Does high public debt consistently stifle economic growth? A critique of Reinhart and Rogoff. Cambridge Journal of Economics.

Jacobo, A. D., & Jalile, I. R. (2017). The Impact of Government Debt on economic Growth: An Overview for LatinAmerica (No. 28/2017). Università di Perugia, Dipartimento Economia.

Reinhart, C. M., Rogoff, K. S., (2010). Growth in a time of debt. *American Economic Review.* Vol. 100 (2): 573-578.

Romer, P. (1986). Increasing Returns and Long-Run Growth. Journal of Political Economy, 94 (5): 1002 - 1037.

Taylor, Lance, Proano, Christian R., Carvalho, Laura de and Barbosa, N. (2011). Fiscal Deficits, Economic Growth, and Government Debt in the USA. Schwartz Center for Economic Policy Analysis and the Department of Economics, The New School for Social Research, Working Paper Series.

Teles, V.K. and Mussolini, C.C. (2014). Public debt and the limits of fiscal policy to increase economic growth. *European Economic Review*, 66: 1-15.

Thanh, S.D. (2015). Threshold effects of inflation on growth in the ASEAN-5 countries: A Panel Smooth Transition Regression approach. *Journal of Economics, Finance and Administrative Science*, *20*(38), pp.41-48.

Vinayagathasan, T. (2013). Inflation and economic growth: A dynamic panel threshold analysis for Asian economies. *Journal of Asian Economics*, 26(1), 31–41.