Review of the Risk-Based Capital Framework for Insurers in Singapore ("RBC 2 Review")

Second Consultation

Follow-up Response on

Risk Free Discount Rate

By

Singapore Actuarial Society

20th March 2015

SINGAPORE ACTUARIAL SOCIETY
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20th March 2015

Ms. Lee Keng Yi
Head, Insurance Department
Monetary Authority of Singapore
10 Shenton Way
MAS Building
Singapore 079117

Dear Ms. Lee

Re: Follow-up Response on Risk Free Discount Rate

Review of the Risk-Based Capital Framework for Insurers in Singapore ("RBC 2 Review") – Second Consultation [Consultation Paper P003-2014]

The Singapore Actuarial Society ("the Society") has in July 2014 submitted its response to MAS' second Consultation Paper on the RBC 2 Review. In that response, the Society committed, amongst other things, to conduct further research on risk free discount rate used for insurance liability valuation.

This document sets out the research findings by the Society's Discount Rate Working Party under the Life Insurance Committee. It also contains the tentative proposals by the members of the Working Party on the design and calibration of discount rate rules under RBC2. These proposals should be further tested in the upcoming QIS2 to confirm their appropriateness and practicality. Views expressed in this document represent a professional standpoint and not those of the employers of, or other parties receiving advice from, the Society's members.

The Society will be publishing this document on its website and it will be available to the public.

If you have any question on this document or wish to discuss its content further, please contact **president@actuaries.org.sg** or **secretary@actuaries.org.sg**.

Yours sincerely,

Choo Oi San
President 2015/2016
Singapore Actuarial Society

Raymond Cheung
Chair, RBC 2 Taskforce & Hon. Secretary 2015/2016
Singapore Actuarial Society

About the Singapore Actuarial Society

The Singapore Actuarial Society was formed in 1976. At that time, the profession was little known in Singapore and there were only a handful of qualified actuaries. The adoption of the new Constitution in July 1996 and the Code of Professional Conduct in November 1997 were the fruition of efforts made in the previous two decades to promote the study of actuarial science and professional standards.

The Society is the recognised representative body of the actuarial profession in Singapore, having the final authority in the setting of professional standards. The objectives of the Society are:

- to uphold the highest professional standards among members;
- to serve the public's interest in matters we are uniquely qualified to respond on;
- to promote the study, discussion, publication and research into the application of economic, financial and statistical principles to practical problems, the actuarial, economic and allied aspects of life assurance, non-life insurance, employee retirement benefits, finance and investment with particular reference to Singapore and the ASEAN region;
- to assist students in the course of their actuarial studies;
- to further the professional development of actuaries; and
- to foster and encourage social relationship among the members.

Our office is located at 163 Tras Street, #07-05 Lian Huat Building, Singapore 079024. Please visit our website www.actuaries.org.sg for more information.

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1. Background and Scope

The Monetary Authority of Singapore ("MAS") issued the Second Consultation Paper on RBC2 on 26 March 2014.

A RBC2 Special Taskforce ("the Taskforce") was set up[1] at the request of the Council of the Singapore Actuarial Society ("the Society") to deliberate on MAS' latest proposal. After gathering the views of the Society's membership, the Society issued a response paper to MAS on 4 July 2014. The Society has committed in that response to conduct further research on several areas of the RBC2 framework, including the risk free discount rate used for insurance liability valuation, which is the subject matter of this document.

The research on risk free discount rate was conducted by the Society's Discount Rate Working Party under the Life Insurance Committee. Views expressed in this document reflect the majority view of the Working Party's members. They are expressed from a professional standpoint and do not represent those of the employers of, or other parties receiving advice from, the Society's members. A summary of the proposals in this document can be found in Appendix 1. The list of members of the Working Party can be found in Appendix 2.

Much of the discussions in this document focus on the risk free discount rate used to value Singapore Dollar-denominated insurance liabilities. However, similar principles and approaches may be applied to the valuation of insurance liabilities denominated in other currencies.

The Society has provided its views in July 2014 on how the illiquid nature of insurance liabilities should be recognized by introducing some form of volatility adjustment ("VA") and modifying the rules for matching adjustment ("MA"). While VA and MA are not the main focus of this document, this document will discuss how the design and operations of VA and MA should be impacted by any change in risk free discount rate calculation method.

The principles and approaches described in this document are applicable to insurers undertaking life, general, and/or health insurance business; and to insurers acting as direct writers and as reinsurers.

The Working Party noted that the issue of risk free discount rate has been intensively researched on and debated in recent years as insurance regulators around the world seek to modernise their solvency regimes. Amongst the research reviewed by the Working Party, two papers issued by the European Insurance and Occupational Pensions Authority ("EIOPA") offered the most comprehensive and recent discussion on the topic. They are:

- Issues paper: "Determination of the risk free interest rate term structure for Solvency II" (March 2012)
- "Technical document regarding the risk free interest rate term structure." (February 2015)

[1] A similar Taskforce was set up in June 2012 to respond to the first RBC 2 Consultation Paper issued by MAS on 22 June 2012. The Taskforce has provided a report on the consolidated comments of the RBC 2 Review in August 2012. The report can be found in the following link: http://actuaries.org.sg/?q=node/4361

The Working Party has relied on these EIOPA papers as the starting point of its discussion, with appropriate adjustments for the context in Singapore and to areas where the discount rate could better reflect the characteristics of the liabilities being valued.

This document is solely directed to the RBC 2 Review and may not necessarily be applicable to other solvency regimes in jurisdictions outside of Singapore.

Proposals on the design and calibration of discount rate rules contained in this document should be viewed as the Working Party's current thinking. These proposals should be further tested in the upcoming QIS2 to confirm their appropriateness and practicality. The Working Party would review its proposals after its members have gained more insights during QIS2.

Section 2 sets out the guiding principles underlying the proposals in this document.

Section 3 describes the data used in this study to develop proposals related to SGD risk free discount rate term structure; and discusses how these data are applied to determine the entry point of yield curve extrapolation.

Section 4 discusses the choices for interpolation/ extrapolation methodologies, setting of extrapolation targets, and establishing criteria for desirable extrapolation methodology-parameter combinations.

Section 5 explores to what extent recommendations made in Sections 3 and 4 for discount rate term structure of SGD-denominated liabilities should apply for non-SGD-denominated liabilities.

RBC2 will give some recognition to the illiquid nature of insurance liabilities. Section 6 tackles how credit for illiquid premium should be extrapolated.

Interest rate mismatch risk is a major source of capital requirement for many life insurers. Section 7 explains how the proposals in Sections 2 to 6 should influence the design and calculation of interest rate mismatch risk requirement.

2. Guiding Principles

In the Society's July 2014 response paper, the Society expressed its wish to help refine the method used to calculate the risk free discount rate for the valuation of insurance liabilities. Of particular concern was MAS' proposal to phase out the current "Long-term Risk Free Discount Rate" ("LTRFDR") mechanism when the growth in supply of long-dated Singapore Dollar-denominated bonds may not be able to keep pace with the growth in insurance liabilities written by insurers in Singapore.

The Society's Discount Rate Working Party believes that it is important to establish a set of principles to guide RBC2's interest rate discussion. Modifying from EIOPA's issues paper, the Working Party proposes the following set of principles that the term structure of discount rate should observe:

- Continuity and smoothness. The term structure should be theoretically and economically sound. As the term structure reflects an expectation about future economic conditions, it would be natural to assume that any forecasted change in economic condition would move smoothly as the forecast horizon increases. (Conversely, it is unreasonable to assume that market participants can develop a consensus view that certain "jump" in economic conditions would occur at a particular point in time decades into the future.) The term structure of discount rate should therefore progress smoothly, not only for spot rates, but also for forward rates. The Working Party does not intend to interpret "smooth" in a very strict sense (e.g. requiring the spot rate curve to be continuously differentiable). However, the forward rate should at least not spike or see sudden dip from year to year – a phenomenon that often occurs in methodologies that focus on extrapolating spot rates.

  In relation to theoretical and economic soundness, Solvency II requires discount rate to be arbitrage-free. However, as market-consistency was not listed as an objective of RBC2, there is no need to introduce the concept of arbitrage-free in the determination of discount rate term structure.

- Robustness and stability. The methodology should produce curves that avoid artificial volatility in valuation and provide for a reasonable variation over time. The question of what is "natural" volatility and what is "artificial" volatility often arise at, or shortly before, the extrapolated part of the term structure. Volatility is more likely to be artificial if it is triggered by pro-cyclical behaviour. (For example, sudden drop in long-dated government bond yields put pressure on life insurers' capital ratios, prompting more demand for those papers, further depressing yield.) Volatility is also likely to be artificial if, owing to the extrapolation methodology, a small change in the last part of the market yield curve leads to a larger change to the extrapolated section.

- Accuracy. The methodology should provide a good fit to liquid market data.

- Transparency and practicability. The methodology should be fully transparent, easy to apply and accessible to insurers so that insurers can produce the entire discount rate term structure on their own.

- Incentives. The methodology should not give inappropriate risk management incentives.

Proposals in this document are developed using above as guiding principles.

While it is not the focus of this document to discuss how illiquid nature of insurance liabilities should be reflected in the discount rate used, the Working Party noted that many of the principles listed above should also apply to the discount rate term structure that includes illiquidity adjustments.

3. SGD-Denominated Liabilities: Data and Entry Point of Extrapolation

Data

MAS has maintained its stance in both rounds of RBC2 consultations that SGD-denominated liabilities are to be valued using risk free term structure derived from Singapore Government Securities ("SGS") as the starting point. The Working Party therefore assumes that other information about Singapore's interest rate environment, such as SGD swap rate, are not admissible under RBC2.

Information about SGS used in this paper has been extracted from MAS website and Bloomberg. Data about potential demand for SGS from insurers in Singapore are extracted from insurance returns available on the MAS website.

Entry Point of Extrapolation

As SGS yield data are available for maturities up to 30 years, this sets the absolute upper bound on the entry point to extrapolate the SGD discount rate term structure.

However, where the market for certain maturities is not sufficiently deep, liquid and transparent, yield data may not give a reliable picture of the expectation about future economic conditions. Longer maturities tend to have a higher risk of experiencing a lack of market depth, liquidity and transparency. When that happens, entry point of extrapolation should be brought forward. The Working Party interprets the concepts of market depth, liquidity and transparency as follows:

- Depth. A market with sufficient depth is one where transactions involving a large quantity of bonds can take place without significantly affecting the price.

- Liquidity. A liquid market is one where bonds can readily be converted through an act of buying or selling without causing significant movement in price. The Working Party is aware that another commonly-used definition of liquidity focuses on the ability of sellers to convert an instrument into cash. "Liquidity risk" is often discussed with this in mind, where the availability of buyers in stressed market conditions is assessed. Under such alternative definition, the situation where buyers significantly outnumber sellers may be perceived as excessive liquidity. Both definitions of liquidity are used in this paper. Where it relates to finding an appropriate entry point of extrapolation, liquidity assessment aims to determine if interest rate data in question give a reliable picture of the expectation about future economic conditions. The first definition of liquidity applies. Where it relates to the liquidity characteristics of insurance liabilities (for example in the discussion in Section 6), the alternative definition is adopted.

- Transparency. A transparent market is one where current trade and price information is readily available to the public, especially to insurers.

EIOPA relied on the following measures to assess at what point in the term structure that interest rate data no longer come from a deep, liquid and transparent market.

- Bid-ask spread;
- Trade frequency: number of trades that take place within a defined period of time;
- Trade volume;
- Trader quotes/dealer surveys (incl. dispersion of answers);
- Quote counts: (1) number of dealer quotes within a few day window; and (2) number of dealers quoting;
- Number of pricing sources;
- Assessment of large trades and movement of prices (depth);
- Residual volume approach ("RVA"); and
- Rates volatility.

Only analysis of rates volatility and bid-ask spread, and implementation of RVA (which requires information about volume of outstanding SGS) are possible using publically available information about SGS.

Information about the 20-year and 30-year benchmark SGS issues are downloaded from Bloomberg. Data since the introduction of these maturities are used. [Bloomberg Tickers for 20-year SGS: EG202147 Corp (from 26 Feb 2007), EI383082 Corp (from 27 Aug 2010), and EJ801575 Corp (from 28 Aug 2013). 30-year SGS: EJ104368 Corp.] To put the results into perspective, information for the 30-year US Treasury benchmark in the last decade are also downloaded from Bloomberg. [Bloomberg Tickers for 30-year UST: 912810FT/ PU/ PX/ QD/ QL/ QT/ QY/ RD/ RJ Govt.] The following sub-sections set out the findings of each analysis. These analyses may be expanded to cover other established sovereign bond markets such as UK Gilts and German Bunds, and possible the swap markets which are EIOPA's focus, after MAS publishes the next RBC2 consultation paper.

Volatility Analysis

This analysis is conducted for rates directly observed in the markets – both on the level of rates and the behaviour of volatility. For volatility, EIOPA considered rates volatility over a rolling 21-day window[2].

[2] The following formulation is used:

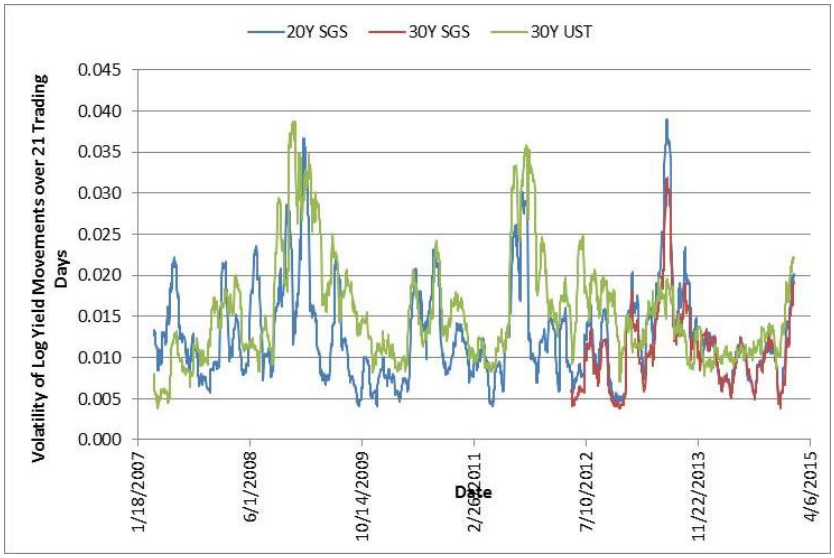
Volatility = standard deviation of natural logarithms of variations

$= \sqrt{\sum \frac{(ln(c_i) - \overline{lnc})^2}{n-1}}$ where $ln(c_k) = ln\left(\frac{rate_k}{rate_{k-1}}\right)$ and $\overline{lnc}$ identifies the simple average of the last 21 daily logarithmic changes. Note that no t^(0.5) adjustment is applied in order to achieve annual volatilities. This has no impact of the conclusions to the extent that the analysis aims at comparing volatilities, not at assessing its values on annual basis.

The Working Party reviewed how rates at the chosen maturities have behaved; and in particular looking out for the lack of/ presence of repeated sudden changes in the level of volatility and the range of variations. Comparisons are also made between the long-dated SGS and US Treasury markets.

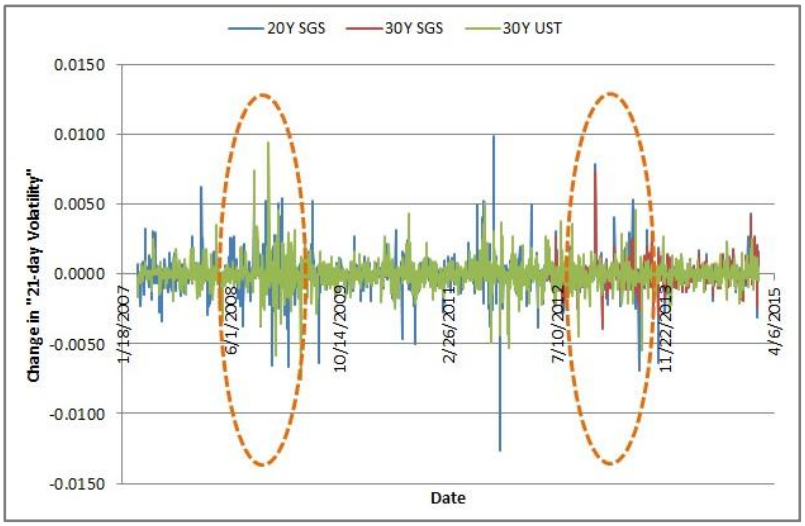
The first chart shows the rates for 20-year and 30-year SGS benchmark, and the 30-year US Treasury benchmark, between February 2007 and January 2015. Generally, long-dated SGS and US Treasuries have moved in the same directions over the investigation period, although the magnitude of movements differ somewhat. 30-year US Treasury rates have been trading higher than 30-year SGS benchmark until recently.

The second chart shows how the rolling 21-day volatility changes over the same period. 30-year US Treasury has exhibited slightly higher volatility than long-dated SGS in general. Volatility has roughly spiked at the same time, with the exception of an episode in June-July 2013 where a spike in SGS volatility reading was observed without similar moves in the US market. This spike is caused by long-date SGS rates selling off from a relatively lower base vis-à-vis US Treasury.



These two charts did not suggest significant difference in the depth, liquidity and transparency of between the long-dated SGS and US Treasury markets.

The Working Party went a step further to analyse the rate of change in 21-day volatility. The third chart shows that under "normal" market condition, the long-dated SGS and US Treasury markets are not significantly different. Rate of change for SGS benchmarks are only mildly higher than the US Treasury benchmarks. However, the differences are more pronounced during times of stress, especially during 2013 when yield suddenly spiked. While this is not a disqualifying criterion, it implies that the SGS market is not as stable as the US, and may exhibit larger swings.

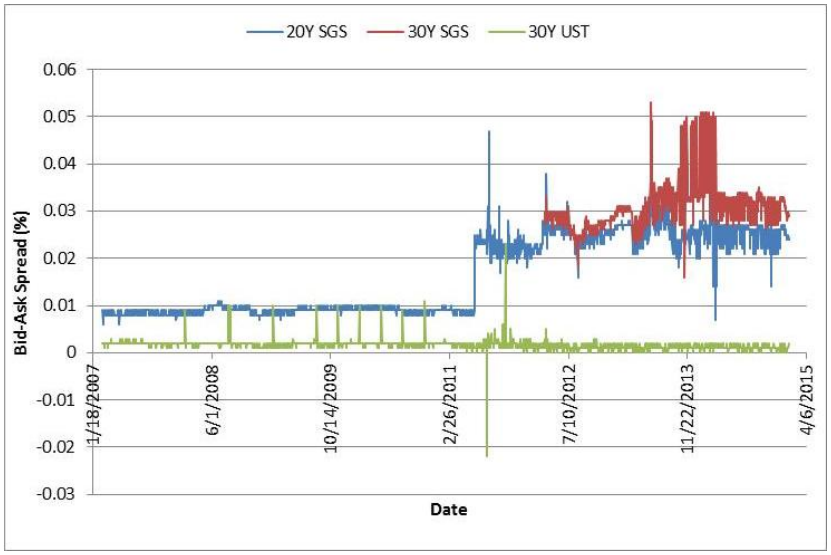


Bid-ask Spread

The Working Party then turned its attention to the statistics for bid-ask spread. Bid-ask spreads for the 20-year and 30-year benchmark SGS issues, as well as the 30-year benchmark US Treasury issues, are downloaded from Bloomberg. The tables below show some key statistics. The first table covers a longer investigation horizon, while the second table covers a shorter horizon (i.e. from 2012) that is aligned to the availability of data for the 30-year SGS benchmark.

Bid-Ask Spread	**SGS 20Y Benchmark (from 2007)**	**SGS 30Y Benchmark (from 2012)**	**UST 30Y Benchmark (from 2004)**
Median	1.0 bps	3.1 bps	0.2 bps
0.5 percentile	0.8 bps	2.3 bps	0.0 bps
99.5 percentile	3.8 bps	5.1 bps	1.0 bps
Bid-Ask Spread	**SGS 20Y Benchmark (from 2012)**	**SGS 30Y Benchmark (from 2012)**	**UST 30Y Benchmark (from 2012)**
Median	2.6 bps	3.1 bps	0.1 bps
0.5 percentile	1.4 bps	2.3 bps	0.0 bps
99.5 percentile	4.0 bps	5.1 bps	0.3 bps

Bid-ask spread information indicates that the liquidity of 30-year SGS benchmark is a fair bit poorer compared to 20-year SGS and 30-year US Treasury, with much wider median spread. The following chart show the historical bid-ask spread movements:



Residual Volume Approach

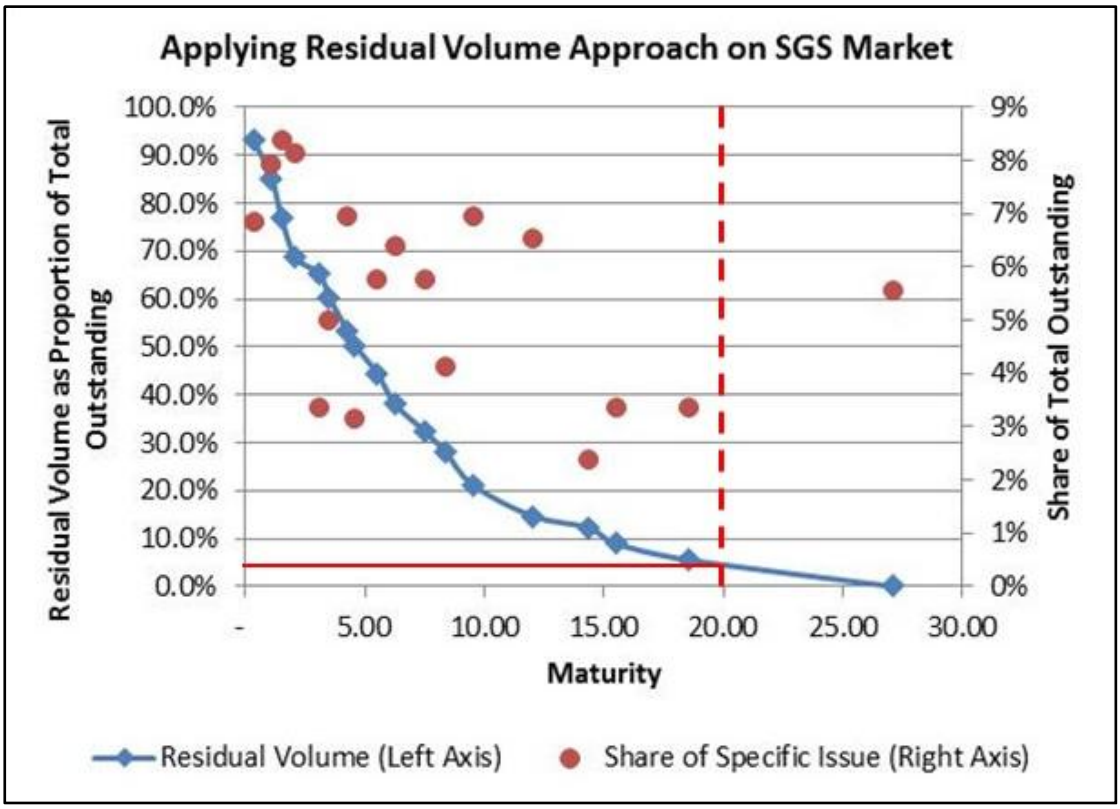
Other than looking at bid-ask spread, EIOPA relied on a criterion called Residual Volume Approach ("RVA"). More specifically, RVA tries to identify the maturity at which the market for bonds ceases to be deep and liquid, and beyond which insurers are no longer able to match their cash flows effectively with bonds.

The RVA criterion is defined by a pre-specified threshold of x% of residual bond volume (= percentage of the total bonds outstanding in the market with residual maturity longer than a designated duration). The bond market will be considered deep and liquid as long as the residual bond volume exceeds the threshold. Thus the entry point of extrapolation would be located where the residual bond volume is close to x%. For SGS, the residual bond volume could be derived from information about outstanding SGS published on the MAS website. A snapshot of that information on 3 Mar 2015 is shown below.

Maturity	Issue Code	Issue Date	Amount (S$ m)	Term to Maturity (Years)	Residual Volume (S$ m)	Residual Volume to Total Outstanding
1/7/2015	N708100S	1/7/2008	6,300	0.33	85,700	93.2%
1/4/2016	N511100W	1/4/2011	7,300	1.08	78,400	85.2%
1/9/2016	NY01100F	3/9/2001	7,700	1.50	70,700	76.8%
1/4/2017	N710100Z	1/4/2010	7,500	2.08	63,200	68.7%
1/4/2018	N513100T	1/4/2013	3,100	3.08	60,100	65.3%
1/9/2018	NY03100A	1/9/2003	4,600	3.50	55,500	60.3%
1/6/2019	NX09100W	1/6/2009	6,400	4.25	49,100	53.4%
1/10/2019	N514100H	1/10/2014	2,900	4.59	46,200	50.2%
1/9/2020	NY05100N	1/9/2005	5,300	5.51	40,900	44.5%
1/6/2021	NX11100X	1/6/2011	5,900	6.25	35,000	38.0%
1/9/2022	NY07100X	3/9/2007	5,300	7.51	29,700	32.3%
1/7/2023	NX13100H	1/7/2013	3,800	8.34	25,900	28.2%
1/9/2024	NY09100H	1/9/2009	6,400	9.51	19,500	21.2%
1/3/2027	NZ07100S	1/3/2007	6,000	12.01	13,500	14.7%
1/7/2029	NY14100E	1/7/2014	2,200	14.34	11,300	12.3%
1/9/2030	NZ10100F	1/9/2010	3,100	15.51	8,200	8.9%

Maturity	Issue Code	Issue Date	Amount (S$ m)	Term to Maturity (Years)	Residual Volume (S$ m)	Residual Volume to Total Outstanding
1/9/2033	NZ13100V	2/9/2013	3,100	18.52	5,100	5.5%
1/4/2042	NA12100N	2/4/2012	5,100	27.10	0	0.0%

The diagram below demonstrates how this approach works.



If the RVA threshold of x% is set at 6%, then, for the SGS market, entry point of extrapolation should start at a maturity of around 20 years because less than 6% of the total outstanding SGS have maturities beyond 20 years. Legislations governing Solvency II prescribed a threshold of 6% for EUR-denominated liabilities. EIOPA suggested that the threshold of x% should be set with due regard to the volume of available bonds versus liabilities to be covered for the respective maturities. The Working Party therefore conducted additional investigation into the profile of insurance liabilities written by Singapore insurers.

Data on Singapore insurers' liabilities at different maturities cannot be directly observed from the statutory returns submissions published on MAS' website. Some crude assumptions have to be made to estimate the value of long-dated liabilities currently on insurers' books. The Working Party has adopted the following approach:

- Insurers' statutory return submissions for Year 2013 from the MAS website were used.

- Long-dated liabilities are defined as liabilities with maturities of about 20 years or higher. As a result, only information about life insurance business is extracted. It is recognized that non-life business may have long-tailed claims liabilities, especially for casualty business. However, when compared to the size of long-dated liabilities from life business, contribution from non-life business would not materially change the conclusion of the study.

- Investment-linked business of life insurers are excluded from the study. While most investment-linked policies are for whole-of-life, insurers' benefits and operating expense outgoes are generally well matched against fees and charges deducted from the policies. This reduces the need for prefunding and hence the demand on long-dated SGS.

- For participating and non-participating business, the Working Party focuses on the present value of benefits and expenses outgoes found in Form 14 of the statutory returns. The Working Party believes that the demand for SGS will likely be driven by the guarantees that insurers have written because guaranteed benefits are valued using discount rate curve derived from SGS. Present value derived on Minimum Condition Liability ("MCL") basis is therefore used for participating business. Information compiled from returns of various insurers can be found in Appendix 3.

- Only part of the liability cash flows belong to the longer maturities. The table below sets out the assumptions about the proportion of present value of benefits and expenses that need to be backed by long-dated SGS for each product group. These assumptions are chosen based on Working Party members' judgement and their understanding of liability profiles gathered through their work experience.

Product Group	**Proportion of Present Value of Benefits & Expenses Assumed to be from Longer Maturities**	**Comments**
Whole life (except single premium whole life products in non-participating fund)	50%	Benefits and expense outgoes tend to increase with duration in-force. Outgoes in early policy durations can be covered by future premium income; but outgoes in later policy durations will need to be prefunded. This need is growing as "limited-pay" products become more popular in the market.
Single premium whole life products in non-participating fund	0%	Most of the liabilities in this category belong to universal life products that are usually denominated in USD, which tend not to create demand for long-dated SGS. Setting an assumption of 0% for this category may slightly understate the demand for long-dated SGS but is unlikely to affect the overall conclusion.

Product Group	Proportion of Present Value of Benefits & Expenses Assumed to be from Longer Maturities	Comments
Annuity	50%	About one-thirds of the outgoes in this category come from non-participating fund. Most of which relates to annuity purchased with CPF monies and are already paid up. Life assureds are likely to be near retirement or at retirement. Two-thirds of the outgoes are from participating annuities, concentrated on a couple of insurers. Profile of life assureds are expected to be similar to their non-participating counterparts.
Endowment	0%	While some endowment products can have maturity going up to 40 years, most are likely to be below 20 years. Setting an assumption of 0% for this category will understate the demand for long-dated SGS somewhat, but is unlikely to affect the overall conclusion.
Term / Accident & Health	0%	Majority of regular premium protection products do not require significant prefunding. Premium inflows are generally sufficient to cover projected outgoes. There are some exceptions, including ElderShield (the national long-term care scheme), “term to 100” products and limited-pay riders. Setting an assumption of 0% for this category will understate the demand for long-dated SGS somewhat, but is unlikely to affect the overall conclusion.
Others	0%	This category accounts for less than 5% of the total present value of benefits and expenses compiled. They are more likely to be protection-oriented products. The assumption is set to 0% to avoid overstating the projected demand for long-dated SGS.

- Using the assumptions above, it is estimated that there are about $25bn worth of guaranteed benefits and expenses at the longer maturities that that need to be funded by life insurers as at end-2013. To put this into perspective, as at end-2013, total policy liability for participating (MCL basis) and non-participating fund, which is net of future premium inflows, was $68bn.

- The estimated amount of guaranteed benefits and expenses at the longer maturities is sensitive to the assumptions used. A couple of different sets of assumptions are tested to for illustrative purpose. The results are set out in Appendix 3.

The 20-year and 30-year SGS benchmark issues have a combined outstanding amount of $8.2bn as end-Mar 2015 – about a quarter of the $25bn estimated amount of guaranteed benefits and expenses at the longer maturities as at end-2013. Note that the value of liability for non-investment-linked business of life insurers has been growing at a compounded rate of 6.8% p.a. between 2009 and 2013. The difference between supply of long-dated SGS and demand generated by long-dated insurance liabilities may therefore widen in future.

In the Society's July 2014 response to RBC2 consultation, it was highlighted that according to the Asian Development Bank, the total outstanding SGD-dominated corporate bonds stood at $116bn at end-2013, of which only about 10% (about $10bn) is above 10 years. Arguably, insurers could back some of its long-dated guaranteed liabilities with such corporate bonds instead of SGS. The incentive to do so will however be driven by the design of the capital requirements. The Society has highlighted the need for a viable VA framework, and MAS' proposed rules for MA need to be changed to admit more matching instruments and relax the matching criteria. All these measures would help alleviate the supply crunch of long-dated SGS that insurers face.

Returning to the question of finding an appropriate threshold of x% for SGS, if long-dated guarantees have to be backed by SGS in full, the estimated volume of $25bn would point to setting the threshold at around 30%. This implies that extrapolation should start at a maturity of about 8 years under RVA. The threshold can be significantly lower if more practical solutions for VA and MA can be found for RBC2. Without prejudicing the outcome of the VA and MA discussions, the Working Party decided to tentatively adopt the same RVA threshold used by EIOPA, i.e. 6%. This implies that extrapolation should start at a maturity of about 20 years under RVA.

Summary of Recommendations

Where the market for certain maturities is not sufficiently deep, liquid and transparent, yield data may not give a reliable picture of the expectation about future economic conditions. When that happens, entry point of extrapolation should be brought forward.

Both RVA and the bid-ask spread analysis gave some indication that rates information about 30-year SGS may not come from a market that is sufficiently deep and liquid. The Working Party does not yet have sufficient conviction to recommend that extrapolation of the RBC2 SGD risk free discount rate curve should start at a maturity of 20 years. However, the Working Party will recommend MAS to at least consider the appropriateness of doing so based on the information it has about future supply of long-dated SGS, growth in insurers' long-dated liabilities, and how RBC2's VA and MA rules would support the use of corporate bonds to match long-dated liability cash flows. MAS may adopt a similar investigation approach as that adopted by the Working Party, but with more accurate information that MAS would have access to.

The Working Party also recommends that MAS review the entry point of extrapolation once every three years. A three-year review cycle is appropriate given the likely pace of change for the SGS market and insurers' liability profile. It also offers some stability for insurers' risk management and planning processes. Insurers should be given sufficient lead time to implement any change in entry point of extrapolation.

4. SGD-Denominated Liabilities: Interpolation and Extrapolation Methodology

Methodology Choices

Under current RBC requirements, risk free discount rate term structure is determined using a mixture of interpolation and extrapolation methodologies for different segments of the yield curve. More specifically,

- For maturities up to 15 years, insurers generally download market yield information for those maturities where benchmark spot rates are available, and apply linear interpolation to the data to obtain spot rate for the maturities in between.

- A LTRFDR[3] is calculated and used as the spot rate for maturities 20 years and above, giving a flat term structure from that point onwards.

- For maturities between 15 and 20 years, a linear interpolation between the 15-year spot rate and the LTRFDR.

The proposed RBC2 requirement in the second consultation retains this mixed methodology feature; ultimately holding the 30-year spot rate flat for cash flows at longer maturities; and moving the linear interpolation range from Year 15-20 to Year 20-30.

In contrast, there are methods available to determine the entire term structure (both before and after the point where data from deep, liquid and transparent market is available) using a single analytical formula. These methods include:

- Nelson-Siegel method where the forward rate is expressed as a single formula with three terms – long-run interest rate, a short-term component and a medium-term component – and an additional parameter governing how quickly rates decay toward the long-term rate level. Parameters to the Nelson-Siegel formula are determined using least-squares or similar regression techniques to obtain the best fit to the spot rates observed in the market. However, it does not guarantee that the resultant function will pass through all spot market yields observed.

- Smith-Wilson method, which was adopted by EIOPA given its ability to achieve market-consistent results. Parameters for the Smith-Wilson method are determined to ensure that forward rates progress smoothly through the term structure, decay towards some ultimate forward rate after the last liquid point in the dataset, and the term structure results in bond prices that exactly match bond prices observed in the market.

The Working Party considered the appropriateness these methodology choices for the purpose of RBC2, given the guiding principles set out in Section 2. There are pros and cons to each choice. Even for the Smith-Wilson method that EIOPA has adopted, EIOPA noted

[3] See MAS Notice 319, available on MAS Website, for how LTRFDR shall be calculated.

several key weaknesses[4] in the methodology. The Working Party therefore decided against recommending the adoption of any specific methodology, but has instead noted the following:

- The Working Party is indifferent whether the entire term structure is determined using the same formula, or different methods are used for different segments of the term structure.

- The term structure should pass through all the data points in the set of observed market yield for SGS. This therefore rules out the use of Nelson-Siegel method.

- It is inappropriate to hold the spot rate constant after the entry point of extrapolation (referred to as the Last Liquid Point, or "LLP" thereafter) for several reasons.

    - Note that by breaking down the spot rate term structure into implied forward rates, it conveys an expectation about future economic environment. Volatility of forward rate at very long maturities should be low as the consensus view should be formed based on long-term macro-economic study about future real interest rate and inflation. Adding one year's worth of data to the inputs to such study should not change these estimates significantly from year to year. With MAS' proposal for RBC2 to ultimately hold the 30-year spot SGS yield flat for longer maturities, the implied forward rate at the very long end will inherit the volatility of implied forward rate at Year 30. This feature is undesirable. It is preferred for volatility to gradually taper off towards the longer maturities.

    - Volatility of forward rate shortly after the LLP should be similar to the volatility of forward rate shortly before the LLP as the consensus view of future economic conditions 20-30 years from the valuation date is unlikely to be very precise. Discrepancy in volatility of forward rates before and after LLP is more pronounced under current RBC regime. Volatility of LTRFDR, and hence the volatility of implied forward rates that affect discounting of cash flows beyond Year 20, has been low historically. The drop in rates volatility over the 5-year interpolation period can be drastic.

    - Sudden fall in rates volatility is challenging from a risk management perspective. Insurers seeking to avoid accounting volatility may be tempted to use short term bonds to back their long-dated liabilities because they exhibit similar volatility in present value. However, this offers poor incentives for managing the real economic risk. Where an insurer wishes to minimize such economic mismatch, it has to apply for the cash flow/ fair value hedging carve out available in MAS Notice 319, thereby dropping the LTRFDR and replacing it with current market yield of the 30-year SGS. As explained earlier, the current approach is undesirable. The insurer also has to sacrifices some operational flexibility when it comes to its investment management in the process.

[4] Key issues with Smith-Wilson method include (1) translating small changes in rates in the last part of the liquid market data into large changes of the extrapolated yield curve; (2) fitted bond price may sometimes be an increasing function of time to maturity, especially for the interpolated segment of the yield curve; and (3) fitted bond price may become negative when interest rate at last liquid point is significantly higher than ultimate forward rate. See discussions in EOIPA's issues paper: "Determination of the risk free interest rate term structure for Solvency II" (March 2012).

- These observations lead the Working Party to recommend introducing the Ultimate Forward Rate ("UFR") feature and defining how long after the LLP should the forward rates converge to UFR[5] when deriving the discount rate term structure for RBC2.

Determining Ultimate Forward Rate

EIOPA is of the opinion that the most important economic factors explaining the long-term forward rate, and hence the estimate of UFR, are long-term expected inflation and expected real interest rates. Two other components that can be seen to influence the long-term forward rate are expected long-term nominal term premium and long-term nominal convexity effect.

Term premium represents the additional return an investor may expect on risk free long dated bonds relative to short dated bonds, as compensation for the longer term investment. This factor can have both a positive and a negative value, as it depends on liquidity considerations and on preferred investor habitats. (Liquidity assessment of long-dated SGS market has already been discussed in Section 3.)

Convexity effect arises due to the non-linear (convex) relationship between interest rates and the bond prices used to estimate the interest rates. This is a purely technical effect and always results in a negative component.

Both the term premium and the convexity premium can only be estimated from unobservable data in the extrapolated part of the curve. They would introduce a strong element of unpredictability in the estimation of UFR. In order to have a robust and credible estimate for the UFR, EIOPA believes that the assessment shall be based only on the estimates of expected inflation and expected real rate – the two components that are deemed to be most relevant, most stable and most reliable.

The Working Party agrees with EIOPA's approach.

EIOPA, in its technical document on risk free rate[6], went on to document its research on each of the two components driving UFR – inflation and real interest rate.

On inflation, EIOPA looked at inflation data between 1994 and 2013 from OECD database and inflation data between 1994 and 2010 from Eco-Win (Reuters) database. Data from selected key economies that were extracted from EIOPA's paper can be found in Appendix 4. EIOPA then classifies economies into standard, low and high inflation groups and assign a long-term inflation rate assumption to each group.

- Low inflation group. It contains Japan and Switzerland; and is assigned a long-term inflation assumption of 1% p.a.. Average inflation rates for the two countries were 0% p.a. and 0.7% p.a. respectively over the investigation period. Japan's deflation and Switzerland's safe haven status were cited as additional justifications.

[5] While the UFR feature and convergence rules exist in the Smith-Wilson methodology, it should not be interpreted as the Working Party recommending the adoption of the Smith-Wilson approach.

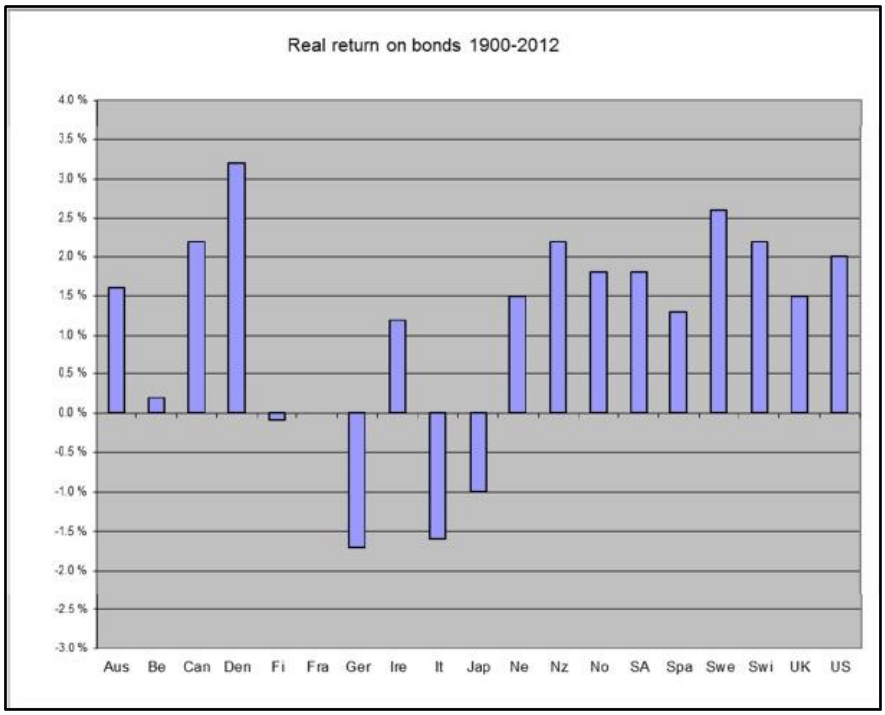
[6] "Technical document regarding the risk free interest rate term structure." (February 2015)

- High inflation group. It includes countries like India and South Africa. Average inflation rates for the two countries were 7.5% p.a. and 6% p.a. respectively over the investigation period. Inflation for countries in this group has been persistently high.

- Standard inflation group. This group is assigned a long-term inflation assumption of 2% p.a.. This seems reasonable compared to the average inflation of countries in this group over the investigation period, including U.S. (2.4% p.a.), U.K. (2.2% p.a.), Germany (1.6% p.a.), France (1.6% p.a.), Hong Kong (1.7% p.a.), South Korea (3.5% p.a.) and Singapore (1.5% p.a.).

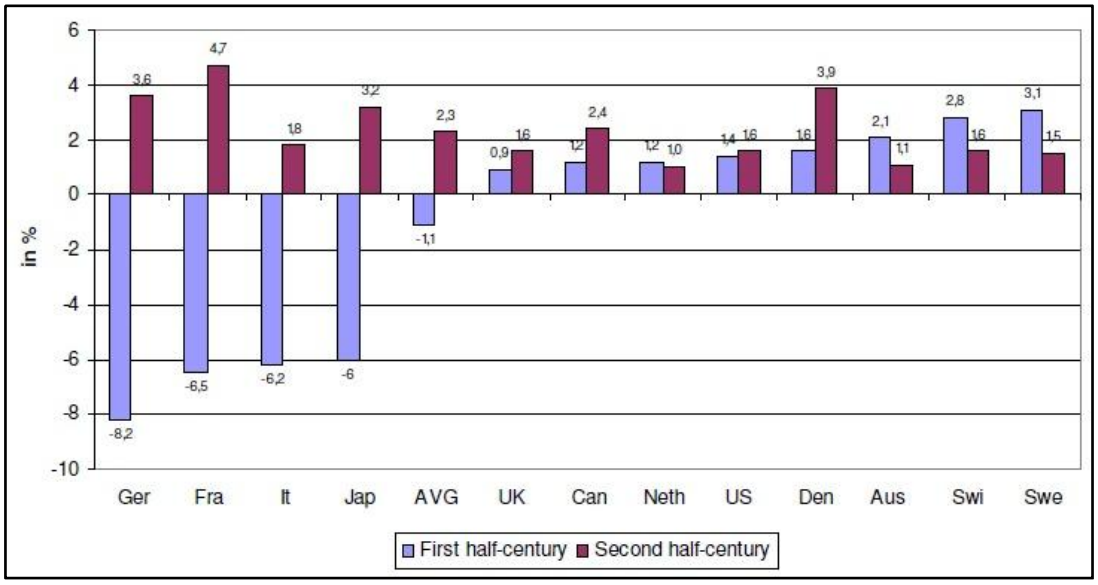
The Working Party noted that these estimates developed by EIOPA covers one-year inflation rate 70-100 years from now. There is a risk that inflation differences seen today and the last 20 years may not persist 100 years into the future. However, this Working Party is still of the opinion that it is not unreasonable to assign Singapore to the standard inflation group together with other developed economies; and to use 2% p.a. as Singapore's long-term inflation rate assumption in RBC2 for a start. This assumption may be reviewed in future if there is increasing evidence that long-term inflation rate environment has changed.

Next, on the estimate of long-term real interest rate. EIOPA referred to two publications[7] by Elroy Dimson, Paul Marsh and Mike Staunton of real interest rate of 19 economies since the 20th century: Belgium, Italy, Germany, Finland, France, Spain, Ireland, Norway, Japan, Switzerland, Denmark, Netherlands, New Zealand, UK, Canada, US, South Africa, Sweden and Australia. The diagram below shows that most countries' bonds gave a positive real return, except four which can be explained due to high inflation or hyperinflation in the early 20th century. The global diversified real return was 1.8% p.a..



[7] Dimson, Marsh and Staunton – Credit Suisse Global Investment Returns Yearbook 2013. Elroy Dimson, Paul Marsh and Mike Staunton, The Millennium Book: A Century of Investment Returns, ABN AMRO/LBS, 2000 Copyright © Dimson, Marsh & Staunton – ABN AMRO/LBS.

The diagram below shows the breakdown of real return in the first and second half of 20th century. The average real bond return over the second half of the 20th century was computed as 2.3% p.a. (compared to -1.1% p.a. for the first half of the 20th century).



EIOPA has chosen a long-term real return assumption of 2.2% p.a., close to the average seen in the second half of 20th century. The Working Party finds that in the absence of any war assumed to happen during the projection horizon, it is not unreasonable to set the assumption of Singapore's long-term real interest rate at 2.2% p.a. in RBC2 for a start. Again, this assumption may be reviewed in future.

Combining the two components – long-term inflation rate of 2% p.a. and long-term real interest rate of 2.2% p.a. – the Working Party therefore recommends testing a UFR of 4.2% for SGD-denominated liabilities as a start in QIS2 of RBC2.

When RBC2 is in operation, UFR should be reviewed once every three years as UFR are not expected to be volatile. It also offers some stability for insurers' risk management and planning processes. Insurers should be given sufficient lead time to implement any change in UFR.

Setting Speed and Method of Convergence

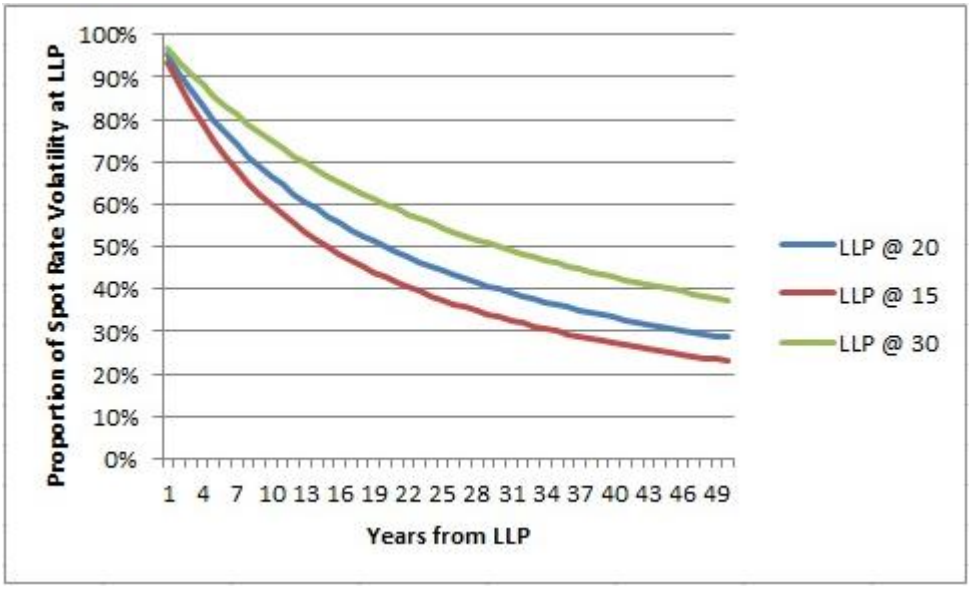
As noted earlier, on one hand, the quick (i.e. within 5 years) convergence towards LTRFDR under current RBC requirements creates disincentives to properly manage economic mismatch. On the other hand, if forward rate after LLP converges too slowly towards UFR, discount rate used to value very long-dated liabilities could be too volatile compared to how long-term inflation and real interest rate expectations evolve. A balance needs to be struck.

For Solvency II, EIOPA required forward rates to converge to UFR 40 years after LLP if LLP is at least 20 years. For currencies with LLP of less than 20 years, forward rates converge to UFR at Year 60. Parameter α in the Smith-Wilson method controls how forward rates asymptotically trend towards UFR between LLP and target year of convergence. These parameter choices represent the negotiated consensus in Europe on how to achieve a balance between various calibration objectives.

For the purpose of valuing SGD-denominated liabilities in RBC2, the Working Party finds it useful to develop its own approach to assess if a certain combination of target convergence year and convergence method is appropriate.

The Working Party starts from a risk management angle. Consider a liability cash flow beyond the LLP. If the discount rate extrapolation method causes the volatility in the present value of this cash flow to be similar to volatility in the value of short-term SGS, the extrapolation method is unlikely to be appropriate. To encourage proper economic matching, the volatility in the present value of this liability cash flow should be similar to the volatility in the value of a risk free zero coupon bond with a residual maturity equals to LLP.

Now assume that LLP is set at 20 years; and it is observed that the mean and standard deviation of 20-year risk free zero coupon yield are 3% and 1% respectively. Record the percentage change in value of a 20-year zero coupon bond when yield moves from the mean up/down one standard deviation. (In this case, bond price changes -17.6% and 21.5% for upward and downward rates movement respectively.) Back-solve for the implied standard deviation of zero-coupon yield at Year X after LLP that would produce the same percentage change in the present value of a liability cash flow a Year X. For example, for the present value of a liability cash flow at Year 50 (i.e. 30 years after LLP) to change by -17.6% when 50-year spot rate move up by one standard deviation, the standard deviation would be about 0.4%, or 40% (=0.4/1) of the standard deviation at LLP. The blue line in the diagram below plots how this proportional reduction in implied spot rate volatility changes going into the longer maturities when LLP is set at 20 years. Tests conducted by the Working Party showed that such proportional reduction in rate volatility is not sensitive to the mean and standard deviation of yield at LLP, but it is sensitive to which year is picked as the LLP. The red and green lines in diagram below show how the implied volatility would reduce proportionately if LLP is set as Year 15 and 30.



The Working Party believes that the glide path shown in the diagram above can be used to assess the appropriateness of any extrapolation methodology-parameter combination. More specifically, if an extrapolation method-parameter combination causes spot rate volatility to drop off too quickly in the term structure when compared against the glide path above, the extrapolation method-parameter combination will likely cause poor incentives for proper

economic matching. This glide path therefore forms some sort of soft lower bound for rate volatility tapering.

Recall that taking spot rate volatility at LLP all the way through to the end of the discount rate term structure will lead to excessively volatile in forward rate at very long end. This is inappropriate because consensus view about future real interest rate and inflation should come from macro-economic study and is expected to move only gradually. Therefore, in addition to having a lower bound to volatility of extrapolated rates, some upper bound needs to be defined. The Working Party turns to how EIOPA came to its conclusion about UFR, and how volatile estimates of UFR would be if the assessment is refreshed annually. This would then drive the volatility of extrapolated spot rate.

First, the long-term inflation component. Starting with inflation data found in Appendix 4 extracted from OECD and Eco-Win, data related to economies from the high and low inflation groups are removed. Also removed are data for G7, OECD - Europe and OECD – Total to avoid double-counting. This leaves a total of 151 data points from 8 economies: Singapore, France, Germany, Hong Kong, U.K., U.S., Malaysia and Korea. Mean and standard deviation of this inflation data set is 2.1% (close to the 2% assumption chosen) and 1.8% respectively. A simulated time series of 1000 years is derived by sampling the dataset with replacement. This gives a series of 981 readings of rolling 20-year average inflation. The year-on-year change of the average inflation reading has a mean and standard deviation of 0.00% and 0.12% respectively. In another words, estimate for long-term inflation is likely to change no more than 0.1% majority of the times from year to year.

Next, for the long-term real return component. Information about real yield in the first half and second half of the 20th century which EIOPA cited was used. Information for 12 economies and an overall average are available. Assume crudely that the reading for the first half of the 20th century changes in equal-sized steps towards the reading for the second half over the 50 year period. (E.g. Germany's 50-year average real yield moves from -8.2% in the first half to 3.6% in the second half, or an average pace of 0.236% p.a..) This gives a dataset of 13 observations of average pace of change in real yield estimate per annum. This dataset has a mean and standard deviation of 0.07% and 0.1% respectively. Again, estimate for long-term real return is likely to change no more than 0.1% majority of the times from year to year.

Combining these results implies that the standard deviation for change in UFR estimate from year to year should not be much more than 0.2%.

Recall that spot rate at Year t is the average forward rate up to Year t. For t > LLP, forward rates up to Year t can be partitioned as follows:

$$i_t = \frac{1}{t}\sum_{1}^{t} f_n = \frac{1}{t}\left(\sum_{1}^{LLP} f_n + \sum_{LLP+1}^{t} f_n\right) = \frac{1}{t}\left(LLP \times i_{LLP} + \sum_{LLP+1}^{t} f_n\right)$$

where i_t refers to spot rate at Year t and f_n refers to 1-year forward rate[8] for Year n.

To estimate variance of spot rate at Year t, for t > LLP, the following additional information/ assumptions are required:

[8] This paper works with discrete time steps for simplicity. Converting to continuous time is not expected to change the results significantly as the purpose is to derive a soft upper bound for volatility tapering. It is not meant to be a hard limit.

- Volatility of spot rate at LLP. That can be extracted from historical data. Zero coupon bond yields for 15-/20-/30-year SGS for every month end from December 2008 (June 2012 for 30-year SGS) were extracted from Bloomberg [F124]. The following volatility of rolling 1-year change in yield was observed:

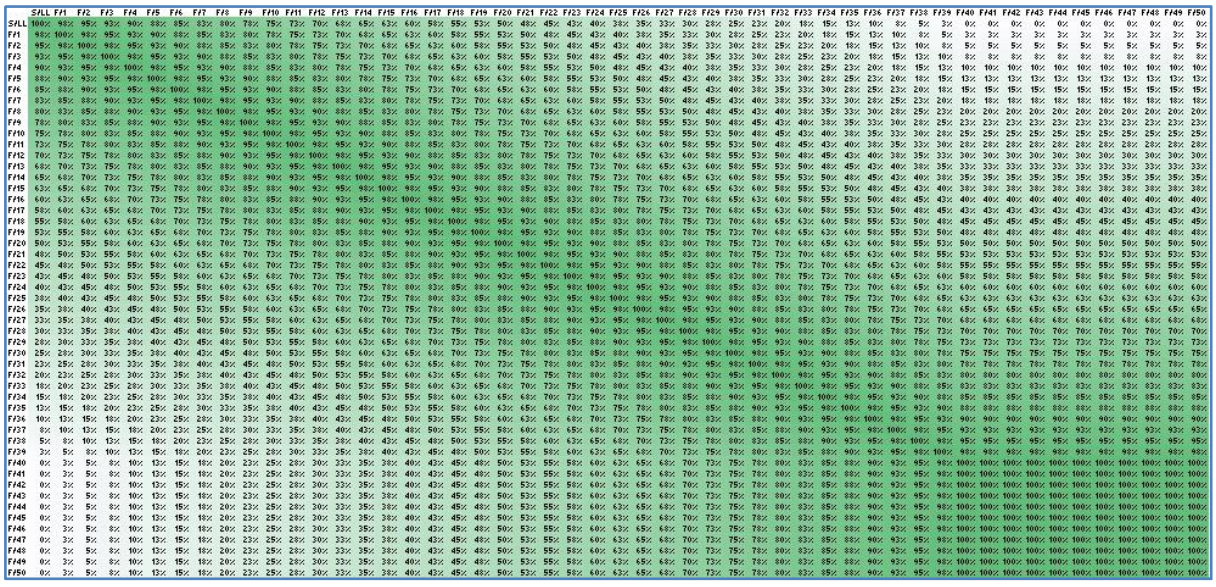
	SGS 15Y ZCB (from 2008)	SGS 20Y ZCB (from 2008)	SGS 30Y ZCB (from 2012)
Standard Deviation	0.65%	0.57%	0.40%

- Volatility of UFR. Standard deviation of UFR has been assessed as 0.2% earlier.

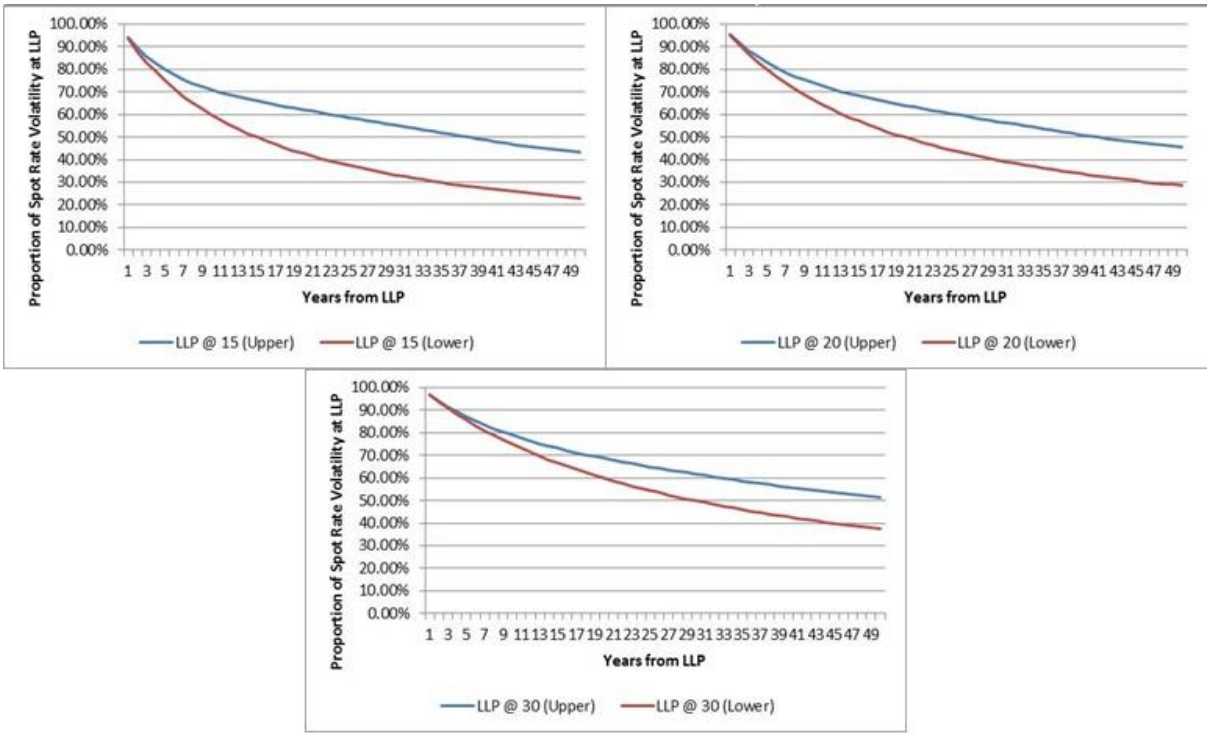
- Target year of convergence. This is set tentatively as 40 years after LLP

- Volatility of forward rates between LLP and successive 1-year periods up to target convergence year. This is calculated by interpolating between spot rate volatility at LLP and volatility of UFR. This simplifying assumption is not unreasonable when the purpose of is only to set a soft upper bound for how spot rate volatility should taper off through the term structure.

- Correlation coefficient between spot and forward rates. Starting with the relationship between LLP and UFR. Interest rate up to LLP is the prevailing nominal interest rate which is market-driven, while UFR relies on average inflation and real yield over a long historical period. One would therefore expect i_{LLP} and $f_{\text{target convergence year}}$ to be fairly independent. (i.e. $\rho \approx 0$). For simplicity, the remaining correlation coefficients between spot and forward rates in the correlation matrix are derived by linear interpolation. Full correlation matrix is reproduced below. (First row/column relates to the spot rate at LLP. Remaining rows/columns refer to the 1-year forward rates after LLP. Stronger correlation is represented by darker colours. White cells represent independence.)



The following diagrams combine the soft upper bounds so calculated, and the soft lower bounds derived earlier, for LLP at 15, 20 and 30 years.



A couple of observations can be made about the soft upper bound. First, for the three choices of LLP tested, the standard deviation of spot rate at target convergence year falls to about half of the standard deviation of spot rate at LLP. Next, if the historical spot rate volatility at LLP were to double, the speed of volatility tapering would accelerate slightly, but only by a few percentage points at the target convergence years.

The soft upper and lower bounds were derived independently using different concepts as starting points. There is a risk that the upper bounds may not always stay above the lower bounds. Fortunately, that did not happen. The areas bounded were not too narrow either.

Empirical Tests

While there are many extrapolation method-parameter combinations available, the following three cases are tested against the upper and lower bounds derived in the last subsection for illustration purpose:

- Prevailing RBC method. It has an implied LLP of 15 years. Volatility of spot rate from Year 20 onwards (i.e. 5 years after LLP) equals to the volatility of LTRFDR.

- Linear interpolation of forward rate. LLP and the target year of convergence are tentatively set at Year 30 and Year 60 (i.e. LLP+30) respectively. UFR is set at 4.2%. Forward rate at LLP moves linearly towards UFR and reaches UFR at the end of the 30-year convergence period.

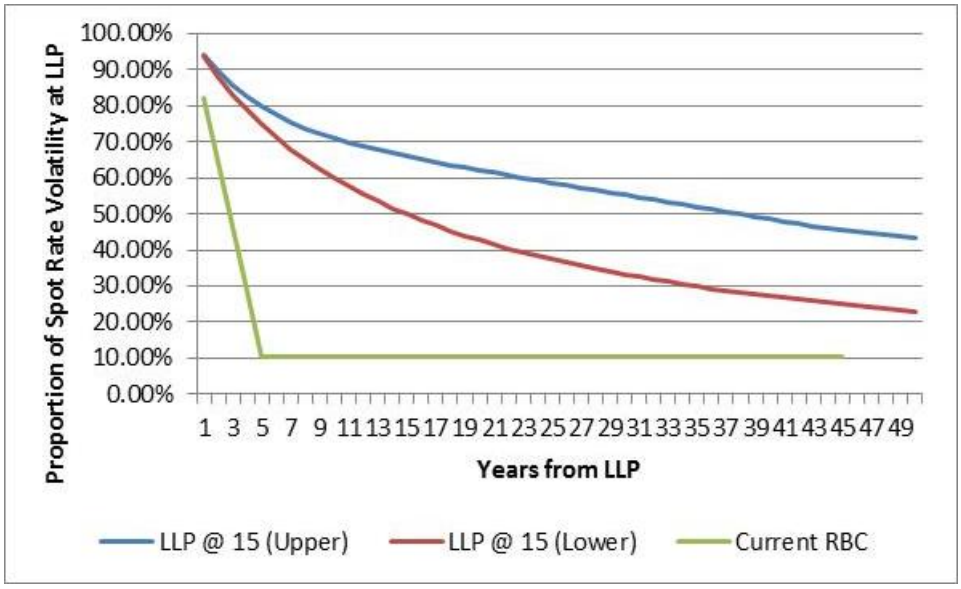
- Smith-Wilson method. LLP and the target year of convergence are tentatively set at Year 20 and Year 60 (i.e. LLP+40). UFR is set at 4.2%. Parameter α which controls how

quickly forward rate at LLP decays towards UFR is set to 0.1. Small α leads to slower convergence. An α of 0.1 was picked by EIOPA in its 2012 Issues Paper as the starting point of calibration. If the α tested produces a forward rate that deviates too much from UFR at the target year of convergence, α is increased until the deviation reduces to an acceptable level. α can change over time at different balance sheet date. For the purpose of this paper, the Working Party has held α constant at 0.1.

The Working Party did not test the treatment of holding spot rate constant from LLP because it clearly exceeds the upper bound by a large margin going into the longer durations.

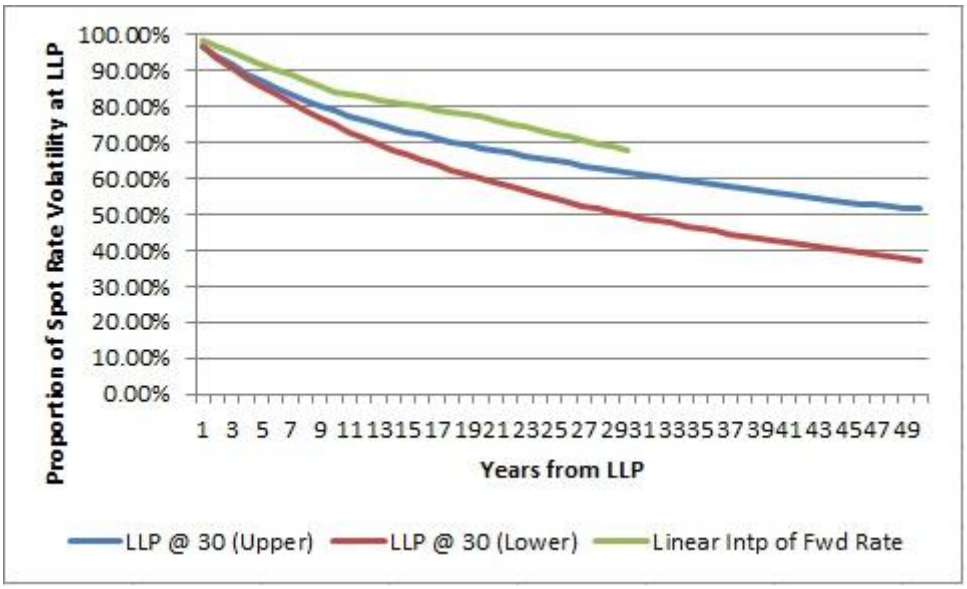
For all the three cases tested, zero coupon bond yields for 15-/20-/30-year SGS for every month end from December 2008 (June 2012 for 30-year SGS) were extracted from Bloomberg [F124].

Current RBC



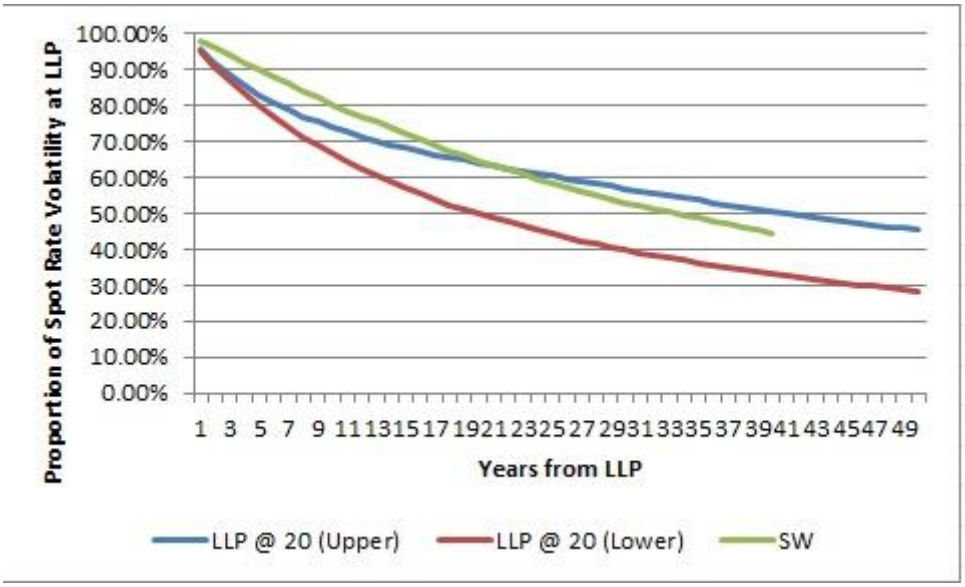
Between 2009 and 2014, volatility of spot rate under current RBC fell below the lower bound from the onset of extrapolation and stayed constant after 5 years when the spot rate reached LTRFDR. This creates strong disincentives for economic matching unless an insurer opts for cash flow hedge/ fair value hedge carve-out which introduces operational constraints.

Linear Extrapolation of Forward Rate



Volatility of spot rate in the extrapolated segment of the curve does trend downwards as required. It stayed above the lower bound, and therefore does not create disincentives for economic matching. However, it has remained slightly higher than the soft upper bound developed earlier. A quicker decay towards UFR would be desirable.

Smith-Wilson



Volatility of spot rate in the extrapolated segment of the curve has also trended downwards as required in this case. It stayed above the lower bound, and therefore does not create disincentives for economic matching. While volatility of extrapolated spot rate was slightly higher than the soft upper bound initially, it enters the ideal volatility zone about 20 years after

LLP. This shows that some form of non-linear decay function can be useful in achieving the balance between appropriate risk management incentives, consistency with macro-economic expectation and rates stability. Using Smith-Wilson method and leveraging on parameter α in its formula to control the speed of convergence is one option. Other decay functions (for example, something with a [β / (t – LLP +1)] term) may be used solely for the extrapolated part of the yield curve to avoid the complex matrix calculations under Smith-Wilson.

Summary of Recommendations

In summary, the Working Party recommends the following with regards to interpolating and extrapolating the risk free term structure for valuing SGD-denominated liabilities:

- To the extent that guiding principles set out in Section 2 governing the term structure of discount rate are observed, interpolation methodology before LLP and extrapolation methodology after LLP may or may not need to follow the same methodology.

- The interpolation/extrapolation methodology should ensure that the discount rate term structure passes through all the data points in the set of observed market yield of SGS.

- Extrapolation methodology should not involve holding spot rate constant.

- Forward rate after LLP should converge to an UFR that is derived based on sound macro-economic assessment. Target year of convergence and method used to achieve this convergence also needs to be defined.

- Tentatively, UFR for SGD-denominated liabilities should be set at 4.2% (making up of 2% long-term inflation rate and 2.2% long-term real interest rate). This should be tested in QIS2.

- When RBC2 is in operation, UFR should be reviewed once every three years as UFR are not expected to be volatile. It also offers some stability for insurers' risk management and planning processes. Insurers should be given sufficient lead time to implement any change in UFR.

- While the Working Party does not offer a recommendation on which specific extrapolation methodology-parameter combination to use, any chosen combination should pass two key criteria regarding risk management incentives and macro-economic soundness. The Working Party has illustrated how these criteria can be translated into quantitative boundaries to facilitate methodology-parameter selection.

    - o <u>Lower bound:</u> To encourage proper economic matching, the volatility in the present value of a liability cash flow beyond LLP should be similar to the volatility in the value of a risk free zero coupon bond with a residual maturity equals to LLP. If the volatility of extrapolated spot rate is too low, it may incentivise using short-dated bonds to avoid accounting mismatch.

    - o <u>Upper bound:</u> As expectations about future real interest rate and inflation should come from macro-economic study and would only change gradually, so would the estimate of UFR. Volatility of extrapolated spot rate should not imply high volatility in UFR estimates.

5. Non-SGD-Denominated Liabilities

This section discusses the extent to which recommendations made in Sections 3 and 4 for discount rate term structure of SGD-denominated liabilities should apply for non-SGD-denominated liabilities.

General Observations

The Working Party started its discussion about valuation of non-SGD-denominated liabilities with data. It was noted that current RBC rules require the use of market yields of foreign government securities. There is no indication to date of a move to swap rate under RBC2. The Working Party therefore assumes that risk free rate under RBC2 will continue to be based on securities issued by foreign governments in their local currencies.

On the assessment of LLP, the Working Party finds that the approach proposed by EIOPA, which is used in this paper to assess LLP of SGS, can be similarly applied to assessment of LLP of markets of securities issued by other governments.

For the interpolation/ extrapolation of non-SGD risk free rate before/ after LLP, the Working Party remains indifferent whether the same method is used for the entire term structure, or different methods are used for different segments of the term structure. The Working Party believes that interpolation before LLP is fairly straightforward for most currencies. This document therefore places greater focus on yield curve extrapolation.

Current RBC rules require insurers to extrapolate from the longest maturity available on foreign government securities by holding spot rate constant for discounting longer-dated liabilities. As explained in the last section, this treatment is inappropriate because it induces a degree of volatility in forward rates at the very long end that is not consistent with what should result from macro-economic analysis. Solutions that the Working Party proposed for SGD discount rates – extrapolating towards an appropriate UFR, ensuring that extrapolated rates give the correct risk management incentives and have macro-economic soundness – should also apply to the development of non-SGD discount rates. To ensure ease of RBC2 implementation, extrapolation methodology for SGD and non-SGD discount rate curve should be the same, but parameterization may vary.

Extrapolation for USD-Denominated Liabilities

Given the liability profile of insurers licensed in Singapore, the Working Party believes that the only currency where insurers have accumulated significant amount of long-dated liabilities that need to be valued using extrapolated yield curve is USD. Parameterization for extrapolating USD risk free rate is therefore singled out for discussion.

Solvency II uses swap rate as the default starting point for deriving risk free rate curve; and EIOPA has assessed that LLP for USD to be 30 years based on the characteristics of the market for USD swaps. EIOPA did not document its assessment for the LLP of the market for US Treasuries. Based on the bid-ask spread analysis in Section 3, the Working Party believes that LLP for US Treasuries should be set at Year 30 – the maximum term available.

EIOPA has also provided a comprehensive documentation on its assessment of UFR for various economies. US was assessed to be part of the standard inflation group. The

Working Party finds that to be not unreasonable, and will therefore recommend testing a UFR of 4.2% for USD-denominated liabilities as a start in QIS2 of RBC2.

Extrapolation for Liabilities Denominated in Other Currencies

EIOPA's LLP analysis for other currencies was mostly related to swaps rather than government securities. For RBC2, LLP analysis should, in principle, be conducted for the markets for government securities. However, from the perspective of materiality, the Working Party accepts that it would be pragmatic to set LLP for non-SGD and non-USD yield curves at the longest maturity available on foreign government securities.

Note that EUR is used by all the countries in the Eurozone, and each country in the Eurozone has different bond market characteristics. To determine the LLP for EUR, the Working Party recommends making reference to the government securities market in the country in Eurozone that has the best credit rating. In the event of a tie between two or more countries, the country with the best government securities market in terms of depth and liquidity should be used as the reference point. At the time of writing, this would be the market for German Bund. This recommendation is consistent with the Society's paper on Counter-cyclical Adjustment[9].

On UFR, the Working Party finds EIOPA's analysis and conclusions to be reasonable starting points to be tested in QIS2 of RBC2. For those economies that EIOPA did not analyse, MAS may consider their characteristics and allocate them to the lower, high, or standard inflation group. UFR assumptions would apply accordingly.

[9] See pages 34 of "Proposal on Counter-cyclical Adjustment" (Jan 2015) by Singapore Actuarial Society.

6. Incorporating Illiquidity Characteristics into Extrapolated Term Structure

Assessment of liquidity characteristics is conducted at the insurance contract level. Unless one cash flow component from a contract is not interrelated to other cash flow components of the same contract (in which case the two components should possibly be valued separately), liquidity characteristics assessment made to the contract would apply to all cash flow components, be it cash flows expected to fall due before or after LLP. It follows that any adjustment to the discount rate to reflect illiquid nature of an insurance contract should apply throughout the entire term structure. MA tested under RBC2 QIS1 applied the adjustment to the basic risk free yield curve in this manner. The Working Party recommends retaining this feature of MA.

The Society has also proposed in July 2014 the introduction of VA into RBC2. Regardless of how the size of adjustment is eventually derived in VA, the Working Party believes that the adjustment should apply throughout the entire term structure.

7. Implications on Interest Rate Mismatch Requirement Calculation

Under current RBC requirements, interest rate mismatch risk is calculated by increasing/ decreasing the spot risk free discount rate by a fixed number of basis points prescribed in the regulations. This change in spot discount rate applies to the entire term structure, including the part which is extrapolated using LTRFDR. The prescribed stress for maturity 7.3 years and beyond is +/-60 bps. In practice, over a 12-months period, a 60 bps movement in LTRFDR will require an immediate shock to the spot yield of 15 and 20 year SGS of circa +/-300bps from prevailing levels. If it is the intention of the regulatory capital requirements to represent the value-at-risk over a 1-year horizon, then the severity implied by the stress to the Year 20+ discount rate would be well beyond a 1-in-200 year event. Such severity will also be inconsistent with the severity implied by the stress to the Year 15 spot rate.

This problem has been carried over to the specifications of RBC2 QIS1. More specifically, interest rate stresses are defined as proportional stress to the spot risk free discount rate. For the extrapolated portion of the term structure, a proportional stress of +/-30% was prescribed. The resultant implied volatility in the long-term forward rate is significantly higher than the likely rate of change in UFR over a 12-months period.

The Working Party recommends that interest rate mismatch requirement be defined in a manner consistent with how risk free term structure is derived for the base case balance sheet. This means:

- Stressed asset value continues to be calculated according to the prescribed interest rate shock without modification.

- The stressed yield curve used to value insurance liability is derived by first applying the prescribed interest rate shock to the original risk free term structure for maturities up to the LLP. Next, carry out extrapolation using a consistent methodology towards a stressed UFR that needs to be separately defined. It was earlier estimated in Section 4 that the standard deviation of 1-year change in UFR is about 20 bps. The Working Party therefore recommends an undiversified 1-in-200 year shock of +50 bps and -50 bps for UFR in the increasing and decreasing interest rate scenarios respectively.

- If defining a separate UFR shock is deemed too complex for use as a standard formula, a simplification can be made by tapering the proportional spot rate stress for the extrapolated part of the yield curve to achieve a similar level of spot rate volatility as would have resulted from having a separate UFR shock.

The Working Party recognizes that as a consequence of this recommendation, if MAS concludes that LLP for SGS is earlier than Year 30, insurers who have used 30-year SGS or corporate bonds/ swaps/ swaptions with similar duration to match their long-dated liabilities will see some degree of accounting mismatch when the yield of 30-year SGS fluctuates. MAS should encourage insurers to understand the impact of this accounting mismatch on their risk management objectives as part of good enterprise risk management practice. A rough and simple measure of mismatch is the difference between weighted yield of assets dated past LLP versus the UFR.

Appendix 1 – Summary of Proposals

Guiding Principles

The following guiding principles are proposed to govern the development of term structure of discount rate:

- Continuity and smoothness. The term structure should be theoretically and economically sound. As any forecasted change in economic condition would move smoothly as the forecast horizon increases, the term structure of discount rate should progress smoothly, not only for spot rates, but also for forward rates. Forward rate should not spike or see sudden dip from year to year.

- Robustness and stability. The methodology should produce curves that avoid artificial volatility in valuation and provide for a reasonable variation over time. Volatility is more likely to be artificial if it is triggered by pro-cyclical behaviour or, owing to the extrapolation methodology, a small change in the last part of the market yield curve leads to a larger change to the extrapolated section.

- Accuracy. The methodology should provide a good fit to liquid market data.

- Transparency and practicability. The methodology should be fully transparent, easy to apply and accessible to insurers so that insurers can produce the entire discount rate term structure on their own.

- Incentives. The methodology should not give inappropriate risk management incentives.

Risk Free Rate for SGD-Denominated Liabilities

- Where the market for certain maturities is not sufficiently deep, liquid and transparent, yield data may not give a reliable picture of the expectation about future economic conditions. When that happens, entry point of extrapolation (referred to as last liquid point or "LLP" in short) should be brought forward.

- MAS to investigate into the appropriateness of setting LLP for SGD risk free rate at Year 20 based on the information it has about future supply of long-dated SGS, growth in insurers' long-dated liabilities, and how RBC2's Volatility Adjustment ("VA") and Matching Adjustment ("MA") rules would support the use of corporate bonds to match long-dated liability cash flows.

- LLP should be reviewed once every three years. Insurers should be given sufficient lead time to implement any change in entry point of extrapolation.

- To the extent that guiding principles governing the term structure of discount rate are observed, interpolation methodology before LLP and extrapolation methodology after LLP may or may not need to follow the same methodology.

- The interpolation/extrapolation methodology should ensure that the discount rate term structure passes through all the data points in the set of observed market yield of SGS.

- Extrapolation methodology should not involve holding spot rate constant.

- Forward rate after LLP should converge to an Ultimate Forward Rate ("UFR") that is derived based on sound macro-economic assessment. Target year of convergence and method used to achieve this convergence also needs to be defined.

- Tentatively, UFR for SGD-denominated liabilities should be set at 4.2% (making up of 2% long-term inflation rate and 2.2% long-term real interest rate). This should be tested in QIS2.

- UFR should be reviewed once every three years. Insurers should be given sufficient lead time to implement any change in UFR.

- Any chosen extrapolation methodology-parameter combination should pass two key criteria regarding risk management incentives and macro-economic soundness.

    - Lower bound: To encourage proper economic matching, the volatility in the present value of a liability cash flow beyond LLP should be similar to the volatility in the value of a risk free zero coupon bond with a residual maturity equals to LLP. If the volatility of extrapolated spot rate is too low, it may incentivise using short-dated bonds to avoid accounting mismatch.

    - Upper bound: As expectations about future real interest rate and inflation should come from macro-economic study and would only change gradually, so would the estimate of UFR. Volatility of extrapolated spot rate should not imply high volatility in UFR estimates.

Risk Free Rate for Non-SGD Denominated Liabilities

- Methodology for LLP assessment used for SGS applies equally to LLP assessment of markets for local currency securities of foreign government. LLP for USD should be therefore be set at Year 30. LLP for EUR would depend on the Eurozone country with the best credit rating and, where there is a tie, the deepest and most liquid market for government securities. For currencies that are less material to Singapore licensed insurers, it would be pragmatic to set LLP at the longest maturity available on foreign government securities.

- Interpolation/ extrapolation of non-SGD risk free rate before/ after LLP can come from the same or from different methodologies.

- EIOPA's analysis and conclusions for UFR should be used as the starting point for testing under QIS2 of RBC2. This means a UFR of 4.2% applies to extrapolating USD risk free curve. For those economies that EIOPA did not analyse, MAS may consider their characteristics and allocate them to the lower, high, or standard inflation group. UFR assumptions would apply accordingly.

- Extrapolation methodology for SGD and non-SGD discount rate curve should be the same, but parameterization may vary. Extrapolation methodology-parameter combinations should be tested to secure the correct risk management incentives and macro-economic soundness.

Incorporating Illiquidity Characteristics into Extrapolated Term Structure

- Any adjustment to the discount rate to reflect illiquid nature of an insurance contract should apply throughout the entire term structure (i.e. both before and after LLP). This approach should be used in both Volatility Adjustments and Matching Adjustments.

Implications on Interest Rate Mismatch Requirement Calculations

- Interest rate mismatch requirement should be defined in a manner consistent with how risk free term structure is derived for the base case balance sheet. This means:
    - Stressed asset value continues to be calculated according to the prescribed interest rate shock without modification.
    - The stressed yield curve used to value insurance liability is derived by first applying the prescribed interest rate shock to the original risk free term structure for maturities up to the LLP. Next, carry out extrapolation using a consistent methodology towards a stressed UFR of +50 bps and -50 bps from the base UFR in the increasing and decreasing interest rate scenarios respectively. This represents an undiversified 1-in-200 year shock.
    - If defining a separate UFR shock is deemed too complex for use as a standard formula, a simplification can be made by tapering the proportional spot rate stress for the extrapolated part of the yield curve to achieve a similar level of spot rate volatility as would have resulted from having a separate UFR shock.

Appendix 2 – Discount Rate Working Party Members

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Also, a big thank you to other members of the Society who have contributed in the research and provided comments in the drafting process.

Appendix 3 – Estimation of Demand for Long-dated SGS

Table 1: Present value of guaranteed benefits and expenses outgoes for participating and non-participating business (2013) (in SGD m)

	In Participating Fund													In Non-Participating Fund								
Company	WL SP (Par)	WL RP (Par)	End SP (Par)	End RP (Par)	A&H (Par)	Annuity (Par)	Others (Par)	End SP (N-Par)	End RP (N-Par)	Term (N-Par)	A&H (N-Par)	Annuity (N-Par)	Others (N-Par)	WL SP	WL RP	End SP	End RP	Term	A&H	Annuity	Others	Total
AIA	24	9771	465	5998	0	64	45	0	0	0	0	0	0	1799	2376	1042	467	937	4635	232	1707	29563
Aviva	0	1111	190	2206	0	0	0	0	0	8	0	0	0	1	38	208	216	123	2789	116	326	7331
AXA	0	364	20	589	0	0	3	0	0	0	0	0	0	0	3	0	52	125	17	0	94	1269
Friend Provident	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2
GE	34	10549	4429	4662	0	0	5	0	0	0	0	0	0	499	179	307	76	435	2523	502	813	25014
Generali	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HSBC	0	253	8	717	0	0	0	0	0	0	0	0	0	988	68	364	73	50	2	31	113	2668
LIC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manulife	92	2107	429	1392	2	0	2	0	0	0	0	0	0	97	230	6	30	187	2	0	2	4577
NTUC	0	9753	7409	5932	0	2929	0	785	142	274	7	157	72	0	0	0	0	1600	212	0	1609	30880
OAC	24	559	73	4180	0	36	1	0	0	0	0	0	0	0	20	0	3	103	0	32	21	5052
Prudential	19	3774	575	11870	0	117	0	0	0	0	0	0	0	689	15	685	48	490	4153	631	25	23091
Scandia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standard Life	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Swiss Life	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TMLS	125	2417	681	1036	0	3	0	0	0	0	0	0	0	0	5	59	3	123	8	109	2	4570
TransAms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	463	0	11	11	0	0	0	485
Zurich Int Life	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	7
Zurich Life	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	12	16
Total	318	40659	14278	38582	2	3149	56	785	142	282	7	157	72	4073	3398	2671	978	4198	14340	1653	4726	134524

Table 2: Estimated value of guaranteed benefits and expenses outgoes at longer maturities (2013)

Product Group	**Proportion of Present Value of Benefits & Expenses Assumed to be from Longer Maturities**		
	Base Scenario	**All Assumptions +10%**	**All Assumptions -10% (subject to floor or 0%)**
Whole life (except single premium whole life products in non-participating fund)	50%	60%	40%
Single premium whole life products in non-participating fund	0%	10%	0%
Annuity	50%	60%	40%
Endowment	0%	10%	0%
Term / Accident & Health	0%	10%	0%
Others	0%	10%	0%
Estimated value of outgoes at longer maturities (SGD bn)	**24.7**	**38.1**	**19.7**

Appendix 4 – Inflation and Real Interest Rate Data

Table 1: Annual CPI Changes from Selected Economies (%)

Economy	Source	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Ave.
France	OECD	1.7	1.8	2	1.2	0.6	0.5	1.7	1.6	1.9	2.1	2.1	1.7	1.7	1.5	2.8	0.1	1.5	2.1	2	0.9	1.6
Germany	OECD	2.7	1.7	1.4	1.9	0.9	0.6	1.4	2	1.4	1	1.7	1.5	1.6	2.3	2.6	0.3	1.1	2.1	2	1.5	1.6
Japan	OECD	0.7	-0.1	0.1	1.8	0.7	-0.3	-0.7	-0.8	-0.9	-0.2	0	-0.3	0.2	0.1	1.4	-1.3	-0.7	-0.3	0	0.4	0.0
Korea	OECD	6.3	4.5	4.9	4.4	7.5	0.8	2.3	4.1	2.8	3.5	3.6	2.8	2.2	2.5	4.7	2.8	2.9	4	2.2	1.3	3.5
Switzerland	OECD	0.9	1.8	0.8	0.5	0	0.8	1.6	1	0.6	0.6	0.8	1.2	1.1	0.7	2.4	-0.5	0.7	0.2	-0.7	-0.2	0.7
U.K.	OECD	2	2.6	2.5	1.8	1.6	1.3	0.8	1.2	1.3	1.4	1.3	2.1	2.3	2.3	3.6	2.2	3.3	4.5	2.8	2.6	2.2
U.S.	OECD	2.6	2.8	2.9	2.3	1.6	2.2	3.4	2.8	1.6	2.3	2.7	3.4	3.2	2.9	3.8	-0.4	1.6	3.2	2.1	1.5	2.4
G7	OECD	2.2	2.3	2.3	2	1.3	1.5	2.3	2.1	1.3	1.8	2	2.4	2.4	2.2	3.3	-0.1	1.4	2.6	1.9	1.3	1.9
OECD-Europe	OECD	8.4	8.5	7.3	7	6.9	5.3	5.5	5.3	4.7	3	2.4	2.4	2.5	2.6	3.8	1.2	2.3	3.2	2.9	1.9	4.4
OECD-Total	OECD	4.8	6	5.6	4.8	4.2	3.6	4	3.6	2.8	2.4	2.4	2.6	2.6	2.5	3.7	0.5	1.9	2.9	2.2	1.6	3.2
India	OECD	10.2	10.2	9	7.2	13.2	4.7	4	3.8	4.3	3.8	3.8	4.2	5.8	6.4	8.3	10.9	12	8.9	9.3	10.9	7.5
South Africa	OECD	8.9	8.7	7.4	8.6	6.9	5.2	5.3	5.7	9.5	5.7	-0.7	2.1	3.2	6.2	10	7.2	4.1	5	5.7	5.8	6.0
Singapore	Eco-Win	2.9	0.8	2	2	-1.4	0.7	2.1	-0.6	0.4	0.7	1.3	1.3	0.8	3.7	5.5	-0.5	4.6				1.5
Hong Kong	Eco-Win	9.6	7.0	6.7	5.2	-1.6	-4	-2.1	-3.6	-1.5	-1.9	0.3	1.4	2.3	3.8	2.0	1.3	3.3				1.7
Malaysia	Eco-Win	3.5	3.2	3.3	2.9	5.3	2.5	1.2	1.2	1.7	1.2	2.1	3.2	3.1	2.4	4.4	1.1	2				2.6

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