The South African – United States Sovereign Bond Spread and its Association with Macroeconomic Fundamentals

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Abstract

The yield spread of South African to United States 10 year government bonds over the last 5 years has increased substantially to levels approaching those last seen during the mid-1980s. This yield spread increase is replicated in spreads relative to long-term German bonds, as well as for the spread of state owned enterprises (ESKOM) to United States and German bonds. This paper examines the association between the spread and macroeconomic fundamentals over the 1960-2019 sample period, under the GARCH and GARCH-M class of estimators. We find that higher South African economic growth, lower inflation, public and private debt, as well as Rand-Dollar appreciation are all associated with a statistically significantly lower South African - United States yield spread. The strongest impact is associated with the public debt-to-GDP ratio. Mean spread levels do not appear to be influenced by yield volatility. Finally, while there is no evidence of sign bias in the impact of shocks on yield volatility (negative shock impacts are no different than positive), there is evidence of size bias for both positive and negative shocks: larger shocks have a larger impact on volatility than small, regardless of their sign. Collectively, and even ignoring the impact of private sector leveraging, South Africa's performance in these macroeconomic fundamentals is associated with an increase in the SA-US yield spread of 363 basis points (since 2012). This constitutes a substantial proportion of the current 741 basis point spread.

Keywords: sovereign bond spreads, macoreconomic fundamentals, South Africa.
JEL Codes: E4, E5, E6.
Word Count: 11,280

[1] All results and interpretations presented in this paper are those of the author, and do not necessarily reflect the views of any institution the author is affiliated with. Useful comments and suggestions were provided by seminar participants in the South African Reserve Bank Research Department in December 2019. Daan Steenkamp provided comments based on a close and detailed reading of the results. All remaining errors are the responsibility of the author alone.

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1 Introduction

Internationally yields on government debt in the post sub-prime crisis period have been low in absolute terms over a protracted period of time. The low cost of borrowing has led to the suggestion that the space for policies emphasizing fiscal activism has widened, since the risk of negative welfare impacts of fiscal deficits has been effectively eliminated. This position has been advanced specifically with respect to the United States and potentially other advanced economies. A core concern with this argument is whether the inference generalizes to other contexts such as emerging markets, and if not, why this might be the case. One indication that this is a relevant question is that in the South African case study, since 2008 yields on long-term government bonds have been relatively low by historical standards, and have also remained relatively constant. But constant South African rates in combination with declining yields in safe assets such as US and German long-term government bonds, has resulted in a widening yield spread between South African and safe assets despite their relatively low absolute levels. This provides the question for the present paper: what might explain the rising yield spread for South Africa, and whether this might reflect more generally on the argument in favour of a widening space for fiscal activism. In particular, the paper examines macroeconomic fundamentals as drivers of the rising yield spread.

The pattern of reduced yields on government bonds for the US (as well as the Euro area, the UK and Japan), sustained over a protracted period of time, has led Blanchard (2019) to suggest that since safe rates are below real growth of the economy and are projected to remain so for some time, the issuance of public debt is without fiscal cost, in the sense that public debt can be issued and rolled over without any need for an increase in taxes. To assess the full welfare effects of public debt, Blanchard draws on the Diamond (1965) overlapping generations model insight that the welfare effects of intergenerational transfers (such as debt rollovers) has two channels, directly through reduced capital accumulation and indirectly through induced changes to the returns to capital and labor. Under certainty (Diamond), the welfare impact depends on the interest rate, which under certainty reduces to the marginal product of capital. As long as the interest rate is then below the growth rate, transfers are welfare improving. By extending the analysis to conditions of uncertainty, Blanchard shows that the net welfare impact depends on both the safe rate, and the risky marginal product of capital. The safe rate determines the welfare impact of reduced capital accumulation, with a positive welfare impact provided that the safe rate is lower than the growth rate. By contrast, the welfare impact of induced changes to the return on labor and capital depends on the risky average marginal product of capital, with a negative impact where the marginal product of capital exceeds the growth rate. Since Blanchard finds the safe rate to be below the growth rate, and the marginal product of capital to lie above the growth rate for the US (which he attributes to a low elasticity of substitution between capital and labor), the net welfare impact depends on the relative size of the two differentials. However, Blanchard also suggests that currently the net effect is positive, and that the marginal product of capital has been declining in the US, ameliorating the negative welfare impact component.[1] Henceforth, we will refer to a positive differential between nominal growth and long term yields as the Blanchard necessity condition (BNC) for a positive welfare impact of public debt.

Since Blanchard (2019) claims that the interest rate versus growth differentials fundamental to his analysis are relatively pervasive, a particularly interesting case study is provided by South Africa. Since the democratic transition of 1994, the understandable South African macroeconomic policy focus on diminishing poverty and lowering income and wealth inequality, has served to anchor the orientation of fiscal policy. An understanding of the scope for debt financing of expenditure is thus of central interest to the South African case.

However, despite Blanchard's (2019) claims to generality for interest rate versus growth differentials fundamentals, unfortunately they do not apply to the South African case. Figure 1 reports the differential between annual nominal GDP growth and either the yield on 10 year government or Eskom bonds for South Africa. It follows immediately that the BNC was met for South Africa at best only until the late 1970s. After 1980, with the brief exception of the 2002-2008 period, the BNC condition has not been met in South Africa, with yields on long term public sector bonds generally comfortably exceeding nominal GDP growth. It is worth noting that while Eskom yields have shown a higher proportional increase than general government

[1] It should be noted that Blanchard (2019) is careful to state that his modeling is not meant to be a blanket endorsement of increasing public debt. For instance, under adverse shocks the safe rate may be increased sufficiently to trigger explosive dynamics, higher debt raising the safe rate, higher safe rates in turn increasing debt over time.

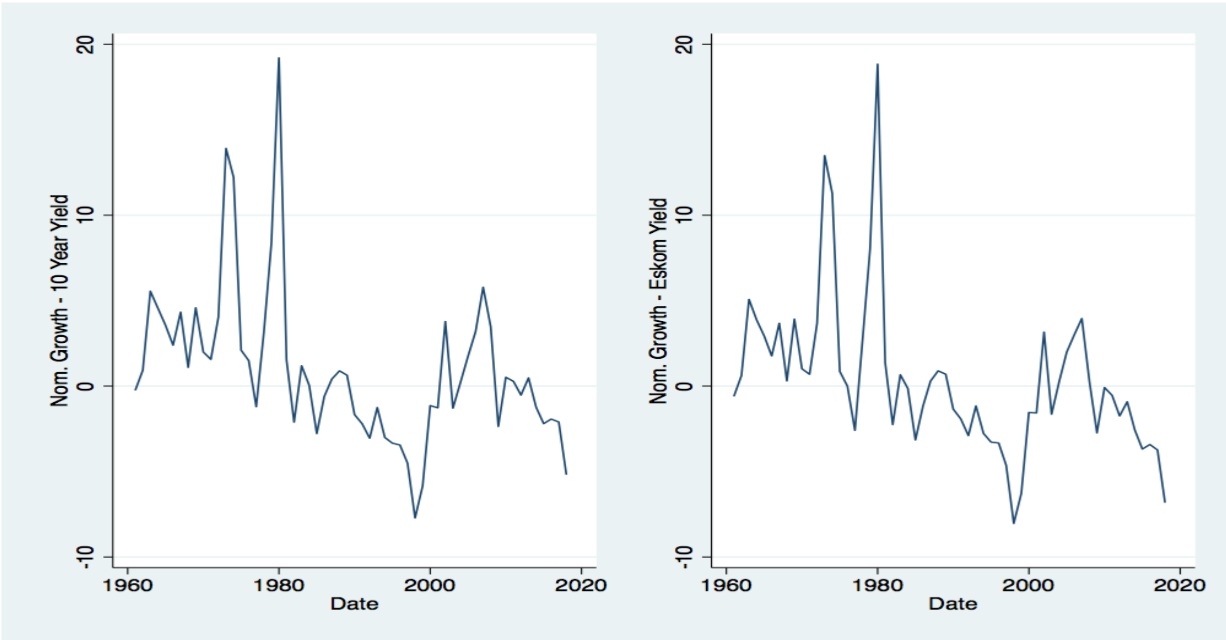

Figure 1: Nominal GDP Growth and 10 Year Government Bond Yield Differential (left); Nominal GDP Growth and Eskom Bond Yield Differential (right)

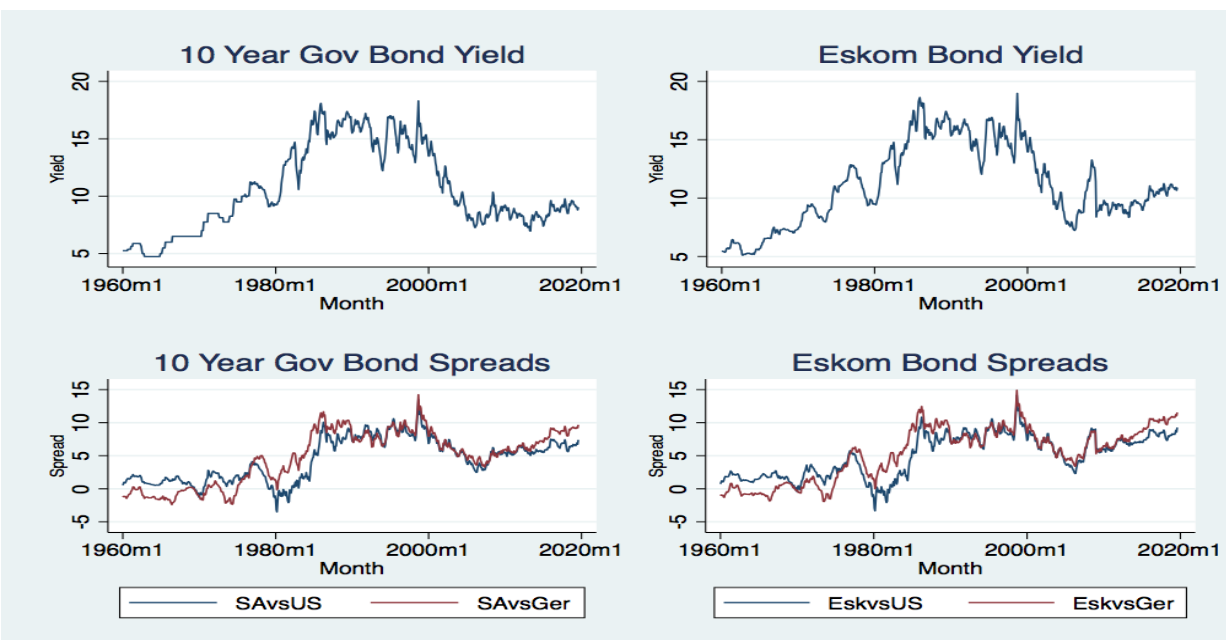

Figure 2: SA Bond Yields and Spreads. South African 10 Year Government bond Yields (upper left). Eskom Long Term Bond Yields (upper right). 10 Year Government Bond Yield Spreads, SA vs USA and SA vs Germany (bottom left). Eskom Long Term Bond Yield Spreads, Eskom vs USA and Eskom vs Germany (bottom left).

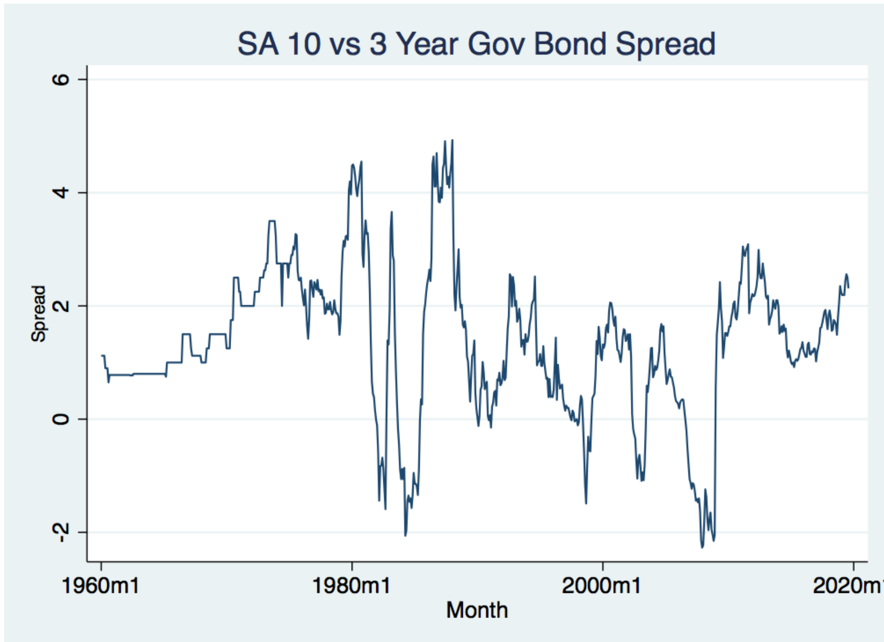

Figure 3: Spread between 10 and 3 Year South African Government Bond Yields.

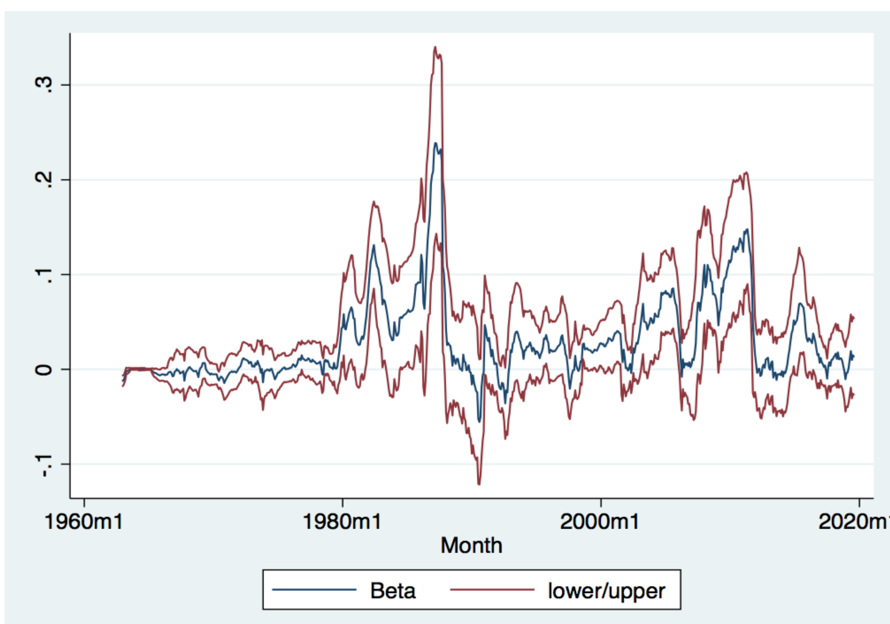

Figure 4: South African Beta with two standard deviation bands. Beta computed on a 36 month window.

bond yields in the most recent sample period, the difference is marginal. Given the broader significance of general government debt, the focus of the analysis in what follows will be on government bond spreads, though the analysis readily transfers to the Eskom bond spreads.

The proximate reason for the post-1980 violation of the BNC condition in South Africa lies in yield movements. Figure 2 shows that long term bond yields for both 10 year government bonds, and Eskom long-term bonds rose dramatically with the onset of high political uncertainty in South Africa during the 1980s, lasting through the political transition of the 1990s to 2000. High yields translated into high spreads between long-term South African bond yields, and both US and German long-term government bond yields. Use of the US and German yields was motivated on the grounds that they constitute two risk-free or at least risk-minimizing bond yield benchmarks. While South African long-term yields declined significantly from 2000 onward (corresponding to the adoption of inflation targeting), this translated into a declining trend in spreads only until mid-2006, since when the trend has been upward. Startling is the observation that the rising spread became evident *prior* to the sub-prime crisis (though the latter arguably accelerated the increase), and that the spread in 2019 had reached levels last seen during the 1980 period of maximal political uncertainty and international financial isolation.

Since the spread between 10 and 3 year government bonds has not shown a comparable return to 1980s levels, and remains at 2% - see Figure 3 - an important question is what has triggered the dramatic increase in yield spreads between South African and international safe assets. A consideration of the South African bond versus stocks beta as a measure of bond risk, does not show a dramatic increase after the subprime crisis - in fact, quite the reverse - see Figure 4.[2] These observations suggest that both term structure and the beta measure of risk are difficult to identify as reasons for the increase in the yield spread.

For this reason this paper turns its attention to the association between the long-term government bond spreads and a range of potential macroeconomic variables, and policy variables in particular. A number of considerations suggest the plausibility of such an exploration. First, the rising spread despite declining long-term yields corresponds to the continued downward trend in the South African economy's growth performance after the brief commodities-driven growth recovery of the later 1990s and early 2000s - see the discussion in Fedderke and Mengisteab (2017), and the sharp downward trend in South African growth since the mid-2000s reported in Figure 5. Similarly, both the government deficit and debt as a percentage of GDP have shown dramatically worsening trends since the mid-2000s - see Figures 7 and 8. Private sector leveraging has also reported a significant increase since 2000 - see Figure 9. South African inflation has continued to demonstrate a positive differential relative to US inflation, though since the introduction of inflation aggregating the inflation rate has shown relatively moderate levels in absolute terms by historical standards - see Figure 6. Finally, the openness of the South African economy, the size of the current account deficit, as well as the Rand-Dollar exchange rate has also reported significant movement since 2000 - see Figures 10, 11 and 12 respectively.

In a comparative context, the South African case study is of general interest. The size of the South African economy relative to other African economies, its relative development (one of only a few upper middle income countries in Africa - and none of the other middle income countries are of comparable absolute size), its membership of the G20 group of countries, the relative sophistication of South African financial markets, as well as its susceptibility to perceptions of risk in portfolio and foreign direct investment flows as well as domestic investment, all suggest that the South African case study merits specific attention.

The paper employs estimators consistent with autoregressive conditional heteroscedastic error structures, which are confirmed in the data, as well as the possibility that the second moment of the yield spread (its volatility) may impact its mean value (its level). Data is drawn from the South African Reserve Bank historical time series data base, and for international comparative data from the Federal Reserve of St. Louis data service.

The descriptive evidence is suggestive of the possibility that the strong movement in the macroeconomic fundamentals since 2000 might be associated with the change in the yield spread. To preempt the remainder of our analysis, the findings of this paper indeed support statistically significant associations between the South African-US yield spread and South African growth, inflation, government and private debt as a proportion of GDP, as well as Rand-Dollar depreciation, over the 1960-2019 time period,.

The paper is structured as follows. Section 2 provides a brief review of the literature. Section 3 provides

[2] The beta and associated standard error intervals here are derived simply from the rolling partial correlation between the 10 year and return on the Johannesburg Sotck Exchange index return and 3 year government bond yields.

details of the estimators employed for the generation of empirical results. In section 4 the data employed for the study is specified, with close attention being paid to the univariate time series characteristics of the data. Given the length of the sample period, covering distinct fiscal and monetary policy regimes, we pay close attention to the possibility of structural breaks in the data. Section 5 then presents the empirical findings, and section 6 concludes.

2 Literature

Studies of sovereign bond yields often rely on the Merton (1974) structural model, in which risky and risk-free zero-coupon bonds have the same pay-off structure, with the risky bond offering a put option equal to the face value of the principal. The value of the put option is then the cost of eliminating risk, and can be priced through standard Black-Scholes option pricing. Since default is triggered once the value of the issuing firm falls below a threshold determined by the total debt issued by the firm, the implication is that the credit risk will be associated with fundamentals such as the leverage ratio and the volatility of the firm's value. While Merton (1974) considered corporate bonds, the model has been extended to sovereign bonds, in which factors underlying sovereign risk relate to volatility of sovereign assets and country leverage - see for instance Gapen et al (2008).

Empirical implementation has identified a number of fundamentals of relevance to bond yields. Investors may manifest a time-varying attitude toward risk driven by variations in uncertainty, with higher uncertainty increasing risk aversion and hence portfolio restructuring in favour of safe haven bonds (say the US).[3] The empirical existence of a common component in excess returns in bonds and stocks - see Fama and French (1989) - has been explained in terms of external habit formation (Campbell and Cochrane, 1999; Campbell et al, 2019), consumption risk (Bansal and Yaron, 2004), and changes in the covariance of inflation with real economic variables (Campbell et al, 2009). For instance, in empirical application, this common risk factor has been attributed to central bank policy,[4] international financial volatility,[5] and US financial conditions.[6]

In addition to the preceding common market risk factors, yield determination models also allow for country-specific risk factors. These have included macroeconomic measures such as debt-to-GDP ratios, budget-deficit-to-GDP ratios, debt service ratios, current account balances, economic activity and sentiment measures, labor market conditions,[7] with fiscal imbalances receiving particular attention.[8] Asset market conditions such as liquidity risk as determined by the size and depth of the market in sovereign debt,[9] local asset and foreign exchange market conditions,[10] and country credit ratings[11] or credit default swap premia[12] as risk proxies have also received attention.[13] Monetary policy interventions have also been explored, with liquidity and collateral policies found to be important in the US but not generally in the Euro area,[14] policies targeted at sovereign debt markets having a significant impact in both the US and Euro area,[15] while the impact of financial support decisions is found to be mixed. An important modelling question given these country-specific risk factors, is that their salience may be time-varying across the business cycle,[16] becoming

[3] See for instance Arghyrou and Kontonikas (2012), Favero et al (2010), Manganelli and Wolswijk (2009), Pozzi and Woslwijk (2012).

[4] See Kilponen et al (2015), Mangatelli and Wolswijk (2009).

[5] See Arghyrou and Kontonikas (2012), Beber et al (2009), Borgy et al (2011), Gerlach et al (2010).

[6] See Attinasi et al (2009), Favero et al (2010), Haugh et al (2009).

[7] See Aßman and Boysen-Hogrefe (2012), Arghyrou and Kontonikas (2012), Attinasi et al (2009), Cooper and Priestly (2009), Fontaine and Garcia (2011), Haugh et al (2009), Huang and Shi (2012), Ludvigson and Ng (2009).

[8] See Arghyrou and Kontonikas (2012), Attinasi et al (2009), Barbosa and Costa (2010), Gerlach et al (2010), Haugh et al (2009).

[9] See Arghyrou and Kontonikas (2012), Aßman and Boysen-Hogrefe (2012), Attinasi et al (2009), Bernoth and Erdogan (2012), Bernoth et al (2012), Fontana and Scheicher (2010), Gómez-Puig (2009), Haugh et al (2009), Von Hagen et al (2011).

[10] See Fontana and Scheicher (2010), Garcia and Werner (2016), Oliviera et al (2012).

[11] See Mangatelli and Wolswijk (2009).

[12] See Arghyrou and Kontonikas (2012), Beber et al (2009).

[13] Choice of risk proxies is often determined by data frequency considerations.

[14] See Kilponen et al (2015), Rai (2013).

[15] See Gagnon et al (2011), Hamilton and Wu (2012), Kilponen et al (2015), Krishnamurthy et al (2011, 2013).

[16] See Boyd et al (2005).

particularly important during financial crises,[17] and/or due to contagion.[18]

The literature has also considered the impact of the second moment of returns on the first, thus allowing the volatility of returns to impact the level of returns. This has been addressed both explicitly in terms of risk premia, as well as yields directly. In terms of modeling approaches, the second moment has been introduced both as a direct observable, and as a latent variable. Both approaches have a long tradition and have generated a large body of literature. Direct use of second moments in modeling time varying risk can be traced to French et al (1987), Merton (1980), Officer (1973) and Schwert (1989), with numerous extensions and refinements, for instance Andersen et al (2003), Andersen et al (2005), Barndorff-Nielsen and Shephard (2004), Viceira (2012), and see the summaries in Andersen et al (2006a,b). Treatment of the second moment as a latent variable, traces back to the development of the ARCH class of estimators by Engle (1982), with a large body of extensions and refinements - see Braun et al (1995), Bollerslev et al (1988), Cho and Engle (1999), Engle (2002), and the summary in Andersen et al (2006b).

Analyses of South African yield spreads does occur in examinations of emerging market bond spreads. These analyses are generally conducted in panel data applications, with South Africa representing one amongst many cross sectional units of analysis. Such analyses have considered the relation of yield spreads to macroeconomic fundamentals, by employing country risk ratings as proxies for fundamentals (see Erb et al, 1996, and Cantor and Packer, 1996).[19] The obvious limitation to these studies is the use of risk ratings as proxies for macroeconomic fundamentals. Other studies have addressed this limitation. For instance, Siklos (2011) considers the impact both of macroeconomic fundamentals (central bank transparency, credit default swaps as proxy for fundamentals, inflation, growth, the current account), and volatility (using an index of SP500 volatility). There is a very large additional literature surrounding panel approaches to yield spreads. Without diminishing its importance, however, these results treat South Africa (if at all) as one of many equally weighted observations, so that there is no possibility of considering the specificities of the South African case study. Given the size of this literature, and that the present study takes the alternative route of a country specific time series approach, it is not practical to review the entirety of the panel data literature. However, Eichengreen and Mody (1998),Siklos (2011) and Comelli (2012) provide a useful entry points.

By contrast to the extensive international literature on yield spreads, the literature that focusses specifically on South Africa is less well developed. Primary focus of the South African literature has been on the term structure of interest rates. Shu et al (2018) use Nelson-Siegel models to forecast the term structure of South African government bond yields, but do not employ macroeconomic fundamentals in doing so. A more extensive literature attempts to use the yield spread to forecast turning-points in the business cycle, but again macroeconomic fundamentals are not material in explaining yield spreads themselves - see Clay and Keeton (2011), Khomo and Aziakpono (2007), Moolman (2002, 2003), Botha and Keeton (2014), Aye et al (2019), Soobyah and Steenkamp (2019). Nel (1996) was the first to link the South African yield curve to GDP-growth, while Robinson (2015) explores fiscal determinants of sovereign risk in South Africa, and Grandes and Peter (2004) and Peter and Grandes (2005) examine sovereign risk as a determinant of corporate default premia. Soobyah (2018) explores the impact of fiscal policy on the yield curve. While the main focus of Kilp et al (2018) is the impact of the global financial safety net on sovereign borrowing costs in emerging markets, some exploration of macroeconomic determinants is included, though in a panel data context rather than a specific focus on South Africa, and by way of additional controls rather than the focus of the analysis. Rapapali and Steenkamp (2019) examine the impact of policy rates on private bank lending rates and hence by implication lending, but do not examine the impact of private sector leveraging on the yield spread. A separate literature has examined sovereign risk ratings by ratings agencies, but again this discussion does not explore explicit links to the yield spread - see Fedderke (2015), Hassan and Soobyah (2016), and Mojapelo and Soobyah (2019). Fedderke and Pillay (2010) develop a theory-consistent measure of risk for South Africa employing the term structure of interest rates - but do not explore the impact of macroeconomic fundamentals on the yield spread or the risk measure.

The contribution that comes closest to the current paper, is Curran (2019), which examines the impact of

[17] Evidence supports a "flight-to-safety" response during crises - Baele et al (2013), Garcia and Gimeno (2014), Garcia and Werner (2016).

[18] See Bernoth et al (2012), Bekaert et al (2014), Caceres et al (2010), Garcia and Werner (2016), Kilponen et al (2015), Von Hagen et al (2011). On contagion for South Africa in the context of the Asian crisis, see Fedderke and Marinkov (2018).

[19] Cantor and Packer (1996) verify that risk ratings reflect macroeconomic fundamentals. Note that Fedderke (2015) considers the role of risk ratings, with some specific South African considerations, in the context of merging market risks already.

macroeconomic fundamentals on yields (but not SA-US yield spreads) across a range of maturity structures of South African public debt. For the 10 year maturity bonds Curran finds significance for the public debt-to-GDP ratio (which corresponds to the findings of this paper), and a measure of business confidence (not included in this study due to data limitations). By contrast, growth, inflation and exchange rate depreciation are found to be insignificant (while the current paper does report significance for all of these variables). Importantly, however, the Curran (2019) results are based on simple regressions of bond yields on macroeconomic fundamentals. The analysis is silent about the univariate time series structure of the data, and appears to mix stationary and non-stationary data in the analysis. In addition, there is no attempt made to exploit any autoregressive conditional heteroscedasticity in the errors. As such, the present analysis, in paying close attention to stationarity, to autoregressive conditional heteroscedasticity, and to the possibility that the first and second moments of the yield distribution may be interdependent, represents a significant methodological advance on the earlier analysis. Certainly we have greater confidence that results should avoid bias and inconsistency arising from the time series structure of the data.

Finally, while contagion has been examined for South Africa, with findings consistent with the importance of macroeconomic fundamentals to the nature of contagion, this literature does not consider the link between the yield spread and fundamentals directly - see Fedderke and Marinkov (2018).

The focus of the present paper on the association between the SA-US yield spread and macroeconomic fundamentals is thus new to the South African debate.

3 Empirical Methodology

Estimation in this paper is under the class of the generalized autoregressive conditional heteroscedasticity (GARCH) estimators.[20] The advantage of this methodology is that it allows for the exploration of direct associations between fundamentals and the yield spread. The estimator explicitly allows for, and exploits the possibility that volatility in the yield spread may be not only persistent (autoregressive, AR), but time-varying (conditionally heteroscedastic, CH) (i.e. be ARCH, or generalized ARCH structure, GARCH). In addition, the estimation approach allows for the possibility that the second moment of the yield spread may influence the first moment - i.e. that the volatility of the spread may affect its level. Indeed, in its original formulation, the estimator consistent with autoregressive conditional heteroscedastic errors influencing the mean of the dependent variable (ARCH-in-mean: ARCH-M) was explicitly developed for the purpose of examining yield spreads - see Engle et al (1987). Noted is the condition that the relevant univariate order of integration of the data condition for stationarity must be met for the reliability of the estimator (where the data $\nsim I(0)$, bias and inconsistency follows).

Thus we proceed under the standard GARCH specification consistent with Engle (1982), as generalized by Bollerslev (1986):

$$S_t = \gamma_0 + \sum_{i=1}^{k} \delta_i S_{t-i} + \sum_{l=0}^{n} \sum_{j=1}^{m} \lambda_{lj} X_{t-l,j} + \sum_{r=1}^{s} \mu_r D_r + \epsilon_t \tag{1}$$

$$\epsilon_t = v_t \sqrt{h_t} \tag{2}$$

$$h_t = \alpha_0 + \sum_{r=1}^{v} \alpha_r \epsilon_{t-r}^2 + \sum_{s=1}^{w} \delta_s h_{t-s} \tag{3}$$

where S_t denotes the spread between South African and US 10 year government bonds in period t, $X_{t-l,j}$ denotes a vector of macroeconomic fundamentals, and the D_r denote a vector of controls for structural breaks in either the underlying data series, macroeconomic policy regimes, or the association being estimated. To allow for the second moment of the interest rate spread to impact the first moment, we also employ the GARCH-in-mean (GARCH-M) estimators introduced by Engle et al (1987) in ARCH-M format,[21] with the

[20] The methodology is well established, beginning with Engle (1982), with a large body of extensions and refinements - see Braun et al (1995), Bollersleve (1986), Bollerslev et al (1988), Cho and Engle (1999), Engle (2002). See Bollerslev et al (1994) for a synoptic discussion of estimation under ARCH and GARCH methodologies, and the summary in Andersen et al (2006b).

[21] See Bollerslev et al (1994) for a synoptic discussion of estimation under ARCH and GARCH methodologies.

GARCH-M specification:

$$S_t = \gamma_0 + \sum_{i=1}^{k} \delta_i S_{t-i} + \sum_{l=0}^{n} \sum_{j=1}^{m} \lambda_{lj} X_{t-l,j} + \sum_{r=1}^{s} \mu_r D_r + \beta h_t + \varepsilon_t \tag{4}$$

Note that the volatility measure, h_t, is explicitly time-varying.

While our baseline specification employs the standard Engle (1982) ARCH process in its GARCH form as generalized by Bollerslev (1986), we also consider the possibility of positive and negative innovation asymmetries in their impact on the spread, as evidenced in the news impact curve - see Engle and Ng (1993). Test of the presence of asymmetry is by means of the Engle and Ng (1993) methodology, such that estimating:

$$y_t = x_t \beta + \epsilon_t \tag{5}$$

$$\epsilon_t = v_t \sqrt{h_t} \; with \; h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i \epsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i h_{t-i} \tag{6}$$

$$S_t^- = \begin{cases} 1 \; for \; \widehat{\epsilon}_t < 0 \\ 0 \; for \; \widehat{\epsilon}_t \geq 0 \end{cases}, \; \widehat{\epsilon}_t^+ = \begin{cases} \widehat{\epsilon}_t \; for \; \widehat{\epsilon}_t \geq 0 \\ 0 \; for \; \widehat{\epsilon}_t < 0 \end{cases}, \; \widehat{\epsilon}_t^- = \begin{cases} \widehat{\epsilon}_t \; for \; \widehat{\epsilon}_t < 0 \\ 0 \; for \; \widehat{\epsilon}_t \geq 0 \end{cases} \tag{7}$$

$$\widehat{\epsilon}_t^2 = a_0 + a_1 S_{t-1}^- + b_1 \widehat{\epsilon}_{t-1}^- + b_2 \widehat{\epsilon}_{t-1}^+ + \eta_t \tag{8}$$

the test considers $a_1 \neq 0$, $b_1 \neq 0$, $b_2 \neq 0$. Where $a_1 \neq 0$, the test confirms sign bias, such that negative shocks have a volatility impact distinct from positive shocks (whether positive or negative attenuation holds is determined by the parameter signs of the asymmetric GARCH process). In the event that $b_1 \neq 0$, negative size bias is confirmed, with large negative shocks having a larger volatility impact than small negative shocks. Under $b_2 \neq 0$, positive size bias follows, with large positive shocks having a larger volatility impact than small positive shocks.

Under confirmation of asymmetries estimation proceeds under the Nelson (1991) EGARCH specification:

$$\log h_t = \alpha_0 + \sum_{r=1}^{v} \alpha_r \left(\frac{\epsilon_{t-r}}{\sqrt[2]{h_{t-r}}} \right) + \sum_{r=1}^{v} \alpha_r^* \left(\frac{|\epsilon_{t-r}|}{\sqrt[2]{h_{t-r}}} - E\left(\frac{|\epsilon_{t-r}|}{\sqrt[2]{h_{t-r}}} \right) \right) + \sum_{s=1}^{w} \delta_s \log h_{t-s} \tag{9}$$

where $E\left(| \frac{\epsilon_{t-r}}{h_{t-r}} | \right)$ depends on the density function assumed for the standardized disturbances $u_t = \frac{\epsilon_t}{h_t}$. For instance, $E\left(\frac{|\epsilon_{t-r}|}{\sqrt{h_{t-r}}} \right) = \left[\frac{2}{\pi} \right]^{0.5}$, if $\epsilon_t \sim N(0,1)$. In the EGARCH specification, asymmetry arises from the $\epsilon_{t-r}/\sqrt{h_{t-r}}$ terms, such that $\alpha_r < 0$ attenuates the volatility impact of positive shocks, while $\alpha_r > 0$ attenuates the volatility impact of negative shocks. For the GARCH(1,1) case, the specific news impact evaluated under the unconditional variance is given by:

$$h_t = \begin{cases} A \exp\left[\left(\frac{\alpha_1 + \alpha_1^*}{\sigma} \right) \epsilon_{t-1} \right] \; for \; \epsilon_{t-1} > 0 \\ A \exp\left[\left(\frac{\alpha_1 - \alpha_1^*}{\sigma} \right) \epsilon_{t-1} \right] \; for \; \epsilon_{t-1} < 0 \end{cases} \tag{10}$$

$$A = \sigma^{2\delta} \exp\left[\alpha_0 - \alpha_1^* \left(\frac{2}{\pi} \right)^{0.5} \right], \; if \; \epsilon_t \sim N(0,1). \tag{11}$$

Macroeconomic fundamentals we control for are economic activity indicators in the form of growth in real GDP, monetary policy measures provided by the CPI-based inflation rate, fiscal balance measures provided by the public debt-to-GDP ratio and the budget deficit-to-GDP ratio, local asset market conditions by private sector debt as a percent of GDP, and foreign exchange market conditions by the current account deficit as a percent of GDP and the Rand-Dollar exchange rate. The exchange rate is included in the form of a measure of the change in the rate (effectively depreciation in the case of the Rand).[22]

[22] One possible consideration surrounding the exchange rate is that for yield spreads a relevant consideration is exchange

Sign expectations are as follows. Since higher growth raises expected tax revenue flows, while lower public debt-to-GDP and public deficit-to-GDP ratios ease debt servicing, the expectation would be of a resultant decrease in default risk, hence a lower risk premium, and yield spread. Thus the three variables are anticipated to report a negative association for growth, and positive associations for the two leverage ratios respectively. Since Rand-Dollar depreciation generates exchange rate risk directly, we anticipate a positive association with the risk premium and the yield spread. Inflation, and in particular a positive inflation differential between SA and the US, would generate the expectation of future Rand-Dollar depreciation, hence exchange rate risk in Rand denominated holdings, and thus a positive association between inflation and the yield spread. The private debt-to-GDP ratio has an ambiguous sign expectation. On the one hand, the ratio could give an indication of the extent of competition for loanable funds (effectively a crowd-out competition), generating the expectation of a positive association with the yield spread. On the other hand, higher private sector leveraging might be interpreted as improved corporate and household confidence, hence an improved risk environment, with an associated negative sign expectation with the yield spread. Finally, we have no strong priors on the openness and current account deficit variables, which are included in order to control for the impact of globalization on the South African economy and its impact on the yield spread.

In controlling for macroeconomic fundamentals we employ two distinct specifications. First, we employ South African measures alone. Second, since we are concerned with the spread of SA bond yields relative to the US, we allow for the possibility that the spread shows a distinct responsiveness to changes in SA and US macroeconomic fundamentals, by employing separate SA and US fundamental measures in estimation. In the results below, we report results for both specifications. Where the US macroeconomic fundamentals prove to be statistically insignificant, one interpretation would be that the US yield provides a safe asset reference point, irrespective of macroeconomic conditions in the US. In effect, the US asset serves as the safe asset benchmark, while SA fundamentals come to be associated with the perceptions of investors of the relative desirability of the corresponding SA asset.

In estimation we consider the yield on Rand-denominated South African public debt. This is motivated by the fact that the preponderance of South African public debt is issued in Rand denomination. As a result, time series for Rand-denominated yields are the most comprehensive in terms of their time coverage, and are the most immediate reflection of the cost of borrowing for the South African public sector. In addition, given that Rand-denominated public debt is actively traded in liquid markets, there is no a fortiori reason to suppose that the yields on Rand-denominated and Dollar- or Euro-denominated debt would show markedly different behavior. This is confirmed by the fact that the correlation between Rand-denominated and South African Eurobond yields is very high ($r \approx 0.96$ for 2019).

Our analysis covers the 1960 - 2019 sample period. Given that GARCH estimators require stationarity of the underlying data, the length of the sample period is an advantage, since a number of our variables that measure rates (eg. inflation, growth, all ratios of GDP) in the long run are bounded both above and below so that they are in principle stationary. The likelihood of confirming stationarity empirically increases with longer time runs, since both bounds in the data are more likely to be observed. A further advantage of the length of the sample period, is that it generates confidence in the possibility that long-run structural associations can be identified. However, it also follows that the data covers a number of quite distinct monetary, exchange rate and fiscal policy regimes. As a consequence, in generating results we pay considerable attention to the possibility of structural breaks in the data and the association between variables. All estimations therefore include a range of controls either for structural changes in the data or the association being estimated.

A critical caveat in the interpretation of estimation result is against causal inference from the associations implicit in the (1) and (4) specifications. For a number of the fundamentals, especially Rand-Dollar exchange rate depreciation, the direction of any causality with the yield spread is ambiguous at best. Reported results should thus be read correlationally, rather than causally.

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rate risk, hence expectations of changes in the rate. Since direct measures of expectations are not available, this would require recourse to a proxy measure, such as those that rely on the use of time series filters. Given that the rand is an actively traded currency in liquid forex markets, implying a significant degree of market efficiency, it is not clear that the loss of precision in estimation that would follow from the use of filters is a modelling cost that is justifiable in a first examination of our question. Alternative possibilities are the use of expectations based on uncovered interest rate parity or forward rates. However, these too introduce the requirement of modelling decisions, and hence additional potential sources of error. Given the liquidity and relatively high degree of efficiency in the South African currency markets, these concerns motivate the use of depreciation directly. Nonetheless, closer attention to exchange rate risk in the directions suggested is worthy of future work.

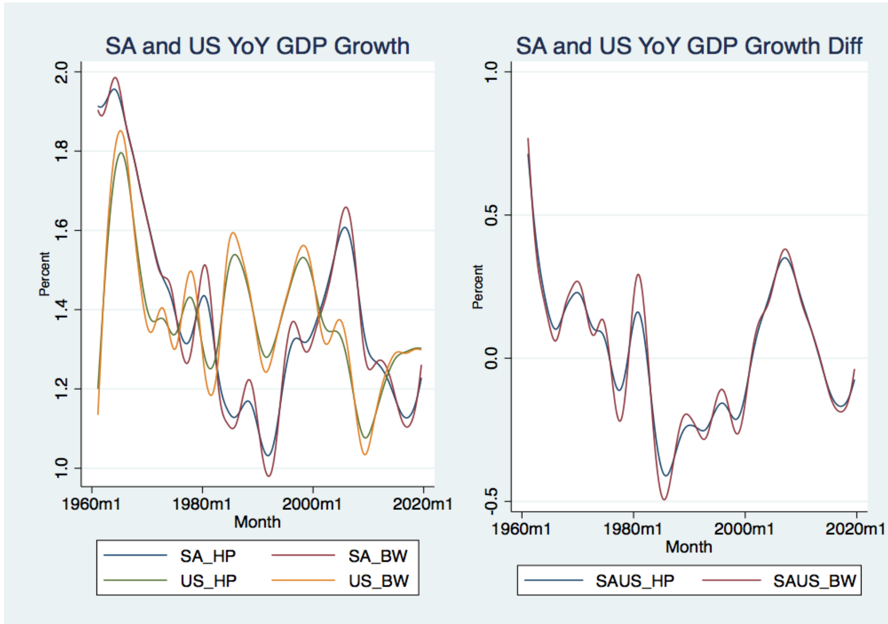

Figure 5: Growth in Real GDP. Month on month growth has been converted to year on year growth. SA denotes South Africa. US denotes the USA. SAUS denotes the SA-US differential. HP denotes the Hodrick-Prescott filtered series. BW denotes the Butterworth filtered series.

4 Data

South African data is sourced from the South African Reserve Bank, that for the US from the Economic Research division of the Federal Reserve Bank of St. Louis. Data on yields and prices is available at the monthly frequency, while economic activity, fiscal balance, asset market and foreign balance variables typically are reported at the quarterly frequency. While we examined associations both at the quarterly and monthly frequency, given the symmetry in results in what follows we report results at the monthly frequency, employing interpolated measures for the quarterly series.

We briefly illustrate the features of the macroeconomic fundamentals we employ, filtering out volatility at the monthly frequency. To do so we employ Hodrick-Prescott (HP)[23] and Butterworth (BW)[24] filters, though the differences between them is marginal.[25] We report the two filtered series for both SA and the US, as well as the macroeconomic fundamental differentials between SA and the US as determined by the two filtered series.

Figure 5 reports the relative SA and US growth performance since 1960. Noteworthy is that SA has not generated a significant catch-up relative to the US after the mid-1970s, the sole exception being the short-lived commodities boom of the early 2000s. Figure 6 reports relative SA-US CPI inflation, with SA inflation maintaining a positive differential to the US throughout the 1960-2019 sample period. Figure 7 reports SA and US government deficits as a percent of GDP - indicating that since 2000 SA has consistently operated under smaller deficits on public accounts than the US, though since the sub-prime crisis the differential has narrowed substantially. Figure 8 repeats for SA and US public debt as a percentage of GDP, indicating the strong improvement of SA public debt positions in the 2000s, as well as the substantial worsening of fiscal space for both the US and SA after the sub-prime crisis. The evidence of Figure 9 on total private

[23] See Hodrick and Prescott, (1997).

[24] See Pollock (2000).

[25] We employ the HP and BW high-pass filters, since they only allow for stochastic cycles that meet a minimum level frequency and block the lower frequency stochastic cycles. Band-pass filters, such as those of Christiano and Fitzgerald (2003) and Baxter and King (1999), by allowing stochastic cycles within a specified range of frequencies, such that any frequency outside an upper and lower bound being filtered out, potentially allow for a filtered series with a higher degree of volatility. See the discussion of the relative performance of the filters in the context of determining South African potential output in Fedderke and Mengisteab (2017).

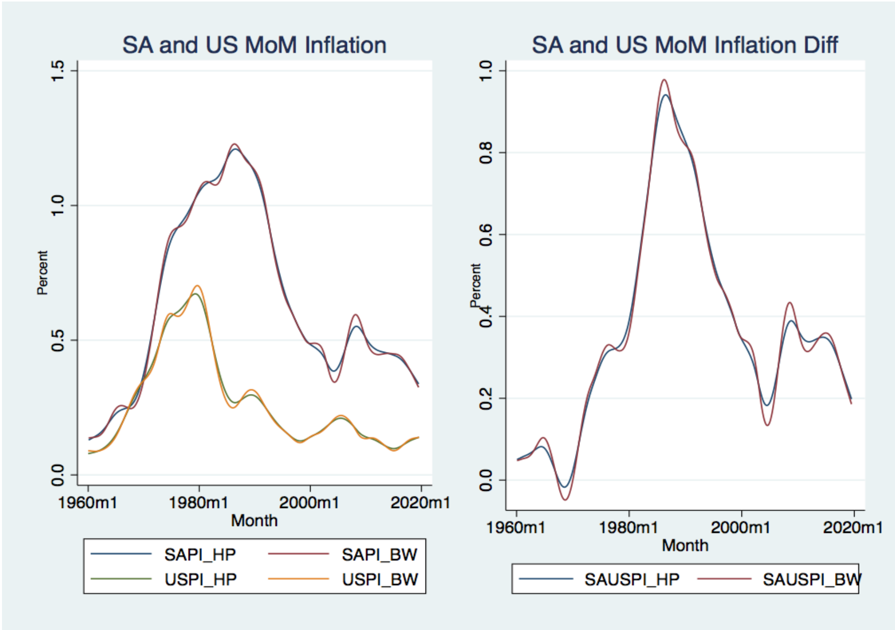

Figure 6: CPI Inflation. SA denotes South Africa. US denotes the USA. SAUS denotes the SA-US differential. HP denotes the Hodrick-Prescott filtered series. BW denotes the Butterworth filtered series.

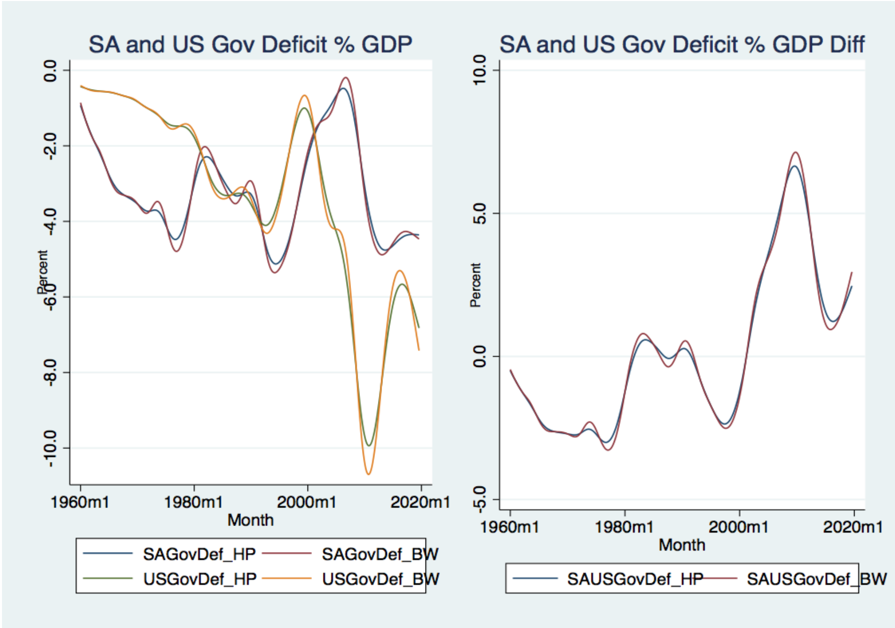

Figure 7: Government Deficits as a Percent of GDP. > 0 denotes surplus; < 0 denotes deficit. SA denotes South Africa. US denotes the USA. SAUS denotes the SA-US differential. HP denotes the Hodrick-Prescott filtered series. BW denotes the Butterworth filtered series.

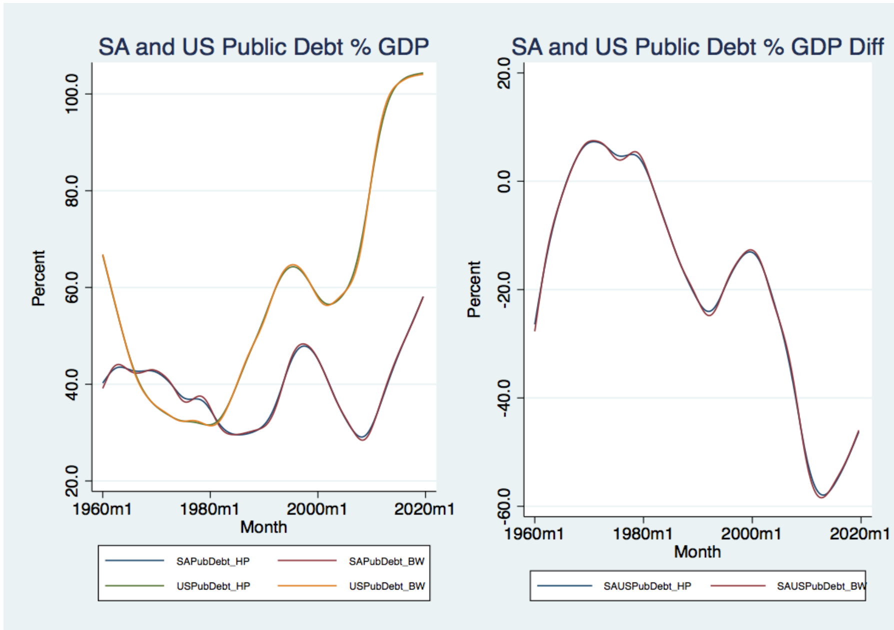

Figure 8: Public Debt as a Percent of GDP. SA denotes South Africa. US denotes the USA. SAUS denotes the SA-US differential. HP denotes the Hodrick-Prescott filtered series. BW denotes the Butterworth filtered series.

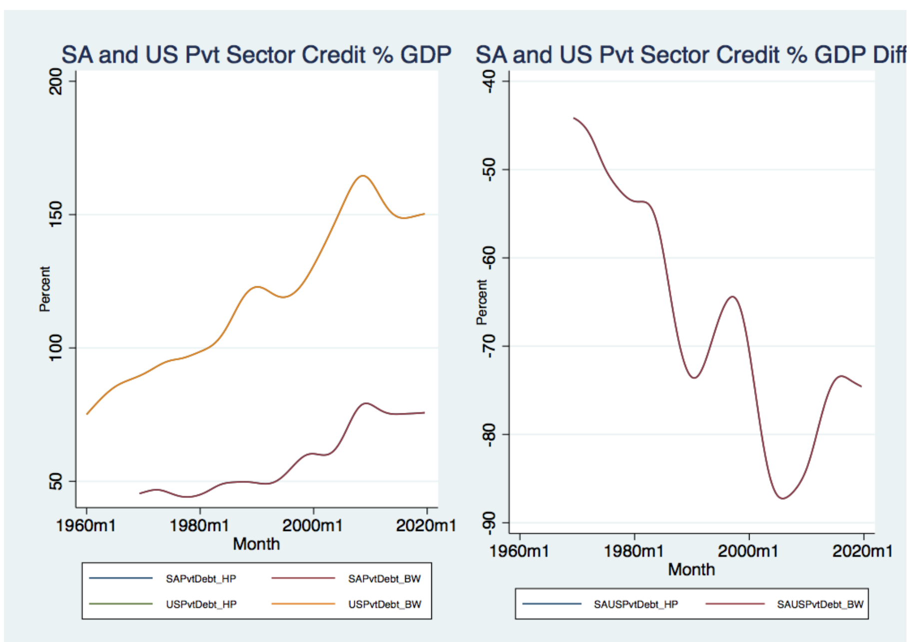

Figure 9: Private Sector Credit as a Percent of GDP. SA denotes South Africa. US denotes the USA. SAUS denotes the SA-US differential. HP denotes the Hodrick-Prescott filtered series. BW denotes the Butterworth filtered series.

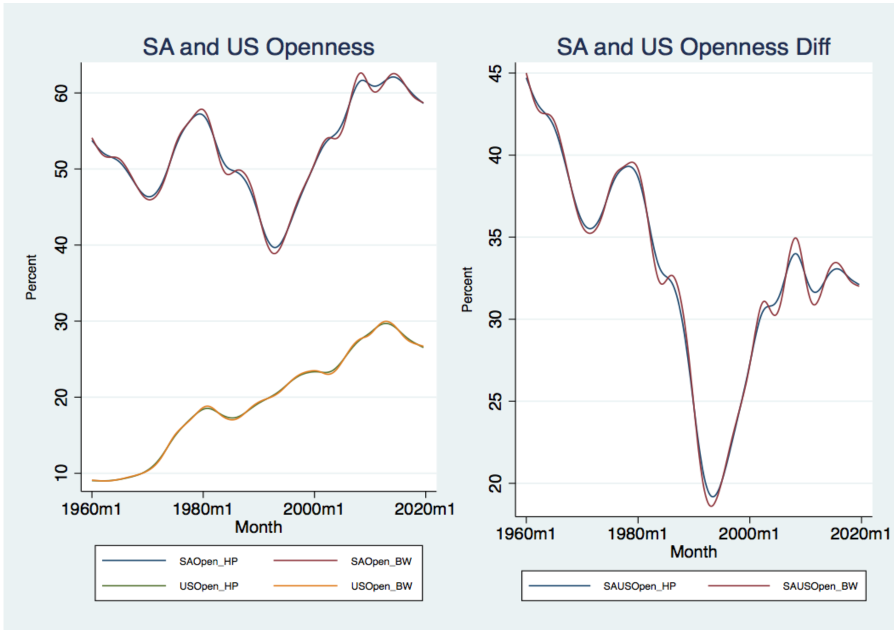

Figure 10: Openness (Percent of GDP traded). SA denotes South Africa. US denotes the USA. SAUS denotes the SA-US differential. HP denotes the Hodrick-Prescott filtered series. BW denotes the Butterworth filtered series.

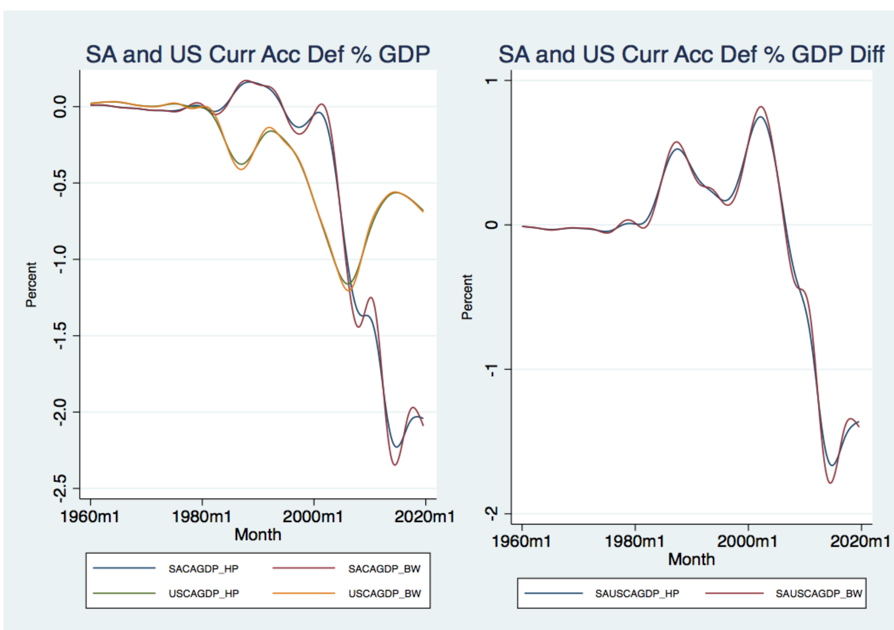

Figure 11: Current Account Deficits as a Percent of GDP. > 0 denotes surplus; < 0 denotes deficit. SA denotes South Africa. US denotes the USA. SAUS denotes the SA-US differential. HP denotes the Hodrick-Prescott filtered series. BW denotes the Butterworth filtered series.

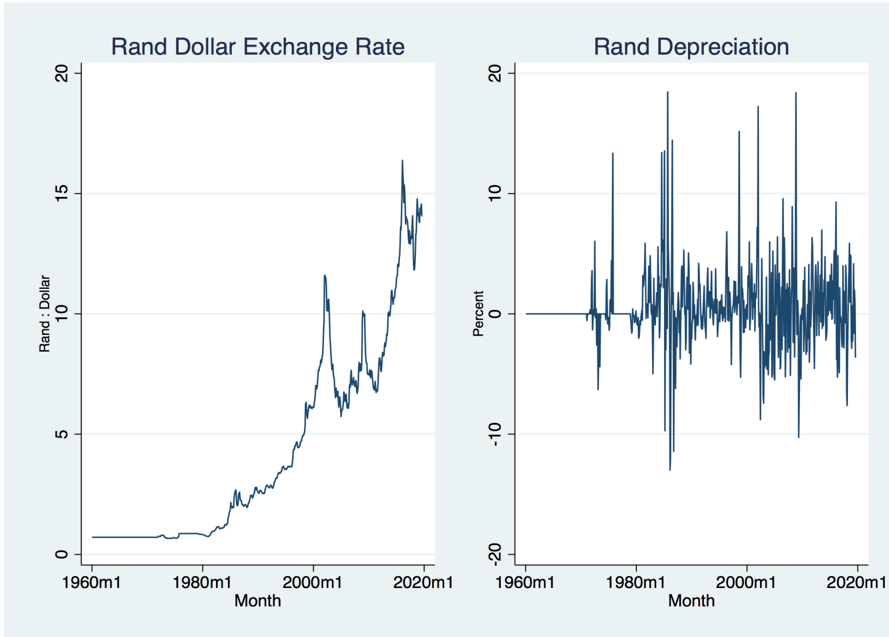

Figure 12: Rand : Dollar Nominal Exchange Rate, and Depreciation. For Depreciation series > 0 denotes depreciation; < 0 denotes appreciation.

sector credit as a percentage of GDP shows the SA private sector to be considerably more leveraged than the US over the full sample period, with the differential widening substantially over the course of the 2000s and 2010s.[26] Figure 10 reports the consistently greater openness of the SA than the US economy, with the differential widening again after 2000. Figure 11 confirms the consistent current account deficits of both SA and the US, with SA reporting a rising differential with respect to the US since the mid 2000s (2006). Finally, Figure 12 reports the nominal Rand:Dollar exchange rate and associated depreciation rate.

4.1 Univariate Time Series Properties of the Data

Since the use of the GARCH and GARCH-M methodologies depend on the satisfaction of stationarity in all structural variables employed in estimation, we pay particularly close attention to the univariate time series characteristics of our data for this study. This is compounded by the fact that the data portrayed in Figures 5 through 12 raises the prospects of the presence of structural breaks in a number of the time series employed, as would be expected over a sample period spanning six decades. This is especially relevant with respect to the variables capturing macroeconomic policy, since the 1960-2019 period has encompassed a number of different fiscal and monetary policy regimes.

Table 1 reports the full sequence of augmented Dickey-Fuller (1979, 1981) tests (henceforth ADF) under the Perron (1988) sequence, with related inferences summarized in Table 2. The implication is that while both the SA and US real GDP growth rates, Rand depreciation, US inflation and the US government deficit as a percent of GDP, the SA-US growth and inflation differentials are stationary in levels ($\sim I(0)$), the remainder of the variables under considerations are all first-difference stationary ($\sim I(1)$). Thus a preponderance of the macroeconomic fundamentals and the yield spread measure itself prove nonstationary at first blush. Phillips-Perron and KPSS tests (Phillips and Perron, 1988; Kwiatkowski et al, 1992) reported in Table 3 confirm this inference, thus lowering the chance that the integration properties of the data are a product of the specific power and size properties of the ADF tests.

[26] Note that in estimation we considered both total private sector debt as a proportion of GDP, and private sector credit disaggregated into household and corporate sector credit as a proportion of GDP. Results reported will focus on to aggregate measure rather than the disaggregated measure, since the latter does not have the stationarity properties required for the GARCH estimator, even hen controlling for structural breaks.

		Dickey-Fuller					
Variable:		τ_τ	Φ_3	Φ_2	τ_μ	Φ_1	τ
SA vs USA 10 Year Bond Spread	Level	-2.13	2.27	1.63	-1.62	1.47	-0.45
	First Diff.	-7.44***	27.67**	18.45**	-7.44***	27.71**	-7.43***
SA Growth	Level	-4.87***	11.89**	7.93**	-4.58***	10.48**	-3.04***
	First Diff.	-15.11***	114.15**	76.11**	-15.12***	114.31**	-15.13***
SA Inflation (CPI)	Level	-2.93	4.51	3.01	-2.91***	4.23	-1.36
	First Diff.	-11.73***	68.78**	45.85**	-11.71***	68.57**	-11.72***
SA Govt Deficit %GDP	Level	-3.07	4.75	3.20	-3.08***	4.79**	-1.13
	First Diff.	-7.56***	28.62**	19.08**	-7.57***	28.65**	-7.57***
SA Public Debt % GDP	Level	-1.33	3.25	2.20	-1.24	0.82	0.11
	First Diff.	-5.61***	16.34**	10.92**	-5.28***	13.99**	-5.29***
SA Private Debt % GDP	Level	-3.09	4.90	3.52	-1.06	0.93	0.65
	First Diff.	-4.67***	10.93**	7.30**	-4.66***	10.89**	-4.58***
SA Household Cr % GDP	Level	-3.24*	5.26	3.54	-1.67	1.44	-0.03
	First Diff.	-3.78**	7.15**	4.78**	-3.77***	7.16**	-3.77***
SA Corporate Cr % GDP	Level	-2.82	3.99	2.93	-1.38	1.36	0.50
	First Diff.	-4.43***	9.87**	6.58**	-4.44***	9.86**	-4.35***
SA Openness	Level	-2.74	3.86	2.59	-2.27**	2.60	-0.09
	First Diff.	-7.12***	25.36**	16.91**	-7.11***	25.29**	-7.11***
SA Current Acc. Def % GDP	Level	-1.83	2.49	2.03	-0.36	0.62	0.16
	First Diff.	-6.86***	23.66**	15.80**	-6.78***	23.01**	-6.72***
Rand Dollar Exchange Rate	Level	-2.96	4.50	4.74**	-0.24	2.61	2.18
	First Diff.	-6.40***	20.48**	13.65**	-6.38***	20.38**	-5.91***
US Growth	Level	-6.56***	21.57**	14.38**	-6.08***	18.45**	-3.27***
	First Diff.	-9.36***	43.84**	29.23**	-9.37***	43.85**	-9.37***
US Inflation (CPI)	Level	-3.43**	6.02	4.01	-2.93	4.29	-1.71
	First Diff.	-9.69**	46.96**	31.31**	-9.68***	46.89**	-9.69***
US Govt Deficit %GDP	Level	-3.50**	6.17	4.22	-2.10**	2.38	-0.94
	First Diff.	-4.92***	12.10**	8.07**	-4.91**	12.07**	-4.89***
US Current Acc. Def % GDP	Level	-1.74	1.54	1.23	-1.20	1.03	-0.35
	First Diff.	-6.60***	21.83**	14.55**	-6.61***	21.83**	-6.57***
US Public Debt % GDP	Level	-2.86	4.64	3.27	-0.84	0.61	0.36
	First Diff.	-3.41*	6.07	4.05	-3.30***	5.43	-3.21***
US Private Debt % GDP	Level	-3.18*	5.17	3.77	-1.30	1.33	0.65
	First Diff.	-3.36*	5.66	3.80	-3.30***	5.57	-3.13***
US Openness	Level	-2.49	3.32	3.28	-1.23	2.34	1.28
	First Diff.	-6.88***	23.66**	15.77**	-6.85***	23.49**	-6.67***

***, **, *, denote significance at the 1%, 5% and 10% levels respectively

Order of ADF augmentation: 12 ; Order of PP augmentation: 12

Table 1: Dickey Fuller Test Statistics

		No Structural Break				With Structural Break		
Variable:		Unit Root	Trend	Drift	$\sim I(d)$	Unit Root	$\sim I(d)$	Breaks
SA vs USA 10 Year Bond Spread	Level	Yes	No	No	1	No	0	1985m3 2001m12
	First Diff.	No	No	No	0	-	-	-
SA Growth	Level	No	No	No	0	-	-	-
	First Diff.	No	No	No	0	-	-	-
SA Inflation(CPI)	Level	Yes	No	No	1	No	0	1972m4 1993m2
	First Diff.	No	No	No	0	-	-	-
SA Govt Deficit %GDP	Level	Yes	No	Yes	1	No	0	1998m7
	First Diff.	No	No	No	0	-	-	-
SA Public Debt % GDP	Level	Yes	No	Yes	1	No	0	1980m1 1991m4 2008m9
	First Diff.	No	No	No	0	-	-	-
SA Private Debt % GDP	Level	Yes	No	Yes	1	No	0	2004m8
	First Diff.	No	No	No	0	-	-	-
SA Household Cr % GDP	Level	Yes	No	No	1	Yes	1	2008m4
	First Diff.	No	No	No	0	-	-	
SA Corporate Cr % GDP	Level	Yes	No	No	1	Yes	1	1999m1 2008m1
	First Diff.	No	No	No	0	-	-	-
SA Openness	Level	Yes	No	Yes	1	No	0	1981m10 2007m1
	First Diff.	No	No	No	0	-	-	-
SA Current Acc. Def % GDP	Level	Yes	No	No	1	No	0	2004m1 2007m1
	First Diff.	No	No	No	0	-	-	-
Rand Dollar Exchange Rate	Level	Yes	No	Yes	1	-	-	-
	First Diff.	No	No	No	0	No	0	-
US Growth	Level	No	No	No	0	-	-	-
	First Diff.	No	No	No	0	-	-	-
US Inflation (CPI)	Level	No†	No	No	0	-	-	-
	First Diff.	No	No	No	0	-	-	-
US Govt Deficit %GDP	Level	No†	No	No	0	-	-	-
	First Diff.	No	No	No	0	-	-	-
US Current Acc. Def % GDP	Level	Yes	No	Yes	1	Yes	1	-
	First Diff.	No	No	No	0	-	-	-
US Public Debt % GDP	Level	Yes	No	Yes	1	No	0	2008m7
	First Diff.	No	No	No	0	-	-	-
US Private Debt % GDP	Level	Yes	No	Yes	1	Yes	1	-
	First Diff.	No	No	No	0	-	-	-
US Openness	Level	Yes	No	No	1	Yes	1	-
	First Diff.	No	No	No	0	-	-	-

Table 2: Inference from the Univariate Tests for Order of Integration Test Statistics

		Phillips-Perron			KPSS
		trend	drift	noconst	
SA vs USA 10 Year Bond Spread	Level	-10.41	-6.28	-1.08	0.41***
	First Diff.	-431.92***	-431.95***	-432.65***	0.05
SA Growth	Level	-121.44***	-124.78***	-152.16***	0.16**
	First Diff.	-393.03***	-393.03***	-393.03***	0.01
SA Inflation (CPI)	Level	-983.15***	-983.42***	-358.62***	0.66***
	First Diff.	-855.92***	-856.01***	-856.01***	0.02
SA Govt Deficit %GDP	Level	-83.25***	-83.29***	-29.15***	0.13*
	First Diff.	-136.20***	-136.18***	-136.19***	0.03
SA Public Debt % GDP	Level	-0.73	-0.61	0.54	0.30***
	First Diff.	-10.82***	-10.82***	-10.83***	0.09
SA Private Debt % GDP	Level	-2.59	-0.39	0.91	0.49***
	First Diff.	-18.15***	-18.14***	-18.14***	0.05
SA Household Cr % GDP	Level	-1.47	-1.11	0.72	0.13*
	First Diff.	-16.81***	-16.81***	-16.78***	0.10
SA Corporate Cr % GDP	Level	-1.86	-0.36	1.23	0.48***
	First Diff.	-24.23***	-24.24***	-24.25***	0.05
SA Openness	Level	-2.81	-2.37	-0.160	0.41***
	First Diff.	-12.02***	-12.03***	-12.04***	0.03
SA Current Acc. Def % GDP	Level	-11.29	-2.46	-0.43	0.63***
	First Diff.	-190.39***	-191.03***	-191.55***	0.03
Rand Dollar Exchange Rate	Level	-2.49	0.13	2.79	0.37***
	First Diff.	-18.77***	-18.79***	-18.79***	0.09
US Growth	Level	-9.51***	-9.38***	-6.44***	0.04
	First Diff.	-31.02***	-31.04***	-31.07***	0.02
US Inflation (CPI)	Level	-14.25***	-13.32***	-7.28***	0.36***
	First Diff.	-58.35***	-58.35***	-58.41***	0.03
US Govt Deficit %GDP	Level	-2.61	-1.59	-0.49	0.14*
	First Diff.	-12.32***	-12.34***	-12.34***	0.03
US Current Acc. Def % GDP	Level	-1.88	-1.18	-0.37	0.22**
	First Diff.	-11.18***	-11.19***	-11.20***	0.08
US Public Debt % GDP	Level	-3.21*	1.18	1.72	0.58***
	First Diff.	-8.19***	-7.56***	-7.48***	0.17**
US Private Debt % GDP	Level	-0.85	-1.40	2.98	0.19**
	First Diff.	-8.93***	-8.84***	-8.20***	0.13*
US Openness	Level	-2.80	-1.26	1.06	0.14*
	First Diff.	-8.80***	-8.80***	-8.76***	0.04
SA US Growth Diff	Level	-11.47***	-11.49***	-11.51***	0.13*
	First Diff.	-46.41***	-46.44***	-46.50***	0.01
SA US Inflation Diff	Level	-14.31***	-13.37***	-7.40***	0.35***
	First Diff.	-58.35***	-58.37***	-58.43***	0.02
SA US Gov Def Diff	Level	-4.56***	-3.20**	-3.20***	0.20**
	First Diff.	-15.14***	-15.18***	-15.21***	0.04
SA US CA Def Diff	Level	-1.84	-1.21	-0.42	0.21**
	First Diff.	-11.18***	-11.19***	-11.20***	0.09
SA US Gov Debt Diff	Level	-3.09	-0.35	0.13	0.43***
	First Diff.	-10.24***	-10.25***	-10.26***	0.18**
SA US Pvt Debt Diff	Level	-2.63	1.51	-0.04	0.56***
	First Diff.	-18.03***	-18.01***	-18.03***	0.03
SA US Openness Diff	Level	-2.59	-2.62*	-0.91	0.51***
	First Diff.	-12.53***	-12.53***	-12.55***	0.03

***, **, *, denote significance at the 1%, 5% and 10% levels respectively
Order of PP augmentation: 12

Table 3: Phillips-Perron and KPSS Test Statistics

		CMR1	ZivAnd	CMR2	
		min t	min t	$T_{1,b}$	$T_{2,b}$
SA vs USA 10 Year Bond Yield Spread	Level	-4.13**	-5.16**	-5.71**	
	Break	1985m3	1984m7	1985m3	2001m12
SA Inflation(CPI)	Level	-3.10	-8.10***	-5.57**	
	Break	1970m12	1972m5	1972m4	1993m2
SA Govt Deficit %GDP	Level	-3.05	-9.72***	-3.89	
	Break	2009m7	1998m7	2000m1	2009m7
SA Public Debt % GDP	Level	-2.33	-1.98	-2.421	
	Break	2016m1	2010m8	1981m4	1995m2
SA Private Debt % GDP	Level	-3.19	-4.49**	-4.94	
	Break	2006m4	2004m8	1996m4	2006m4
SA Household Cr % GDP	Level	-2.81	-2.14	-3.43	
	Break	2008m4	2003m12	1991m6	2007m11
SA Corporate Cr % GDP	Level	-3.36	-3.09	-4.19	
	Break	2008m1	1997m12	1999m1	2008m1
SA Openness	Level	-3.68**	-4.66*	-4.37	
	Break	2007m1	1981m10	1990m1	2001m1
SA Current Acc. Def % GDP	Level	-4.63***	-4.26*	-5.66**	
	Break	2007m1	2004m1	2004m7	2012m7
US Current Acc. Def % GDP	Level	-2.38	-3.12	-3.40	
	Break	2006m2	2008m10	2001m4	2009m7
US Public Debt % GDP	Level	-2.84	-5.50**	-3.63	
	Break	2011m4	2008m7	1991m4	2011m4
US Private Debt % GDP	Level	-2.57	-3.09	-3.32	
	Break	2008m10	2009m10	1987m1	2003m10
US Openness	Level	-2.08	-4.43	-2.97	
	Break	2008m11	1972m1	1980m4	2008m11
***, **, *, denote significance at the 1%, 5% and 10% levels respectively					

Table 4: CMR1, CMR2 and ZivAnd Test Statistics for Structural Breaks

Since unit root tests suffer from poor power characteristics in the presence of structural breaks (Perron, 1989, 1994; Holden and Perman, 1994), and given our observation of the likely presence of such breaks from a visual inspection of the data, we test for unit roots in the presence of up to two structural breaks for variables not found to be stationary under the test sequence of Tables 1 through 3, allowing for the structural breaks to be endogenously identified under both the Clemente et al (1992) and Zivot and Andrews (1992) methodologies.[27] We report the results in Table 4, reporting the Clemente et al (1992) test for a single (CMR1) and two (CMR2) structural breaks, and the Zivot and Andrews (1992) test for a single structural break (ZivAnd). The evidence confirms not only the presence of structural breaks in the data, but also univariate stationarity of all variables except the SA Public Debt as a % of GDP, SA household and corporate credit as a % of GDP, the US Current Account Deficit as a % of GDP, US Private Debt as a % of GDP, and US Openness. However, consideration of the SA Public Debt as a % of GDP variable - see Figure 13 - suggests not that the variable is non-stationary, but that there are 3 structural breaks rather than 2: 1980m1, 1991m4, and 2008m9. By contrast, the US Current Account Deficit as a % of GDP, US Private Debt as a % of GDP, and US Openness are all unambiguously nonstationary, and are therefore employed in first difference format in estimation. For SA private sector debt measures, since the aggregate measure does prove stationary in the presence of structural breaks, whereas the household and corporate disaggregated measures do not, we employ only the aggregate measure in estimation. In Table 2 we report the implied stationarity properties of those variables not found stationary in the absence of structural breaks, as well as the structural breaks found for each of the variables as reported in the evidence of Table 4.

In estimation we employ variables found to be $\sim I(0)$ in levels, those found to be $\sim I(1)$ in first

[27] See also the discussion in Perron (1989), Holden and Perman (1994), Glynn et al (2007).

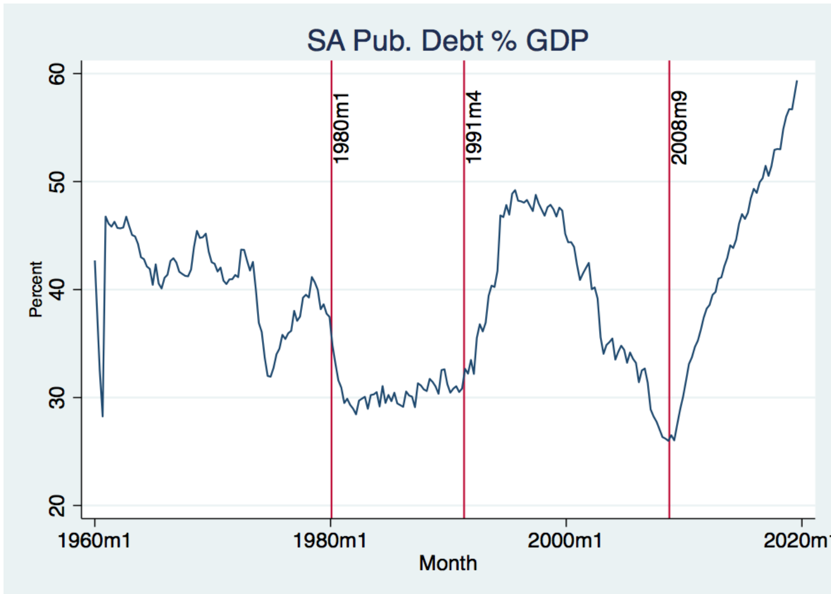

Figure 13: SA Public Debt as % of GDP.

difference format. Throughout, we control for the structural breaks determined under the univariate time series properties of the data diagnostics.

From the endogenous testing for structural breaks in the data, we infer two sets of structural break dummies. The first is for the specification loading only SA fundamentals; the second is for the specification including both SA and US fundamentals. Table 5 lists the two full sets of structural break dummies, in each instance indicating the full list of structural dummies found in the univariate data diagnostics.[28] However, using univariate structural break evidence may lead to an overproliferation of controls for structural breaks in structural estimation, especially since univariate breaks that are displaced by small calendar time periods may be controlling for the same structural change. In estimation, in addition to the full set of reported structural breaks, we therefore also employ a restricted set of structural break dummies based on significance, to explore whether estimation results are sensitive to which structural breaks are included in estimation (they are not).

5 Estimation Results

Our empirical specifications are premised on the GARCH class of estimators. Section 4.1 established that the necessary stationarity properties of the data required to ensure stability in GARCH estimation is satisfied, conditional on structural breaks being controlled for. Given the sample period covering almost 60 years, and the maintenance of a number of distinct policy regimes in both fiscal and monetary space over this time, the presence of structural breaks is not surprising.

In executing our empirical methodology, we begin by establishing the presence of ARCH effects in our data. We then proceed with (G)ARCH estimation.

5.1 ARCH Effects

Given that our specifications employ the GARCH class of estimators, we begin by testing for the presence of ARCH effects in our specifications. Table 6 reports the relevant tests. Given the use of data at the monthly frequency, we report for both 12 and 24 lags. For both the specification employing only SA structural variables (column 1) and the specification employing both SA and US structural variables (column 2), the null of no ARCH structure in the residuals is decisively rejected. We thus proceed with GARCH estimation.

[28] The only exception is where two structural breaks are indicated that are not separated by more than a small number of months.

	Full		Restricted
Set 1 (SA only):	D1972m4	D1980m1	D1981m10
	D1981m10	D1984m7	D1984m7
	D1985m3	D1991m4	D2001m1
	D1993m2	D1998m7	D2001m12
	D2001m1	D2001m12	D2004m8
	D2004m8	D2007m1	
	D2008m9	D2012m7	
Set 2: (SA & US):	D1972m4	D1980m1	D1981m10
	D1981m10	D1984m7	D1984m7
	D1985m3	D1991m4	D2004m8
	D1993m2	D1998m7	
	D2001m1	D2001m12	
	D2004m8	D2007m1	
	D2008m7	D2008m9	
	D2012m7		

Table 5: Structural Breaks for Estimation

	(1)	(2)
	Only SA Structural Variables	SA and US Structural Variables
AR(12)	562.56^{***} [0.00]	489.43^{***} [0.00]
AR(24)	564.75^{***} [0.00]	491.73^{***} [0.00]
ARCH(12)	409.53^{***} [0.00]	335.29^{***} [0.00]
ARCH(24)	399.27^{***} [0.00]	341.48^{***} [0.00]
*, **, *** denotes significance at the 10, 5, 1% levels of significance respectively		

Table 6: Tests for AR and ARCH Effects

5.2 Estimation Results: GARCH and GARCH-M

Estimation results are presented in Table 7 for the specification including only South African macroeconomic fundamentals, and Table 8 for the specification including both SA and US fundamentals. Columns (1) and (2) report GARCH results, columns (3) and (4) GARCH-M results. Columns (1) and (3) include the full set of structural break dummies, while columns (2) and (4) include the set of restricted structural break dummies. Our results are restricted to GARCH(0,2) and GARCH-M(0,2) specifications, since the use of GARCH(i,2), $i > 0$, specifications did not add significantly to the statistical coherence of results, and the substantive implications of the estimation results are substantially unchanged from the ARCH-specifications. Hence the prioritization of the more parsimonious GARCH-specifications.

Immediate structural implications are as follows. All specifications satisfy the Bollerslev (1986) conditions for dynamic stability (viz. the null that $\alpha_1 + \alpha_2 = 1$ is rejected). Results do not provide evidence that volatility in the SA-US yield spread (the second moment) impacts the mean level of the SA-US yield spread (the first moment), since for all ARCH-M specifications h_t proves insignificant. While surprising, the most likely explanation of this finding is that the SA-US yield spread simply does not show that much volatility – see the descriptive evidence of Figure 2. By contrast, the underlying macroeconomic fundamentals have shown substantial variability (see Figures 5 through 12), and as such ultimately appear to have been the principal drivers of the spread. This interpretation would be consistent with the existence of liquid markets for SA public debt, and the ubiquity of SA public debt in the portfolios of international asset managers, such that long-run risk factors matter supervene short-term volatility in the factors determining demand for SA public debt assets.

For all specifications reported in Table 8, the US macroeconomic fundamentals are strictly statistically insignificant. By contrast, a consistent set of SA macroeconomic fundamentals does report statistically significant associations with the SA-US yield spread, across all specifications in Tables 7 and 8. Inference is thus that the US yield provides a safe asset reference point for SA long-term government bonds, irrespective of macroeconomic fundamentals in the US.

Specifically, we find that higher economic growth in South Africa is associated with a statistically significantly lower SA-US yield spread. By contrast, higher inflation, higher public and private debt, as well as Rand-Dollar depreciation are all associated with a statistically significantly higher SA-US yield spread. These findings correspond to the sign expectations specified in section 3. In the case of the private debt-to-GDP ratio, for which we had indeterminate sign expectations, note that we find a net positive association, consistent with the interpretation of competition for loanable funds (crowd-out) between the private and public sector. Deficits on the government account, openness of the economy and the current account deficit all prove to be statistically insignificantly associated with the SA-US yield spread.

Results are thus consistent with a decrease in default risk associated with growth, and increased default risk due to higher public debt-to-GDP ratios. The Rand-Dollar depreciation and inflation findings in turn are consistent with exchange rate risk from depreciation and inflation. As already noted, the private debt-to-GDP ratio may serve as an indicator of competition over loanable funds between the private and public sectors.

It is noteworthy that these findings of statistical significance are consistent across all specifications. What is more, regardless of specification (i.e. inclusion or exclusion of US fundamentals, and full or restricted structural break dummies), the substantive strength of association also varies across a narrow range.[29]

In Table 9 we report the basis point impact of the specified changes in macroeconomic fundamentals. Thus a percentage point increase in growth is associated with a yield spread lower by between 4 and 6 basis points (basis points are defined as $\frac{1}{100}'ths$ of one percent), while a percentage point increase in inflation is associated with an increase of the spread by between 4 and 11 basis points. A 10% depreciation of the Rand is associated with an increase of the spread by 16-17 basis points. Finally, the strongest association comes from the public and private credit channels. An increase of the public debt-to-GDP ratio of 10 percentage points is associated with an increased spread of between 50 and 80 basis points, and an equivalent increase

[29] A tempting extension to the analysis would be to conduct the estimations over sub-samples, in order to establish whether the nature of the associations alter either in sign, or size of impact, or both. This option was explored at some length. However, the univariate stationarity properties of the data alter dramatically over sub-samples of our data - in general proving non-stationarity for shorter time periods (a common finding in time series data). Hence either the GARCH class of estimators is inadmissible, or the data would have to be employed in first difference format, rendering the results non-comparable. As a result, despite an extensive search, no internally consistent testing methodology was able to be isolated.

		(1)	(2)	(3)	(4)
		Yield Spread	Yield Spread	Yield Spread	Yield Spread
Yield Spread:	t-1	0.90^{***} (0.01)	0.91^{***} (0.01)	0.90^{***} (0.01)	0.91^{***} (0.01)
SA Growth:	t	-5.01^{***} (1.77)	-5.95^{***} (1.72)	-5.01^{***} (1.77)	-5.83^{***} (1.73)
	t-1	2.32 (1.54)	2.34 (1.51)	2.32 (1.54)	2.32 (1.51)
SA Inflation:	t	4.83^{**} (2.21)	6.53^{***} (2.06)	4.44^{**} (2.21)	6.30^{***} (2.08)
	t-1	2.28 (2.47)	4.49^{*} (2.39)	2.28 (2.47)	4.14^{*} (2.42)
SA Govt Deficit %GDP:	t	-0.004 (0.01)	-0.003 (0.01)	-0.005 (0.01)	-0.004 (0.01)
	t-1	0.005 (0.01)	0.002 (0.01)	0.005 (0.01)	0.002 (0.01)
SA Public Debt % GDP:	t	0.079^{*} (0.04)	0.094^{**} (0.04)	0.074^{*} (0.04)	0.091^{**} (0.04)
	t-1	-0.071 (0.04)	-0.089^{**} (0.04)	-0.067 (0.04)	-0.086^{**} (0.04)
SA Private Debt % GDP:	t	-1.48^{***} (0.52)	-1.45^{***} (0.51)	-1.43^{***} (0.52)	-1.44^{***} (0.51)
	t-1	1.66^{***} (0.52)	1.69^{***} (0.51)	1.61^{***} (0.52)	1.67^{***} (0.50)
SA Openness:	t	0.30 (1.29)	0.07 (1.23)	0.26 (1.28)	0.06 (1.23)
	t-1	-0.12 (1.24)	-0.08 (1.19)	-0.17 (1.23)	-0.09 (1.18)
SA Current Acc. Def % GDP:	t	-1.02 (1.27)	-0.97 (1.21)	-0.94 (1.27)	-0.92 (1.21)
	t-1	1.00 (1.31)	0.86 (1.27)	0.92 (1.32)	0.80 (1.27)
Rand Dollar Depreciation:	t	1.60^{***} (0.43)	1.63^{***} (0.39)	1.63^{***} (0.42)	1.64^{***} (0.38)
h (Second Moment Volatility)	t	-	-	0.17 (0.15)	0.11 (0.14)
α_1	t-1	0.42^{***} (0.07)	0.39^{***} (0.07)	0.42^{***} (0.07)	0.40^{***} (0.07)
α_2	t-2	0.23^{***} (0.07)	0.23^{***} (0.06)	0.22^{***} (0.07)	0.23^{***} (0.06)
α_0	-	0.06^{***} (0.01)	0.06^{***} (0.01)	0.06^{***} (0.01)	0.06^{***} (0.01)
$Bollerslev:$ $\alpha_1+\alpha_2=1$	-	64.04^{***} [0.000]	74.15^{***} [0.000]	63.10^{***} [0.000]	72.11^{***} [0.000]
Structural Breaks	-	Set 1 Full	Set 1 Restr.	Set 1 Full	Set 1 Restr.

*, **, *** denotes significance at the 10, 5, 1% levels of significance respectively
Figures in round parentheses are s.e.'s. Figures in square parentheses are p-values.

Table 7: ARCH and ARCHM Results with South African Fundamentals

		(1)	(2)	(3)	(4)
		Yield Spread	Yield Spread	Yield Spread	Yield Spread
Yield Spread:	t-1	0.91***	0.92***	0.91***	0.92***
		(0.01)	(0.01)	(0.01)	(0.01)
SA Growth:	t	−4.73**	−4.52**	−4.56**	−4.22**
		(2.09)	(2.07)	(2.09)	(2.07)
	t-1	2.47	2.15	2.66	2.16
		(1.78)	(1.73)	(1.77)	(1.74)
SA Inflation:	t	4.17*	7.98***	3.81*	7.41***
		(2.28)	(2.21)	(2.27)	(2.23)
	t-1	2.07	6.35**	1.65	5.53**
		(2.67)	(2.59)	(2.66)	(2.64)
SA Govt Deficit %GDP:	t	−0.01	−0.003	−0.01	−0.004
		(0.01)	(0.01)	(0.01)	(0.01)
	t-1	0.01	0.001	0.01	0.001
		(0.01)	(0.01)	(0.01)	(0.01)
SA Public Debt % GDP:	t	0.10**	0.084*	0.10**	0.080*
		(0.04)	(0.04)	(0.04)	(0.04)
	t-1	−0.09**	−0.081*	−0.09**	−0.076*
		(0.04)	(0.04)	(0.04)	(0.04)
SA Private Debt % GDP:	t	−1.36**	−1.23**	−1.33**	−1.20**
		(0.55)	(0.53)	(0.52)	(0.53)
	t-1	1.70***	1.48***	1.67***	1.45***
		(0.54)	(0.52)	(0.54)	(0.51)
SA Openness:	t	−0.12	−1.15	−0.18	−1.14
		(1.29)	(1.28)	(1.27)	(1.26)
	t-1	0.73	0.71	0.67	0.69
		(1.32)	(1.27)	(1.31)	(1.26)
SA Current Acc. Def % GDP:	t	−1.23	−0.90	−1.24	−0.87
		(1.39)	(1.32)	(1.39)	(1.31)
	t-1	1.00	0.48	1.03	0.43
		(1.48)	(1.37)	(1.48)	(1.37)
Rand Dollar Depreciation:	t	1.55***	1.64***	1.55***	1.66***
		(0.44)	(0.45)	(0.45)	(0.46)
US Growth:	t	−8.79	−10.28	−8.06	−9.22
		(8.28)	(8.10)	(8.36)	(8.28)
	t-1	−4.04	2.29	−5.36	0.56
		(8.36)	(7.89)	(8.54)	(8.19)
US Inflation:	t	0.02	0.04	0.02	0.05
		(0.09)	(0.08)	(0.09)	(0.08)
	t-1	0.02	−0.02	0.02	−0.01
		(0.09)	(0.08)	(0.09)	(0.08)
US Govt Deficit %GDP:	t	8.28	7.89	8.26	8.08
		(5.58)	(5.36)	(5.52)	(5.51)
	t-1	−8.97	−7.64	−8.78	−7.90
		(5.84)	(5.39)	(5.77)	(5.52)
ΔUS Public Debt % GDP:	t	0.05	0.03	0.05	0.02
		(0.08)	(0.08)	(0.08)	(0.08)
	t-1	−0.03	−0.002	−0.03	0.004
		(0.08)	(0.08)	(0.08)	(0.08)
ΔUS Private Debt % GDP:	t	−0.08	−0.10	−0.08	−0.10
		(0.09)	(0.10)	(0.10)	(0.10)
	t-1	0.03	0.04	0.02	0.05
		(0.09)	(0.10)	(0.10)	(0.10)
ΔUS Openness:	t	0.15	0.10	0.14	0.09
		(0.12)	(0.11)	(0.12)	(0.11)
	t-1	−0.09	−0.07	−0.10	−0.08
		(0.10)	(0.10)	(0.10)	(0.10)
ΔUS Current Acc. Def % GDP:	t	−0.05	−0.02	−0.06	−0.02
		(0.10)	(0.10)	(0.10)	(0.10)
	t-1	−0.03	−0.09	−0.03	−0.08
		(0.11)	(0.10)	(0.11)	(0.10)
h (Second Moment Volatility)	t	-	-	0.16	0.20
				(0.17)	(0.13)
α_1	t-1	0.45***	0.42***	0.44***	0.43***
		(0.08)	(0.08)	(0.08)	(0.08)
α_2	t-2	0.21***	0.23***	0.21***	0.22***
		(0.07)	(0.06)	(0.07)	(0.06)
α_0	-	0.06***	0.06***	0.06***	0.06***
		(0.01)	(0.01)	(0.01)	(0.01)
$Bollerslev:$ $\alpha_1+\alpha_2=1$	-	47.81***	53.63***	48.26***	53.82***
		[0.000]	[0.000]	[0.000]	[0.000]
Structural Breaks	-	Set 3 Full	Set 3 Restr.	Set 3 Full	Set 3 Restr.
*, **, *** denotes significance at the 10, 5, 1% levels of significance respectively					
Figures in round parentheses are s.e.'s. Figures in square parentheses are p-values.					

Table 8: ARCH and ARCHM Results with SA and US Fundamentals

		Basis Points	
	Chg:	Low	High
Growth	↑ 1%	-4	-6
Inflation	↑ 1%	4	11
Public Debt % GDP	↑ 10%	50	80
Private Debt % GDP	↑ 10%	180	340
Rand Depreciation	↑ 10%	16	17

Table 9: Substantive Strengths of Statistically Significant Yield Spread to Macroeconomic Fundamentals Associations

in the private credit-to-GDP ratio is associated with a spread raised by between 180 and 340 basis points. The strong impact of the private credit variable implies a strong competition between the public and private sector over credit.

While the individual effects may appear modest, note the implication of the recent performance of South Africa in terms of these macroeconomic fundamentals (we consider upper bounds). A decline of the structural growth rate of the economy from 4-1% is associated with an increase in the yield spread of 18 basis points. An increase of the public debt-to-GDP ratio from 25% to 60% is associated with an increase in the yield spread of 280 basis points. An increase in inflation from 4% to 6% is associated with an increase in the yield spread of 22 basis points. And a 25% depreciation of the Rand from 12:1 to 15:1 is associated with an increase in the yield spread of 42.5 basis points. Thus, even ignoring the high leverage ratio of the private sector, collectively these macroeconomic fundamental performance indicators are associated with an increase in the yield spread of 363 basis points.

Perhaps more instructively, in Figure 14 we report the cumulative association of the historical values of the four policy related variables with the SA-US yield spread over the full sample period. It follows immediately that while the South African growth performance, inflation rate, and Rand-Dollar depreciation are statistically significant, the substantive strength of association between these variables and the SA-US yield spread is dwarfed by the strength of the association of the spread with the SA public debt-to-GDP ratio. In particular, since 2008, the increase in public debt has been associated with an increase in the yield spread from 2 to 4.62%. Historically the public debt position appears to have been the dominant association with the yield spread.

Where we also allow for private sector debt, as in Figure 15, while there is a moderate impact from the leveraging of the private sector, the substantive implication remains consistent with that of Figure 14, viz. that the primary association between the yield spread and macroeconomic fundamentals is with the size of the public debt.

Finally, as indicated in section 3, we allow for the possibility of asymmetry in the impact of positive and negative shocks, allowing for the possible recourse to asymmetric estimators such as the EGARCH. We test for the possibility of asymmetry by means of the Engle and Ng (1993) methodology. Estimating under (8), the test considers $a_1 \neq 0$, $b_1 \neq 0$, $b_2 \neq 0$. Where $a_1 \neq 0$, the test confirms sign bias, such that negative shocks have a volatility impact distinct from positive shocks (whether positive or negative attenuation holds is determined by the parameter signs of the asymmetric GARCH process). In the event that $b_1 \neq 0$, negative size bias is confirmed, with large negative shocks having a larger volatility impact than small negative shocks. Under $b_2 \neq 0$, positive size bias follows, with large positive shocks having a larger volatility impact than small positive shocks.

Results for our eight specifications from Tables 7 and 8 are reported in Table 10.

Implication of the results is that for all specifications there is no sign bias, such that positive and negative shocks do not show a differential impact on yield spread volatility. However, for all specifications both positive and negative size bias is confirmed, such that large positive or negative shocks have a larger impact on yield spread volatility than do small shocks. Estimation under EGARCH is thereby obviated. The implied impact on the volatility of the yield spread for ϵ_{t-1} and ϵ_{t-2} is thus symmetric, but increasing in the size of any shock, and is illustrated for our estimated GARCH coefficients in Figure 16.

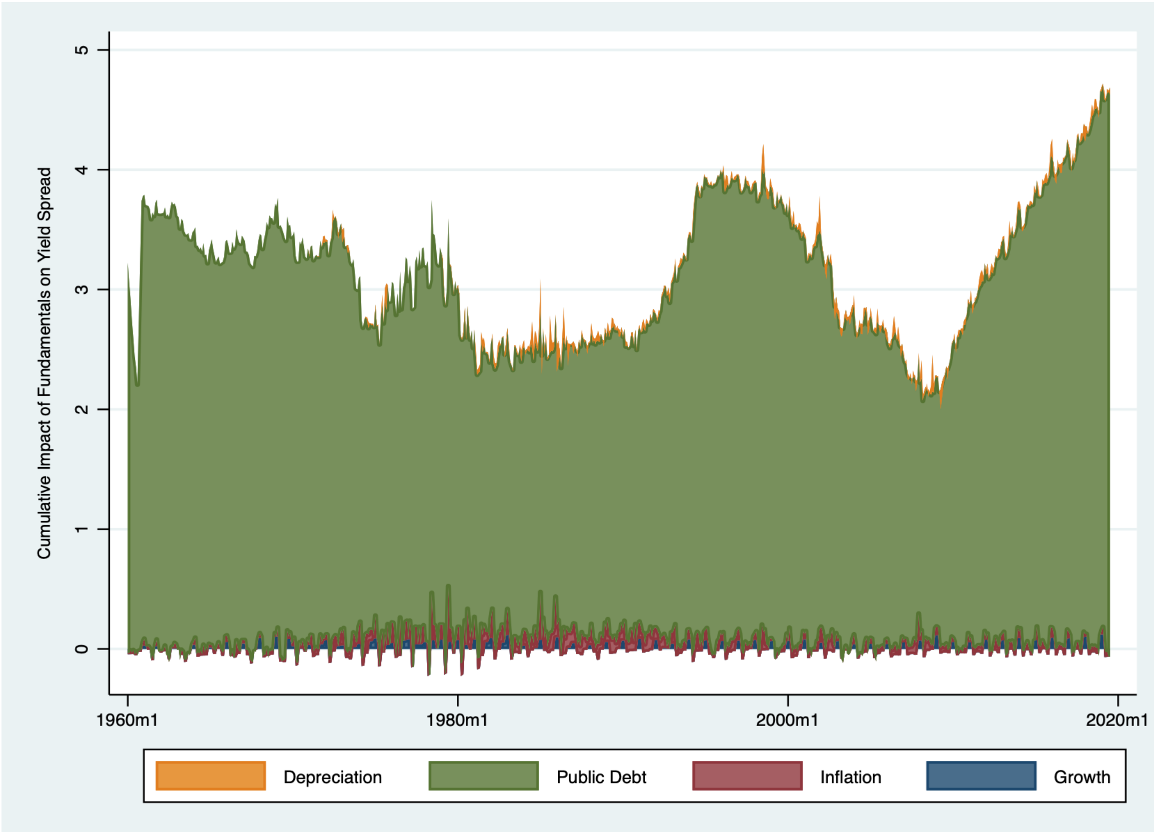

Figure 14: Cumulative Association between Macroeconomic Fundamentals and SA-US Yield Spread

	Str.Breaks		Sign Bias	Pos. Size Bias	Neg. Size Bias
Only SA Structural Variables	Set 1 Full	ARCH(2)	0.01 (0.04)	0.44*** (0.06)	−0.35*** (0.07)
	Set 1 Rest.	ARCH(2)	−0.01 (0.03)	0.39*** (0.06)	−0.37*** (0.07)
	Set 1 Full	ARCH-M(2)	−0.01 (0.03)	0.42*** (0.06)	−0.42*** (0.07)
	Set 1 Rest.	ARCH-M(2)	−0.01 (0.03)	0.39*** (0.06)	−0.41*** (0.07)
SA & US Structural Variables	Set 3 Full	ARCH(2)	0.01 (0.03)	0.45*** (0.06)	−0.33*** (0.07)
	Set 3 Rest.	ARCH(2)	0.01 (0.04)	0.42*** (0.06)	−0.32*** (0.07)
	Set 3 Full	ARCH-M(2)	−0.004 (0.03)	0.44*** (0.06)	−0.40*** (0.07)
	Set 3 Rest.	ARCH-M(2)	0.01 (0.03)	0.43*** (0.06)	−0.38*** (0.07)

Table 10: Engle-Ng Test for Asymmetry

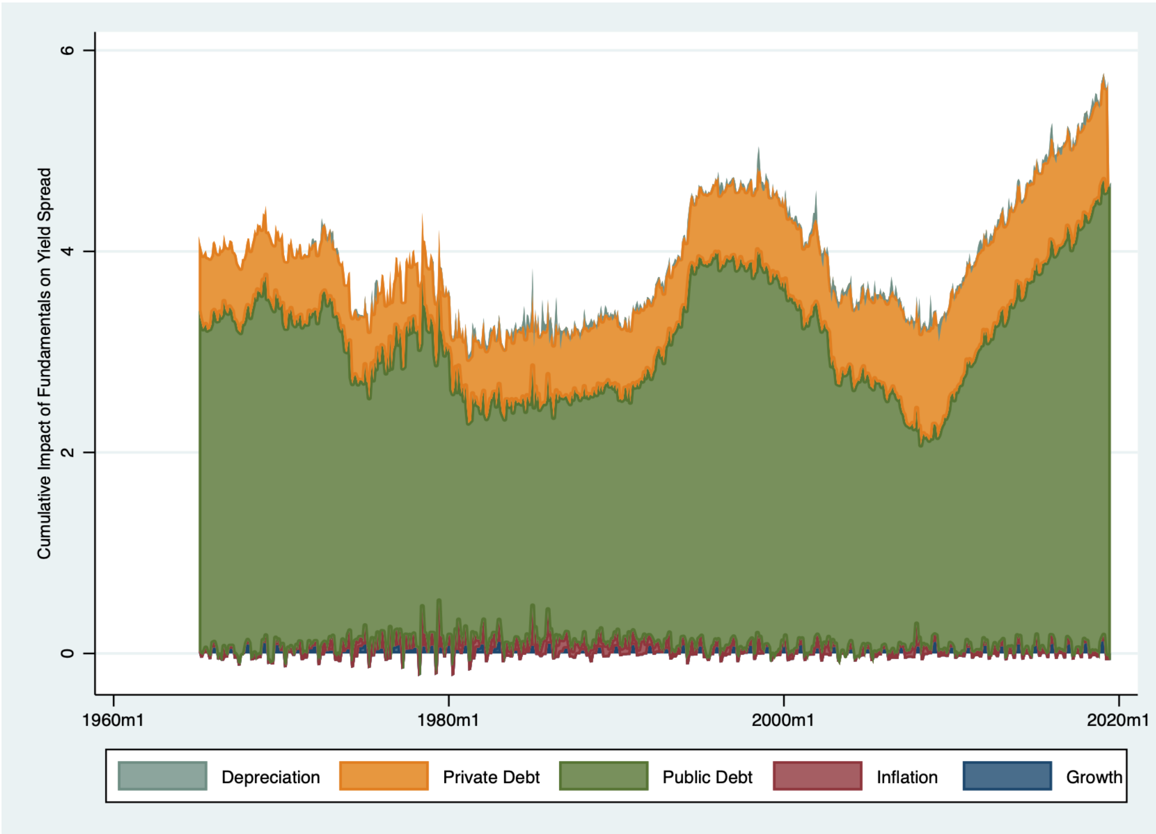

Figure 15: Cumulative Association between Macroeconomic Fundamentals and SA-US Yield Spread

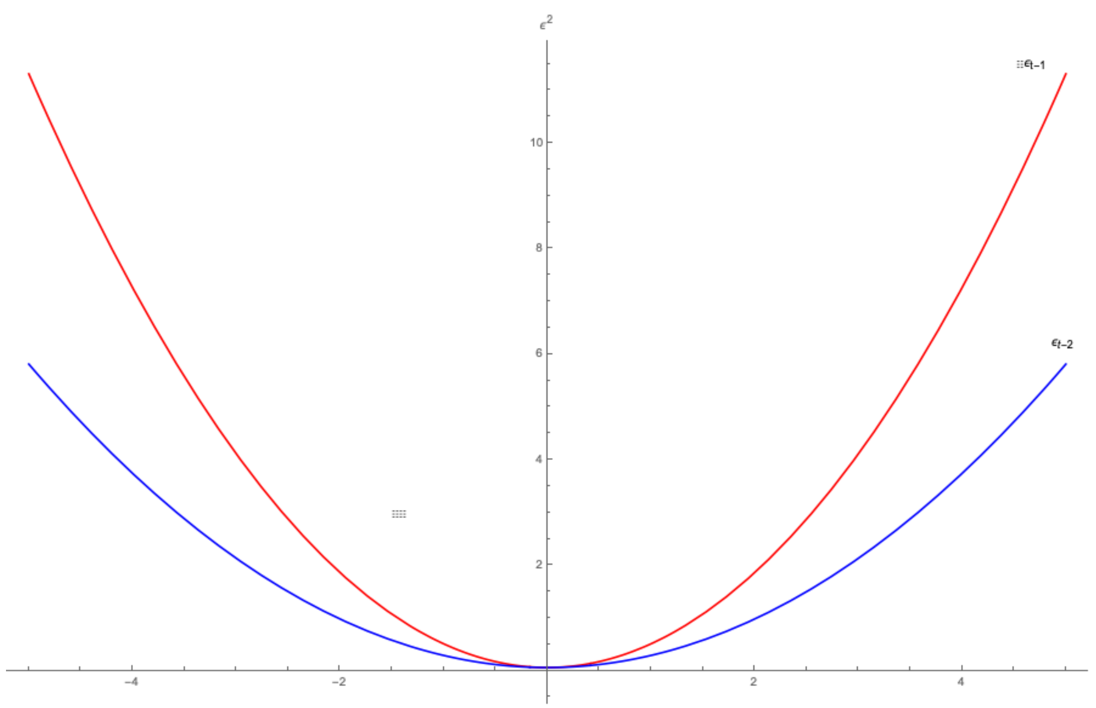

Figure 16: News Curve for ϵ_{t-1} and ϵ_{t-2}

6 Conclusion and Evaluation

Yields on long-term government bonds have been declining internationally, leading to the inference that the space for fiscal activism has increased. For South Africa this fiscal space has not materialized. South African long-term yields have effectively remained constant after 2008, while the spread of South African long-term government bond yields to safe assets such as US or German long-term government bonds has risen. Indeed, the increase in the yield spread is such that it is approaching levels last seen during the period of heightened political uncertainty in the 1980s.

In this paper the association between the South African-US long-term government bond yield spread with a set of macroeconomic fundamentals is considered. Macroeconomic fundamentals controlled for are economic activity indicators in the form of growth in real GDP, monetary policy measures provided by the CPI-based inflation rate, fiscal balance measures provided by the public debt-to-GDP ratio and the budget deficit-to-GDP ratio, local asset market conditions by private sector debt as a percent of GDP, and foreign exchange market conditions by the current account deficit as a percent of GDP and the rand-dollar exchange rate. Both South African and US macroeconomic fundamentals are considered.

Estimation is under the GARCH and GARCH-M class of estimators, controlling for a wide range of potential structural breaks present in the 1960-2019 sample period. Structural breaks are endogenously determined from the univariate time series structure of the data, and reflect distinct policy regimes present over the sample period. Results confirm the suitability of the GARCH class of estimators. However, there is little evidence that the second moment of the yield spread (its volatility) affects the first moment of the spread (its level). Findings thus focus on the results to emerge from the GARCH (rather than GARCH-M) estimators.

There is no evidence of asymmetry in the impact of shocks on the volatility of the yield spread. Thus positive and negative shocks do not show a differential impact on yield spread volatility. However, both positive and negative size bias is confirmed, such that large positive or negative shocks have a larger impact on yield spread volatility than do small shocks. The implied impact on the volatility of the yield spread for lagged shocks is thus symmetric, but increasing in the size of any shock.

Estimation results confirm that higher economic growth in South Africa is associated with a statistically significantly lower South African-US yield spread. By contrast, higher inflation, higher public and private debt, as well as Rand-Dollar depreciation are all associated with a statistically significantly higher South African-US yield spread. Deficits on the government account, openness of the economy and the current account deficit all prove to be statistically insignificantly associated with the South African-US yield spread. US fundamentals are uniformly insignificant in estimation, such that the US long-term government bond yield provides a safe asset reference point for SA long-term government bonds, irrespective of macroeconomic fundamentals in the US.

These findings of statistical significance are consistent across all specifications, regardless of specification (inclusion or exclusion of US fundamentals, and full or restricted structural break dummies), with the substantive strength of association also varying across a very narrow range.

In terms of the substantive strength of the associations, a decline of the structural growth rate of the economy from 4-1%, an increase of the public debt-to-GDP ratio from 25% to 60%, an increase in inflation from 4% target mid-point of to 6%, and a 25% depreciation of the Rand from 12:1 to 15:1 would be associated with an increase in the yield spread of 363 basis points. In considering the cumulative impact of the historical values of the four policy-related variables on the SA-US yield spread over the full sample period, the substantively dominant association is between the spread and the South African public debt-to-GDP ratio. Specifically, since 2008, the increase in public debt has been associated with an increase in the yield spread from 2 to 4.62%.

The implications of these findings is fundamentally that in terms of macroeconomic fundamentals, since it is the size of government debt that is the main variable of association with the yield spread, it may well be the potential risk of default that accompanies government debt that influences the yield on long-term government debt in South Africa. While both expected tax revenue (growth) and exchange rate risk (Rand-Dollar Depreciation, inflation) matter, they are of less consequence than the most proximate determinant of risk on government debt. The yield spread is thus a reflection of fiscal rather than monetary policy orientation.

It is also worth pointing out that there are a number of questions that arise from the results of this paper worthy of further exploration. The current set of results does not explicitly control for political risk - primarily because at present there are no theoretically coherent measures of risk available for South Africa,[30] and also since the historical time series do not exist at sufficiently high frequency. Second, the present study makes no attempt to disaggregate public debt into Rand and Dollar denominated debt due to data availability. Since most South African public debt is Rand denominated, this may not be material (and also serve to explain the relative unimportance of Rand depreciation and inflation), controlling for the two types of public debt may be a useful avenue for future exploration. Additional work isolating both distinct policy regimes and business cycles, and variation in the association of macroeconomic fundamentals with the yield spread between regimes and across the cycle, may also be a fruitful avenue of additional research. Finally, placing South Africa in a comparative analysis with other emerging markets may also carry useful insight in terms of its relative attractiveness to financial asset portfolios.

A consideration of the descriptive evidence makes clear that South Africa has not realized the opportunity for increased fiscal activism without negative welfare costs identified for the US by Blanchard (2019). The evidence of this paper suggests that this is the consequence of macroeconomic policy choices - above all the sharp increase in the level of public debt as a proportion of aggregate output. The strong substantive impact of government debt on the yield spread, suggests that the failure of South Africa to meet the Blanchard necessity condition for a positive welfare impact of public debt is an endogenous result of a strong expansion of government debt. In short, the South African - US yield spread is simply an expression of the consequence of persistent deficits on the public accounts, with the resultant deficit financing driving up the cost of financing. More generally, therefore, any emergence of the space for fiscal activism, with low interest rates curtailing negative welfare impacts of public debt, would itself be the *result* of fiscal restraint and prudence. The US experience may thus be of very little general relevance beyond countries that issue government bonds that serve as safe assets, since in general the impact of debt issue on yields would rapidly eliminate the space for fiscal activism.

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