03.01.2020

IFRS 17 - Future of Discount Rates Working Party

Case study on the 'top-down' approach[1]

1. Introduction

Under IFRS 17 a principle – based approach is used to determine the yield curve for discounting cash-flows. The discount rates can be estimated using a 'bottom-up' or a 'top-down' approach. This case study aims to investigate how a top-down discount curve could be estimated, using a reference portfolio of UK government bonds. This case study aims to stimulate further the discussion on the different approaches for estimating IFRS 17 discount curves. In particular, alternative methods for estimating credit risk premiums are examined and a number of practical issues are highlighted. At a glance the approach adopted in this case study is summarised below.

IFRS 17 Standard on the 'top-down' approach

Paragraph B81

Alternatively, an entity may determine the appropriate discount rates for insurance contracts based on a yield curve that reflects the current market rates of return implicit in a fair value measurement of a reference portfolio of assets (a top-down approach). An entity shall adjust that yield curve to eliminate any factors that are not relevant to the insurance contracts, but is not required to adjust the yield curve for differences in liquidity characteristics of the insurance contracts and the reference portfolio.

IFRS 17 Insurance Contracts, May 2017 (see Appendix A)

The main risk inherent in the market yields which is not relevant to insurance liabilities is the credit risk. Another factor is the duration mismatch between the reference portfolio and insurance liabilities. In this case study it is assumed that there is no duration mismatch and consequently the yields will be adjusted only for credit risk.

Overview of the case study

The approach set out in this case study for estimating a 'top-down' discount curve is split into seven different sections. The choice of reference portfolio and a comparison of the UK yield curve to the UK swap curve are discussed in Section 2 and Appendix B. This reference portfolio could be appropriate for discounting very liquid insurance liabilities. The zero-coupon rates required for discounting liabilities are calculated in Section 3. Alternative methodologies for estimating the credit risk premium of the reference portfolio are discussed in Section 4 and Appendices C and D. The extrapolation of credit-adjusted zero coupon rates is implemented in Section 5 and the results are presented in Section 6 as well as in Appendix E.

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Finally, some of the practical challenges related to the transition from Solvency II to IFRS 17 are discussed in Section 7.

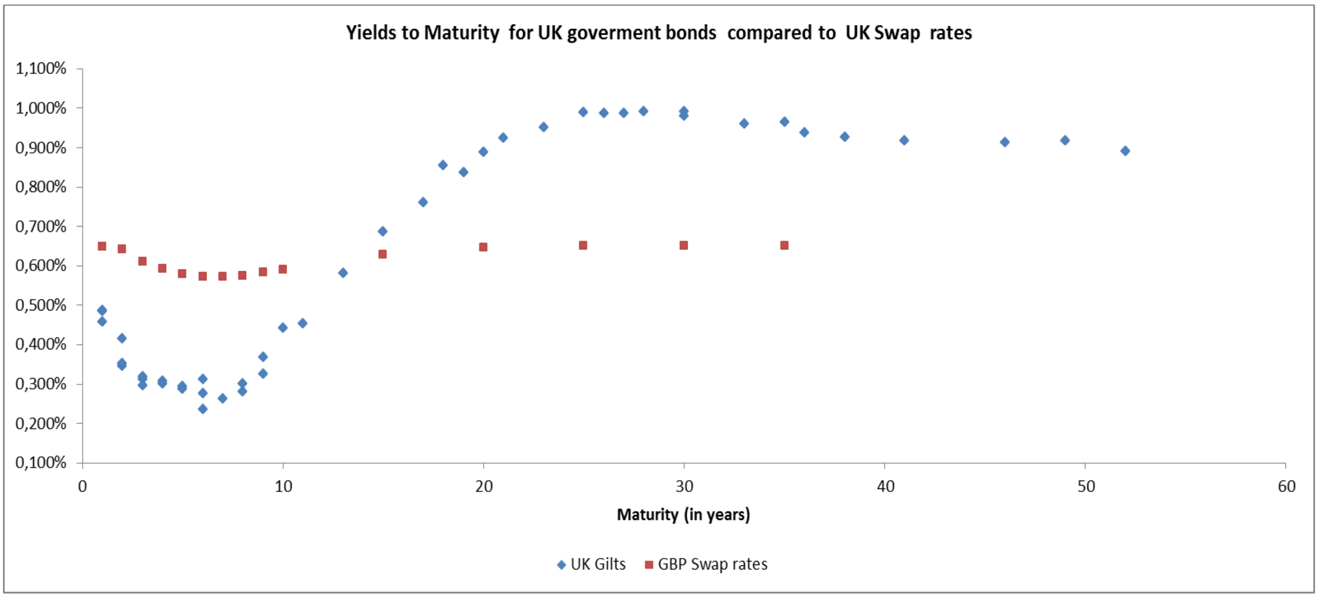
2. Reference portfolio

The reference portfolio assumed in our case study consists of UK government bonds and is presented below.

Table 1 Description of the reference portfolio.

Description of the reference portfolio	
Type of bonds	UK gilts
Number of bonds	45
Weight for each bond	1/45 (2.22%)
Duration	12.7 years
Yield to maturity	0.617%
Date of valuation	29/08/2019
Source	Bloomberg

The characteristics of bonds are presented in Appendix B. The reference portfolio is equally weighted to each of the 45 bonds. The duration of the reference portfolio is sufficiently large, 12.7 years, to match the duration of a hypothetical portfolio of long-term insurance liabilities. The UK government bond yield curve and the UK spot swap curve are illustrated below.



The UK yield curve has a sigmoid shape and it is quite different from the UK spot swap curve. In particular for maturities up to 15 years swap rates are higher than bond yields. For maturities greater than 15 years bond yields are higher than swap rates. This difference was discussed by Walton and Rowland (Yield curves working party[2], 2009). They argue that long term swap spreads are lower partially due to higher demand for long term swaps for hedging.

Furthermore, the bonds' yield curve is inverted. More specifically, the yield at maturity year 30 (0.993%) is higher than the yield at maturity year 52 (0.892%). According to literature[3], the shape of a government yield

[2] Implications of Divergence between Gilt and Swap Curves , 21-23 June 2009
[3] Estrella, Arturo and Trubin, Mary, The Yield Curve as a Leading Indicator: Some Practical Issues. Current Issues in Economics and Finance, Vol. 12, No. 5, July/August 2006. Available at SSRN: https://ssrn.com/abstract=931184

curve can be used as a leading indicator for predicting future GDP growth. However, the economic interpretation of UK yield curve is out of the scope of this case study. It is worth noting that the difference between bond yields and swaps rates implies that the discount curve based on bond yields will be materially different from the discount curve based on swap rates. This is further discussed in Section 6.

3. Estimating the zero-coupon bond rates from the bonds yield curve

The liabilities are discounted using the spot rates (or zero-coupon bond rates) which are derived from the bonds yield curve using a method called 'bootstrapping'. The calculation is described in Hull[4] and the results are presented in the table below.

Table 2 Estimation of zero-coupon bond rates.

Maturity (in years)	UK Government bonds		UK Swap rates
	Yield to Maturity	Estimated zero-coupon bond rates	
1	0.478%	0.478%	0.650%
2	0.371%	0.734%*	0.643%
3	0.309%	0.485%	0.612%
4	0.305%	0.291%	0.594%
5	0.290%	0.295%	0.580%
6	0.275%	0.383%	0.573%
7	0.264%	0.265%	0.573%
8	0.291%	0.217%	0.574%
9	0.347%	0.248%	0.583%
10	0.442%	0.439%	0.591%
11	0.455%	0.374%	-
13	0.582%	0.679%	-
15	0.688%	0.731%	0.628%
17	0.761%	0.916%	-
18	0.855%	0.888%	-
19	0.838%	0.865%	-
20	0.890%	0.977%	0.646%
21	0.924%	0.982%	-
23	0.952%	1.028%	-
25	0.990%	1.146%	0.652%
26	0.987%	1.144%	-
27	0.987%	1.065%	-
28	0.993%	1.034%	-
30	0.987%	1.057%	0.652%
33	0.961%	1.040%	-
35	0.964%	0.989%	0.652%
36	0.939%	0.967%	-
38	0.928%	0.946%	-
40	-	-	0.660%
41	0.918%	0.981%	-
46	0.913%	0.914%	-
49	0.917%	0.919%	-
50	-	-	0.659%
52	0.892%	0.873%	-

**The zero-coupon bond rate in the 2nd year is unusually high. This is due to the bond GB0009997999 which matures in 2021 and has coupon rate of 8%, which is the highest coupon rate in the portfolio. If this bond is excluded the zero-coupon bond rate at year 2 reduces to 0.513%.*

[4] Hull, J. (2009). Options, futures and other derivatives , John C. Hull, 7th Edition, p.80 – 82.

The zero-coupon bond rates will be subsequently smoothed out. The smoothing methodology is described in Section 5. The estimated credit risk premium will be deducted from the zero-coupon bond rates.

4. Estimation of credit risk premium

The main theme of this section is the estimation of credit risk premium of the reference portfolio. The credit risk premium will be deducted from the zero-coupon bond rates, calculated in the previous section.

"Adjustments for credit risk

For debt instruments, the effect of credit risk would need to be eliminated from the total bond yield. The effect of credit risk usually comprises two components: the expected credit losses and the unexpected credit losses (i.e., compensation for bearing that risk). There is a wide range of practices used to estimate the required deduction for credit risk inherent in bond yields. Observed practices include:

i. *Market-based techniques: Credit Default Swap (CDS) spread, where available, is used as a measure of the inherent credit risk in bonds and comprise the expected as well as the unexpected credit losses.*
ii. *Structural-model techniques such as the Merton Model, Leland and Toft Model and EDF-Based Model.*
iii. *Expected / Unexpected Credit Loss (ECL / UCL) models: ECL models usually comprise an estimation of the probability of defaults (including the future cost of downgrades) and an estimation of the loss given default.*

NB - several of the above approaches used to estimate the deduction for credit risk are complex and as such it has been observed that insurers have typically simplified expressions for the deductions required for credit risk and calibrating these expressions based on the above approaches. Examples of such expressions include:

- *Deduction for credit risk = Expected Default Rate + X% (Total Bond Spread – Expected Default Rate)*
- *Deduction for credit risk = X% (Total Bond Spread)*
- *Deduction for credit risk = Expected Default Rate * (1+compensation risk)*

The advantage of the first two approximations is that the credit risk premium changes as a function of the corporate spread."

Exposure Draft of International Actuarial Note 100, Application of IFRS 17 Insurance Contracts (p.59 - 60)

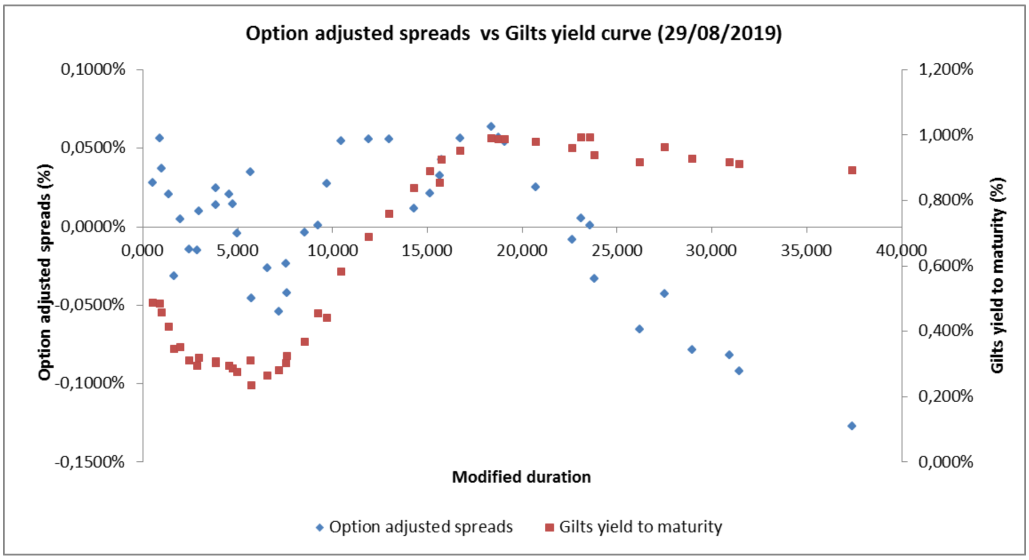
In the following sections the credit risk premium is estimated using option-adjusted spreads, CDS spreads and Expected Credit Loss models.

4.1. Option adjusted spreads

"The option-adjusted spread (OAS) is the measurement of the spread of a fixed-income security rate and the risk-free rate of return which is adjusted to take into account an embedded option.[5]" Option adjusted spreads are readily available from Bloomberg and they can be used as a proxy for credit risk premiums. Amato and Remolona[6] note that credit risk; liquidity risk as well as taxation may affect the size of option-adjusted spreads.

[5] https://www.investopedia.com/terms/o/optionadjustedspread.asp
[6] Amato, J. D., & Remolona, E. M. (2003). The credit spread puzzle. *BIS Quarterly Review, December*

The advantages of option adjusted spreads are that they are closely related to bond yields and they are available on a daily basis. However, a particular issue observed in option adjusted spreads for UK gilts is that they take positive and negative values (see chart below).



Option-adjusted spreads reflect the distance of bonds yields over the risk-free rates, adjusted for embedded options. The calculation requires an estimation of a risk-free yield curve. The convention used by Blomberg is to smooth the yields of UK gilts and use this smoothed curve as an input to the calculation of option-adjusted spreads As a result, the option-adjusted spreads for UK gilts are small positive or negative quantities and overall close to zero (see Appendix B). Hence, the use of option adjusted spreads as proxy for credit risk premium may not be appropriate for government bonds. Instead, they could be considered for corporate bonds.

Next the estimation of credit risk premium based on CDS spreads is examined.

4.2. CDS spreads

"A credit default swap (CDS) is a financial derivative or contract that allows an investor to "swap" or offset his or her credit risk with that of another investor[7]." The CDS spread is the cost as a percentage of the face value of the bond that an investor has to pay in order to buy this derivative. CDS are over the counter (OTC) derivatives and therefore they have their own liquidity risk. The UK CDS curve - which is available on a daily basis – as well as some practical challenges of using CDS spreads for estimating credit risk premiums are discussed in this section. It is worth noting that the movements of CDS spreads are related to bond yields but may not be always perfectly synchronised. For example, the value of CDS spreads may exceed the value of bond yields in times of crisis. This was observed in the Greek debt crisis in 2015 (see Appendix C).

Practical issue #1 : Extrapolation of CDS spreads

The UK CDS curve stops at year 10 but the maturity of UK government bonds extend to 52 years; hence we may choose to extrapolate the CDS curve in order to estimate the credit risk premiums for long-term gilts. A relatively simple option is to fit a linear regression to the UK CDS term structure. The results are presented below.

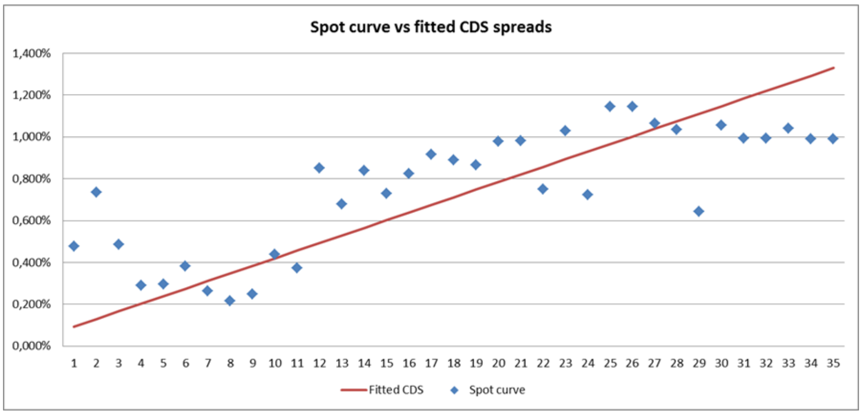
[7] https://www.investopedia.com/terms/c/creditdefaultswap.asp

Table 3 CDS spreads of UK government bonds.

Years	Bid CDS spread (bps)	Ask CDS spread (bps)	Mid CDS spread (bps)*	Fitted Mid CDS spread (bps)**
0.5	5.86	11.17	8.52	9.72
1	7.25	14.26	10.76	12.09
2	12.16	18.71	15.44	16.84
3	19.25	26.25	22.75	21.60
4	25.2	30.89	28.05	26.35
5	31.19	34.86	33.03	31.10
7	39.75	46	42.88	40.60
10	47.5	56	51.75	54.86
Average	**23.52**	**29.76**	**26.64**	**26.64**

*Source: Bloomberg (29/08/2019) * The mid CDS is the average of Bid and Ask CDS **The fitted CDS spreads are estimated using a linear regression.*

The linear regression has R^2 = 98%, which indicates a good fit.



The advantage of using a linear model is the simplicity whereas the disadvantage is that the estimated long term CDS spreads will increase linearly, and they could eventually be higher than the corresponded long-term yields. This would imply a zero long term discount curve, which is not realistic.

Based on the above results we conclude that a linear model may not be appropriate for extrapolating CDS rates for maturities beyond 10 years. However this is highlighted as one of the practical challenges that have to be addressed.

Practical issue #2: CDS own liquidity risk

CDS are OTC derivatives and thus they have their own liquidity risk. According to literature[8] , CDS spreads are not pure measures of credit risk and their liquidity varies both cross-sectionally and over time. However, there is no universally accepted methodology for measuring and removing the illiquidity component of the CDS spreads. A simple approach would be to estimate CDS illiquidity risk as the difference in the bid – ask spread over the mid spread, as shown below. The mid CDS spread is used as an approximation of the market value of the CDS spread.

CDS-illiquidity factor = (Ask – Bid)/Mid = (29.76 - 23.52)/ 26.64 = 23.45%

The estimated ‘CDS-illiquidity factor’ will be used to reduce CDS spreads to remove their illiquidity component. In other words, the wider range of ‘Bid-Ask’ CDS spread the larger the illiquidity component and vice versa. In this case study, the CDS spreads across all maturities as will be reduced by 23.45% in order to remove the illiquidity element included in the spreads. The main assumptions are that the liquidity-adjusted CDS spreads reflect the pure credit risk of UK government bonds and that the deduction is appropriate for all maturities.

[8] Brigo, D., Predescu, M., & Capponi, A. (2010). Credit default swaps liquidity modeling: A survey. arXiv preprint arXiv:1003.0889.

The quantification of the illiquidity component of CDS spreads is highlighted as one of the practical challenges that have to be addressed. A limitation of this approach is it does not allow for expenses related to the administration of CDS contracts.

Practical issue #3: Average CDS spread as a proxy for credit risk premium

As a simplification, the average of mid CDS spreads across all maturities is used as a proxy for the credit risk premium, as shown below.

*Proxy for credit risk premium = {26.64 *(1-23.45%)}/10000=0.204%*

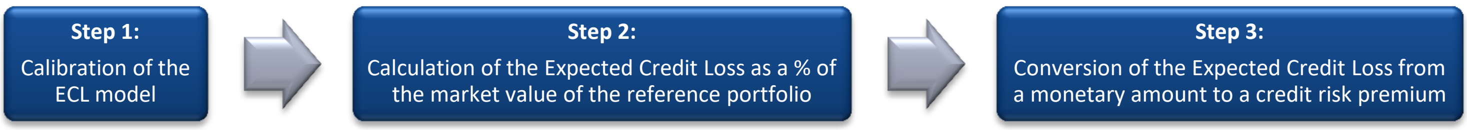
The estimated credit risk premium will be reduced from the spot rates derived in Section 3. Moreover, the European Insurance and Occupational Pensions Authority (EIOPA) estimates the Credit Risk Adjustment in order to reflect the credit risk included in GBP swap rates that should be deducted in order to arrive at a risk free interest rate for the purpose of Solvency II reporting. The Credit Risk Adjustment is 0.11% (at 31/08/2019) but can move between 0.10% and 0.35% depending on market conditions. Note that the two credit risk estimates are close but not equal. Recall that IFRS 17 requires insurers to estimate a discount curve based on a reference portfolio of assets. Therefore, unless the reference portfolio consist only of swaps, a separate estimation of credit risk premium is required. The use of a reference portfolio based only on swaps is further discussed in Section 7.

4.3. Expected Credit Loss models

Expected Credit Loss (ECL) models are used for estimating the impairment value of financial assets under IFRS 9[9]. The main objective of ECL models is to calculate 'unbiased and probability weighted' amounts to represent impairments to the value of financial assets in Balance Sheet. The general calculation formula is[10]:

$$Expected\ Credit\ Risk = Exposure\ at\ Default * Loss\ Given\ Default * Probability\ of\ default$$

ECLs are implemented in three steps.



Step 1: Calibration of the ECL model

The first step is to calibrate the inputs of the ECL model.

- Calibration of 'Exposure at Default'

The reference portfolio does not represent actual investments. So assume that 'Exposure at Default' is £1.

- Calibration of 'Loss Given Default'

[9] Exposure Draft ED/2013/3, Financial Instruments: Expected Credit Losses , March 2013. Available at: https://www.ifrs.org/-/media/project/fi-impairment/exposure-draft-2013/published-documents/ed-expected-credit-losses.pdf

[10] Volarević, H. & Varović, M. (2018). Internal model for IFRS 9-Expected credit losses calculation. Ekonomski pregled, 69(3), 269-297

‘Loss given default’ (LGD) is the amount of money lost when a borrower defaults on an obligation and it is expressed as a percentage of ‘Exposure at Default’ the time of default. Rating agencies provide estimates for the recovery rates for government bonds. The recovery rates are related to the loss given default rates as follows.

$$Loss\ Given\ Default\ (\%) = 1 - Recovery\ rate\ (\%)$$

A recovery rate for government bonds equal to 41%, provided by Moody’s, implies a Loss given default of 59%. In other words, if government bond defaults, 59% of the exposure will be lost and 41% will be recovered. Please note that recovery rate estimates may vary by country, currency or region.

- Calibration of ‘Probability of Default’

Long-term default probabilities are provided by the rating agencies S&P and Moody’s (Table 4).

Table 4 Default probabilities of AA rated government bonds based on rating agencies reports.

Time horizon	Cohort	Source description	Default probabilities
One Year	12-month	Default, Transition and Recovery: 2018 Annual Sovereign Default And Rating Transition Study. S&P . March 2019. 12-month cohort between 1993 and 2018 annualized.	0%
One Year	12-month	Average 12-month rating migration rates. 1983-2018. Moody's Investors Service 12-month cohort. The first cohort considered is the 1-year cohort starting on January 1. 1983. The last cohort considered is the 1-year cohort starting on January 1. 2018.	0%
One Year	180-month	Default, Transition and Recovery: 2018 Annual Sovereign Default And Rating Transition Study . S&P . March 2019 Average transitions over each 180-month cohort between 1993 and 2018 annualized.	4.6%

For comparison purposes, the implied default probabilities derived from CDS spreads can be calculated using the formula below, described in Hull[11] (Table 5).

$$Probability\ of\ default = 1 - e^{\frac{-spread*t}{1-R}}$$

Where,

- ‘Spread’ is the spread of the bond yield over the risk-free rate. In this case study the mid CDS spreads - adjusted for illiquidity - are used instead.
- ‘t’ is the time horizon. The average maturity of the CDS contracts is used, which is 4 years.
- ‘R’ is the recovery rate. A value of 41% is used, provided by Moody’s.

Table 5 Implied default probabilities from mid CDS spreads.

Years	Mid CDS spread (bps)*	Implied default probabilities
0.5	5.86	0.055%
1	7.25	0.139%
2	12.16	0.400%
3	19.25	0.882%
4	25.2	1.445%
5	31.19	2.120%
7	39.75	3.819%
10	47.5	6.494%
Average	**23.52**	**1.919%**

**The mid CDS spreads are adjusted for CDS liquidity risk, as discussed in Section 4.2.*

[11] Hull, J. (2009). Options, futures and other derivatives/John C. Hull, 7th Edition, p.490 – 492.

Step 2: Calculation of the Expected Credit Loss as a % of the market value of the reference portfolio

Having calibrated the ECL model, the next step is to calculate the expected credit losses using the formula above. Default probabilities are multiplied by the Loss Given Default estimate (59%). The default probabilities based on 12-month bond cohorts (i.e. bonds issued over 1 year and their transitions observed for the following 1 year) are 0%. A zero default probability implies no credit losses.

The default probability based on 180-month bond cohort (i.e. bonds issued over 15 years and their transitions observed for the following 1 year) is 4.6% whereas the average implied default probability based on CDS spreads is 1.919%. The estimated ECLs are 2.714% (=4.6%*59%) and 1.132% (=1.919%*59%) respectively. As expected, the expected credit loss increases in line with the value of default probability.

Step 3: Conversion of the Expected Credit Loss from a monetary amount to a credit risk premium

A reduction in portfolio market value due to a credit loss implies an increase in the portfolio yield. This increase in yield can be considered as a proxy of the reference portfolio credit risk premium. A series of approximations - described in the Appendix D - are implemented to convert the expected credit loss from a monetary amount to a risk premium.

For example, a credit loss of 2.714% implies that the portfolio market value will be reduced and consequently the reference portfolio yield will increase from 0.617% to 0.825%. The difference in yields (0.208%) is a proxy for the credit risk premium. Furthermore, a credit loss of 1.132% implies that the portfolio market value will be reduced and consequently the reference portfolio yield will increase from 0.617% to 0.704%. The difference in yields (0.086%) is a proxy for the credit risk premium. The results are summarised in Table 6.

Table 6 Expected Credit Loss estimates.

Source description	**Default probabilities**	**Credit risk as a % of the portfolio's market value**	**Credit - stressed YTM**	**Credit risk premium***
Default, Transition and Recovery: 2018 Annual Sovereign Default And Rating Transition Study . S&P . March 2019 Average transitions over each 180-month cohort between 1993 and 2018 annualized.	4.6%	2.714%	0.825%	0.208%
UK CDS spreads	1.919%	1.132%	0.704%	0.087%

** This is the difference between the credit-stressed yield to maturity and the unstressed yield to maturity (0.617%).*

An advantage of Expected Credit Loss models is the possible consistency with IFRS 9 whereas their main difficulty is the calibration. It is worth mentioning that the credit migration rates and the recovery rates, provided by rating agencies, are long-term averages updated on an annual basis.

5. Credit-risk-adjusted zero-coupon rates extrapolation

The selected estimate for the credit risk premium is 0.204% based on CDS spreads (see Section 4.2). The credit risk premium is deducted from the zero-coupon rates, calculated in Section 3. Next, the Nelson-Siegel[12] method and the Smith-Wilson method for extrapolating the credit-risk adjusted zero-coupon rates are implemented. The Nelson-Siegel method is implemented in RStudio, using the R package 'Yield Curve[13]',

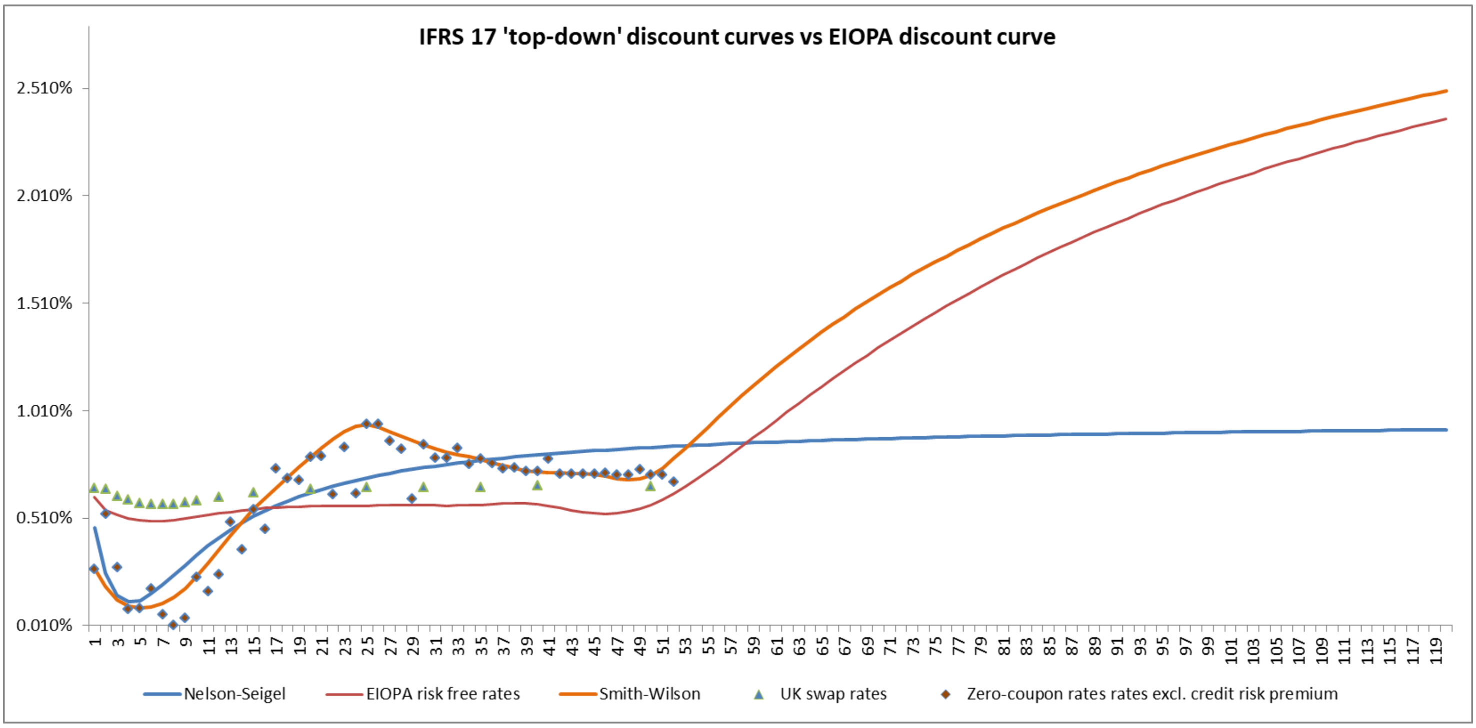
[12] Nelson, C. R., & Siegel, A. F. (1987). Parsimonious modeling of yield curves. Journal of Business, 473-489.

[13] https://cran.r-project.org/web/packages/YieldCurve/index.html

whereas the Smith-Wilson method is implemented using the Excel tool provided by EIOPA[14]. It is worth mentioning that the Nelson-Siegel method needs no explicit assumption about the Ultimate Forward Rate.

6. Results

The following chart summarises the key rates and the discount curves estimated in this case study. The discount curves are also presented in Appendix E.



As expected, the 'top-down' discount curves estimated using Nelson-Siegel and Smith-Wilson methods are close to the shape of zero-coupon rates derived by UK government bonds. On the other hand, the EIOPA risk free curve (estimated on GBP swap rates using the Smith-Wilson method, 31/08/2019) is close to the shape of the UK swap rates. The top-down' discount curves differ from EIOPA curve due to the following reasons:

i. The UK yield curve has a sigmoid shape and it is different from the UK swap curve (see Section 2). In particular for maturities up to 15 years the swap rates are higher than bond yields. For maturities greater than 15 years the bond yields are higher than swap rates. Hence, the short and medium term discount rates are not similar because they are based on different underlying rates.

ii. Beyond maturity year 50, EIOPA risk free rates converge toward the UFR which is currently estimated at 3.9%. However, the yield curve inversion observed for long term government bonds (see Section 2) implies that long term yields will remain low. The yield curve inversion feature is picked-up by the Nelson-Siegel model and thus long term discount rates are estimated about 0.9%. On the other hand, if the Smith-Wilson method with an explicit assumption of UFR is used, the EIOPA discount curve is not materially different from the IFRS 17 discount curve.

[14] https://eiopa.europa.eu/Publications/Standards/Smith-Wilson Risk-Free Interest Rate Extrapolation Tool v1.2.xlsb

7. Practical challenges related to the transition from Solvency II to IFRS 17

The main challenges related to the transition from Solvency II to IFRS 17 are the selection of the reference portfolio and the methodology for extrapolating discount rates. The following points relate to the 'top-down' approach only.

Selection of reference portfolio

The standard requires discount rates, and hence the reference portfolio, to reflect the liquidity characteristics of insurance contracts. Therefore, the allocation of insurance liabilities in liquidity buckets is an important input for selecting reference portfolios.

First, consider the very liquid liabilities. If the reference portfolio consists only of swaps then the EIOPA discount curve could be appropriate for discounting liabilities under IFRS 17. Interest rate swaps have positive default risk and negligible liquidity risk[15]. As IFRS 17 does not impose any restrictions on the assets included in the reference portfolio, this choice may be justifiable for discounting very liquid liabilities. Under this approach, the justification should include the reasons for which liabilities have negligible liquidity risk which can be reflected in a portfolio of swaps. Alternatively a portfolio of government bonds can be used to discount liquid liabilities.

On the other hand, if less liquid liabilities exist then the reference portfolio should include less liquid assets, such as corporate bonds. In this case the portfolio's credit risk premium should be estimated and deducted from the zero-coupon bond rates. EIOPA discount curve may no longer be appropriate for discounting these liabilities.

Methodology for extrapolating discount rates

The main difference in the 'top-down' curves estimated by Nelson-Siegel and Smith-Wilson methods is the use of Ultimate Forward Rate (UFR). EIOPA calculates the UFR on an annual basis and restricts its annual change 15 basis points[16]. The UFR is the sum of an expected real rate and an expected inflation rate. The expected real rate is calculated as a simple average of the past real rates since 1961 and it is the same for all currencies. The expected inflation rate is currency-specific and it is based on the inflation target of central banks. The estimate for 2020 is 3.55% for both GBP and EUR. However, due to the annual change restriction the applicable UFR in 2020 is 3.75%. So a decision related to discount rates for IFRS 17 is whether a UFR will be used.

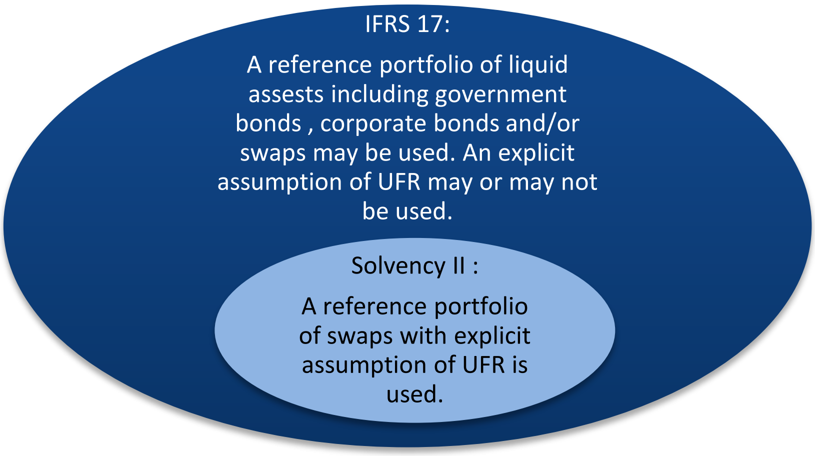
The choice of last liquid point (LLP) is another parameter that needs justification. For GBP swaps is set to 50 years whereas for EUR swaps is set to 20 years. If a UFR is not used at all (e.g. if the Nelson-Siegel model is used), the impact is expected be greater for liabilities denominated in EUR, as the extrapolation period is larger. In short, the smaller the LLP, the larger the extrapolation period and the larger the sensitivity of long-term discount rates to UFR. If the reference portfolios consist of bonds, the last liquid point could be set by taking into account the bonds' term to maturity and the depth of the relevant bond market.

As IFRS 17 does not require a particular estimation technique for determining discount rates, insurers have to justify their approach. The parameters that may require further justification under IFRS 17 include:

[15] Liu, J., Longstaff, F. A., & Mandell, R. E. (2006). The market price of risk in interest rate swaps: The roles of default and liquidity risks. The Journal of Business, 79(5), 2337-2359.
[16] Calculation of the UFR for 2020, EIOPA-BoS-19/115, 21 May 2019 https://eiopa.europa.eu/Publications/Reports/Calculation%20of%20the%20UFR%20for%202020.pdf

- Whether a UFR will be used in the extrapolating methodology at all.
- If a UFR is used, the calculation of UFR. For example, whether the expected real rate will be the same across all currencies.
- If a UFR is used, the restriction in annual change. For example, adopting the limit of 15 basis points introduced by EIOPA.
- The determination of last liquid point which depends on the reference portfolio.

Overall IFRS 17 is more flexible in the estimation of discount curves compared to Solvency II.



Matching Adjustment

Insurers that use a Matching Adjustment may look to maximise synergies and reduce complexity of Solvency II and IFRS 17 reporting. The Matching Adjustment (MA) is added to the basic risk-free interest rate term structure in order to value long term insurance liabilities backed by "hold-to-maturity" assets. It is calculated as the spread over risk-free rates on the "hold-to-maturity" assets less an allowance for probability of default and cost of downgrade. Certain extracts from EIOPA Technical documentation[17] that are relevant to matching adjustment are presented below.

"The matching adjustment (MA) is an adjustment to the basic risk-free interest rate, based on the spread on an undertaking's own portfolio of matching assets, less a fundamental spread that allows for default and downgrade risk. Undertakings must calculate the MA themselves, based on their own assigned portfolios of eligible assets. Rather than publishing the MA, EIOPA publishes only the fundamental spreads that undertakings should use, together with the following information:

a. for assets other than government bonds, the probability of default (PD) to use in the de-risking of the cash flows of the assigned assets,
b. the probability of default expressed as a part of the spread used to calculate the fundamental spread,
c. the cost of downgrade (CoD),
d. the long-term average spread (LTAS).

Where no reliable credit spread can be derived from the default statistics, as in the case of exposures to sovereign debt, the fundamental spread for the calculation of the matching adjustment and the volatility adjustment should be equal to the long-term average of the spread over the risk-free interest rate.

[17] Technical documentation of the methodology to derive EIOPA's risk-free interest rate term structures. EIOPA-BoS-15/035

For corporate bonds the fundamental spread is calculated as FS = max(PD+CoD, 35%·LTAS). Consequently, the fundamental spread is not always the sum of PD and CoD. Where the floor relating to the LTAS applies the fundamental spread is larger than that sum. In general, the MA should be calculated on the basis of the amount FS – PD = max(CoD, 35%·LTAS – PD).

The calculation of the PD derives an amount that is interpreted as an investor's required compensation for assuming the risk of the expected probability of default of a bond. The expectation of a default (based on historical default probabilities derived from the transition matrices) is thus combined with an assumption on the recovery value in case of default, which is assumed to be 30% of the market value.

For each relevant currency, the Matching Adjustment for an undertaking will be a single number expressed in basis points. This single number should be added to the basic risk-free interest rate term structure for that currency at all maturities (i.e. it should be applied as a parallel shift of the whole of the basic risk-free interest rate term structure)."

Possible synergies between IFRS 17 and Solvency II calculation of Matching Adjustment are examined below.

Table 7 Scope for synergies between Solvency II and IFRS 17.

Element of Matching Adjustment calculation	Solvency II	IFRS 17	Scope for synergies
Portfolio of assets	A portfolio of "hold-to-maturity" assets	A reference portfolio of assets	Synergies are possible if the reference portfolio to include only the "hold-to-maturity" assets.
Calibration of Fundamental Spread	Based on long-term average spreads (LTAS)	Calibration has to 'reflect current market conditions' not historical.	Solvency II calibration cannot be used. Synergies are limited.
Calibration of PD and CoD	Based on annual credit migration matrices.	Calibration has to 'reflect current market conditions' not historical.	Solvency II calibration may be used. Synergies are limited.
Formula for Fundamental Spread	▪ Government bonds: 30% Or 35% of LTAS ▪ Corporate bonds: max(PD+CoD, 35%·LTAS)	No formula is specified for estimating credit risk premium	The fixed parameters 30% and 35% may require justification under IFRS 17.
Estimation of discount curve	MA is added to the risk-free rates.	Bottom-up or top-down approach could be used.	More synergies exist under the 'bottom-up' rather than the 'top-down' approach.

The estimation process of a discount curve under the 'top-down' approach based on a "hold-to-maturity" portfolio of assets, used for the matching adjustment calculation, is outlined below:

- Set the reference portfolio to be the portfolio of "hold-to-maturity" assets
- Estimate the zero-coupon bond rates and the credit risk premium for this portfolio. The credit risk premium should 'reflect current market conditions'.
- Deduct the credit risk premium from the zero-coupon bond rates
- Smooth and extrapolate the zero-coupon bond rates

Portfolios used for MA calculations are developed in order to replicate insurance liabilities cashflows. Therefore, it is assumed that no other adjustments to the yields will be required (e.g. there is no duration mismatch).

Summary of practical challenges

A summary of the practical difficulties in estimating IFRS 17 ‘top-down’ discount curves is presented below.

Stage in the process of estimating IFRS 17 ‘top-down’ discount curves	**Description of the practical challenge**	**Approach adopted in this case study and additional considerations**
Selection of reference portfolio	Decide the portfolio mixture (e.g. Government /Corporate /Covered/Swaps)	UK Government bonds are selected. Corporate bonds may introduce additional difficulties (e.g. availability of CDS contracts)
	Set weights for individual bonds	The reference portfolio is equally weighted. Alternatively, weights can be selected to match target duration or/and target credit rating.
Zero-coupon bond rates	Calculation of zero-coupon bond rates	Zero-coupon bond rates instead of yields to maturity are required to discount liabilities The “bootstrapping” method is applied.
Estimation of credit risk premium	Option adjusted spreads include both credit and liquidity risk. They might also take negative values.	Option adjusted spreads are not a good proxy for government bonds. However, for corporate bonds with embedded options option adjusted spreads may be a better proxy.
	CDS spreads for government bonds stop at maturity year 10.	Extrapolation using linear regression over-estimates long-term CDS spreads. Hence, CDS spreads are used as provided.
	CDS spreads consist of both credit and illiquidity components.	The ‘CDS-illiquidity factor’ is quantified using the difference in the bid – ask CDS spread over the mid CDS spread.
	Approximation a single credit risk premium value from CDS spreads.	The average of mid CDS spreads across all maturities is used.
	Calibration of ‘Exposure at Default’ component for ECL models	The portfolio is notional, so assume that ‘Exposure at Default’ is £1.
	Calibration of ‘Loss Given Default’ component for ECL models	The recovery rates for government bonds provided by rating agencies are used.
	Calibration of ‘Probability of Default component for ECL models	The long-term default probabilities provided by the rating agencies are used. In addition the implied default probability based on CDS spreads is calculated.
	Conversion of the Expected Credit Loss from a monetary amount to a credit risk premium	A series of approximations are developed for the conversion. Alternatively an analytic calculation per bond could be implemented.
Derivation of discount curve	Smoothing and extrapolation of credit-risk-adjusted zero-coupon rates	Options include: ▪ The Nelson-Siegel method, without an explicit assumption on Ultimate Forward Rate. ▪ The Smith-Wilson method with an explicit assumption on UFR

It is worth mentioning that an issue not addressed in this case study is how to adjust the discount curve for the different liquidity characteristics of the liabilities. For example, liquidity characteristics may include the existence (or not) of a surrender option or the application of a surrender penalty.

Appendix A: Extracts from IFRS 17 related to discount rates

Paragraph B78

"Discount rates shall include only relevant factors, i.e. factors that arise from the time value of money, the characteristics of the cash flows and the liquidity characteristics of the insurance contracts. Such discount rates may not be directly observable in the market. Hence, when observable market rates for an instrument with the same characteristics are not available, or observable market rates for similar instruments are available but do not separately identify the factors that distinguish the instrument from the insurance contracts, an entity shall estimate the appropriate rates. IFRS 17 does not require a particular estimation technique for determining discount rates. In applying an estimation technique, an entity shall:

(a) Maximise the use of observable inputs and reflect all reasonable and supportable information on non-market variables available without undue cost or effort, both external and internal. (…)

(b) Reflect current market conditions from the perspective of a market participant.

(c) Exercise judgement to assess the degree of similarity between the features of the insurance contracts being measured and the features of the instrument for which observable market prices are available and adjust those prices to reflect the differences between them. (…)

Paragraph B79

For cash flows of insurance contracts that do not vary based on the returns on underlying items, the discount rate reflects the yield curve in the appropriate currency for instruments that expose the holder to no or negligible credit risk, adjusted to reflect the liquidity characteristics of the group of insurance contracts. (…)

Paragraph B81

Alternatively, an entity may determine the appropriate discount rates for insurance contracts based on a yield curve that reflects the current market rates of return implicit in a fair value measurement of a reference portfolio of assets (a top-down approach). An entity shall adjust that yield curve to eliminate any factors that are not relevant to the insurance contracts, but is not required to adjust the yield curve for differences in liquidity characteristics of the insurance contracts and the reference portfolio.

Paragraph B85

IFRS 17 does not specify restrictions on the reference portfolio of assets used in applying paragraph B81. However, fewer adjustments would be required to eliminate factors that are not relevant to the insurance contracts when the reference portfolio of assets has similar characteristics. For example, if the cash flows from the insurance contracts do not vary based on the returns on underlying items, fewer adjustments would be required if an entity used debt instruments as a starting point rather than equity instruments. For debt instruments, the objective would be to eliminate from the total bond yield the effect of credit risk and other factors that are not relevant to the insurance contracts. One way to estimate the effect of credit risk is to use the market price of a credit derivative as a reference point."

IFRS 17 Insurance Contracts, May 2017

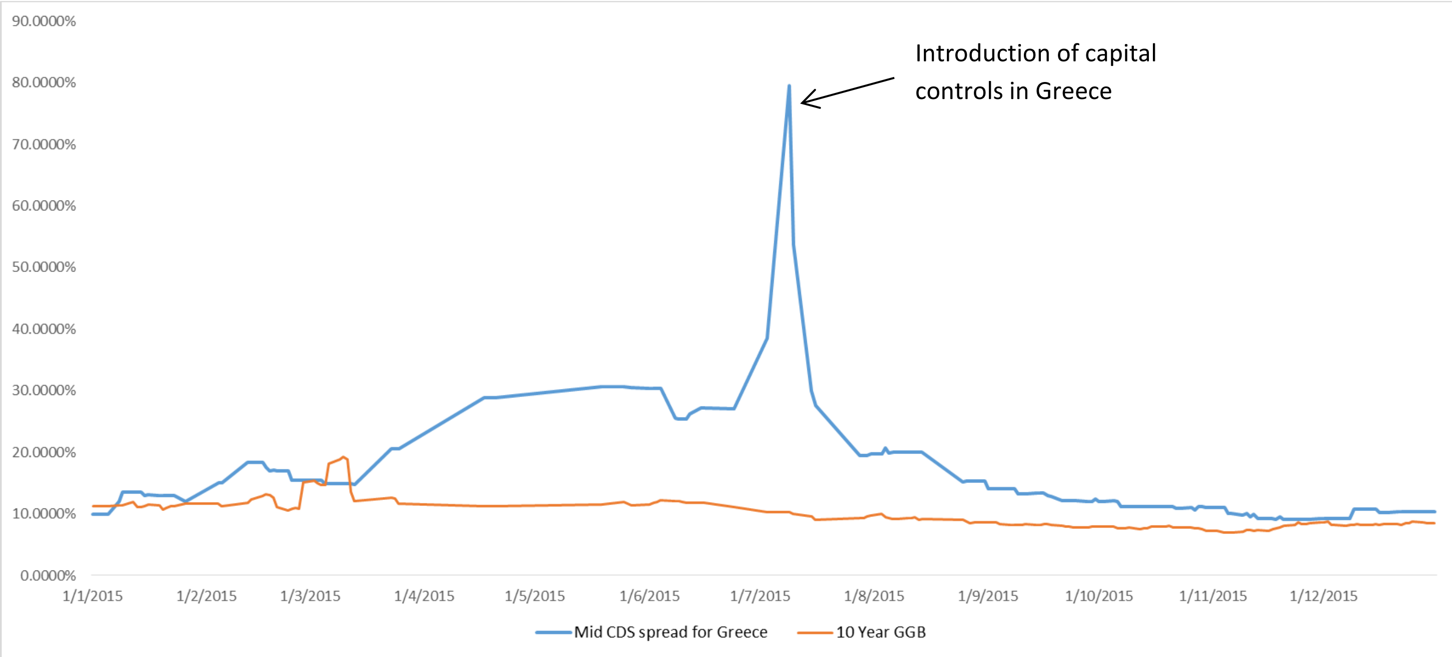
Appendix B: Characteristics of bonds included in the reference portfolio.

ISIN	Ask Price	Maturity year	Coupon rate (%)	Modified Duration	Yield to maturity	Option adjusted spread*
GB00B058DQ55	102.23	2020	4.75	0.520	0.488%	0.028%
GB00BN65R198	101.36	2020	2	0.887	0.486%	0.056%
GB00B582JV65	103.36	2020	3.75	1.010	0.458%	0.036%
GB00BYY5F581	101.53	2021	1.5	1.380	0.415%	0.020%
GB0009997999	113.55	2021	8	1.664	0.347%	-0.032%
GB00B4RMG977	106.87	2021	3.75	1.966	0.352%	0.004%
GB00B3KJDQ49	109.29	2022	4	2.426	0.312%	-0.015%
GB00BD0PCK97	100.62	2022	0.5	2.871	0.296%	-0.015%
GB00B7L9SL19	104.33	2022	1.75	2.954	0.318%	0.009%
GB00BF0HZ991	101.72	2023	0.75	3.837	0.308%	0.024%
GB00B7Z53659	107.82	2023	2.25	3.870	0.302%	0.014%
GB00BFWFPL34	103.28	2024	1	4.530	0.294%	0.020%
GB00BHBFH458	112.31	2024	2.75	4.740	0.287%	0.014%
GB0030880693	125.92	2025	5	4.971	0.276%	-0.005%
GB00BK5CVX03	101.82	2025	0.625	5.663	0.312%	0.034%
GB00BTHH2R79	110.57	2025	2	5.718	0.236%	-0.046%
GB00BYZW3G56	108.46	2026	1.5	6.573	0.264%	-0.027%
GB00BDRHNP05	107.41	2027	1.25	7.537	0.302%	-0.024%
GB00B16NNR78	132.45	2027	4.25	7.185	0.281%	-0.055%
GB00BFX0ZL78	111.30	2028	1.625	8.515	0.368%	-0.004%
GB0002404191	151.82	2028	6	7.600	0.325%	-0.043%
GB00BJMHB534	104.30	2029	0.875	9.703	0.442%	0.027%
GB00B24FF097	147.17	2030	4.75	9.256	0.455%	0.000%
GB0004893086	145.11	2032	4.25	10.433	0.582%	0.054%
GB00B52WS153	154.38	2034	4.5	11.917	0.688%	0.055%
GB0032452392	154.13	2036	4.25	12.980	0.761%	0.055%
GB00BZB26Y51	114.98	2037	1.75	15.677	0.855%	0.032%
GB00B00NY175	169.54	2038	4.75	14.317	0.838%	0.011%
GB00B3KJDS62	161.55	2039	4.25	15.118	0.890%	0.020%
GB00B6460505	164.14	2040	4.25	15.746	0.924%	0.042%
GB00B1VWPJ53	173.96	2042	4.5	16.723	0.952%	0.056%
GB00B84Z9V04	148.94	2044	3.25	18.388	0.990%	0.063%
GB00BN65R313	156.40	2045	3.5	18.744	0.987%	0.056%
GB00B128DP45	177.89	2046	4.25	19.091	0.987%	0.054%
GB00BDCHBW80	112.38	2047	1.5	23.090	0.993%	0.005%
GB00BFWFPP71	119.31	2049	1.75	23.580	0.993%	0.000%
GB00B39R3707	185.54	2049	4.25	20.696	0.980%	0.025%
GB00B6RNH572	178.57	2052	3.75	22.645	0.961%	-0.009%
GB00BJLR0J16	119.76	2054	1.625	27.500	0.964%	-0.043%
GB00B06YGN05	201.63	2055	4.25	23.809	0.939%	-0.034%
GB00BD0XH204	126.27	2057	1.75	28.958	0.928%	-0.079%
GB00B54QLM75	203.89	2060	4	26.208	0.918%	-0.066%
GB00BYYMZX75	159.48	2065	2.5	31.435	0.913%	-0.092%
GB00BBJNQY21	201.67	2068	3.5	30.927	0.917%	-0.082%
GB00BFMCN652	130.61	2071	1.625	37.377	0.892%	-0.128%
Average	**133.99**	-	**3.08**	**12.7**	**0.617%**	**0.000374%**

*Source: Bloomberg, Date: 29/08/2019. *Option-adjusted spreads for UK gilts are calculated by Bloomberg using a yield curve estimated by UK gilts. Therefore, option-adjusted spreads take small positive or negative values which reflect the differences between the actual bond yields and the estimated yield curve.*

Appendix C: CDS spreads vs bond yields during Greek debt crisis.

CDS spreads and bond yield movements are correlated but not perfectly synchronised. As an example, the Greek 5-year mid CDS spread is compared to the yield of 10-yearGreek government bond during 2015. In June 2015 capital controls were introduced in Greece[18], increasing fears of default in government debt. As a result the Greek CDS spread increases to 79.5% at 09/07/2015.



Source: Thomson Reuters

[18] https://en.wikipedia.org/wiki/Capital_controls_in_Greece
https://www.reuters.com/article/us-eurozone-greece/greece-imposes-capital-controls-as-crisis-deepens-idUSKBN0P40EO20150628

Appendix D: Conversion of Expected Credit Loss from monetary amount to yield (%)

The market value of a bond is given by:

$$MV = \sum_t \frac{CF_t}{(1+YTM)^t} \approx \frac{Total\ undiscounted\ cashflow}{(1+YTM)^{Duration}}$$

Where, YTM is the Yield to Maturity

The reduced market value after adjusting for the expected credit loss is:

$$MV^* = MV * (1 - ECL)$$

Where, ECL is the Expected Credit Loss (%)

The credit-adjusted market value is given by:

$$MV^* = \sum_t \frac{CF_t}{(1+YTM^*)^t} \approx \frac{Total\ undiscounted\ cashflow}{(1+YTM^*)^{Duration}}$$

The only unknown parameter is YTM* which is the yield corresponding to the credit-adjusted market value.

If we take the difference in market values we get

$$MV - MV^* = \frac{Total\ undiscounted\ cashflow}{(1+YTM)^{Duration}} - \frac{Total\ undiscounted\ cashflow}{(1+YTM^*)^{Duration}}$$

$$\Rightarrow \quad MV * ECL = \frac{Total\ undiscounted\ cashflow}{(1+YTM)^{Duration}} - \frac{Total\ undiscounted\ cashflow}{(1+YTM^*)^{Duration}}$$

Re-arrange to solve for YTM* and get the following formula.

$$YTM^* = \left\{\frac{1}{(1+YTM)^{Duration}} - \frac{MV * ECL}{Total\ undiscounted\ cashflow}\right\}^{\frac{-1}{Duration}} - 1$$

The above formula is applied on the reference portfolio with the following inputs.

Description of the reference portfolio	
Type of bonds	UK gilts
Number of bonds	45
Weight foe each bond	2.22%
Duration	12.7 years
Yield to maturity	0.617%
Market value *(Weighted average of the Ask price at 29/08/2019)*	131.09
Total undiscounted cashflows *(Weighted average of nominal + coupons)*	152.33
ECL based on CDS spreads	1.132%
ECL based on S&P credit transition matrix	2.713%

Appendix E: IFRS 17 discount curves under the 'top-down approach'

Year	Zero-coupon bond rates excl. credit risk premium*	Discount curve using Nelson-Siegel model and zero-coupon bond rates	Discount curve using Smith-Wilson method , zero-coupon bond rates and UFR = 3.9%	EIOPA risk free rates using Smith-Wilson method and UFR = 3.9%**
1	0.274%	0.464%	0.273%	0.608%
2	0.530%	0.253%	0.191%	0.546%
3	0.281%	0.152%	0.131%	0.523%
4	0.087%	0.120%	0.101%	0.508%
5	0.091%	0.127%	0.091%	0.499%
6	0.179%	0.157%	0.096%	0.494%
7	0.061%	0.199%	0.113%	0.496%
8	0.013%	0.245%	0.143%	0.500%
9	0.044%	0.292%	0.183%	0.508%
10	0.235%	0.337%	0.235%	0.516%
11	0.170%	0.380%	0.298%	0.524%
12	0.246%	0.419%	0.365%	0.532%
13	0.490%	0.455%	0.430%	0.539%
14	0.364%	0.488%	0.492%	0.545%
15	0.551%	0.518%	0.550%	0.551%
16	0.458%	0.544%	0.603%	0.556%
17	0.739%	0.568%	0.653%	0.559%
18	0.695%	0.590%	0.701%	0.561%
19	0.687%	0.610%	0.747%	0.563%
20	0.795%	0.628%	0.792%	0.565%
21	0.798%	0.645%	0.837%	0.566%
22	0.620%	0.660%	0.878%	0.566%
23	0.840%	0.674%	0.912%	0.567%
24	0.625%	0.686%	0.936%	0.568%
25	0.949%	0.698%	0.945%	0.568%
26	0.948%	0.709%	0.934%	0.569%
27	0.870%	0.719%	0.914%	0.569%
28	0.832%	0.728%	0.891%	0.570%
29	0.598%	0.737%	0.869%	0.570%
30	0.853%	0.745%	0.849%	0.570%
31	0.790%	0.752%	0.832%	0.569%
32	0.790%	0.760%	0.818%	0.568%
33	0.836%	0.766%	0.806%	0.569%
34	0.762%	0.773%	0.795%	0.570%
35	0.785%	0.778%	0.782%	0.572%
36	0.763%	0.784%	0.768%	0.576%
37	0.739%	0.789%	0.753%	0.579%
38	0.743%	0.794%	0.741%	0.580%
39	0.727%	0.799%	0.731%	0.579%
40	0.727%	0.804%	0.725%	0.575%
41	0.784%	0.808%	0.721%	0.566%
42	0.715%	0.812%	0.720%	0.556%
43	0.715%	0.816%	0.719%	0.546%
44	0.715%	0.820%	0.717%	0.538%
45	0.715%	0.823%	0.712%	0.533%
46	0.721%	0.827%	0.703%	0.531%
47	0.709%	0.830%	0.695%	0.534%
48	0.709%	0.833%	0.690%	0.541%
49	0.734%	0.836%	0.694%	0.554%
50	0.713%	0.839%	0.710%	0.572%
100	-	0.842%	2.233%	2.064%
120	-	0.921%	2.498%	2.368%

**The credit risk premium is 0.204% , Date: 29/08/2019, ** Date : 31/08/2019*