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# Non-linear Effects of Public Debt on Economic Growth in Southern Africa Development Community (SADC) Countries

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## ABSTRACT

Over the years, public debt has been an important source of funding the growth and development projects for developing countries. As a result, public debt size in these countries has risen substantially over the past decades. In particular, sub-Saharan African countries' public debt levels have reached unprecedented levels in recent decades, thereby, making the debate on its role in the growth process particularly important. This study contributes to the public debt and economic growth nexus by investigating the non-linear effects of public debt on economic growth in Southern African Development Community (SADC) with the aid of a non-linear autoregressive distributed lag model (NARDL) within a panel framework. Results from the study confirm the existence of non-linearity between public debt and economic growth in the long run. This indicates that public debt drives growth before counteracting it upon reaching the threshold level. The results show that public debt threshold stands at 57% of GDP for the SADC in the long run. The study concludes that public debt is an important expansionary fiscal policy in SADC if put into productive use and contained within an optimal range.

**JEL Classification:** H63, E62
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## INTRODUCTION

Over the years, public debt has been an important source of funding the growth and development projects for several countries (Ouedraogo, 2015). As a result, public debt has risen substantially over the past decades, with the size of governments also expanding in parallel. In particular, sub-Saharan African countries' public debt levels have reached unprecedented levels in recent decades, thereby, making the debate on its role in the growth process particularly important (Drine and Nabi, 2010). Of more concern is the fact that these debt levels have become unsustainable for most countries in sub-Saharan Africa. Findings by Loser (2004) and Iyoha (1999) state that African countries' government debt levels have remained unsustainable since the beginning of the multi-national debt crisis in the early 1980s. This condition was worsened by the spillover effect of the financial crisis in 2007/2008. The financial crisis was occasioned by the unwinding US subprime mortgage market, which led to economic recession in many countries, as subsequent discretionary fiscal loosening and banking industry bail-outs by various governments contributed to a sharp rise in public debt for many countries (Balazs, 2013).

Meanwhile, government debt has become one of the major economic problems for the developed countries also. This is due to the global crisis, and expansionary fiscal policies have caused rapid increases in government borrowing and the resulting unsustainable public debt in some European countries such as Greece, Portugal, Spain and Italy. This situation has aroused the attention of policy makers and researchers to the scourge of excessive indebtedness in the affected countries**.** The unsustainability of public debt in several developing countries and some developed countries, has received adequate empirical research (Reinhart and Rogoff, 2010a; Reinhart and Rogoff, 2011; Balazs, 2013; Lopes da Veiga et al., 2014). However, there is no consensus in the literature about the manner of the impact of public debt on economic growth. Empirical studies in this direction have largely followed a non-linear pattern more recently, with most findings indicating that government borrowing can impact economic growth positively or negatively, depending on the level of borrowing. While a negative effect of public debt on long-run growth is consistent with both neo-classical and endogenous growth models, the positive effect of public debt on growth is in line with the stance of Keynesians**,** who hold that increased debt is a requirement for economic recovery (Oleksandr, 2003; Saint-Paul, 1992; Diamond, 1965). Some of the studies that investigate the non-linear effect of public debt on economic growth with varying findings include Reinhart and Rogoff (2010a), Reinhart and Rogoff (2010b), Caner et al. (2010), Herndon et al. (2014), and Pescatori et al. (2014).

This paper aims at investigating the non-linear effect of public debt on economic growth in Southern Africa Development Community (SADC) countries. While the few recent academic articles on this subject deal prevalently with developed countries (Reinhart and Rogoff, 2010b), empirical work for low- and middle-income countries is limited, and most efforts in this direction for African countries deal exclusively with public external debt. This can be ascribed to the lack of reliable data on domestic debt for a large sample of countries, which, according to Reinhart and Rogoff (2011) accounts for almost two-third of public debt. Also, as claimed by Panizza (2008) and Hanson (2007), several developing and emerging countries started substituting external debt with domestic debt since the 1990s. This paper therefore seeks to contribute to a better understanding of the implication of public debt levels in developing countries by investigating the non-linear effect of public debt on economic growth in SADC countries.

## REVIEW OF LITERATURE

The relationship between public debt and economic growth has for a long time been a subject of discourse and controversy in economic literature. However, empirical debates on this subject matter have consequently revolved around non-linear effects and unsustainability of public debt. The overwhelming findings show that government debt might have positive and negative impact on economic growth. Presbitero (2010) carried out a panel analysis of low- and middle-income countries over the period 1990-2007. His empirical efforts show that public debt has a negative impact on output growth up to a threshold of 90 percent of GDP, beyond which its effect becomes irrelevant. He argued that non-linear effect can be explained by country-specific factors since debt overhang is a growth constraint only in countries with sound macro-economic policies and stable institutions.

Checherita-Westphal and Rother (2012) investigate the relationship between public debt and economic growth in 12 Euro region countries for the period 1990 to 2010. They employed a dynamic threshold panel methodology in order to analyze the non-linear impact of public debt on GDP growth. Their empirical results suggest that the short-run impact of debt on GDP growth is positive and highly statistically significant, but decreases to around zero and loses significance beyond public debt-to-GDP ratios of around 67%. They also argue that high debt-to-GDP ratios (above 95%) has a negative impact on economic activity. They conclude that the long-term interest rate is subject to increased pressure when the public debt-to-GDP ratio is above 70%. Cecchetti et al. (2011) were concerned with the research question of when does debt change from good to bad impacts? The concern was consequent upon their theoretical position that moderate levels of debt improves welfare and enhances growth. Consequently, they investigated this question for 18 OECD countries from 1980 to 2010. Their empirical results support the view that, beyond a certain level, debt is a drag on growth. For government debt, the threshold is around 85% of GDP in this case. The immediate implication is that countries with high public debt must act quickly and decisively to address their fiscal problems. The longer-term lesson is that, to build the fiscal buffer required to address extraordinary events, governments should keep debt well below the estimated thresholds. Their examination of other types of debt yields similar conclusions. When public debt goes beyond 90% of GDP, it becomes a drag on growth. In addition, for household debt, a threshold of around 85% of GDP is reported, although the impact is very imprecisely estimated. Their empirical positions support the earlier findings such as Iyoha (1999), Drine and Nabi (2010), and Reinhart and Rogoff (2010a).

Motivated by their findings and the earlier position of Reinhart and Rogoff (2010a) that substantial economic growth decline was observed for advanced economies with a debt ratio above 90%. They explore the relevance of the exogenous threshold and reveal an endogenously-estimated threshold around a debt-to-GDP ratio of 115%, above which the negative debt-growth link changes sign. They argued that, although higher public debt reduces growth for debt ratios below the threshold considered by Reinhart and Rogoff (2010a), this negative effect is declining as debt increases. Their findings emphasized the presence of non-linearities in the effect of debt on growth for debt ratios above 90%. They submitted that debt still reduces growth for countries with a debt-to-GDP ratio below a threshold estimated at around 115%, as acknowledged by Reinhart & Rogoff (2010a).

Meanwhile Lopes da Veiga et al. (2014) analyze the implications of public debt on economic growth and inflation in a group of 52 African economies between 1950 and 2012. Their results indicate high levels of public debt affect economic growth negatively, with an inverted U-shape behaviour regarding the relationship between economic growth and public debt. They argued that the highest average rates of real and per capita growth are achieved when public debt reaches 60% of the real GDP and at an average inflation rate of 8.2%. The highest rate of economic growth is recorded when the ratio of public debt/GDP is below 30% of GDP and corresponds to an average inflation rate of 5.3%. However, the highest growth rate of the GDP and GDP *per capita* is registered when the public debt/GDP ratio is in the second interval (30-60%). For SADC countries, the highest average rate of economic growth (6.8%) is similar to North African countries, when the ratio public debt/GDP is below 30% of GDP, with an average inflation rate of 11%. Eberhardt and Presbitero (2015) were motivated by the theoretical arguments and data considerations, and as a result investigated the debt–growth nexus adopting linear and non-linear specifications, employing novel methods and diagnostics from the time-series literature adapted for use in the panel and they also examined the long-run relationship between public debt and growth in a large panel of countries. Their empirical findings support a negative relationship between public debt and long-run growth across countries, but no evidence for a similar, let alone common, debt threshold within countries.

Balázs (2013) attempted to put the Reinhart-Rogoff dataset to a more econometric testing to determine whether public debt has a negative non-linear effect on growth when public debt exceeds 90% of GDP. He made use of non-linear threshold models and show that the negative non-linear relationship between debt and growth is significantly sensitive to modelling choices. He concludes that when non-linearity is detected, the negative non-linear effect kicks in at much lower levels of public debt (between 20% and 60% of GDP).

## RESEARCH METHODOLOGY

Empirical studies generally prefer the non-linear approach when analyzing the effect of public debt on economic growth. Against this backdrop, the study adopts a standard quadratic relationship between public debt and economic growth which can be written as:

$$Y_{it} = \alpha_i + \beta_1 PD_{it} + \beta_2 PD^2{}_{it} + \beta_3 X_{it} + \varepsilon_{it} \quad (1)$$

Where the subscripts $i$ and $t$ represent the cross-section unit and time period, respectively, $Y$ is economic growth measured by per capita GDP, $PD$ is public debt–to-GDP ratio, $X$ is the set of control variables, $\alpha_i$ is the country-specific effect, $\beta_1, \beta_2,$ and $\beta_3$ are the coefficients to be estimated, and $\varepsilon_{it}$ is the error term. As regards the control variables used in this study, investment, government expenditure, inflation rate and trade openness have been suggested by existing literature (Panizza and Presbitero, 2012; Presbitero, 2010), and they make up the set of control variables for the study.

The main focus of this study is to determine the significance and magnitude of $\beta_1$ and $\beta_2$, wherein it is hypothesized that the relationship between public debt and economic growth can be U-shaped or inverted U-shaped depending on the sign for $\beta_1$ and $\beta_2$, if both coefficients turn out to be significant. If $\beta_1$ is negative and $\beta_2$ is positive, the public debt-economic growth nexus follows a U-shaped non-linear relationship. On the other hand, if $\beta_1$ is positive and $\beta_2$ is negative, then the relationship between the two variables follows an inverted U-shaped non-linear pattern. However, if both of them carry the same sign, then the relationship between public debt and economic growth is linear. The public debt threshold can be obtained by first estimating the first-order partial derivative of equation (1) with respect to $PD$ and setting it equal to zero, then solve for the amount of public debt (as a percentage of GDP) to get the following as a candidate for an optimum:

$$\widehat{PD} = \frac{-\beta_1}{2\beta_2} \quad (2)$$

To investigate the long-run cointegrating relationship among the variables, the Autoregressive Distributed Lag (ARDL) procedure is proposed by Pesaran et al. (2001). Over the years, several econometric techniques have been proposed in the literature to investigate long-run cointegration amongst the variables. Cointegration techniques for univariate analysis include Engle and Granger (1987) and the fully modified OLS approach of Phillips and Hansen (1990). As regards multivariate cointegration analysis, the popular technique is the maximum likelihood procedure of Johansen (1988) and Johansen and Juselius (1990) which is preferred over other traditional techniques because it gives more than one cointegrating relation and overcomes small sample bias, besides being a multivariate procedure. However, one major drawback of all these techniques lies in their requirement for all variables to be integrated of the same order.

Meanwhile, the ARDL procedure allows the estimation of long-run cointegration relationship amongst variables, regardless of whether the variables are all integrated of order zero, integrated of order one, or are partially integrated between orders zero and one. In this regard, the ARDL techniques is particularly suitable for this study as all the variables are a combination of *I*(0) and *I*(1) variables. In addition to the aforementioned, the superiority of ARDL procedure over other cointegration techniques also lies in the fact that it affords the exploration of the short-run relationship with the error correction term, which indicates the speed of adjustment, following initial divergence from equilibrium, by employing the ARDL-ECM framework. Furthermore, endogeneity problems are avoided with the use of ARDL method. To this end, the following ARDL equation formulated from equation (1) is estimated to examine the cointegration relationship:

$$\begin{aligned}\Delta lnY_{it} = {} & \beta_0 + \beta_1 lnY_{i,t-1} + \beta_2 PD_{i,t-1} + \beta_3 (PD_{i,t-1})^2 + \beta_4 INV_{i,t-1} + \beta_5 GEX_{i,t-1} + \beta_6 INF_{i,t-1} \\ & + \beta_7 TRD_{i,t-1} + \sum_{i=1}^{p} \alpha_i \Delta lnY_{i,t-1} + \sum_{j=0}^{q} \alpha_j \Delta PD_{i,t-1} + \sum_{k=0}^{r} \alpha_k \Delta INV_{i,t-1} + \sum_{l=0}^{s} \alpha_l \, \Delta GEX_{i,t-1} \\ & + \sum_{m=0}^{t} \alpha_m \Delta INF_{i,t-1} + \sum_{n=0}^{u} \alpha_n \Delta TRD_{i,t-1} + \epsilon_{it}\end{aligned} \quad (3)$$

where $lnY$ is the log of GDP per capita, $PD$ is general government gross debt as a percentage of GDP, $INV$ is investment, proxied by gross capital formation, $GEX$ is government expenditure, $INF$ is inflation rate, and $TRD$ is trade openness. The terms $p, q, r, s, t$ and $u$ represent the optimal lag length respectively, while $\epsilon_{it}$ is a normally distributed error term with zero mean and constant variance. Identifying cointegration among the variables involves two important steps. First, equation (3), is estimated using the ordinary least squares technique. Second, the null hypothesis of no cointegration ($H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = 0$) is tested against the alternative hypothesis of the existence of long-run relationship ($H_1: \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq \beta_7 \neq 0$). The existence of long-run association is examined by comparing the value of the F-statistic obtained, based on the Wald test with the two critical values (upper and lower bounds) provided by Pesaran et al. (2001). If the F-statistic value is greater than the critical value of the upper bound, then the null hypothesis of no cointegration among the variables is rejected; if it falls below the critical value of the lower bound, then the null hypothesis of no cointegration amongst the variables cannot be rejected; if it falls between the critical values of the lower and upper bounds, then the result is inconclusive.

For the purposes of this analysis, a total of 19 years annual data is used covering the period 1998 to 2016 for the 16 countries that make up the Southern African Development Community (SADC). The countries are Angola, Botswana, Comoros, Democratic Republic of Congo, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe. The data on general government gross debt as a percentage of GDP, which is a measure of public debt are extracted from the IMF's World Economic Outlook (WEO), while data on GDP per capita which measures economic growth, gross capital formation as a percentage of GDP which measures investment, gross national expenditure as a percentage of GDP which measures government expenditure, inflation (consumer prices), and trade as a percentage of GDP which measures trade openness are all sourced from the World Bank's World Development Indicator (WDI).

## RESULTS AND DISCUSSION

Table 1 shows the descriptive statistics of the variables. The mean and median of LGDP, INV and GEX are very close in values, which implies that their distributions are nearly symmetrical. This is an indication of very low variability, as opposed to other variables whose variability is relatively high. The skewness statistics reveals that all the variables are positively skewed. The Jarque-Bera probability values for all the variables are below the 0.05 critical level. This suggests a rejection of the null hypothesis of normal distribution for all the variables at 5 per cent level of significance. The absence of normality in their distribution may be as a result of the cross-sectional and heterogeneous nature of the data employed in the study. However, such heterogeneities are corrected for in panel data analysis.

Table 1 Descriptive statistics

| Variable | LGDP | PD | INV | GEX | INF | TRD |
|---|---|---|---|---|---|---|
| Mean | 7.3667 | 56.1059 | 21.7632 | 110.5288 | 214.7237 | 90.4418 |
| Median | 7.1397 | 42.5685 | 20.8682 | 108.9253 | 6.9632 | 80.2682 |
| Maximum | 9.5135 | 260.9640 | 55.3626 | 164.7184 | 24411.03 | 225.0231 |
| Minimum | 5.5082 | 6.2280 | 1.5251 | 59.1820 | -9.6161 | 25.0419 |
| Std. Dev. | 1.1869 | 42.9523 | 8.9831 | 17.1336 | 1955.921 | 38.9007 |
| Skewness | 0.1297 | 1.6207 | 0.5772 | 0.6599 | 10.4573 | 0.9388 |
| Kurtosis | 1.5590 | 5.8006 | 3.5976 | 4.1126 | 114.3203 | 3.5500 |
| Jarque-Bera | 26.3500 | 232.4521 | 21.4085 | 37.7494 | 162508.6 | 48.4906 |
| Probability | 0.0002 | 0.0000 | 0.0022 | 0.0000 | 0.0000 | 0.0000 |
| Sum | 2173.20 | 17056.19 | 6616.015 | 33600.74 | 65276.00 | 27494.32 |
| Sum Sq. Dev. | 414.179 | 559004.8 | 24451.03 | 88949.68 | 1.16E+09 | 458520.0 |
| Observations | 304 | 304 | 304 | 304 | 304 | 304 |

While the ARDL approach to cointegration is applicable whether the variables are all integrated of order zero or of order one, it is still necessary to carry out unit root tests on the variables in order to be sure that no I(2) variable is involved, as its presence renders the Fisher-statistic for testing cointegration invalid. The results of the Levin, Lin and Chu (LLC), Im, Pesaran and Shin (IPS), Augmented Dickey-Fuller (ADF), and Phillips Peron (PP) panel unit root tests carried out on the variables are presented in Table 2. Individual intercept was

included in the test equation for each of the unit root tests, while the lag length for each variable was automatically selected by the Schwarz Information Criterion (SIC).

As shown in Table 2, inflation rate and government expenditure are integrated of order zero at 1% and 10% levels of significance respectively, with only ADF indicating significance at 5% for government expenditure. Meanwhile, government expenditure becomes stationary at 1% significance level at first difference. Furthermore, all the tests are in agreement that LGDP, public debt, investment and trade openness are all stationary at first difference at 1% significance level. It is also noteworthy that according to LLC, all the variables, except public debt, are stationary at levels. Hence, the choice of panel ARDL for the analysis is justified, given the integration properties of the variables in the model employed.

Table 2 Panel Unit root tests

| Variable | Level | LLC | P-v | IPS | P-v | ADF | P-v | PP | P-v |
|---|---|---|---|---|---|---|---|---|---|
| LGDP | 0 | -2.14 | 0.02** | 0.99 | 0.84 | 24.64 | 0.82 | 22.58 | 0.89 |
| | 1 | -7.58 | 0.00*** | -5.89 | 0.00*** | 96.54 | 0.00*** | 128.36 | 0.00*** |
| PD | 0 | -0.96 | 0.17 | 0.87 | 0.81 | 18.61 | 0.97 | 16.84 | 0.99 |
| | 1 | -4.17 | 0.00*** | -4.47 | 0.00*** | 75.06 | 0.00*** | 133.33 | 0.00*** |
| $PD^2$ | 0 | -1.95 | 0.03** | 0.45 | 0.67 | 24.28 | 0.83 | 33.52 | 0.39 |
| | 1 | -5.51 | 0.00*** | -4.92 | 0.00*** | 84.18 | 0.00*** | 139.48 | 0.00*** |
| INV | 0 | -2.31 | 0.01** | -0.95 | 0.17 | 38.89 | 0.19 | 43.6 | 0.08 |
| | 1 | -9.78 | 0.00*** | -9.17 | 0.00*** | 140.48 | 0.00*** | 239.89 | 0.00*** |
| GEX | 0 | -1.45 | 0.07* | -1.54 | 0.06* | 47.58 | 0.04** | 43.01 | 0.09* |
| | 1 | -6.19 | 0.00*** | -8.11 | 0.00*** | 124.19 | 0.00*** | 405.15 | 0.00*** |
| INF | 0 | -5.44 | 0.00*** | -4.52 | 0.00*** | 80.73 | 0.00*** | 91.83 | 0.00*** |
| | 1 | -11.29 | 0.00*** | -11.83 | 0.00*** | 180.09 | 0.00*** | 807.35 | 0.00*** |
| TRD | 0 | -2.29 | 0.01** | -1.28 | 0.10 | 41.95 | 1.11 | 41.05 | 0.13 |
| | 1 | -7.44 | 0.00*** | -7.77 | 0.00*** | 120.22 | 0.00*** | 209.49 | 0.00*** |

Notes: P-v denotes probability value. ***, **, and * represent significance at 1%, 5% and 10% levels of significance respectively.

Next, the ARDL bounds testing is applied to investigate the cointegrating relationship among the variables. The result of the bounds test procedure is presented in Table 3, which shows that the calculated value of the F-Statistic (15.72) is greater than the 95% upper bound critical value (3.79). This result indicates a rejection of the null hypothesis of no cointegration and confirms that there is a long-run association among the variables at 5% level of significance. This, in turn, enables the examination of the long-run results based on the panel ARDL. Moreover, the dynamic results to identify the short-run effects are also examined.

Table 3 Bounds test for cointegration

| F-Statistic | 95% Lower Bound | 95% Upper Bound |
|---|---|---|
| 15.70 | 2.62 | 3.79 |

The long-run estimations are provided in Table 4. The results reveal that there is a double impact of public debt on economic growth in the SADC countries which confirms the existence of non-linearity. This indicates that public debt enhances growth before counter-acting it upon reaching a certain threshold. This result is implied by the significance of the public debt variables ($PD$ and $PD^2$) and the opposite signs of their coefficients. The inference that can be deduced from this finding is that an unrestrained accumulation of debt stock slows down economic growth in the SADC area in the long run. Hence, initiatives to reduce the debt stock in the community could be a veritable step towards enhancing the growth level in the area. This result is in agreement with some previous findings such as Iyoha (1999), Drine and Nabi (2010), and Reinhart and Rogoff (2010a) which claim that excessively high stock of debt is deleterious to economic growth in developing countries. However, it contradicts the finding of Herndon et al. (2013) who conclude that the rates of economic growth when public debt exceeds the estimated threshold of 90% of GDP are not dramatically different from when public debt-to-GDP ratio are lower.

Given the inverted U-shaped relationship between public debt and economic growth, the public debt threshold in the relationship is obtained as equation$(2)$, that is, by solving the first derivative of growth with respect to public debt equated to zero. Upon solving the equation, a public debt threshold that stands at 57% of GDP for is realized in respect of the sample under study. This implies that beyond this level of public debt, accumulation of debts becomes deleterious to growth in SADC.

Both investment and trade openness have positive impacts on economic growth in the long run. A unit increase in investment would lead to a 0.05% increase in economic growth at 1% level of significance, while a unit increase trade openness would enhance growth by 0.02% at 1% level of significance. Inflation has a negative impact on economic growth in the long run, as a unit increase in inflation rate would slow down growth minimally at 1% significance level. The coefficient of government expenditure is insignificant, indicating that government expenditure does not affect economic growth in the long run.

Table 4 Panel ARDL long-run estimates

| Variable | Coefficient | Std. error | t-Statistic | Prob. |
|---|---|---|---|---|
| PD | 0.44520 | 0.1608 | 2.7683 | 0.0004** |
| $PD^2$ | -0.00390 | 0.0017 | -2.3259 | 0.0283** |
| INV | 0.04840 | 0.0150 | 3.2257 | 0.0015*** |
| GEX | 0.01080 | 0.0075 | 1.4369 | 0.1526 |
| INF | 0.000060 | 2.22E-05 | -2.7413 | 0.0068*** |
| TRD | 0.01970 | 0.0052 | 3.7694 | 0.0002*** |

Note: ***, **, and * represent significance at 1%, 5% and 10% levels of significance respectively.

The short-run estimations are provided in Table 5. As opposed to the case in the long run, the public debt coefficients in the short run are both negative and insignificant, which implies that in the short run, public debt does not have impact on economic growth in the sample under study. Furthermore, the relationship between public debt and economic growth in the sample does not follow a nonlinear pattern in the short run. Similarly, inflation and trade openness do not have significant impact on economic growth in the short run. However, investment and government expenditure have significant coefficients in the short run. In the case of investment, the coefficient is negative, which indicates that an increase of by one unit in investment would enhance economic growth marginally in the short run at 1% level of significance. The coefficient of government expenditure is negative, implying that that a unit increase in government expenditure would slow down growth marginally in the short run at 1% significance level.

Another important result in the short-run estimations is that of the error correction term (ECT). The coefficient of the ECT is expected to be negative, less than unity and significant, if long-run relationship exists among the variables in the model. This condition is satisfied in the model as shown in Table 5, further reinforcing the result of the bound test for cointegration earlier discussed. It could therefore be concluded that roughly 1% of the disequilibrium in the previous years is corrected within one year. It also indicates a relatively slow convergence to the long-run equilibrium.

Table 5 Panel ARDL short-run estimates

| Variable | Coefficient | Std. error | t-Statistic | Prob. |
|---|---|---|---|---|
| D(PD) | -5.52E-05 | 0.0016 | -0.0337 | 0.9731 |
| $D(PD^2)$ | -2.57E-05 | 4.42E-05 | -0.5803 | 0.5625 |
| D(INV) | 0.0022 | 0.0007 | 3.1272 | 0.0021*** |
| D(GEX) | -0.0020 | 0.0004 | -4.8597 | 0.0000*** |
| D(INF) | 0.0007 | 0.0005 | 1.1930 | 0.2345 |
| D(TRD) | 0.0002 | 0.0004 | 0.5373 | 0.5917 |
| $ECM_{t-1}$ | -0.0099 | 0.0035 | -2.8035 | 0.0228** |

Note: ***, and ** represent significance at 1%, 5% and 10% levels of significance respectively.

## ROBUSTNESS CHECK

To test the robustness of our results, an alternative cointegration technique, namely the group mean panel fully modified ordinary least squares (FMOLS), advanced by Pedroni (2000) is also employed to estimate our model. This technique is esteemed for its ability to control for the endogeneity bias of the regressors by integrating the semi-parametric correction of Phillips and Hansen (1990) to the OLS estimator. Furthermore, FMOLS estimators are adjusted for serial correlation, thereby improving the efficiency of the estimates. Before proceeding to panel FMOLS estimation, panel unit root tests and test for cointegration are conducted on our variables, all in logarithm form.

The results of the panel unit root tests are presented in Table 6. Four different panel unit root tests were carried out, namely Levin, Lin and Chu (LLC), Im, Pesaran and Shin (IPS), Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. Individual intercept was included in the test equation for each of the unit root tests, while the lag length for each variable was automatically selected by the Schwarz Information Criterion (SIC). Almost all the tests failed to reject the null hypothesis that the variables contain unit root at level. At first differences, however, all the tests reject the null hypothesis of non-stationarity. These results indicate that all the variables are stationary at first differences or are generated by an I(1) process.

Table 6 Panel Unit root tests

| Variable | Level | LLC | P-v | IPS | P-v | ADF | P-v | PP | P-v |
|---|---|---|---|---|---|---|---|---|---|
| LGDP | 0 | -2.14 | 0.02** | 0.99 | 0.84 | 24.64 | 0.82 | 22.59 | 0.89 |
| | 1 | -7.59 | 0.00*** | -5.89 | 0.00*** | 96.54 | 0.00*** | 128.36 | 0.00*** |
| LPD | 0 | -0.52 | 0.30 | 0.84 | 0.79 | 19.58 | 0.96 | 16.34 | 0.99 |
| | 1 | -4.53 | 0.00*** | -4.47 | 0.00*** | 72.69 | 0.00*** | 128.94 | 0.00*** |
| $LPD^2$ | 0 | -0.59 | 0.28 | 0.91 | 0.82 | 18.88 | 0.97 | 15.68 | 0.99 |
| | 1 | -4.08 | 0.00*** | -4.36 | 0.00*** | 71.59 | 0.00*** | 129.06 | 0.00*** |
| LINF | 0 | -1.66 | 0.05* | -0.94 | 0.17 | 41.94 | 0.11 | 51.94 | 0.10 |
| | 1 | -7.69 | 0.00*** | -7.83 | 0.00*** | 123.32 | 0.00*** | 264.58 | 0.00*** |
| LINV | 0 | 0.05 | 0.52 | -0.8 | 0.21 | 18.93 | 0.96 | 22.03 | 0.91 |
| | 1 | -12.44 | 0.00*** | -10.15 | 0.00*** | 161.94 | 0.00*** | 233.69 | 0.00*** |
| LGEX | 0 | -1.10 | 0.13 | -1.34 | 0.09* | 43.66 | 0.18 | 43.12 | 0.11 |
| | 1 | -5.87 | 0.00*** | -8.11 | 0.00*** | 124.34 | 0.00*** | 411.59 | 0.00*** |
| LTRD | 0 | -0.49 | 0.31 | -1.3 | 1.00 | 22.77 | 0.89 | 21.03 | 0.93 |
| | 1 | -7.59 | 0.00*** | -7.72 | 0.00*** | 119.47 | 0.00*** | 189.5 | 0.00*** |

Note: ***, ** and * represent significance at 1%, 5% and 10%, respectively.

Having confirmed that all the variables are generated by an I(1) process, the next step is to test for the presence of cointegrating relationship among the variables. For this test, we employed the panel cointegration approach suggested by Pedroni (1997, 1999) for investigating cointegration in heterogeneous panels. This cointegration technique is based on seven panel cointegration statistics, developed by Pedroni (1997, 1999). Four of these statistics are within-dimension based statistics and are called panel cointegration statistics, while the remaining three are between-dimension based statistics and are called group mean panel cointegration statistics. The results of the panel cointegration tests are reported in Table 7. To ensure robustness, two different tests were carried out, one with intercept and trend, and the other with intercept only. Results from the Table shows that for the model with intercept and trend, five out of the seven statistics reject the null hypothesis of no cointegration. On the other hand, results for the model without trend show that four out of the seven statistics reject the null hypothesis of no cointegration. Overall, results from these cointegration tests support the presence of long-run association among the variables.

Table 7 Panel Cointegration test results

| | With trend | | Without trend | |
|---|---|---|---|---|
| | Statistic | Prob. | Statistic | prob. |
| Panel v-stat | 1.932658 | 0.0266** | -3.144306 | 0.9992 |
| Panel rho-stat | 4.084908 | 1.0000 | 3.246881 | 0.9994 |
| Panel pp-stat | -2.59176 | 0.0048*** | -1.43457 | 0.0357** |
| Panel adf-stat | -3.165037 | 0.0008*** | -1.66553 | 0.0479** |
| Group rho-stat | 5.651137 | 1.0000 | 4.622756 | 1.0000 |
| Group pp-stat | -1.416695 | 0.0483** | -1.641205 | 0.0504* |
| Group adf-stat | -2.521485 | 0.0058*** | -2.241924 | 0.0125** |

Note: ***, **, * represent significance at 1%, 5% and 10%, respectively.

Having confirmed cointegration, we go ahead with the panel group mean FMOLS estimations, as reported in Table 8. The results suggest that public debt has a nonlinear effect on economic growth, given the opposite signs and the statistical significance of the two public debt variables. Specifically, the positive and negative signs of public debt and its squared term, respectively, implies that the relationship between public debt and economic growth follows an inverted U-shaped pattern, thereby supporting the results of our panel ARDL regression. In addition, the public debt threshold from our panel FMOLS estimations is estimated as 26% of GDP, as opposed to 57% derived in our panel ARDL regression. This implies that below this threshold, public debt enhances growth, while it depresses it above the threshold. Also, the results of the control variables

are similar to those in our main estimation, with the exception of the inflation variable which bear negative sign in our panel FMOLS estimation, as opposed to its positive sign in the panel ARDL regression. Overall, the results of Table 6 are consistent with that of Table 5, thereby confirming that our results are robust to the panel FMOLS estimation.

Table 8 Panel FMOLS results

| Variable | Coefficient | Std. Error | t-Stat | Prob. |
|---|---|---|---|---|
| LPD | 0.502186 | 0.03456 | 14.53104 | 0.0000*** |
| $LPD^2$ | -0.00981 | 0.00329 | -2.97226 | 0.0032*** |
| LINF | -0.10341 | 0.05129 | -2.01587 | 0.0449** |
| LINV | -0.02358 | 0.04353 | -0.54167 | 0.0589* |
| LGEX | 0.06522 | 0.03281 | 1.98764 | 0.0479** |
| LTRD | 0.00892 | 0.03339 | 0.26725 | 0.0895* |

Note: ***, ** and * represent significance at 1%, 5% and 10%, respectively.

## CONCLUSIONS

The nexus between public debt and economic growth has, in recent time, centered on nonlinear effects of public debt on economic growth. Earlier studies have been largely preoccupied with the effects of public debt on economic growth. This present study contributes to this discourse by examining the nonlinear effects of public debt on economic growth in Southern African Development Community. The ARDL bounds testing was applied to investigate the cointegrating relationship among the variables. This result indicates a rejection of the null hypothesis of no cointegration and confirms that there is a long-run association among the variables at 5% level of significance. The results reveal that there is a double impact of public debt on economic growth in the SADC countries in the long run. This finding confirm the existence of nonlinearity between public debt and economic growth in the long run. This indicates that public debt drives growth before counteracting it upon reaching the optimal or threshold level. A public debt threshold was computed that stands at 57% of GDP for the sample under study, which implies that beyond this level of public debt, accumulation of debts becomes deleterious to growth in SADC. As opposed to the case in the long run, the public debt coefficients in the short run are both negative and insignificant, which implies that in the short run, public debt does not have impact on economic growth in the sample under study. Furthermore, the relationship between public debt and economic growth in the sample does not follow a nonlinear pattern in the short run. Consequently, if put into productive use and contained with optimal range, public debt would continue to have positive impacts on economic growth.

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