SOUTH AFRICAN RESERVE BANK

Prudential Authority

Position Paper on the Prudential Authority Government Bond Curve Review

Table of Contents

Executive summary

The Insurance Act 18 of 2017 (Insurance Act) mandates the Prudential Authority (PA) to publish a government bond curve, as prescribed in Prudential Standard (FSI[1]) 2.2, which insurers must use as the risk-free interest rate term structure to discount cash flows for the purpose of valuing technical provisions.

In this position paper, the current methodology and constituent data set, which underlie the published PA government bond curve, are presented, along with the results of a review of both the methodology and the constituent data set.

The first part of the review presents the constituent data set management framework and further enhancements to this framework to arrive at an optimal constituent data set based on guiding principles.

The second part presents alternative curve construction methodologies and their relative merits in comparison to the methodology used by the PA (Linear interpolation and extrapolation). In particular, the Cubic spline, Monotone convex, Nelson-Siegel, Nelson-Siegel Svensson and Smith-Wilson methodologies are presented.

The recommendations include the continued use of the constituent data set management framework as well as a revision to the nominal ultimate forward rate (UFR). In addition to this, it is recommended that the current curve construction methodology be retained given its relative merit of simplicity.

[1] Framework for Financial Soundness of Insurers

1. Problem statement and aim of the review

1.1 Introduction

1.1.1 This paper aims to set out the basis for, and the findings of, a review conducted about the current curve construction methodology (methodology) and constituent data set (data set) that underlie the PA government bond curve (PA curve), which is published monthly. Alternative curve construction methodologies have been researched with the aim to compare them with the current methodology and recommend changes as deemed necessary to achieve an optimal methodology and data set to adopt.

1.1.2 In terms of section 63(1)(a) of the Insurance Act, the PA may prescribe prudential standards on any matter that is required or permitted to be prescribed in terms of the Insurance Act.

1.1.3 Paragraphs 13.1 and 13.2 of Prudential Standard FSI 2.2 (Valuation of Technical Provisions) state that:

> *13.1 Unless otherwise approved by the Prudential Authority, insurers must use the government bond curve published by the Prudential Authority as the risk-free interest rate term structure to discount cash-flows for the purposes of valuing technical provisions.*
>
> *13.2. An insurer may apply to the Prudential Authority to use an alternative interest rate term structure to discount cash-flows on liabilities that are matched with swap-based assets, and where those liabilities are valued using the relevant swap curve. If the Prudential Authority grants approval to use a swap curve, the swap curve must be constructed by the insurer using observable market data and must not include any margins for credit or liquidity risk.*

1.1.4 The PA methodology was developed in accordance with the principles of the Solvency Assessment and Management (SAM) framework. The SAM principles, in turn, are aligned with the Insurance Core Principles (ICPs) published by the International Association of Insurance Supervisors (IAIS).

1.1.5 Starting in 2012 and following the first quantitative impact study (QIS1) by the then Financial Services Board (FSB), a government bond curve has been published on the first working day of each month. Since then, the then FSB, and subsequently the PA, has monitored the published government bond curve and engaged, from time to time, with various market participants who use the published curves. The main observations and industry feedback are detailed in section 1.4 below.

1.2 Problem statement

1.2.1 In line with the principles of good governance, which by implication suggests that a regular review of regulatory instruments is desirable, a review of the methodology, including the data set, was undertaken by the PA.

1.2.2 Movements in the published PA curve are monitored, from month to month, in relation to the market forces affecting the yields on the instruments in the data set. For example, some volatility was observed in the PA curve caused by market responses to both the coronavirus disease 2019 (COVID-19) pandemic and a sovereign ratings downgrade in 2020. The sensitivity of the PA curve to these changes was exacerbated by a combination of the construction methodology and data set. Annexure A shows the history of the data set used in the published government bond curve since December 2012.

1.3 Aim of the review

1.3.1 In January 2018, the SAM Steering Committee[2] published the policy steer document on the financial soundness standards, which incorporated the principles by which the various approaches available in the South African context were weighed up in deciding on an appropriate approach. These principles are quoted in section 4.1 below. The review is therefore limited to the construction methodology and data set of the government bond curve.

1.3.2 The construction methodology of the PA curve had not been previously documented, and this has been addressed as part of this review.

1.3.3 To satisfy these aims, the review has been split into two parts:

1.3.3.1 a review of the data set, which covers the inclusion criteria for instruments; and

1.3.3.2 a review of different curve construction methodologies, including interpolation, bootstrapping and extrapolation techniques, as well as choices for the UFR.

1.4 Key observations from industry feedback

1.4.1 The following observations have been made based on feedback from the industry using the PA curve:

1.4.1.1 As the current methodology was previously not documented, it presents a challenge for insurers who seek to replicate the PA curve and produce it at intervals more frequent than monthly.

[2] The SAM Structures included a number of different Working Groups, Task Groups, three Sub Committees and the Steering Committee, which were populated by industry representatives and employees of the then FSB. The Working Groups and Task Groups were mandated to make proposals in respect of SAM, which were considered by the SAM structures and eventually adopted by the SAM Steering Committee. More information is available from: https://www.fsca.co.za/Regulated%20Entities/SAM%20DOCUMENTS/FSB%20Policy%20Steer%20on%20Financial%20Soundness%20Standards.pdf

1.4.1.2 In 2020, the level of the PA curve was generally above the spot yields observed in the market, even when compared to forward rates. This observation is more pronounced during periods of market volatility where the movements in the PA curve tend to be greater in magnitude when compared to the movements in the observed spot yields at longer terms.

1.4.1.3 For example, this observation was evidenced in the months following the first quarter of 2020. This observation can, in part, be explained by the inter- and extrapolation methodologies, and an investigation of these is therefore included in the scope of the review to consider the effect of curve sensitivity to market movements.

1.4.1.4 The data set used to construct the PA curve consists of government bonds issued by the South African government. Previously, the instruments remained in the data set until they mature. This had the effect that sudden discontinuities may arise in the PA curve, at terms corresponding to the outstanding maturity of these bonds, and this may result as the trading volumes of these bonds decrease as maturity is approached, and differentials are observed in the yields of these bonds as compared to the cash instruments at the short end[3] of the PA curve.

1.5 Structure of the paper

1.5.1 The remainder of this paper is set out as follows: section 2 describes the current PA methodology, including the current data set; section 3 deals with the principles underlying an optimal data set; section 4 investigates alternative curve construction methodologies on the liquid part of the curve; section 5 discusses the extrapolated (illiquid) part of the curve; section 6 concludes the findings made; and finally section 7 lists the recommendations emanating from the review. The annexures to this paper present the results of the investigations emanating from the industry feedback to the discussion document.

2. Description of the curve construction methodology

2.1 Introduction

2.1.1 The data set of the PA curve consists of South African government bonds, inflation-linked bonds, currency deposit rates, implied forward rates and currency swaps that are used to obtain a risk-free interest rate term structure. The closing yields on the last working day of the month for instruments in the data set are obtained from Bloomberg[4].

2.1.2 In documenting the existing PA methodology, investigations and interviews with key role players, at the time when the first curve was published by the then FSB, were conducted.

[3] These refer to yields for instruments that have a term to maturity of 12 months or less.
[4] Bloomberg (www.bloomberg.com) is a software platform that provides real-time financial market data.

2.2 The data set and the previous (pre 2020) management criteria

2.2.1 The data set consists of South African government bonds with durations from 1 to 30 years, currency deposit rates, implied forward rates and currency swaps on the South African rand (ZAR) at shorter durations.

2.2.2 The government bonds included in the data set prior to 1 November 2020 were approved by the SAM Steering Committee during the development of the SAM framework. These bonds have been consistently included in the data set, with each bond being held until maturity.

2.2.3 Bonds that are constituents of the GOVI Index, which is the JSE[5] All Bond Government Index, were considered for the nominal bond curve. The GOVI Index contains all the bonds issued by the South African government, which fall into the top 10 positions (based on market capitalisation[6]) of the JSE All Bond Index (ALBI)[7].

2.2.4 Bonds that are constituents of the Inflation Linked Government Index (IGOV) were considered for the real bond curve, that is, the coupon was linked to consumer price inflation (CPI). The IGOV Index is a sub-index of the Composite Inflation Linked Index (CILI) that encompasses bonds which are issued by the South African government. The CILI Index measures the daily movement of inflation-linked bonds which are dually ranked by average liquidity and average market capitalisation.

2.2.5 This approach represented an effective framework for managing the constituents of government bond curves.

2.2.6 Given that there are no inflation-linked bonds issued by government at the one-day and three-month duration points, the ZAR real yield swap one-year rate[8] is used as a proxy at both these durations to ensure that the forward rate curve[9] is monotone-increasing.

2.2.7 Prior to November 2020, no new government bonds were added to the data set, which led to a thinning of the data points used in the mid-terms (between 10 and 30 years), as the maturing bonds exiting the data set were not replaced by new government bond issues, which increased the curve's sensitivity at these terms. The inclusion criteria of the data set were reviewed during October 2020; this framework is presented in section 3 below.

[5] This is the Johannesburg Stock Exchange.
[6] Market capitalisation is the value of the debt outstanding on the bond.
[7] The All-Bond Indices are Vanilla Indices that are comprised of 'vanilla' bonds from across the full range of maturities in the bond market. They serve as a useful measure of the daily movement in the bond market. More information is available from https://www.jse.co.za/albi.
[8] The ZAR real yield Swap 1 Year rate is described as the 'derivative used to transfer inflation risk from one party to another through exchange of cash flows. In a zero-coupon inflation swap, only one payment is done at maturity where one party pays [a] fixed rate on a notional principle amount, while [an]other party pays a floating rate linked to the inflation index' (sourced from Bloomberg).
[9] The forward rate curve is a plot of the future one-month interest rates at different terms, derived from forward rates, based on the government bonds used in the PA curve construction.

2.2.8 The change in the data set resulted in a restatement of the PA curve for the October 2020 month-end; thereafter the PA curve has been published on the revised data set. All the analyses presented in this paper are based on the PA curve as at 31 December 2020, with the historical curves presented in section 2.5.

2.2.9 Table 1 below shows the data set in terms of which the nominal PA curve is constructed (as published monthly).

Table 1: Data set – nominal PA curve

Bloomberg ticker symbol	Instrument description	Maturity date
SADR1T	South African rand overnight deposit	1 day
SADRC	South African rand 3-month deposit	3 months
SADRF	South African rand 6-month deposit	6 months
ZARI9M	South African rand 9-month forward implied yield	9 months
ZARI12M	South African rand 9-month forward implied yield	1 year
R208	Government bond	31-03-2021
R2023	Government bond	28-02-2023
R186	Government bond	21-12-2026
R2030	Government bond	31-01-2030
R213	Government bond	28-02-2031
R2032	Government bond	31-03-2032
R2035	Government bond	28-02-2035
R209	Government bond	31-03-2036
R2037	Government bond	31-01-2037
R2040	Government bond	31-01-2040
R2044	Government bond	31-01-2044
R2048	Government bond	28-02-2048

2.2.10 Table 2 shows the data set in terms of which the real PA curve is constructed (as published monthly).

Table 2: Data set – real PA curve

Bloomberg ticker symbol	Instrument description	Maturity date
SASWRY1*	ZAR real yield swap one year	1 day
SASWRY1	ZAR real yield swap one year	3 months
R212	Government CPI bond	31-01-2022
R197	Government CPI bond	07-12-2023
I2025	Government CPI bond	31-01-2025
R210	Government CPI bond	31-03-2028
R202	Government CPI bond	07-12-2033
I2038	Government CPI bond	31-01-2038
I2050	Government CPI bond	31-12-2050

* Refer to paragraph 2.2.6.

2.2.11 Hereinafter, these instruments will constitute the data set in terms of which alternative curve construction methodologies are reviewed.

2.3 Curve interpolation and bootstrapping

2.3.1 The PA curve is based on a linear interpolation method, which is considered relatively uncomplicated to obtain a risk-free interest rate term structure.

2.3.2 The interpolation method uses the Newton-Raphson[10] algorithm to bootstrap the yield curve. Bootstrapping is an iterative process used to derive a zero-coupon curve[11] from the observed market data set. Bootstrapping produces a risk-free interest rate term structure that exactly prices back all input constituents. The rounding and pricing rules used by the JSE debt market when valuing the bond constituents are applied during this process.

2.4 Curve extrapolation and the UFR

2.4.1 A linear extrapolation method is used from the last liquid point of the bonds included in the data set to the end date of the projection period. A period of 150 years was chosen to allow for life insurance liabilities of longer durations.

2.4.2 The UFR is the long-term rate to which the forward rate curve is expected to ultimately converge. After this convergence is reached, the forward curve is expected to be constant at this rate for all further periods. For the nominal PA curve, the UFR is 6.0%, which represents the upper bound of South Africa's long-term inflation target band. The UFR is reached at the 150-year point on the curve.

[10] The Newton-Raphson method uses an iterative-based approach which estimates the value of the root of a real valued function.
[11] This is a curve that shows rates of return on zero-coupon bonds at different terms to maturity.

2.4.3 The speed of convergence (i.e. the rate at which the curve converges to the UFR from the last liquid point) is gradual. For some curve construction methodologies, a 'speed of convergence' is explicitly specified.

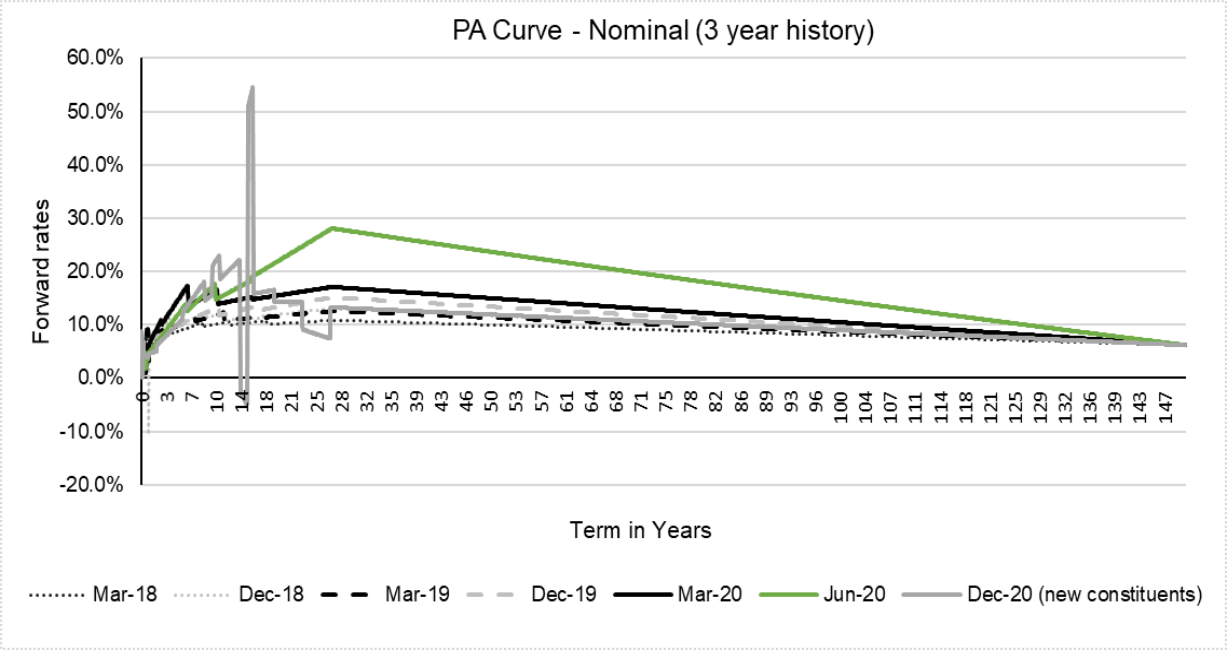
2.4.4 On the real PA curve, the UFR is 1.5%. This value is calculated by halving the difference between the upper and lower bound of the inflation target band. The convergence of the UFR is similar to that of the nominal PA curve.

2.5 Plots of historical PA curves

2.5.1 Plots of historical PA curves[12] show the general feature of the curve as well as the effect of the change in the data set during November 2020.

2.5.2 Figure 1 below shows the nominal PA curve for two quarter-ends over the last three years, including the June 2020 quarter-end.

Figure 1: PA curve – nominal (3-year history)



[12] The forward rate curve is based on the nominal annual compounded annually (NACA) rates.

2.5.3 The features of the PA curve before the last liquid point broadly mirror those of a normal yield curve (i.e. not inverted, steep or flat) in that it increases with a high gradient at first, which slows down at terms approaching the last liquid point. The curve, however, slopes downwards after the last liquid point – a result of the UFR being lower than the observable long-term yields (15-to-30-year yields). A linear extrapolation is used in the convergence to the UFR, where the forward curve reaches the UFR at 150 years. The PA curves are not smooth, as they show evidence of discontinuous movements in the liquid part[13] of the curve due to the interpolation method used in this part of the curve. The forward rates at the 14-to-16-year terms of the curve are negative. This is discussed in paragraph 2.5.5 below. The volatility in the short end of the curve is caused by the instruments used (i.e. currency deposit rates and implied forward rates), which tend to trade at different yields compared to those of nearly maturing bonds.

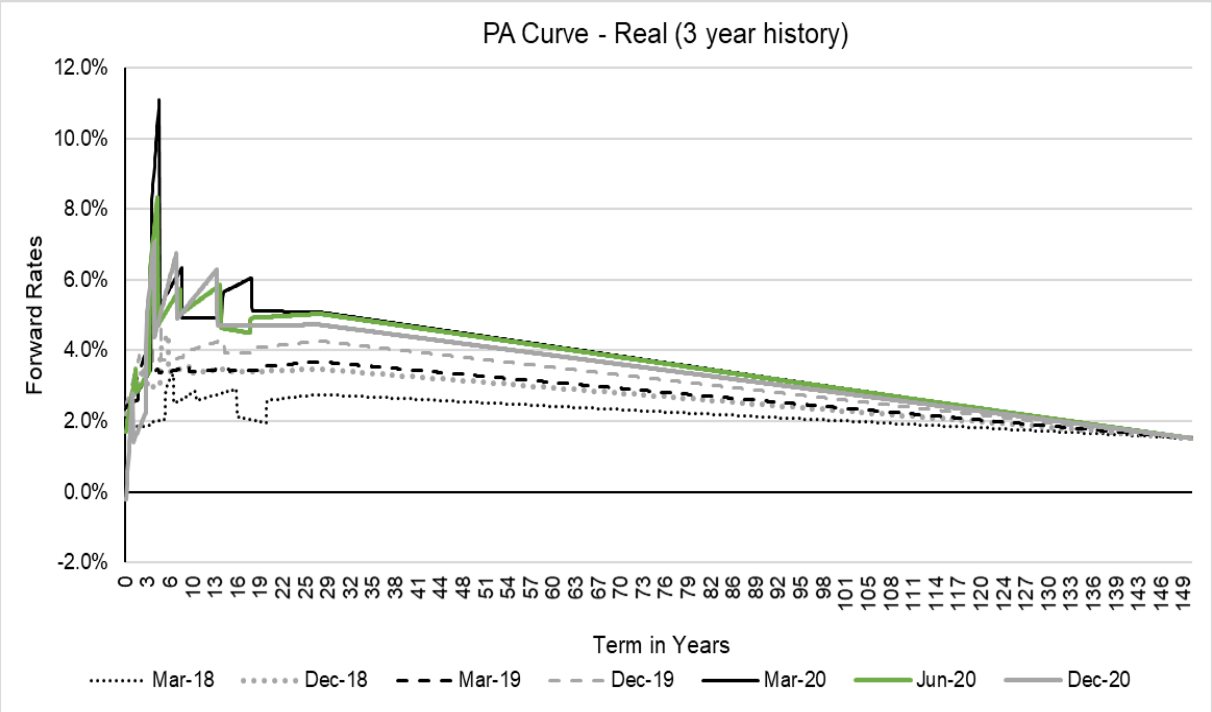
2.5.4 Another notable feature of the PA curve is that it shows a general increase in its level over time, as shown by the level of the 2019 curves (a set of thicker dashed curves) being above the level of the 2018 curves (a set of thinner dashed curves) in Figure 1 above, similarly the level of the 2020 curves (a set of solid lined curves) are above the level of the 2019 curves. An increase in the level of the PA curves over time may reflect an increase in expectations of future interest rates or inflation rates over time. The noticeable increase in the level of the 2020 curves compared to the 2019 curves appears to have been driven by the response of the current methodology and data set to the volatile market conditions in 2020. Following the revised data set implemented during November 2020, the effect on the level of the curve appears to have stabilised at longer durations. However, in the mid-terms, a noticeable shift in the level of the curve remained, which could potentially be linked to the interpolation methodology applied.

2.5.5 Furthermore, it has been observed that the December 2020 curve exhibits some volatility between the 14- and 16-year term (with the negative forward rates applicable for these durations). This is caused by the inclusion of the R209 at the 15-year term, as it has a coupon rate of 6.5% compared to the bonds on either side of the maturity date (i.e. the R2035 and R2037) both having coupon rates of 8.5%. The trading yields on the R209 thus tend to be different from the yields on the R2035 and R2037.

[13] These are terms at which there is observable market bond data.

2.5.6 Figure 2 below shows the real PA curve at two quarter-ends over the last three years, including the June 2020 quarter-end.

Figure 2: PA curve – real (3-year history)



2.5.7 The features of the real PA curve, including the lack of smoothness and the upward shifts in the level of the curve over time, mirror those of the nominal PA curve, reflecting stable expectations of future inflation.

2.5.8 The increase in the level of the curves in 2020 is also evident in the real curves. For the real curve, the data set remained unchanged following the review in October 2020.

3. Optimal data set and current management criteria

3.1 Principles

3.1.1 According to Hagan and West (2008: 71), the determination of the number of instruments to include in the data set is not an exact science:

> *Excluding too many, runs the risk of disposing of market information which is actually meaningful, on the other hand, including too many could result in a yield curve which is implausible, with a multitude of turning points, or even a bootstrap algorithm which fails to converge.*

3.1.2 Periodic reviews of the data set are necessary to ensure that the instruments used to construct the PA curve meet the principles that are deemed desirable, including an assessment of the depth, liquidity and transparency of the market for these instruments, for the construction of a government bond curve to obtain a risk-free interest term structure:[14]

3.1.2.1 *credit risk:* government bonds are considered to be free from credit risk;

3.1.2.2 *liquidity:* rates should be derived from instruments for which reliable market values are observable from a deep, liquid and transparent market; the term structure should be extrapolated from the longest maturity for which there is sufficient liquidity;

3.1.2.3 *objectivity:* bid-offer spreads are narrow; and

3.1.2.4 *the impact of the bond instruments on the shape of the PA curve should be considered:* if a government bond affects the positivity of forward rates or the continuity of the curve, then it will be considered for exclusion.

3.1.3 The risk-free interest term structure should allow investors to earn these rates in the market (realism), and the data set and methodology of the risk-free interest term structure should be robust, especially during times of market volatility (reliability).

3.1.4 Furthermore, the quarterly review of the data set of the PA curve is tracked against the PA's inclusion criteria for the nominal and real PA curve.

3.2 The inclusion criteria for the nominal and real PA curve are as follows:

3.2.1 *credit risk:* this refers to the inclusion of fixed-interest South African government bonds for the nominal PA curve and inflation-linked South African government bonds for the real PA curve;

3.2.2 *liquidity*[15]*:* the bid-offer spread and bond yield volatility measures are used with appropriate limits set;[16]

3.2.3 *depth:* the daily trading volumes and the minimum nominal issue size measures are used with appropriate limits set;

3.2.4 *transparency:* bonds should be traded on the JSE;

---

[14] Solvency Assessment and Management: FSB Policy Steer on Financial Soundness Standards. More information is available from:https://www.fsca.co.za/Regulated%20Entities/SAM%20DOCUMENTS/FSB%20Policy%20Steer%20on%20Financial%20Soundness%20Standards.pdf

[15] Government bonds tend to become illiquid when they are nearing maturity and may conflict with other short-end instruments.

[16] The limits set for the data set management framework to construct the nominal and real PA curve will be reviewed from time to time.

3.2.5 *time to maturity:* bonds with a maturity exceeding 12 months are included in the nominal PA curve and bonds with a maturity exceeding three months are included in the real PA curve; and

3.2.6 *impact on the shape of the curve:* the inclusion of a government bond and inflation-linked government bonds does not lead to negative forward rates or affect the continuity of the PA curve.

3.3 Revised 2020 and 2022 data set

3.3.1 The data set of the nominal PA curve and its management criteria were reviewed during October 2020 and subsequently in 2022 to align with the inclusion criteria as set out in paragraph 3.2 above.

3.3.2 In 2020, all the fixed-interest securities issued by the South African government were included in the data set, provided that they met the inclusion criteria for the nominal and real PA curve. The data set will be adjusted from time to time with the inclusion of newly issued instruments and the exclusion of maturing instruments.

3.3.3 The R2023 bond was removed from the data set with effect from 1 April 2022 due to breaching the criteria as the bond neared maturity.

3.3.4 Table 3 below shows the result of the review of the data set for the nominal PA curve.

Table 3: Revised data set – nominal PA curve

Bloomberg ticker symbol	Maturity	Coupon	PA curve pre-October 2020	PA curve post-October 2020	PA curve 2022
R208	31-03-2021	6.75%	✓	✓	×
R2023	28-02-2023	7.75%	✓	✓	×
R186	21-12-2026	10.50%	✓	✓	✓
R2030	31-01-2030	8.00%	×	✓	✓
R213	28-02-2031	7.00%	✓	✓	✓
R2032	31-03-2032	8.25%	×	✓	✓
R2035	28-02-2035	8.50%	×	✓	✓
R209	31-03-2036	6.50%	✓	✓	✓
R2037	31-01-2037	8.50%	×	✓	✓
R2040	31-01-2040	9.00%	×	✓	✓
R214	28-02-2041	6.50%	×	×	×
R2044	31-01-2044	8.75%	×	✓	✓
R2048	28-02-2048	8.75%	✓	✓	✓

3.3.5 Furthermore, the majority of respondents to the discussion document indicated that the PA should consider alternative constituents such as Treasury bills (T-bills) as well as alternative overnight rates on the short end of the PA curve. Annexure B provides the outcome of the investigation performed on the short end of the nominal PA curve.

3.3.6 Annexure B indicates that T-bills may be considered as a replacement of the current constituents on the short end of the PA curve. However, this would be best conducted with an update to the overnight rate. Furthermore, it was indicated in the Consultation paper on selected interest rate benchmarks in South Africa, published on the SARB website in August 2018, that the secondary market for T-bills in South Africa is illiquid. Therefore, a fair assessment of the short end of the PA curve could be performed once the South African Rand Overnight Index Average (ZARONIA) has been adopted in the market. The South African Rand overnight deposit (SADR1T) will therefore be retained in the PA curve, as will the 3-month up to 12-month constituents.

3.3.7 A similar review of the data set of the real PA curve was undertaken; the resulting changes are indicated in Table 4 below.

Table 4: Current data set – real PA curve

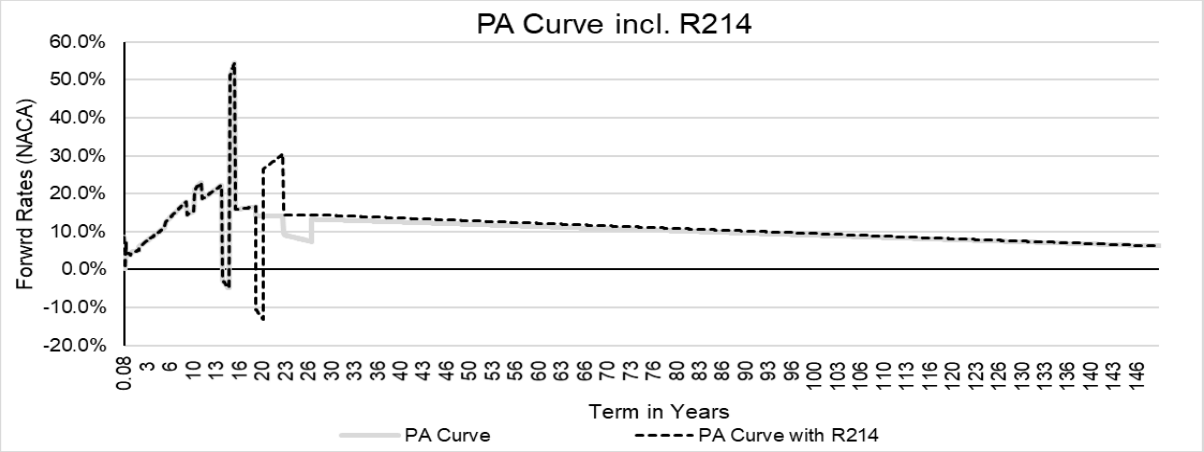
Bloomberg ticker symbol	Maturity	Coupon	PA curve October 2020	PA curve 2022
R212	31-01-2022	2.75%	×	×
R197	07-12-2023	5.50%	✓	✓
I2025	31-01-2025	2.00%	✓	✓
R210	31-03-2028	2.60%	✓	✓
I2029	31-03-2029	1.87%	×	✓
I2033	28-02-2033	1.88%	×	✓
R202	07-12-2033	3.45%	✓	✓
I2038	31-01-2038	2.25%	✓	✓
I2046	31-03-2046	2.50%	×	✓
I2050	31-12-2050	2.50%	✓	✓

3.4 Government bonds with undesirable characteristics

3.4.1 From time to time, the government bonds in issue may exhibit characteristics that are undesirable for use by the PA due to these not conforming to the principles set out in sections 3.1. and 3.2 above. The inclusion criteria of instruments in the data set must be such that any government bonds which display undesirable features, such as low liquidity, can be excluded.

3.4.2 In line with the current criteria set out above, the characteristics of the R214 (currently excluded from the data set) and the R209 (currently included in the data set) were reviewed. With the inclusion of the R214, the PA curve as at 31 December 2020 was as indicated in Figure 3 below.

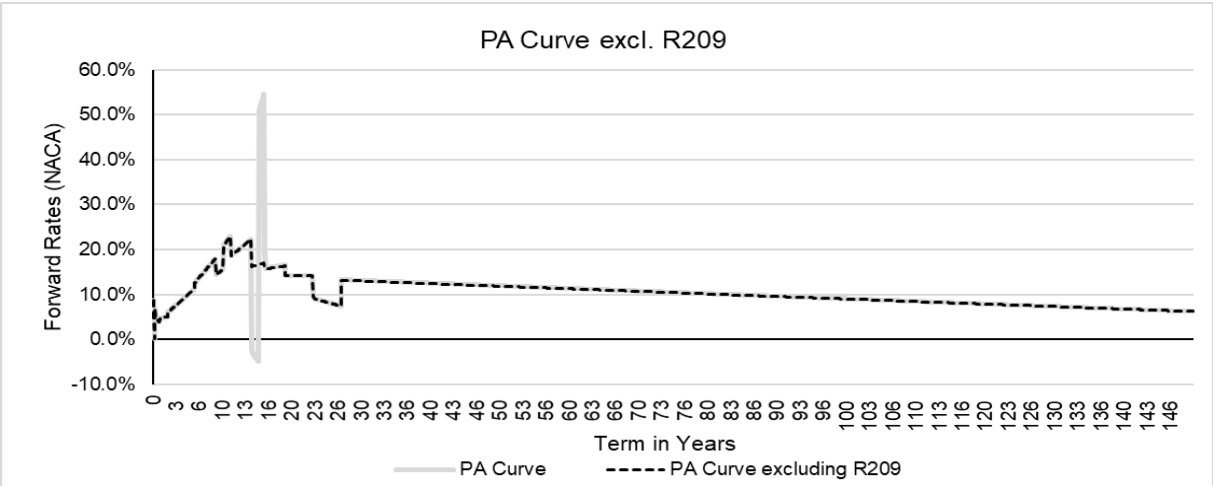
Figure 3: Nominal PA curve including R214



3.4.3 The inclusion of the R214 bond in the data set underlying the PA curve as at 31 December 2020 introduces volatility in the forward curve around the term which corresponds with the maturity of this bond. This is shown by the additional 'zig-zag' feature in the forward rate curve above, as well as by the further negative forward rates near the 21-year term. Looking at the coupon rates of this bond shown in Table 3 above, it is noted that this bond has similar features to the R209 discussed in paragraph 2.5.5. Thus, as the inclusion of the R214 would be contrary to the principles of smoothness and continuity in the forward curve, it should be excluded from the data set. The PA continues to monitor the R214 bond, and if a stable trend is observed, the bond will be considered for inclusion.

3.4.4 The exclusion of the R209 bond was considered as at 31 December 2020. With the exclusion of the R209, the PA curve is shown in Figure 4 below.

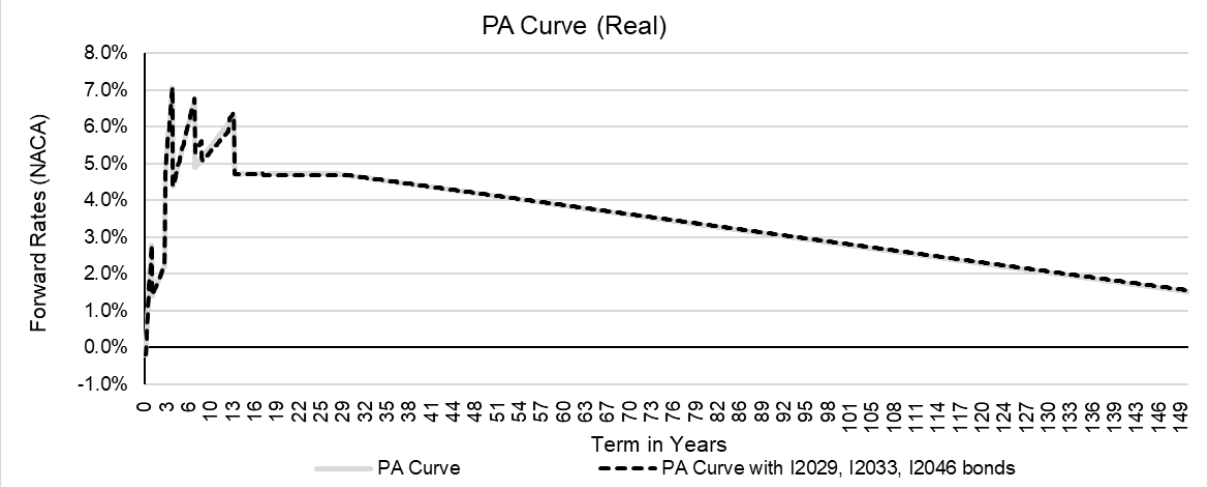
Figure 4: Nominal PA curve excluding R209



3.4.5 Figure 4 above shows that the exclusion of the R209 as at 31 December 2020 removes the 'zig-zag' feature in the current PA curve, addressing the largest discontinuity in the forward rate curve, which enhances adherence to the principles and inclusion criteria set out in paragraphs 3.1 and 3.2 above. Notably, the forward rates remain positive when the R209 bond is excluded. Although this bond presented a breach to one of the elements of the inclusion criteria (impact on the curve) as at the above date, the subsequent monitoring in the following periods indicated that the breach was not sustained. Reviews performed in 2021 and 2022 on the bond have since satisfied the inclusion criteria. It is thus deemed reasonable to retain this bond in the PA curve.

3.4.6 Similarly, the inclusion of the three previously excluded inflation-linked bonds that are in issue (i.e. the I2029, I2033 and I2046) was investigated. With the inclusion of these bonds, the real PA curve as at 31 December 2020 is shown in Figure 5 below.

Figure 5: PA curve – real



3.4.7 Figure 5 above shows that the inclusion of these bonds has a near negligible effect on the overall level and shape of the real PA curve. The inclusion of these bonds was therefore supported.

4. Alternative methodologies

4.1 Principles

4.1.1 This section presents and compares the alternative curve construction methodologies available to the PA for the liquid part of the curve. Section 4.1 considers the general principles that guide the PA's curve construction process, while sections 4.2 to 4.7 consider the different methods respectively.

4.1.2 The then FSB determined that the following principles[17] outline the desirable characteristics of a government bond curve to obtain a risk-free interest rate term structure:

4.1.2.1 *credit risk:* the curve should be credit risk-free;

4.1.2.2 *realism:* it should be possible for all insurers to earn the specified risk-free rate in a risk-free manner;

4.1.2.3 *reliability:* the data basis and methods used to determine the risk-free term structure should be robust, particularly in times of market crisis or turbulence;

4.1.2.4 *liquidity: rates should be derived from instruments for which reliable market value is observable from a deep, liquid and transparent market; the term structure should be extrapolated from the longest maturity for which there is sufficient liquidity;*

4.1.2.5 *objectivity: bid-offer spreads are very low; and*

4.1.2.6 *simplicity: the derivation of the risk-free rates term structure should be uncomplicated (simple).*

4.1.3 These principles are further articulated in Attachment 4 of Prudential Standard FSI 2.2 as a guide to insurers who construct their own curves to obtain a risk-free interest rate term structure.

4.1.4 Other general principles

Barrie and Hibbert (2008: 6) suggest the following desirable properties for constructing forward yield curves:

1. *Where a liquid market exists, the yield curve should accurately price that market.*
2. *The (forward rate) curve should be continuous.*
3. *The (forward rate) curve should be smooth. That is, its first derivative should be continuous.*
4. *On average, the variability of long-term (forward) interest rates should be lower than shorter-term (forward) rates.*

[17] Solvency Assessment and Management: FSB Policy Steer on Financial Soundness Standards. More information is available from: https://www.fsca.co.za/Regulated%20Entities/SAM%20DOCUMENTS/FSB%20Policy%20Steer%20on%20Financial%20Soundness%20Standards.pdf

4.1.5 International standards: the IAIS's ICPs

In ICP 14, which deals with valuations, the following paragraphs refer:

14.10.1 The solvency regime allows for the time value of money to be recognised in the determination of technical provisions and should establish criteria for the determination of appropriate interest rates to be used in the discounting of technical provisions (discount rates). In developing these criteria, the supervisor should consider the following:

- *the economics of the insurance obligations in its jurisdiction including their nature, structure and term; and*
- *the extent (if any) to which benefits are dependent on underlying assets.*

14.10.3 To the extent that a risk is provided for elsewhere in the balance sheet by alternative means, there should be no allowance for that risk in the chosen discount rates.

14.10.5 The criteria should also allow appropriate interpolation and extrapolation for non-observable market data and maturities. To provide for consistent, reliable, economic values, the criteria for discount rates should utilise the entire interest rate term structure.

4.1.6 When comparing the alternative curve construction methodologies, the above principles will be considered.

4.1.7 This review considers the interpolation methods set out in Hagan and West (2008). It considers an alternative to linear methods, being splines, and further builds on this to develop the Monotone convex method. Additionally, the Nelson-Siegel, Nelson-Siegel Svensson and Smith-Wilson methods are also considered as alternatives.

4.1.8 In the sections below, the curves reproduced are based on the 'post-October 2020' data set (refer to paragraphs 3.3.4 and 3.3.7 above).

4.2 Linear interpolation

4.2.1 There are various known linear interpolation methods. A straight-line linear interpolation method on the instantaneous zero rates, which requires knowledge of two points, and the constant rate of change between those two points, is used in the PA curve.

4.2.2 The drawbacks of the linear method are widely documented and include discontinuities (or jumps) in the forward rates at terms where the observable instruments have different characteristics.

4.2.3 Another drawback is the possibility of negative forward rates. This is an undesirable feature as it implies the possibility of arbitrage opportunities in the interest rate market.

4.2.4 The use of splines seeks to address the first of these drawbacks.

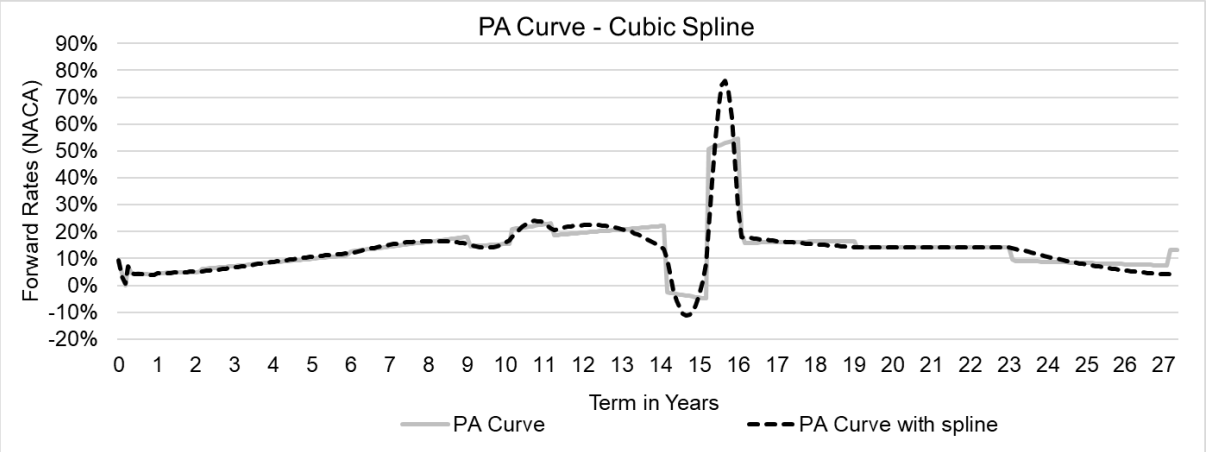
4.3 Cubic spline – the Bessel/Hermite method

4.3.1 Splines are sets of polynomials with different coefficients, which are applied in a piecewise manner at different intervals of the curve (Hagan and West, 2008: 74). The polynomials (specified by the coefficients) are arranged such that the resulting curve overlaps the input data set.

4.3.2 The Bessel/Hermite method, being the cubic spline specifically, ensures continuity by ensuring that the curve is twice differentiable. This means that the overall shape of the curve is also controlled by limiting points of inflection.

4.3.3 Figure 6 shows the nominal PA curve (forward) as at 31 December 2020 using the Bessel/Hermite cubic spline method of interpolation for the liquid part of the PA curve.

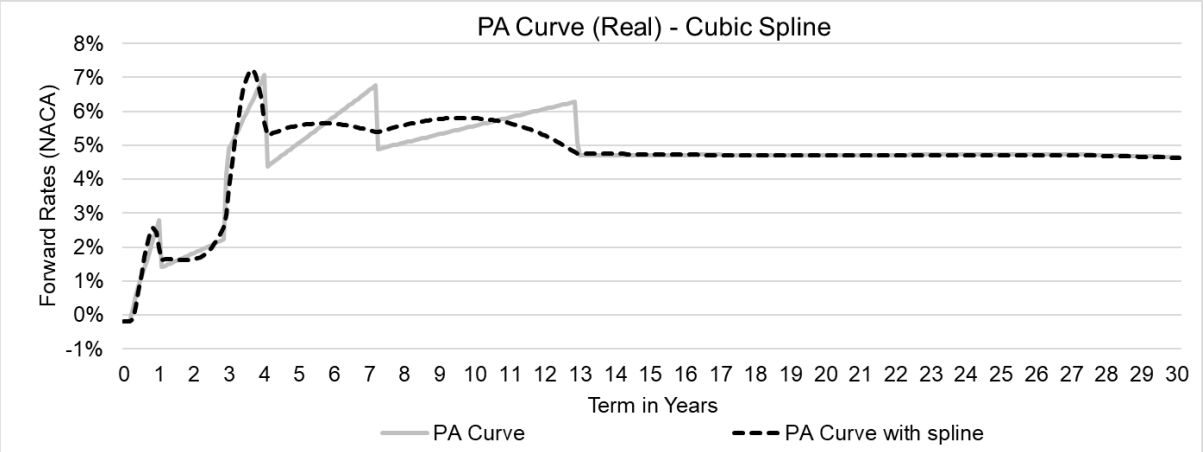
Figure 6: Nominal PA curve – cubic spline



4.3.4 The forward rate curve in Figure 6 above shows that although the overall path of the rates mirrors the linear interpolation method, the curve is smoother under the cubic spline method.

4.3.5 Figure 7 below shows the real PA curve (forward) as at 31 December 2020 using the cubic spline method of interpolation.

Figure 7: Real PA curve – cubic spline



4.3.6 The effect of the cubic spline is similar to that shown in the nominal curve since the curve is smoother at the liquid points under the cubic spline.

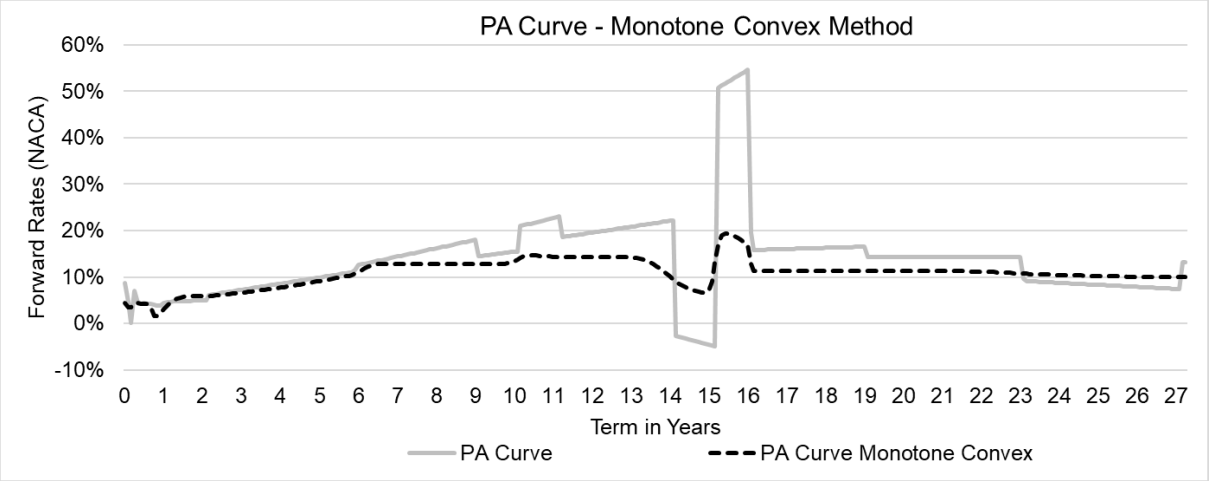
4.3.7 One notable drawback of the cubic spline is that it does not ensure strict positivity in the forward rates. The next method seeks to address this.

4.4 The Monotone convex method

4.4.1 The Monotone convex method imposes a strict positivity of the forward rates (except where there are negative yields observed in the market) while ensuring that the original rates are reproduced in the bootstrap. This ensures that the yield curve produced under this method prices back to the market.

4.4.2 Figure 8 below shows the nominal PA curve (forward) as at 31 December 2020 constructed using the Monotone convex method.

Figure 8: Nominal PA curve – Monotone convex method

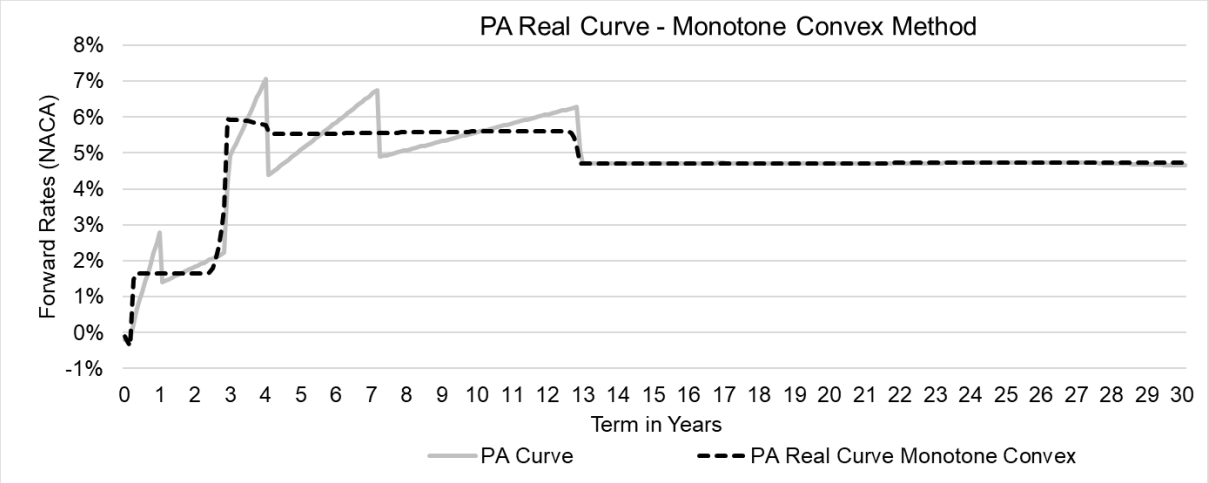


4.4.3 Figure 8 above highlights the main strength of this method, as the curve, although maintaining the overall shape of the PA's current method, is smooth and consistently above zero. This is a desirable feature in forward rates as it is consistent with the no-arbitrage feature of a liquid market.

4.4.4 The effect of this method is that the 'hump' between the 7-year and 27-year terms is also muted, similarly to the result using the cubic spline.

4.4.5 The effect of this method on the real curves is also assessed. Figure 9 below shows the real PA curve (forward) as at 31 December 2020 constructed using the Monotone convex method.

Figure 9: Real PA curve – Monotone convex method



4.4.6 Similarly to the nominal curve, the real curve produced by the Monotone convex method exhibits more continuity. It is also notable that although this method ensures positivity in the forward rates, the negative yields observed in the inputs at the short end of the curve are also retained. This exhibits the robust nature (limited sensitivity to small changes in the market) of the method under scenarios where there are negative yields in the market.

4.4.7 The Monotone convex method seems to bear the most consistency to the principles indicated in section 3.1 above compared to the cubic spline and the linear methods. However, this method contradicts the principle in paragraph 4.1.2.6 above: that the derivation of the risk-free rates term structure should be uncomplicated.

4.5 The Nelson-Siegel method

4.5.1 The Nelson-Siegel curve is one of the most popular construction methods. It falls within a group of parametric yield curve methods. As a result of its parametric form, this method (as well as the Svensson extension of the method) is generally considered to be consistent with the principles that have already been outlined and set out in Hagan-West (2008). The Nelson-Siegel method is extensively used by central banks and other market specialists to represent financial markets in the form of yield curves.

4.5.2 The Nelson-Siegel method is fitted to observations by using the specified functions defined by Nelson and Siegel. The forward and spot curves are a linear combination of three component functions with different shapes – a level (flat) curve, a sloped curve and a humped curve – to arrive at a best fit.

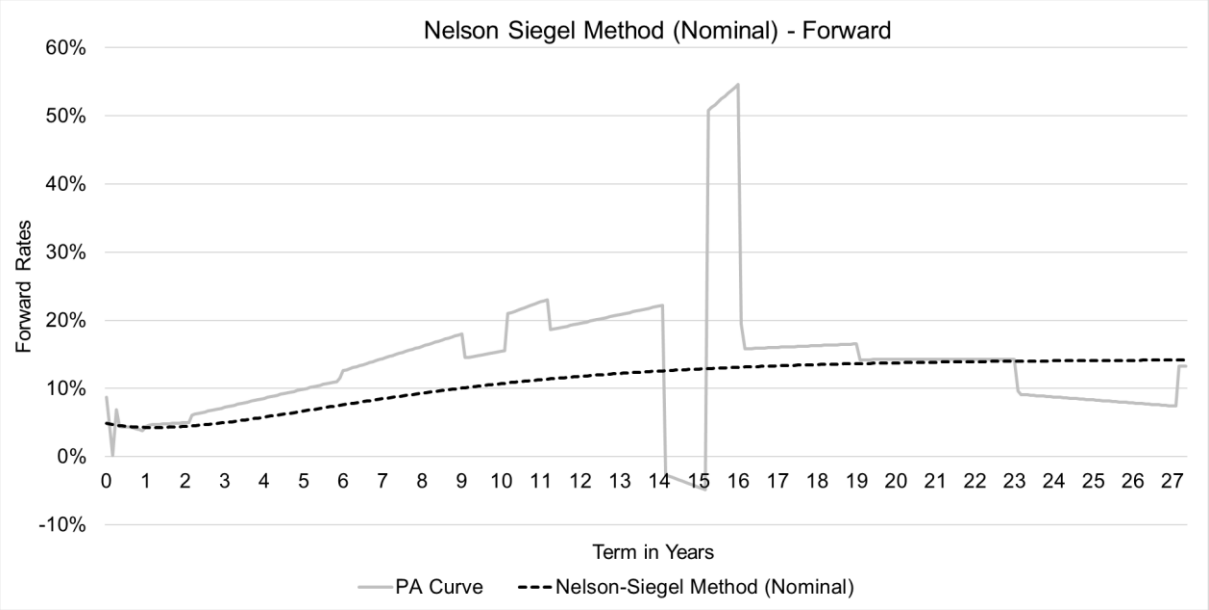
4.5.3 The parameters, as indicated in Table 5 below, were estimated by minimising the least squares error as part of the forward rate curve construction.

Table 5: Nelson-Siegel method parameters

Nelson-Siegel method		
Parameters	**Nominal curve**	**Real curve**
β_0	0.1427	0.0478
β_1	-0.0933	-0.0493
β_2	-0.1393	-0.0285
λ	3.9944	2.7625

4.5.4 Figure 10 below shows the nominal PA curve (forward) under the Nelson-Siegel method as at 31 December 2020.

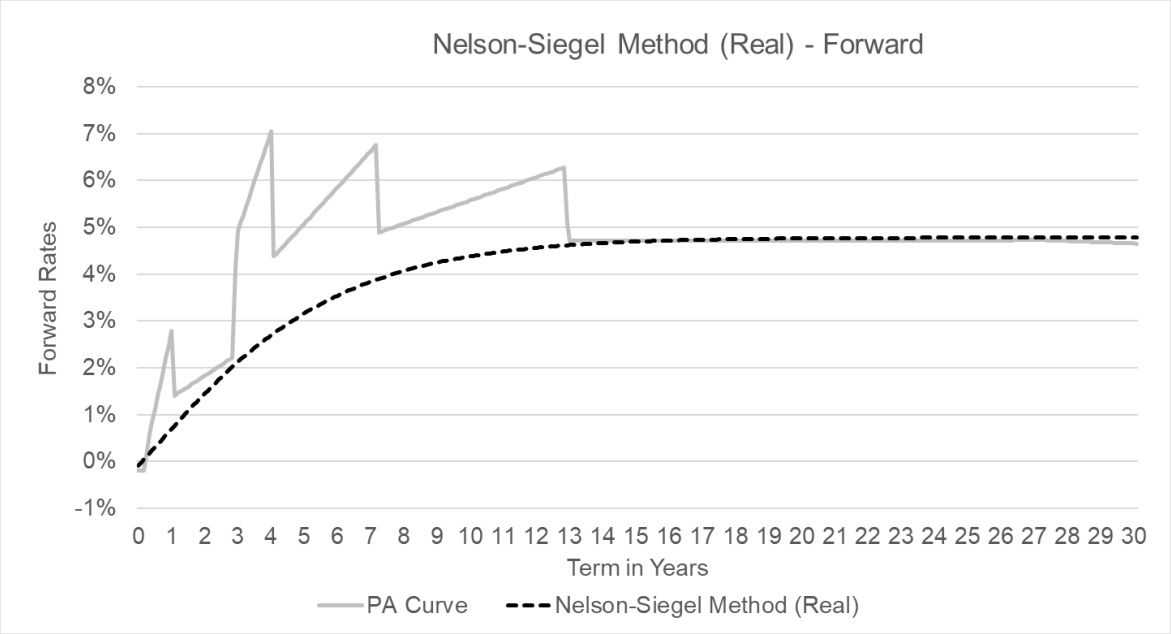
Figure 10: Nominal PA curve – Nelson-Siegel method



4.5.5 The Nelson-Siegel regression method produces a forward curve that has a more linear slope in the shorter terms and a more gradual hump shape. It is noted that the β_0 parameter was unconstrained at the upper bound in the estimation process (i.e. only strict positivity was applied).

4.5.6 Figure 11 below shows the real PA curve (forward) under the Nelson-Siegel method as at 31 December 2020.

Figure 11: Real PA curve – Nelson-Siegel method



4.5.7 Similarly, the real curve constructed under the Nelson-Siegel method is smoother compared to the PA curve in the terms before the last liquid point. As in the nominal case, the β_0 parameter was unconstrained at the upper bound in the estimation process.

4.6 The Nelson-Siegel Svensson method

4.6.1 The Nelson-Siegel Svensson method is an extension of the Nelson-Siegel method, which allows for a potential second hump in the term structure. Similarly to the Nelson-Siegel method, Nelson-Siegel Svensson is also extensively used by central banks to represent the financial markets.

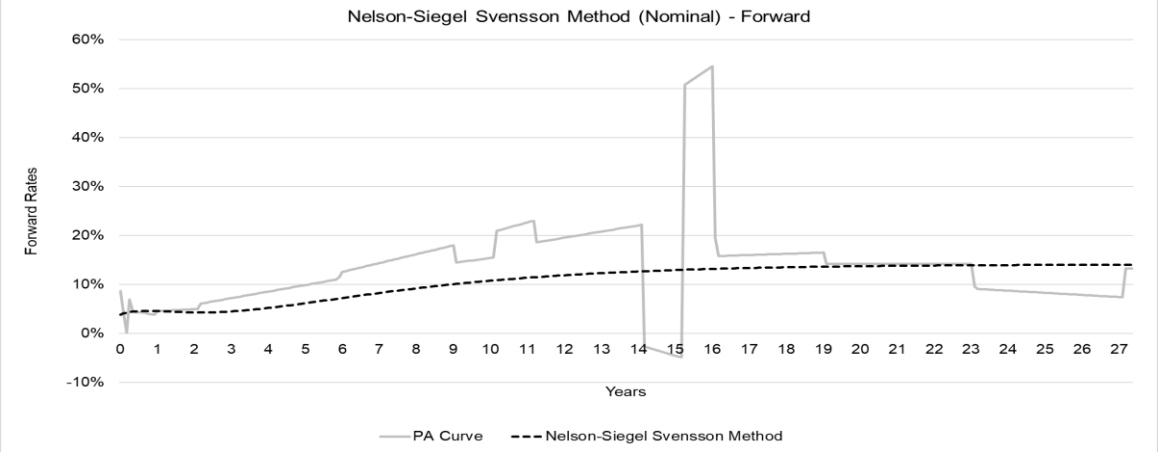
4.6.2 The parameters shown in Table 6 below were estimated by minimising the least squares error as part of the model construction (the treatment of the β_0 parameter is as outlined in the Nelson-Siegel method in section 4.5 above).

Table 6: Nelson-Siegel Svensson method parameters

Nelson-Siegel Svensson method		
Parameters	**Nominal curve**	**Real curve**
β_0	0.1412	0.0475
β_1	-0.1049	-0.0737
β_2	-0.1621	-0.0281
β_3	0.0504	0.0667
λ_1	3.5697	2.3486
λ_2	1.0068	0.5294

4.6.3 Figure 12 below shows the nominal forward curve under the Nelson-Siegel Svensson method as at 31 December 2020.

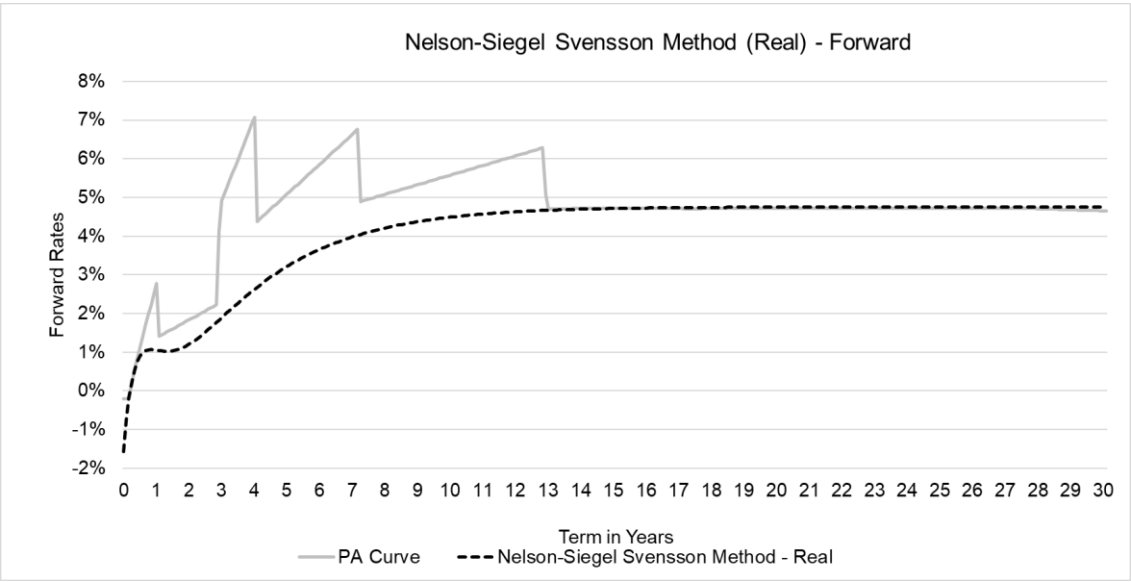
Figure 12: Nominal PA curve – Nelson-Siegel Svensson method



4.6.4 The shape of the interest rate term structure under Nelson-Siegel Svensson, which is an extension of the Nelson-Siegel method, is not materially different from the one determined by the normal Nelson-Siegel method. This is also shown by the similarity in the estimated values of the model parameters. This implies that the extra complexity accommodated for by the Nelson-Siegel Svensson function form may not be needed in fitting the current set of constituents.

4.6.5 Figure 13 below shows the real forward curve under the Nelson-Siegel Svensson method as at 31 December 2020.

Figure 13: Real PA curve – Nelson-Siegel Svensson method



4.6.6 As in the nominal case, the Nelson-Siegel Svensson extension outputs a real forward rate curve that is similar to the normal Nelson-Siegel method. This is shown by the estimated parameters in Tables 5 and 6 as well.

4.7 The Smith-Wilson method

4.7.1 The Smith-Wilson method is another curve-fitting method that can be used for the interpolation and extrapolation process of the term structure of interest rates. The main advantage of this method is its ability to account for long-term rates through explicit parameters such as the UFR.

4.7.2 The above-mentioned ability brings this method broadly in line with the PA's current practice of letting the forward curve converge to a known fixed point, although it has the added sophistication of being able to account for the speed of this convergence. This method has been recommended by the European Insurance and Occupational Pensions Authority (EIOPA) and is currently used in the Solvency II framework.

4.7.3 EIOPA's risk-free rate term structure uses instruments with a maturity from one year onwards. The reason for this is that instruments below one-year rates may add unnecessary complexity to the calculations. According to EIOPA, this would have an insignificant impact on the rates extrapolated with the Smith-Wilson method and thus very little impact on the amount of long-term technical provisions.

4.7.4 The following parameters, as indicated in Table 7 below, were chosen for the construction of the curves.

Table 7: Smith-Wilson method parameters

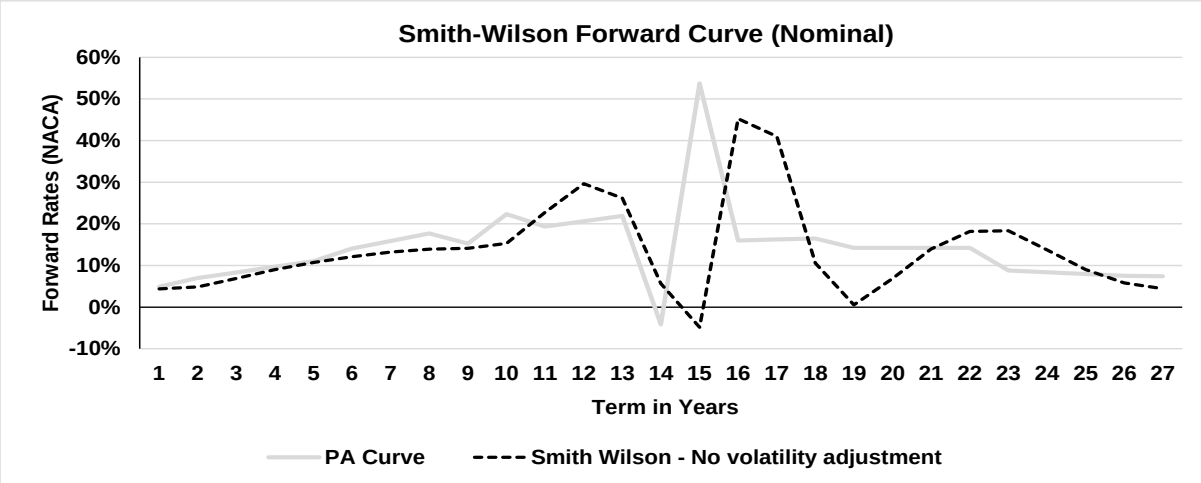
Smith-Wilson method		
Parameters	**Nominal curve**	**Real curve**
Constituents	South African nominal government bonds	South African inflation-linked government bonds
Years to convergence	67 years	70 years
UFR – nominal bond curve	6.00% (NACC*)	1.50% (NACC)
Calibrated alpha	0.1	0.1
Bootstrapping	Not applicable	Not applicable
Calculation date	31 December 2020	31 December 2020
Volatility adjustment	0%	0%

*Nominal Annual Compounded Continuously

4.7.5 The calibrated alpha is used to adjust the speed of convergence. For the above-specified years to convergence, the optimal alpha was calibrated at 0.1. The extrapolated forward rates converge faster to the UFR for a higher alpha.

4.7.6 Figure 14 below shows the nominal bond curve constructed using the Smith-Wilson method as at 31 December 2020.

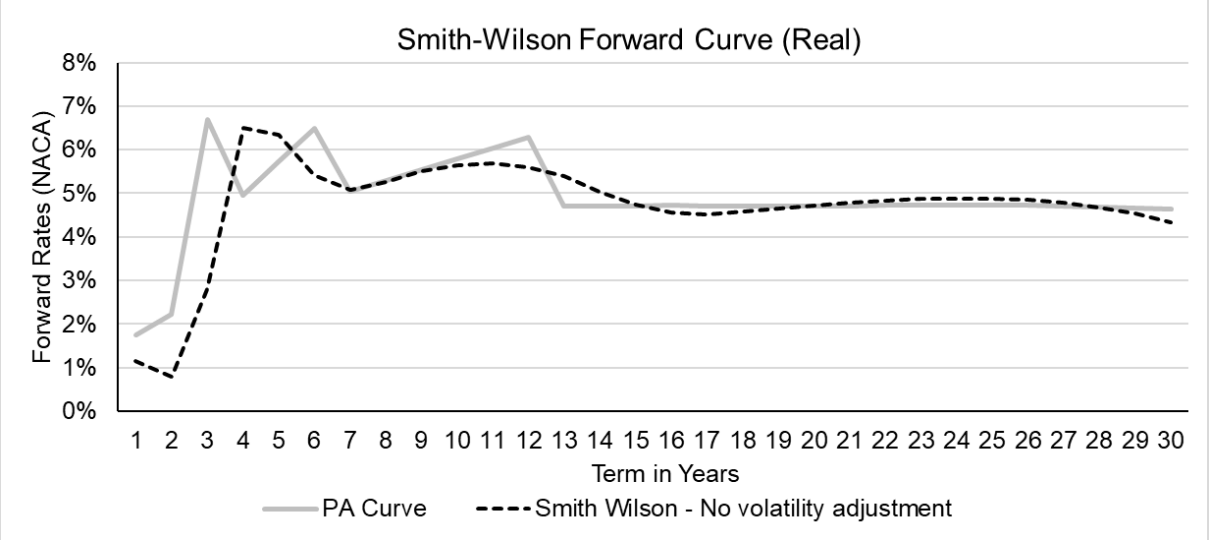
Figure 14: Nominal PA curve – Smith-Wilson method



4.7.7 The nominal curve, constructed using the Smith-Wilson method, presents additional spikes compared to the PA curve and does not bring any additional benefits over the PA curve in the liquid parts of the term structure.

4.7.8 Figure 15 below shows the real spot rates under the Smith-Wilson method (ranging from 1 to 30 years).

Figure 15: Real PA curve – Smith-Wilson method

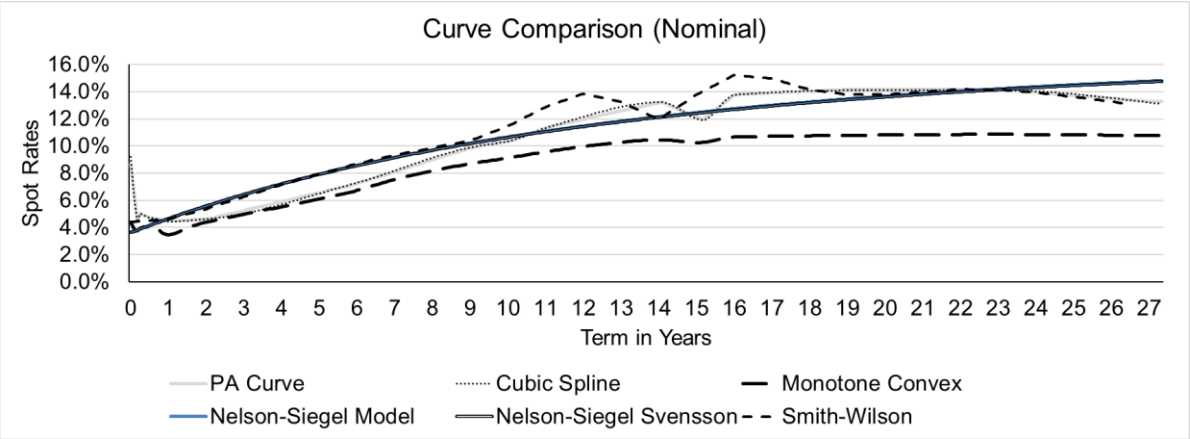


4.7.9 Similar to the effects seen above, the Smith-Wilson method appears to be broadly in line with the current method in the liquid parts of the term structure.

4.7.10 Finally, Figure 16 below shows a spot rate comparison of the nominal yields under the alternative methods.

4.8 Curve comparisons

Figure 16: Nominal PA curve comparison

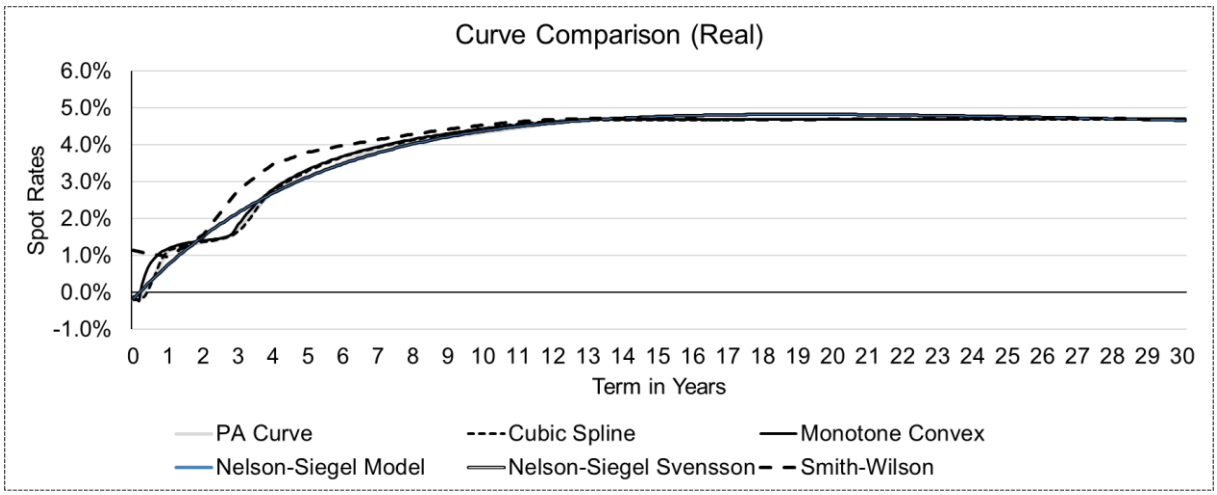


4.8.1 This comparison shows that the parametric methods produce the smoothest shape of the curve, with the Cubic spline, Monotone convex and Smith-Wilson methods retaining the overall shape of the current PA curve, given that these methods do not specify a shape for the curve like the Nelson-Siegel and Nelson-Siegel Svensson methods do.

4.8.2 The parametric methods, however, produce higher rates as the estimated forward rates do not converge to an explicit predefined UFR.

4.8.3 Figure 17 below shows the comparison of the real yields under the alternative methods.

Figure 17: Real PA curve comparison



4.8.4 The distinctions in the alternative methods for the real curves are less pronounced than those of the nominal curves, with the Nelson-Siegel methods specifying a shape that increases slightly more gradually in the liquid points of the curve.

4.8.5 In conclusion, the relative merits of each of the above methods for interpolating in the liquid part of the curve are also considered in Table 8 below.

Table 8: Advantages of the five construction methods reviewed

	Advantages
Current PA approach	• Simple method • Easy to implement practically. • Easy to integrate into regular corporate processes • Can be built in-house, eliminating reliance on vendors
Monotone convex	• Allows for more shapes at various segments of the curve. • Ensures positive and smooth forward rates
Nelson-Siegel	• Widely used by central banks and practitioners • Allows the user to match the slope of the fitted curve at the start of the extrapolation. • The UFR does not need to be explicitly specified
Nelson-Siegel Svensson	• Widely used by central banks and practitioners • Fits the data slightly better than the Nelson-Siegel method. • Provides a more accurate yield curve than the Nelson-Siegel method. • The UFR does not need to be explicitly specified
Smith-Wilson	• Transparent • The computing tool is easily accessible. • Provides a perfect fit to liquid market data (no smoothing is performed) • Uses the UFR which is reached asymptotically

4.8.6 Table 9 below provides an overview of the disadvantages of the five methods.

Table 9: Disadvantages of the five construction methods reviewed

	Disadvantages
Current PA approach	• Can show negative forward rates beyond the liquid part of the curve • The curve can contain discontinuities where the yield is not consistent within an interval
Monotone convex	• Requires the estimation of discrete functions at various stages of the calculation
Nelson-Siegel and Nelson-Siegel Svensson	• Requires the estimation of a set of parameters which may not be straightforward • Not the best choice of method to use if accurate estimations are required or when dealing with a complex yield curve • Time series of the estimated parameters can be unstable • Assumes that the forward rates are always positive and the discount factor approaches zero as maturity increases • The over-parameterisation of the method can cause convergence problems
Smith-Wilson	• Can show negative forward rates beyond the liquid part of the curve • Expert/economic judgment is needed for the appropriate term-to-convergence parameter

5 Curve extrapolation and UFR

5.1 Extrapolating to the UFR

5.1.1 Having chosen a suitable set of constituents as well as a robust interpolation and bootstrapping method, the next feature to consider in the curve construction is the extrapolation, which is itself linked to the decision on the UFR.

5.1.2 In the 2019 study conducted by the Society of Actuaries on extrapolation methods (Akinyemi et al., 2019), the panellists loosely define the UFR as the 'infinite-maturity, unconditional forward rates of interest'.

5.1.3 Barrie and Hibbert (2008: 9) suggest the following principles for estimating the unconditional nominal UFR:

5.1.3.1 The nominal UFR should not be materially affected by short-term economic changes.

5.1.3.2 The UFR should be globally consistent.

5.1.3.3 The approach to estimating the UFR should be simple and easy to understand.

5.1.4 The long-term nominal UFR is typically constructed as the sum of the following components (Akinyemi et al., 2019: 11):

5.1.4.1 the real expected short-term interest rates;

5.1.4.2 the long-term expected inflation;

5.1.4.3 the long-term nominal term premium; and

5.1.4.4 the long-term nominal convexity effect.

5.1.5 Paragraphs 2.4.2 and 2.4.4. above reflect the current UFR used by the PA in constructing both the nominal and the real curves respectively. A comparison to the above principles shows the shortcoming in the current PA UFR assumption in that it consists only of an inflation expectation assumption.

5.1.6 Following the feedback received from respondents to the discussion document, an investigation into alternative options for deriving an appropriate UFR for the PA curve was performed. The results of this investigation are presented in Annexure C of this paper.

5.1.7 The investigation concluded with the following recommendations:

5.1.7.1 The PA will adopt a method based on an adjustment of the EIOPA method to construct the UFR, that is: the nominal UFR in calendar year t = the EIOPA real expected short-term rate (published in calendar year t-1) + the midpoint of South Africa's inflation target range (4.5%).

5.1.7.2 The convergence term of the UFR will be set at 120 years.

5.1.7.3 The implementation of the revised UFR will commence in January 2024 (to be published with effect from 1 February 2024).

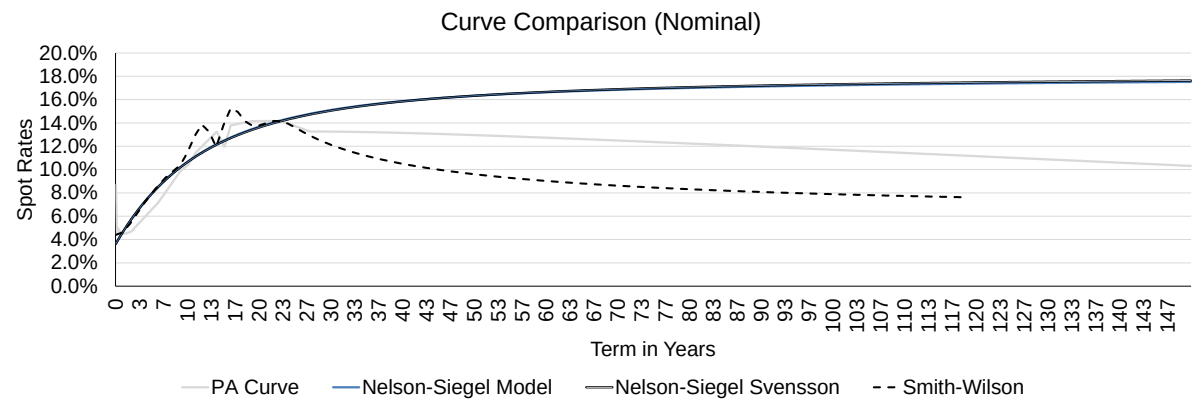
5.2 Extrapolation methodologies

5.2.1 Section 4 above presented a comparison between different methods that can be used to interpolate between the observable market data in the liquid part of the curve.

5.2.2 In this section, the extrapolation of the PA curve is considered. Specifically, the current linear extrapolation method is compared to both the parametric methods and the Smith-Wilson extrapolation.

5.2.3 For the charts reflected in this section, the current PA UFR and convergence periods are assumed. The following chart (Figure 18) shows the nominal curve constructed by extrapolating using the different methods.

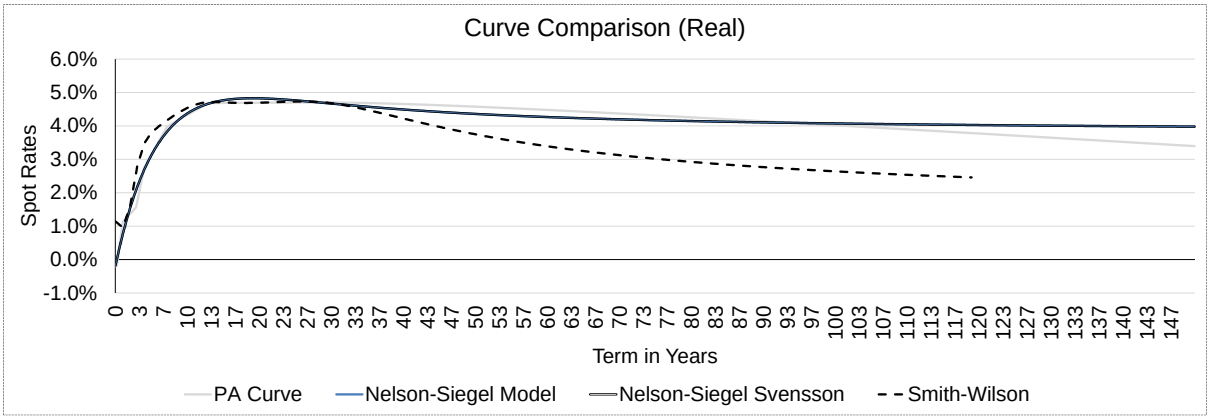
Figure 18: Nominal curve comparison



5.2.4 The Smith-Wilson method presents a smoother transition between the liquid and the extrapolated parts of the curve compared to the linear extrapolation used in the current PA curve, with the latter allowing for a significant increase in the rates before the reversion towards the UFR. The parametric methods have the advantage that they produce a smooth and monotone curve, however, and they also produce higher rates as the estimated forward rates do not converge to an explicit predefined UFR. Therefore, the market consistency principle is significantly compromised in the extrapolated part of the curves, with the rates tending towards a theoretical asymptote. This makes the use of these methods inappropriate for market-consistent valuation purposes.

5.2.5 The following chart (Figure 19) shows the real curve constructed by extrapolating using the different methods.

Figure 19: Real curve comparison



5.2.6 Similarly to the nominal curve comparison, the Smith-Wilson method presents a smooth transition between the liquid and the extrapolated parts of the curve, and allows for the choice of a convergence period to the UFR. Furthermore, the parametric methods have the advantage that they produce a smooth and monotone curve. However, the market consistency principle is significantly compromised in the extrapolated part of the curves, with the rates tending towards a theoretical asymptote. This makes the use of these methods inappropriate for market-consistent valuation purposes.

6 Conclusions

6.1 Based on the review conducted, the following observations are noted:

6.1.1 Section 2 of this paper presents the details of the current curve construction methodology.

6.1.2 A data set management framework has been adopted and implemented by the PA, as outlined in sections 3.1 and 3.2 above for the PA curve. With reference to the short end of the PA curve, T-bills may be considered as a replacement of the current constituents on the short end of the PA curve. However, this would best be conducted with an update to the overnight rate. Therefore, a fair assessment of the short end of the PA curve might be feasible once ZARONIA has been adopted and established in the market.

6.1.3 An investigation into alternative options of deriving an appropriate UFR for the PA curve was performed. The results of this investigation are presented in Annexure C to this paper.

6.1.4 Table 10 below summarises the general principles that guide the PA's curve construction process, together with the alternative curve construction methodologies.

Table 10: Checklist of different methods against the principles

Principles	Methods					
	PA method (linear interpolation and extrapolation)	**Cubic spline**	**Monotone convex**	**Nelson-Siegel**	**Nelson-Siegel Svensson**	**Smith-Wilson**
Credit risk	✓	✓	✓	✓	✓	✓
Realism	✓	✓	✓	×	×	✓
Reliability	✓	✓	✓	✓	✓	✓
Simplicity	✓	×	×	×	×	✓
Continuous	×	×	✓	✓	✓	✓
Strict positivity of forward rates	×	×	✓	✓	✓	×

6.1.5 Table 10 indicates that each method considered exhibits strengths and weaknesses based on the principles outlined. Furthermore, the current PA method and the Smith-Wilson method seem to bear the most adherence to the guiding principles above.

6.1.6 Given the relative merits of these two methods, a further retrospective analysis was performed on the forward rates, with a focus on the response of the curve to market shocks under each method. Annexure D to this paper presents a summary of the quarterly deviations observed in the forward rates under each method from 1 January 2019 to 30 June 2022. This period was chosen to capture a broad set of market movements, including the shocks experienced in the bond markets in 2020. No material differences in the behaviour of the forward rates were apparent from the analysis performed, with the quantum of the swings in the curve being similar under both methods.

6.1.7 As such, the current PA construction method may be best suited for the purposes under consideration given its relative merits of simplicity, subject to frequent monitoring of the data set.

7 Recommendations

7.1 The data set management criteria will continue to be used.

7.2 For the short end of the PA curve, the SADR1T will be retained in the PA curve as well as the 3-month up to 12-month constituents. Furthermore, any changes to the 3-month up to 12-month instruments could be considered together with the sustainability of the overnight rate. Therefore, another review of the short end of the PA curve could be performed following the market adoption of ZARONIA.

7.3 UFR recommendations

7.3.1 The PA will adopt a method based on an adjustment of the EIOPA method to construct the UFR, namely the nominal UFR in calendar year t = the EIOPA real expected short-term rate (published in calendar year t-1) + the midpoint of South Africa's inflation target range (4.5%).

7.3.2 The consideration of the convergence term of the UFR to be set at 120 years.

7.3.3 The implementation of the revised UFR recommendations will commence in January 2024 (to be published with effect from 1 February 2024).

7.4 Notwithstanding the limitations of the current curve construction methodology attributable to the interpolation and extrapolation methods, the current methodology has the advantage of simplicity. Therefore, this method will be retained.

7.5 The use of alternative curve construction methodologies will not be considered at this stage.

References

Akinyemi, K., Kerbeshian, J., Leiser, B. & Matson, P., 2019. *Society of Actuaries: Yield Curve Extrapolation Methods.* [Online]
Available at: https://www.soa.org/globalassets/assets/Files/resources/research-report/2019/yield-curve-report.pdf
[Accessed 30 June 2022].

Anon., n.d. *A Technical Note on the Smith-Wilson Method.* [Online]
Available at:
http://janroman.dhis.org/finance/Smith%20Wilson/A_Technical_Note_on_the_Smith-Wilson_Method_100701.pdf
[Accessed 01 July 2021].

Barrie, A. & Hibbert, J., 2008. *A framework for estimating and extrapolating the term structure of interest rates. Exposure draft.* [Online]
Available at:
http://janroman.dhis.org/finance/Curves%20%20Interpolation/A_Framework_for_Estimating_and_Extrapolating_the_Term_Structure.pdf
[Accessed 01 July 2021].

European Insurance and Occupational Pensions Authority, 2021. *Technical documentation of the methodology to derive EIOPA's risk-free interest rate term structures.* [Online]
Available at: https://www.eiopa.europa.eu/sites/default/files/eiopa-bos-21-475-technical-documentation.pdf
[Accessed 30 June 2022].

Financial Stability Board, n.d. *Solvency Assessment and Management: Pillar 1 - Sub Committee Technical Provisions Task Group Discussion Document 40 (v 3).* [Online].

Hagan, P. S. & West, G., 2018. Methods for Constructing a Yield Curve. *Wilmott Magazine,* Volume May, pp. 70-81.

International Association of Insurance Supervisors, 2022. *IAIS ICP14.* [Online]
Available at: https://www.iaisweb.org/
[Accessed 30 June 2022].

Johannesburg Stock Exchange, n.d. *Instrument Pricing Specifications.* [Online]
Available at: https://www.jse.co.za/instrument-pricing-specifications
[Accessed 30 June 2022].

Nelson, C. & Siegel, A., 1987. Parsimonious Modeling of Yield Curves. *Chicago Journals,* 60(No.4 (Oct, 1987)), pp. 473-489.

Preez, P. F. d., 2012. *An investigation into popular methods for constructing yield curves.* [Online]
Available at: https://repository.up.ac.za/handle/2263/25882
[Accessed 01 July 2021].

Prudential Authority of South Africa, 2018. *Prudential Standards for Insurers.* [Online] Available at: https://www.resbank.co.za/content/dam/sarb/publications/prudential-authority/pa-department-documents/Prudential%20Standards%20Financial%20Soundness%20Standards%20for%20Insurers.zip
[Accessed 01 August 2021].

Annexure A: History of the data set

Table A.1 below shows the set of constituents that was used from the inception of the nominal government bond curve (shown by the ticks). Bonds which have been removed from the data set are marked with an ‘x’ symbol, and new bonds which have been added are marked with a dash (-) symbol in the period before they were added. The table shows the data set at each quarter-end and at the months where reconstitutions were made.

Table A.1: History of the nominal curve data set

Year	2012	2013						2014						2015				2016				2017					2018					2019					2020				
Month	12	3	6	9	10	11	12	3	6	7	8	9	12	3	6	9	12	3	6	9	12	3	6	8	9	12	3	6	9	10	12	3	6	9	11	12	3	6	9	10	12
cash:BA:1d	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
cash:BA:3m	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
cash:BA:6m	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
cash:BA:9m	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
cash:BA:1y	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R201	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
R157	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
R203	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
R204	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×
R207	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×	×	×	×	×	×
R208	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R2023	-	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R186	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R213	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R209	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R214	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
R2048	-	-	-	-	-	-	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R2030	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓
R2032	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓
R2035	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓
R2037	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓
R2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓
R2044	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓

Table A.2 below shows the set of constituents that was used from the inception of the real government bond curve, shown by ticks (✓). Bonds which have been removed from the data set are marked with an 'x' symbol, and new bonds which have been added are marked with a dash (-) symbol in the period before they were added. The table shows the data set at each quarter-end and at the months where reconstitutions were made.

Table A.2: History of the real curve data set

Year	2012	2013					2014				2015					2016					2017					2018					2019					2020				
Month	12	3	6	7	9	12	3	6	9	12	3	6	7	9	12	3	6	7	9	12	1	3	6	9	12	3	6	9	10	12	3	6	9	11	12	3	6	9	10	12
cash:BA:1d	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
cash:BA:3m	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R211	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
R212	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R197	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
I2025	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R210	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
I2029																		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
I2033													-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
R202	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
I2038	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
I2046				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
I2050	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Annexure B: Prudential Authority government bond curve short-term yields investigation

1. Introduction and background

1.1 The purpose of this Annexure is to provide the outcome of the investigation into alternative short-term[18] instruments compared with the current data set in the PA curve.

1.2 In response to the PA's government bond curve discussion document, some observations were raised with regards to the nominal PA curve by members of the insurance industry that the PA should consider alternative constituents on the short end[19] of the PA curve. For example, one of the observations indicated that T-bills are auctioned each week and form a large proportion of South Africa's money market instruments, thus providing an alternative to the current constituents used on the short end of the nominal PA curve.

1.3 For the real PA curve, it is worth noting that there are no government-issued inflation-linked bonds at the 1-day and 3-month terms to maturity, and the South African rand (ZAR) real yield Swap 1 Year rate[20] is used as a proxy at both these terms to maturity to ensure that the forward rate curve is monotone-increasing. The short-term yield investigation is therefore limited to the nominal PA curve.

1.4 In terms of the structure of this Annexure, section 3 provides a description of the current data set used in the short end of the nominal PA curve. Section 4 provides an overview of the alternative overnight rate for consideration in the nominal PA curve. Section 5 provides an overview of T-bills. Section 6 outlines the decision considerations that are made for the constituents on the short end of the nominal PA curve. Section 7 provides the analysis performed on the overnight rates, and section 8 provides the analysis performed on the 3-month to 12-month data set. Section 9 illustrates the overall impact of the alternative instruments on the short end of the nominal PA curve. Section 10 illustrates the impact of consistently priced instruments on the PA curve. Section 11 concludes with findings, and section 12 provides the recommendations.

[18] This would be a term to maturity of 12 months or less.
[19] These refer to yields for instruments that have a term to maturity of 12 months or less.
[20] The ZAR real yield Swap 1 Year rate is described as the 'derivative used to transfer inflation risk from one party to another through exchange of cash flows. In a zero-coupon inflation swap, only one payment is done at maturity where one party pays [a] fixed rate on a notional principal amount, while [an]other party pays a floating rate linked to the inflation index' (sourced from Bloomberg).

2. Current data set of the PA curve

2.1 The current data set of the nominal PA curve consists of South African government bonds, currency deposits and implied forwards rates that are used to obtain a risk-free interest rate term structure. The closing yields for instruments in the data set are obtained from Bloomberg[21].

2.2 Table B.1 below shows the data set in terms of which the nominal PA curve is constructed (as published monthly) for instruments on the short end of the curve.

Table B.1: Data set – nominal PA curve

Bloomberg ticker symbol	Instrument description	Term of the instruments
SADR1T Curncy	South African rand overnight deposit	1 day
SADRC Curncy	South African rand 3-month deposit	3 months
SADRF CMPL Curncy	South African rand 6-month deposit	6 months
ZARI9M Curncy	South African rand 9-month forward implied yield	9 months
ZARI12M CMPL Curncy	South African rand 12-month forward implied yield	1 year

2.3 The ZAR deposit rates and the implied forward yields are used on the short end of the nominal PA curve. The overnight, 3-month and 6-month deposit rates are defined as 'the annualised rate of interest that a bank will charge for lending or pay for borrowing a currency for a specific tenor. When entering a deposit contract both the seller and buyer will agree upon the currency, principal amount, day count, maturity and interest rate'[22].

[21] Bloomberg (www.bloomberg.com) is a software platform that provides real-time financial market data.
[22] This information was sourced from Bloomberg.

2.4 The data source for the deposit is from the Bloomberg New York Composite[23] Rate (CMPN), which represents the best bid and best ask market quote from qualifying price contributors within a rolling time window.[24] Bloomberg also indicates that, in order to account for the open and closed prices for each day[25] for the different currency markets, there are currently three timeframes represented on Bloomberg: the Bloomberg Tokyo Composite Rate (CMPT), the Bloomberg London Composite Rate (CMPL) and CMPN. It is indicated on Bloomberg that the same data goes to all three composites; the only difference lies in the times at which the opening and closing data sets are taken.[26]

2.5 The South African implied forward yields which are used at the 9-month and 12-month data points of the nominal PA curve are sourced from the Bloomberg Generic Price (BGN[27]). The South African implied forward yields are defined as the 'annualised interest rates for the given currency and tenor, derived from the covered interest rate parity theorem[28]. They are derived from the prevailing spot and forward rates for the currency versus the [United States] (US)[29] dollar for the corresponding time period, along with the US interest rate for the same period".[30]

2.6 In documenting the PA methodology in the PA government bond curve review discussion document, investigations and interviews were conducted with some key role players when the first curve was published by the then Financial Services Board (FSB). Although the 9-month and 12-month South African deposit rate (SADR1T) as well as the 3-month and 6-month ZAR forward implied yield can be sourced from Bloomberg, the rationale for using the current constituents (i.e. a combination of the deposit rates and the implied forward yields) for the nominal PA curve was not provided during the interviews with some of these role players.

[23] "This is the predecessor to the BGN and has not been retired for a variety of reasons. In some instances, a currency may not have a BGN due to low liquidity; in these instances Bloomberg will fall back and retrieve the composite. The composite covers a larger universe of currencies, and Bloomberg [does not] recogni[s]e all client systems, but can accept different sources for [Foreign Exchange] FX and thus the composites are maintained. In many instances, the liquidity of the composite is identical to the BGN." (This information was sourced from Bloomberg.)

[24] This information was sourced from Bloomberg.

[25] Bloomberg tracks and records currency market data for five days of the week (Monday to Friday). (This information was sourced from Bloomberg.)

[26] This information was sourced from Bloomberg.

[27] The BGN is the preferred default source for generic FX data designed to show market consensus bid/ask rates.

[28] The interest rate parity theory refers to an interest rate differential between two countries and is equal to the differential between the forward exchange rate and the spot exchange rate; more information can be obtained from https://www.investopedia.com.

[29] United States

[30] This information was sourced from Bloomberg.

3. Alternative overnight rates

3.1 In this section, an overview of suitable alternative overnight rates is provided. The South African Rand Overnight Deposit Rate (RAONON) is considered as an alternative to the current overnight rate used in the nominal PA curve. It was suggested by members of the insurance industry that a South African Futures Exchange (SAFEX[31]) overnight rate be used. The RAONON data is extracted from Bloomberg, and the data source indicated on Bloomberg is SAFEX. The RAONON is defined as 'the weighted average of the overnight call deposit rates paid by A1-rated local and F1-rated foreign financial institutions where SAFEX places its daily margin deposits received by members".[32]

3.2 The South African Benchmark Overnight Rate (SABOR) (Bloomberg code: SAONBOR) is another alternative overnight rate of which the data was extracted from Bloomberg. It should be noted that the data source indicated on Bloomberg for the SABOR is the SARB. It is also indicated that 12 banks[33] contribute their rates in the computation of the SABOR.[34] Also note that a reference rate reform on the SABOR is being conducted by the Market Practitioners Group (MPG)[35] at the SARB.

3.3 In a feedback report titled 'Report on stakeholder feedback on the reform of interest rate benchmarks in South Africa', published on the SARB website in May 2019, it is indicated that the SABOR would be reformed and renamed to 'SABOR Money Market'. The responses showed wide support for the proposed reform of the SABOR and indicated further that this would enhance transparency in the domestic money market. In addition to this, the respondents indicated that the SABOR Money Market could be considered for use in the new monetary policy implementation framework (MPIF) and for general risk-free rate purposes as it is closely aligned to international practice and presents limited operational issues. Nevertheless, other respondents indicated that a comparative study with other risk-free benchmarks would need to be conducted. Subsequently, there was also a proposal to change the SABOR Money Market to ZARONIA, which was considered by the SARB.[36]

[31] SAFEX was formed in 1990 and is a futures exchange subsidiary of JSE Limited. More information is available from https://en.wikipedia.org/wiki/South_African_Futures_Exchange.
[32] This information was sourced from Bloomberg.
[33] These would be Absa Bank, African Bank, Bidvest Bank, FirstRand Bank, Grindrod Bank, HBZ Bank, Investec Bank, Mercantile Bank, Nedbank, Soc Gen, Standard Bank and Standard Chartered Bank.
[34] This information was sourced from Bloomberg.
[35] The MPG is a joint public and private sector body, comprised of representatives from the SARB and the Financial Sector Conduct Authority as well as other senior professionals representing different market interest groups active in the domestic financial market.
[36] Report on stakeholder feedback on the reform of interest rate benchmarks in South Africa. More information is available from: https://www.resbank.co.za.

3.4 Following the feedback report, the SARB published the 'Draft statement of methodology and the policies governing the SARB-administered interest' document on 19 June 2020. The document details the methodology and policies of the overnight rates, one of them being ZARONIA, which is the reformed version of the SABOR and will therefore most likely replace the benchmark in due time. ZARONIA was also included in the industry comments as an alternative overnight rate to the SADR1T overnight rate pending the work being conducted by the SARB on the reference rate reform. ZARONIA is defined as 'the measure of the interest rate at which rand-denominated overnight wholesale funds in South Africa are obtained by banks, where credit, liquidity and other risks are minimal'. [37]

3.5 ZARONIA is based on unsecured overnight call deposits placed with commercial banks, with the exclusion of foreign exchange (FX) swaps from the SABOR[38].[39] It should be noted that ZARONIA rates are not yet available on Bloomberg. For this reason, section 5 of this Annexure analyses the SABOR rates.

3.6 In the 'Feedback on the statement of methodology and policies governing the SARB-administered interest rate benchmarks' document published by the SARB in November 2021, it is indicated that ZARONIA will make available a common point of reference that should shape the pricing behaviour of banks. In addition, ZARONIA appears to adjust well to changes in the repurchase (repo) rate. The SARB will publish a final technical specification paper once the work of the MPG has been completed.[40]

3.7 Furthermore, in light of the regulatory changes for the reference rate (ZARONIA) and the work that is pending by the MPG, it appears that the overnight rate from SAFEX, particularly, the RAONON may not be used as a benchmark rate. However, this Annexure includes an assessment of the RAONON given that the rates are available.

[37] This information was sourced from Bloomberg.
[38] Report on stakeholder feedback on the reform of interest rate benchmarks in South Africa. More information is available from: https://www.resbank.co.za.
[39] Draft statement of methodology and the policies governing the SARB-administered interest. More information is available from: https://www.resbank.co.za.
[40] Feedback on the statement of methodology and policies governing the SARB-administered interest rate benchmarks. More information is available from: https://www.resbank.co.za.

4. T-bills overview

4.1 T-bills are short-term debt instruments denominated in the ZAR which are sold at a discount to par and have zero-coupon rates.[41] T-bills are issued by National Treasury on a weekly basis to the market at maturities of one year or less.

4.2 The yields for T-bills are obtained from Bloomberg. The rates are calculated as the average rate at which T-bills are allotted during the weekly T-bill auction.[42]

4.3 Table B.2 shows the data set of the T-bills used as the proposed alternative to the current constituents of the nominal PA curve.

Table B.2: Proposed alternative constituents (3-month to 12-month)

Bloomberg ticker symbol	Instrument description	Term of the instruments
SATA3MAD	South African Treasury Bill Auction results	3 months
SATA6MAD	South African Treasury Bill Auction results	6 months
SATA9MAD	South African Treasury Bill Auction results	9 months
SATA12AD	South African Treasury Bill Auction results	12 months

4.4 According to the Consultation paper on selected interest rate benchmarks in South Africa (2018), the SARB Working Group on [the] Rand Interest Rate Benchmark (Working Group) conducted research on risk-free rates and found the following:[43]

4.5 There are no risk-free money market interest rate benchmarks currently published in the South African financial markets.

4.6 The secondary market for T-bills in South Africa, which is a potential source market for calculating risk-free term rates, is illiquid, mainly due to banks buying and holding T-bills for prudential reasons (i.e. this market is dominated by buy-and-hold strategies by the banking sector).

4.7 Price discovery is insufficient due to a lack of dedicated trading screens and/or market makers, thus making it challenging to purchase T-bills in the secondary market.

[41] Treasury Bill Information Memorandum of the Republic of South Africa. More information is available from: http://www.treasury.gov.za/divisions/alm/treasury%20bills%20information%20memorandum.pdf

[42] More information is available from: https://www.resbank.co.za/en/home/what-we-do/statistics/key-statistics/current-market-rates

[43] Consultation paper on selected interest rate benchmarks in South Africa, August 2018. More information is available from: https://www.resbank.co.za/en/home/publications/publication-detail-pages/markets-consultation-paper/2018/8722

4.8 Despite the current state of T-bills, the Working Group considers T-bills a potentially useful and appropriate basis for calculating risk-free term rates, with a need to develop a secondary liquid market.

4.9 In addition, Table B.3 below summarises the advantages and disadvantages of T-bills given that these instruments are being considered as an alternative to the current constituents of the nominal PA curve.

Table B.3: Advantages and disadvantages of T-bills

Advantages	Disadvantages
T-bills are potentially risk-free.	The secondary market is illiquid.
They are mainly used to achieve fixed returns (i.e. they are predictable).	If interest rates start rising in the market, existing T-bills may become unfavourable. Therefore, there is exposure to interest rate risk, which is the case for other types of instruments.
They are considered to be in demand due to the take-up during auctions in the primary market.	Market consistency is limited due to weekly issues instead of daily.
There is one issuer (i.e. National Treasury), but T-bills can also be sourced on the SARB website.	

5. Decision considerations

5.1 The PA does not endeavour to make frequent changes to the PA curve, as this would create some instability in the PA curve. As indicated in paragraph 4.5 of this Annexure, there are no risk-free money market interest rate benchmarks currently published in the South African financial markets. Notwithstanding this, the following decision factors should be considered when constructing the nominal PA curve on the short end:

5.1.1 instruments which are close to risk-free in nature;

5.1.2 the impact of the instruments on the shape of the PA curve (if an instrument affects the continuity of the curve and presents significant kinks[44] in its shape, then it should be considered for exclusion).

5.1.3 consistent pricing of instruments (which is generally enabled by having one issuer)

5.1.4 availability of pricing (information which is frequently available is favourable for use in constructing the PA curve); and

5.1.5 liquidity considerations based on available data.[45]

[44] This refers to a point where the curve is continuous yet the first derivative (gradient) is not continuous.
[45] Due to limited data, the liquidity assessment will be limited to bid-to-cover ratios and bid offer spreads.

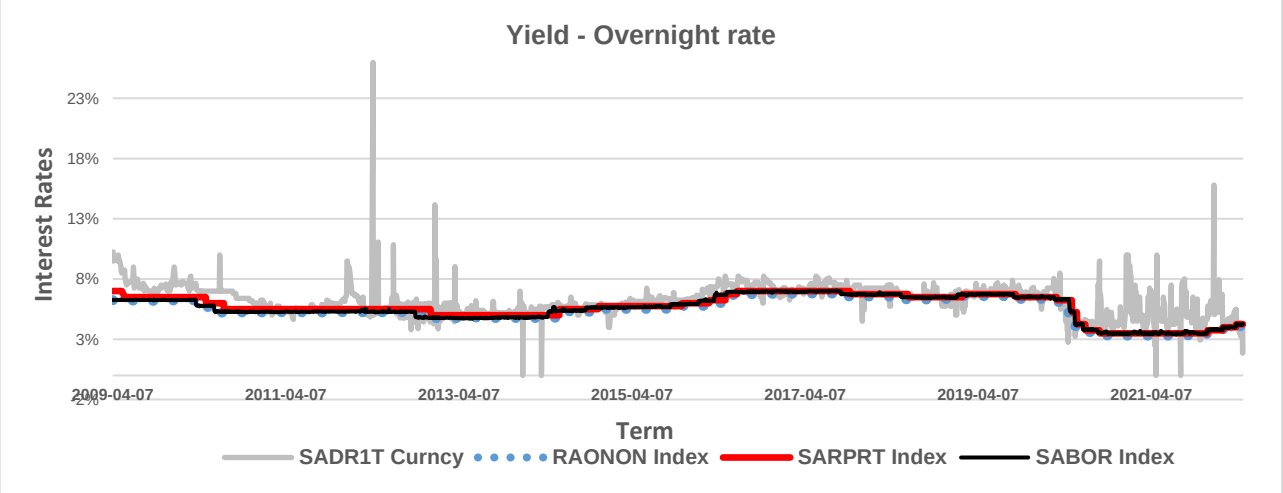
5.2 Decision factors should be considered and expert judgement should be applied. Furthermore, any changes to the 3-month up to 12-month instruments should be considered together with the overnight rate.

6. Analysis of overnight rates

6.1 In this section, the yields for the SADR1T, the RAONON and the SABOR are analysed and compared with the South African Repo Average Rate (SARPRT or repo rate[46]). This is to understand whether changes in the repo rate prompt similar changes in the overnight rates in particular.

6.2 Figure B.1 below shows the comparison of the above-mentioned overnight rates.

Figure B.1: Overnight rate yields



6.3 Figure B.1 indicates that both the SABOR and the RAONON appear to adjust well to changes in the repo rate. The responsiveness of a benchmark to changes in the policy rate is desirable as it suggests that it will most probably be effective in reflecting monetary policy.[47] In addition to this, the RAONON is consistently below the SABOR.

6.4 The SADR1T shows many spikes compared to the RAONON and the SABOR, both of which are more stable.

6.5 There was a significant drop in the yields from March 2020 onwards, attributed to some market forces affecting the yields. For example, some volatility was observed in the PA curve caused by market responses to both the coronavirus disease 2019 (COVID-19) pandemic and a sovereign ratings downgrade in 2020.

[46] This is the interest rate at which commercial banks borrow from the SARB.
[47] Draft statement of methodology and the policies governing the SARB-administered interest. More information is available from: https://www.resbank.co.za.

6.6 Table B.4 below shows the spread of the overnight rates compared with the repo rate (calculated as the difference between the respective overnight rates and the repo rate over the period April 2010 to April 2022).

Table B.4: Spread of the overnight rates

Bloomberg ticker symbol	Average spread
SADR1T Curncy	0.45%
RAONON	-0.21%
SABOR	-0.08%

6.7 From the table above, it is observed that the average spread for the SADR1T is much higher compared to the RAONON and the SABOR, thus reflecting higher deviation from the repo rate.

7. Analysis of T-bills versus current instruments

7.1 Yield volatility

7.1.1 Price volatility[48] is another indicator of liquidity (Committee on the Global Financial System, 1999). The volatility, measured as standard deviations on the weekly changes in the yield (in place of the price) of the instruments, is assessed to investigate the differences of volatility observed between the T-bills and the current data set on the short end of the nominal PA curve.

7.1.2 The rolling 13-week (corresponding with the 91-day average volatility) volatility of the T-bills and current data set on the short end of the nominal PA curve, calculated as the standard deviation of the average yields on the instrument, are compared to assess the overall volatility. This analysis reveals that the volatility of both instrument sets is relatively similar.

7.1.3 The table below shows the average 13-week yield volatility for the T-bills and current constituents over the period July 2017 to April 2022.

[48] The degree of change in the price of the government bond.

Table B.5: Yield volatility on 3-month to 12-month instruments

Maturity date	Bloomberg ticker symbol	Average volatility	Standard deviation
3 months	SADRC Curncy	0.14	0.15
	SATA3MAD Index	0.15	0.16
6 months	SADRF CMPL Curncy	0.13	0.15
	SATA6MAD Index	0.17	0.15
9 months	ZARI9M Curncy	0.17	0.17
	SATA9MAD Index	0.17	0.14
12 months	ZARI12M CMPL Curncy	0.18	0.17
	SATA12AD Index	0.18	0.14

7.1.4 It is noted that the average volatility for the current constituents and T-bills is equivalent for the 9-month and 12-month points. The average volatilities for the current constituents and T-bills are slightly different for the 3-month and 6-month points.

7.1.5 Due to the marginal differences in the yield volatilities, neither the current constituents nor the South African T-bills present an advantage over the other.

7.1.6 Table B.8 of this Annexure includes the table above with the 3-month and 6-month implied forward rates as well as the 9-month and 12-month currency deposit rates added for an assessment of instruments that are consistently priced on the short end of the PA curve given the considerations outlined in paragraph 5.1 of this Annexure.

7.1.7 Although the additional instruments assessed in Table B.8 would present instruments on a consistent-pricing basis, the yield volatility and the standard deviation of the additional instruments are different to those of the current constituents and the T-bills, thereby reducing support for their inclusion in the nominal PA curve.

7.2 Bid-offer spread and bid-to-cover ratio

7.2.1 According to the Committee on the Global Financial System (1999), the bid-offer spread is one of the major proxies of liquidity. The bid-offer spread reflects the price of immediacy[49] (Demsetz, 1968), which indicates that there is a cost to trading.

[49] Immediacy represents the speed with which orders can be executed, and reflects the efficiency of the trading, clearing and settlement systems (Abdourahmane and Tonny, 2002: 5).

7.2.2 The bid-offer spreads of the yield to maturity for the current constituents on the short end of the nominal PA curve were obtained from Bloomberg but were not accessible for the T-bills. The bid-to-cover ratios has been used to assess the demand and thus liquidity characteristics of T-bills.

7.2.3 According to the Debt Management Report, the bid-to-cover ratio expresses the demand for a particular security during its auction. It is calculated as the total amount of bids divided by the total amount of bids accepted.

7.2.4 The bid-offer spreads for the current data set on the short end of the nominal PA curve are shown in the table below.

Table B.6: Bid-offer spreads on yields of current data set

Maturity date	Bloomberg ticker symbol	Average bid-offer spread	Standard deviation of bid-offer spread
3 months	SADRC Curncy	1.301	0.436
6 months	SADRF CMPL Curncy	1.203	0.424
9 months	ZARI9M Curncy	0.080	0.070
12 months	ZAI12M CMPL Curncy	0.080	0.077

7.2.5 The average bid-offer spreads of the yields show that the currency deposits (3-month and 6-month) appear to be high, indicating higher costs of trading, which is not a desirable feature. The bid-offer spreads for the 9-month and 12-month ZAR implied forward yields are low, demonstrating a desirable feature.

7.2.6 Based on data from January 2008[50] to April 2022, the average bid-to-cover ratios were above 2.0 for each of the T-bills from 3 months to 12 months. This indicates a reasonable market appetite for T-bills.[51]

7.3 Graphs of the yield to maturities of the current data set on the short end of the nominal PA curve versus the T-bills at the respective times are included in this Annexure. These graphs indicate that the current data set and the T-bills are closely aligned with each other over the period July 2017 to May 2022. Generally, the T-bills react first to changes in the market and are then followed by the current data set at the respective point.

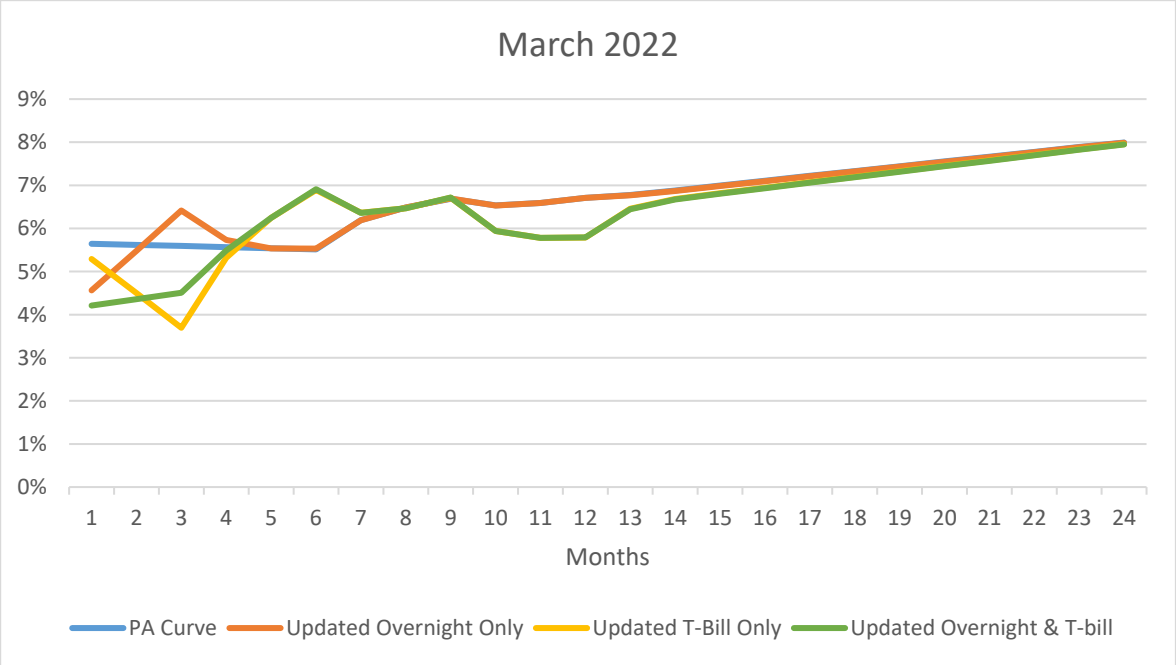
7.4 Based on the assessment of the bid-to-cover ratios, the T-bills possess reasonable market appetite in the primary market. However, the secondary market for T-bills in South Africa is non-existent and thus illiquid.

[50] This was the earliest available data from Bloomberg.
[51] National Treasury of South Africa, 2022. *Debt Management Report.* More information is available from*: http://www.treasury.gov.za*

8. Assessing the impact on the PA curve

8.1 Figure B.2 below shows the nominal PA curves having replaced the current constituents on the short end with the proposed alternative constituents as at 31 March 2022.

Figure B.2: T-bills' impact on the PA curve



8.2 Observations of the nominal PA curve compared with the updated overnight-only curve included the following:

8.2.1 Replacing the SADR1T in the nominal PA curve with the RAONON results in a sharp increase in the forward rate up to the 3-month period, which appears to contradict the principle of smoothness in the forward curve.

8.2.2 From month 3 onwards, the two curves gradually align, which is expected given that the same instruments are used beyond this point.

8.3 Observations of the nominal PA curve with the 3-month to 12-month points updated to T-bills included the following:

8.3.1 The updated T-bills-only curve shows reduced smoothness due to kinks in the short end of the curve. This is contrary to the principle of smoothness in the forward curve.

8.3.2 The inclusion of the T-bills also results in generally lower forward rates from the 3-month up to the 12-month points.

8.4 Observations of the nominal PA curve with the overnight to 12-month points updated to the RAONON and T-bills respectively included the following:

8.4.1 The update of the overnight rate and T-bills reduces the overall smoothness of the curve when compared to the current PA curve. This is particularly observed at the 6-month, 9-month and 12-month points of the curve where there are additional kinks in the curve compared to the nominal PA curve.

8.4.2 It is also noted that updating for both the overnight rate and T-bills removes the kink presented by only updating the T-bills and maintains the monotone-increasing principle between the overnight and 3-month points in the curve. This suggests that an update to the T-bills may be better suited to be conducted together with an update of the overnight rate.

8.5 Overall, T-bills appear to reduce the smoothness of the yield curve when compared to the current constituents on the short end of the nominal PA curve. The impact is reduced when the overnight rate is also updated to the RAONON. This observation remains true for all yield curves dating back to June 2019, as shown in Figure B.6 of this Annexure.

9. Impact of consistently priced instruments on the PA curve

9.1 As indicated in section 2 of this Annexure, the current constituents on the short end of the curve are formed by South African deposit rates over the 3-month and 6-month terms to maturity as well as South African implied forward yields over the 9-month and 12-month terms to maturity.

9.2 This section considers the impact of the consistent pricing of instruments in the construction of the short end of the PA curve given the decision considerations outlined in section 5 of this Annexure.

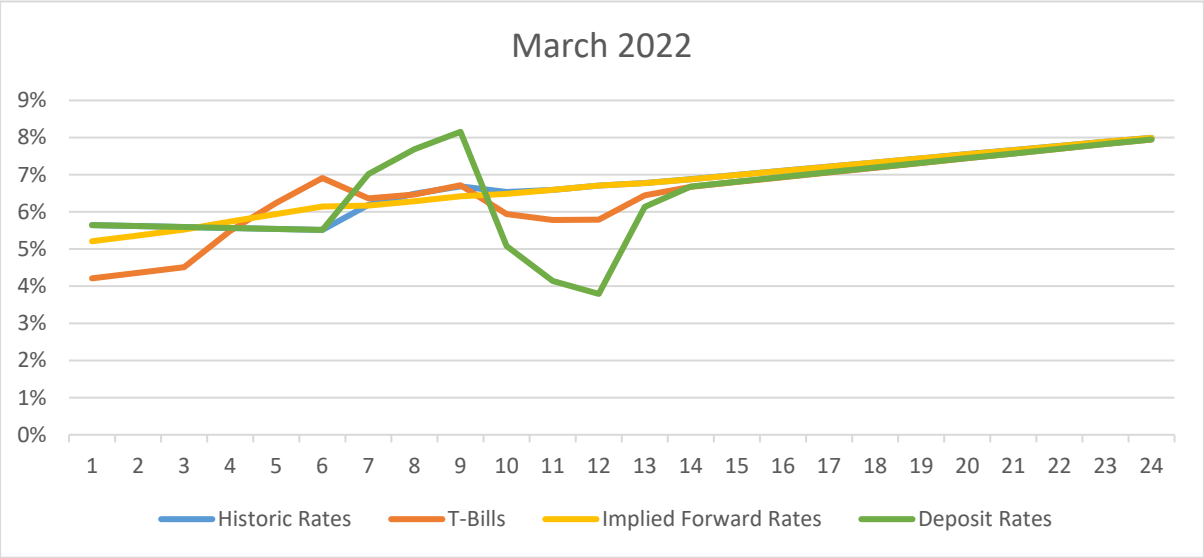
9.3 The following table shows the constituents of the curves shown in paragraph 9.4 below.

Table B.7: Current and alternative constituents

Term to maturity	PA curve	T-bills	Implied forward rates	Currency deposit rates
Overnight	SADR1T Curncy	SADR1T Curncy	SADR1T Curncy	SADR1T Curncy
3 months	SADRC Curncy	SATA3MAD	ZARI3M BGN Curncy	SADRC Curncy
6 months	SADRF CMPL Curncy	SATA6MAD	ZARI6M BGN Curncy	SADRF CMPL Curncy
9 months	ZARI9M Curncy	SATA9MAD	ZARI9M Curncy	SADRI CMPN Curncy
12 months	ZARI12M CMPL Curncy	SATA12AD	ZARI12M CMPL Curncy	SADR1 CMPN Curncy

9.4 The following graph shows a comparison of the curves where the 3-month to 12-month terms to maturity are all composed of the same instrument type.

Figure B.3: Impact of consistently priced instruments on the PA curve



9.5 Figure B.3 above presents the following observations:

9.5.1 The implied forward rates result in a relatively straight line between the 3-month to 12-month terms, suggesting that the additional market information between these terms to maturity may not be adequately captured.

9.5.2 In contrast, the currency deposit rates present additional volatility in the curve compared to the other curves, thereby reducing the smoothness.

9.5.3 These two observations further support the exclusion of using implied forward rates only or currency deposit rates only for the construction of the yield curve.

10. Conclusion

10.1 The following observations are noted:

10.1.1 The RAONON appears to be more stable compared to the SADR1T and adjusts well to changes in the repo rate. However, given the regulatory changes on ZARONIA, there is a view that the RAONON should not be used as a benchmark rate.

10.1.2 ZARONIA was included in the industry comments as an alternative overnight rate to the SADR1T. However, data for this instrument is currently not available pending the work being conducted by the Financial Markets Department of the SARB.

10.1.3 There were marginal differences in the yield volatilities observed between the current constituents on the short end of the nominal PA curve and the South African T-bills, therefore neither of them presents an advantage over the other in this respect.

10.1.4 Furthermore, the yield volatility and the standard deviation of the additional instruments in Table B.8 of this Annexure are different to those of the current constituents and the T-bills, thereby reducing support for their inclusion in the nominal PA curve.

10.1.5 Based on an assessment of the bid-to-cover ratios, the T-bills possess reasonable market appetite in the primary market. However, the secondary market for T-bills in South Africa is illiquid, mainly due to banks buying and holding T-bills for prudential reasons.

10.1.6 In addition, T-bills are issued on a weekly basis to the market compared to the current constituents which are issued daily.

10.1.7 When considering the impact on the shape of the nominal PA curve, it is noted that updating the nominal PA curve with the proposed alternative constituents (i.e. the RAONON and T-bills) reduces the overall smoothness of the curve when compared to the current PA curve.

10.1.8 Further to paragraph 10.1.7 above, it is worth highlighting that an update of the overnight rate from the current constituents to an alternative constituent (RAONON) presents additional benefits of improved smoothness in the shape of the curve when compared to updating the proposed constituents only for the 3-month to 12-month points. This suggests that an update to the T-bills may be better suited to be conducted together with an update of the overnight rate to RAONON or another suitable alternative.

10.1.9 Finally, when assessing the impact of consistently priced instruments on the PA curve, it appears that the forward rates result in a relatively straight line while the currency deposit rates present additional volatility in the curve. Therefore, this further supports the exclusion of using implied forward rates only or currency deposit rates only for the construction of the PA curve.

10.2 T-bills were proposed by insurance industry participants as alternative constituents due to the market appetite in the primary market. However, it was indicated in the consultation paper on selected interest rate benchmarks in South Africa, published in August 2018, that the secondary market for T-bills in South Africa is illiquid. The Working Group considered T-bills as a potentially useful and appropriate basis for calculating risk-free term rates, with a need to develop a secondary liquid market.

10.3 T-bills may be considered as a replacement of the current constituents on the short end of the PA curve, but this would best be conducted with an update to the overnight rate. Therefore, a fair assessment of the short end of the PA curve could be performed once ZARONIA has been adopted in the market.

11. Recommendation

11.1 It is recommended that the SADR1T be retained in the PA curve as well as the 3-month up to 12-month constituents. Furthermore, any changes to the 3-month up to 12-month instruments should be considered together with the sustainability of the overnight rate. Therefore, another review of the short end of the PA curve could be performed following the market's adoption of ZARONIA.

References

Committee on the Global Financial Systems, 1999. *Market Liquidity: Research Findings and Selected Policy Implications, Bank of International Settlements (BIS).* [Online]
Available at: https://www.bis.org/publ/cgfs11.htm
[Accessed 01 July 2022].

Hayes, A., 2021. *Interest Rate Parity.* [Online]
Available at: https://www.investopedia.com/terms/i/interestrateparity.asp#:~:text=What%20Is%20Interest%20Rate%20Parity,and%20the%20spot%20exchange%20rate.
[Accessed 30 June 2022].

Lybek, A. S. a. T., 2002. *International Monetary Fund Publications.* [Online]
Available at: https://www.imf.org/external/pubs/ft/wp/2002/wp02232.pdf
[Accessed 30 June 2022].

National Treasury of South Africa, 2008. *Treasury Bill Information Memorandum.* [Online]
Available at: http://www.treasury.gov.za/divisions/alm/treasury%20bills%20information%20memorandum.pdf
[Accessed 30 June 2022].

National Treasury of South Africa, 2022. *Debt Management Report.* [Online]
Available at: http://www.treasury.gov.za/publications/other/Debt%20Report/Debt%20Management%20Report%202020-21.pdf
[Accessed 30 June 2022].

South African Reserve Bank | Financial Markets Department, 2021. *Feedback on the statement of methodology and policies governing the SARB administered benchmarks.* [Online]
Available at: https://www.resbank.co.za/en/home/publications/publication-detail-pages/media-releases/2021/Feedback-on-the-statement-of-methodology-and-policies-governing-the-SARB-administered-benchmarks
[Accessed 2 September 2022].

South African Reserve Bank: Financial Markets Department, 2018. *Consultation Paper on SelectedInterest Rate Benchmarks in South Africa.* [Online]
Available at: https://www.resbank.co.za/content/dam/sarb/publications/markets-consultation-paper/2018/8722/Consultation-Paper-28-08-2018.pdf
[Accessed 30 June 2022].

South African Reserve Bank: Financial Markets Department, 2020. *Report on stakeholder feedback on the reform of interest rate benchmarks in South Africa - May 2019.* [Online]
Available at: https://www.resbank.co.za/en/home/publications/publication-detail-pages/mpg-related-documents/2020/10185
[Accessed 30 June 2022].
South African Reserve Bank, 2022. SARV. [Online]
Available at: https://www.resbank.co.za/en/home/what-we-do/statistics/key-statistics/current-market-rates
[Accessed 09 September 2022]

1. Supplementary tables and figures

Table B.8: Comparison of the short-term instruments

Maturity date	Bloomberg ticker symbol	Instrument type	Average volatility	Standard deviation
3 months	SATA3MAD Index	South African T-bill	0.15	0.16
	ZARI3M BGN Curncy	South African rand forward implied yield	0.18	0.20
	SADRC Curncy	South African rand deposit	0.14	0.15
6 months	SATA6MAD Index	South African T-bill	0.13	0.15
	ZARI6M BGN Curncy	South African rand forward implied yield	0.17	0.18
	SADRF CMPL Curncy	South African rand deposit	0.13	0.15
9 months	SATA9MAD Index	South African T-bill	0.17	0.14
	ZARI9M Curncy	South African rand forward implied yield	0.17	0.17
	SADRI CMPN Curncy	South African rand deposit	0.13	0.16
12 months	SATA12AD Index	South African T-bill	0.18	0.14
	ZARI12M CMPL Curncy	South African rand forward implied yield	0.18	0.17
	SADR1 CMPN Curncy	South African rand deposit	0.14	0.16

Figure B.5: 3-month up to 12-month current constituents compared with T-bills

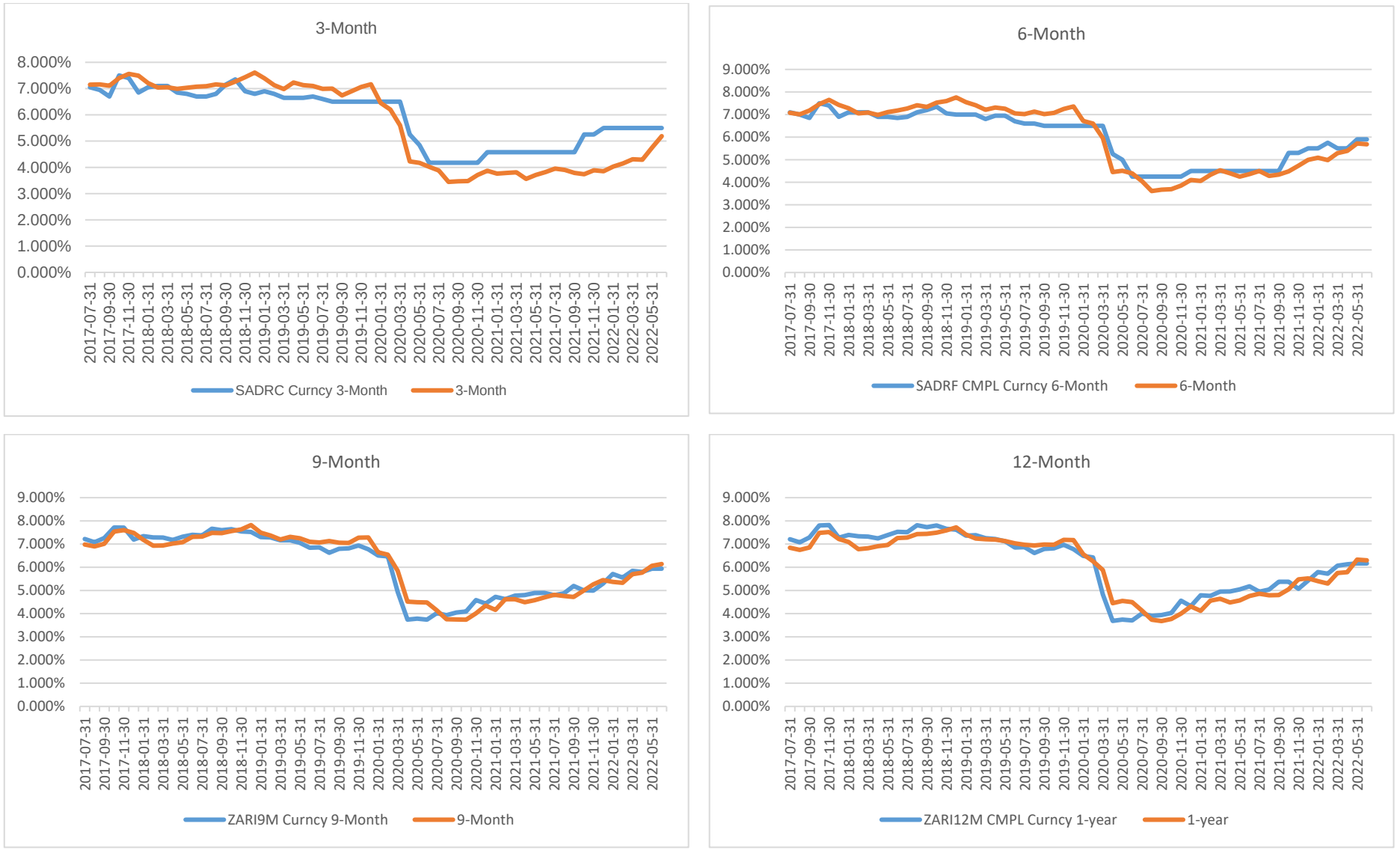
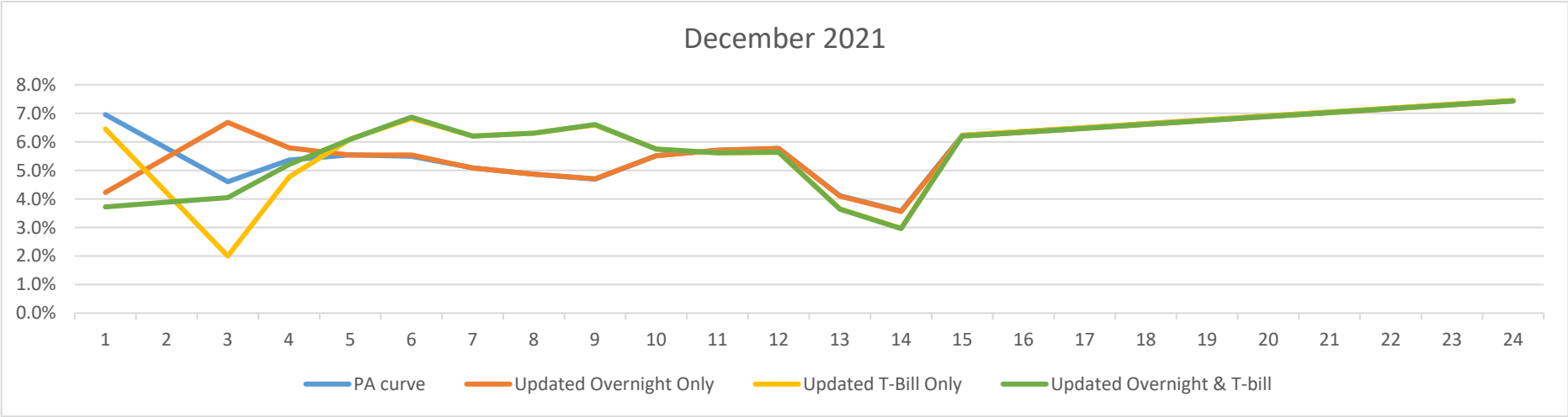
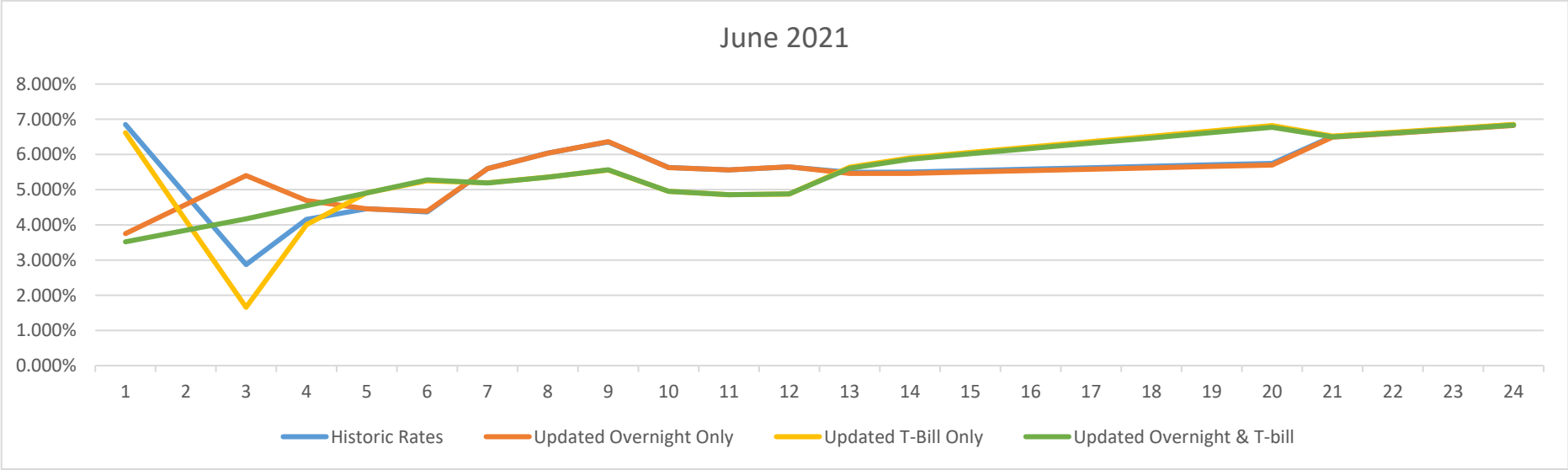
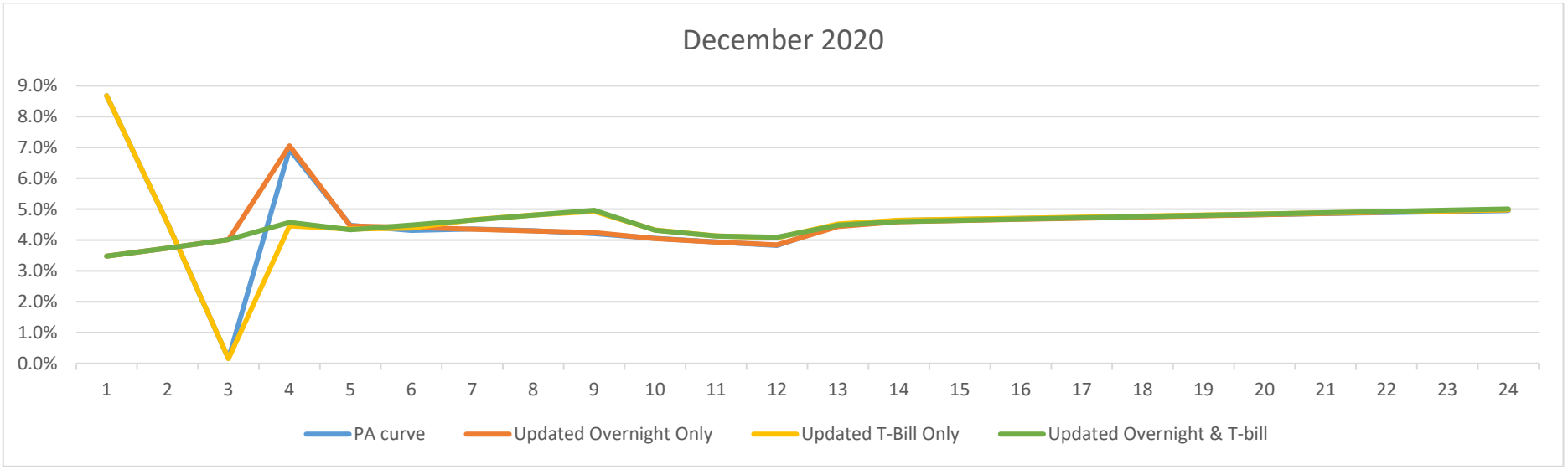
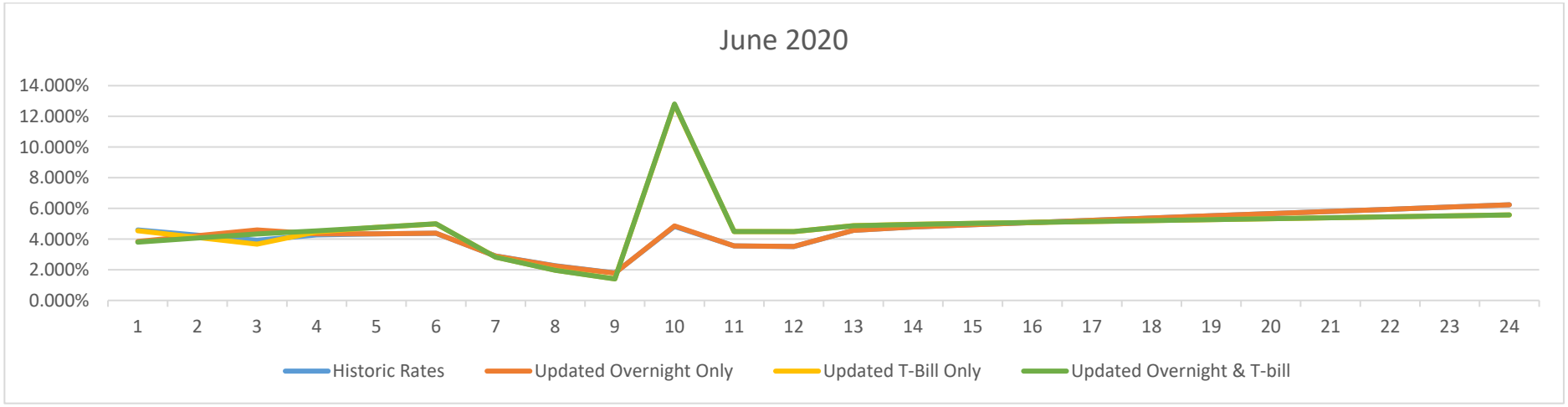


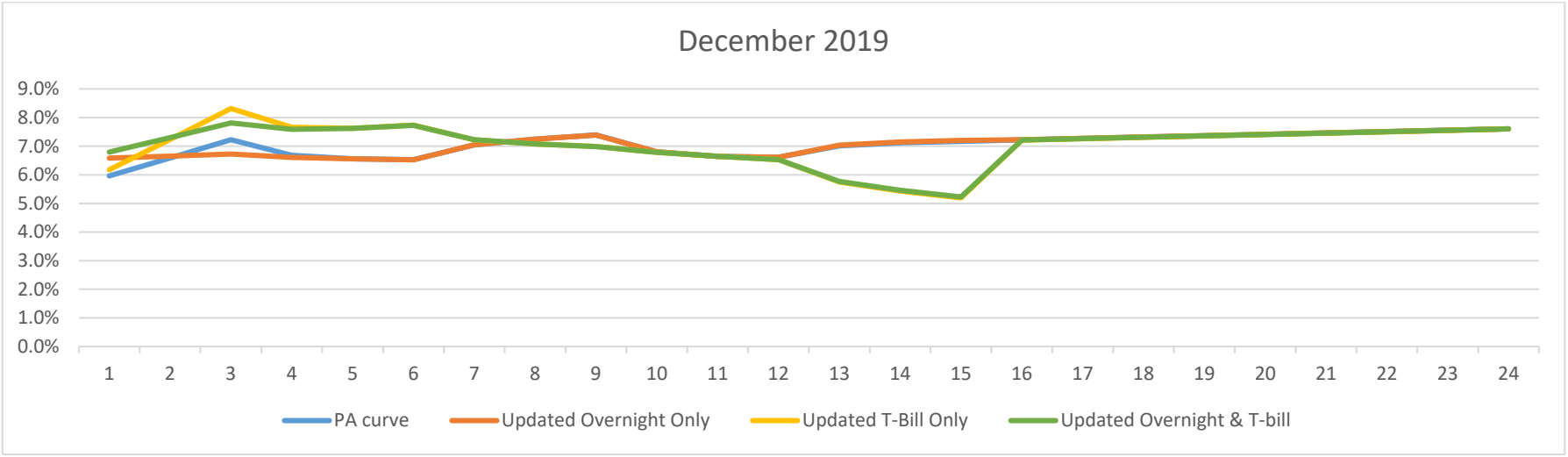
Figure B.6: Historical comparison

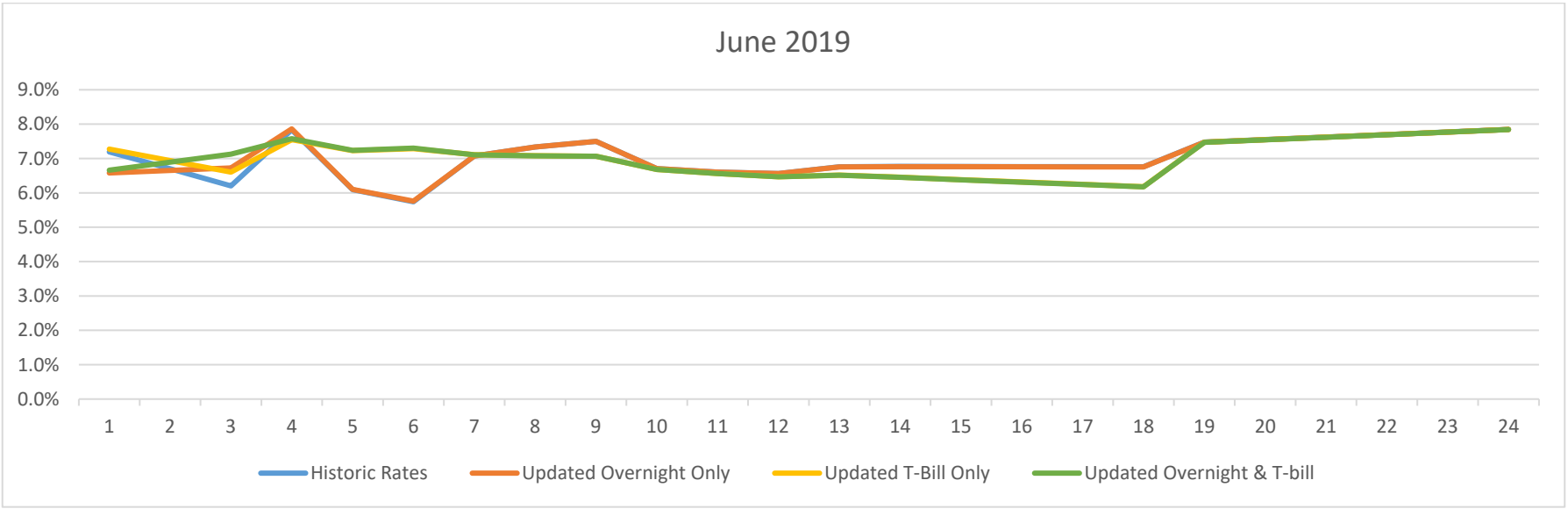





December 2020
9.0%
8.0%
7.0%
6.0%
5.0%
4.0%
3.0%
2.0%
1.0%
0.0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
PA curve
Updated Overnight Only
Updated T-Bill Only
Updated Overnight & T-bill


June 2020
14.000%
12.000%
10.000%
8.000%
6.000%
4.000%
2.000%
0.000%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Historic Rates
Updated Overnight Only
Updated T-Bill Only
Updated Overnight & T-bill


December 2019
9.0%
8.0%
7.0%
6.0%
5.0%
4.0%
3.0%
2.0%
1.0%
0.0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
PA curve
Updated Overnight Only
Updated T-Bill Only
Updated Overnight & T-bill


June 2019
9.0%
8.0%
7.0%
6.0%
5.0%
4.0%
3.0%
2.0%
1.0%
0.0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Historic Rates
Updated Overnight Only
Updated T-Bill Only
Updated Overnight & T-bill

Annexure C: Outcomes of the research performed on setting an appropriate ultimate forward rate for the Prudential Authority government bond curve

1. Introduction and background

1.1 The International Association of Insurance Supervisors' (IAIS) Insurance Core Principle 14.10 (ICP 14.10) on the valuation of assets and liabilities requires the following: "The supervisor establishes criteria for the determination of appropriate rates to be used in the discounting of technical provisions."

1.2 ICP 14.10 further requires as follows: "The criteria should also allow appropriate interpolation and extrapolation for non-observable market data and maturities. To provide for consistent, reliable, economic values, the criteria for discount rates should utilise the entire interest rate term structure."

1.3 These requirements suggest that the Prudential Authority (PA) extrapolate the PA curve beyond the observable market data and maturities to some future, economically consistent interest rate, namely the ultimate forward rate (UFR).

2. Definition of the UFR

2.1 In the 2019 study conducted by the Society of Actuaries on extrapolation methods (Akinyemi et al., 2019), the panellists loosely define the UFR as the 'infinite-maturity, unconditional forward rate of interest'.

2.2 Barrie and Hibbert (2008: 9) suggest the following principles for estimating the nominal UFR:

2.2.1 The nominal UFR should not be materially affected by short-term economic changes.

2.2.2 The UFR should be globally consistent.

2.2.3 The approach to estimating the UFR should be simple and easy to understand.

2.3 The long-term nominal UFR is typically constructed as the sum of the following components (Akinyemi et al., 2019: 11):

2.3.1 the real expected short-term interest rate;

2.3.2 the long-term expected inflation;

2.3.3 the long-term nominal term premium; and

2.3.4 the long-term nominal convexity effect.

2.4 Connected to the choice of the UFR is an assumption on the period to convergence to the UFR.

3. Current PA practice and industry engagement

3.1 The UFR of the nominal PA curve is currently set at 6.0%, being the upper bound of the South African monetary policy inflation-targeting range of 3.0–6.0%. Thus, the current nominal UFR only constitutes a long-term expected inflation assumption.

3.2 The UFR of the real PA curve is currently set at 1.5%, being half of the difference between the upper and lower bounds of the South African monetary policy inflation-targeting range of 3.0–6.0%.

3.3 The current PA curve allows for convergence at 150 years on both the nominal and the real curves.

3.4 A review of the current PA curve UFR was proposed in the discussion document on the PA's government bond curve review. Several comments were received from industry on the derivation and use of the UFR.

3.4.1 The salient points made by various respondents highlighted that the linking of the nominal and real UFRs to the upper bound of South Africa's inflation target range seems arbitrary and could give rise to uncertainty should the range be amended in future. It was proposed that the UFR should be set in line with current long-term developed market nominal rates, as this would be reflective of South Africa transitioning into a developed economy over time. It was further noted by some respondents that the choice of the UFR conversion time period, currently 150 years, should be supported and reviewed as an economic assumption on a regular basis.

3.5 In addition to the above, several respondents to the discussion document expressed a preference for the approach to determining the UFR used by the European Insurance Occupational and Pensions Authority (EIOPA). This approach is considered below.

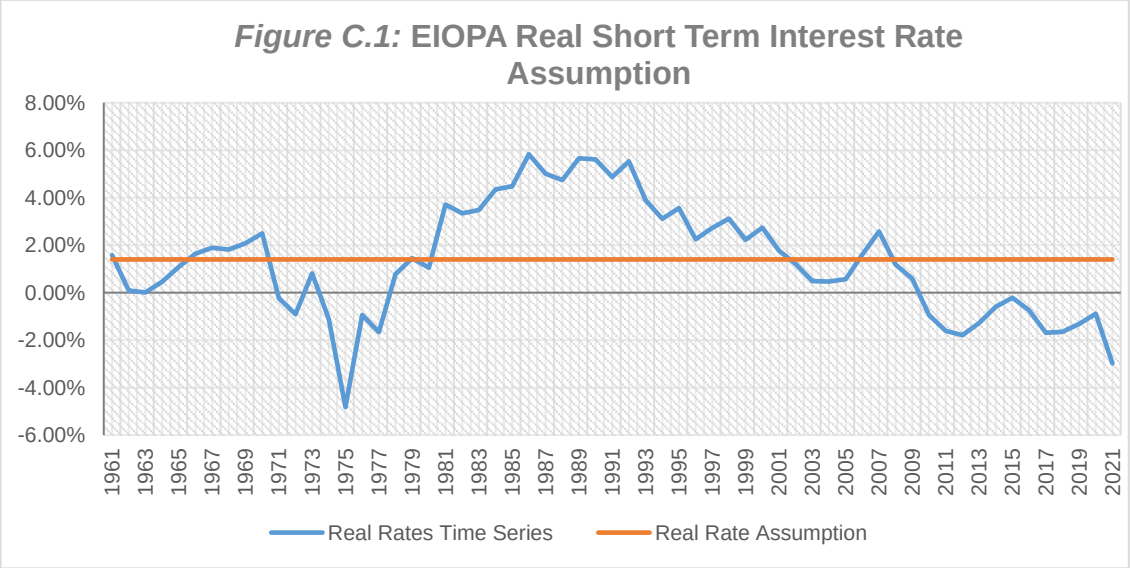
4. International best practice

4.1 EIOPA administers the Solvency II risk-based solvency regime used for supervision in the United Kingdom (UK) and other European jurisdictions. The EIOPA curve construction method[52] determines the nominal UFR as the sum of an expected real rate and an expected inflation rate, by currency. This means that the EIOPA UFR assumption comprises the elements listed in paragraphs 2.3.1 and 2.3.2 of this Annexure.

4.2 The expected real interest rate is calculated as a simple average of the past real rates of a basket of representative countries[53] since 1961. The simple arithmetic mean of annual real rates from these countries is calculated, from 1961 to the year before the recalculation of the UFRs (i.e. with a two-year lag). This means that the expected real rate assumption is the same for all currencies, including the South African rand (ZAR).

4.3 Figure C.1 below shows the history of the real rates used in the derivation of the EIOPA UFR, effective for 2023.

Figure C.1: EIOPA real short-term interest rate assumption



4.4 For the year 2023, the expected real rate is set at 1.40%, derived as above. The calculated expected real rate is rounded off to the nearest 50 basis points and published annually at least six months ahead of each calendar year.

[52] The EIOPA report on the calculation of the UFR for 2023 can be found at: https://www.eiopa.europa.eu/sites/default/files/risk_free_interest_rate/eiopa-bos-22-161-report-on-the-calculation-of-the-ufr-for-2023.pdf

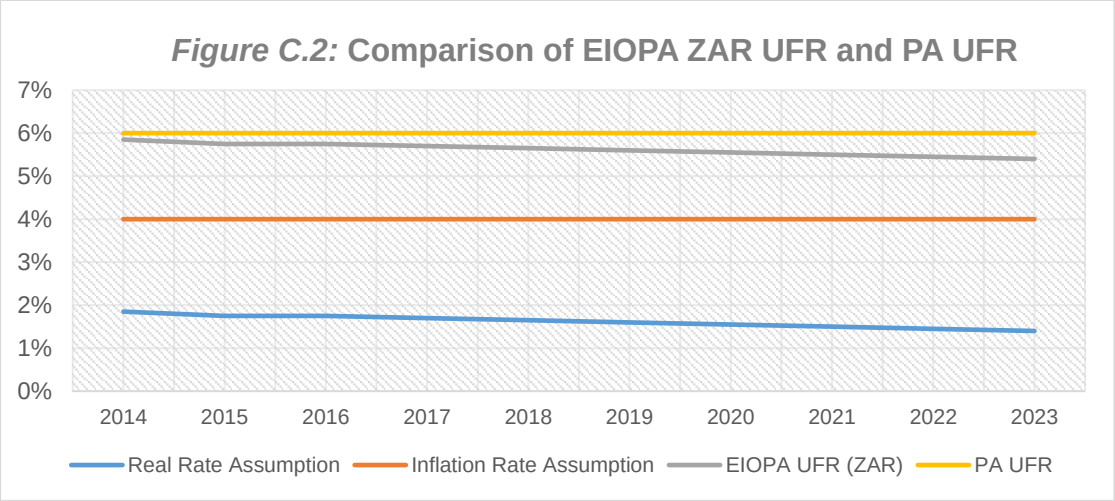
[53] These were Belgium, France, Germany, Italy, the Netherlands, the United Kingdom and the United States.

4.5 The second assumption comprising the EIOPA UFR is the expected inflation rate assumption. The expected inflation rate is currency-specific. It is based on the inflation target of central banks and can take the values of 1.0%, 2.0%, 3.0% or 4.0% depending on the range of the respective central bank's inflation target. For inflation target ranges higher than 4.0%, the value of the expected inflation assumption is set at 4.0%. Thus, for the ZAR, the expected inflation rate is set at 4.0%.

4.6 This means that, for the ZAR, EIOPA determined the UFR to be 5.40% for 2023 in its curve construction.

4.7 Figure C.2 below shows the historical UFR determined by EIOPA for the ZAR and used in the Solvency II ZAR risk-free rates curve construction.

Figure C.2: Comparison of EIOPA ZAR UFR and PA UFR



4.8 Figure C.2 shows the main drawback of the EIOPA approach compared to the current PA approach, which is that the annual UFR determined by EIOPA has been showing a decreasing trend since its adoption for Solvency II purposes. This decrease has been driven by the decreasing and negative real rates observed in the developed market currencies since 2007. In contrast, the PA UFR assumption is a constant 6.0%, as shown above.

5. Alternative derivation of the PA government bond curve UFR

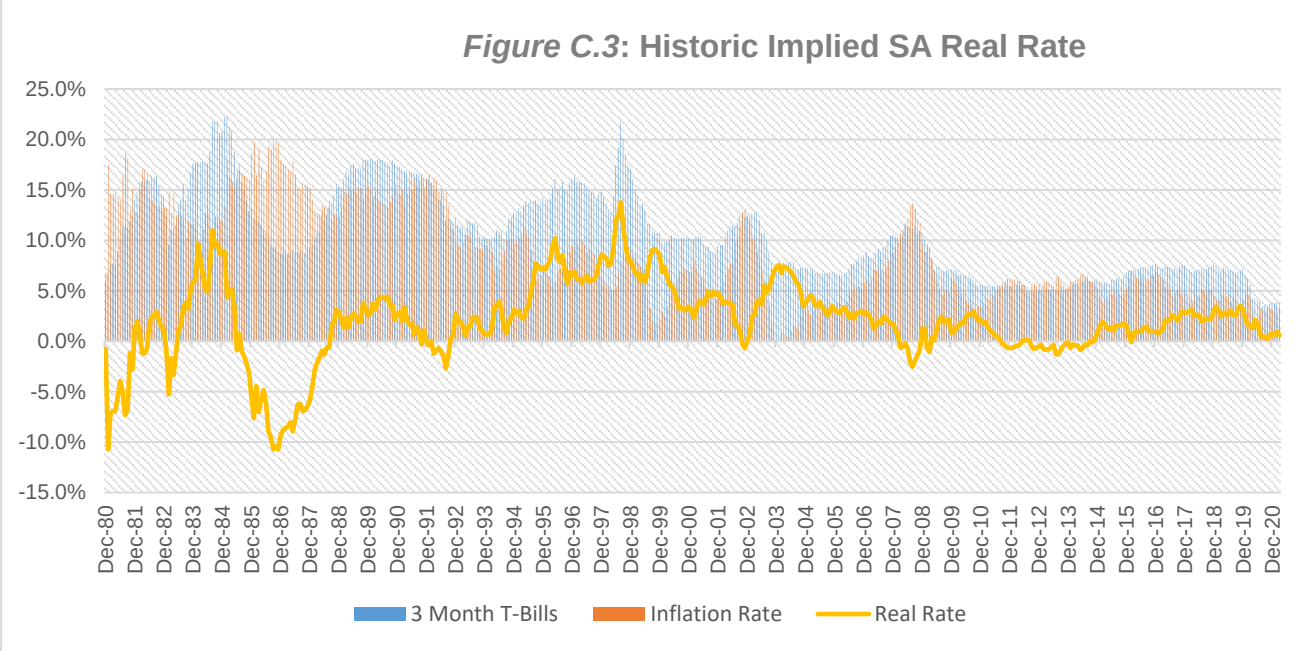
5.1 Given that the derivation of a UFR should ideally be globally consistent, the other elements of the assumption should also be considered. In the following subsections, an analysis is performed on alternative assumptions for each of the components of the UFR.

5.2 The expected real short-term interest rate

5.2.1 The expected real short-term interest rate represents the interest rate that an investor expects to earn in future for an investment held over a short period of time, typically one to three months, net of the expected inflation in the period. As such, this is a non-observable rate that is estimated based on investors' expectations of future short-term rates and the expectations of future inflation. Additionally, the Fisher equation[54] allows us to estimate the prevailing and historical real interest rates through the relationship between the nominal rates and inflation rates.

5.2.2 In South Africa, the real short-term rates have historically been volatile in accordance with the factors affecting rates in emerging market economies. Figure C.3 below shows the implied historical real short-term rates from December 1980 to February 2021.

Figure C.3: Historical implied South African real rate



[54] Fisher, Irving (1907). The Rate of Interest. Mansfield Centre, CT: Martino Publishing (2009); MacMillan (1907).

5.2.3 In the period before 1988, the real rates displayed significant volatility, often negative. This was driven by high inflation resulting from political instability in the country during that period. The period between 1988 and 1998 was marked by increasing real rates which flowed from decreasing inflation trends and economic growth. Though generally decreasing, inflation was still volatile during this period, reaching as high as 14.0% in 1998. In 2000, the South African Reserve Bank (SARB) adopted inflation targeting[55]. This brought inflation levels down to record lows by the year 2003, bringing the real short-term rate to a level below 5.0%. The real short-term rates became negative again in 2008–2009 following the global financial crisis which pushed inflation, albeit temporarily, beyond the upper limit of the inflation target range. After this market shock, inflation has generally stayed within the SARB's inflation target range, with a few temporary breaches.

5.2.4 The arithmetic mean of the South African historical real rates from February 2000 (the period coinciding with the adoption of the SARB's current monetary policy) to February 2021 is 1.90%.

5.2.5 Future expected real short-term rates required in the derivation of the UFR may, however, be different from past rates. This is especially true for emerging market economies where future economic conditions are expected to be different from past conditions in line with a country's growth agenda. Thus, an assumption is typically made that, in the long term, emerging market economies will converge to developed market economies with respect to growth and structural factors such as employment rates. This assumption allows for the adoption of a developed market expected short-term real interest rate assumption as a proxy for the emerging market expected short-term real interest rates.

5.2.6 On the other hand, in an economic note titled 'Revisiting [emerging market] economic development and convergence', SARB Economist Jean-François Mercier (2022: 41)[56] notes the following:

> *Economic convergence of [emerging markets] towards rich countries' income levels has improved in recent decades; yet it is far from being the norm and may prove more challenging in coming years in an environment of slow global potential growth and rising protectionist pressures. The fast convergence of China in the last few decades appears an exception that will be hard to match. Better macro policies and improved governance may not be sufficient to shift a country like South Africa onto a significantly higher growth path. In the longer run, stronger growth – that reverses the widening income gap between [South Africa] and high-income economies (or successful [emerging markets]) – may require a reallocation of resources to higher-productivity sectors.*

[55]A short background on the SARB's inflation targeting is available at: https://www.resbank.co.za/en/home/what-we-do/monetary-policy/inflation-targeting-framework

[56]South African Reserve Bank Occasional Bulletin of Economic Notes OBEN/22/01. This paper is available at: https://www.resbank.co.za/en/home/publications/publication-detail-pages/occasional-bulletin-of-economic-notes/2022/occasional-bulletin-economic-notes-2201-revisiting-emerging-mark

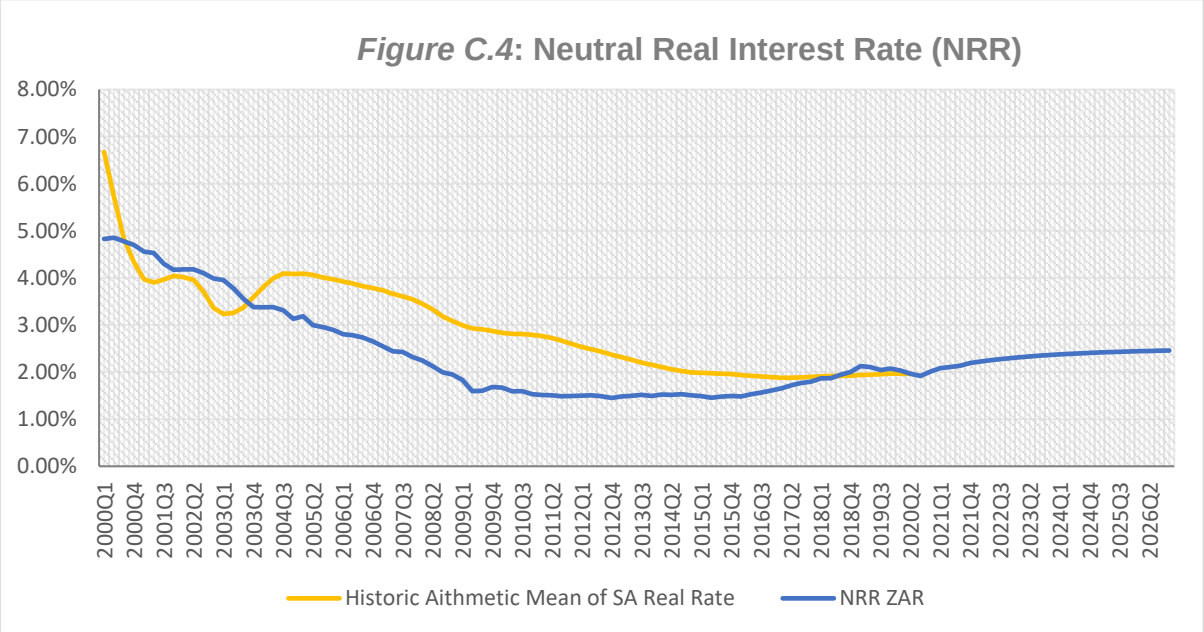
5.2.7 The above implies that the assumption of South Africa's convergence to developed economies may require conditions such as stronger economic growth and changes to resource allocation by government. In the long term, however, these conditions can be assumed to hold, given the general growth agenda of the South African government. The adoption of the EIOPA expected real short-term rate assumption would thus be in line with this assumption.

5.2.8 An alternative to the historical implied real rate would be some form of forecast of the expected short-term real rate. In this regard, the neutral real interest rate (NRR) was considered. "A neutral real interest rate provides a broad indication of the level of real interest rates where monetary policy is neither contractionary nor expansionary. In this sense a neutral real interest rate can be thought of as a benchmark" (Archibald and Hunter, 2001).[57]

5.2.9 As part of its monetary policy implementation, the SARB's Monetary Policy Committee (MPC) estimates South Africa's NRR and describes it as 'a key variable to determine the appropriate stance of monetary policy'.[58]

5.2.10 Figure C.4 shows a comparison of a time series of the historical arithmetic mean of the implied real short-term rates with the NRR published by the SARB MPC, at each quarter.

Figure C.4: Neutral real interest rate



[57] The paper "What is the neutral real interest rate, and how can we use it?" by the Economics Department in the Reserve Bank of New Zealand can be found here: https://www.rbnz.govt.nz/-/media/f8acef7c3ad7428e89e43294cdbfd063.ashx?sc_lang=en

[58] The QPM assumptions summary table May 2022 MPC can be accessed: https://www.resbank.co.za/content/dam/sarb/publications/statements/monetary-policy-statements/2022/statement-of-the-monetary-policy-committee-may-2022--/Assumptions%20May%202022.pdf

5.2.11 The main advantage of the NRR is that it displays lower volatility over time. This is because it is a theoretical rate that indicates monetary policy being at an equilibrium (neither expansionary nor contractionary). Additionally, the MPC provides a four-year forecast of the NRR quarterly. This is a step towards a forward-looking assumption for the expected real short-term rates, in contrast to the backwards-looking historical implied real short-term rates.

5.2.12 In April 2022, the MPC determined the NRR for the fourth quarter of 2026 as 2.50% (rounded up to the nearest 50 basis points).

5.2.13 One of the drawbacks of using the NRR is that it is an unobservable rate which is estimated using models and assumptions of factors such as the 'domestic net savings and investment, South Africa's country risk premium, and the potential growth rate of our trading partners' (Kuhn, Ruch and Steinbach, 2019)[59]. This is undesirable for use in the UFR as it will tend to violate the global consistency principle of the UFR.

5.2.14 Given the highlighted features of each of the alternative rates above (namely the EIOPA-derived, South African historical and NRR rates), the EIOPA-derived expected real short-term interest rate bears the most consistency with the requirements of setting an appropriate assumption for the PA curve UFR.

5.3 The long-term expected inflation

5.3.1 The inflation target is set by the Minister of Finance in consultation with the Governor of the SARB. Since 2017, the MPC has been emphasising that the ideal would be for inflation to be close to the 4.5% midpoint of the 3.0–6.0% inflation target range.[60]

5.3.2 This means that inflation rates above the midpoint ought to be corrected for by the MPC, although they may lie within the broader 3.0–6.0% target range. This would imply that an appropriate long-term expected inflation rate for South Africa might be 4.5% rather than either the lower or the upper bounds of the target range.

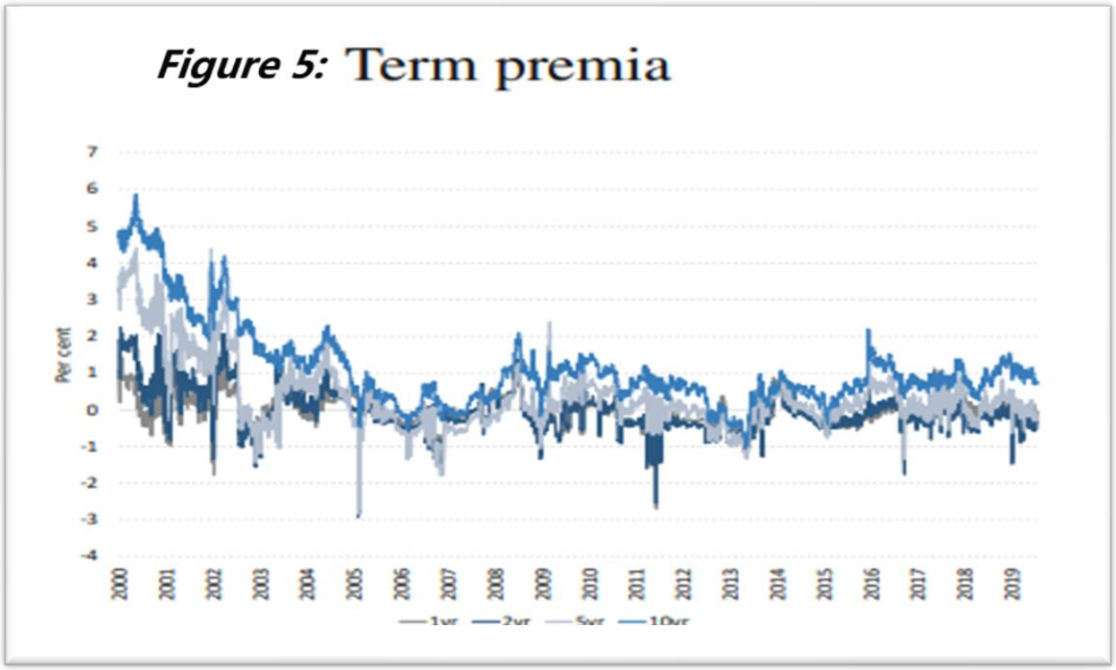
5.4 The long-term term premium and convexity effect

5.4.1 In their working paper titled 'Term premium and rate expectation estimates from the South African yield curve', SARB Economists Soobyah and Steenkamp (2020)[61] estimate the term premium embedded in the South African yield curve.

5.4.2 Figure C.5 below shows the historical term premium estimates across the different tenures (i.e. 1 year, 2 years, 5 years and 10 years).

[59] Reaching for the (r)-stars: estimating South Africa's neutral real interest rate: https://www.resbank.co.za/en/home/publications/publication-detail-pages/working-papers/2019/9097
[60] A brief background on the SARB's monetary policy can be read here: https://www.resbank.co.za/en/home/what-we-do/monetary-policy
[61] The paper 'Term premium and rate expectation estimates from the South African yield curve' can be accessed here: https://www.resbank.co.za/en/home/publications/publication-detail-pages/working-papers/2020/9998

Figure C.5: Term premiums



5.4.3 Figure C.5 shows that the term premiums have been decreasing in the short period leading up to 2019. The premiums increase with increasing tenure, as expected. The real expected short-term interest rate assumption should be added to the long-term expected inflation rate. For the 10-year tenure, the term premium was estimated to be approximately 1.5% at the end of the sample.

5.4.4 The authors observe that 'analysts tend to focus on a 10-year horizon when estimating the term premium, and the estimate at this horizon is the most volatile, given higher uncertainty at a long horizon' (Soobyah and Steenkamp, 2020). As such, estimates for tenures longer than 10 years (for the purpose of deriving the UFR) are not readily available.

5.4.5 Given the difficulty in deriving the term premium, methodologies such as those adopted by EIOPA ignore this effect for simplicity. For the discounting of insurance technical provisions, this is also prudent as it assumes a lower long-term nominal rate.

5.5 The period to convergence

5.5.1 The use of the PA curve for the valuation of insurance technical provisions is based on the principle of market-consistent valuation, set out in the prudential standards. As such, it is desirable that the PA curve, as far as possible, reflects the market-related forward rates.

5.5.2 The use of the UFR in the PA curve slightly deviates from this principle as it sets a point beyond which the forward curve lies at a fixed, predetermined level. As such, it is desirable that the period to convergence to the UFR is set far enough into the term structure to allow for the most use of the market-related rates within the liquid portion of the curve, while also retaining the economic relevance of this assumption.

5.5.3 The EIOPA regime sets this as the maximum between the last liquid point plus 40 years and 60 years. For the South African jurisdiction, this method would imply a point of convergence of 65 years, as the last liquid point on the current constituents is 25 years (for the R2048) based on bond data as at 31 July 2022. This would mean that, after 65 years, the forward curve would be constant or near constant at the asymptote of the UFR, depending on the extrapolation method.

5.5.4 From an economic perspective, the research set out in paragraphs 5.2.6 and 5.2.7 above implies that the period to convergence to developed market economic fundamentals might be longer-dated for South Africa as an emerging market jurisdiction. This suggests that a longer-period-to-convergence assumption might be appropriate for the PA curve.

5.5.5 The current PA approach allows for convergence at the 150-year point of the curve. However, the drawbacks of the current approach are detailed in the discussion document. Thus, a proposal is made to amend the period to convergence to 120 years (illustrated in the supplementary figures below as Figure C.7 and Figure C.8, reflecting the following:

5.5.5.1 the structural challenges facing South Africa’s path to convergence to developed market jurisdictions;

5.5.5.2 the preference for a higher weighting to observable market data in the liquid portion of the curve; and

5.5.5.3 the average duration of the longest-termed liabilities found in the insurance sector.

6 Summary and conclusions

6.1 Having considered the parameters comprising the UFR as well as the possible parameter assumptions that can be made, the PA may consider the following alternatives.

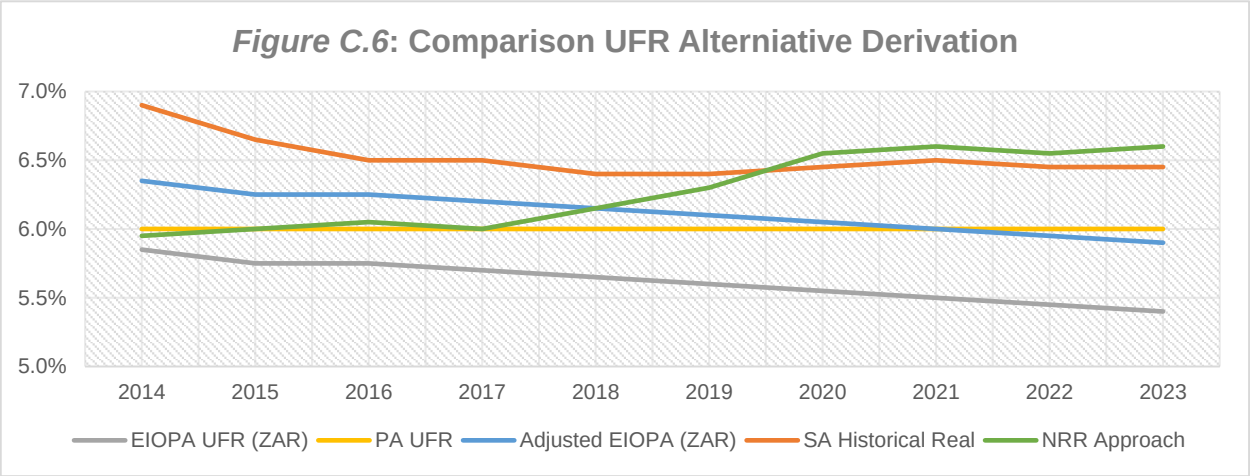
Table C.1: Summary of derivation of the UFR under different options

	Option 1	Option 2	Option 3	Option 4	Option 5
Option description	Current PA approach	EIOPA approach	Adjusted EIOPA approach	South African historical mean real rates	NRR approach
Expected real rate assumption	1.5%	1.40% (determined annually)	1.40% (determined annually)	1.90% (determined annually)	2.50%
Inflation rate assumption	6.0%	4.0% (fixed)	4.5% (SARB inflation rate target)	4.5% (SARB inflation rate target)	4.5% (SARB inflation rate target)
Term premium and convexity	n/a	n/a	n/a	n/a	n/a
Real UFR 2023	**1.50%**	**1.40%**	**1.40%**	**1.90%**	**2.50%***
Nominal UFR 2023	**6.00%**	**5.40%**	**5.90%**	**6.40%**	**7.00%**

***This is based on the NRR forecast for 2026**

6.2 Figure C.6 below compares the historical UFR under the different options.

Figure C.6: Comparison of UFR alternative derivation



6.3 The adjusted EIOPA approach shown in the tables and figure above is a combination of all the preferred components of the UFR highlighted in sections 5.2.14, 5.3.2 and 5.4.5. The Swiss Financial Market Supervisory Authority (FINMA) uses a similar method to determine the UFR under its risk-based supervisory regime, wherein the Solvency II UFR is adjusted by 30 basis points for the non-Swiss currencies.

7. Practical considerations

7.1 The most significant practical implication for the PA to consider under the alternative methods is the variable nature of the UFR. Under the alternative approaches, the UFR requires periodic (e.g. annual) re-estimation and communication. This variability would impact upon the valuation of technical provisions by insurers with longer-dated liabilities.

7.2 As highlighted in the discussion document, the PA currently manages the data set of the PA curve through a quarterly constituent review process. This process could be expanded to account to the annual review and publication of the UFR.

8. Recommendations

8.1 Having considered the alternatives available to the PA, the following is recommended:

8.1.1 Given the analysis set out in section 5.2 above, the EIOPA-derived expected real short-term interest rate should be adopted as the assumption for the PA curve UFR as it bears the most consistency with the principles of setting this assumption.

8.1.2 The long-term expected inflation rate for the PA curve should be set at 4.5% rather than either the lower or the upper bound of the inflation target range.

8.1.3 No term or convexity premiums should be included in the assumption.

8.1.4 The term of convergence to the UFR will be set at 120 years.

8.1.5 The UFR for each calendar year be determined in the PA's quarterly curve assessment process in the fourth quarter of the previous calendar year. As such, the updated UFR would be communicated alongside the PA curve published.

References

Akinyemi, K., Kerbeshian, J., Leiser, B. & Matson, P., 2019. *Society of Actuaries: Yield Curve Extrapolation Methods.* [Online]
Available at: https://www.soa.org/globalassets/assets/Files/resources/research-report/2019/yield-curve-report.pdf
[Accessed 30 June 2022].

Archibald, J. & Hunter, L., n.d. *Reserve Bank of New Zealand: What us the Neutral Real Interest Rate, and How Can We Use It?.* [Online]
Available at: https://www.rbnz.govt.nz/-/media/f8acef7c3ad7428e89e43294cdbfd063.ashx?sc_lang=en
[Accessed 30 June 2022].

Barrie, A. & Hibbert, J., 2008. *A framework for estimating and extrapolating the term structure of interest rates. Exposure draft.* [Online]
Available at: http://janroman.dhis.org/finance/Curves%20%20Interpolation/A_Framework_for_Estimating_and_Extrapolating_the_Term_Structure.pdf
[Accessed 01 July 2021].

EIOPA - Supervisory Process Department, 2022. *EIOPA: Report on the Calculation of the UFR for 2023.* [Online]
Available at: https://www.eiopa.europa.eu/sites/default/files/risk_free_interest_rate/eiopa-bos-22-161-report-on-the-calculation-of-the-ufr-for-2023.pdf
[Accessed 30 June 2022].

European Insurance and Occupational Pensions Authority, 2021. *Technical documentation of the methodology to derive EIOPA's risk-free interest rate term structures.* [Online]
Available at: https://www.eiopa.europa.eu/sites/default/files/eiopa-bos-21-475-technical-documentation.pdf
[Accessed 30 June 2022].

Fisher, I., 2009. *The Rate of Interest.* Mansfield(MAssachusetts): Martino Publising; MacMillan.

International Association of Insurance Supervisors, 2022. *IAIS.* [Online]
Available at: https://www.iaisweb.org/
[Accessed 30 June 2022].

International Monetary Fund, 2019. *Technical Note - Insurance Regulation and Supervision.* [Online]
Available at: https://www.sipotra.it/wp-content/uploads/2019/06/No.-19-185-SWITZERLAND.pdf
[Accessed 30 June 2022].

Mercier, J.-F., 2022. *Occasional Bulletin Economic Notes 2201 Revisiting Emerging Markets Economic Development and Convergence June 2022.* [Online]
Available at: https://www.resbank.co.za/content/dam/sarb/publications/occasional-bulletin-of-economic-notes/2022/occasional-bulletin-economic-notes-2201-revisiting-emerging-markets-economic-development-and-convergence-june-2022.pdf
[Accessed 30 June 2022].

Soobyah, L. & Steenkamp, D., 2020. *South African Reserve Bank: Term premium and rate expectation estimates from the South African yield curve.* [Online]
Available at: https://www.resbank.co.za/content/dam/sarb/publications/working-papers/2020/9998/WP-2003.pdf
[Accessed 30 June 2022].

South African Reserve Bank, 2022. *Inflation Targeting Framework.* [Online]
Available at: https://www.resbank.co.za/en/home/what-we-do/monetary-policy/inflation-targeting-framework
[Accessed 30 June 2022].

South African Reserve Bank, 2022. *Summary assumptions May 2022 MPC.* [Online]
Available at:
https://www.resbank.co.za/content/dam/sarb/publications/statements/monetary-policy-statements/2022/statement-of-the-monetary-policy-committee-may-2022--/Assumptions%20May%202022.pdf
[Accessed 30 June 2022]

Supplementary figures

Figure C.7: Comparison of shorter convergence period – nominal

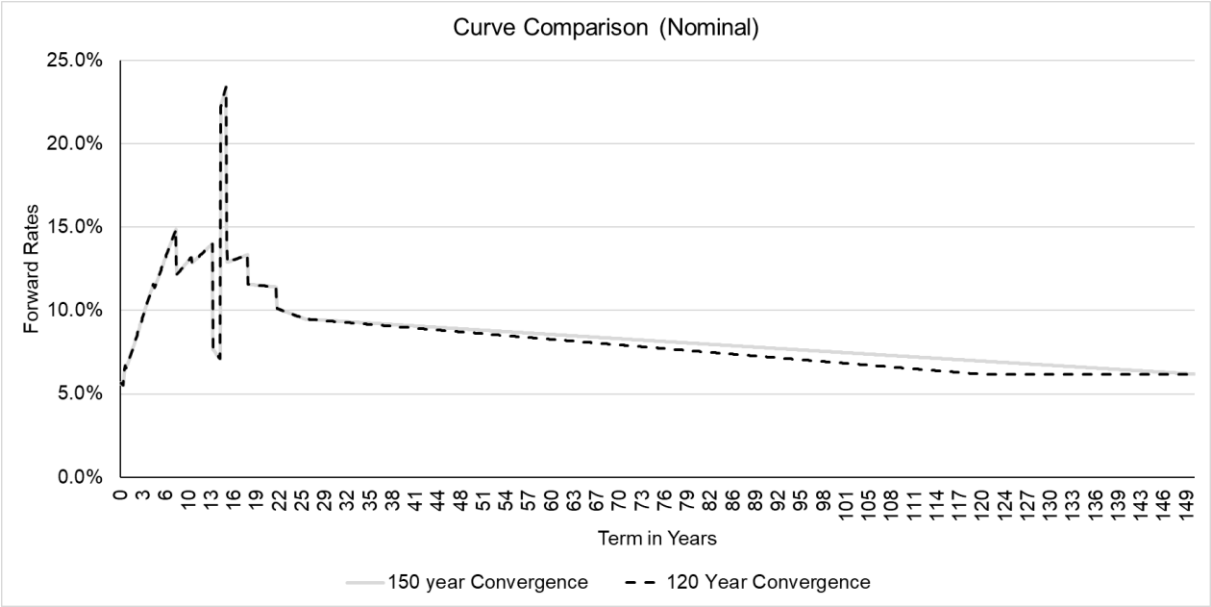
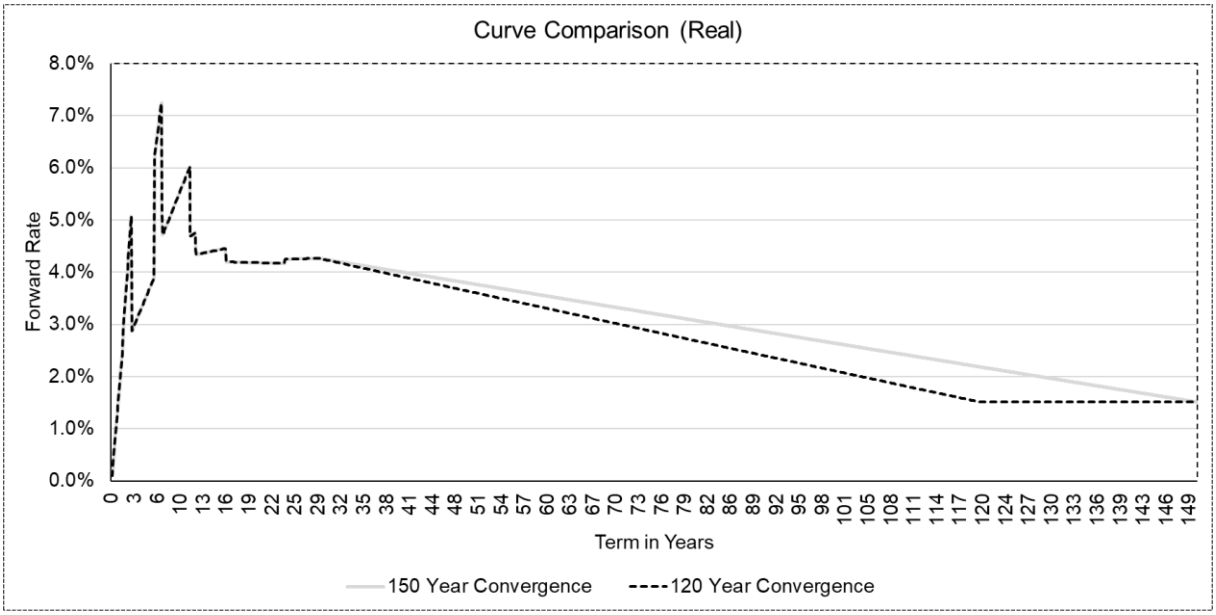


Figure C.8: Comparison of shorter convergence period – real



Annexure D: Historical comparison of the Prudential Authority government bond curve and the Smith-Wilson curve

Figure D.1 and D.2 below show the monthly deviations of the forward rates under the Prudential Authority (PA) curve and the Smith-Wilson curve for the nominal and real rates respectively. The Smith-Wilson curve is fitted as specified in section 4.7 above. For each calendar month, the monthly deviation over the annual tenures in the liquid portion of the curve is shown for comparative purposes. In each case, the maximum and minimum deviation scale shown is 10% and -10% respectively.

Figure D.1: Quarterly deviations of nominal forward rates

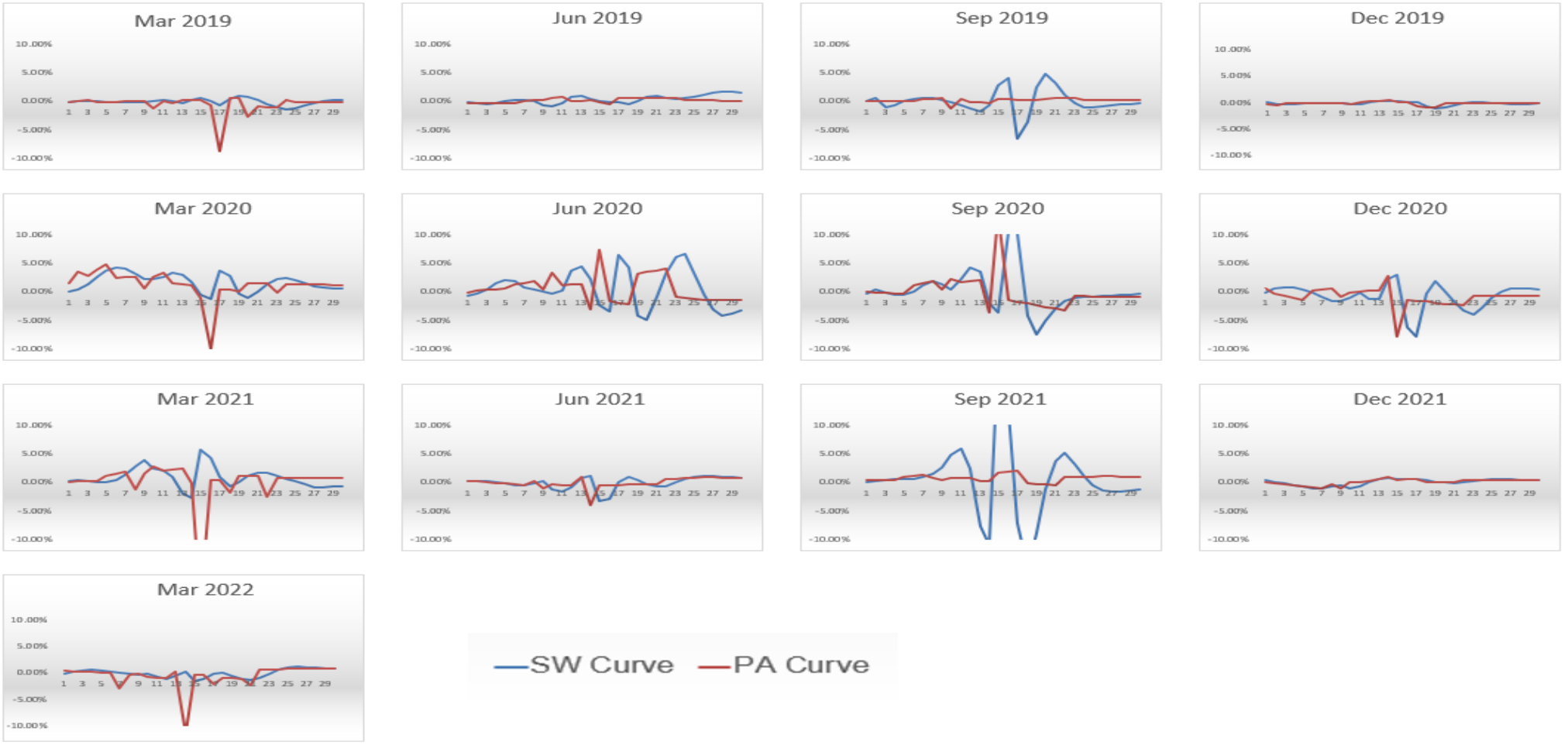


Figure D.2: Quarterly deviations of real forward rates