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**Article**

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## FINANCIAL ECONOMICS | RESEARCH ARTICLE

# Macroeconomic determinants of long-term sovereign bond yields in South Africa

Sheunesu Zhou<sup>1\*</sup>

**Abstract:** This paper seeks to analyse the impact of government debt and other macroeconomic variables on the long term bond yield for South Africa. Recent increases in the government budget deficit and its corresponding borrowing has renewed interest in understanding fiscal dynamics within the economy. The study employs both the linear and non-linear Auto-regressive distributed lag (ARDL) technique to estimate the determinants of the long-term bond yield. Our results show that the short-term interest rate is the major determinant of the long term yield in both the short-run and long-run. Government debt and the US long term yield positively impact long term bond yields both in the short- and long-run. The rate of inflation, economic growth, nominal effective exchange rate and bank credit all have negative effects on the bond yield in the long-run. Tests for non-linearity reveal that the short-term interest rate has an asymmetric relationship with the long-term bond yield. However, we only establish non-linearity between government debt and bond yields in the long-run. We suggest complementarity between monetary policy and fiscal policy, a systematic program of deleveraging and implementation of structural changes aimed at increasing production.

**Subjects:** Macroeconomics; Econometrics; Public Finance; Investment & Securities

**Keywords:** government bond yield; government debt; short-term interest rate; non-linear ARDL

**JEL classifications:** C51; E43; E62

### ABOUT THE AUTHOR

Sheunesu Zhou is an Economist based at the University of Zululand. His research interests include Financial Economics, Macroeconomics, Development Economics and Entrepreneurship.

### PUBLIC INTEREST STATEMENT

Long term government bond yields represent the interest rate payable on government's long term borrowing and also signal the level of sovereign risk for a country. Higher bond yields signal higher costs of borrowing and are a function of the country's risk profile. Countries which are considered less risk such as advanced economies borrow at low rates compared to emerging markets and developing economies. Thus understanding the drivers of the long term bond yields in South Africa is imperative as it points to the sources of sovereign risk. This analysis is necessitated by recent increases in public debt in South Africa and the credit rating downgrades experienced by the country recently. This paper finds a positive relationship between public debt and long term bond yields for South Africa.

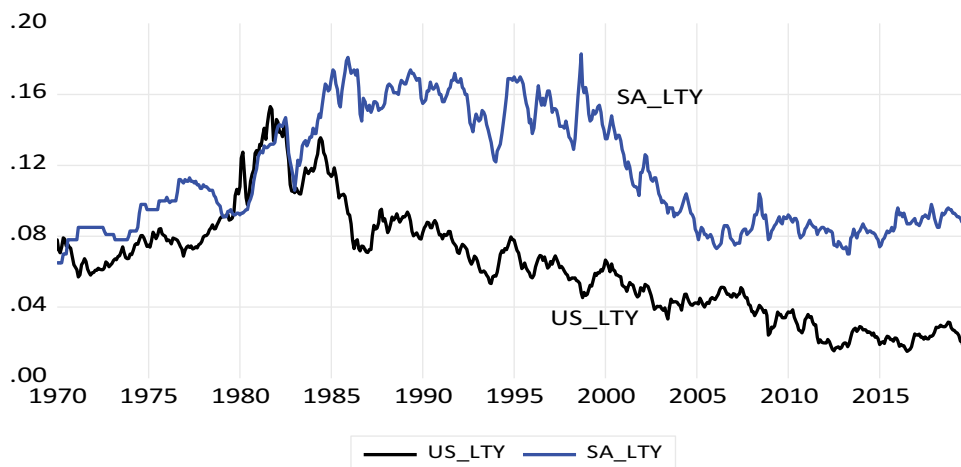
### 1. Introduction

The rate of interest at which the government borrows is determined by both domestic and external economic factors. Primarily a functional and growing economy tends to provide signal to investors of the ability of the borrower (government) to service debt. On the contrary, widening fiscal deficits accompanied by slow growth increases both the stock of debt and the interest rate on debt to compensate for high credit risk. South Africa has experienced an increase in fiscal budget deficits in the past 12 years, with an accompanying upsurge in government debt to Gross Domestic product (GDP) ratio, reaching 63% by the first quarter of 2020. The result has been several credit rating downgrades by credit rating agencies. In view of this development, we reckon the need to investigate the relationship between the long-term government bond yield and its determinants in South Africa, focusing specifically on the impact of government debt. Recent studies covering different countries have given mixed results, with some finding a positive relationship as expected from theory, whilst others do not find any statistically significant relationship (Akram & Das, 2019; Akram & Li, 2017, 2019; Poghosyan, 2014). This paper therefore seeks to empirically analyse the relationship between the long term bond yield and its macroeconomic determinants in South Africa. We ask the question; which macroeconomic factors impact the long-term bond yield in South Africa? The benefits of doing so are two fold, firstly, from a theoretical point of view no comprehensive evidence is available on the determinants of sovereign long term bond yields in South Africa. Secondly, we extend the analysis to capture possible non-linearity between both the short-term interest rate and government debt, and long-term bond yields. We also seek to provide policy makers with evidence that can be used to resolve the current debt crisis.

The South African bond market is the largest in Africa and the South African government is the main issuer of debt instruments with 77.1% issuance by end of 2019 (QUANTEC, 2020). By the end of September 2019 total debt issued by government at all levels amounted to R3,02 trillion with 89% of that comprising debt issued by national government. More concerning is that during the period between 2008 and 2019, the growth in government debt accelerated, increasing by approximately 530%. However, the growth of the bond market in South Africa has not been accompanied by an increase in economic activity, leading to a number of negative ratings from rating agencies which culminated in sovereign bonds being assigned junk status by Fitch and Standard and Poor (S&P) in 2017, and Moody's in 2020. As opined by Gruber and Kamin (2012) this is expected to have a positive impact on government bond yields and should result in a positive sovereign bond yield spread. During the same period, yield spreads between long-term and short-

**Figure 1. South Africa and US long-term bond yield relationship.**

Source: Own compilation



term government bonds have remained positive in support of the liquidity preference theory, and the yield spread between South African and the United States of America (US) long-term bond yields was also positive. Figure 1 below shows the relationship between the South African long-term bond yield and the US long-term bond yield. The spread between the two rates has only been negative between 1979 and 1983 as shown in the graph, showing higher risk for investing in South African bonds compared to the US bonds. However, whilst the US long-term rate has an impact on the South African domestic interest rates, other domestic macroeconomic influences need to be taken into account.

On the main, the present study relates to literature on the determinants of sovereign bond yields (Afonso & Rault, 2015; Akram & Das, 2014; Goyari & Kamaiah, 2016; Ichiue & Shimizu, 2012) as well as literature on the determinants of sovereign long-term bond yield spreads (Capelle-blancard et al., 2019; Vocke, 2003). We acknowledge the existence of a vast literature on long term bond yield determination from an advanced economies perspective (Afonso and Jalles, 2019; Capelle-blancard et al., 2019; Gilchrist et al., 2014; Gruber & Kamin, 2012). However, literature on the same has not extensively covered emerging markets and developing countries and reported results show disparities between countries (Akram & Das, 2019; Goyari & Kamaiah, 2016). In the South African context, several papers have investigated other characteristics of the term structure (Clay & Keeton, 2011; Dube & Zhou, 2013; Shu et al., 2018) but no study have been undertaken to analyse the determinants of the sovereign long-term bond yield. Thus our study will contribute to this line of literature by analysing the determinants of the long term bond yield for South Africa.

We investigate both the short-run and long-run influences of the bond yield using both a linear and a non-linear ARDL framework. Our results show that the short-term interest rate is the main determinant of long-term bond yields. Government debt is also found to have a positive impact on the long-term bond yield in both the short-run and the long-run. Tests for non-linearity show that in the short-term the short-term interest rate has an asymmetric relationship with the long-term yield. Government debt only shows asymmetric behaviour in the long term. We suggest complementarity between monetary policy and fiscal policy, a systematic program of deleveraging and implementation of structural changes aimed at increasing production. This section is of an introductory nature and the rest of the paper proceeds as follows: Section 2 reviews literature on the determination of bond yields. In Section 3, the methodology used in the paper is discussed and in Section 4, we discuss results of the analysis. Conclusion and policy recommendations and given in Section 5.

## 2. Literature review

Laubach (2009) and Poghosyan (2014) show that the long-term interest rate is a function of both the growth rate in the economy and the level of government debt. The relationship emanates from Ramsey's optimal growth model, which suggests that the real interest rate can be determined as follows:

$$r = \sigma g + \theta, \tag{1}$$

Where  $r$  is the real interest rate in the long-run,  $g$  is the growth rate of the output, technology and consumption and  $\sigma$  is the coefficient of risk aversion. The variable  $\theta$  is the rate of time preference for the household. The relationship captures the impact of output growth or changes on the long-term interest rate. Changes in government debt are also expected to impact sovereign bond yields, albeit in two ways, first, through its impact on credit risk and also through its impact on the marginal product of capital. Furthermore, Poghosyan (2014) show that disregarding the Ricardian equivalence, increases in sovereign debt that results in crowding out of the private sector, increases the marginal product of capital, hence, results in high real interest rates. Gruber and Kamin (2012) suggest four ways through which government debt impacts interest rates. Firstly,

crowding out results in an increase in the interest rates as the economy adjust to increased demand for loanable funds. The second channel is through default risk premium effected by lenders as the government accumulate more debt. Thirdly, Gruber and Kamin (2012) identify the portfolio balance channel in which investors demand a higher yield to hold bonds, whose prices have decreased due to increased supply. The fourth channel captures the impact of inflation expectations deriving from possible monetisation of the huge debt stock.

Furthermore, traditional theories of the term structure propose different paths for the long term yield. The Keynesian liquidity preference theory suggest that long term yields are higher than short-term yields due to compensation required for undertaking higher risk associated with a longer term. Long term yields are therefore a function of the short-term yield plus a risk premium charged for deferred consumption. The expectations theory on the other hand suggests that long term rates can be computed by finding the weighted average of current and future short-term rates. In both these theories, the short term rate is at the centre of the determination of the long term rate. These relationships are further exposed by Akram and Das (2019), whose model suggests that the long term yield is a function of the short term yield, economic growth rate, a government fiscal variable and the rate of inflation. Other variables shown to impact the long-term yield include expected inflation as seen from the Fisher equation (Wesso, 2000), the exchange rate and other fiscal variables. Gadanez et al. (2014) also suggests the importance of foreign exchange risk in determining domestic bond yields.

### **2.1. Empirical literature**

We review empirical studies on the determinants of long term bond yields and also the sovereign bond yield spread. Akram and Das (2019) investigate the determinants of long term yields in India using the ARDL technique. Their results show that the short term interest rate is the main driver of long term bond yields for India. Their measure of government debt gives mixed results. However, the negative effect of government debt to GDP on long term yields is dominant. Their findings confirm similar findings for the US by Akram and Li (2017) who employs a vector auto-regressive model (VAR/VECM) technique to estimate the determinants of the US long term interest rates. (Akram & Li, 2017) find that the short-term rate accounts for the greater proportion of movement in long-term rates. In their findings government debt to GDP is negatively related to the long term rates in the long-run and positively related to long-term rates in the short-run.

Again Akram and Li (2019) use monthly data for the US and investigates the determinants of long-term interest rate. Their main finding does not deviate from previous findings and the short-term interest rate remains the major determinant of long-term rates. They employ the ARDL technique and fit various models, in which the long term rate is the dependent variable. They also find inflation rate, industrial production index to exert a positive influence on the long-term yield. Narrowing the government fiscal deficit is also found to have a negative effect on the yield. The findings further buttresses results in Kumar and Baldacci (2010) who studied a panel of 31 developed and emerging economies and found that the short-term rate has a positive and persistent effect on the long-term yield. Their study uses the fixed effects estimator and also accounts for various initial conditions. Both the inflation rate and the fiscal balance is found to have a positive and significant effect on the long rate.

In another panel study, Afonso and Rault (2015) investigate the influence of inflation expectations, current account balance and government debt to GDP ratio on long term rates for 17 OECD economies. The study implements panel cointegration and error correction methods to distinguish between the long-run and short-run influences of the long term bond yield. Government debt is found to have a positive and statistically significant impact on long term government yields. However, they found inflation surprises to have a negative effect on long term yields. There were also mixed results for current account balance for the different countries in the sample, with some countries having a positive impact, whereas others reported a negative impact of the external balance. Poghosyan

(2014) also uses panel cointegration technique in the form the pooled mean group technique and data between 1980 and 2010 for 22 developed economies to analyse the influences of long term government bond yields. Their results supports Afonso and Rault (2015) and reports the positive effect of government debt on long-term yields. They also find potential growth to have a positive impact on the long term interest rate, a finding that support the notion that high growth countries pay high returns. The short-term rate is also found to positively influence long-term interest rates.

Lange (2005) also estimates the determinants of long-term bond yields for Canada. The study uses a VAR model and reports on impulse response functions and variance error decompositions. They demonstrate that monetary policy shocks of both Canada and the US have significant impact on long-term rates. This finding is in line with previous works which argue that the short-term interest rate is the main determinant of long-term rates. GDP growth and growth in commodity prices in addition the short-term rate are also found to explain relatively high proportions of the variance in the long-term rate. Their major finding is supported by Akram and Das (2014) who investigated determinants of the Japanese long-term rates and find that low monetary policy rates had an influence on the long-term rates in Japan.

Jaramillo and Weber (2013) and Chowdhury et al. (2013) focus on the impact of fiscal policy variables on the long-term rate in different regimes. Using panel threshold technique, Jaramillo and Weber (2013) investigate the determinants of the long-term bond yields on 26 emerging market economies for the period 2005 to 2011. However, a weakness in their analysis was in using data with several gaps since most emerging economies did not have consistent data on long-term bond yields or other variables. They find that in periods of high risk aversion government debt has a positive and significant influence on the long-term rate but has no effect when risk aversion is low. GDP growth is found to have no effect when risk aversion is high but has a negative impact on the long-term rate during times of low risk aversion. Chowdhury et al. (2013) investigates the impact of macroeconomic variables on the bond index for emerging markets. They also establish a negative effect of economic growth on the bond index. Furthermore, the impact of the short-term yield is positive for both periods albeit with a high magnitude during high risk aversion periods. Other Fiscal variables are also found to have a positive and statistically significant effect on the long-term yield in Laubach (2009).

Gevorkyan and Kvangraven (2016) on the other hand argues for the importance of external influences on sub-Saharan African bond yields. Whilst they do not include South Africa in their sample, their study finds global volatility, commodity prices and global liquidity to determine sub-Saharan Africa bond yields. Their findings are supported by Ncube et al. (2012) and Ncube et al. (2013) who investigates the impact of the US and Euro long-term yields on the South African economy respectively. They find that an increase in Euro area and US bond yields results in an increase in the nominal bond yields in South Africa. These findings further support the intuition that monetary policy in major global financial centres has an impact on macroeconomic and financial variables in small open economies. Thus any study on the determinants of sovereign bond yield should account for the impact of global financial markets developments.

In the South African case Robinson (2015) and Robinson (2007) analyse the determinants of the sovereign risk spread. Their findings show that government debt in South Africa positively impacts the bond yield spread. In a similar study, Wesso (2000) investigates the relationship between expected inflation and the long-term interest rates in South Africa. The study finds that long-term rates do not predict inflationary pressures. However, expected inflation is found to have a positive and significant influence in long-term interest rates. The rejection of the proposition that the term structure influences the path of inflation is dismissed however, in Ntshakala and Harris (2018) who argue that the slope of the yield curve in South Africa as measured by the interest rate spread has an impact on expected inflation.

To sum up, the reviewed literature identifies the short-term interest rate as the main driver of long-term bond yields. In addition, macroeconomic variables such as government debt, economic growth rate, expected inflation and the fiscal deficit also have an impact on long term yields. Developments in international bond markets have been captured using the US government bond yield and changes in the exchange rate. We consider these variables in building our model in the next section.

### 3. Methodology

We use monthly time series data primarily from the South African Reserve bank for the period 1980M01 to 2019M12. Due to the length of our time series (600 observations), we test for unit roots using the Breakpoint unit root test to account for any breaks in the series. Furthermore, preliminary transformations are made to the data to prepare the data for estimation. Specifically, we take the logarithm of manufacturing production, bank credit, the stock market index and the CPI index. All the other data is in percentage form. We present the variables used in the model in [Table 1](#) below, together with the expected sign from theory and the source of the data.

#### 3.1. Model

We follow standard models as used in previous studies to formulate a model for the determination of the long term bond yield (Akram & Das, 2014, 2019; Rault & Afonso, 2011). We model the long term bond yield (*LTY*) as a function of the short-term treasury bill rate (*sr*), the rate of growth of the industrial production index (*growth*), debt to GDP ratio (*D.GDP*), inflation (*infl*), share price index (*SMI*) and also bank credit to the private sector (*cred*). Our basic linear time series model is specified as follows:

$$LTY_t = \alpha_1 + \beta_1 sr_t + \beta_2 growth_t + \beta_3 D_{GDP_t} + \beta_4 infl_t + \beta_5 cred_t + \beta_6 SMI_t + \varepsilon_t \tag{2}$$

The variable in the model are as defined in [Table 1](#),  $\alpha_1$  is a constant and  $\beta_n$  are the coefficients of the different factors affecting the long-term bond yield.  $\varepsilon_t$  is the error term, which is assumed to be independently and identically distributed (i.i.d). Concerns about multi-collinearity in the model are addressed through estimating different models in which variables that are highly correlated are interchanged.

**Table 1. Variables and data**

Variable	Description	Expected sign	Source
<i>LTY</i>	Long term G yield	Dependent variable	
<i>sr</i>	Short term	+	SARB/EASY DATA
<i>D.GDP</i>	Debt to GDP ratio	+	SARB/EASY DATA
<i>infl</i>	Expected inflation	+	SARB/EASY DATA
<i>growth</i>	Log of total manufacturing production	-	SARB/EASY DATA
<i>LTY_us</i>	US long term yield	+	SARB/EASY DATA
<i>SMI</i>	Foreign bond fund flows	-	SARB/EASY DATA
<i>cred</i>	Bank credit	Not clear	SARB/EASY DATA
<i>NEER</i>	Nominal Effective Exchange Rate	-	SARB/EASY DATA



### 3.2. Estimation technique

The approach taken to estimate the model follow standard time series estimation procedure. After our data cleaning and preparation, we note the need to test time series data for stationarity. Bispham (2005) posits that it is common for macroeconomic time series to display non-stationarity. Therefore all variables are tested for stationarity using both the Augmented Dickey Fuller Test and the Break point unit root test of Perron (1990). The use of the break point unit root test is necessitated by the length of the time series which captures different periods in the economic history of the country.

The estimation technique used in the paper is the ARDL model of Pesaran and Shin (1998) and Pesaran et al. (2001). The technique captures the error correction and cointegration properties of the model in a single equation framework. Furthermore, unlike the Engle Granger and the Johansen approaches which are also commonly used, the ARDL technique is applicable in cases where variables are of mixed integration levels (Pesaran & Shin, 1998). The Bounds test approach to testing for a long run relationship is used. The bounds test procedure as suggested by Pesaran et al. (2001) is an F-test (critical values provided in Pesaran et al. (2001)) with an upper bound at I(1) and a lower bound at I(0). The null hypothesis of the test states that there is no cointegration. If the F-statistic lies above the upper bound, then the null hypothesis can be rejected and if it lies below the lower bound, the null hypothesis of no cointegration cannot be rejected. If the statistic lies between the upper bound and the lower bound, the no conclusive result can be inferred.

The above model (equation 2) can be transformed into the following conditional error correction form following Pesaran and Shin (1998) and Nusair (2017):

$$\Delta LTY_t = \alpha_1 + \sum_{i=1}^q \beta_1 \Delta LTY_{t-i} + \sum_{i=0}^q \beta_1 \Delta sr_{t-i} + \sum_{i=0}^q \beta_2 \Delta growth_{t-i} + \sum_{i=0}^q \beta_3 \Delta D_{GDP_{t-i}} + \sum_{i=0}^q \beta_4 \Delta infl_{t-i} + \sum_{i=0}^q \beta_6 \Delta NEER_{t-i} + \beta_1 LTY_{t-1} + \beta_1 sr_{t-1} + \beta_2 growth_{t-1} + \beta_3 D_{GDP_{t-1}} + \beta_4 infl_{t-1} + \beta_6 NEER_{t-1} + \varepsilon_t \quad (3)$$

Whilst changes in government debt have potential negative effects on the long term cost of debt for the country, it is imperative to understand whether these effects are the same for both positive and negative changes in government debt. The ordinary ARDL framework assumes a symmetric relationship between variables. This implies that increases in government debt are assumed to have an equivalent impact as decreases in debt. To address this concern and analyse separately the effects of increases in debt and deleveraging, we adopt the non-linear ARDL technique (NARDL) suggested by Shin et al. (2014). The NARDL method is able to show the different impact of an increase in debt and a decrease in debt on the long-term yield. This asymmetric approach is powerful in that it is capable of informing policy makers on the expected impact of any actions to reduce or increase government debt or the short-term rate on the long-term government yield. To illustrate the change in equation (3) effected by controlling for asymmetry effects following Shin et al. (2014), we state the asymmetric error correction model below, assuming the  $D\_GDP$  is the asymmetric variable.

$$\Delta LTY_t = \alpha_1 + \sum_{i=1}^q \beta_1 \Delta LTY_{t-i} + \sum_{i=0}^q \beta_2 \Delta sr_{t-i} + \sum_{i=0}^q \beta_3 \Delta growth_{t-i} + \sum_{i=0}^q \beta_4 \Delta D\_GDP_{t-i}^+ + \sum_{i=0}^q \beta_5 \Delta D\_GDP_{t-i}^- + \sum_{i=0}^q \beta_6 \Delta infl_{t-i} + \sum_{i=0}^q \beta_7 \Delta NEER_{t-i} + \beta_8 LTY_{t-1} + \beta_9 sr_{t-1} + \beta_{10} growth_{t-1} + \beta_{11} D\_GDP_{t-1}^+ + \beta_{12} D\_GDP_{t-1}^- + \beta_{13} infl_{t-1} + \beta_{14} NEER_{t-1} + \varepsilon_t \quad (4)$$

Where  $\beta_4^+$ ,  $\beta_5^-$ ,  $\beta_{11}^+$  and  $\beta_{12}^-$  are the asymmetric distributed lag coefficients. The basic model assumes that the variables  $D\_GDP_{t-i}^+$  and  $D\_GDP_{t-i}^-$  lie around a threshold of zero, which makes it easier to identify the effects of positive and negative changes of government debt. One can see that turning to the NARDL increases the number of coefficients as the asymmetric variables are decomposed into two. Firstly the  $D\_GDP_{t-i}^+$  is a partial sum of positive changes to government debt. The second term  $D\_GDP_{t-i}^-$  is a partial sum of negative changes to government debt. To test for the asymmetry in the long-run, we test the hypothesis:  $\beta_{11}^+ = \beta_{12}^-$ . Rejecting this hypothesis implies the presence of an asymmetric relationship between government debt and the long term bond yield. Another important attribute of the NARDL technique is that we are able to test for both short-run and long-run asymmetry and cointegration in the non-linear model (Cheah et al., 2017). We find this approach intuitive to address the inconclusive results in literature.

#### 4. Estimation results

The results from our estimated models are shown in Tables 4 and 5. We use the Bounds test for long-run relationship as suggested by Pesaran et al. (2001) and find that in both our models, the F-statistic is greater than the upper bound critical values at least at the 5% level of significance, confirming the presence of a long-run relationship in all models estimated. The error correction terms are negative and significant in all cases, showing that any deviation from the long-run path of the yield is corrected, starting from the following period. We adopt Newey and West (1987) covariance estimator, which is consistent in the presence of both autocorrelation and heteroscedasticity of unknown form (HAC). Automatic lag selection criteria is used with a maximum lag of 12 months for both the dependent and the independent variables. Bispham (2005) suggest that for annual data 1 lag is acceptable, quarterly data 4 lags and monthly data one can use 12 lags. Firstly, we present results of the stationarity tests in Table 2. These results show that the order of integration is mixed with two variables being stationary at levels whilst all other variables are stationary at the 1<sup>st</sup> difference. No variable is integrated at the 2<sup>nd</sup> order or higher, which allows the data to be modelled using the ARDL technique.

First, we present the results from the linear ARDL model in Table 3 below. Four models are estimated to ensure robustness of the results to changes in some of the variables and also to cater for two both our full sample (1980–2019) and a sub-sample covering 2008–2019. Diagnostic tests results are provided below the coefficients.

**Table 2. Unit root tests**

Variable	ADF		Break-point		Decision
	Level	1 <sup>st</sup> Difference	Level	1 <sup>st</sup> Difference	
<i>LTY</i>	-2.1236	-17.686***	-3.6946	-18.208***	I(1)
<i>sr</i>	-2.0102	-16.123***	-3.3758	-19.099***	I(1)
<i>D.GDP</i>	-1.4168	-3.1157**	-2.7709	-9.7621***	I(1)
<i>infl</i>	0.9906	-10.641***	-2.5191	-23.634***	I(1)
<i>growth</i>	-2.6757	-15.382***	-4.4995	-39.802***	I(1)
<i>LTY_us</i>	-2.4297	-17.856***	-2.6944	-18.851***	I(1)
<i>SMI</i>	-4.3364***		-4.6448*		I(0)
<i>cred</i>	-3.3439**		-5.6752***		I(0)
<i>NEER</i>	-2.0618	-18.958***	-4.8136	-19.875***	I(1)

The superscripts \*\*\*, \*\* and \* represents 1%, 5% and 10% level of significance respectively.

**Table 3. Estimation results: linear models**

Dependent: LTY	Model (1) 1980–2019	Model (2) 2008–2019	Model (3) 1980–2019	Model (4) 2008–2019
<b>Short-run</b>				
D(D_GDP)	0.102*** [2.71]		0.101*** [2.79]	0.199*** [3.31]
D(SR)	0.216*** [7.92]	0.336*** [4.32]	0.228*** [8.53]	0.375*** [3.82]
D(growth)	0.024 [1.43]	0.032* [1.78]	0.021 [1.29]	0.034* [1.94]
D(INFL)	0.253*** [4.95]	0.400*** [4.54]	0.266*** [3.97]	
D(NEER)	-0.096*** [-8.89]	-0.100*** [-8.85]	-0.094*** [-9.06]	-0.107*** [-9.18]
D(SMI)				
D(USlty)		0.572*** [7.51]	0.255*** [5.26]	0.589*** [7.35]
D(cred)		0.065 [1.11]		0.025 [0.39]
ECT	-0.075*** [-6.48]	-0.253*** [-7.48]	-0.079*** [-7.16]	-0.254*** [-7.06]
<b>Long-run</b>				
D_GDP	0.066** [2.55]	0.215*** [3.07]	0.081*** [3.11]	0.409*** [4.63]
SR	0.347*** [6.15]	0.596*** [5.57]	0.478*** [5.79]	0.747*** [5.99]
Growth	-0.332*** [-2.99]	-0.391*** [-3.52]	-0.158 [-1.29]	-0.531*** [-4.16]
INFL	-0.106** [-2.13]	0.071 [0.47]	-0.086* [-1.70]	

(Continued)

**Table 3. (Continued)**

Dependent: LTY	Model (1) 1980–2019	Model (2) 2008–2019	Model (3) 1980–2019	Model (4) 2008–2019
NEER	-0.126*** [-2.76]	-0.055*** [-2.33]	-0.082* [-1.82]	-0.087*** [-3.87]
SMI				
USLTY		0.317** [2.31]	-0.058 [-0.16]	0.457*** [3.46]
cred				-0.383*** [-4.22]
Constant	1.129*** [5.13]	2.260*** [3.06]	0.638*** [2.73]	3.517*** [4.76]
F-Bounds test Statistic	5.92***	5.83***	6.30***	5.87***
JB statistic	46.28*** (0.000)	1.83 (0.400)	19.05*** (0.000)	1.11 (0.574)
LM test statistic	0.46 (0.458)	0.66 (0.622)	0.18 (0.835)	0.59 (0.558)
Heteroscedasticity	HAC	1.11 (0.339)	HAC	1.01 (0.463)
B-P-G F-test				
RESET test	0.67 (0.412)	0.57 (0.471)	2.21 (0.111)	0.03 (0.303)
CUSUM	Stable	Stable	Stable	Stable

The superscripts \*\*\*, \*\* and \* represents 1%, 5% and 10% level of significance respectively. Post estimation tests conducted show that all estimations do not suffer from Serial correlation. However, to address heteroscedasticity that is detected in the full sample models, Heteroscedasticity and Autocorrelation consistent (HAC) standard errors are used for the full sample (1980–2019). Model selection is done using the Akaike Information Criterion. B-P-G is the Breusch Pagan Godfrey test for Heteroscedasticity. Numbers in parenthesis [] are t-values and () are p-values.

**Table 4. Estimation results: non-linear models**

Dependent: <i>ity</i>	Model (5) 1980–2019 Asyvar: D_GDP	Model (6) 2008–2019 Asyvar: D_GDP	Model (7) 1980–2019 Asyvar: sr	Model (8) 2008–2019 Asyvar: sr	Model (9) 1980–2019 Asyvar: sr and D_GDP	Model (10) 2008–2019 Asyvar: sr and D_GDP
Short-run						
D(D_GDP)			0.094** [2.55]			
D(D_GDP <sup>+</sup> )		-0.026 [-0.45]				
D(D_GDP <sup>-</sup> )	0.236*** [3.49]	0.226 [0.77]			0.229*** [3.42]	0.532** [2.45]
D(SR)	0.213*** [7.89]	0.296*** [4.17]				
D(SR <sup>+</sup> )			0.186*** [5.59]	0.724*** [3.75]	0.192*** [6.12]	0.310*** [4.43]
D(SR <sup>-</sup> )			0.376*** [6.68]	0.127 [1.27]	0.288*** [5.46]	0.298*** [2.91]
D(growth)	0.021 [1.31]	0.035** [2.16]	0.027* [1.69]	0.042** [2.51]	0.018 [1.16]	0.041** [2.51]
D(INFL)	0.280*** [5.63]	0.344*** [3.64]	0.233*** [3.46]	0.276*** [3.11]	0.213*** [3.42]	
D(NEER)	-0.095*** [-8.87]	-0.104*** [-9.91]	-0.088*** [-8.33]	-0.099*** [-9.03]	-0.083*** [-8.52]	-0.100*** [-9.40]
D(SMI)					-0.038*** [-5.59]	
D(USlty)		0.558*** [7.86]		0.593*** [8.57]	0.254*** [5.79]	0.041*** [8.33]
D(cred)		0.007 [0.14]				-0.058 [-1.01]
ECT	-0.089*** [-6.45]	-0.345*** [-9.54]	-0.071*** [-5.80]	-0.232*** [-6.36]	-0.099*** [-7.13]	-0.330*** [-6.99]

(Continued)

**Table 4. (Continued)**

Dependent: <i>ity</i>	Model (5) 1980–2019	Model (6) 2008–2019	Model (7) 1980–2019	Model (8) 2008–2019	Model (9) 1980–2019	Model (10) 2008–2019
<b>Long-run</b>						
D_GDP			0.066* [1.89]	0.171** [2.04]		
D_GDP <sup>+</sup>	0.033 [1.26]	0.321*** [4.99]			0.162 [1.57]	0.232*** [3.00]
D_GDP <sup>-</sup>	0.135*** [2.66]	-1.462*** [-4.69]			0.081 [0.71]	-0.909** [-2.52]
SR	0.282*** [4.72]	0.184** [1.90]				
SR <sup>+</sup>			0.321*** [3.14]	1.001*** [4.63]	0.395*** [5.29]	0.599** [2.45]
SR <sup>-</sup>			0.299*** [4.22]	0.098 [0.49]	0.173** [2.53]	0.122 [1.01]
Growth	-0.241** [-2.22]	-0.097 [-1.65]	-0.373*** [-3.31]	-0.081 [-0.87]	-0.440*** [-4.35]	-0.036 [-0.57]
infl	-0.052 [-1.08]	-0.207 [0.12]	-0.105 [-1.52]	0.014 [0.066]	-0.127** [-2.24]	
near	-0.105*** [-2.65]	-0.157*** [-5.36]	-0.114** [-2.39]	-0.81*** [-2.63]	-0.122*** [-3.17]	-0.136*** [-4.61]
cred		-0.404*** [-3.94]		-0.376** [-2.33]		-0.504*** [-5.36]
USlty		0.361*** [3.86]		0.353** [2.48]	0.448** [2.18]	0.325*** [3.28]
smi					0.066*** [3.16]	
Constant		3.464*** [5.36]	1.174*** [4.41]			

(Continued)

**Table 4. (Continued)**

Dependent: <i>ity</i>	Model (5) 1980–2019	Model (6) 2008–2019	Model (7) 1980–2019	Model (8) 2008–2019	Model (9) 1980–2019	Model (10) 2008–2019
Bounds test F-statistic	5.12*** (0.000)	8.43*** (0.136)	4.14*** (0.000)	3.75** (0.641)	4.99*** (0.000)	4.52*** (0.205)
JB statistic	81.64*** (0.000)	3.98 (0.136)	99.43*** (0.000)	0.89 (0.641)	39.12*** (0.000)	3.16 (0.205)
LM F-test statistic	1.09 (0.367)	1.11 (0.333)	1.54 (0.138)	0.64 (0.630)	1.51 (0.222)	0.36 (0.834)
Heteroscedasticity B-P-G F-stat	2.85*** (0.000)	1.00 (0.476)	3.66*** (0.000)	0.94 (0.536)	3.06*** (0.000)	0.78 (0.758)
RESET test F-Statistic	0.85 (0.390)	0.30 (0.587)	1.60 (0.109)	1.99 (0.160)	1.49 (0.163)	0.42 (0.674)
CUSUM	Stable	Stable	Stable	Stable	Stable	Stable

The superscripts \*\*\*, \*\*, \* and \* represents 1%, 5% and 10% level of significance respectively. Post estimation tests conducted show that all estimations do not suffer from Serial correlation. However, to address heteroscedasticity that is detected in the full sample models, Heteroscedasticity and Autocorrelation consistent (HAC) standard errors are used for the full sample (1980–2019). Model selection is done using the Akaike Information Criterion. B-P-G is the Breusch Pagan Godfrey test for Heteroscedasticity. Numbers in parenthesis [] are t-values and () are p-values.

The results from our linear models show that the short term bill rate (*SR*) has a positive and statistically significant impact on the long term bond yield (*lty*) both in the short-run and in the long-run. This finding supports previous studies (Akram & Das, 2019; Akram & Li, 2019; Lange, 2005) and the Keynesian theory of liquidity preference. The implication is that monetary policy has influence on the level of long term rates and monetary authorities by setting the central bank rate, determine the level of the long term yield. This finding puts South Africa in the same group as India, US and Canada, which have also shown that their long term rates are explained to a greater extent by the short term rates (Afonso & Rault, 2015; Akram & Das, 2014, 2019; Kumar & Baldacci, 2010). Using model (1) a 1 percentage point increase in the short term rate results in a 21 basis point increase in the long term rate in the short-run. In the long-term a 1 percentage point change in the short-term rate results in approximately 35 basis points change in the long term bond yield. The sign of the coefficient is consistent for all the models estimated.

A second and equally important finding is the positive impact observed of the *D.GDP* ratio on the long term yield (*lty*). In both the short-run and the long-run, government debt has a positive and significant impact on the long-term yield. The finding also supports previous studies by Poghosyan (2014), Kumar and Baldacci (2010), and Ichiue and Shimizu (2012). However, it is also contrary to studies by Akram and Das (2019) who do not find any effect of government debt on the long term yield. Specifically model (1) shows that a 1 percentage point increase in *D.GDP* in the short-run results in a 10 basis point increase in *lty*. For South Africa, this implies that the markets factor in credit risk associated with accumulation of huge stock of debt in pricing debt to the South African government. Further increase in the government budget deficit could therefore increasingly make it difficult for the government as interest repayments will also increase.

Another important finding is the impact of economic growth rate on the *lty*. In all the linear models estimated, the coefficient of economic growth takes a positive sign in the short-run although it is not significant in two of the models. In fact, the short-run influence is weaker compared to the negative impact in the long-run. For instance, in model (1) a 1 percentage point increase in the growth rate results in -0.322 percentage point decrease in the *lty* in the long-run whilst the short-run coefficient of the same is 0.024 and is not significant. The long-run sign of the coefficient is in line with the findings by Chowdhury et al. (2013). This finding shows that increased economic activity improves investor confidence and lowers their risk perception. Inflation is found to be positively influencing *lty* in the short-run but in the long-run it has a negative impact. The short-run impact confirms the importance of inflation expectations in driving interest rates. However, in the long-run, the negative impact of inflation on the long-term rate could be linked to the negative impact that inflation has on the real interest rate and economic growth.

The effects of the US long term bond yield on the South African *lty* are positive both in the short-run and in the long-run. In model (2) for instance, a 1 percentage point increase in the *USlty* results in a 57 basis points increase in South Africa's *lty* in the short-run. In the long-run the response is

**Table 5. Test for linearity**

	Wald test stat	Model (5) 1980–2019	Model (6) 2008–2019	Model (9) 1980–2019	Model (10) 2008–2019
Short-run	F-stat (p-value)	N/A	6.55** (0.011)	N/A	N/A
Long-run	F-stat (p-value)	2.26 (0.132)	19.56*** (0.000)	1.44 (0.231)	8.85*** (0.004)

**H0:  $D.GDP^+ = D.GDP^-$  (the relationship between *D.GDP* and *lty* is linear)**

The superscripts \*\*\*, \*\*, \* represents 1%, 5% and 10% significance respectively. Number in parenthesis () are p-values.



a 32 basis points increase. We support previous findings by Ncube et al. (2012) and Goyari and Kamaiah (2016) that show that both US monetary policy stance and the US long-term bond yield have a significant influence on interest rates in South Africa and other emerging economies.

The relationship between the long-term yield and bank credit is only significant and negative in the long-run both for the linear and non-linear models. In Table 3, model (4), a 1 percentage point increase in bank credit results in a  $-0.383$  change in the *lty* in the long-run. Bank credit should impact bond yields through its effect on productivity of the private sector. Increased production due to increased bank credit impact bond yields negatively as economic growth increases. Reduced bond demand by the private sector as they can access credit will lower the bond yields. We find a negative relationship between the nominal effective exchange rate (*neer*) and the long term bond yield (*lty*) for South Africa in both the short-run and in the long-run. From model (1), a 1 percentage point change in the *neer* results in a  $-0.126$  change in the long term bond yield in the long-run. In the short-run a 1 percentage point increase *inneer* leads to a 9 basis points fall in the *lty*. Thus an appreciation of the rand lowers the *lty*. From a portfolio balance perspective, demand for South African sovereign bonds increase as the currency strengthens lowering the yields in the process.

To further our analysis, we investigate the non-linearity between the long term government bond yield (*lty*), and the short term yield (*SR*) and government debt (*D\_GDP*). Thus, *D\_GDP* and *SR* are specified as our asymmetric variables in the models estimated. We estimate four models as follows: Models (5) and (6) assumes that *D\_GDP* is the asymmetric variable and models (7) and (8) assumes the *SR* is the asymmetric variable. Models (9) and (10) make both *D\_GDP* and *SR* asymmetric variables simultaneously. The results are presented in Table 4 below.

As outline above, we estimate several non-linear models distinguished mainly by the period sample and the choice of the asymmetric variable. Our findings show that *D\_GDP* has an asymmetric influence on *lty* only if we consider the 2008–2019 sample. In the total sample covering 1980 to 2019, we do not find any evidence of non-linearity in *D\_GDP*. We test for linearity using standard Wald tests shown in Table 5. Of noteworthy is the finding that there is no asymmetric relationship between the two variables in the short-run in all models but one. However, in the long-run, the 2008–2019 sample period shows the existence of an asymmetric relationship. The coefficient of *D\_GDP* also give mixed information for the two sample periods.

Again, we test for linearity between the short-term rate and the long-term rate both in the short-run and also in the long-run. In the short-run, we find that  $D(SR^+)$  and  $D(SR^-)$  both impact the *lty* positively, implying that an increase in *SR* results in an increase in *lty*, whereas a fall in *SR* leads also to a decrease in *lty*. The 2008–2019 sample period shows that an increase in the short-term rate (*SR*) has more impact on the *lty* than a decrease in the same. For example, in model (10) the coefficient of  $D(SR^+)$  is 0.310 compared to  $D(SR^-)$  which is at 0.298. These findings are confirmed by Wald tests for linearity in Table 6 below.

Table 6. Tests for linearity					
	Wald test stat	Model (7)	Model (8)	Model (9)	Model (10)
Short-run	F-stat (P-value)	4.89** (0.028)	6.44** (0.012)	5.60** (0.018)	4.69** (0.033)
Long-run	F-stat (p-value)	3.52* (0.061)	4.47** (0.036)	4.09** (0.044)	1.74 (0.189)

**H0:  $D(SR^+) = D(SR^-)$  (the relationship between *SR* and *lty* is linear)**

The superscripts \*\*\*, \*\*, \* represents 1%, 5% and 10% significance respectively. Numbers in parenthesis () are p-values

Furthermore, we find that the non-linearity between the short-term rate and the long-term rate also exists in the long-run. Except for model (10), all estimated models reject the null hypothesis of a linear relationship in Table 6. Increases in the short-term rate are shown to have more impact on the *lty* in the long-run also compared to decreases in the short-term rate. A particular finding is that the non-linearity is high in the short-run compared to the long-run. This finding supports Dube and Zhou (2013) who establishes threshold effects in both long-term and short-term interest rates for South Africa. Monetary policy authorities will have to consider this asymmetry in estimating the level of the long term yield for a given level of short-term interest rate.

Care should however be taken when interpreting our results as the models estimated here may not have covered all variables that impact the long-term bond yield. In addition, long time series may be affected by structural breaks, which can make the findings from the full sample models unreliable. Nevertheless, to address this weakness of the study, we have estimated both the full sample results and the post crisis results. This has not changed most of the coefficients reported in the results. Further research could estimate models for different periods and investigate changes in coefficients over time. Another approach could be employing time varying coefficients to analyse how the coefficients of the determinants of long-term bond yields have evolved over time.

## 5. Conclusion and policy recommendations

The study investigated the short-run and long-run determinants of the long term bond yield for South Africa. We employ both a linear and a non-linear ARDL framework, in which the long-term bond yield is a function of the short-term bill rate, macroeconomic factors and external financial markets dynamics as represented by the US long term bond yield. We estimate several models for two periods, the full period sample covering 1980–2019 and the post crisis period covering 2008 to 2019. The bounds test for a long-run relationship shows that a long-run relationship exists between the long-term bond yield and its determinants.

Our findings suggest that the short term rate is the main determinant of the long-term bond yield. We also established that this relationship is non-linear, with increases in the short-term rate having more impact on the long-term yield compared to decreases in the short-term rate. Furthermore, we investigate the impact of government debt on the long-term yield and find a positive relationship between the two both in the short-run and in the long-run. However, we do not find convincing evidence of the existence of a non-linear relationship between government debt and the long-term yield in the short-run. The non-linear estimation shows that increases and decreases in government debt both increase the long-term yield in the long-run, which may indicate to the role of other variables, and further confirms the non-linearity between government debt and the long-term bond yield.

We find economic growth to have a positive impact on the long-term yield in the short-run and a negative impact in the long-run. The deviations of the long-term bond yield from the equilibrium is further corrected by the rate of inflation, exchange rate, stock market returns and the US long-term bond yield. The inflation rate and the US long-term rate impact the South African bond yield positively in the short-run. Stock market returns as represented by the all share index, show a negative impact on the long-term bond yield. Positive exchange rate movements also have a negative impact on the long-term yield in the short-run. In the long-run inflation, stock market returns and the nominal effective exchange rate all have negative influences on the long term bond yield.

These findings have important implications for policy. Firstly, monetary policy remains an effective tool in determining long term bond yields and thus complementarity between monetary and fiscal policy is argued for. Reducing government debt is important in curbing the sovereign borrowing rates. The government can therefore focus on a systematic deleveraging process with

specific debt targets and avoid accelerated debt accumulation. Finally, stimulating economic growth remains the most effective way to improving market confidence and lower the sovereign cost of borrowing in the long-run.

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