South African Reserve Bank Working Paper Series WP/22/04

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Authorised for distribution by Konstantin Makrelov

17 March 2022

South African Reserve Bank

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Analysing the spillover effects of the South African Reserve Bank's bond purchase programme

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22 July 2022

Abstract

Using daily bond purchase volume data, we evaluate the effects of the South African Reserve Bank's bond purchase programme on the term structure of the sovereign bond yield curve. Our results indicate that bond purchases significantly flatten the slope and lower the curvature of the sovereign bond curve by 4 bps and 10 bps respectively on impact; however, we find that bond purchases increase the level factor. The latter result is attributed to the increased sovereign risk stemming from the significant fiscal stimulus measures announced around the same period. We also examine how the programme's announcement influenced South Africa's corporate bond market using the FTSE/JSE All Bond Other Index and find that the SARB programme announcement had meaningful spillover effects by lowering yields in the South African corporate bond market.

JEL classification: E43, E44, E52

Keywords: Bond purchase programme; Spillovers; Covid-19; Term structure; Corporate bonds.

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1. Introduction[1]

The global economic uncertainty triggered by the onset of the Covid-19 pandemic forced many emerging market central banks into uncharted territory, prompting them to expand their toolkits to include measures such as asset purchase programmes for the first time to alleviate liquidity concerns and stabilise markets. One such example is the South African Reserve Bank (SARB), which announced a bond purchase programme in March 2020 to stabilise excess volatility and enable price discovery in the sovereign bond market (South African Reserve Bank, 2020).

While the effects of bond purchase programmes as implemented in advanced economies is well researched, the emerging market experience using such measures and how it compares to the prevailing understanding of its effects in advanced economies is a novel research area worth investigating. As such, this paper contributes to this growing strand of literature by answering two key questions: firstly, how the SARB's bond purchase programme impacted the term structure of the sovereign bond yield curve, and secondly, whether this programme announcement had effects that spilled over onto South Africa's corporate bond market.

Despite being focused on broader financial market stability (South African Reserve Bank, 2020), this programme is likely to affect the shape of the sovereign bond yield curve, an important predictor of economic activity. Therefore, using a three-factor yield curve decomposition, we estimate a vector autoregression (VAR) and construct impulse response functions (IRF) to estimate the effect of an increase in bond purchases on each portion of the sovereign bond yield curve. A novel component of this paper is that data on the SARB's daily bond purchase volume has been used to estimate the effects of the programme on yields; this allows the change in yields directly attributable to SARB bond purchase activity to be more clearly isolated as compared to many similar studies. We find that while an increase in bond purchase volume lowers the slope and curvature of the yield curve by 4 basis points (bps) and 10 bps respectively on impact, it increases level by 5 bps. We interpret this final result to be due to the fiscal stimulus announcement by the South African National Treasury and the resulting increase in default risk as perceived by market participants. These findings demonstrate that while such programmes can significantly lower yields on certain portions of the curve, sovereign risk can hamper the effectiveness of central bank interventions to improve market functioning.

Such programmes are also known to have spillover effects by either strengthening broader market confidence, adjusting expectations of the future interest rate environment, or leading investors to search for higher yields in other markets (or some combination of these effects) (Krishnamurthy and Vissing-Jorgensen, 2011). In particular, the existing literature points to crisis regime monetary expansions having significant spillover effects on corporate bond yields (Guidolin et al., 2014). As South African sovereign debt is speculatively graded, a likely im-

[1] We are grateful to Matthew Greenwood-Nimmo, Daan Steenkamp and Peter Wallis for valuable comments and suggestions.

perfect substitute for investors searching for yields in response to fluctuations in the sovereign bond market would be South African corporate bonds. South African corporate debt is also expected to be affected by volatility in sovereign yields, which serve as the reference rate for broader asset yields. Combined, these factors motivate an examination of South Africa's corporate bond market for evidence of spillovers.

Therefore, by employing an event study, we analyse how the SARB's programme announcement affected South African corporate bonds as measured using the FTSE/JSE All Bond Other Index, which comprises solely of South African corporate bonds. The findings from each model suggest that the SARB announcement placed significant downward pressure on corporate bond yields. This is a significant result as it suggests that the SARB's programme objective of financial stability can be achieved by simply intervening in the sovereign bond market.

The paper proceeds as follows. In Section 2 we provide an overview of the South African context. Section 3 summarises the existing literature. In Section 4 we detail the chosen empirical methodology and in Section 5 we present the estimation results. Finally, Section 6 offers some concluding remarks.

2. South African market dynamics in March 2020

2.1. South Africa's sovereign bond market

As shown in Figure 1, the emergence of Covid-19 saw a rapid rise in yields across the South African sovereign bond curve. In response, on 25 March 2020, the SARB announced its sovereign bond purchase programme to reduce excess volatility and enable effective price discovery in the market for government bonds (South African Reserve Bank, 2020). Figure 2 provides an overview of the key events surrounding the SARB's bond purchase programme announcement. While the SARB gave little indication upon the announcement of the size, duration, or target maturities of the programme, the size of the programme as at February 2021 was over ZAR 30 billion per the SARB's balance sheet (Figure 3), or approximately 0.8% of South Africa's gross domestic product (GDP). This is small compared to both advanced economies like the US, whose sovereign bond purchase programme constituted approximately 9% of GDP, and other emerging market programmes such as in Indonesia and the Philippines, which amounted to 3.7% and 5.7% of their GDP respectively.[2] The announcement of the programme seems to temporarily reduce long-term yields, which suggests the announcement is viewed by the market as a credible intervention that calmed markets. However, towards the end of April there is a divergence in the trajectories of short- and medium-term compared to long-term yields which seems to correspond to the South African government's announcement on 21 April 2020 of expansionary fiscal measures to combat the economic consequences of

[2] IMF Global Financial Stability Report, October 2020 (https://www.imf.org/-/media/Files/Publications/GFSR/2020/October/English/ch2.ashx).

Figure 1: South African sovereign bond yields

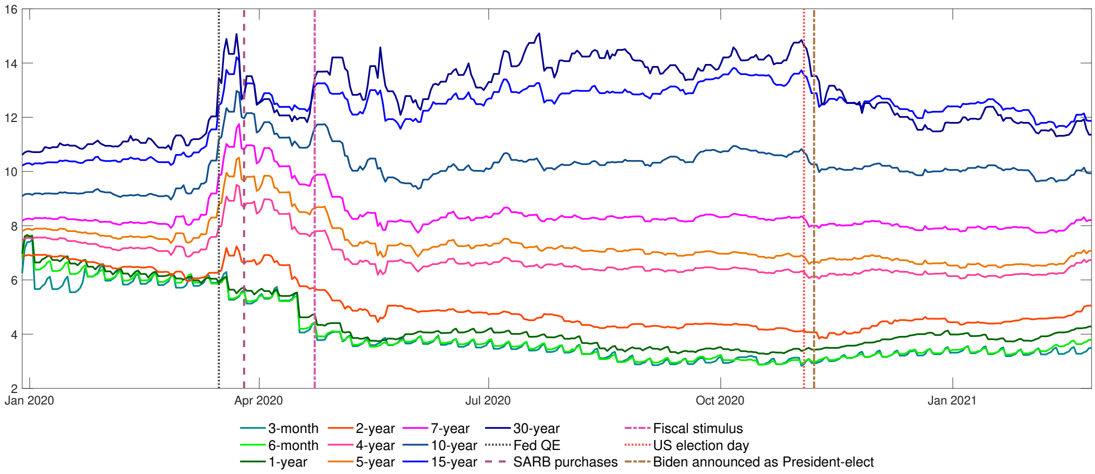
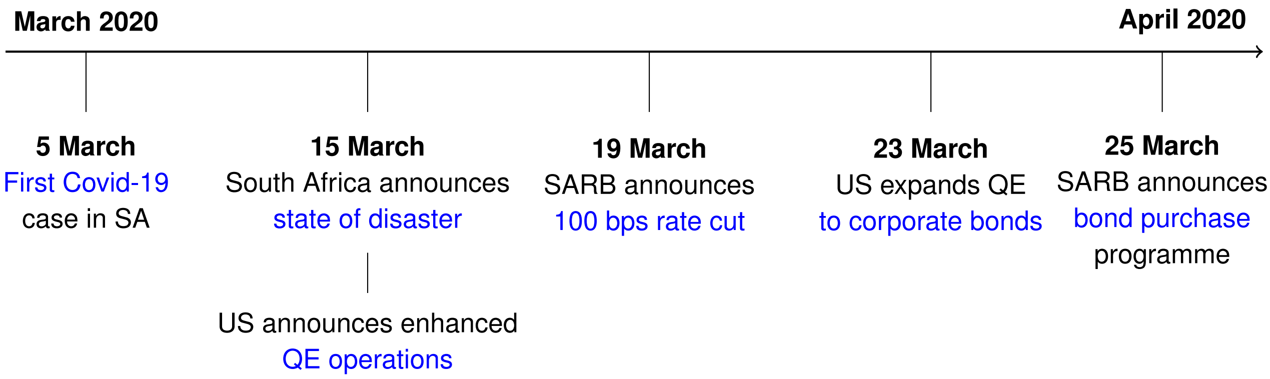


Figure 2: Key announcements in March 2020



Notes: Press release hyperlinks have been provided within the figure.

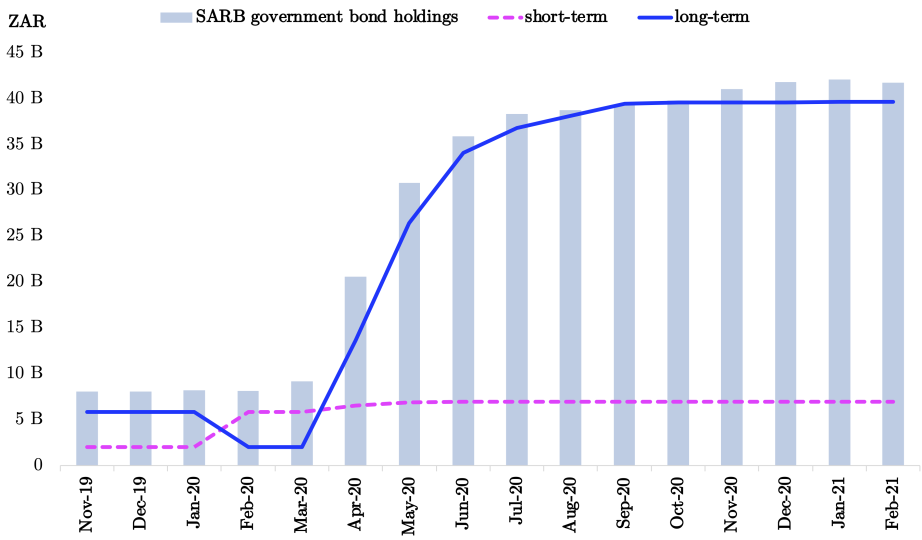
the Covid-19 pandemic.[3] This stimulus constituted 10% of GDP, making it the largest stimulus package among emerging economies relative to GDP and larger on a percent of GDP basis than economies like Canada and South Korea (Bhorat et al., 2020). It also pushed South Africa's debt-to-GDP ratio up to 81.8% (South African National Treasury, 2020).[4] Despite a significant portion of this stimulus being tied to a credit guarantee scheme for banks, which suggests that the size of this debt – and thus sovereign risk – is dependent on the subscription to this scheme by banks, markets demonstrably priced this commitment to substantially higher

[3] This announcement was made at 8:30pm on 21 April, so the effect of this announcement is reflected the next day. As such, the marker on Figure 1 is placed on 22 April 2020.

[4] The government committed 40% of this stimulus to a credit guarantee scheme for banks to improve liquidity and credit to businesses. The other key focus areas of the stimulus included wage protection, financial support to households and job creation. It is also worth noting that alongside the Covid-19 relief package, the government's debt issuance demands were significantly driven by automatic stabilisers. Government debt issuance for the 2020-21 year reached R560.8 billion, the majority of which was in fixed-income bonds. This was primarily concentrated in the short- to medium-term portions of the curve, with 69.4% of the issuance lying between the 2-year and 14-year maturity range (http://www.treasury.gov.za/publications/other/Debt%20Report/Debt%20Management%20Report%202020-21.pdf).

debt levels in the sovereign bond market.[5,6] Additionally, some participants may have viewed the composition of this stimulus being heavily targeted towards lending in the banking sector – rather than direct additional discretionary expenditure – as *compromising* the magnitude of the desired Keynesian stimulus gains that would be expected from such expansionary policy to appease markets that this increased debt can indeed be serviced by the government in the longer term.[7]

Figure 3: SARB government bond holdings: November 2019 to February 2021



Notes: SARB government bond holdings obtained from the SARB's monthly Statement of Assets and Liabilities from November 2019 to February 2021. Short-term (defined as less than 3-year maturity) and long-term bond holdings (greater than 3-year maturity) were obtained from the SARB's *Quarterly Bulletin*.

The final two markers on Figure 1 denote the US election day and the day that Joe Biden became President-elect. These announcements had material effects on lowering yields following the months of consistently high yields attributed to the fiscal stimulus; this highlights the sensitivity of South Africa to US conditions and the magnitude of reverberations in South Africa that can be traced back to fluctuations in global markets.

2.2. South Africa's corporate bond market

The corporate bond market in South Africa has seen considerable growth over the past 20 years, with the number of bonds outstanding increasing from 12 to over 1,500.[8] It is also

[5] Practitioner-trusted sources pointed to uncertainty regarding the South African government's repayment capacity as a key driver of the adverse market response for sovereign bonds (https://www.reuters.com/article/safrica-markets-idUSL5N2CA6BL).

[6] An analyst comment demonstrates the particular impact of this stimulus on longer-term sovereign bonds: "the yield curve should continue to steepen and explains why the government is selling more short-dated bonds, because the longer-term bonds are going to battle to sell." (https://www.reuters.com/article/safrica-markets-bonds-idUKL8N2CI5GH).

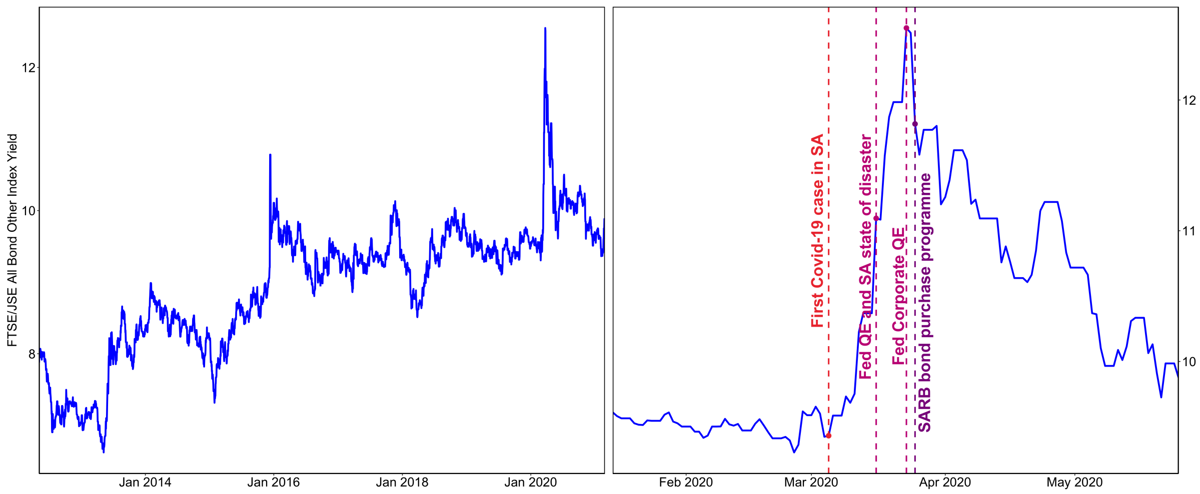
[7] For details, see: https://www.bloomberg.com/news/articles/2020-04-21/south-africa-unveils-26-billion-plan-to-help-virus-hit-economy.

[8] For details, see: https://www.oecd.org/dev/pgd/29863781.pdf and JSE.

one of the few emerging markets to have corporate debt issued in its own currency. While historically the key players have been state-owned enterprises (SOE) and financial services (Ojah and Pillay, 2009), companies outside these sectors are beginning to have an increasing presence in this market.

To summarise the dynamics of this growing market, we rely on the FTSE/JSE All Bond Other Index, which comprises the top 10 South African corporate debt ranked dually by liquidity and market capitalisation.[9] As seen in Figure 4, the corporate bond market experienced a rise in yields similar to the sovereign bond market following the onset of the pandemic. Yields rose further following the announcement of the Federal Reserve's (Fed) Quantitative Easing (QE) programme, which occurred on the same day that the South African government announced a state of disaster due to Covid-19. Ordinarily, one might have expected the Fed's announcement to lead to US investors engaging in 'search for yield' behaviour in emerging markets like South Africa, which would contribute to lower yields (as found by Bhattarai et al. (2021)). However, others such as Vissing-Jorgensen (2021) have argued that that investors in Treasury markets had immediate liquidity needs which meant the announcement effect of the programme was minimal, so that it was only upon actual Fed purchases that Treasury yields fell. In a South African context, the government's state of disaster announcement likely also increased the risk profile of corporate and sovereign debt by creating expectations of a contraction in economic activity, and therefore also higher yields. Therefore, while we would not expect the Fed announcement to generate a marked reduction in yields, we anticipate the South African state of disaster announcement to increase corporate bond yields.

Figure 4: Yields on the FTSE/JSE All Bond Other Index



Notes: The LHS panel plots yields on the FTSE/JSE All Bond Other Index from May 2012 to February 2021. The RHS panel illustrates the movements in yields of the index in early 2020 following the onset of the Covid pandemic.

Following this, on 23 March 2020, the Fed announced further market interventions to alleviate distress in the US corporate bond market. From Figure 4, there does not appear to be any

[9] For details, see: https://www.jse.co.za/albi

yield response from this announcement on the corporate bond market; indeed, the index yield peaks on March 23 and remains elevated until the SARB's announcement on March 25.[10] The SARB's bond purchase programme announcement appears to lead to the index yield declining and gradually returning to its pre-March trajectory. This serves as preliminary evidence of some spillover from this programme onto the corporate bond market.

3. Relevant literature

This paper contributes to growing literature on the effects of novel central bank market-easing measures as implemented in emerging markets. Research such as by Sever et al. (2020) examines solely the announcement effect of programmes across a panel of emerging markets, while Fratto et al. (2021) finds evidence that both the announcement and implementation dates improved emerging market sovereign bond yields. However, as this is a developing strand of the literature, comparable studies in emerging markets that isolate the effect of actual central bank purchases on the yield curve term structure, and that consider the effects on corporate bonds is to our knowledge limited. The closest paper to this one is by Havemann et al. (2022) which examines the effects of the SARB's programme on yields, liquidity, and market confidence. Their paper examines the heterogeneity of response to the bond purchase programme on yields of varying maturities which further motivates our analysis to specifically trace the change to the shape of the yield curve attributed to the programme under an alternative methodological framework. Our paper also extends Havemann et al. by contextualising our results in the different channels through which such programmes ease market conditions and examining the spillover effects of this programme onto South Africa's corporate bond market, an area not previously investigated.

Where there does exist an established body of research is in the spillover effects of central bank balance sheet expansions in advanced economies on other domestic markets and on international markets. These are discussed in further detail below.

3.1. The effects of unconventional monetary policy in advanced economies

The introduction of the Fed's QE programme in response to the Global Financial Crisis has been widely studied and as such has motivated much of the economic theory on the transmission channels of unconventional and novel central bank market-easing strategies. This serves as a useful framework to guide the interpretation of the observed market response that underpins the effects of these programmes on market activity. Krishnamurthy and Vissing-Jorgensen (2011) for example, find that the *signalling channel*, where such programme announcements can demonstrate and clarify central bank objectives to market participants to coordinate expectations, had a sizeable effect on yields as investors viewed US QE as a signal of lower rates in the future. By ensuring an ongoing source of demand for long-term assets, this *liquidity channel* implies that investors can take out larger positions or trade more knowing they

[10] It is also worth noting that no effect is seen in South African sovereign bond yields following this announcement.

have a buyer in the central bank, thereby lowering liquidity risk and thus yields (Gagnon et al., 2010).

The existing literature on the effects of asset purchase programmes has also identified spillover effects onto other asset classes, such as corporate bonds (Guidolin et al., 2014). This can arise via a *signalling channel* by affecting the expected future path of interest rates, influencing duration risk premia and therefore corporate bond spreads. Additionally, there is evidence of unconventional monetary policy lowering yield in markets outside those targeted by the programme via a *portfolio rebalancing channel*, in which low yields in markets targeted by the programme drive investors to ‘reach for yields’ in other assets, often resulting in more exuberant investor behaviour (Bhar et al., 2015). As QE programmes have been designed with the objective of stimulating the economy, they may serve to lower default risk premia for corporates (Krishnamurthy and Vissing-Jorgensen, 2011).

3.2. Spillovers from advanced economies onto emerging markets

There is consensus that both conventional and unconventional monetary policy strategies undertaken by advanced economies have material effects that spill over into emerging economies through lower bond yields and increased stock market activity (Takáts and Vela, 2014; Bowman et al., 2015; Beirne et al., 2020). Additionally, Bhattarai et al. (2021) find that US QE has larger effects on the economic conditions of the ‘Fragile Five’, which includes South Africa, compared to other emerging economies. To account for this, we explicitly control for the stance of US monetary policy and macroeconomic conditions in our analysis.

We make three principal contributions to the literature. Firstly, by considering the effects of the SARB’s bond purchase programme on the sovereign bond market, we examine how investor response compares to past experiences in advanced economies given the different objectives, programme size, and market characteristics. This is a novel addition to the literature as it considers how such programmes as implemented in an emerging market context like South Africa affect market conditions, and whether there are challenges posed by emerging economy financial markets that affect the transmission of such bond purchase programmes. By virtue of using data on bond purchase activity undertaken by the SARB, there is an enhanced ability to identify and isolate the effects of this programme on yields which even amongst the existing literature for advanced economies is difficult to find. Additionally, by examining the spillover effects of the SARB’s bond purchase programme on corporate bonds, we attempt to enhance the understanding of the inter-relationships between the sovereign and corporate bond markets and the extent to which the SARB can achieve broader market stability by solely intervening in the former.

4. Data and methodology

4.1. SARB programme effects on the sovereign bond yield curve

Our methodology to estimate the changes to the term structure of the sovereign bond yield curve relies firstly on using a three-factor yield curve model to summarise the dynamics of the yield curve. We use the methodology proposed by Diebold and Li (2006) (DL), which extends the influential Nelson-Siegel model of yield curves to capture the dynamic nature of its shape. Nelson-Siegel classes of models are preferred methods of analysing yield curve due to the ease of economic interpretation, estimation and parsimony (Krippner, 2010). DL and Diebold et al. (2006) (DRA) methodologies are thus widely used by central banks and monetary policymakers to guide analysis and decision-making (European Central Bank, 2007). The DL dynamic model is given by:

$$y_t(\tau) = L_t + S_t\left(\frac{1 - \mathrm{e}^{-\lambda_t\tau}}{\lambda_t\tau}\right) + C_t\left(\frac{1 - \mathrm{e}^{-\lambda_t\tau}}{\lambda_t\tau} - \mathrm{e}^{-\lambda_t\tau}\right)$$

where $y_t(\tau)$ denotes the yield on day t at maturity τ, L_t is the level of the yield curve, S_t is the slope, C_t is the curvature, and λ_t is a decay parameter determined *a priori* to maximise the medium-term factor loading.[11] Zero-coupon sovereign bond data from 30 January 1995 to 25 February 2021 has been used to construct the latent factors.

Characterising the yield curve into level, slope, and curvature is advantageous as it allows these factor estimates to be mapped to empirical properties of the yield curve found in the literature. For example, large changes in household consumption preferences are linked to changes in the level of the yield curve (Evans and Marshall, 2007), while changes in central bank conventional monetary policy strategies are associated with changes to the slope (Wu, 2001). To construct estimates for level, slope, and curvature, daily zero-coupon bond yields from 30 January 1995 to 25 February 2021 have been used for 3- and 6-month maturities, and those that span 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15 and 30 years.

One key limitation of following the methodology proposed by DL is that their estimate of the value λ_t that maximises the factor loading on C_t is chosen *a priori* at 30 months. While doing so increases the simplicity of estimation, a question could be raised as to whether the factor estimates are sensitive to the chosen value of λ_t. Therefore, as a robustness check, we have constructed estimates of level, slope, and curvature following Diebold et al. (2006) which extends the DL model to have a state-space representation and for the parameter value of λ_t, while still being fixed, to be estimated directly.

The measurement equation in the DRA model to relate the yields at each of the N maturities

[11] The factor loadings indicate the relationship between factors and the term structure of the yield curve. The factor loading on L_t is 1, which allows it to be interpreted as the long-term factor as it does not decay to zero in the limit. The factor loading on S_t starts at 1 but quickly and monotonically decreases to zero, indicating that it primarily governs short-term yield dynamics. The C_t loading starts at 0 (so not short-term), increases, and decays to zero in the limit (and so not long-term) – this leads to it being viewed as a medium-term factor.

to the three latent factors is derived using the DL estimation:

$$\begin{bmatrix} y_t(\tau_1) \\ y_t(\tau_2) \\ \vdots \\ y_t(\tau_N) \end{bmatrix} = \begin{bmatrix} 1 & \frac{1-e^{-\lambda_t\tau_1}}{\lambda_t\tau_1} & \frac{1-e^{-\lambda_t\tau_1}}{\lambda_t\tau_1} - e^{-\lambda_t\tau_1} \\ 1 & \frac{1-e^{-\lambda_t\tau_2}}{\lambda_t\tau_2} & \frac{1-e^{-\lambda_t\tau_2}}{\lambda_t\tau_2} - e^{-\lambda_t\tau_2} \\ \vdots & \vdots & \vdots \\ 1 & \frac{1-e^{-\lambda_t\tau_N}}{\lambda_t\tau_N} & \frac{1-e^{-\lambda_t\tau_N}}{\lambda_t\tau_N} - e^{-\lambda_t\tau_N} \end{bmatrix} \begin{bmatrix} L_t \\ S_t \\ C_t \end{bmatrix} + \begin{bmatrix} \epsilon_t(\tau_1) \\ \epsilon_t(\tau_2) \\ \vdots \\ \epsilon_t(\tau_N) \end{bmatrix} \tag{1}$$

A VAR(1) model of level, slope, and curvature is then fitted to serve as the transition equation of the dynamics for each factor:[12]

$$\begin{bmatrix} L_t - \mu_L \\ S_t - \mu_S \\ C_t - \mu_C \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} L_{t-1} - \mu_L \\ S_{t-1} - \mu_S \\ C_{t-1} - \mu_C \end{bmatrix} + \begin{bmatrix} \eta_t(L) \\ \eta_t(S) \\ \eta_t(C) \end{bmatrix} \tag{2}$$

All variances are initialised at 1.0, λ_t to 0.0609 (the chosen value per DL), and Kalman filtering is applied to estimate optimal yield predictions. The Kalman filter is initialised using the unconditional mean and covariance of the state vector. To use the Kalman filter under linear least squares, the white noise transition disturbances (η_t) and measurement equation disturbances (ϵ_t) are orthogonal to each other and to the initial state:

$$\begin{bmatrix} \eta_t \\ \epsilon_t \end{bmatrix} \sim \left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} Q & 0 \\ 0 & H \end{pmatrix} \right] \tag{3}$$

$$\mathbb{E}(f_0 \eta_t') = 0$$

$$\mathbb{E}(f_0 \epsilon_t') = 0$$

where $f_0 = [L_0 \quad S_0 \quad C_0]'$. This model assumes that the deviations of yields at different maturities from the yield curve are uncorrelated (implying that the covariance matrix H is diagonal) but allows for shocks to level, slope, and curvature to be correlated (implying that no diagonality condition is imposed on the matrix Q).

To estimate the effect of bond purchases on each factor, IRFs are plotted using a VAR(3,0) model fitted to level, slope, curvature, SARB bond purchases, and the 3-month Johannesburg Interbank Rate (JIBAR). While the inter-relationships between yield curve factors and macroeconomic variables has been previously studied using a VAR system (Diebold et al., 2006), analysing bond purchase effects on the yield curve under a latent factor model is a relatively novel approach.[13]

The chosen Cholesky ordering is Log(purchases)$_t$, JIBAR$_t$, L_t, S_t, C_t, implying that bond purchases are most exogenous within the system – this is reasonable given that the objective of the SARB's programme was not focused on yield-curve targeting, but it would be expected that

[12] We have chosen to fit a VAR(1) model for consistency with the DRA method. Doing so does not compromise the dynamic stability of the model, as the largest eigenvalue of the characteristic polynomial is 0.99.

[13] To our knowledge, the only paper to use a similar three-factor term structure model to analyse central bank balance sheet expansions is Hamilton and Wu (2012).

yield curve factors respond to increased purchases. The lag length is selected by minimising the Schwarz information criterion (SIC).

A VAR specification has been chosen to account for any contemporaneous feedback across factors that may influence the dynamic effect of purchases on the system. DL in their model however, find strong self-persistence among factors but little evidence of cross-factor dynamics (i.e., that factors exhibit low cross-correlation), which enables them to use an autoregressive (AR) specification. Therefore, we test whether a simpler model specification can be used by imposing the assumption of weak exogeneity and estimating each equation using an Autoregressive Distributed Lag (ARDL) framework to construct ARDL dynamic multipliers. The dynamic multipliers and IRFs should be largely equivalent if the regressors are weakly exogenous, the VAR residuals exhibit independence and there is no serial autocorrelation.[14]

Alongside the endogenous regressors, we also control for macroeconomic links between the US and South Africa and reverberations of uncertainty in US markets that may appear in the South African sovereign bond market described in Section 3 using the Chicago Board of Operations Exchange's Volatility Index (VIX). Despite the VIX being an equity measure, research has found that credit flows in emerging markets do co-move with the VIX (Rey, 2015); it is therefore often used as a barometer of global uncertainty in analyses of emerging markets (Sever et al., 2020). Additionally, to control for the overall stance of US monetary policy accounting for unconventional measures, the Shadow Short Rate is also included as an exogenous regressor. A full summary of the data used for this analysis is provided in Table A.1.[15]

Daily data and yield curve factors from 25 March 2020 (the commencement of the bond purchase programme) to 25 February 2021 have been used to estimate the VAR and construct IRFs. From South Africa's experience, daily data is a suitable frequency to examine the effects of the SARB's bond purchases (Havemann et al.).

4.2. Effects of SARB programme announcement on corporate bonds

To examine the announcement effect on returns in the corporate bond market, we use a regression framework akin to an event study where the FTSE/JSE All Bond Other Index (FTSE/JSE) is regressed on an indicator variable denoting the announcement of the SARB's programme along with an array of control variables designed to reflect market dynamics using a typical ARDL framework in an error-correction model (ECM), which is a linear reparameterisation of a standard levels ARDL model. This is done to capture both short- and long-run dynamics of variables in the model. As a baseline (Eq. (4)), we control for global risk sentiment (using the VIX) and inflation expectations (using the 5-year break-even inflation rate). We also include a dummy variable to capture the effect of South Africa's state of disaster announcement on

[14] See Stein and Song (2002) for further discussion.

[15] Data on the bond purchase programme was obtained under a non-disclosure agreement. As such, summary statistics on the bond purchase programme cannot be provided.

corporate bond yields.

$$
\begin{aligned}
\Delta\ FTSE/JSE_t = {} & \alpha_0 + \mu t + \alpha_1 FTSE/JSE_{t-1} + \alpha_2 VIX_{t-1} + \alpha_3 5YBEInf_{t-1} \\
& + \alpha_4\ SA\ announcement_t + \alpha_5\ State\ of\ disaster_t \\
& + \sum_{i=1}^{p} \beta_i \Delta\ FTSE/JSE_{t-i} + \sum_{i=0}^{q} \gamma_i \Delta\ VIX_{t-i} + \sum_{i=0}^{s} \eta_i \Delta\ 5YBEInf_{t-i}
\end{aligned}
\tag{4}
$$

Three extensions to this baseline are estimated: controlling for idiosyncratic volatility, changes to investor risk appetite, and time-varying volatility in the index. An estimate of idiosyncratic risk has been constructed by extracting the residuals of a regression of the South African Volatility Index (SAVIT40) and the VIX. Given that the VIX is typically viewed as a measure of 'fear' among investors and captures market-level risk, the orthogonal component to this regression should capture idiosyncratic volatility. Idiosyncratic volatility (IVOL) is included in the model as investors are found to often have under-diversified portfolios (Goetzmann and Kumar, 2008) and thus contrary to the efficient markets hypothesis may respond to fluctuations in idiosyncratic risk, which would have been particularly high upon the emergence of Covid-19 in South Africa. Therefore, it would be expected that high IVOL could affect the returns on the FTSE/JSE index.

Uncertain global economic conditions brought on by the advent of Covid-19 may have also shifted investors' risk tolerance as conditions worsened in South Africa. Therefore, while US QE programmes traditionally create stock market booms in emerging markets as investors search for higher yields (Bhattarai et al., 2021), in the weeks following the Fed's announcement foreign investors may also have chosen a 'flight-to-quality' in search of safer assets; controlling for a change in volatility risk premium (VRP) could thus be useful to better capture the changes in investor risk appetite that may have affected the corporate bond index around the time of the SARB announcement. A measure of VRP has been estimated for the S&P500 in line with the method outlined by Zhou (2018), where the difference between implied and expected volatility is viewed as an indicator of investors' risk appetite. The conditional expectation of realised volatility is estimated by:

$$RV_t = \alpha_0 + \alpha_1 IV_t + \beta_1 RV_{t-1} + \epsilon_t \tag{5}$$

VRP is then calculated as: $VRP_t = IV_t - \hat{RV}_t$ (6)

where RV_t is the annualised daily 5-minute intraday squared returns on the S&P500 index, $\hat{RV}_t$ is the fitted values from (5), and IV_t is the measure of implied volatility, which in this case is the VIX.

Finally, as shown in Figure 4, the weeks surrounding the bond purchase announcement also experienced a burst of volatility in response to the increasingly uncertain macroeconomic conditions; therefore, estimating the relationship between volatility and the index may improve the identification of the effect of the announcement as distinct from the broader increase in volatility present during the period. Ideally, with intraday data on the corporate bond index, estimates of the realised volatility in the index could be estimated – however, due to data limitations, we estimate a GARCH(1,1) model for the corporate bond index to obtain an implied volatility measure. We extract the conditional variances of the index estimated by the model and run an auxiliary GARCH model to estimate the effects of volatility on the index.

This dummy-variable approach used in each model performs comparably to standard event study methods and provides consistent estimates if it can be demonstrated that investors do not update their probability of the event based on pre-event information (Acharya, 1993). As the SARB's bond purchase programme announcement is considered to be a genuine policy surprise (Havemann et al.), it renders any market expectation of the announcement to be unlikely.

Daily frequency data is used for all variables – as markets respond almost in real time to public statements and macroeconomic fluctuations, there is the potential for the market to be responding to other announcements made on the same day *along* with those being estimated. However, as the SARB announcement was unanticipated and the programme introduced for the first time, this announcement is expected to influence most of the activity for that day. To balance a parsimonious model with one that best explains the determinants of the corporate bond index value, the lag lengths for the ARDL models are chosen using the general-to-specific method.

5. Results

5.1. SARB programme effects on the sovereign bond yield curve

Table 1 provides some descriptive statistics on the estimated factors. Proceeding with using the DL estimation method to characterise the yield curve is contingent upon this model appropriately capturing the South African yield curve dynamics. This is first ascertained by examining the estimated factors' yield curve fit, as shown in Figure 5. The first row of plots have been chosen due to their non-traditional yield curve shapes – the yield curve in December 1997 appears to be inverted, and the curve in February 2017 has certain yields between 3 months and 5 years being lower than the 3-month yield. The second row has plotted the yield curves on the day of the SARB announcement and at the end of our sample period. From Figure 5, it is clear the DL model is able to replicate different observed yield curve shapes across time and closely fits the data in each case.

Table 1: Descriptive statistics for estimated factors

	Mean	Min	Max	Std. Dev.
Level	11.145	6.691	18.797	2.871
Slope	-1.429	-11.184	8.849	3.164
Curvature	-2.856	-21.251	9.064	4.757

Additionally, Figure 6 plots the estimated factors alongside the empirical definition of each factor. DL define the empirical level to be the yield on the longest maturity in the sample (in this case 30 years), the negative of slope as the difference in the 30-year and 3-month yields,

Figure 5: Yield curve fitting using estimated factors

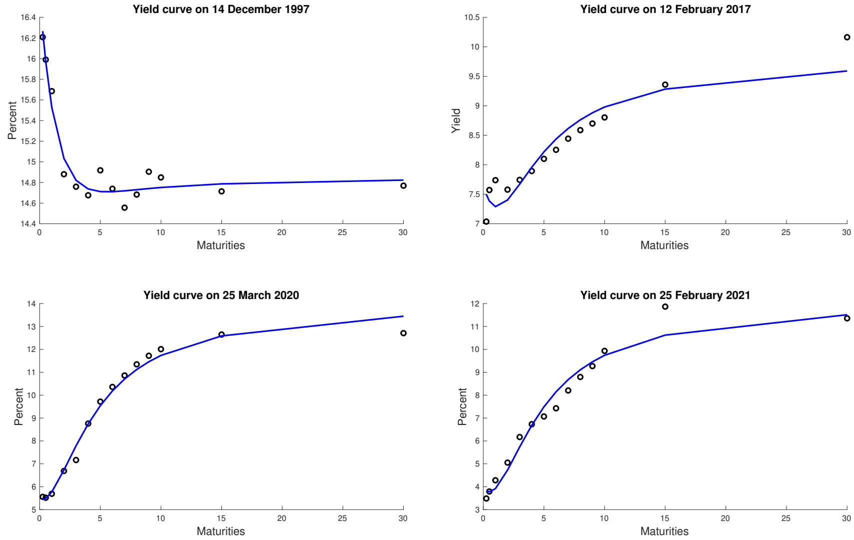
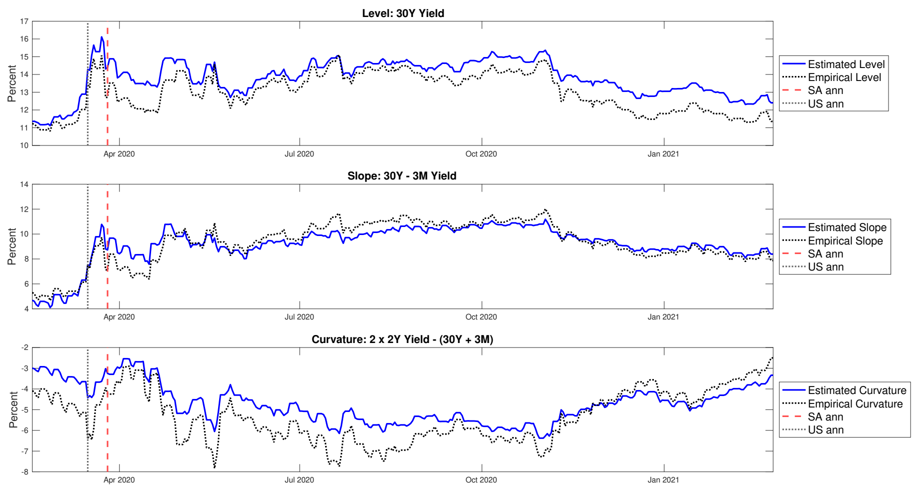


Figure 6: Empirical vs. estimated yield curve factors



and 0.3 of curvature as equivalent to twice the 2-year yield minus the sum of the 30-year and 3-month yields. The close relationship between the empirical definition of level, slope, and curvature and the fitted model using the DL approach validates this method as appropriate to capture the dynamics of the South African yield curve.

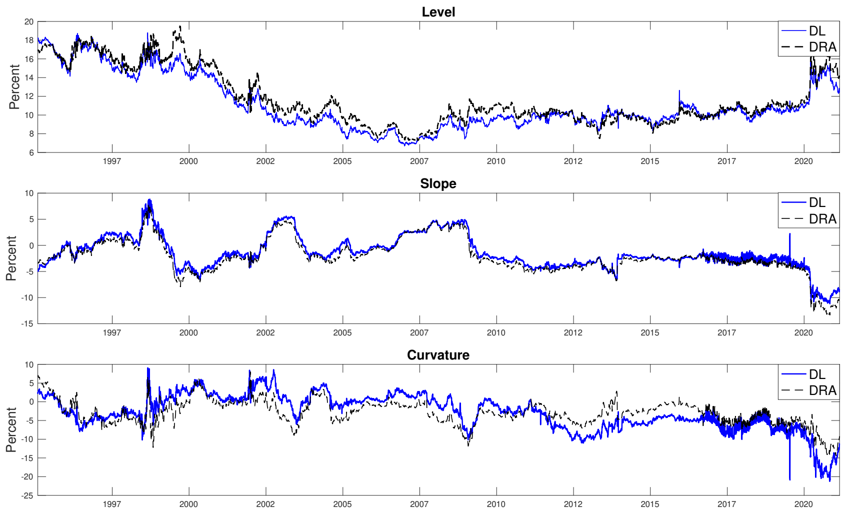
5.1.1. Robustness check: State-space representation

As shown in Table 2 and Figure 7, allowing λ_t to be freely estimated under a state-space representation does not substantially change the dynamics of each factor. In addition, Table 2 illustrates that estimates of own- and cross-factor relationships bear close resemblance between the DL and DRA models. Specifically, each factor exhibits strong self-persistence, but cross-factor dynamics are marginal across level, slope, and curvature – this motivates testing the effect on purchases under an ARDL framework in Sub-section 5.1.3, to observe whether treating factors as weakly exogenous can yield similar estimates of the relationship between bond purchases and the yield curve factors.

Table 2: Comparing DL estimates to DRA

Factor means			
	L_t	S_t	C_t
DRA	12.415	-3.303	-2.616
DL	11.145	-1.429	-2.856
Transition matrices			
	L_{t-1}	S_{t-1}	C_{t-1}
		DRA	
L_t	0.9992	0.0003	0.0008
S_t	-0.0003	0.9988	0.0028
C_t	0.0024	0.0001	0.9931
		DL	
L_t	0.9989	0.0000	0.0001
S_t	0.0003	0.9940	0.0045
C_t	0.0025	0.0085	0.9921

Figure 7: Comparing estimated factors under DL and DRA



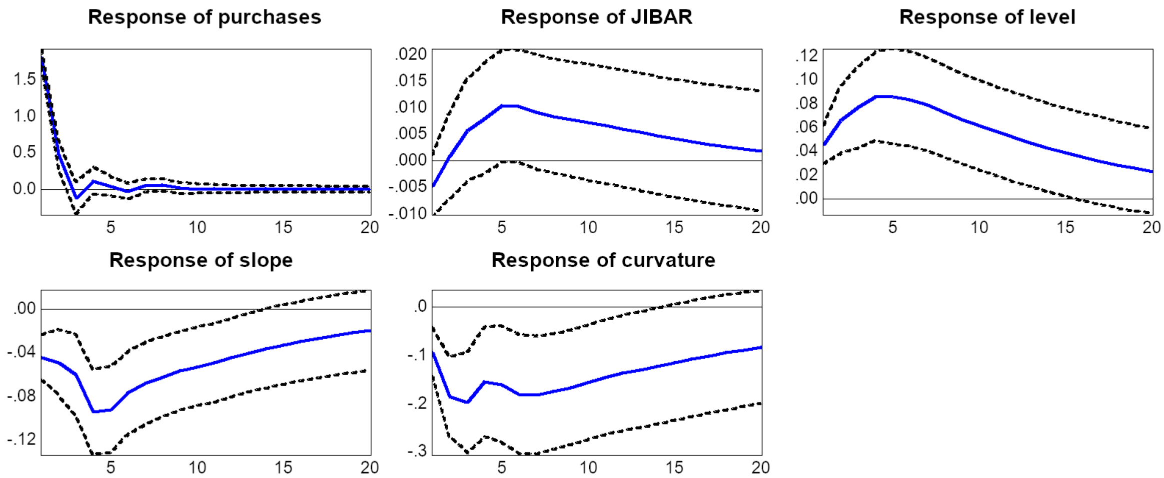
Using the DL approach to summarise the yield curve for impulse response analysis thus appears to be appropriate as this method can sufficiently capture the dynamics of the South African sovereign bond yield curve, and the specification is not compromised by λ_t being pre-specified.

5.1.2. Effect of the SARB programme on yield curve factors

Unit root testing using the Augmented Dickey Fuller (ADF) test reveals that level, slope, and curvature are $I(1)$ while the VIX, JIBAR, and Log(purchases) are $I(0)$. Interestingly, the ADF test suggests the shadow short rate to be $I(2)$. Given that $I(2)$ variables are rare and may not match intuition for the short rate, it is likely that the characteristics of the series during the sample period may be leading the tests to erroneously detect a unit root. We have estimated the VAR treating the shadow short rate as $I(1)$, which results in a dynamically stable model with the largest eigenvalue of the characteristic polynomial being 0.98, and so have proceeded by treating the shadow short rate as $I(1)$.

Figure 8 plots the IRFs following a shock to bond purchases. Both slope and curvature decline by around 4 bps and 10 bps on impact respectively and the effects persist for more than two weeks. This is a significant finding given the size of the overall programme when compared with other emerging markets is relatively small (see Section 2), that SARB purchases can meaningfully and persistently affect the portions of the sovereign yield curve captured by slope and curvature.

Figure 8: Shock to Log(purchases) ± 2 S.E. Analytical Confidence Interval (CI)



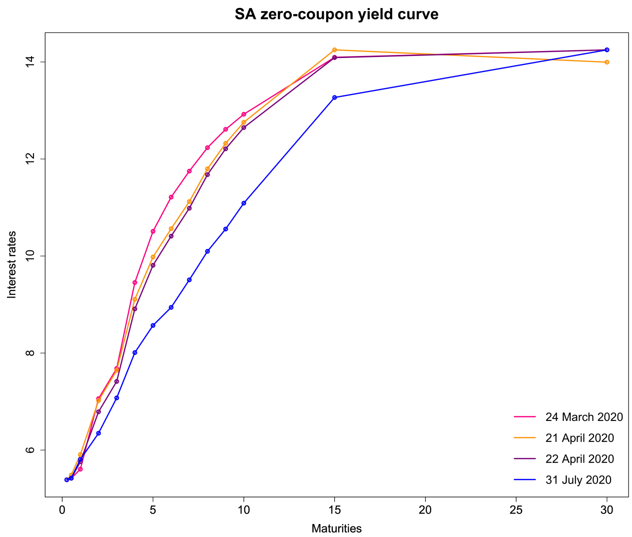
Note: Cholesky ordering: Log(purchases)$_t$, JIBAR$_t$, L_t, S_t, C_t. The effect of each factor to a shock to Log(purchases) and JIBAR in particular is not sensitive to the ordering of the variables. IRFs for the entire system are provided in Figure A.1 located in the Appendix.

What is interesting is that bond purchases appear to increase the level factor. To verify the reliability of the impulse responses, Figure 9 plots the yield curves for selected dates during the sample period to confirm whether an increase in long-term yields did indeed occur. The dates chosen are the day before the SARB's programme announcement, the day prior to and the day of the South African fiscal stimulus announcement, and the end of July 2020, which per Figure 3 was the last month that the SARB was actively expanding its balance sheet. Downward pressure on level (which perhaps would ordinarily be expected from such a programme) should shift down the entire yield curve and lead to a lower yield earned on 30-year maturity bonds – however, it appears that 30-year yields seem to converge to around the same level.[16] The largest flattening of the curve occurs at the medium-term end, which is reflected in the magnitude of the reduction in curvature in the impulse responses plotted

[16] The 30-year yield the day before the fiscal stimulus announcement (21 Apr) is lower than the day before the SARB announcement (24 Mar), which again reflects yields across the curve declining up until the fiscal stimulus announcement.

in Figure 8. The heterogeneous response to bond purchases across the term structure and bonds with maturity less than 15 years exhibiting a particularly strong response ties with the findings from Havemann et al..

Figure 9: South African sovereign zero-coupon bond yields: staggered dates

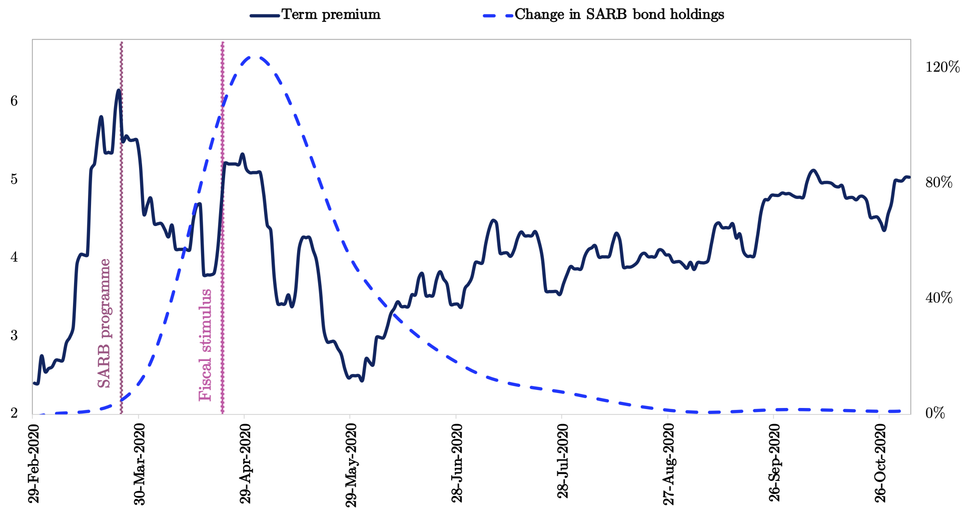


As described in Section 2, the South African government's fiscal stimulus announcement marked a change in the trajectories for sovereign bonds at 15- and 30-year tenors compared to the rest of the yield curve. The size of this stimulus and it raising the debt-to-GDP ratio by almost 20 percentage points from the previous fiscal year (South African National Treasury, 2020), makes it likely that investors adversely responded to this announcement as a signal of higher default risk in the long term. Figure 10, which plots the South African 10-year sovereign bond term premium along with the change in SARB bond holdings, reflects this; while the weeks following the SARB announcement saw a decline in the 10-year term premium as purchases start to rise, the announcement of the fiscal stimulus appears to persistently increase the term premium for several days, despite this being precisely the same period that the Bank's balance sheet expansion reached its peak.[17] While the 10-year yield does eventually decline following the fiscal stimulus announcement, the persistently high yields for 15- and 30-year maturities may have led to these term premia remaining high after the fiscal announcement, thus reflecting the ongoing uncertainty surrounding the government's capacity to meet its debt obligations in the long term. As such, the IRF for level is likely capturing this ongoing effect of the fiscal stimulus on market sentiment. [18]

[17] Term premium estimates from Soobyah and Steenkamp (2020) are only available up to a 10-year maturity. As such, the response of the 10-year term premium has been used to draw conclusions on the response of 15- and 30-year term premia to the fiscal stimulus announcement.

[18] Disentangling the bond purchase programme effect from the fiscal stimulus is challenging as it requires constructing a high-frequency measure of South African fiscal stance and associated market uncertainty. We have sought to do so in many ways, the most promising of which is including the South African 5-year Credit Default Swap spread in the VAR system as an additional endogenous variable. While this does not reverse the sign of the IRF for level, it does reduce the *persistence* of the bond purchase effects on all factors by half as many periods as compared to the IRFs in Figure 8. As such, accounting for sovereign credit risk lowers how long bond purchases can have a statistically significant effect on yield factors.

Figure 10: South African 10-year term premium: February 2020 to November 2020



Sources: 10-year sovereign bond term premium (LHS axis): estimates obtained from Soobyah and Steenkamp (2020); Change in SARB bond holdings (RHS axis): SARB Statement of Assets and Liabilities. For details on term premium estimation, please see Soobyah and Steenkamp (2020).

For US Treasuries, a one percentage point rise in the debt-to-GDP ratio 5 years ahead corresponds to around a 2 bp increase in the long term interest rate (Chadha et al., 2013); this effect is pronounced amongst emerging market economies, where a one percentage point increase in the debt-to-GDP ratio when global risk aversion is elevated corresponds to an approximate 6 bp increase in domestic bond yields (Jaramillo and Weber, 2013). The much more transitory effect of the fiscal stimulus announcement on bonds at short and medium tenors compared to longer-term bonds is therefore likely due to the announcement signifying expansionary measures that investors would benefit from in the short to medium term; however, looming debt repayments must be financed in the long term by generating sustained growth, austerity measures, or by governments inflating their way out of debt. While the former is the ideal outcome for such stimulus measures, the latter two financing methods would increase term premium risk among longer-term bonds.

There are two potential mechanisms through which this fiscal stimulus announcement and its associated default risk may have increased term premia for bonds with maturity greater than 10 years. Firstly, while the SARB may have been purchasing bonds at 15- and 30-year maturities, the increase in default risk following the fiscal announcement may have led investors to adjust their portfolios away from long-term bonds.[19] This would be evidence of the *liquidity channel* described by Gagnon et al. (2010) being weakened in the presence of sovereign debt risk, as investors in this scenario would be unwilling to hold longer-term assets despite the promise of there being a buyer in the central bank.

Alternatively, it may be that the SARB programme simply focused on bonds with a maturity of up to 10 years. Per Figure 3, while the focus of the programme seems to be in maturities

[19] Details on the maturities specifically targeted by the SARB programme is unavailable.

greater than 3 years, whether 15- and 30-year maturities were targeted is unclear. In the event that they were not in focus, this suggests that the decline in yields in the long end of the curve between the SARB's programme announcement and the fiscal stimulus announcement – in part operated via the signal of the SARB credibly intervening to ensure market stability – was sufficient to bring down long-term yields.[20] From Havemann et al., the announcement effect of the SARB's programme was larger than past QE programmes in advanced economies, which demonstrates the importance of this *signalling channel* in easing market conditions. Once the fiscal stimulus was announced, market participants withdrew from this market and there was no stabilisation via bond purchases. This may explain the persistently high yields until the latter end of 2020.

This effect of the fiscal stimulus demonstrates a clear trade-off for policymakers, that in the presence of high sovereign risk counter-cyclical fiscal policy can both compromise sovereign spreads to achieve Keynesian stimulus gains (Bianchi et al., 2019), and weaken the effectiveness of such interventions by central banks to improve market dysfunction. These findings align with the existing literature that historical coordination between fiscal and monetary policy is an important contributor to maximising the gains from each measure (Hausmann et al., 2022).[21]

While the IRFs of interest are those that correspond to a shock to bond purchases, the factor responses to macroeconomic variables presented in Figure A.1 also align with intuition. For example, a shock to slope lowers the JIBAR rate, which is tied to the repo rate. This is evidence that increases in the steepness of the slope factor is generally associated with expansionary monetary policy as a response to maintain the target short-term interest rate, that is then reflected in a lower JIBAR rate. Similarly, a shock to the JIBAR rate creates an increase in slope, thus representing higher interest rates flowing through to short-term bond yields.[22]

5.1.3. Model specification check: Dynamic multipliers

From Figures 11, 12, and 13, the close resemblance between the dynamic multipliers and IRFs suggests that treating the factors as weakly exogenous does not materially change the results obtained. Particularly for a shock to purchases, the trajectories of level, slope, and curvature are largely comparable. The magnitude of the effects however, for level and slope, are approximately 5 bps lower in each case under the dynamic multipliers. The effect on curvature is both a similar sign and magnitude to the impulse responses.

The cross-factor relationships estimated by the dynamic multipliers however, are larger than the IRFs in Figure A.1. While the IRFs estimate marginal changes to level from a shock to slope

[20] This argument is closely linked to findings from Gertler and Kiyotaki (2015), that central bank balance sheet expansions can have *ex-ante* benefits on liquidity and market dysfunction by shoring market confidence.

[21] The importance of South Africa's fiscal stance is also highlighted in Havemann et al., which points to the threat of fiscal dominance as potentially impacting the effectiveness of the SARB programme.

[22] A final noteworthy point is the statistically insignificant response of the JIBAR from a shock to bond purchases – this is likely driven by the programme targeting maturities of more than 3 years per Figure 3, and the JIBAR being anchored by the repo rate, making it unlikely that it fluctuates significantly to bond purchases.

Figure 11: Dynamic multipliers for level equation

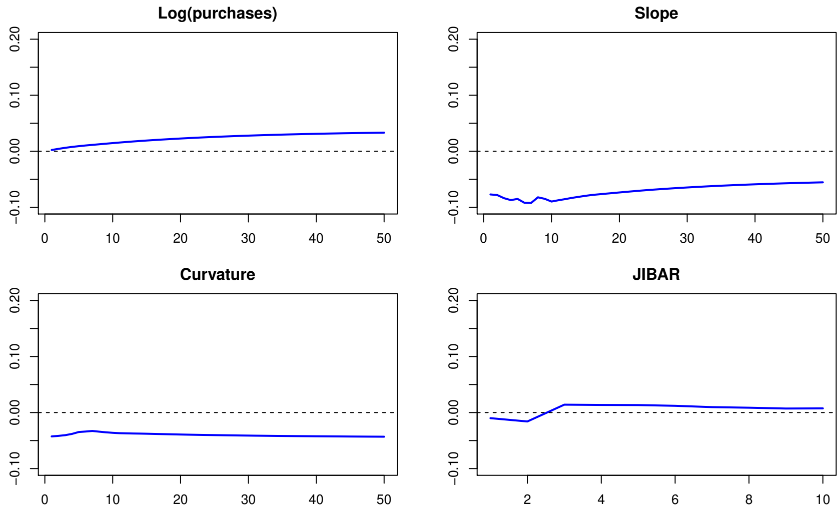
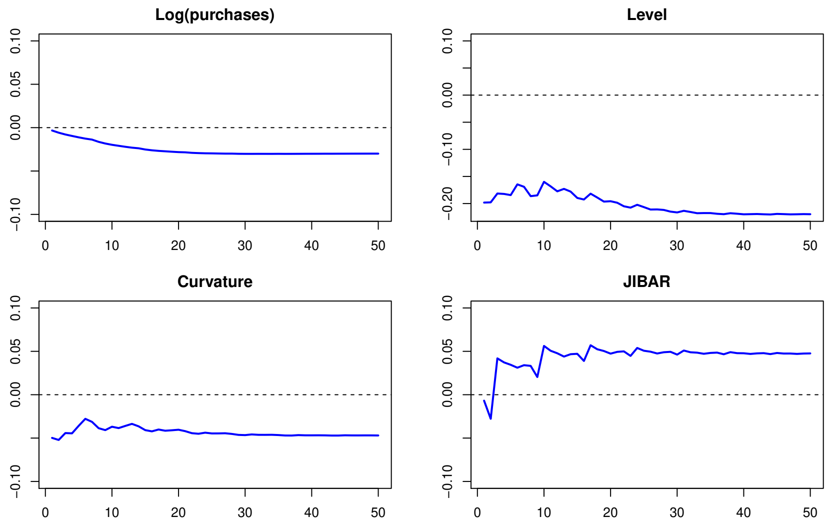


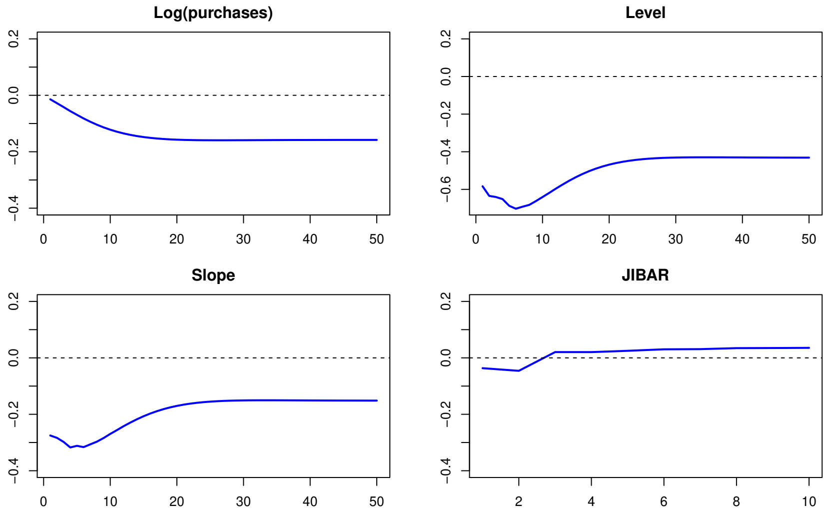
Figure 12: Dynamic multipliers for slope equation



and curvature, the dynamic multipliers estimate large contemporaneous effects that lower the level factor. For slope, despite the contemporaneous effects being similar, the magnitude of the effect is approximately 5 bps larger under the dynamic multipliers. For curvature, the trajectories following a shock to level and slope bear close similarities to the corresponding IRFs, but the magnitude of the contemporaneous effect is larger under a shock to level, and for slope does not appear to converge to zero.

The ARDL model specification used to estimate the multipliers regress the yield-curve factors, which are $I(1)$, on a combination of $I(1)$ and $I(0)$ variables: this specification is only appropriate in the presence of a long-run relationship between variables. To test for this, we conduct ARDL bounds testing as proposed by Pesaran et al. (2001), which involves reparameterising each levels equation to be in error-correction form and testing for joint significance of the lagged levels of the regressors. An F-statistic that exceeds the $I(1)$ critical value suggests the presence of a long-run relationship between variables. If below the $I(0)$ critical value, there is

Figure 13: Dynamic multipliers for curvature equation



Note: The magnitude of the shocks has been set to be of equal size as the IRFs for comparability.

no long-run levels relationship, and between the $I(0)$ and $I(1)$ critical values are inconclusive. For all three models, the null hypothesis of no relationship in levels is rejected (Table 3), which leads to the conclusion that the model specification is appropriate and there exists some long-run relationship between the factors and macroeconomic variables.

Table 3: ARDL bounds tests

	F-statistic	I(0)	I(1)
Level	7.325	2.45	3.61
Slope	5.555	2.45	3.61
Curvature	7.219	2.45	3.61

The results from both the IRFs and dynamic multipliers imply that the bond purchase programme, despite being comparatively small in size to programmes implemented by other central banks (see Section 2), materially lowered yields at short and medium tenors. However, the inability for bond purchases to taper yields in the long end of the curve highlights the challenge faced by the SARB in a fiscal environment that is characterised by high sovereign risk, and suggests that there are limits to the scope of the SARB's programme in an uncertain fiscal policy setting.

5.2. Effects of SARB programme announcement on corporate bonds

Finally, we assess how the announcement of the SARB programme affected the corporate bond market. To do so, we first examine the characteristics of our variables, which reveal that other than the 5Y BE Inflation, which is $I(1)$, the VIX, IVOL, and VRP are all $I(0)$ per the ADF tests. An interesting result is that the corporate bond index is considered $I(0)$ – as a cross-check, we also perform the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test which tests the null hypothesis of trend stationarity on the index. The test statistic obtained is 0.475 which is beyond the critical values for all conventional statistical significance levels. Given the superior statistical power of the KPSS test, we have estimated the models treating the index as $I(1)$.

5.2.1. Regression results

The baseline ECM results are displayed in Table 4. The SARB's bond purchase announcement coefficient is strongly statistically significant and negative, in line with the visual inspection of the SARB announcement on the index from Figure 4. This therefore serves as strong evidence of a spillover from the SARB's programme announcement to the corporate bond market.[23]

Table 4: Baseline ECM

Variable	Coef.	Std. Error
SA announcement$_t$	-0.185***	0.037
State of disaster$_t$	0.254***	0.025
VIX$_{t-1}$	0.000**	0.000
5Y BE Inf$_{t-1}$	0.007***	0.002
FTSE/JSE$_{t-1}$	-0.012***	0.003
Δ VIX$_t$	0.005***	0.001
Δ VIX$_{t-1}$	0.002**	0.001
Δ VIX$_{t-2}$	0.002***	0.001
Δ VIX$_{t-3}$	-0.001**	0.001
Δ VIX$_{t-4}$	0.003***	0.001
Δ 5Y BE Inf$_t$	0.623***	0.014
Δ 5Y BE Inf$_{t-2}$	0.027**	0.014
Δ FTSE/JSE$_{t-1}$	0.057***	0.014
Δ FTSE/JSE$_{t-4}$	-0.089***	0.013
t	0.000***	0.000
Constant	0.041***	0.014
R-squared		0.457
Adjusted R-squared		0.455
SIC		-3.109
F_{PSS}		6.942

Note: *p < 0.1; **p < 0.05; ***p < 0.01. F_{PSS} is the F-statistic corresponding to ARDL bounds testing by Pesaran et al. (2001). $I(0)$ critical value: 4.87; $I(1)$ critical value: 5.85.

There are several potential channels through which the SARB's programme announcement may have generated a spillover to corporate bonds. Firstly, the SARB's announcement may have had the dual effect of signalling lower reference rates in the future, and representing the SARB's commitment to supporting markets in times of heightened instability. Combined, these effects may have shored up market confidence in the corporate bond market and potentially lowered investors' perception of corporate default risk by committing to lower reference rates, as argued by Krishnamurthy and Vissing-Jorgensen (2011) for the US. Secondly, the SARB's intervention may also have led investors to begin searching for yield via the *portfolio rebal-*

[23] Including an indicator variable corresponding to the Fed's intervention in the US corporate bond market on March 23 does not affect the magnitude, sign, or statistical significance of the SARB announcement variable.

ancing channel from depressed yields in the sovereign bond market. However, this period was characterised by widespread uncertainty — investors in advanced economies exhibited a 'flight to quality' and subsequently a 'dash for cash' in response to higher market illiquidity and a rapidly deteriorating in the market outlook (Financial Stability Board, 2020). Therefore, this is unlikely to be the primary channel through which the SARB programme affected the corporate bond market.[24]

The coefficients of control variables in the regression also align with intuition. For example, the coefficients on the VIX being largely positive reflects a higher required yield as global uncertainty increases. Similarly, higher inflationary expectations – as represented by the five-year break-even inflation rate – corresponds to higher corporate bond yields. Interestingly, the effect of the state of disaster announcement is statistically significantly positive and the magnitude of the impact on the index is larger than the SARB announcement. This is potentially indicative that the market outlook for South African corporate bonds had severely deteriorated, and was only partially reversed by the SARB's purchase announcement (Figure 4). Table 5 summarises the results from the auxiliary GARCH model and additional controls for IVOL and VRP.[25] In all three cases, the magnitude and statistical significance of the SARB announcement variable are largely unchanged.

6. Conclusion

This paper addresses two key questions: how the SARB's bond purchase programme altered the term structure of the sovereign bond yield curve, and whether the SARB programme announcement had material effects on South African corporate bond yields. We find that purchases depress slope and curvature by 4 bps and 10 bps respectively, but appear to increase long-term yields due to sizable counter-cyclical fiscal policy measures announced and the resulting increase in sovereign risk. This demonstrates the additional complexities in implementing such bond purchase programmes in the presence of an uncertain fiscal policy environment. The SARB's bond purchase programme also had a statistically significant effect on lowering corporate bond yields, which is indicative of a meaningful spillover from SARB's announcement by easing stress in this market.

Future research would benefit from considering how to reliably measure default risk and investor uncertainty to parse out the SARB programme effects from the fiscal stimulus. Additionally, examining how the timing and size of the programme could be optimised to maximise the effects of the SARB's bond purchases, and further exploring the extent to which this programme met its desired objectives of financial stability, would also be useful to guide future decision-making.

[24] It is also possible that the decline in the index yield simply reflected lower reference rates. Had the deteriorated economic outlook from the Covid-19 pandemic raised default risk on corporate bonds, one might have expected spreads to rise if the SARB announcement had no effect on the corporate bond market. We observe a slight narrowing in spreads between the SARB announcement until the end of our sample period.

[25] As VRP is a function of the VIX, the VIX has been omitted as a regressor.

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Table 5: ARDL results: Auxiliary GARCH, Controlling for IVOL, and Controlling for VRP

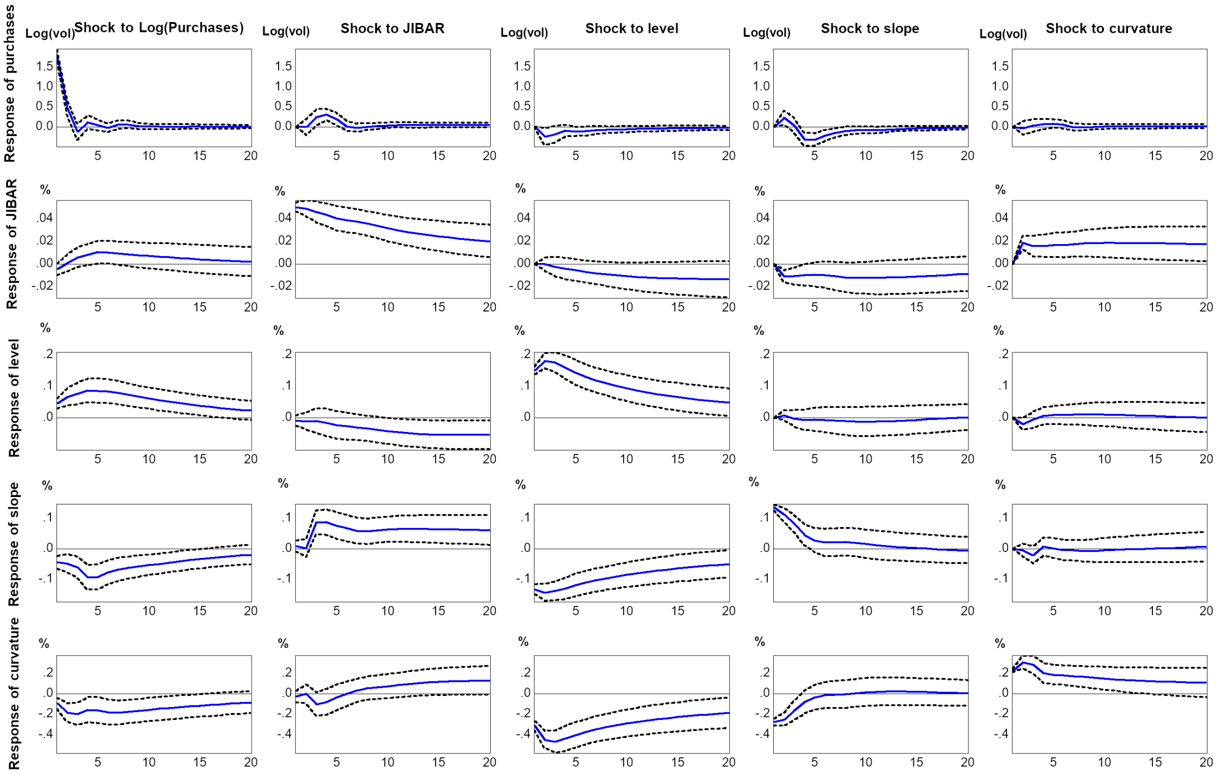
Auxiliary GARCH			Control for IVOL			Control for VRP		
Variable	Coef.	Std. Error	Variable	Coef.	Std. Error	Variable	Coef.	Std. Error
SA announcement$_t$	-0.170***	0.038	SA announcement$_t$	-0.163***	0.037	SA announcement$_t$	-0.174***	0.038
State of disaster$_t$	0.263***	0.025	State of disaster$_t$	0.275***	0.025	State of disaster$_t$	0.283***	0.025
VIX$_{t-1}$	0.001***	0.000	VIX$_{t-1}$	0.000	0.000	VRP$_{t-1}$	-0.001*	0.000
5Y BE Inf$_{t-1}$	0.006***	0.002	5Y BE Inf$_{t-1}$	0.006***	0.002	5Y BE Inf$_{t-1}$	0.005***	0.001
FTSE/JSE$_{t-1}$	-0.006***	0.002	FTSE/JSE$_{t-1}$	-0.013***	0.003	FTSE/JSE$_{t-1}$	-0.011***	0.002
Δ VIX	0.005***	0.001	IVOL$_{t-1}$	0.001**	0.000	IVOL$_{t-1}$	0.000	0.000
Δ VIX$_{t-1}$	0.002***	0.001	Δ VIX$_{t-1}$	0.002***	0.001	Δ VRP$_{t-3}$	-0.002***	0.000
Δ VIX$_{t-2}$	0.001**	0.001	Δ VIX$_{t-2}$	0.003***	0.001	Δ 5Y BE Inf$_t$	0.637***	0.014
Δ VIX$_{t-3}$	-0.002**	0.001	Δ VIX$_{t-4}$	0.003***	0.001	Δ 5Y BE Inf$_{t-2}$	0.028**	0.014
Δ VIX$_{t-4}$	0.003***	0.001	Δ 5Y BE Inf$_t$	0.639***	0.014	Δ FTSE/JSE$_{t-1}$	0.065***	0.014
Δ 5Y BE Inf$_t$	0.628***	0.014	Δ FTSE/JSE$_{t-1}$	0.057***	0.014	Δ FTSE/JSE$_{t-4}$	-0.089***	0.014
Δ 5Y BE Inf$_{t-2}$	0.029**	0.014	Δ FTSE/JSE$_{t-4}$	-0.091***	0.014	Δ IVOL$_{t-3}$	0.003**	0.001
Δ FTSE/JSE$_{t-1}$	0.058***	0.014	Δ IVOL$_{t-2}$	0.003**	0.002	t	0.000***	0.000
Δ FTSE/JSE$_{t-4}$	-0.088***	0.013	Δ IVOL$_{t-3}$	0.003***	0.001	Constant	0.056***	0.016
t	0.000***	0.000	t	0.000***	0.000			
h_t	-0.517***	0.157	Constant	0.059***	0.016			
R-squared		0.458	R-squared		0.447	R-squared		0.444
Adjusted R-squared		0.455	Adjusted R-squared		0.444	Adjusted R-squared		0.442
SIC		-3.110	SIC		-3.090	SIC		-3.091
F_{PSS}		5.554	F_{PSS}		6.143	F_{PSS}		6.248

Note: *p $<$ 0.1; **p $<$ 0.05; ***p $<$ 0.01. h_t denotes the auxiliary GARCH term. t denotes a deterministic trend. F_{PSS} is the F-statistic corresponding to ARDL bounds testing by Pesaran et al. (2001). The $I(0)$ critical value is 4.01 and the $I(1)$ critical value is 5.07.

Appendices

A Cholesky IRFs

Figure A.1: Cholesky IRFs ± 2 S.E. Analytical CI



Note: Cholesky ordering: Log(purchases)$_t$, JIBAR$_t$, L_t, S_t, C_t. The effect of each factor to a shock to Log(purchases) and JIBAR in particular is not sensitive to the ordering of the variables.

Table A.1: Summary of data

Data	Time period	Source
Sovereign bond market		
Zero-coupon bond yields	30/01/1995 to 25/02/2021	Bloomberg
CBOE VIX Index	25/03/2020 to 25/02/2021	St. Louis Fed
JIBAR	25/03/2020 to 25/02/2021	Bloomberg
US Shadow Short Rate	25/03/2020 to 25/02/2021	Leo Krippner estimations
SARB Bond Purchases	25/03/2020 to 25/02/2021	SARB
South Africa 5Y CDS Spread	25/03/2020 to 25/02/2021	Bloomberg
Corporate bond market		
FTSE/JSE All Bond Other Index	07/05/2012 to 25/02/2021	Bloomberg
CBOE VIX Index	07/05/2012 to 25/02/2021	St. Louis Fed
SAVIT40 Index	07/05/2012 to 25/02/2021	Datastream
5-year Break-even Inflation Rate	07/05/2012 to 25/02/2021	Bloomberg
S&P500 Realised Volatility	07/05/2012 to 25/02/2021	Oxford Man Institute