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EXAMINING THE SOURCES OF SOVEREIGN RISK FOR SOUTH AFRICA: A TIME VARYING FLEXIBLE LEAST SQUARES APPROACH

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Abstract

This paper analyzes the determinants of the South African long-term sovereign bond yield spread using 10-year bond yield spread. We employ the Auto-Regressive Distributed Lag and Flexible Least Squares techniques to demonstrate the impact of macroeconomic and financial variables on the yield spread. Our results show that the short-term interest rate is positively related to the bond yield spread both in the short and long run. We also establish a long-run positive influence of government debt on the bond yield spread whilst on the other hand, economic growth, the nominal effective exchange rate, stock market returns and bank credit all have a negative impact on the bond yield spread in the long run. We examine the time varying coefficient of government debt and reveal that the long-run impact of government debt has varied over the period under analysis. Time varying coefficients capture some important periods in the history of the South African economy, indicating that underlying economic conditions and exogenous shocks influence the determination of sovereign risk. Our results imply the need for synchronization of fiscal and monetary policy. In addition, economic policy should address economic growth and macroeconomic instability to complement deleveraging efforts aimed at curbing sovereign credit risk.

Keywords: Bond Yield Spread, Government Debt, Auto-Regressive Distributed Lag, Flexible Least Squares, Sovereign Risk

JEL Classifications: E43, G12, H63

1. Introduction

The information content of sovereign yield spreads is well documented in literature and several studies have investigated the major determinants of the sovereign yield spread (Wellmann and Trück, 2018; Bianchi and Rocco, 2016). However, less attention has been given to analysis of sovereign risk in emerging and developing economies despite high risk associated with investments in these countries. The yield spread represents the risk premium investors charge for higher country risk compared to another country or reference asset. According to Haugh *et al.* (2009), the interest rate spread captures both liquidity risk and credit risk associated with the debt originator. However, South African financial markets, including the government bond market are relatively deep and liquid reducing the impact of liquidity risk. In addition, Kennedy and Palerm

(2014) suggest that market risk emanating from global financial markets also affects sovereign bond markets. We set out in this paper to analyze the impact of the rising sovereign debt, macroeconomic and financial factors on the long-term sovereign bond yield spread in South Africa.

South Africa experienced an upsurge in the debt-to-GDP ratio, which stood at 64% at the end of 2019. The increasing level of government debt is compounded by low economic growth, resulting in increased economic uncertainty, and dwindling fiscal space. By the first quarter of 2020, government and some corporate debt had been accorded junk status rating by the major rating agencies (Fitch, S&P and Moody's). The country has run a fiscal budget deficit between 2008 and 2020, which amounted to 180.7 billion for the 2019/2020 fiscal year, which is approximately 6.3% of its Gross Domestic Product (GDP). As the Covid-19 economic crisis ensues, it is imperative to understand both drivers of sovereign risk in South Africa and analyze the flexibility of fiscal policy. Furthermore, in response to the Covid-19 crisis, a R500 billion fiscal stimulus has been sourced from internal sources and multi-lateral institutions, ensuring that the country does not acquire debt from the markets, signaling a constrained fiscal space. Part of this money is sourced from the domestic banking institutions through credit guarantees, which also put the stability of the banking system under threat as the government is the largest borrower from the domestic banking system (South African Reserve Bank [SARB], 2020). SARB (2020) further shows that sovereign risk is the leading source of instability to the financial sector even prior to the Covid-19 crisis. Given this background, we find it intuitive to investigate the sources of South African sovereign risk.

The majority of papers investigating sovereign bond yield spreads have adopted the US, Euro or Japanese long-term yields as their reference rates (Caggiano and Greco, 2012; Favero and Missale, 2012). There have been also a vast literature covering sovereign bond yield spreads for the Euro region especially during and after the European debt crisis between 2009-2012 (Afonso *et al.* 2015; Afonso and Jalles, 2019; Barbosa and Costa, 2010). In the South African case, the works of Robinson (2015) stand out as the main attempt to empirically determine the sources of the sovereign yield spread. We add to this line of research by extending the sample period to cover the period up to 2019, during which the country has experienced further credit rating downgrades. In addition, we consider several other spreads - including Euro Area, USA, China, UK and Japan; and also divide the sample into two covering both the pre- and post-crisis periods. Decomposing bond yield spreads allows us to comparatively assess the factors that investors price when considering investing in South African sovereign bonds compared to its main trading partners. In addition, unlike our predecessors, we consider time varying coefficients approach to understand the evolution of the coefficients of the determinants of the long-term bond yield over time. Primarily, we focus on the coefficient of government debt to analyze the extent to which the level of debt is detrimental to the South African economy. The time varying approach will assist in revealing the salient effects of macroeconomic policy under different political or policy regimes (Bernoth and Erdogan, 2012). Specifically, the impact of government debt during the period of fiscal consolidation (2001 to 2008) can be compared with effect after the crisis (2009 to 2019), during which fiscal deficits increased.

Our baseline results which report constant coefficients are derived from several single equation models estimated using the Autoregressive Distributed lag (ARDL) technique. Constant coefficient results show that the short-term rate of interest, government debt, economic growth, the exchange rate and developments in international financial markets all impact the sovereign bond yield spread. The short-term interest rate positively impacts long-term bond yield spreads both in the long-term and in the short-term, showing the importance of monetary policy in determining the pricing of bonds. Importantly, we find government debt to impact the bond yield spread positively in the long run and economic growth to have a negative impact on the bond yield spread. An important finding from the time varying regression is that the coefficient of government debt has fluctuated over time, showing sensitivity to prevailing economic conditions.

The present section introduces the paper and the rest of the study proceeds as follows: Section 2 examines theoretical and empirical literature related to the study. In Section 3, we outline the methodology followed in the study and in Section 4, the results from the analysis are presented and discussed. Conclusion and policy recommendations are given in Section 5.

2. Literature review

We find a vast amount of literature on both the determinants of bond yields and bond yield spreads (Afonso *et al.* 2012; Afonso *et al.* 2015; Capelle-Blancard *et al.* 2019; Wellmann and Trück, 2018). The literature covers both sovereign bond yields and yield spreads (Robinson, 2015; Vocke, 2003), and corporate bond yield spreads (Liu *et al.* 2009; Radier *et al.* 2016). Whilst sovereign bond yields depict the sovereign risk premium, corporate bond yields are also an important signal of the corporate risk premium. We also acknowledge the availability of several works that investigates the yield curve's forecasting ability on macroeconomic variables in South Africa (Afonso and Martins, 2012; Clay and Keeton, 2011; Thomas and Maré, 2007; Ntshakala and Harris, 2018). For the purpose of this paper however, we focus on literature covering sovereign yield spreads as a measure of sovereign risk in order to capture the sources of South African sovereign risk premium.

In theory, the push and pull model is frequently used to analyze both global and domestic sovereign bond yield spreads determinants (Feyen *et al.* 2015; Wellmann and Trück, 2018; Vocke, 2003). Pull factors emanate from the domestic economic environment and draw capital flows to the country or repel investors in the case that these indicators worsen. Senga *et al.* (2018) identify several pull variables including higher economic growth and higher return in emerging economies compared to developed economies. Push factors describe economic conditions in countries of origin, typically those associated with portfolio choice of investors such as average stock market and bond returns. In addition, Senga *et al.* (2018) also identify monetary policy stance of the originating country. For instance, a lax monetary policy stance increases supply of loanable funds, which can be used to purchase bonds across different bond markets. In addition, developments in international bond markets are also an essential variable in determining any country's yield spread.

Furthermore, interest rate differentials have been explained using the uncovered interest rate parity (UIRP) condition (Wellmann and Trück, 2018). The UIRP, which assumes risk neutrality is a no arbitrage approach to asset valuation that relates interest rate differentials between identical assets sold in different countries to the changes in the exchange rate (difference between the expected and spot exchange rate) between the two countries. The UIRP asserts that interest rate differentials on fixed income instruments with the same liquidity, default risk and maturity can be explained by the following relationship:

$$\left(r_{t,k}^{i}+1\right)=\left(r_{t,k}^{*}+1\right)\left(\frac{S_{t+k}^{e}}{S_{t}}\right) \tag{1}$$

where; $r_{t,k}^{i}$ is the domestic interest rate and $r_{t,k}^{*}$ is the foreign interest rate. S_{t+k}^{e} is the expected nominal exchange rate at time t, whereas S_t is the spot exchange rate. In essence, Equation (1) postulates that a country with a high interest rate will experience depreciation of its currency. Thus, the interest rate differential is captured by the changes in the exchange rate. However, results from several empirical studies have shown that the UIRP holds in the long run and fails to hold for short-term securities (Chin and Liang, 2009; Ilut, 2012). Nevertheless, the theory still remains useful in explaining interest rate differentials.

Empirical studies on interest rate spreads have considered both external and domestic macroeconomic factors as explanatory variables for the changes in sovereign spreads (Feyen *et al.* 2015). Domestic variables include economic growth rate, debt to GDP ratio, the primary balance and also the monetary policy rate. The impact of sovereign debt on sovereign yield spreads is well documented in recent attempts to explain the European debt crisis (Caggiano and Greco, 2012; Gómez-Puig *et al.* 2014; Bernoth and Erdogan, 2012). Bernoth and Erdogan (2012) use time varying non-parametric approach and find that government debt-to-GDP ratio has a statistically significant relationship with the sovereign yield spread. Whilst in other studies, macroeconomic variables are concluded to impact the sovereign yield spread in the long-term (Barbosa and Costa, 2010). Caggiano and Greco (2012) argue that fiscal policy decisions can impact the spread in the short run too through its impact on investor sentiment. This finding is in line with Robinson (2015), who finds a positive relationship between the risk premium and public debt in South Africa. Thus, we can expect macroeconomic variables to have an impact of the sovereign risk premium both in the short-term and also in the long-term.

Robinson (2015) undertakes an investigation into the sources of sovereign risk for South Africa using data between 1994 and 2014. Their study employs VECM approach and single equation three step approach of Engle and Yoo (1991). Robinson's (2015) analysis focuses more on fiscal variables such as government expenditure, government revenue and government debt although they also control for short-term and long-term interest rate. Their results show that fiscal developments are an important determinant of the sovereign bond yield spread. Specifically, both debt and government spending are found to have a positive impact on the bond yield spread. These findings are supported by Gómez-Puig *et al.* (2014) who find that changes in sovereign debt explain much of the variation in bond spreads for EU countries.

Senga *et al.* (2018) and Feyen *et al.* (2015) further include bond specific characteristics such as maturity and size in their analyses. In addition to common domestic macroeconomic factors, political factors have also been explored as determinants of the interest rate spread. Eichler (2014) investigates the political influences of the sovereign spreads for 27 emerging economies and find low governance quality to drive yields upwards. Political stability and the ability to implement austerity measures are found to lower interest rate spreads. Furthermore, Capelle-Blancard *et al.* (2019) incorporates Environmental Social and Governance (ESG) factors in the determination of sovereign bond yields. Their study uses a panel of 20 countries and the Least Squares Dummy Variable Corrected (LSDVC) regression. They find that social and governance factors negatively influence the sovereign interest rate spread.

We contribute to this line of literature in two ways; firstly, we extend the sample used in (Robinson, 2015) to cover 1994m01 to 2019m12. We further decompose the sovereign spreads by computing five different spreads using the leading trade partners for South Africa. This approach allows us to assess the competitiveness of South African bonds against similar investments in its trading partners. Furthermore, we analyze the evolution over time of the coefficients in our model using the time varying Flexible Least Squares approach, which is capable of informing us the impact of underlying economic and structural policies, and changes in risk pricing on sovereign riskiness.

3. Methodology

The paper uses monthly data spanning the period 1994m01 to 2019m12 for South Africa. Data on macroeconomic variables is obtained from the SARB, whereas data on government yields for other countries is obtained from the Federal Reserve Bank of St Louis website. Data on the S&P index is obtained from Yahoo Finance and the monthly closing index is used in the study. Preliminary data preparations conducted include transformation of data into logarithms where the time series are indexes or data is provided in rand value. Thus, all coefficients can be interpreted as elasticities. The data on government debt to GDP is available at a quarterly frequency. We transform this variable into monthly frequency using Litterman's (1983) interpolation[1], which uses an ARMA(1,1,0) model. For robustness purposes, we run a model with quarterly data[2] and do not find any significant changes in our coefficient signs.

Variables used in the study are tabulated in Table 1 together with the data sources for each variable. Of noteworthy is the computation of the various sovereign yield spreads used as dependent variables. We follow Gómez-Puig *et al.* (2014) and take the differential between the 10 year bond yield for South Africa and that of its five leading trading partners, which includes the Euro Area, United States of America (US), China, United Kingdom (UK) and Japan. However, due to lack of data for China[3] beyond 2006, the pre-crisis period for China only covers 2006M03 to 2008M03. Furthermore, to control for international and domestic financial markets

[1] The interpolation is done in Eviews.

[2] These results are available on request or can simply be replicated using publicly available data.

[3] Data for China 10-year bond yield is extracted from the People's Bank of China. The data is provided daily on a five-day week frequency. The study uses monthly averages to compute the time series used in the study. For all other countries, the data for the long-term bond yield is extracted from the Federal Reserve of St Louis and OECD data.

developments, we use the S&P index and the growth in bank credit to the private sector respectively.

Table 1. Variables and data

Variable	Description	Source
Dependent Variables: $spr\_us, spr\_euro, spr\_chn, spr\_uk, spr\_jap$		
Independent Variables		
sr	Short-term bill rate for South Africa	SARB
lsp	Log of the S&P 500 index	Yahoo Finance
$DEBT$	Debt to GDP ratio	SARB
$infl$	Log of the CPI index	SARB
$growth$	Log of total manufacturing production	SARB
SM	Log of the JSE total market capitalization	SARB
$credit$	Bank credit to private sector	SARB
$NEER$	Nominal Effective Exchange Rate	SARB

3.1. Model specification

Having identified the variables, Equation (2) states the baseline model used in the study. However, to meet the correct statistical requirements relating to model specification and other diagnostic tests, some variables are dropped in some of the estimated models.

$$spr\_M_t = \alpha_1 + \beta_1 sr_t + \beta_2 lsp_t + \beta_3 growth_t + \beta_4 D_{GDP_t} + \beta_5 infl_t + \beta_6 cred_t + \beta_7 SMI_t + \varepsilon_t, \quad (2)$$

where; spr_M is the differential between the South African 10-year bond yield and its counterpart from the five countries mentioned above at time t. All the other variables are as defined in Table 1 and ε_t is the error term assumed to be independent and identically distributed (i.i.d).

3.2. Estimation techniques

The paper initially employs the Auto-Regressive Distributed lag (ARDL) technique of Pesaran and Shin (1998) to estimate the determinants of the sovereign yield spread for South Africa for both pre- and post-crises periods. The ARDL framework enables us to identify both short-term and long-term influences of the long-term yield spread, and apply the bound test approach to test for the long-run relationship (Pesaran *et al.* 2001). However, like any other linear regression technique, the ARDL technique as proposed by Pesaran and Shin (1998) assumes constant parameters throughout the period under study. To capture the changes in the coefficients due to time and policy changes, we first divide our sample into two, pre- and post-crisis. We estimate ARDL models for the pre-crisis period using five different interest rates spreads as dependent variables. The countries used in this analysis are selected depending on their contribution to South African trade[4] as determined by the South African Reserve Bank (Motsumi *et al.* 2008). We use these baseline results to compare our findings with previous studies.

To further explore the evolution of the pricing of debt and other key variables by investors in South African government bonds, the study utilizes the Flexible Least Squares technique (Kalaba and Tesfatsion, 1989; Alptekin *et al.* 2019). The technique relaxes the assumption of constant coefficients used in most regression techniques, allowing coefficients to slowly evolve with time. Alptekin *et al.* (2019) argue that the FLS approach lies between the rolling regressions and state space techniques. In our case, allowing the coefficients to vary over time adds to our understanding of the importance attached to macroeconomic factors in the South African economy, and the effectiveness of some policy decisions over time. In this regard, the coefficient of debt to GDP is central to our analysis since it depicts the extent to which government borrowing impacts the overall riskiness of government bonds.

[4] Specifically, top trading partners for South Africa used in the study are the Euro Area, United States, China, United Kingdom and Japan.

The Flexible Least Squares (FLS) approach introduced by Kalaba and Tesfatsion (1989) and Tesfatsion and Veitch (1990) extends the Least Squares technique to account for variable coefficients. Assume the following FLS regression model:

$$Y_t = \beta_t X_t + u_t, \tag{3}$$

where; Y are the observations of the dependent variable and X is a vector of independent variables as used in the Ordinary Least Squares (OLS) regression. However, the β_t can be seen to be changing with time. To allow for coefficient variability, Kalaba and Tesfatsion (1989) firstly give the following two assumptions that are required for coefficient stability and linear measurement:

$$Y - \beta X \approx 0, \tag{4}$$

and,

$$\beta_{n+1} - \beta_n \approx 0, \tag{5}$$

where; $\beta_n 1 \dots\dots\dots\dots \beta_n M = K \times 1$ vector of unknown coefficients. Whilst Assumption (4) is a common regression assumption, Assumption (5) allows the model to have coefficients that can slowly evolve (Montana *et al.* 2009). In practice however, Montana *et al.* (2009) show that FLS remains efficient even with large variations in the coefficients. Failure to meet the given assumptions could result in two types of errors as identified by Kalaba and Tesfatsion (1989). Firstly, β could fail to satisfy Assumption (4), resulting in the first error, which can be measured by the sum of squared residuals as in the OLS method.

$$\varepsilon_m^2 = \sum_{t=1}^{T} (Y_t - \beta_t X_t)^2, \tag{6}$$

In addition, error assigned to the violation of Assumption (5) is measured by sum of squared residual dynamic errors and can be shown in the following cost function:

$$\varepsilon_d^2 = \sum_{t=1}^{T-1} (\beta_{t+1} - \beta_t)(\beta_{t+1} - \beta_t), \tag{7}$$

Combining (6) and (7), the FLS method provides the time path for $\beta_1 1 \dots\dots\dots\dots \beta_T M$ which minimizes the following cost function:

$$C_{\beta,\gamma} = \sum_{t=1}^{T} (Y_t - \beta_t X_t)^2 + \gamma \sum_{t=1}^{T-1} (\beta_{t+1} - \beta_t)(\beta_{t+1} - \beta_t), \tag{8}$$

where; γ is a predefined scalar that is used as a smoothing parameter, which penalizes the dynamic component of the cost function. Montana *et al.* (2009) show that the coefficient vector can be estimated sequentially, starting with coefficient β_T. We employ this technique to investigate the evolution of the coefficients of the determinants of the long-term bond interest rate spread for South Africa.

4. Results and discussion

In this section, we present the results of the paper, starting with individual characteristics of the series. Summary Statistics are presented in Table A1 in the appendix. Notable from the statistics is that all five spread measures are positive and have never been negative as indicated by their minimum values. This confirms that South Africa is highly risk in comparison to its trading partners as a capital destination. In addition, to ensure that there are no I(2) regressors among the series as required to run the ARDL model, we undertake unit root tests.

4.1. Unit root tests

The study uses two unit root tests, the Phillips and Perron (1988) unit root test and also Perron (1989)'s break-point unit root test. The results which are reported in Table 2 show that bank credit to private sector is integrated of order zero or an I(0) variable. The spread between South Africa bond yields and Japan and China also show seem to be stationary at levels using the PP test but are found to be I(1) in the Break-point test results. The rest of the variables are integrated of order 1 or simply become stationary after the first difference. Since all variables are either I(1) or I(0) we proceed with estimation of the fixed coefficient models using the ARDL technique.

Table 2. Unit root tests

Variable	PP[5]		Break-point		Conclusion
	Level	1st Difference	Level	1st Difference	
sr	-0.237341	-8.482093***	-4.173843	-4.833238**	I(1)
sm	1.722825	-10.82380***	-3.010299	-12.71101***	I(1)
$DEBT$	-3.047232	-4.902365***	-1.476966	-5.120408**	I(1)
$infl$	-2.191130	-9.140566***	-2.539598	-10.02215***	I(1)
$growth$	-0.037269	-16.60057***	-3.267717	-17.17488***	I(1)
LSP	-2.013436	-11.59642***	-1.816697	-12.95885***	I(1)
$credit$	-4.762928***		-4.782815*		I(0)
$NEER$	-1.859354	-10.48216***	-3.837502	-11.50161***	I(1)
SPR_EUR	-2.583829	-11.80396***	-4.415003	-11.67240***	I(1)
SPR_UK	-3.012375	-30.77230***	-4.419061	-11.53157***	I(1)
SPR_JAP	-3.259963*		-4.142819	-11.75423***	I(1)
SPR_US	-2.928853	-11.36887***	-4.167120	-12.01354***	I(1)
SPR_CHN	-6.352557***		-3.436160	-18.13924***	I(1)

Note: *, **, *** represent 10%, 5% and 1% significance respectively. Null hypothesis is that there is a unit root in the series.

4.2. Estimated results

Our estimated results are divided between baseline estimations which are conducted using the ARDL technique and the time varying estimation conducted using the Flexible Least Squares approach. Firstly, we discuss and present results from the ARDL estimations divided into two periods, pre- and post-crisis. We estimate (5) models based on the spread between the South African 10-year bond yield and its five leading trading partners. For each country, we estimate the model both for the pre- and post-crisis periods resulting in 10 different regression results. Whilst traditionally the US interest rate is used as the reference rate, considering other trading partners allows us to analyze their importance as well in the determination of long-term bond yield spreads for South Africa.

4.2.1. Fixed coefficients – ARDL Technique

Table 3 shows the short-run coefficients for all estimated models. In the short run, we find that the short-term interest rate has a positive and significant relationship with the long-term bond yield. For instance, the response to a 1 percentage point increase in the short-term interest rate (sr) has a median value of 0.312 percentage point increase and 0.417 percentage point increase in the spread before and after the crisis respectively. We confirm previous literature, which find that the short-term interest rate is the major determinant of the long-term bond yields and bond

[5] Null hypothesis is that there is unit root.

yield spreads (Akram and Das, 2019; Goyari and Kamaiah, 2016). The finding also validates the expectations theory of interest rate determination, which suggest that long-term rates are determined by expectations of short-term rates plus a given risk premium (Kikugawa and Singleton, 1994). Furthermore, we also find that the inflation rate is positively related to the bond yield spread with a positive and significant coefficient in all the models in both the pre- and post-crisis periods in the short run. In the Euro model a, 1 percentage point increase in the inflation rate results in a 38.4 basis points and 51.8 basis point increase in the spr_eur for the pre- and post-crisis respectively. Inflation increases investment risk in the short-term. And interpreting the long-term yield as the real interest rate could also lead to a conclusion that the Fisher (1930) effect holds for South Africa.

Other short-term influences include the nominal effective exchange rate $(neer)$ and the log of the S&P index (lsp). The S&P index does not have a significant impact on the bond yield spread prior to the crisis but shows a negative and significant effect in the post-crisis period. This shows that the influence of global financial markets on emerging economies has been more pronounced since the crisis. An appreciation of the South African rand also reduces the bond yield spread as indicated by the negative impact of a change in the $NEER$ on the bond yield spread. For instance, in the Euro model a, 1 percentage point increase in the $NEER$ results in a -8.8 and -9.3 basis points change in the spr_eur for pre- and post-crisis periods respectively. We interpret this to imply increased exchange rate risk for external investors. It also confirms the possibility of the uncovered interest rate parity holding for South Africa although our specification does not specifically address the theory. The negative effect of domestic stock market returns sm on the bond spread can also be identified, especially during the pre-crisis period. An increase in stock returns might signal higher risk in capital markets, which in turn increases domestic bond yields and hence negatively impacts the yield spread.

Long-run coefficients are given in Table 4. We find that government debt and the short-term interest rate impact the yield spread positively. A closer examination of the results reveals that investors price South African government debt against all other countries except for Japan, which might be due to Japanese interest rates which are very low (closer to zero). These results complement earlier studies which find that government fiscal position impacts the yield spread (Klose and Weigert, 2014; Robinson, 2015). In addition, we find that economic growth has a negative and significant effect on the bond yield spread in the long run. In all the models estimated, the coefficient of growth is negative although it is not significant for the Chinese models. The implication is that an increase in economic activity in South Africa improves economic prospects for the country and reduces sovereign risk.

We also find that in the long-term bank $credit$, $NEER$ and lsp all have significant impact on the long-term bond yield spread. Bank credit to private sector shows a positive and significant influence on the spread prior to the crisis for all models but China model. This may indicate that periods of higher economic growth were marked by high risk from the banking sector. In contrast, the last decade in which growth has been sluggish has seen a more stable banking sector. Again, the coefficient of lsp is negative and significant during the post-crisis period and not significant during the pre-crisis period, which support findings in Capelle-Blancard *et al*. (2019). International financial risk has become an important element in the valuation of sovereign bonds. The channel through which this risk impacts domestic bonds (both Euro-bonds and domestic currency issues) is identifiable: an increase in risk in international financial markets increases bond yields in counterpart countries, reducing the bond spread between counterparty countries and South African bonds.

These results also underscore the rise in importance of China as a trading partner of South Africa and a financial center. Prior to the GFC, the relationship between spr_chn and other variables is weak compared to the post-crisis period. For instance, for both the short run and the long run, the magnitude of the short-term interest rate (sr) coefficients increased drastically between the two periods. During the post-crisis, the magnitude of the sr coefficients at 0.723 and 0.676 percentage points for the short run and long run respectively, are greater than coefficients for all other trading partners. With these findings in mind, we turn to analyze the relationship using time varying coefficients.

Table 3. Short-run Coefficients

	Pre-crisis 1994m01-2008m03					Post-crisis 2009m01-2019m12				
Dependent	*dSpr_us*	*dSpr_Eur*	*dSpr_uk*	*dSpr_jap*	*dSpr_chn* 0306-0308	*dSpr_us*	*dSpr_Eur*	dSpr_uk	dSpr_jap	dSpr_chn
ΔSr	0.373*** [7.09]	0.397*** [8.19]	0.317*** [7.32]	0.313*** [6.15]	0.006 [0.086]	0.576*** [4.31]	0.296*** [2.68]	0.416*** [4.19]	0.713*** [4.50]	0.723*** [4.24]
$\Delta debt$	0.048 [0.66]		-0.142*** [-2.86]			-0.074 [-0.061]		0.029 [0.32]	0.218 [1.67]	0.095 [0.65]
$\Delta Infl$	0.414*** [3.73]	0.384*** [3.63]	0.353*** [3.06]	0.224** [2.07]		0.243* [1.74]	0.518*** [4.45]	0.333*** [3.17]	0.113 [0.75]	0.130 [0.77]
$\Delta growth$	0.050 [1.65]	0.049* [1.81]	0.003 [0.14]	0.0009 [0.03]		0.027 [1.47]	0.077*** [3.35]	0.043** [2.28]	-0.027 [-1.00]	0.059** [2.00]
$\Delta Credit$	-0.002 [-0.051]				-0.132*** [-4.94]	0.088 [1.01]	1.219*** [2.71]		-0.129 [-1.39]	-0.114 [-1.03]
$\Delta neer$		-0.088*** [-5.64]	--0.086*** [-5.97]	-0.104*** [-5.84]	-0.130 [-11.59]		-0.093*** [-6.36]	-0.079*** [-6.15]	-0.144*** [-7.12]	
Δsm	-0.068*** [-5.11]	-0.045*** [-4.18]	-0.082*** [-6.79]	-0.046*** [-3.89]		0.006 [0.33]			0.024 [0.1.26]	
Δlsp	-0.019 [-1.40]		0.004 [0.32]			-0.069*** [-4.94]	-0.019* [-1.80]	-0.045*** [-4.98]	-0.048*** [-2.87]	-0.041*** [-2.94]
ECT	-0.183*** [-6.45]	-0.177*** [-7.56]	-0.187*** [-8.42]	-0.157*** [-6.44]	-0.950*** [-48.04]	-0.280*** [-5.24]	-0.293*** [-8.17]	-0.239*** [6.79]	-0.857*** [-6.49]	-0.379*** [-4.73]
JB statistic	0.45 (0.796)	2.20 (0.332)	0.09 (0.954)	0.23 (0.891)	0.0003 (0.999)	2.88 (0.236)	3.83 (0.147)	2.61 (0.271)	1.45 (0.483)	0.62 (0.730)
LM F-test statistic	0.02 (0.977)	2.21 (0.111)	0.09 (0.910)	0.94 (0.390)	1.48 (0.266)	0.67 (0.510)	0.64 (0.528)	1.77 (0.173)	0.54 (0.583)	0.20 (0.814)
Heteroscedasticity B-P-G F-stat[h]	0.99 (0.483)	1.36 (0.114)	1.46* (0.075)[h]	1.32 (0.137)	0.42 (0.909)	092 (0.605)	0.55 (0.983)	1.05 (0.404)	0.97 (0.548)	0.99 (0.503)
RESET test F-Statistic	1.26 (0.174)	0.88 (0.348)	0.67 (0.415)	1.41 (0.236)	1.20 (0.292)	0.09 (0.754)	0.27 (0.602)	0.84 (0.399)	1.57 (0.215)	1.68 (0.198)
CUSUM	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	stable	Stable
Max lags	3/3f;AIC	7,7; AIC	6,6;AIC	5,5;AIC	1/1;AIC	4,4f;AIC	8/8;AIC	4/4; BIC	8/8f;AIC	7/7f;AIC

Note: ***, **, * represents 1%, 5% and 10% level of significance respectively. Figure in parenthesis [ ] are t-statistics and ( ) are p-values. Lags indicated f are fixed lags whereas the rest are automatically chosen by the programs using the given criteria.

Table 4. Long-run coefficients

Dependent / Independent	Pre-crisis 1994m01-2008m03					Post-crisis 2009m01-2019m12				
	$dSpr\_us$	$dSpr\_Eur$	$dSpr\_uk$	$dSpr\_jap$	$dSpr\_chn$ 200603 − 200803	$dSpr\_us$	$dSpr\_Eur$	$dSpr\_uk$	$dSpr\_jap$	$dSpr\_chn$
Sr	0.306*** [3.85]	0.576*** [4.20]	0.303*** [3.72]	0.402*** [4.60]	0.231** [2.40]	0.319* [1.87]	0.623*** [3.56]	0.579*** [3.32]	1.188*** [8.80]	0.676*** [4.11]
$debt$	0.270*** [3.42]	0.228*** [4.21]	0.182** [2.07]	0.253*** [5.89]	0.220*** [3.68]	0.287*** [3.13]	0.192** [2.59]	0.256** [2.59]	0.131 [1.16]	0.276*** [2.92]
$Infl$	-0.195* [-1.71]	-0.111 [-0.98]	0.044 [0.27]	0.009 [0.08]	0.491*** [4.03]	-0.199 [-0.98]	0.066 [0.31]	0.511*** [2.83]	-419*** [-2.01]	-0.351 [-1.66]
$growth$	-0.414*** [-3.07]	-0.511*** [-2.98]	-0.916*** [-3.67]	-0.335*** [-2.94]	-0.028 [-0.62]	-0.125 [-0.78]	-0.777*** [-4.12]	-0.124 [-1.11]	-0.580*** [-6.07]	-0.177 [-1.21]
$Credit$	0.301** [2.57]	0.269** [2.52]	0.281*** [3.63]	0.116** [1.99]	-0.264*** [-4.97]	0.157* [1.93]	-0.112 [-0.59]	-0.293* [-1.77]	-1.359*** [-8.19]	0.194** [2.48]
$neer$		0.039 [1.38]	-0.054 [-1.13]	-0.015 [-0.42]	-0.164*** [-11.31]		-0.183*** [-4.15]	-0.004 [-0.12]	-0.175*** [-6.20]	
sm	-0.124*** [-2.80]	-0.179*** [-4.99]	-0.120*** [-5.04]	-0.050*** [-2.61]		-0.0003 [-0.01]		0.042 [1.11]	0.179*** [6.44]	
lsp	-0.031 [-1.06]		0.016 [0.78]			-0.144*** [-3.06]	-0.027 [-0.84]	-0.175*** [3.91]	-0.156*** [-5.95]	-0.101*** [-2.74]
Bounds test F-statistic	4.43***	5.09***	7.46***	4.99***	211.6***	3.19**	6.81***	4.79***	4.04**	2.96*

Note: ***, **, * represent 1%, 5% and 10% level of significance respectively. Figures in parenthesis [ ] are t-statistics.

4.2.2. Time varying FLS results

Our time varying coefficients are reported in this section. To derive these, we estimate a time varying FLS regression in which the long-term interest rate spread (based on the US long 10-year bond yield) is determined by $sr_t, debt_t, growth_t,\ infl_t,\ lsp_t$, and sm_t. We drop $credit$ from the equation since it is the only variable that is integrated of order zero. Whilst Wood (2000) and Tesfatsion and Veitch (1990) show that stationarity can be disregarded in time varying regression, we continue to test for cointegration and error correction using the Engle and Granger (1987) two step approach before estimating a time varying model [6]. Our results confirm that the variables are cointegrated. On the backdrop of this finding, we estimate the model using FLS technique of Kalaba and Tesfatsion (1989). The time varying estimates for the long-run equation are reported below. We focus primarily on the coefficient of government debt.

Figure 1 shows the evolution of the coefficient of government debt. In essence, it shows how the sovereign yield spread have responded to changes in government debt over time as suggested by Haugh *et al.* (2009). Clearly, the market has consistently factored in the level of government debt in pricing South African long-term bonds as shown by a positive coefficient of debt throughout the period under study supporting findings by Bernoth and Erdogan (2012). Furthermore, it should be noticeable that from the time of independence in 1994 up until 2003, the impact has trended downwards. Important periods with marked differences with this trend are 1997-1999, 2003 and also post 2008 period. The 1997-1999 period could explain the impact of the Asian crisis on emerging market debt risk and adjustments to re-integration into the global economy (IDC, 2013). The period 2002-2003 was also marred with international shocks from the SARS virus, corporate failures and geo-political destabilization involving Iraq (Mboweni, 2003). These conditions increased uncertainty resulting in higher pricing of debt. The 2008-2009 Global Financial Crisis is also identifiable in the graph, resulting in increased impact of debt on the yield spread, showing increased risk aversion and an increase in the importance of fiscal actions. The impact of the '*Ramaphoria*' effect is seen by a drop in the coefficient in 2018, which however is corrected the same year. Since 2018, the impact of debt has been increasing, confirming the concerns raised on the level of debt and the fiscal position of the country. What is also clear from this analysis is that the level of debt has not had a huge negative impact on the economy as yet, dismissing claims that write-off South African fiscal consolidation benefits (Burger *et al.* 2016). Figure 2 depicts all the other coefficients.

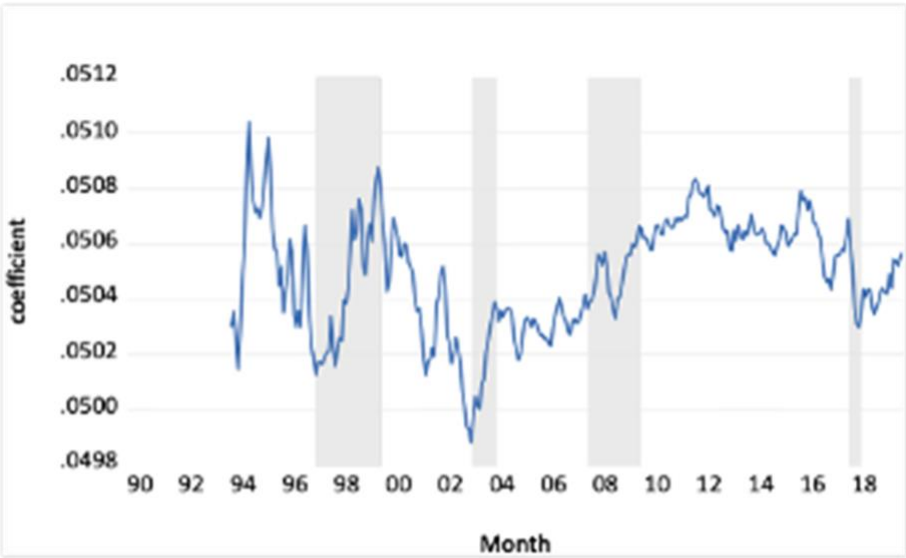

Figure 1. Coefficient of government debt
Source: Author's computations

[6] These tests results are available on request.

The short-term interest rate's impact on the long-term bond yield spread is shown in panel **a** of Figure 2. We interpret the coefficient to mean the impact of monetary policy on the bond market. The coefficient has trended downwards from the year 2000 up until the crisis in 2008. We ascribe this to the monetary policy framework - inflation targeting. However, the changes, which have not been very large have not persisted after the crisis, which may imply that there have not been huge surprises from the monetary policy side. In addition, the impact of economic growth on the bond market can also be analyzed. Panel **d** of Figure 2 shows the time varying coefficient of economic growth. Again, the sensitivity of the bond yield spread to changes in the economic growth rate has tended to decrease over time, especially from 1994 to 2003. This might show the long-term focus of bond investors.

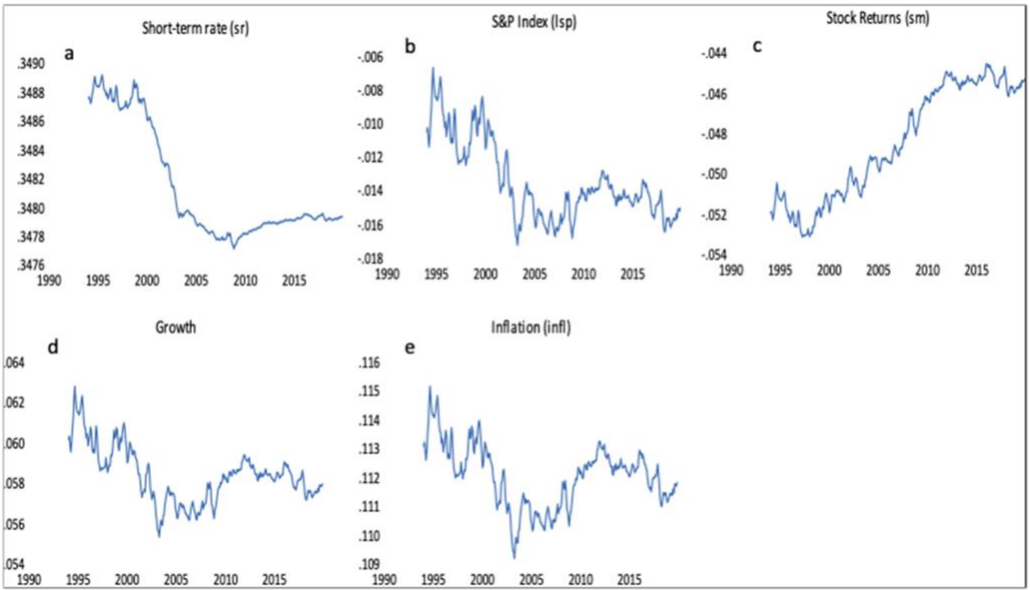

Figure 2. Time varying coefficients
Source: Author's computations

Panel **b** of Figure 2 shows the impact of the log of S&P index on the bond yield spread, which we interpret to indicate the impact of international financial markets developments. The evolution of the coefficient confirms our findings in the fixed coefficient models, which portray a statistically insignificant relationship between the two variables prior to the crisis but indicate a negative and statistically significant relationship in the post-crisis period. As alluded to earlier, a negative coefficient would imply that improvements in international financial markets signal improved risk environment hence reduces bond yields for emerging market economies. In panel **c**, the coefficient of domestic stock market returns is given and shows the negative influence of stock market returns on the bond yield spread. Our interpretation is that increased risk in domestic financial markets results in increased bond-yields for South Africa, hence negatively impacts the bond yield spread. Lastly, panel **e** shows the positive and significant impact of inflation on the bond yield spread.

Given these findings, it is important to point out the limitations of this study. Firstly, the data for government debt-to-GDP ratio ($debt$) is available in quarterly frequency and it has been interpolated to create a variable with monthly frequency data. To address, we also run the model with quarterly frequency data and do not find any changes in coefficient signs. Furthermore, the Flexible Least Squares regression technique does not account for time varying cointegration and instead, we have tested for cointegration using the Engle and Granger (1987) two-step procedure, which also confirms the presents of a long-run relationship established by the ARDL estimations.

5. Conclusion and recommendations

This study investigates the determinants of the long-term bond yield spread for South Africa. We contribute to literature on the long-term bond yield spread in two ways. Firstly, we estimate constant parameter regressions using the five top trading partners' bond yields as reference rates. This approach helps us to find out how South Africa debt is priced in comparison to its main trading partners. Furthermore, we compare the effects for the pre- and post-crisis periods. Our second contribution stems from the analysis of time varying regression coefficients to further explore the evolution of the coefficients of the long-term sovereign yield spread.

We find that the short-term interest rate, the inflation rate, S&P index and the exchange rate are the major short-term determinants of the bond yield spread in South Africa in both the pre- and post-crisis periods. Specifically, the short-term interest rate and the rate of inflation positively impact the long-term bond spread. These findings confirm theoretical expectations in the Fisher (1930) equation and the uncovered interest rate parity. Furthermore, the log of the S&P index and the exchange rate portrays negative influence on the bond yield spread in the short-term. We interpret this to imply that positive developments in international financial markets reduce risk associated with holding emerging market bonds. The evidence is mixed for both bank credit and stock market returns.

In the long run, the bond-yield spread is determined by the short-term rate of interest, government debt, economic growth, stock market returns and also international financial market developments. We find government debt and the short-term rate to have a positive influence on the bond yield spread. As expected, we also find economic growth to have a constraining effect on the bond yield spread, signaling that high levels of economic growth should drive down the yield spread. Developments in international financial markets as measured by the S&P index also are negatively related to the spread.

To further analyze the discrepancies found in the coefficients for the pre- and post-crisis periods, we use the time varying regression to analyze the evolution of the long-term coefficients. Results from the time varying FLS regression show that the coefficient of government debt has trended downwards between 1994 and 2003, and has risen during and after the crises, showing an upward trend in the recent years. This shows that macroeconomic developments and market sentiments have an impact on the extent to which government debt is priced in bond markets. The implication for this finding is that macroeconomic stability in South Africa has had an impact on market pricing of South African debt. Recent increases in the coefficient also confirm reactions to escalating debt levels in the recent three years. However, we conclude that South Africa has not reached a debt trap due to the low magnitude of the coefficient compared to crises periods.

Our findings present several implications for policy; firstly, the linkage between monetary policy and developments in debt markets is acknowledged. This implies the need for a synchronized approach between monetary and fiscal policy to avoid policy incoherence. Secondly, macroeconomic certainty and instability should be taken into account when analyzing the level of indebtedness. Thus debt becomes detrimental to the economy when accompanying macroeconomic fundamentals are not supporting macroeconomic growth and stability. We argue that addressing economic growth and governance issues including corruption increases access to credit without effecting an upsurge in borrowing costs.

References

Afonso, A. and Jalles, J. T., 2019. Quantitative easing and sovereign yield spreads: euro-area time-varying evidence. *Journal of International Financial Markets, Institutions and Money,* 58**,** pp. 208-224. https://doi.org/10.1016/j.intfin.2018.10.003

Afonso, A. and Martins, M. M., 2012. Level, slope, curvature of the sovereign yield curve, and fiscal behaviour. *Journal of Banking & Finance,* 36**,** pp.1789-1807. https://doi.org/10.1016/j.jbankfin.2012.02.004

Afonso, A., Arghyrou, M. and Kontonikas, A., 2012. *The determinants of sovereign bond yield spreads in the EMU*. Working Papers, No 2012/36. Department of Economics, ISEG -

Lisbon School of Economics and Management, Department of Economics, Universidade de Lisboa. https://doi.org/10.2139/ssrn.2223140

Afonso, A., Arghyrou, M. G. and Kontonikas, A., 2015. *The determinants of sovereign bond yield spreads in the EMU*. European Central Bank Working Paper, No 1781.

Akram, T. and Das, A., 2019. The long-run determinants of Indian government bond yields. *Asian Development Review,* 36(1)**,** pp.168-205. https://doi.org/10.1162/adev_a_00127

Alptekin, A., Broadstock, D. C., Chen, X. and Wang, D., 2019. Time-varying parameter energy demand functions: benchmarking state-space methods against rolling-regressions. *Energy Economics,* 82**,** pp. 26-41. https://doi.org/10.1016/j.eneco.2018.03.009

Barbosa, L. and Costa, S., 2010. *Determinants of sovereign bond yield spreads in the euro area in the context of the economic and financial crisis*. Banco de Portugal Working Paper, No. 22.

Bernoth, K. and Erdogan, B., 2012. Sovereign bond yield spreads: a time-varying coefficient approach. *Journal of International Money and Finance,* 31(3)**,** pp. 639-656. https://doi.org/10.1016/j.jimonfin.2011.10.006

Bianchi, M. L. and Rocco, M., 2016. Disentangling the information content of government bonds and credit default swaps: an empirical analysis on sovereigns and Banks. *Frontiers in Applied Mathematics and Statistics,* 2**,** pp. 1-22. https://doi.org/10.3389/fams.2016.00022

Burger, P., Siebrits, K. and Calitz, E., 2016. Fiscal consolidation and the public sector balance sheet in South Africa. *South African Journal of Economics,* 84(4)**,** pp. 501-519. https://doi.org/10.1111/saje.12126

Caggiano, G. and Greco, L., 2012. Fiscal and financial determinants of Eurozone sovereign spreads. *Economics Letters,* 117(3)**,** pp. 774-776. https://doi.org/10.1016/j.econlet.2012.08.041

Capelle-blancard, G., Crifo, P., Diaye, M.-A., Oueghlissi, R. and Scholtens, B., 2019. Sovereign bond yield spreads and sustainability: An empirical analysis of OECD countries. *Journal of Banking & Finance,* 98**,** pp. 156-169. https://doi.org/10.1016/j.jbankfin.2018.11.011

Chin, C.-C. and Liang, H.-M., 2009. The long-run uncovered interest rate parity in view of a trading strategy. *Applied Economics,* 41(21)**,** pp. 2727-2739. https://doi.org/10.1080/00036840701320225

Clay, R. and Keeton, G., 2011. The South African yield curve as a predictor of economic downturns: an update. *African Review of Economics and Finance,* 2**,** pp. 157-193.

Eichler, S., 2014. The political determinants of sovereign bond yield spreads. *Journal of International Money and Finance,* 46**,** pp. 82-103. https://doi.org/10.1016/j.jimonfin.2014.04.003

Engle, R. and Yoo, B., 1991. *Cointegrated economic time series: an overview with new results*. Pennsylvania State-Department of Economics Report, No 8-89-13.

Engle, R. F. and Granger, C. W., 1987. Co-integration and error correction: representation, estimation, and testing. *Econometrica: Journal of the Econometric Society,* 55(2), pp. 251-276.

Favero, C. and Missale, A., 2012. Sovereign spreads in the eurozone: which prospects for a Eurobond? *Economic Policy,* 27(70)**,** pp. 231-273. https://doi.org/10.1111/j.1468-0327.2012.00282.x

Feyen, E., Ghosh, S., Kibuuka, K. and Farazi, S., 2015. *Global liquidity and external bond issuance in emerging markets and developing economies*. Research Working Paper 7363. World Bank. [online] Available at: <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2630379> [Accessed on 22 March 2021]. https://doi.org/10.1596/1813-9450-7363

Fisher, I., 1930. *The theory of interest*. New York: Macmillan 43.

Gómez-Puig, M., Sosvilla-Rivero, S. and Del Carmen Ramos-Herrera, M., 2014. An update on EMU sovereign yield spread drivers in times of crisis: a panel data analysis. *The North American Journal of Economics and Finance,* 30**,** pp.133-153. https://doi.org/10.1016/j.najef.2014.09.003

Goyari, P. and Kamaiah, B., 2016. Determinants of sovereign bond yields in emerging economies: Some panel inferences. *Theoretical and Applied Economics,* 23**,** pp. 101-118.

Haugh, D., Ollivaud, P. and Turner, D., 2009. What drives sovereign risk premiums? an analysis of recent evidence from the Euro area. *OECD Economic Department Working Papers*, No 718.

IDC, 2013. South African economy: An overview of key trends since 1994. Gauteng: Industrial Development Corporation. [online] Available at: <https://www.idc.co.za/wp-content/uploads/2018/11/Economic_Trends_Key_trends_in_SA_economy_March_2014.pdf> [Accessed on 1 March 2021].

Ilut, C., 2012. Ambiguity aversion: Implications for the uncovered interest rate parity puzzle. *American Economic Journal: Macroeconomics,* 4(3), pp. 33-65. https://doi.org/10.1257/mac.4.3.33

Kalaba, R. and Tesfatsion, L., 1989. Time-varying linear regression via flexible least squares. *Computers & Mathematics with Applications,* 17(8-9), pp. 1215-1245. https://doi.org/10.1016/0898-1221(89)90091-6

Kennedy, M. and Palerm, A., 2014. Emerging market bond spreads: the role of global and domestic factors from 2002 to 2011. *Journal of International Money and Finance,* 43, pp. 70-87. https://doi.org/10.1016/j.jimonfin.2013.12.008

Kikugawa, T. and Singleton, K. J., 1994. Modeling the term structure of interest rate in Japan. *The Journal of Fixed Income,* 4(2), pp. 6-16. https://doi.org/10.3905/jfi.1994.408111

Klose, J. and Weigert, B., 2014. Sovereign yield spreads during the euro crisis: fundamental factors versus redenomination risk. *International Finance,* 17(1), pp. 25-50. https://doi.org/10.1111/infi.12042

Litterman, R.B., 1983. A random walk, Markov model for the distribution of time series. *Journal of Business & Economic Statistics*, 1(2), pp. 169-173. https://doi.org/10.1080/07350015.1983.10509336

Liu, S., Shi, J., Wang, J. and Wu, C., 2009. The determinants of corporate bond yields. *The Quarterly Review of Economics and Finance,* 49(1), pp. 85-109. https://doi.org/10.1016/j.qref.2007.10.006

Mboweni, T. T., 2003. *Inflation targeting in South Africa*. 2 September, 5th Annual African Development Conference, Pretoria.

Montana, G., Triantafyllopoulos, K. and Tsagaris, T., 2009. Flexible least squares for temporal data mining and statistical arbitrage. *Expert Systems with Applications,* 36(2), pp. 2819-2830. https://doi.org/10.1016/j.eswa.2008.01.062

Motsumi, L., Oldfield, M., Mokoetla, A., Swart, P. and De Beer, B., 2008. Note on the revision of South Africa's nominal and real effective exchange rate indices. *South African Reserve Bank Quarterly Bulletin Articles and Notes*. Pretoria: SARB

Ntshakala, M. and Harris, L., 2018. *The information content of the yield spread about future inflation in South Africa*. WIDER Working Paper, No. 2018/63. Helsinki: UNU-WIDER. https://doi.org/10.35188/UNU-WIDER/2018/505-3

Perron, P., 1989. The great crash, the oil price shock, and the unit root hypothesis. *Econometrica: Journal of the Econometric Society*, 57(6), pp. 1361-1401. https://doi.org/10.2307/1913712

Pesaran, M. H. and Shin, Y., 1998. An autoregressive distributed-lag modelling approach to cointegration analysis. *Econometric Society Monographs,* 31, pp. 371-413. https://doi.org/10.1017/CBO9781139052221.011

Pesaran, M. H., Shin, Y. and Smith, R. J., 2001. Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics,* 16(3), pp. 289-326. https://doi.org/10.1002/jae.616

Phillips, P. C. and Perron, P., 1988. Testing for a unit root in time series regression. *Biometrika,* 75(2), pp. 335-346. https://doi.org/10.1093/biomet/75.2.335

Radier, G., Majoni, A., Njanike, K. and Kwaramba, M., 2016. Determinants of bond yield spread changes in South Africa. *African Review of Economics and Finance,* 8(2), pp. 50-81. https://doi.org/10.2139/ssrn.2742963

Robinson, Z., 2015. An analysis of sovereign risk in South Africa with the focus on fiscal determinants. *Southern African Business Review,* 19(3), pp. 154-173.

SARB, 2020. *Financial stability review*. Pretoria: South African Reserve Bank.

Senga, C., Cassimon, D. and Essers, D., 2018. Sub-Saharan African Eurobond yields: what really matters beyond global factors? *Review of Development Finance,* 8(1)**,** pp. 49-62. https://doi.org/10.1016/j.rdf.2018.05.005

Tesfatsion, L. and Veitch, J. M., 1990. US money demand instability A flexible least squares approach. *Journal of Economic Dynamics and Control,* 14(1)**,** pp. 151-173. https://doi.org/10.1016/0165-1889(90)90010-E

Thomas, M. and Maré, E., 2007. Long term forecasting and hedging of the South African yield curve. In: *2007 ASSA Convention, The Actuarial Society of South Africa*.

Vocke, M., 2003. Sovereign risk spreads under inflation targeting. *IMF Country Report,* 3**,** pp. 87-102.

Wellmann, D. and Trück, S., 2018. Factors of the term structure of sovereign yield spreads. *Journal of International Money and Finance,* 81**,** pp. 56-75.

Wood, B. D., 2000. Weak theories and parameter instability: using flexible least squares to take time varying relationships seriously. *American Journal of Political Science***,** 44(3), pp. 603-618.

Appendix

Table A1. Univariate characteristics of data series

	CREDIT	DEBT	INFL	GROWTH	LSP	NEER	SM	SR	SPR_EUR	SPR_UK	SPR_JAP	SPR_US	SPR_CHN
Mean	5.968	0.409	1.709	1.948	3.037	2.070	1.460	0.099	0.064	0.063	0.093	0.067	0.050
Median	5.979	0.411	1.716	1.963	3.076	2.035	1.384	0.092	0.060	0.061	0.090	0.065	0.050
Maximum	6.588	0.625	2.055	2.041	3.509	2.482	2.067	0.216	0.140	0.131	0.172	0.135	0.068
Minimum	5.168	0.260	1.227	1.803	2.483	1.713	0.737	0.049	0.032	0.025	0.055	0.025	0.035
Std. Dev.	0.440	0.086	0.220	0.060	0.252	0.213	0.412	0.038	0.019	0.018	0.022	0.018	0.008
Skewness	-0.233	0.179	-0.284	-0.694	-0.404	0.302	-0.0197	0.677	0.753	0.348	0.680	0.215	-0.011
Kurtosis	1.686	2.273	2.146	2.282	2.445	2.006	1.617	2.419	3.465	3.247	2.894	3.210	1.936
Jarque-Bera	29.167	9.847	15.782	36.650	14.392	20.282	28.720	32.204	37.257	8.171	27.945	3.435	7.900
Probability	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.017	0.000	0.180	0.019
Sum	2148.454	147.358	615.290	701.369	1093.490	745.217	525.666	35.744	23.076	22.670	33.350	24.134	8.267
Sum Sq. Dv.	69.502	2.656	17.347	1.262	22.766	16.221	60.889	0.526	0.130	0.119	0.172	0.122	0.010
Observations	360	360	360	360	360	360	360	360	360	360	360	360	166