RFR Technical Documentation

The methodology to derive EIOPA's risk-free interest rate term structures

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NOTE ON CHANGES SINCE LAST PUBLISHED VERSION

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The amendments to the Solvency II Directive and the Delegated Regulation have introduced changes to several key elements of the RFR methodology, notably the interpolation and extrapolation techniques and the volatility adjustment, which is now undertaking specific. These changes were incorporated and presented in the previous version of the RFR Technical Documentation (RFR TD) of May 2026.

The May 2026 version was already restructured to improve its accessibility for different audiences, from high-level stakeholders to technical experts. The revised structure begins with an overview of the underlying principles, assumptions, and methodological building blocks, followed by progressively detailed descriptions of each component, including their mathematical formulation.

Due to its time of publication, the May 2026 version of the RFR TD did not yet incorporate the results of the DLT assessment or the annual update of the representative portfolios (including the newly introduced frozen cash flows), as these regular updates are performed later in the year once the underlying data has become available.

The current updated version of the RFR TD contains these parameter updates and incorporates stakeholder feedback received on the previous version. In particular it includes:

- the results of the 2026 DLT assessment, including the determination of the first smoothing points, and the weights for calculating the last liquid forward rates (see subsection 5.2.8);
- the description of the construction of the representative portfolios which has been completed for the treatment of missing data (see ANNEX E);
- the results of the 2026 update of the representative portfolios, including the newly introduced frozen cash flows (separate Excel file).
- the applicable percentage for the euro as a reference for the calculation of the residual volume criterion (see subsection B.4.2);
- the strengthened criterion for assessing the relevance of currencies (see subsection 4.2.2) leading to a reduction in the number of relevant currencies and a change for calculating the credit risk adjustment (see Section 6).

This updated version of the RFR TD will apply from 30 January 2027.

CONTENTS

Note on Changes since last published version 2

List of Abbreviations 8

1. Legal foundations 9

1.1. Legal notice 9

1.2. Legal basis 9

2. Disclaimers 11

2.1. S&P disclaimer 11

2.2. S&P Dow Jones Indices disclaimer 11

3. Methodological principles and assumptions 12

3.1. Relevant criteria 12

3.2. Financial market data used as inputs 12

3.3. Use of market data with maturities below one year 13

3.4. Assessment of deep, liquid and transparent financial markets (DLT assessment) 13

3.5. Credit risk adjustment (CRA) 14

3.6. Currency risk adjustment (CURA) 14

3.7. Interpolation method 15

3.8. Extrapolation method 15

3.9. Volatility adjustment (VA) 15

3.10. Matching adjustment (MA) 16

4. Data sources for the inputs from financial markets 17

4.1. Financial market data providers 17

4.2. Selection of the relevant currencies 18

4.3. Selection of market rates 18

5. Identification and DLT assessment of relevant financial instruments 22

5.1. Legal framework 22

5.2. Conceptual framework for the DLT assessment 22

5.3. Update of the DLT assessment 25

5.4. Currencies without DLT financial instruments 25

6. Credit risk adjustment (CRA) 26
6.1. Legal framework 26
6.2. Application of the CRA 26
6.3. Calculation of the CRA 26
6.4. First situation 26
6.5. Second situation 27
6.6. Third situation 27
6.7. Final rounding of the CRA 28
6.8. Data sources for the CRA 28
7. Currency risk adjustment (CURA) 30
7.1. Legal framework 30
7.2. Application of the CURA 30
7.3. Calculation of the CURA 30
7.4. Update of the CURA 31
8. Basic RFR term structure construction 32
8.1. Inputs and control parameters 32
8.2. First smoothing point 33
8.3. Last liquid forward rate 33
8.4. Ultimate forward rate 34
8.5. Interpolation and extrapolation 34
9. Volatility adjustment 38
9.1. Conceptual framework 38
9.2. Understanding risk-corrected spreads 40
9.3. Currency volatility adjustment 42
9.4. Macro volatility adjustment for euro countries 42
9.5. Publication of the risk-corrected spread 43
10. RFR term structure with VA 45
10.1. Inputs and control parameters 45
10.2. Extrapolation 46

11. Matching adjustment 47

11.1. Conceptual framework 47

11.2. FS for government bonds 48

11.3. FS for corporate bonds 48

ANNEXES 50

ANNEX A Relevant currencies 51

A.1 EEA currencies 51

A.2 Other currencies 51

ANNEX B DLT assessment 52

B.1 General approach to DLT assessment criteria 52

B.2 DLT assessment criteria for the swap market 54

B.3 DLT assessment criteria for the government bond market 54

B.4 Determination of the FSP 55

B.5 History of relevant financial instruments 56

ANNEX C UFR methodology 63

C.1 Introduction 63

C.2 Calculation of the UFR 63

C.3 Calculation of the expected real rate 64

C.4 Calculation of the expected inflation rate 65

C.5 Implementation of the methodology 65

ANNEX D Bootstrapping risk-free rates 67

D.1 Using par swap rates as inputs 67

D.2 The fixed leg of a swap 67

D.3 The floating leg of a swap 68

D.4 Step 1 for par swap rates 69

D.5 Step 2 for par swap rates 70

D.6 Newton-Raphson algorithm in EIOPA's Excel VA-tool 73

D.7 Using zero-coupon government bond rates as inputs 73

D.8 Step 1 for zero-coupon government bond rates 74

D.9 Step 2 for zero-coupon government bond rates 75

ANNEX E Representative portfolios 76

E.1 Introduction 76

E.2 Practical assumptions made 76

E.3 Source data and adjustments 77

E.4 Look-through mapping 79

E.5 Weights and durations for currency and country portfolios 80

E.6 Weight and durations for government and corporate bond portfolios 82

ANNEX F Reference portfolios 85

F.1 Introduction 85

F.2 Bond reference portfolios 85

F.3 Internal rate of returns for bond reference portfolios 86

F.4 Mapping IRRs to spreads and risk corrections 87

ANNEX G Yield proxies 89

G.1 Introduction 89

G.2 Government bond yields 89

G.3 Peer country government bond yields 90

G.4 Risk-free yields 91

G.5 Corporate bond yields 91

G.6 Risk corrections 94

ANNEX H LTAS calculation specificities 102

H.1 History of LTAS government bond rates 102

ANNEX I Calculation of the CoD and PD 106

I.1 Legal context 106

I.2 Method for deriving the PD and the CoD 106

I.3 Market data for the calculation of the PD and CoD 108

I.4 Probability 109

I.5 Zero-coupon bond cash flows 110

I.6 Discount factor 111

I.7 Cost of downgrade and probability of default in a nutshell 111
I.8 Reducing computational and numerical complexity 114
I.9 A remark about probability in continuous time and why it has not been used here 114
I.10 A remark about intra-year chains of rating changes 115
I.11 Transition matrices for CoD and PD 116
ANNEX J Diagram of calculations 117

LIST OF ABBREVIATIONS

CoD	Cost of downgrade
CQS	Credit quality step
CRA	Credit risk adjustment
CSSR	Credit spread sensitivity ratio
CURA	Currency risk adjustment
DLT	Deep, liquid and transparent
DITTAR	Debt-investments-to-total-assets ratio
EBA	European Banking Authority
ECB	European Central Bank
EEA	European Economic Area
FS	Fundamental spread
FSP	First smoothing point
GVT	Government bond
IBOR	Interbank offered rate
IRR	Internal rate of return
IRS	Interest rate swap
LLFR	Last liquid forward rate
LTAS	Long-term average spread
MA	Matching adjustment
OIS	Overnight indexed swap
PD	Probability of default
RC	Risk correction
RCS	Risk-corrected spread
RFR	Risk-free rate
RGLA	Regional government and local authorities
RIC	Refinitiv instrument code
SCR	Solvency capital requirement
SWP	Interest rate swap
VA	Volatility adjustment
UFR	Ultimate forward rate

1. LEGAL FOUNDATIONS

1.1. LEGAL NOTICE

1.1.1. This document aims to assist users in complying with their obligations under Directive 2009/138/EC of the European Parliament and of the Council[1] (hereinafter the 'Solvency II Directive'). Information in this document does not constitute legal advice. Usage of the information remains under the sole responsibility of the user. EIOPA does not accept any liability regarding the use that may be made of the information.

1.1.2. The references to financial data, financial and statistical methodologies, and trademarks mentioned in this document are protected by their respective property rights (be they proprietary to EIOPA or third parties). The references to such information neither mean any change of such rights, nor constitute any type of explicit or implicit authorisation of EIOPA for any use, nor provide any type of opinion of EIOPA in respect of them for purposes other than those proposed in this technical documentation.

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1.2. LEGAL BASIS

1.2.1. The Union legislator entrusted EIOPA to lay down and publish technical information on risk-free interest rates with the purpose of allowing for the consistent calculation of technical provisions by insurance and reinsurance undertakings under Article 77e(1) of the Solvency II Directive.

1.2.2. To further reinforce the importance of that technical information towards achieving consistency in the calculation of technical provisions, the Union legislator provided for binding effects of this technical information on insurance and reinsurance undertakings, subject to the inclusion of this information into an implementing act of the European Commission (Article 77e(2) of the Solvency II Directive).

[1] Directive 2009/138/EC of the European Parliament and of the Council of 25 November 2009 on the taking-up and pursuit of the business of Insurance and Reinsurance (Solvency II) (OJ L 335, 17.12.2009, pp. 1–155, ELI: http://data.europa.eu/eli/dir/2009/138/oj).

1.2.3. In accordance with Article 43(2) of the Commission Delegated Regulation (EU) 2015/35[2] (hereinafter the 'Delegated Regulation'), the present EIOPA technical documentation is published by EIOPA as part of the technical information published pursuant to Articles 77e(1) of the Solvency II Directive. The technical documentation explains in a transparent manner how the relevant risk-free interest rate term structures are derived. It is published to achieve a consistent calculation of technical provisions.

[2] Commission Delegated Regulation (EU) No 2015/35 of 10 October 2014 supplementing Directive 2009/138/EC of the European Parliament and of the Council on the taking-up and pursuit of the business of Insurance and Reinsurance (Solvency II) (OJ L 12, 17.01.2015, pp. 1–797, ELI: http://data.europa.eu/eli/reg_del/2015/35/oj).

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3. METHODOLOGICAL PRINCIPLES AND ASSUMPTIONS

3.1. RELEVANT CRITERIA

3.1.1. For the development of the methodology to calculate the relevant risk-free interest rate term structures EIOPA applied several principles and assumptions regarding the methods and inputs used in the calculations.

3.1.2. EIOPA based those principles and assumptions on the following criteria:

(a) respecting the essential elements underpinning the political agreement of Directive 2014/51/EU of the European Parliament and of the Council[3] (hereinafter the 'Omnibus II Directive') and all relevant prevailing directives and regulations (including the amending Directive (EU) 2025/2 of the European Parliament and of the Council[4] as well as the amending Commission Delegated Regulation (EU) 2026/269[5])
(b) transparency of all the elements of the process of calculation,
(c) replicability of the calculations, which directly leads to the restriction of expert judgement to the minimum extent possible, if any, and
(d) market consistency, prudent assessment of the technical provisions and optimal use of market information.

The following subsections describe the main principles and assumptions for the essential parts of the method to calculate the risk-free rate term structures.

3.2. FINANCIAL MARKET DATA USED AS INPUTS

3.2.1. This technical documentation identifies the financial market data used as inputs to the calculations.

[3] Directive 2014/51/EU of the European Parliament and of the Council of 16 April 2014 amending Directives 2003/71/EC and 2009/138/EC and Regulations (EC) No 1060/2009, (EU) No 1094/2010 and (EU) No 1095/2010 in respect of the powers of the European Supervisory Authority (European Insurance and Occupational Pensions Authority) and the European Supervisory Authority (European Securities and Markets Authority) (OJ L 153, 22.5.2014, pp. 1–61, ELI: http://data.europa.eu/eli/dir/2014/51/oj).

[4] Directive (EU) 2025/2 of the European Parliament and of the Council of 27 November 2024 amending Directive 2009/138/EC as regards proportionality, quality of supervision, reporting, long-term guarantee measures, macro-prudential tools, sustainability risks and group and cross-border supervision, and amending Directives 2002/87/EC and 2013/34/EU (OJ L, 2025/2, 8.1.2025, ELI: http://data.europa.eu/eli/dir/2025/2/oj).

[5] Commission Delegated Regulation (EU) 2026/269 of 29 October 2025 amending Delegated Regulation (EU) 2015/35 as regards technical provisions, long-term guarantee measures, own funds, equity risk, spread risk on securitisation positions, other standard formula capital requirements, reporting and disclosure, proportionality and group solvency (OJ L, 2026/269, 18.2.2026, ELI: http://data.europa.eu/eli/reg_del/2026/269/oj)

3.2.2. EIOPA keeps unambiguous neutrality regarding the market data providers competing in the market. The reason for selecting market data providers relies only on the high priority given to:

(a) the legal imperative of publishing the concrete figures of the technical information set out in Article 77e(1) of the Solvency II Directive;
(b) the full traceability of the calculations, as part of EIOPA's commitment to the principle of transparency;
(c) the 'replicability' of the process of calculation by those stakeholders wishing to reproduce the technical information;
(d) the ability to put into place an appropriate process of validation.

3.2.3. To ensure the appropriateness of the data, two market data sources are used: one for production and the other for validation.

3.2.4. EIOPA sources data on swaps and government bonds rates used for production from a single provider, while data on corporate bond yields and default statistics are obtained from a separate provider. This approach is intended to mitigate operational risk and reduce dependency on any single data provider.

3.2.5. The selection of these providers should not be understood as EIOPA's preference for them. The selection does not constitute advice to undertakings when deciding which provider better fits their needs.

3.3. USE OF MARKET DATA WITH MATURITIES BELOW ONE YEAR

3.3.1. EIOPA publishes the relevant risk-free interest rate term structure from one-year maturity onwards. Instruments with a maturity below one year are not always swaps and the adjustment of their credit risk, among other features, may add unnecessary complexity to the calculations. Furthermore, below one-year rates have a negligible impact on the extrapolated rates and hence on the amount of long-term technical provisions.

3.4. ASSESSMENT OF DEEP, LIQUID AND TRANSPARENT FINANCIAL MARKETS (DLT ASSESSMENT)

3.4.1. Based on academic literature and the methods applied by practitioners, EIOPA has analysed the metrics and criteria commonly used for assessments of market liquidity and evaluated their applicability for the purposes of setting a conceptual framework for the DLT assessment.

3.4.2. Bearing in mind that the national competent authorities have better knowledge of the financial markets of each currency, the DLT assessment of the bond markets for non-euro EEA currencies is performed by the respective national competent authority. All national authorities apply the same methodology and report their findings in a common template.

3.4.3. Three main findings have been extracted from the set of lessons learnt through the DLT assessment experience.

(a) The application of the common conceptual framework should not rely on hard thresholds and should not disregard qualitative information. Some criteria are interlinked and the markets for the same financial instruments for different currencies may present different features.
(b) The DLT assessment is a demanding exercise and therefore the frequency of updating the assessment should be carefully considered.
(c) Furthermore, except for crisis situations, frequent changes in the outputs of the DLT assessment do not seem plausible. Rather, a plausible future trend is the continued development of financial markets, resulting in a broader range of market interest rates meeting DLT requirements.

3.5. CREDIT RISK ADJUSTMENT (CRA)

3.5.1. Articles 44 and 45 of the Delegated Regulation cover the calculation of the CRA for basic risk-free interest rates derived based on DLT swap markets (interest rate swaps other than overnight indexed swaps) and, in the absence thereof, derived based on government bonds.

3.5.2. The CRA assumptions, calculations, and applications are defined in Section 6.

3.6. CURRENCY RISK ADJUSTMENT (CURA)

3.6.1. According to Article 48 of the Delegated Regulation, the basic risk-free interest rate term structure for a currency pegged to the euro should be the term structure for the euro, adjusted for currency risk.

3.6.2. The CURA assumptions, calculations, and applications are defined in Section 7.

3.7. INTERPOLATION METHOD

3.7.1. Interpolation is based on the constant forward assumption to fill gaps in discrete zero-coupon bond interest rates, i.e. the forward interest rate remains constant between known DLT points.

3.7.2. If the input instruments used are swaps, then the corresponding zero-coupon bond interest rates are numerically solved ('bootstrapped') using the par-swap pricing formula in combination with the constant forward assumption. For details, see Annex D.1-D.5.

3.7.3. If the input instruments used are government bonds, then the respective interest rates are already zero rates, and the constant forward assumption can be applied directly. For details, see Annexes D.7-D.9.

3.8. EXTRAPOLATION METHOD

3.8.1. The extrapolation method of Article 77a of the Solvency II Directive uses the concept of a first smoothing point (FSP). The FSP is one of the known DLT points used for the interpolation, i.e. up to the FSP the risk-free rate term structure is based on interpolation.

3.8.2. The extrapolation method ensures that the forward rates after the FSP converge to an ultimate forward rate (UFR), i.e. after the FSP the risk-free rate term structure is based on extrapolation.

3.8.3. For full details on the inter- and extrapolation-methods, see Subsection 8.5.

3.9. VOLATILITY ADJUSTMENT (VA)

3.9.1. Article 77d of the Solvency II Directive sets out the VA to the basic risk-free interest rate term structure, the application of which is subject to prior approval by the supervisory authority.

3.9.2. For each relevant currency, the VA shall be based on the spread between the interest rate that could be earned from assets included in a reference portfolio of investments in debt instruments for that currency and the rates of the relevant basic risk-free interest rate term structure for that currency.

3.9.3. The VA assumptions, calculations, and applications are defined in Section 9.

3.10. MATCHING ADJUSTMENT (MA)

3.10.1. The steps involved in calculating the MA are set out in Article 77c of the Solvency II Directive and Articles 52 to 54 of the Delegated Regulation.

3.10.2. The 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.

3.10.3. The MA assumptions, calculations, and applications are defined in Section 11.

4. DATA SOURCES FOR THE INPUTS FROM FINANCIAL MARKETS

4.1. FINANCIAL MARKET DATA PROVIDERS

4.1.1. To mitigate operational risks associated with the failure of a market data provider, the calculation of the technical information should avoid undue reliance on a single market source.

4.1.2. One option to ensure this would be to derive each input using data obtained from a range of providers. An alternative would be to calculate a given input based on data from a single market provider, but to use different providers for different inputs or functions, under the condition that all sources are sufficiently consistent.

4.1.3. Generally, EIOPA has opted for the second of these options, on the basis that the application of the first option to all inputs would introduce additional complexity and increase the operational risks, without providing material benefits compared to the alternative option.

4.1.4. EIOPA has no evidence of the superiority of a particular market data provider. The choice of market data providers included in this technical documentation is disclosed only for the purposes of transparency (recital 23[6] and Article 43(2) of the Delegated Regulation).

4.1.5. In accordance with recital 23 and Article 43(2) of the Delegated Regulation, EIOPA's technical documentation will accompany the technical information set out in Article 77e(1) of the Solvency II Directive to ensure transparency.

4.1.6. The following providers are used (see subsections below for detail):

(a) swaps and overnight indexed swaps: LSEG;
(b) government bonds: LSEG and ECB[7];
(c) bonds other than government bonds: iBoxx® Indices and, for Danish covered bonds, LSEG;
(d) default statistics: S&P Global Ratings;
(e) outstanding volumes of relevant bonds: ECB's Centralised Securities Database (CSDB).

[6] Please see the original 2015 version as published in OJ L 12, 17.01.2015, pp. 1–797 (prior to amendments) for this recital and any other recitals of the Delegated Regulation that are referenced in this document.

[7] ECB Euro area all bonds spot yield curves only

4.1.7. The market data inputs will be analysed under the relevant review process according to Sections 3.1-3.4.

4.2. SELECTION OF THE RELEVANT CURRENCIES

4.2.1. EIOPA applies the following criteria to select the currencies for which technical information is published:

(a) all currencies of the EEA,
(b) all currencies of the Group of Seven (G7),
(c) all other non-EEA currencies, where EIOPA has evidence on their materiality for the EU insurance sector and where reliable and adequate financial market data are publicly available to perform the necessary calculations.

4.2.2. For assessing the relevance of a non-EEA currency under point (c) of paragraph 4.2.1, the following materiality indicators are used, where the assessment is made separately for solo undertakings and groups:

(a) the currency contributes at least 0.1% to the total technical provisions (TP) and;
(b) at least 3 undertakings or groups have exposure to that currency of at least 1% of their total TP.

4.2.3. The list of relevant currencies can be found in ANNEX A. For currencies not deemed relevant by EIOPA see also Subsection 5.4.

4.2.4. EIOPA will review the list of relevant currencies on an annual basis. Any changes will be announced three months before their implementation. In exceptional circumstances, EIOPA may deviate from this process to change the list of relevant currencies.

4.3. SELECTION OF MARKET RATES

4.3.1. The construction of the basic risk-free interest rate term structures is based on swaps and/or government bonds as set out in Article 44 of the Delegated Regulation.

4.3.2. EIOPA applies the financial references in Table 1 below from the market data provider selected.

4.3.3. The GVT/SWP/OIS column of the table specifies whether the financial instruments used in the construction of the basic risk-free interest rate term structures are government bonds, swaps or overnight indexed swaps. For a clear identification of swaps, the floating leg is also included.

4.3.4. In the process of calculating the basic risk-free interest rate term structures, the Refinitiv instrument codes (RICs) for government bonds (listed in the 'GVT RIC' column) are used only for the currencies with 'GVT' in the 'GVT/SWP/OIS' column.

4.3.5. For all countries, the 'GVT RIC' column also corresponds to the government bond-related inputs that feed into the process of calculating the volatility adjustment and the matching adjustment. This column indicates too if the respective country is using government bond yields from a peer country as further specified in paragraph G.2.5.

Table 1 - Swap and government bond RICs used for the derivation of the technical information

COUNTRY CODE	COUNTRY	ISO 4217	GVT/SWP/OIS	SWP RIC	SWP FREQ	GVT RIC
EA	Euro area	EUR	SWP	EURAB6EIRS=	1	ECB (see 4.3.9)
AT	Austria	EUR	SWP	EURAB6EIRS=	1	0#ATXZ=R
AU	Australia	AUD	SWP	AUDSM6ABIRS=	2	0#AUXZ=R
BE	Belgium	EUR	SWP	EURAB6EIRS=	1	0#BEXZ=R
BG	Bulgaria	EUR	SWP	EURAB6EIRS=	1	0#BGXZ=R
CA	Canada	CAD	OIS	CADOIS=	2	0#CAXZ=R
CH	Switzerland	CHF	OIS	CHFOIS=	1	0#CHXZ=R
CN	China	CNY	SWP	CNYQM7RIRS=	4	0#CNXZ=R
CY	Cyprus	EUR	SWP	EURAB6EIRS=	1	0#CYXZ=R
CZ	Czechia	CZK	SWP	CZKAM6PRIRS=	1	0#CZXZ=R
DE	Germany	EUR	SWP	EURAB6EIRS=	1	0#DEXZ=R
DK	Denmark	DKK	SWP	EURAB6EIRS=	1	0#DKXZ=R
EE	Estonia	EUR	SWP	EURAB6EIRS=	1	*Peer Country: BE*
EL	Greece	EUR	SWP	EURAB6EIRS=	1	0#GRXZ=R
ES	Spain	EUR	SWP	EURAB6EIRS=	1	0#ESXZ=R
FI	Finland	EUR	SWP	EURAB6EIRS=	1	0#FIXZ=R
FR	France	EUR	SWP	EURAB6EIRS=	1	0#FRXZ=R
HR	Croatia	EUR	SWP	EURAB6EIRS=	1	0#HRXZ=R
HU	Hungary	HUF	GVT			0#HUXZ=R
IE	Ireland	EUR	SWP	EURAB6EIRS=	1	0#IEXZ=R
IS	Iceland	ISK	GVT			0#ISXZ=R

COUNTRY CODE	COUNTRY	ISO 4217	GVT/SWP/OIS	SWP RIC	SWP FREQ	GVT RIC
IT	Italy	EUR	SWP	EURAB6EIRS=	1	0#ITXZ=R
JP	Japan	JPY	OIS	JPYOIS=	1	0#JPXZ=R
LI	Liechtenstein	CHF	OIS	CHFOIS=	1	*Peer Country: CH*
LT	Lithuania	EUR	SWP	EURAB6EIRS=	1	0#LTXZ=R
LU	Luxembourg	EUR	SWP	EURAB6EIRS=	1	*Peer Country: NL*
LV	Latvia	EUR	SWP	EURAB6EIRS=	1	*Peer Country: SK*
MT	Malta	EUR	SWP	EURAB6EIRS=	1	0#MTXZ=R
NL	Netherlands	EUR	SWP	EURAB6EIRS=	1	0#NLXZ=R
NO	Norway	NOK	SWP	NOKAB6OIRS=	1	0#NOXZ=R
PL	Poland	PLN	SWP	PLNAB6WIRS=	1	0#PLXZ=R
PT	Portugal	EUR	SWP	EURAB6EIRS=	1	0#PTXZ=R
RO	Romania	RON	GVT			0#ROXZ=R
SE	Sweden	SEK	SWP	SEKAB3SIRS=	1	0#SEXZ=R
SI	Slovenia	EUR	SWP	EURAB6EIRS=	1	0#SIXZ=R
SK	Slovakia	EUR	SWP	EURAB6EIRS=	1	0#SKXZ=R
UK	United Kingdom	GBP	OIS	GBPOIS=	1	0#GBXZ=R
US	United States	USD	OIS	USDSROIS=	1	0#USXZ=R

4.3.6. These swap and government bond RICs are general RICs describing the specific instruments and their available tenor points within LSEG's data universe. To access specific tenor points, tenor-specific RICs are used according to the following conventions.

(a) For SWP plain vanilla interest rate swaps (IRS) RICs: remove the 'IRS=' part of the RIC and append the code for the tenor of interest using convention 'XX=', where XX can be '1M', '3M', …, '1Y', …, '50Y' according to the available tenors from the general RIC. For example, 'EURAB6E10Y=' is the RIC for the 10-year EUR par swap rate.

(b) For SWP OIS RICs: the general RIC for the tenor of interest is denoted by 'CCCXXOIS=', where CCC is in general the three-letter ISO 4217 code and XX is analogous to the SWP IRS tenor coding convention. For example, 'GBP10YOIS=' is the UK Pound Sterling 10-year SONIA Overnight Index Swap.

(c) For GVT RICs: the general RIC to access a specific tenor point is 'CCGOVXXZ=R', where CC is in general the two-letter ISO 3166 code and XX is analogous to the SWP tenor coding convention. Example: 'USGOV5YZ=R' is the RIC for the 5-year USD zero government bond yield.

4.3.7. LSEG's identifiers used: Fields 'Universal Close Price' (GVT and Nykredit indices), 'Mid Price' (SWP/OIS) for Datascope Select RICs.

4.3.8. Where the field 'Universal Close Price' returns discount factors (GVT), the data is converted to the underlying annually compounded spot rates before application, where relevant, of the credit risk adjustment.

4.3.9. Although the EUR zero government bond yields are available from LSEG (RIC: 0#EUGOVZBMK=ECB), it should be noted that the underlying data is not always perfectly aligned with the source data available from the ECB statistical data warehouse[8] (SDW). Therefore, the EUR zero government bond yields are being downloaded directly from the ECB SDW.

4.3.10. Specific cases are indicated below:

(a) for those non-euro area countries with contracts where the benefits guaranteed to the policy holders are valued in euro while the payments (including the evolution of the exchange rate) are in the local currency, the term structure is derived based on the interest rates denominated in the local currency;
(b) for the Danish krone, the basic risk-free interest rate term structure is based on the financial instruments used for the euro because this currency meets the legal conditions to be considered as pegged to the euro.

[8] The series name is 'Yield curve spot rate, Government bond, nominal, all issuers all ratings included - Euro area (changing composition), Euro area, Daily - Businessweek'.

5. IDENTIFICATION AND DLT ASSESSMENT OF RELEVANT FINANCIAL INSTRUMENTS

5.1. LEGAL FRAMEWORK

5.1.1. According to Article 77a of the Solvency II Directive, the relevant risk-free interest rate term structure should be based on relevant financial instruments traded in deep, liquid and transparent (DLT) markets. This provision is further specified in Articles 1(32-34), 43, 44 and 46 of the Delegated Regulation. The identification of the relevant financial instruments is based on a DLT assessment.

5.1.2. The inputs for the DLT assessment are market data on interest rate swaps, government bonds and corporate bonds.

5.1.3. The output of the DLT assessment is a list, for each relevant currency, of the maturities for which the market of the relevant financial instrument is considered DLT, including the identification of the first smoothing point (FSP).

5.2. CONCEPTUAL FRAMEWORK FOR THE DLT ASSESSMENT

5.2.1. First, the DLT assessment of the swap market is carried out by EIOPA for each relevant currency. The assessment is conducted using clearly specified and objective criteria applied to swap trade data, including average daily notional amount traded and average daily number of trades as detailed in paragraph B.2.1.

5.2.2. Second, as detailed in Annex B.3, the DLT assessment of the government bond market is conducted for each relevant currency, based on the trading volume and frequency of government bonds. This step is carried out by EIOPA for the euro as well as non-EEA currencies, and by the national competent authorities for their respective currency. EIOPA has a process in place aimed at ensuring homogeneity across national assessments and preserving a level playing field.

5.2.3. For both steps above, market transparency is assessed based on the availability of up-to-date rate information from a reliable data provider on each working day for the relevant financial instrument and maturity. Market liquidity and depth assessment is based on data that covers the period of one year, whenever possible. Where trade data is not available or their analysis is not conclusive, other criteria (e.g. number and total amount of outstanding instruments, bid-ask spreads and rate volatility) are used. EIOPA's general approach to DLT assessment criteria is discussed in Annex B.1

5.2.4. The two steps above provide a list of DLT tenor points for each currency, separately for the swap and government bond markets. Following Article 44 of the Delegated

Regulation, when deriving the risk-free interest rate term structure, the use of swap rates is prioritised over government bond rates when both markets are considered DLT.

5.2.5. The third step of the DLT assessment process involves the identification of the FSP for each relevant currency, beyond which the relevant risk-free interest rate shall be extrapolated.

5.2.6. The FSP is the longest DLT maturity for which the percentage of outstanding bonds of that or a longer maturity among all outstanding bonds denominated in that currency is 'sufficiently high'. The currency-dependent percentage that will be considered sufficiently high is specified in Article 43a of the Delegated Regulation and further detailed in Annex B.4.

5.2.7. Highlighted cells in Table 2 below set out the tenors used for the derivation of the basic risk-free interest rate term structures for all relevant currencies. For the instruments used, please refer to the GVT/SWP/OIS column of Table 1 above. A blank cell indicates that there are no DLT markets available for the given maturity. In each column, the first cell with a percentage value corresponds to the FSP for the given currency.

5.2.8. The percentage values in the table correspond to the weights used in the calculation of the last liquid forward rate as defined in Article 46(1c) of the Delegated Regulation and further detailed in paragraph 8.5.6. The relevant risk-free interest rates are based on market data for integer maturities from one year onwards.

Table 2 - Tenors used for the derivation of the basic risk-free interest rate term structures and the associated LLFR weights

	EEA CURRENCIES									NON-EEA CURRENCIES					
	EUR	CHF	CZK	HUF*	ISK*	NOK	PLN	RON*	SEK	AUD	CAD	CNY	GBP	JPY	USD
1Y															
2Y															
3Y															
4Y															
5Y												100%			
6Y															
7Y															
8Y															
9Y					100%										
10Y		100%	100%	100%		100%	100%	100%	100%	87%	89%				
11Y															
12Y										3%					
13Y															
14Y															
15Y										4%					
16Y															
17Y															
18Y															
19Y															
20Y	29%									3%				63%	25%
21Y															
22Y															
23Y															
24Y															
25Y	7%									1%				6%	5%
26Y															
27Y															
28Y															
29Y															
30Y	57%									2%	11%		100%	31%	70%
31Y															
32Y															
33Y															
34Y															
35Y															
36Y															
37Y															
38Y															
39Y															
40Y	4%														
41Y															
42Y															
43Y															
44Y															
45Y															
46Y															
47Y															
48Y															
49Y															
50Y	3%														

Notes: For currencies with an asterisk the term structure is based on government bond data. Highlighted cells denote DLT tenor points for each currency. A non-highlighted cell indicates the absence of DLT markets for the given currency-maturity. The percentage values listed are the last liquid forward rate (LLFR) weights, as further detailed in paragraph 8.5.6. In each column, the first cell with a percentage value corresponds to the first smoothing point. Note also that no DLT assessment is made for the Danish krone. Since this currency is pegged to the euro, its basic risk-free interest rates are based on the DLT assessment for the euro.

5.3. UPDATE OF THE DLT ASSESSMENT

5.3.1. EIOPA will update the DLT assessment for the relevant currencies on an annual basis. In case of indications that the depth, liquidity or transparency of financial markets has significantly changed, EIOPA may update the DLT assessment for the affected currencies outside the annual update cycle.

5.3.2. The changes resulting from a regular DLT assessment will be implemented after a notice period of up to three months. The length of the notice period will depend on the urgency of the changes and the materiality of their impact. Where appropriate, EIOPA will avoid the implementation of changes at the end of a quarter.

5.3.3. The update will be based on the methodology for the DLT assessment set out in this technical documentation.

5.4. CURRENCIES WITHOUT DLT FINANCIAL INSTRUMENTS

5.4.1. For those currencies where EIOPA does not publish the technical information set out in Article 77e of the Solvency II Directive, the methodology described in this document should be applied[9].

5.4.2. In case of lack of reliable financial market data to apply the methodology, it is expected that insurance and reinsurance undertakings, the relevant EEA supervisor and the supervisor of the corresponding country will have a dialogue to derive appropriate technical information.

5.4.3. For that purpose, the use of the basic risk-free interest rate term structures of economies sufficiently similar or interlinked may be an option, provided that any adjustment to the term structure used as reference is made under a prudent and objective process, and it is compatible with the methodology described in this document.

[9] Please refer to the EIOPA website for the recommended parameters for constructing the corresponding term structures for the currencies that have been removed from the list of relevant currencies as of 30 January 2027 (i.e. COP, HKD and TWD).

6. CREDIT RISK ADJUSTMENT (CRA)

6.1. LEGAL FRAMEWORK

6.1.1. The calculation of CRA has been developed in accordance with recital 20 and Articles 44 & 45 of the Delegated Regulation. According to Article 44 (1), the CRA does not apply to overnight indexed swap rates (OIS).

6.2. APPLICATION OF THE CRA

6.2.1. For currencies where a CRA is applicable it is applied as a parallel downward shift of all deep, liquid and transparent (DLT) input rates including the input rates used for calculating the last liquid forward rate according to Section 8.3.

6.2.2. For swap-based inputs, where the observed par swap rates are plain vanilla interest rate swap rates, CRA is applied to these observed par swap rates prior to the derivation of zero-coupon rates.

6.2.3. For risk-free interest rate term structures based on government bond yields, the input data already consists of zero-coupon rates; the CRA is therefore applied directly to those rates.

6.2.4. A CRA may lead to negative interest rates (i.e. there is no floor for the adjusted rates).

6.3. CALCULATION OF THE CRA

6.3.1. The calculation of the CRA considers three possible situations, which are successively described below.

6.4. FIRST SITUATION

6.4.1. In the first situation, the risk-free interest rate term structure is based on swap rates that are not OIS rates, and the relevant OIS rate meets the DLT requirements.

6.4.2. In this case, the approach prescribed in Article 45 of the Delegated Regulation for the CRA applies, with the following methodological conventions.

(a) The maturity of the OIS rate used to derive the CRA is consistent with the tenor of the floating leg of the swap instrument used to derive the term structure. For example, in the case of the Swedish currency, the risk-free interest rate term structure is based on swaps with a floating leg that refers to the 3-month

STIBOR, and consequently the Swedish OIS rate used in the CRA calculation is the 3-month Swedish krona OIS rate.

(b) For the euro, the OIS rate to be used is the 3-month rate, as specified in recital 20 of the Delegated Regulation.

(c) The calculation of the one-year average referred to in Article 45 of the Delegated Regulation is based on daily data for the last twelve months. The average is a simple average, calculated by giving equal weight to all the observations.

6.4.3. In cases where market data is missing for either the interbank offered rate (IBOR) or for the relevant OIS rate, the missing data is completed by linear interpolation and flat extrapolation. If for more than 20% of the business days during the preceding year the swap rate or the OIS rate or both are missing, it is considered that DLT requirements are not met. In that case the third method described in this subsection applies for non-EEA currencies and second situation for EEA currencies.

6.5. SECOND SITUATION

6.5.1. The second situation considered for the calculation of the CRA concerns EEA currencies that are not in the first situation. For these currencies, the same CRA as for the euro applies.

6.5.2. A specific case is the Norwegian krone. For that currency the CRA for the Swedish krona applies.

6.6. THIRD SITUATION

6.6.1. In the third situation, i.e. for the remainder of the currencies, the following method is used to calculate the CRA.

6.6.2. If the number of remaining currencies is smaller than four then the CRA is set to 35bp for all remaining currencies.

6.6.3. If the number of remaining currencies is at least four then for each remaining currency X, a scaling factor SF_X is calculated according to the following formula:

$$SF_X = \frac{\sum_{t \in JDLT}(r_t^X - \theta^{Euro})}{\sum_{t \in JDLT}(r_t^{Euro} - \theta^{Euro})}$$

with $\theta^{Euro} = \min_{t \in JDLT}\{0, r_t^{Euro}\}$.

r_t^X: the input rates for calculating the risk-free interest rate term structure of currency *X*;

r_t^{Euro}: the input rates for calculating the risk-free interest rate term structure of the euro;

θ^{Euro}: The most negative input rate of the euro or zero in case there are no such negative input rates;

Both sums run over the Joint DLT (JDLT) tenor points (up to and including 10Y) of currency X and the euro currency, i.e. the intersection of the DLT points of both currencies up to and including 10Y.

6.6.4. Let $SF^{25\%}$ be the level of the scaling factor corresponding to the (linearly interpolated) 25th percentile of the scaling factors over all situation 3 currencies.

6.6.5. Let $CRA^{25\%}$ be the corresponding threshold level for the CRA, currently set equal to 35bp, i.e.

$$CRA^{25\%} = 35\text{bp}.$$

6.6.6. The CRA threshold will be reviewed whenever the number of remaining currencies changes from one year to the next, provided it remains at least four.

6.6.7. The CRA for currency X is calculated according to the following formula:

$$CRA_X = \frac{SF_X}{SF^{25\%}} \cdot CRA^{25\%}.$$

6.7. FINAL ROUNDING OF THE CRA

6.7.1. For all currencies, irrespective of their situation, a corridor of 10 to 35 bps for the CRA applies as set out in Article 45 of the Delegated Regulation. The CRA is rounded to the nearest integer basis points. The rounding is applied in the final step of the calculation.

6.8. DATA SOURCES FOR THE CRA

6.8.1. The following table lists the currencies for which the criteria set out in paragraph 6.4.1 are checked each month. For these currencies the CRA is calculated with IBORs and OIS rates as specified in Table 3.

Table 3 - Currencies with DLT overnight indexed swap markets

Currency	ISO 4217	IBOR RIC	OIS RIC
EURO	EUR	EURIBOR3MD=	EUREST3M=
SWEDISH KRONA	SEK	STISEK3MDFI=	SEKAMTNS3M=
AUSTRALIAN DOLLAR	AUD	AU6MBA=	AUD6MOIS=

Note1: Until 1 January 2020, for reference dates after 31 May 2015, the overnight swap rates were based on specific Bloomberg fixings, i.e. European currencies were based on London fixing (CMPL), American currencies were based on New York fixing (CMPN), while the currencies of Asia and Australia were based on Tokyo fixing (CMPT). For earlier reference dates, all overnight swap rates were based on New York fixing only, irrespective of their currency.

Note2: The IBOR- and OIS-RICs are retrieved using the field 'Universal Close Price'.

7. CURRENCY RISK ADJUSTMENT (CURA)

7.1. LEGAL FRAMEWORK

7.1.1. According to Article 48 of the Delegated Regulation, the basic risk-free interest rate term structure for a currency pegged to the euro should be the term structure for the euro, adjusted for currency risk. The Danish krone is identified as a relevant currency that meets the requirements set out in that article.

7.2. APPLICATION OF THE CURA

7.2.1. The CURA is applied in addition to, and in the same way as the credit risk adjustment (see Section 6).

7.2.2. The CURA may lead to negative interest rates (i.e. there is no floor for the adjusted rates). The CURA for the Danish krone equals 1 bp.

7.3. CALCULATION OF THE CURA

7.3.1. According to Article 48(2) of the Delegated Regulation, the CURA should correspond to the cost of hedging against the risk that the value in the pegged currency of an investment denominated in euro decreases because of changes in the level of the exchange rate between the euro and the pegged currency.

7.3.2. In line with that provision, the CURA for the relevant currency is based on the following formula:

$$CURA = -f \cdot \frac{BE}{SCR(0)} \cdot \frac{LAC}{Duration} \cdot \frac{RM}{TP},$$

where:

- $CURA$ denotes the currency risk adjustment;
- f denotes the adjusted currency risk factor for the exchange rate of the relevant currency to the euro as set out in Commission Implementing Regulation (EU) 2015/2017 of 11 November 2015[10] BE denotes the best estimate;

[10] Commission Implementing Regulation (EU) 2015/2017 of 11 November 2015 laying down implementing technical standards with regard to the adjusted factors to calculate the capital requirement for currency risk for currencies pegged to the euro in accordance with Directive 2009/138/EC of the European Parliament and of the Council (OJ L 295, 12.11.2015, pp. 21–22, ELI: http://data.europa.eu/eli/reg_impl/2015/2017/oj)

- $SCR(0)$ denotes the current solvency capital requirement applied to calculate the risk margin;
- LAC denotes the ratio of the adjustment for the loss-absorbing capacity of technical provisions and $SCR(0)$;
- $Duration$ denotes the modified duration of the technical provisions;
- RM denotes the risk margin;
- TP denotes the technical provisions.

The *CURA* is calculated regarding insurance and reinsurance obligations denominated in the relevant currency. As the adjustment should be the same for all insurance and reinsurance undertakings, an average adjustment for all undertakings is estimated.

7.3.3. The rationale of the formula is as follows.

1) The cost of hedging against currency risk referred to in Article 48(2) of the Delegated Regulation corresponds to the cost of providing eligible own funds to cover the SCR for currency risk.
2) The SCR for currency risk is calculated as $f.BE.LAC$, based on the assumption that all the liabilities give rise to currency risk (i.e. it is not hedged) and that the loss-absorbing capacity of technical provisions mitigates the risk.
3) The cost of capital for covering the SCR for currency risk is derived by multiplying the ratio of the SCR for currency risk and the total SCR by the risk margin, resulting in:

$$\frac{f \cdot BE \cdot LAC}{SCR(0)} \cdot RM.$$

The cost of capital is translated into a change of the discount rate by dividing it by the amount and the duration of technical provisions.

7.4. UPDATE OF THE CURA

7.4.1. EIOPA will monitor the CURA on an annual basis by means of the formula set out in paragraph 7.3.2. The CURA will only be amended where the difference to the formula result is material. When updates are necessary, they are implemented at the start of the next year.

8. BASIC RFR TERM STRUCTURE CONSTRUCTION

8.1. INPUTS AND CONTROL PARAMETERS

8.1.1. For each currency, the basic risk-free interest rate term structure is constructed from instruments being either par swap rates or zero-coupon government bond rates for a finite number of deep, liquid and transparent (DLT) maturities. The DLT maturities are set out in Sections 4 and 5.

8.1.2. Data is usually retrieved on the first EIOPA working day of the month after 12 o'clock. However, confirmed market data issues might require a reimport of the data before the final publication on EIOPA's third working day of the month.

8.1.3. If at least 80% of the rates according to section 8.1.1 are available, including the 1Y-rate and the FSP-rate, then the term structure is derived using these available rates. Otherwise, the market information of the first preceding trading day meeting these requirements is used to derive the term structure.

8.1.4. EIOPA publishes the risk-free interest rates for integer maturities from one-year to 150 years.

8.1.5. Interest rates to be used as input to the interpolation (hereafter: the input rates) are the market rates from the respective instruments after deduction of a credit risk adjustment (CRA) and a currency risk adjustment (CURA) when applicable as described in Sections 6 and 7.

8.1.6. The control parameters for the interpolation are the input rates of the DLT maturities of the respective instrument and the 'constant forward'-assumption. The constant forward assumption states that the behaviour of the forward rate between two non-consecutive DLT maturities is constant. Using this assumption, it is possible to calculate, starting with the shortest DLT maturity, the forward rates out of the rates of the DLT maturities and construct risk-free zero rates for all maturities of interest. The input rates of the DLT maturities are updated monthly, while the DLT maturities are updated annually.

8.1.7. The control parameters for the extrapolation are the risk-free zero rate at the first smoothing point (FSP - see paragraph 8.2), a last liquid forward rate (LLFR - see paragraph 8.3), an ultimate forward rate (UFR - see Subsection 8.4), and a convergence parameter α. The FSP rate and the LLFR are updated monthly, while the FSP and the UFR are updated annually.

8.1.8. In accordance with Articles 46(1b) and 46a of the Delegated Regulation, the convergence parameter α equals 40% for the Swedish Krona and 11% for all other currencies, except when insurance or reinsurance undertakings are allowed to apply

the phasing-in mechanism referred to in Article 77a(2) of the Solvency II Directive. In such case, the convergence parameter is according to Table 4 below.

Table 4 - Convergence Parameters Phasing-In Mechanism

Date Interval	Swedish Krona	All Other Currencies
01/01/2027 – 31/12/2027	70.0%	20.0%
01/01/2028 – 31/12/2028	64.0%	18.2%
01/01/2029 – 31/12/2029	58.0%	16.4%
01/01/2030 – 31/12/2030	52.0%	14.6%
01/01/2031 – 31/12/2031	46.0%	12.8%
01/01/2032 – and beyond	40.0%	11.0%

8.2. FIRST SMOOTHING POINT

8.2.1. According to Article 77a (1) first subparagraph of the Solvency II Directive, the FSP for a currency equals the longest maturity for which two criteria are fulfilled:

(a) it is DLT,

(b) the percentage of outstanding bonds of that or a longer maturity among all outstanding bonds denominated in the currency is sufficiently high ("the Residual Volume Criterion" (RVC)).

8.2.2. FSPs are updated together with the DLT assessment.

8.3. LAST LIQUID FORWARD RATE

8.3.1. The LLFR introduced in Article 77a (1) subparagraph 3 of the Solvency II Directive and further specified in Article 46 (1c) of the Delegated Regulation defines the level of the instantaneous forward rate at the FSP. It is calculated as a weighted average of the last forward rate just before the FSP and – if available - specific forward rates after the FSP.

8.3.2. The number of specific forward rates to be considered after the FSP corresponds to the number of DLT maturities beyond the FSP. Each of these forward rates starts at the FSP and has a horizon equal to the difference between the respective DLT

maturity and the maturity of the FSP. These forward rates follow from the calculated risk-free zero rates according to paragraph 8.1.6.

8.3.3. The weights to be used for calculating the weighted average are according to the following. For each of the DLT maturities from the FSP to the longest DLT maturity the DLT assessment determines the annual average notional of traded swaps. Now, for each of the DLT maturities the corresponding weight equals the corresponding annual average of daily notional amounts divided by the sum of all annual averages of daily notional amounts.

8.3.4. In case the FSP has the longest DLT maturity, the LLFR equals the last forward rate just before the FSP and the associated weight equals 100%.

8.4. ULTIMATE FORWARD RATE

8.4.1. The methodology to derive the UFR is set out in ANNEX C. The UFR is currency specific and is calculated in accordance with that methodology on an annual basis. A continuously compounded UFR defines the ultimate level of the instantaneous forward rate as used in the extrapolation of the term structure.

8.5. INTERPOLATION AND EXTRAPOLATION

8.5.1. Assume we observe L market rates according to EIOPA's DLT criteria. Hence, the maturities of the DLT points are:

$$t_k\colon\ k = 1,2,\dots,L.$$

These observed market rates are either par swap rates (interest rate swaps/overnight indexed swaps) or zero-coupon government bond rates (GVT) corrected for a CRA and a CURA where applicable.

8.5.2. As the tenors of the observed market rates are not necessarily consecutive, there could be gaps between the observed DLT points resulting in the question of how to calculate the risk-free zero rates for these missing tenor points. To calculate such zero rates, an additional assumption is made called the 'constant forward' assumption. This type of calculation is generally referred to as 'bootstrapping'. ANNEX D shows how to calculate the risk-free zero rates for the several scenarios of missing tenor points.
Hence, by bootstrapping the following (discretely compounded) risk-free zero rates are calculated:

$$z_t\colon\ t = 1,2,\dots,t_L.$$

8.5.3. Next, the Residual Volume Criterion (RVC) defines the DLT maturity t_F of the FSP:

$$t_F \in \{t_k:\ k = 1,2, \dots, L\} \Rightarrow t_F \leq t_L.$$

8.5.4. Now, the interpolated part of the basic risk-free interest rate term structure of discretely compounded zero-rates is defined as:

$$z_t:\ t = 1,2, \dots, t_F.$$

8.5.5. According to Article 46(1b) of the Delegated Regulation the basic risk-free interest rate term structure beyond the FSP is constructed by extrapolation according to the following. For annualised continuously compounded forward rates starting at the FSP with horizon h the following definition is used:

$$f^c_{t_F,t_F+h} = UFR^c + (LLFR^c - UFR^c) \cdot B(a,h)$$

$$= UFR^c \cdot (1 - B(a,h)) + LLFR^c \cdot B(a,h),$$

with: $UFR^c = \ln(1 + UFR)$ and $B(a,h) = \frac{1-e^{-ah}}{ah}$ with $a > 0$.

Note 1: Variables having a superscript 'C' represent rates that are continuously compounded, while variables not having a superscript represent rates that are discretely compounded.
Note 2: Variable a in the in the formula above represents the convergence parameter. Hence, when calculating the formula, variable a takes the prevailing value of the convergence parameter α according to paragraph 8.1.8.

From the right side of the definition, it follows that the forward rates are a weighted average of the ultimate forward rate (UFR^c) and a last liquid forward rate ($LLFR^c$). From this definition, we obtain the following limits.

(a) $\lim_{h\to 0} B(a,h) = 1 \Longrightarrow \lim_{h\to 0} f^c_{t_F,t_F+h} = LLFR^C.$

Hence, $LLFR^C$ is the instantaneous forward rate at the FSP.

(b) $\lim_{h\to \infty} B(a,h) = 0 \Longrightarrow \lim_{h\to \infty} f^c_{t_F,t_F+h} = UFR^C.$

Hence, $f^C_{t_F,t_F+h}$ converges to the UFR^C when the horizon increases.

(c) Due to the symmetry of a, h in the definition of $B(a,h)$ both points (a) and (b) also hold for the convergence parameter a, i.e. the higher a the faster will $f^C_{t_F,t_F+h}$ converge to UFR^C.

8.5.6. Now, the last liquid forward rate ($LLFR^C$) is defined as a weighted average of the following $L-F+1$ forward rates: one just before the FSP, and the remaining, if any, after the FSP, i.e.

$$\left\{f^C_{t_{F-1},t_F}, f^C_{t_F,t_k}, \mid k = F+1,\dots,L\right\}.$$

The additional *L-F* tenor points $t_{F+1},\dots,t_L$ are according to EIOPA's DLT assessment as stated under paragraph 8.5.1. If any of these points are not available at the reference date, then the respective points are simply ignored in the calculation of the LLFR.

In case there are no additional forward rates after the FSP it holds that *L=F* and

$$LLFR^C = f^C_{t_{F-1},t_F}.$$

In case there are additional forward rates after the FSP then the $LLFR^C$ is defined as:

$$LLFR^C = w_{t_F}\cdot f^C_{t_{F-1},t_F} + w_{t_{F+1}}\cdot f^C_{t_F,t_{F+1}} + \cdots + w_{t_L}\cdot f^C_{t_F,t_L},$$

with:

$$f^C_{t_{k-1},t_k} = \frac{t_k\cdot z^C_{t_k} - t_{k-1}\cdot z^C_{t_{k-1}}}{t_k - t_{k-1}} \quad \text{and} \quad z^C_{t_k} = \ln(1+z_{t_k}),$$

where the z_{t_k} are the bootstrapped discretely compounded risk-free zero rates according to 8.5.2., and:

$$w_{t_k} = \frac{V_{t_k}}{V_{t_F} + V_{t_{F+1}} + \cdots + V_{t_L}}\cdot 100\%, \qquad k = F, F+1,..,L.,$$

where V_{t_k} represents the annual average notional of traded swaps with maturity t_k according to EIOPA's DLT assessment. Again, if any of these tenor points are not available at the reference date, then the respective tenors are simply ignored.

If there are no additional forward rates after the FSP, then $w_{t_F} = \frac{V_{t_F}}{V_{t_F}}\cdot 100\% = 100\%$, and hence the general formula applies to this special case as well.

8.5.7. According to Article 46(1a) of the Delegated Regulation the continuously compounded risk-free zero rates after the FSP follow now from the following formula:

$$z^c_{t_F+h} = \frac{t_F \cdot z^c_{t_F} + h \cdot f^c_{t_F,t_F+h}}{t_F + h}, \text{for } h = 1, \ldots, 150 - t_F.$$

8.5.8. Finally, the extrapolated part of the basic risk-free interest rate term structure follows from:

$$z_{t_F+h} = e^{z^c_{t_F+h}} - 1, \text{for } h = 1, \ldots, 150 - t_F.$$

9. VOLATILITY ADJUSTMENT

9.1. CONCEPTUAL FRAMEWORK

9.1.1. According to Article 77e of the Solvency II Directive:

EIOPA shall lay down and publish for each relevant currency the following technical information at least on a quarterly basis:
[…]

(c) for each relevant currency and national insurance market, a risk-corrected spread as referred to in Article 77d(3) and (4) respectively;
(d) for each relevant Member State, the percentage of investments in debt instruments relative to total assets held by insurance and reinsurance undertakings authorised in the country as referred to in Article 77d(4).

9.1.2. The derivation of the risk-corrected spread (RCS) requires decisions on the following:

(a) appropriate levels of granularity regarding key risk characteristics like type of debt instrument, issuing country or sector, credit rating, etc.,
(b) the source data for the long-term average of spreads (LTAS) calculation,
(c) the method of constructing missing data of the 30-year spread history,
(d) the treatment of currencies for which source data is not available.

9.1.3. The methodology to derive the RCS in accordance with Article 77d of the Solvency II Directive and Articles 49 to 52 of the Delegated Regulation, including the decisions from paragraph 9.1.2, are explained below in 9.2 of this technical documentation.

9.1.4. The volatility adjustment (VA) for a given currency is an adjustment to the relevant risk-free interest rate term structure. It is based on the RCS between the yield from a reference portfolio of investments in debt instruments for that currency and the associated basic risk-free yield. The VA is also a function of the credit spread sensitivity ratio (CSSR) of an undertaking for the given currency and is therefore specific to each undertaking.

9.1.5. There is no VA at group level. The influence of the VA at group level will be derived from the VA applied by each component of the group, according to the method of calculation of the group solvency.

9.1.6. The RCS is derived for each relevant currency and for each country of the euro area. It is published monthly by EIOPA.

9.1.7. For the calculation of a RCS, the relevant representative portfolio of debt instruments must be mapped to an appropriate level of granularity of 'yield proxies'. These yield

proxies should reflect key risk characteristics - such as type of debt instrument, issuing country or sector, and credit rating/quality step - being representative for the debt instrument in question. Based on these risk characteristics, a suitable yield proxy is selected, typically in the form of either a yield curve or a yield index.

9.1.8. If the debt instrument is a bond, then a model bond is defined as the combination of exposure in terms of weight and duration, supplemented with a suitable yield proxy.

9.1.9. A reference portfolio consists of a set of model bonds whose weights sum to one. The duration of a reference portfolio equals the weighted average of the durations of the model bonds within the reference portfolio.

9.1.10. Similarly, any combination of reference portfolios - each with its own weight - defines a new reference portfolio if the sum of the associated weights equals one. Again, the duration of this new reference portfolio equals the weighted average of the durations of the respective reference portfolios.

9.1.11. Article 77d of the Solvency II Directive distinguishes between two types of reference portfolios:

- Paragraph 2 states the definition of a currency reference portfolio:
  '… The reference portfolio of investments in debt instruments for a currency shall be representative for the assets which are denominated in that currency and in which insurance and reinsurance undertakings invest to cover the best estimate for insurance and reinsurance obligations denominated in that currency.'
- Paragraph 4 states under the explanation of the RCS for a country the following definition of a country reference portfolio:
  '…shall be calculated in the same way as the risk-corrected spread for the euro…,but based on a reference portfolio that is representative for the assets which insurance and reinsurance undertakings are investing in to cover the best estimate for insurance and reinsurance obligations of products sold in the insurance market of that country and denominated in euro.'

9.1.12. Due to the RCS for a country being calculated in the same way as the RCS for the euro, it follows that a country reference portfolio is similarly based on investments in debt instruments, but this time only the debt instruments of the insurance market of the respective euro country.

9.1.13. Investments in debt instruments as mentioned in paragraphs 9.1.12 are understood to mean:

- Either 'government bonds': any exposure to central governments, central banks, and exposures to regional governments and local authorities (RGLA) that are reported as 'listed' according to Commission Implementing Regulation (EU) 2019/981.

- Or 'corporate bonds': any exposure to bonds other than 'government bond' plus exposures to loans, mortgages and securitisations.
- Or both, in which they are simply called 'bonds'.

9.1.14. Currency and country reference portfolios are made up of a government bond reference portfolio and a corporate bond reference portfolio.

9.1.15. The following subsection explains the calculation of the risk-corrected spreads for the currency and country reference portfolios and how they factor into the VA.

9.2. UNDERSTANDING RISK-CORRECTED SPREADS

9.2.1. An RCS applies equally to currency and country reference portfolios. A risk-corrected currency spread is calculated for all relevant currencies, while a risk-corrected country spread is calculated for euro area countries only.

9.2.2. To determine a risk-corrected currency spread (RCS_{cu}), the following inputs are used:

(a) Currency representative portfolios[11] of exposures to bonds to the extent that they cover the best estimate of liabilities denominated in that currency.
(b) Currency reference portfolios being the representative portfolios from (a) supplemented with the appropriate yield proxies for the underlying government bond reference portfolio and the underlying corporate bond reference portfolio.

9.2.3. To determine a risk-corrected country spread (RCS_{co}), the following inputs are used:

(a) Country representative portfolios[11] of exposures to bonds to the extent that they cover the best estimate of liabilities of products sold in the respective euro area country and which are denominated in euro.
(b) Country reference portfolios being the representative portfolios from (a) supplemented with the appropriate yield proxies for the underlying government bond reference portfolio and the underlying corporate bond reference portfolio.

9.2.4. For each currency and country according to paragraph 9.2.1 either of these inputs is used to calculate the following outputs:

(a) a spread (S),
(b) a risk correction (RC),
(c) a risk-corrected spread (RCS), which is the difference between the spread S and the risk correction RC.

[11] See ANNEX E for a detailed description of the construction of the representative portfolios.

9.2.5. In accordance with Article 50 of the Delegated Regulation, the spread S of reference portfolio c, being either a currency (cu) reference portfolio or a country (co) reference portfolio, is equal to:

$$S_c = \boldsymbol{w_{c,gov|B}} \cdot S_{c,gov} + \boldsymbol{w_{c,corp|B}} \cdot S_{c,corp},$$

where:

(a) $c \in \{cu, co\}$;
(b) $\boldsymbol{w_{c,gov|B}}$ denotes the share of government bonds (gov) included in the respective reference portfolio c of bonds (see ANNEX E in particular E.5.3);
(c) $S_{c,gov}$ denotes the spread on the respective reference portfolio c of government bonds;
(d) $\boldsymbol{w_{c,corp|B}}$ denotes the share of corporate bonds (corp) included in the respective reference portfolio c of bonds (see ANNEX E, in particular E.5.3);
(e) $S_{c,corp}$ denotes the spread on the respective reference portfolio c of corporate bonds.

Here, the bold notation of both weights indicates that those values are only updated once per year as part of the update of the representative portfolios. This contrasts with both spread values which change from day to day as being based on market data.

9.2.6. The risk correction RC is given by:

$$RC_c = \boldsymbol{w_{c,gov|B}} \cdot RC_{c,gov} + \boldsymbol{w_{c,corp|B}} \cdot RC_{c,corp},$$

where:

(a) $c \in \{cu, co\}$;
(b) $\boldsymbol{w_{c,gov|B}}$ and $\boldsymbol{w_{c,corp|B}}$ are defined as in 9.2.5;
(c) $RC_{c,gov}$ denotes the risk correction corresponding to the portion of the spread $S_{c,gov}$ that is attributable to a realistic assessment of the expected losses, unexpected credit risk or any other risk;
(d) $RC_{c,corp}$ denotes the risk correction corresponding to the portion of the spread $S_{c,corp}$ that is attributable to a realistic assessment of the expected losses, unexpected credit risk or any other risk.

9.2.7. The risk-corrected spread RCS_c is now defined as

$$RCS_c = S_c - RC_c \qquad c \in \{cu, co\}.$$

Note: RCS can be negative.

9.3. CURRENCY VOLATILITY ADJUSTMENT

9.3.1. For each relevant currency cu, the undertaking-specific currency VA shall be calculated as follows:

$$VA_{cu} = 85\% \cdot CSSR_{cu} \cdot RCS_{cu},$$

where:

(a) VA_{cu} is an undertaking-specific volatility adjustment for a currency cu;
(b) $CSSR_{cu}$ is the undertaking-specific credit spread sensitivity ratio for the currency cu, such that $0 \leq CSSR_{cu} \leq 1$, as detailed in Article 51a of the Delegated Regulation;
(c) RCS_{cu} is the risk-corrected spread for currency cu.

9.3.2. RCS_{cu} in the above formula is equal to the relevant risk-corrected currency value published by EIOPA (RCS) subject to the following. All undertakings can make use of an undertaking-specific adjustment (USA; in %) to the RCS value published by EIOPA, provided that the undertaking complies with the requirements of Article 77d(1c) of the Solvency II Directive.

9.3.3. Undertakings of countries of the euro area that do not use a USA must use the macro VA on top of their currency VA. Such undertakings cannot use both adjustments simultaneously.

9.3.4. When undertakings use a USA according to paragraph 9.3.2 then the USA shall correspond to the lower of 105% and the ratio of the RCS calculated based on the undertaking's own bond portfolio and the RCS value published by EIOPA. In this case the applicable risk-corrected currency spread equals: $RCS_{cu} = USA \cdot RCS$.

9.3.5. Note: The currency VA can be negative.

9.4. MACRO VOLATILITY ADJUSTMENT FOR EURO COUNTRIES

9.4.1. According to Article 77d(4) of the Solvency II Directive, the currency VA for each euro area country co is increased by a macro volatility adjustment $VA_{co,macro}$, with:

$$VA_{co,macro} = 85\% \cdot CSSR_{euro} \cdot \max(RCS_{co} - 1.3 \cdot RCS_{euro}\,; 0) \cdot \omega_{co}$$

where:

(a) $VA_{co,macro}$ is the macro volatility adjustment for country co;
(b) When country co makes use of a peer country[12] the macro VA is zero;

[12] See column 'GVT RIC' from Table 1.

(c) $CSSR_{euro}$ is the undertaking-specific credit spread sensitivity ratio for the euro calculated according to Article 51a of the Delegated Regulation;
(d) RCS_{co} is the risk-corrected spread for country co;
(e) RCS_{euro} is the risk-corrected spread for the euro;
(f) ω_{co} is the country adjustment factor for country co.

9.4.2. ω_{co} in the above formula, in turn, is calculated as:

$$\omega_{co} = \max\left(\min\left(\frac{RCS_{co} \cdot \boldsymbol{DITTAR_{co}} - 0.6\%}{0.3\%}; 1\right); 0\right)$$

9.4.3. Where $\boldsymbol{DITTAR_{co}}$ is the debt-investments-to-total-assets ratio for country co, i.e. the percentage of investments in bonds relative to the total assets held by insurance and reinsurance undertakings authorised in country co.

With reference to ANNEX E, in particular to E.5.2, the DITTAR for country co is calculated as:

$$\boldsymbol{DITTAR_{co}} = \frac{\boldsymbol{AMV_{co,gov}} + \boldsymbol{AMV_{co,corp}}}{\boldsymbol{AMV_{co,gov}} + \boldsymbol{AMV_{co,corp}} + \boldsymbol{AMV_{co,other}}} = \boldsymbol{w_{co,gov}} + \boldsymbol{w_{co,corp}}$$

Here, bold notations indicate that values are only updated once per year as part of the update of the representative portfolios. This contrasts with the risk-corrected country spread value RCS_{co} which changes from day to day as being based on market data.

9.4.4. For all countries of the euro area EIOPA will publish the associated $DITTAR_{co}$.

9.4.5. In case there is no government yield curve for a country of the euro area, EIOPA applies the following criteria:

(a) the macro-VA for these countries will be zero;
(b) for countries which do have exposure to a euro area country without a government yield curve in their country government bond portfolio the government yield curve of a peer country will be used to calculate the macro VA;
(c) the LTAS of the government bonds to be used for calculating the macro-VA will be approximated with the LTAS of the peer country, considering those countries with similar credit quality and level of interest rates for the financial instruments used for the respective basic risk-free curves.

9.5. PUBLICATION OF THE RISK-CORRECTED SPREAD

9.5.1. According to Article 77d of the Solvency II Directive, the quantities RCS_{co} and $DITTAR_{co}$ are not undertaking specific. Their values are equally applied to calculate

the best estimate of all liabilities denominated in euro and which are held in country co.

9.5.2. EIOPA calculates and publishes RCS_{cu} and RCS_{co} monthly. $DITTAR_{co}$ are calculated annually as outputs from the update of the representative portfolios.

10. RFR TERM STRUCTURE WITH VA

10.1. INPUTS AND CONTROL PARAMETERS

10.1.1. Like the construction of the basic risk-free rate term structure in Section 8 the construction of the risk-free rate term structure with volatility adjustment (VA) uses inputs and control parameters.

10.1.2. Inputs to the calculation are the discretely compounded zero rates of the basic risk-free rate term structure up to and including the applicable first smoothing point (FSP) t_F for the respective currency according to paragraph 8.5.4, i.e.

$$z_t:\ t = 1,2,\dots,t_F.$$

10.1.3. Another input is the applicable VA as calculated according to Section 9. It is assumed that this VA is denoted in integer basis points. The VA only impacts the interpolated part of the curve up to and including the FSP.

10.1.4. The control parameters for the extrapolation are the continuously compounded risk-free zero rate at the FSP-maturity $z^C_{t_F}$, a continuously compounded last liquid forward rate $LLFR^c$, the first weight w_{t_F} as used in the calculation of the $LLFR^c$, a discretely compounded ultimate forward rate (UFR), and a convergence parameter α.

10.1.5. All these values are either published by EIOPA as part of the publication of the basic risk-free rate term structures or can be directly derived from there.

10.1.6. As the extrapolation method is based on continuously compounded forward rates the construction of the term structure with VA will follow a similar basis. First, the continuously compounded forward rates with VA are calculated according to the following:

Let:

$$z^C_t = \ln(1 + z_t),\ t = 1,2,\dots,t_F.$$

Then:

$$f^C_{t-1,t} = t \cdot z^C_t - (t-1) \cdot z^C_{t-1}, \quad t = 1,2,\dots,t_F\ ,$$

and

$$f^{VA^C}_{t-1,t} = f^C_{t-1,t} + VA^C, \quad t = 1,2,\dots,t_F,$$

with

$$VA^C = \ln\left(1 + \frac{VA}{10000}\right).$$

10.2. EXTRAPOLATION

10.2.1. The extrapolation method of the continuously compounded forward rates is according to paragraph 8.5.5 but with a slightly changed LLFR. According to paragraph 8.5.6 the first term of the $LLFR^C$ equals:

$$w_{t_F} \cdot f^C_{t_{F-1},t_F}.$$

i.e. the first weight w_{t_F} and the continuously compounded one-year forward rate immediately preceding the FSP-maturity t_F. According to paragraph 10.1.6 this forward rate incorporates the impact of the VA, i.e. it corresponds to $f^{VA^C}_{t_{F-1},t_F}$.
Now, the LLFR adjusted for the volatility adjustment $LLFR^{VA^C}$ is calculated according to the following:

$$LLFR^{VA^C} = LLFR^C + w_{t_F} \cdot \left(f^{VA^C}_{t_{F-1},t_F} - f^C_{t_{F-1},t_F}\right).$$

10.2.2. Now, the method of extrapolation of the forward rates is similar, i.e. for annualised continuously compounded forward rates with VA starting at the FSP with horizon h the following slightly amended definition is used:

$$f^{VA^C}_{t_F,t_F+h} = UFR^C + \left(LLFR^{VA^C} - UFR^C\right) \cdot B(a,h)$$

$$= UFR^C \cdot (1 - B(a,h)) + LLFR^{VA^C} \cdot B(a,h),$$

with: $UFR^C = \ln(1 + UFR)$ and $B(a,h) = \frac{1-e^{-ah}}{ah}$ with $a > 0$.

10.2.3. Subsequently the risk-free zero rates with VA (continuously compounded) from the following formulas:

$$z^{VA^C}_t = \frac{1}{t} \cdot \sum_{u=1}^{t} f^{VA^C}_{u-1,u} = \frac{(t-1) \cdot z^{VA^C}_{t-1} + f^{VA^C}_{t-1,t}}{t}, \quad t = 1,2,\ldots,t_F$$

and

$$z^{VA^C}_{t_F+h} = \frac{t_F \cdot z^{VA^C}_{t_F} + h \cdot f^{VA^C}_{t_F,t_F+h}}{t_F+h}, \text{for } h = 1,\ldots,150 - t_F.$$

10.2.4. Finally, the basic risk-free interest rate term structure with VA (annually compounded) follows from:

$$z^{VA}_t = e^{z^{VA^C}_t} - 1, \text{ for } t = 1,\ldots,150.$$

11. MATCHING ADJUSTMENT

11.1. CONCEPTUAL FRAMEWORK

11.1.1. For each relevant currency, the matching adjustment (MA) 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 entire basic risk-free interest rate term structure).

11.1.2. Undertakings must calculate the MA themselves, based on their own assigned portfolios of eligible assets. EIOPA publishes the fundamental spread (FS) that undertakings should use in the calculation of the MA, at the breakdown of each relevant duration, credit quality, and asset class, together with the following information:

(a) the long-term average spread (LTAS),
(b) for assets other than government bonds:

i. the probability of default (PD) to use in the de-risking of the cash flows of the assigned assets,
ii. the PD expressed as a part of the spread used to calculate the FS,
iii. the cost of downgrade (CoD).

11.1.3. The derivation of the FS requires decisions on the following:

(a) the source data for the LTAS calculation,
(b) the method of constructing missing data of the 30-year spread history,
(c) the treatment of currencies for which source data is not available,
(d) the source data for the PD calculation,
(e) the method of deriving PD from source data,
(f) the source data for the CoD calculation,
(g) the method of deriving CoD from source data.

11.1.4. As the LTAS is an input to the volatility adjustment as well, the methodology for the LTAS calculation and the decisions regarding (a) to (c) are discussed in the RCS-related annex G.6. This section will therefore cover the CoD- and PD-related decisions above as well as the formulas used to calculate the FS.

11.2. FS FOR GOVERNMENT BONDS

11.2.1. According to Article 77c of the Solvency II Directive, the FS on government bonds is equal to the maximum of:

(a) the sum of the credit spread corresponding to the PD of the assets considered and the credit spread corresponding to the expected loss resulting from downgrading of the assets concerned;
(b) a percentage of the LTAS of assets of the same duration, credit quality and asset class, as observed in financial markets. This percentage is 30% for exposures to governments of EEA member states, and 35% for exposures to other governments (Article 77c(2)(b) and (c) of the Solvency II Directive).

11.2.2. Recital 22 of the Delegated Regulation specifies that '*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 … should be equal to the long-term average of the spread over the risk-free interest rate set out in Article 77c(2)(b) and (c) of Directive 2009/138/EC'*.

11.2.3. Therefore, the FS at time t on government bonds with maturity T for country i corresponds to:

(a) $FS_{gov,i}(t,T) = 30\% \cdot LTAS_{gov,i}(t,T)$ if issuing country i is an EEA member;
(b) $FS_{gov,i}(t,T) = 35\% \cdot LTAS_{gov,i}(t,T)$ if issuing country i is not an EEA member.

Where $LTAS_{gov,i}(t,T)$ is the long-term average spread at time t on government bonds with maturity T for issuing country i (see Annex G.6.2).

11.2.4. For countries which do have exposure to a euro area country without a government yield curve in their MA portfolio, the government yield curve of a peer country will be used to calculate the MA.

11.2.5. The LTAS of the government bonds to be used for calculating the MA will be approximated with the LTAS of the peer country, considering those countries with similar credit quality and level of interest rates for the financial instruments used for the respective basic risk-free curves.

11.2.6. EIOPA publishes the FS for all government bonds for maturities $T = 1, 2, \ldots, 30$.

11.3. FS FOR CORPORATE BONDS

11.3.1. Article 77c of the Solvency II Directive and Articles 53 and 54 of the Delegated Regulation set down several aspects of the methodology for calculating the FS of

assets other than government bonds. The methodology to be used depends on whether reliable credit spreads can be derived from long-term default statistics.

11.3.2. With reference to ANNEX G, and noting that 1) each issuing country i defines its currency cu_i, and 2) where reliable credit spreads can be derived from such statistics, the FS at time t on corporate bonds for all issuing countries i and all $s \in S \times Q$ corresponds to:

$$FS_{i,corp,s}(t,T) = \\ max\left(PD_{i,corp,s}(t,T) + CoD_{i,corp,s}(t,T), 35\% \times LTAS_{i,corp,s}(t,T)\right)$$

where:

(a) $PD_{i,corp,s}(t,T)$: the credit spread at time t corresponding to the probability of default of corporate bonds of issuance type s denominated in currency cu_i with maturity T;

(b) $CoD_{i,corp,s}(t,T)$: the credit spread at time t corresponding to the expected loss resulting from downgrading corporate bonds of issuance type s denominated in currency cu_i with maturity T;

(c) $LTAS_{i,corp,s}(t,T)$: the long-term average of the spread at time t of market yields over the corresponding risk-free yields of corporate bonds of issuance type s denominated in currency cu_i with maturity T (see Annex 0).

11.3.3. For the methodology and the source data used to derive the PD and CoD see ANNEX I.

11.3.4. EIOPA publishes the FS, PD and CoD for all corporate bonds for maturities $T = 1, 2, \ldots, 30$.

ANNEXES

ANNEX A RELEVANT CURRENCIES

A.1 EEA CURRENCIES

Table 5 - EEA Currencies

ISO 4217	Currency	Countries where the currency is used
EUR	Euro	Euro area members
CHF	Swiss franc	Liechtenstein, Switzerland
CZK	Czech koruna	Czechia
DKK	Danish krone	Denmark
HUF	Forint	Hungary
ISK	Króna	Iceland
NOK	Norwegian krone	Norway
PLN	Zloty	Poland
RON	Romanian leu	Romania
SEK	Krona	Sweden

A.2 OTHER CURRENCIES

Table 6 - Other currencies

ISO 4217	Currency	Countries where the currency is used
AUD	Australian dollar	Australia
CAD	Canadian dollar	Canada
CNY	Renminbi-yuan	China
GBP	Pound sterling	United Kingdom
JPY	Yen	Japan
USD	US dollar	United States

ANNEX B DLT ASSESSMENT

B.1 GENERAL APPROACH TO DLT ASSESSMENT CRITERIA

B.1.1 Solvency II sets out market consistency as a core principle for the assessment of the financial and solvency position of insurance and reinsurance undertakings. The principle of market consistency applies to both assets and liabilities.[13] In particular, for the calculation of technical provisions the relevant risk-free interest rate term structure should be used. That term structure should be based on up-to-date and credible information.[14]

B.1.2 These principles underpin the assessment of the depth, liquidity and transparency of markets where the interest rates are observed. As well as providing assurance that the relevant deep, liquid and transparent (DLT) requirements are met, the DLT assessment should foster the optimal use of the information provided by financial markets.[15]

B.1.3 In developing the methodology applied for the DLT assessment, EIOPA has analysed the generally applied practices and the academic literature on the issue. This analysis has dealt in particular with the process of liquidity assessment but has also considered the available measures of market depth and transparency.

B.1.4 EIOPA's work and lessons learnt during 2013 are in line with EBA's report on high quality liquid assets (HQLA).[16]

B.1.5 While acknowledging the differences between the banking and insurance sectors, EIOPA recognises the existence of commonalities between the DLT assessment for risk-free interest rate term structures and the work carried out by EBA on HQLA.

B.1.6 Although there is a set of generally applied metrics for the purpose of making a DLT assessment, carrying out the assessment in practice is currently constrained by the following limitations:

B.1.7 While there is a general approach to assessing liquidity and depth, the precise definitions of these terms depend on the context. For example, the definition of 'liquidity' for the purpose of the liquidity coverage ratio in the banking sector is quite

[13] Recital 53, Articles 75 and 76 of the Solvency II Directive.

[14] Recital 58 and Article 77 of the Solvency II Directive.

[15] Recital 45 of the Solvency II Directive.

[16] EBA, *Report on appropriate uniform definitions of extremely high quality liquid assets (extremely HQLA) and high quality liquid assets (HQLA) and on operational requirements for liquid assets under Article 509(3) and (5) CRR*, 2013.

similar to its definition in the case of the DLT assessment in the insurance sector. Having said that, the purpose of the DLT assessment is focused on ensuring the reliability of market interest rates rather than the need to convert assets into cash.

B.1.8 There are several factors influencing the liquidity and depth of financial markets. Furthermore, the influence of these factors varies across markets (e.g. according to their practices, conventions and operational rules) and varies over time within the same market (e.g. according to changes in the environment). Finding a generalised way to measure the level of these factors is the subject of continuing research.

B.1.9 It is generally accepted that no single metric can be conclusive in assessing the DLT nature of a financial instrument. For example, high trading volumes and turnovers indicate that assets are liquid, while the converse does not necessarily hold true (some assets may be in high demand without being traded often, and hence could be easily liquidated if necessary).[17]

B.1.10 There are severe limitations for the calculation of some metrics, in terms of the availability and reliability of the inputs necessary for the calculation and the completeness or homogeneity of the data series.

B.1.11 Finally, practitioners, academics and supervisors acknowledge the relevance of supplementing quantitative metrics with qualitative information or expert judgement. EIOPA supports the appropriate consideration of qualitative information, and this view is also reflected in the EBA (2013) report.[18] In particular, EIOPA is of the view that the assessment of the depth of a financial market should take into account the existence of appropriate supervision; such supervision can be an effective mechanism to ensure that large transactions will only affect prices according to the natural trends of the market, and not because of any spurious influence. Another relevant qualitative consideration for the assessment of market depth is the way in which market prices are collected; market data providers have developed effective methods and controls that can help to give reassurance that the influence of large transactions or unusual trades on prices is likely to be immaterial.

B.1.12 EIOPA's methodology aims to provide a stable DLT assessment; this is considered a necessary condition to allow insurance and reinsurance undertakings to implement the relevant calculation processes.

[17] EBA report on HQLA (p. 16).

[18] EBA report on HQLA (p. 26).

B.2 DLT ASSESSMENT CRITERIA FOR THE SWAP MARKET

B.2.1 The thresholds used for the DLT assessment of the swap market are defined as follows, drawing on the liquidity criteria set out in Commission Delegated Regulation (EU) 2017/583 for single currency fixed-to-floating swaps:

(a) the average daily number of trades is at least 10;
(b) the average daily notional amount traded is at least EUR 50 000 000.

B.2.2 The swap trade data that EIOPA has access to via the European Market Infrastructure Regulation (EMIR) covers most of the swap trade in EEA currencies. Furthermore, additional swap trade data, such as publicly available data from the US and CA, or data obtained through exchange agreements with third countries should be considered. Trade volumes and counts are scaled up to account for trades not covered by the data sources, based on scaling factors that are derived from the triannual OTC derivative statistics of the Bank for International Settlements. The same approach is taken for other relevant currencies, where data on most swap trades is available.

B.2.3 To ensure the stability of DLT tenor points:

(a) a market assessed as liquid in the past is considered to have become illiquid only if it is at least 20% below one of the two thresholds set out above;
(b) a market assessed as illiquid in the past is considered to have become liquid only if it is at least 20% above the two thresholds set out above and has been like this for two years in a row.

B.2.4 Furthermore, availability of data for the DLT points (especially non-standard swap tenors and the first smoothing point (FSP)) should be taken into account. If for instance a point is considered DLT due to the aforementioned criteria, but the main market data provider does not provide quotes, the point should be rejected, as it cannot be used for the creation of the term structures.

B.3 DLT ASSESSMENT CRITERIA FOR THE GOVERNMENT BOND MARKET

B.3.1 The DLT assessments of the government bond markets for EEA currencies other than the euro are conducted by the respective national competent authorities (NCAs), based on a common framework provided by EIOPA.

B.3.2 According to the framework, the depth and liquidity assessment of the government bond market should primarily rely on the trading volume and frequency of government bonds. This approach ensures improved consistency in DLT assessment across currencies. It also

aligns government bond market's DLT assessment methodology with that of the swap market.

B.3.3 Where such trade data are not available or their analysis inconclusive, the framework requires other criteria to be assessed, including the following:

(a) bid-ask spread,
(b) volatility of rates,
(c) number of zero-trading days,
(d) trader quotes/dealer surveys,
(e) quote counts.

B.3.4 No hard thresholds are set, as a single threshold is unlikely to fit all currencies. Moreover, given data limitations, the assessment may incorporate expert judgement where necessary.

B.3.5 Like paragraph B.2.4, availability of data for the DLT points (especially non-standard swap tenors and the FSP) should be taken into account. If for instance a point is considered DLT due to the aforementioned criteria, but the main market data provider does not provide quotes, the point should be rejected, as it cannot be used for the creation of the term structures.

B.4 DETERMINATION OF THE FSP

B.4.1 Once the list of DLT tenor points has been formed, the final step of the DLT assessment process involves the identification of the FSP for each relevant currency. The FSP is the longest DLT maturity for which the percentage of outstanding bonds of that or a longer maturity among all outstanding bonds denominated in that currency is 'sufficiently high'. Article 43a of the Delegated Regulation specifies this threshold as the following:

(a) for the euro, the applicable percentage shall be the closest half-integer or integer percentage greater than or equal to the sum of:

i. 1.5 percentage point;
ii. the lowest percentage of outstanding bonds which would result in the determination of an FSP of 20 years on 28 January 2025;

(b) for currencies other than the euro, where on 29 January 2027 the last maturity for which the relevant risk-free interest rate term structure is not extrapolated was at least 20 years, the applicable percentage shall be the same as that applicable for the euro;

(c) for currencies other than those referred to in points (a) and (b), the applicable percentage shall be half of the one applicable for the euro.

B.4.2 The applicable percentage for the euro has been calculated by EIOPA as 9.5%. This same percentage applies to all other relevant currencies having 20 years or longer as their last liquid point as of 29 January 2027. For all other relevant currencies, the percentage will be half of 9.5%, i.e. 4.75%.

B.5 HISTORY OF RELEVANT FINANCIAL INSTRUMENTS

The following tables specify the relevant financial instruments that were used to derive risk-free interest rates in the past since 1 January 2016. For currencies that do not appear in those tables, the relevant financial instruments have been unchanged since 1 January 2016. The currently used financial instruments are set out in Table 1 and Table 2 of the main text. Market data until (and including) 31 December 2019 was received from Bloomberg.

B.5.1 EEA currencies

Table 7 - History of financial instruments used for EEA currencies

	Financial instruments used **OIS = Overnight indexed swaps, SWP=swaps, GVT=government bonds.** **All maturities in years.**	**Period**
EUR	SWP 1-10, 12, 15, 20	1 January 2016 – 31 December 2019
	SWP 1-15, 20	1 January 2020 – 31 March 2021
	SWP 1-12, 15, 20	1 April 2021 – 31 December 2024
	SWP 1-13, 15, 19, 20	1 January – 29 June 2025
	SWP 1-13, 15, 20	30 June – 31 December 2025
	SWP 1-15, 20	1 January 2026 – 29 January 2027
CHF	SWP 1-15, 20, 25	1 January 2016 – 31 March 2021
	SWP 2, 5, 10, 25	1 April – 31 December 2021
	GVT 1-3, 5-13, 15	1 January – 31 December 2022
	OIS 2, 5, 10	1 January – 31 December 2023
	OIS 1, 2, 5, 10	1 January 2024 – 31 December 2025
CZK	SWP 1-10, 12, 15	1 January 2016 – 31 March 2021
	SWP 1, 2, 5, 10, 15	1 April – 31 December 2021
	SWP 2, 5, 10, 15	1 January – 31 December 2022

	Financial instruments used OIS = Overnight indexed swaps, SWP=swaps, GVT=government bonds. All maturities in years.	Period
	SWP 1, 2, 5, 10, 15	1 January – 31 December 2023
	SWP 1-3, 5, 10	1 January 2024– 29 January 2027
HRK	GVT 1-4, 10	1 January – 30 December 2016
	GVT 1, 3, 4, 8, 9	1 January 2020 – 31 March 2021
	GVT 1-9	1 April – 31 December 2021
	GVT 1-7, 9	1 January – 31 December 2022
	Note: Croatia adopted the euro from 2023 onwards. Therefore, the HRK-currency will be no longer used from 2023 onwards.	
HUF	GVT 1-10, 15	1 January 2016 – 31 March 2021
	GVT 1-15	1 April 2021 - 29 January 2027
ISK	GVT 2, 4, 5, 8, 10	1 January – 30 December 2016
	GVT 2, 3, 6, 8	31 December 2020 – 31 March 2021
	GVT 1, 2, 3, 5, 8	1 April – 31 December 2021
	GVT 1, 2, 4, 8	1 January – 31 December 2022
	GVT 1-4, 9	1 January – 31 December 2023
	GVT 1, 2, 6, 8, 9	1 January – 31 December 2024
	GVT 1-4, 7, 9	1 January – 31 December 2025
	GVT 1, 3, 5, 9	1 January 2026 – 29 January 2027
NOK	SWP 1-10	1 January 2016 – 31 December 2019
	SWP 1-5, 10	1 January 2020 – 31 March 2021
	SWP 1, 2, 5, 10	1 April – 31 December 2021
	SWP 2, 5, 10	1 January 2022 – 29 January 2027
PLN	GVT 1-10	1 January 2016 – 29 January 2027
RON	GVT 1-5, 7-10	1 January 2016 – 31 March 2021
	GVT 1-6, 8-10	1 April – 31 December 2021

	Financial instruments used OIS = Overnight indexed swaps, SWP=swaps, GVT=government bonds. All maturities in years.	Period
	GVT 1-7, 10	1 January – 31 December 2022
	GVT 1-10	1 January 2023 – 31 December 2025
SEK	SWP 1-10	1 January 2016 – 31 December 2019
	SWP 1-7, 10	1 January 2020 – 31 March 2021
	SWP 1-5, 10	1 April – 31 December 2021
	SWP 2, 5, 10	1 January – 31 December 2022
	SWP 2, 3, 5, 10	1 January 2023 – 31 December 2025

B.5.2 Non-EEA currencies

Table 8 - History of financial instruments used for non-EEA currencies

	Financial instruments used OIS = Overnight indexed swaps, SWP=swaps, GVT=government bonds. All maturities in years.	Period
AUD	SWP 1-10, 12, 15, 20, 25, 30	1 January 2016 – 31 December 2019
	SWP 1-5, 7, 10 ,12, 15, 20, 25, 30	1 January 2020 – 31 March 2021
	SWP 1-10, 12, 15, 20, 25, 30	1 April 2021 – 31 December 2025
	SWP 1-12, 15, 20, 25, 30	1 January 2026 – 29 January 2027
BRL	GVT 1-10	1 January 2016 – 31 December 2024
	Removed from list of relevant currencies as of 1 January 2025	
CAD	SWP 1-10, 12, 15, 20, 25	1 January – 30 December 2016
	SWP 1-10, 12, 15, 20, 30	31 December 2016 – 31 December 2019
	SWP 1-5, 7, 10, 30	1 January 2020 – 31 December 2023
	OIS 1-5, 7, 10, 30	1 January – 31 December 2024
	OIS 1-5, 10, 30	1 January 2026 – 29 January 2027
	SWP 1-10	1 January – 30 December 2016

	Financial instruments used OIS = Overnight indexed swaps, SWP=swaps, GVT=government bonds. All maturities in years.	Period
CLP	SWP 1-5, 7, 10	31 December 2016 – 31 December 2019
	GVT 1-5, 7, 10	1 January 2020 – 31 December 2021
	GVT 1-4, 7, 9, 10	1 January – 31 December 2022
	GVT 1-4, 6, 8-10	1 January – 31 December 2023
	GVT 1-3, 7, 8, 10	1 January – 31 December 2024
	Removed from list of relevant currencies as of 1 January 2025	
CNY	SWP 1-10	1 January – 30 December 2016
	SWP 1-5, 7, 10	31 December 2016 – 31 December 2019
	SWP 1, 2, 5, 10	1 January 2020 – 31 December 2021
	SWP 1, 5, 10	1 January 2022 – 29 January 2027
COP	SWP 1-5, 7, 8, 10	1 January – 30 December 2016
	GVT 1-10	1 January 2017 – 31 December 2021
	GVT 1-6, 8, 10	1 January – 31 December 2022
	GVT 1-6, 8-10	1 January – 31 December 2023
	GVT 1-10	1 January 2024 – 29 January 2027
	Removed from list of relevant currencies as of 30 January 2027	
GBP	SWP 1-20, 25, 30, 35, 40, 45, 50	1 January 2016 – 31 December 2019
	SWP 1-10, 12, 15, 20, 25, 30, 40, 50	1 January 2020 – 31 March 2021
	SWP 1-10, 15, 20, 30, 50	1 April 2021 – 31 December 2021
	OIS 1-5, 7, 9, 10, 15, 20, 30	1 January – 31 December 2022
	OIS 1-7, 9, 10, 12, 15, 20, 30, 50	1 January – 31 December 2023
	OIS 1-7, 9, 10, 12, 15, 20, 25, 30, 50	1 January – 31 December 2024
	OIS 1-10, 12, 15, 20, 25, 30, 40, 50	1 January – 31 December 2025
	OIS 1-13, 15, 20, 25, 30, 40, 50	1 January 2026 – 29 January 2027
	SWP 1-5, 7, 10, 12, 15	1 January 2016 – 31 December 2019

	Financial instruments used OIS = Overnight indexed swaps, SWP=swaps, GVT=government bonds. All maturities in years.	Period
HKD	SWP 1-3, 5, 10, 15	1 January 2020 – 31 December 2021
	SWP 1-5, 10, 15	1 January – 31 December 2022
	SWP 1-5, 7, 10, 15	1 January – 31 December 2023
	SWP 1-3, 5, 10, 15	1 January 2024 – 29 January 2027
	Removed from list of relevant currencies as of 30 January 2027	
INR	GVT 1-10	1 January 2016 – 31 December 2023
	OIS 1-5	1 January – 31 December 2024
	Removed from list of relevant currencies as of 1 January 2025	
JPY	SWP 1-20, 25, 30	1 January – 30 December 2016
	SWP 1-10, 12, 15, 20, 25, 30	31 December 2016 – 31 December 2019
	SWP 1-10, 12, 15, 20, 30	1 January 2020 – 31 March 2021
	SWP 1-10, 12, 15, 20, 25, 30	1 April – 31 December 2021
	GVT 1-20, 25, 30	1 January – 31 December 2022
	OIS 1-10, 12, 15, 20, 25, 30	1 January – 31 December 2023
	OIS 1-10, 12, 15, 20, 30	1 January 2024 – 31 December 2025
	OIS 1-3, 5, 7, 10, 20, 30	1 January 2026 – 29 January 2027
KRW	SWP 1-5, 7, 10, 12, 15, 20	1 January 2016 – 31 December 2019
	Removed from list of relevant currencies as of 1 January 2025	
MYR	SWP 1-10, 12, 15, 20	1 January – 30 December 2016
	SWP 1-5, 7, 10, 12, 15, 20	31 December 2016 – 31 December 2019
	Removed from list of relevant currencies as of 1 January 2025	
MXN	GVT 1-10, 15, 20	1 January – 30 December 2016
	SWP 1-5, 7, 10, 15, 20	31 December 2016 – 31 December 2019
	SWP 1-5, 7, 10, 20	1 January 2020 – 31 March 2021
	SWP 1-5, 10, 20	1 April – 31 December 2021

	Financial instruments used OIS = Overnight indexed swaps, SWP=swaps, GVT=government bonds. All maturities in years.	Period
	SWP 1-5, 10	1 January 2022 – 31 December 2023
	SWP 1-5, 7, 10	1 January – 31 December 2024
	Removed from list of relevant currencies as of 1 January 2025	
NZD	SWP 1-10, 12, 15, 20	1 January 2016 – 31 December 2019
	SWP 1-10, 20	1 January 2020 – 31 December 2021
	SWP 1-7, 10, 20	1 January 2022 – 31 December 2023
	SWP 1-5, 10, 20	1 January – 31 December 2024
	Removed from list of relevant currencies as of 1 January 2025	
RUB	SWP 1-10	1 January – 30 December 2016
	SWP 1-7, 10	31 December 2016 – 31 December 2019
	GVT 1-5, 7, 9, 10, 12, 15	1 January 2020 – 31 December 2021
	GVT 1-10, 12, 14	1 January – 31 December 2022
	GVT 1-9, 12, 14	1 January – 31 December 2023
	Removed from list of relevant currencies as of June 2024	
SGD	SWP 1-10, 12, 15, 20	1 January – 30 December 2016
	SWP 1-5, 7, 10, 12, 15, 20	31 December 2016 – 31 December 2019
	SWP 1-3, 5, 10, 20	1 January 2020 – 31 December 2022
	OIS 1-3, 5, 10	1 January – 31 December 2023
	OIS 1, 2, 5, 10	1 January – 31 December 2024
	Removed from list of relevant currencies as of 1 January 2025	
THB	SWP 1-10, 12, 15	1 January – 30 May 2016
	SWP 1-5, 7, 10, 12, 15	31 May 2016 – 31 December 2019
	GVT 1-10, 12, 15	1 January 2020 – 31 December 2021
	GVT 1-10, 15	1 January 2022 – 31 December 2023
	OIS 1-2, 4, 10	1 January – 31 December 2024

	Financial instruments used OIS = Overnight indexed swaps, SWP=swaps, GVT=government bonds. All maturities in years.	Period
	Removed from list of relevant currencies as of 1 January 2025	
TRY	SWP 1-5, 7, 10	31 May 2016 – 31 December 2019
	GVT 1-5, 7, 9	1 January 2020 – 31 March 2021
	GVT 1-5, 7, 8	1 April – 31 December 2021
	GVT 1-9	1 January – 31 December 2022
	GVT 1-6, 8, 9	1 January – 31 December 2023
	GVT 1-5, 7-9	1 January – 31 December 2024
	Removed from list of relevant currencies as of 1 January 2025	
TWD	GVT 1-10	1 January 2016 – 29 January 2027
	Removed from list of relevant currencies as of 30 January 2027	
USD	SWP 1-15, 20, 25, 30, 35, 40, 45, 50	1 January – 30 December 2016
	SWP 1-12, 15, 20, 25, 30, 40, 50	31 December 2016 – 31 December 2019
	SWP 1-10, 12, 15, 20, 25, 30, 50	1 January 2020 – 31 December 2022
	OIS 1-5, 7, 9, 10, 15, 20, 30	1 January – 31 December 2023
	OIS 1-10, 12, 15, 20, 25, 30	1 January – 31 December 2024
	OIS 1-10, 12, 15, 16, 20, 25, 30	1 January – 31 December 2025
ZAR	SWP 1-10, 12, 15	1 January 2016 – 31 December 2019
	SWP 1-3, 5, 10, 15	1 January 2020 – 31 December 2021
	SWP 1-7, 10, 15	1 January – 31 December 2022
	SWP 1-6, 10, 15	1 January – 31 December 2023
	SWP 1-8, 10, 15	1 January – 31 December 2024
	Removed from list of relevant currencies as of 1 January 2025	

ANNEX C UFR METHODOLOGY

C.1 INTRODUCTION

C.1.1 This annex sets out the methodology to derive the ultimate forward rate (UFR) and its implementation as decided by EIOPA at the end of March 2017. The methodology is in accordance with Article 47 of the Delegated Regulation which requires in particular that such a methodology shall be clearly specified in order to ensure the performance of scenario calculations by insurance and reinsurance undertakings.

C.2 CALCULATION OF THE UFR

C.2.1 Update of the UFR: EIOPA will annually calculate the UFR for each relevant currency and, where they are sufficiently different according to the methodology from the then applicable UFRs, update them at the beginning of the next year. The updated UFRs will be announced every year by the end of March on EIOPA's website. Nine months after the announcement of the updated UFRs, EIOPA will use them to calculate the risk-free interest rate term structures starting from 1 January of the following year.

C.2.2 Calculation of the UFR: For each currency, the change of the UFR is limited in such a way that it increases or decreases by 15 bps or remains unchanged in accordance with the following rule:

$$UFR_t^L = \begin{cases} UFR_{t-1}^L + 15\ bps & if\ \ UFR_t \geq UFR_{t-1}^L + 15\ bps \\ UFR_{t-1}^L - 15\ bps & if\ \ UFR_t \leq UFR_{t-1}^L - 15\ bps \\ UFR_{t-1}^L & otherwise \end{cases},$$

where:

(a) UFR_t^L denotes the *UFR* of year *t*, after limitation of the annual change;
(b) UFR_{t-1}^L denotes the *UFR* of year *t-1*, after limitation of the annual change;
(c) UFR_t denotes the *UFR* of year *t*, before limitation of the annual change.

C.2.3 For each currency the UFR before limitation of the annual change is the sum of an expected real rate and an expected inflation rate. The expected real rate is the same for each currency. The expected inflation rate is currency specific.

C.3 CALCULATION OF THE EXPECTED REAL RATE

C.3.1 The expected real rate is the simple arithmetic mean of annual real rates from 1961 to the year before the recalculation of the UFRs according to the following formula:

$$R = \frac{1}{n}\sum_{i=1}^{n} r_{1960+i},$$

where:

(a) *R* is the expected real rate;
(b) *n* is the number of years since end of 1960;
(c) r_i is the annual real rate for the year 1960+*i*.

C.3.2 For each of the years since 1961 the annual real rate is derived as the simple arithmetic mean of the annual real rates of Belgium, Germany, France, Italy, the Netherlands, the United Kingdom and the United States.

C.3.3 For each of those years and each country the annual real rate is calculated as follows:

real rate = (*short-term nominal rate – inflation rate*) / (1 + *inflation rate*)

C.3.4 The short-term interest rate series were historically sourced from EUROSTAT. In 2024, EUROSTAT discontinued the UK and US time series for 3-month short-term interest rates following the transition away from LIBOR. As an alternative, the series are now sourced from the 'Key short-term economic indicators' of the OECD.[19]

C.3.5 The inflation rates are sourced from the 'Consumer price indices (CPIs, HICPs), COICOP 1999' of the OECD.[20]

C.3.6 The expected real rate is rounded to full five basis points as follows:

(a) when the unrounded rate is lower than the rounded rate of the previous year, the rate is rounded upwards;
(b) when the unrounded rate is higher than or equal to the rounded rate of the previous year, the rate is rounded downwards.

[19] OECD Data Explorer • Key short-term economic indicators

[20] OECD Data Explorer • Consumer price indices (CPIs, HICPs), COICOP 1999

C.4 CALCULATION OF THE EXPECTED INFLATION RATE

C.4.1 For currencies where the central bank has announced an inflation target, the expected inflation rate is based on that inflation target according to the following rules:

(a) the expected inflation rate is:

i. 1%, where the inflation target is lower than or equal to 1%;
ii. 2%, where the inflation target is higher than 1% and lower than 3%;
iii. 3%, where the inflation target is higher than or equal to 3% and lower than 4%;
iv. 4%, where the inflation target is 4% or higher;

(b) where a central bank is not targeting a specific inflation figure but tries to keep the inflation in a specified corridor, the midpoint of that corridor is relevant for the allocation to the four inflation rate buckets.

C.4.2 For currencies where the central bank has not announced an inflation target, the expected inflation rate is 2% by default. However, where past inflation experience and projection of inflations both clearly indicate that the inflation of a currency is expected in the long-term to be at least 1 percentage point higher or lower than 2%, the expected inflation rate will be chosen in accordance with those indications. The expected inflation rate will be rounded downwards to full percentage points.

C.4.3 The past inflation experience will be assessed against the average of 10 years annual inflation rates. The projection of inflation rates will be derived based on an autoregressive–moving-average model.

C.5 IMPLEMENTATION OF THE METHODOLOGY

C.5.1 The methodology to derive the UFR was implemented in 2018. The first UFRs calculated according to the methodology were announced at the beginning of April 2017 and were used for the first time at the start of 2018 to calculate the risk-free interest rate term structures at that time.

C.5.2 The initial application of the methodology in 2018 was based on the following additional specifications:

(a) the UFR for 2017, denoted UFR_{t-1}^{L} in paragraph C.2.2, was:

i. 3.2% for the Swiss franc and the Japanese yen;
ii. 5.2% for the Brazilian real, the Indian rupee, the Mexican peso, the Turkish lira and the South African rand;
iii. 4.2% for all other relevant currencies;

(b) the rounded expected real rate of the previous year referred to in paragraph C.3.6 was equal to 2.2%.

ANNEX D BOOTSTRAPPING RISK-FREE RATES

D.1 USING PAR SWAP RATES AS INPUTS

D.1.1 Assume we observe, according to EIOPA's deep, liquid and transparent (DLT) criteria, the following L par swap rates with coupon frequency m_1, corrected for a credit risk adjustment (CRA) and a currency risk adjustment (CURA) where applicable, denoted by:

$$s_{t_k}:\ k = 1,2,\dots,L\ with\ t_k \in \mathbb{N},$$

where the coupon payments are equal to:

$$s_{t_k}^{(m_1)} = \frac{s_{t_k}}{m_1}.$$

D.1.2 The full set of available DLT tenor-points is given by:

$$DLT = \{t_k | k = 1,2,\dots,L\}.$$

D.1.3 The missing DLT tenor points follow from:

$$nonDLT = \{t \in \mathbb{N} | t \notin DLT\ \wedge t < t_L\}.$$

Hence, missing tenor points $t \in \mathbb{N}$ can only be observed:

1. before the start of the series of DLT points: $t < t_1$, or
2. within the series of DLT points: $t_k < t < t_{k+1}$, where $t_{k+1} - t_k > 1$.

D.2 THE FIXED LEG OF A SWAP

D.2.1 The observed swap-rate s_{t_k} denotes the fixed annual rate of a swap contract with maturity $t_k \in \mathbb{N}$ and coupon frequency m_1. If we denote the notional of the swap contract by N and the periodic fixed cash flows to be paid at the end of each period at time $t = \frac{j}{m_1}$ by $CF_{\frac{j}{m_1}}$, then the cash flows are according to the following formula:

$$CF_{\frac{j}{m_1}} = s_{t_k}^{(m_1)} \cdot N = \frac{s_{t_k}}{m_1} \cdot N \quad for\ j = 1,2,\dots,m_1 \cdot t_k - 1, m_1 \cdot t_k\ and\ k = 1,2,\dots,L.$$

D.2.2 The value of the fixed leg equals the sum of its discounted cash flows. If we denote by $d_{u,v}$ the discount factor from time $t = v$ back to time $t = u$, then the value of the fixed leg follows from the following formula[21]:

$$V_{t_k}^{fixed} = \sum_{j=1}^{m_1 \cdot t_k} d_{\frac{j}{m_1}} \cdot CF_{\frac{j}{m_1}} = \frac{s_{t_k}}{m_1} \cdot N \cdot \sum_{j=1}^{m_1 \cdot t_k} d_{\frac{j}{m_1}} \quad for\ k = 1,2,\dots,L.$$

Note: $d_{u,u} = 1 \Longrightarrow d_0 = 1$.

D.3 THE FLOATING LEG OF A SWAP

D.3.1 If we denote the frequency of the floating cash flows by m_2, then at the start of each period the floating rate for that period equals the forward rate for that period, which is subsequently paid at the end of the period.

Given the notional *N* of the swap contract, if we denote by $f_{u,v}$ the discrete forward rate at time $t = u$ with horizon $v - u$, then the periodic floating cash flows to be paid at the end of each period are denoted by:

$$CF_{\frac{j}{m_2}} = f_{\frac{j-1}{m_2},\frac{j}{m_2}} \cdot N \quad for\ j = 1,2,\dots,m_2 \cdot t_k - 1, m_2 \cdot t_k\ and\ k = 1,2,\dots,L.$$

D.3.2 Like the value of the fixed leg, the value of the floating leg equals the sum of its discounted cash flows. Hence the value of the floating leg follows from the following formula:

$$V_{t_k}^{float} = \sum_{j=1}^{m_2 \cdot t_k} d_{\frac{j}{m_2}} \cdot CF_{\frac{j}{m_2}} = N \cdot \sum_{j=1}^{m_2 \cdot t_k} d_{\frac{j}{m_2}} \cdot f_{\frac{j-1}{m_2},\frac{j}{m_2}} \quad for\ k = 1,2,\dots,L.$$

D.3.3 Now, note the following relation between two consecutive periodic discount factors:

$$\frac{d_{\frac{j-1}{m_2}}}{1+f_{\frac{j-1}{m_2},\frac{j}{m_2}}} = d_{\frac{j}{m_2}} \Leftrightarrow d_{\frac{j}{m_2}} \cdot f_{\frac{j-1}{m_2},\frac{j}{m_2}} = d_{\frac{j-1}{m_2}} - d_{\frac{j}{m_2}}.$$

D.3.4 Substituting into the formula for $V_{t_k}^{float}$ results in:

$$V_{t_k}^{float} = N \cdot \sum_{j=1}^{m_2 \cdot t_k} d_{\frac{j}{m_2}} \cdot f_{\frac{j-1}{m_2},\frac{j}{m_2}} = N \cdot \sum_{j=1}^{m_2 \cdot t_k} \left(d_{\frac{j-1}{m_2}} - d_{\frac{j}{m_2}} \right) = N \cdot \left(1 - d_{t_k}\right).$$

[21] If *u = 0* then $d_{u,v}$ will simply be denoted by d_v.

D.3.5 Using this result and the fact that at start of the swap contract both legs have the same value we can derive the following equation:

$$V_{t_k}^{fixed} = V_{t_k}^{float} \Leftrightarrow s_{t_k}^{(m_1)} \cdot \sum_{j=1}^{m_1 \cdot t_k} d_{\frac{j}{m_1}} = 1 - d_{t_k},$$

or equivalently:

$$s_{t_k}^{(m_1)} \cdot \sum_{j=1}^{m_1 \cdot t_k - 1} d_{\frac{j}{m_1}} + \left(1 + s_{t_k}^{(m_1)}\right) \cdot d_{t_k} = 1.$$

Which shows that the coupon payment related to the par swap rate $s_{t_k}^{(m_1)}$ can be seen as the coupon of a bond with maturity t_k having a coupon frequency m_1 and a face value of 1, which values the bond at par.

This formula, together with the constant forward assumption, will be used to bootstrap the risk-free zero rates.

D.4 STEP 1 FOR PAR SWAP RATES

D.4.1 Start with the par swap rate having the smallest observed maturity: s_{t_1}.

From $V_{t_1}^{fixed} = V_{t_1}^{float}$ it follows that:

$$s_{t_1}^{(m_1)} \cdot \sum_{j=1}^{m_1 \cdot t_1} d_{\frac{j}{m_1}} = 1 - d_{t_1}.$$

D.4.2 Now, the constant forward assumption for Step 1 reads:

$$f_{\frac{j-1}{m_1}, \frac{j}{m_1}} = f_{0, \frac{1}{m_1}} \equiv f_{\frac{1}{m_1}} \quad for\ j = 1,2, \dots, m_1 \cdot t_1.$$

D.4.3 From which it follows that:

$$d_{\frac{j}{m_1}} = d_{\frac{1}{m_1}}{}^{j} \quad for\ j = 1, 2, \dots, m_1 \cdot t_1.$$

D.4.4 And hence that:

$$d_{t_1} = d_{\frac{1}{m_1}}{}^{m_1 \cdot t_1}.$$

D.4.5 Which allows for rewriting the sum as:

$$\sum_{j=1}^{m_1 \cdot t_1} d_{\frac{j}{m_1}} = \sum_{j=1}^{m_1 \cdot t_1} d_{\frac{1}{m_1}}{}^{j} = -1 + \sum_{j=0}^{m_1 \cdot t_1 - 1} d_{\frac{1}{m_1}}{}^{j} + d_{\frac{1}{m_1}}{}^{m_1 \cdot t_1}$$

$$= \sum_{j=0}^{m_1 \cdot t_1 - 1} d_{\frac{1}{m_1}}{}^{j} - \left(1 - d_{t_1}\right)$$

$$= \frac{1-d_{t_1}}{1-d_{\frac{1}{m_1}}} - \left(1 - d_{t_1}\right) = \left(1 - d_{t_1}\right) \cdot \frac{d_{\frac{1}{m_1}}}{1-d_{\frac{1}{m_1}}}.$$

D.4.6 Now, using $d_{\frac{1}{m_1}} = \left(1 + f_{\frac{1}{m_1}}\right)^{-1}$ it follows that:

$$\left(1 - d_{t_1}\right) \cdot \frac{d_{\frac{1}{m_1}}}{1-d_{\frac{1}{m_1}}} = \frac{\left(1-d_{t_1}\right)}{f_{\frac{1}{m_1}}}.$$

D.4.7 Substituting into the initial relation $V_{t_1}^{fixed} = V_{t_1}^{float}$ it follows that:

$$s_{t_1}^{(m_1)} \cdot \frac{\left(1-d_{t_1}\right)}{f_{\frac{1}{m_1}}} = \left(1 - d_{t_1}\right) \Leftrightarrow f_{\frac{1}{m_1}} = s_{t_1}^{(m_1)} = \frac{s_{t_1}}{m_1}.$$

D.4.8 Hence, for the discount factors up to and including t_1 it follows that:

$$d_{\frac{j}{m_1}} = \left(1 + \frac{s_{t_1}}{m_1}\right)^{-j} \quad for\ j = 1,2, \dots, m_1 \cdot t_1.$$

D.4.9 Resulting into the following zero rates up to and including t_1:

$$z_{\frac{j}{m_1}} = \left(d_{\frac{j}{m_1}}\right)^{-\frac{m_1}{j}} - 1 \quad for\ j = 1,2, \dots, m_1 \cdot t_1.$$

D.5 STEP 2 FOR PAR SWAP RATES

D.5.1 Assume we have calculated zero rates up to and including swap tenor t_k. Now, for the next non-consecutive DLT swap tenor t_{k+1} we can derive the following relation:

From $V_{t_{k+1}}^{fixed} = V_{t_{k+1}}^{float}$ it follows that:

$$s_{t_{k+1}}^{(m_1)} \cdot \sum_{j=1}^{m_1 \cdot t_{k+1}} d_{\frac{j}{m_1}} = 1 - d_{t_{k+1}}.$$

D.5.2 First, the sum on the left can be rewritten as:

$$s_{t_{k+1}}^{(m_1)} \cdot \sum_{j=1}^{m_1 \cdot t_{k+1}} d_{\frac{j}{m_1}} = s_{t_{k+1}}^{(m_1)} \cdot \sum_{j=1}^{m_1 \cdot t_k} d_{\frac{j}{m_1}} + s_{t_{k+1}}^{(m_1)} \cdot \sum_{j=m_1 \cdot t_k + 1}^{m_1 \cdot t_{k+1}} d_{\frac{j}{m_1}}$$

$$= \frac{s_{t_{k+1}}^{(m_1)}}{s_{t_k}^{(m_1)}} \cdot \left(1 - d_{t_k}\right) + s_{t_{k+1}}^{(m_1)} \cdot d_{t_k} \cdot \sum_{j=1}^{m_1 \cdot (t_{k+1} - t_k)} d_{t_k, t_k + \frac{j}{m_1}}$$

$$= \frac{s_{t_{k+1}}^{(m_1)}}{s_{t_k}^{(m_1)}} \cdot \left(1 - d_{t_k}\right) + s_{t_{k+1}}^{(m_1)} \cdot d_{t_k} \cdot \left(-1 + \sum_{j=0}^{m_1 \cdot (t_{k+1} - t_k) - 1} d_{t_k, t_k + \frac{j}{m_1}} + d_{t_k, t_{k+1}}\right)$$

$$= \frac{s_{t_{k+1}}^{(m_1)}}{s_{t_k}^{(m_1)}} \cdot \left(1 - d_{t_k}\right) + s_{t_{k+1}}^{(m_1)} \cdot d_{t_k} \cdot \left(\sum_{j=0}^{m_1 \cdot (t_{k+1} - t_k) - 1} d_{t_k, t_k + \frac{j}{m_1}} - \left(1 - d_{t_k, t_{k+1}}\right)\right).$$

D.5.3 Now, the constant forward assumption for Step 2 reads:

$$f_{t_k + \frac{j-1}{m_1}, t_k + \frac{j}{m_1}} = f_{t_k, t_k + \frac{1}{m_1}} \quad for\ j = 1,2, \ldots, m_1 \cdot (t_{k+1} - t_k).$$

D.5.4 From which it follows that:

$$d_{t_k, t_k + \frac{j}{m_1}} = d_{t_k, t_k + \frac{1}{m_1}}{}^{j} \quad for\ j = 1, 2, \ldots, m_1 \cdot (t_{k+1} - t_k),$$

and hence that:

$$d_{t_k, t_{k+1}} = d_{t_k, t_k + \frac{1}{m_1}}{}^{m_1 \cdot (t_{k+1} - t_k)} = \left(1 + f_{t_k, t_k + \frac{1}{m_1}}\right)^{-m_1 \cdot (t_{k+1} - t_k)},$$

which allows for rewriting the sum term as:

$$\sum_{j=0}^{m_1 \cdot (t_{k+1} - t_k) - 1} d_{t_k, t_k + \frac{j}{m_1}} = \sum_{j=0}^{m_1 \cdot (t_{k+1} - t_k) - 1} d_{t_k, t_k + \frac{1}{m_1}}{}^{j} = \frac{1 - d_{t_k, t_{k+1}}}{1 - d_{t_k, t_k + \frac{1}{m_1}}}.$$

D.5.5 Substituting results in:

$$= \frac{s_{t_{k+1}}^{(m_1)}}{s_{t_k}^{(m_1)}} \cdot \left(1 - d_{t_k}\right) + s_{t_{k+1}}^{(m_1)} \cdot d_{t_k} \cdot \left(\frac{1 - d_{t_k, t_{k+1}}}{1 - d_{t_k, t_k + \frac{1}{m_1}}} - \left(1 - d_{t_k, t_{k+1}}\right)\right)$$

$$= \frac{s_{t_{k+1}}^{(m_1)}}{s_{t_k}^{(m_1)}} \cdot \left(1 - d_{t_k}\right) + s_{t_{k+1}}^{(m_1)} \cdot d_{t_k} \cdot \left(1 - d_{t_k, t_{k+1}}\right) \cdot \frac{d_{t_k, t_k + \frac{1}{m_1}}}{1 - d_{t_k, t_k + \frac{1}{m_1}}}.$$

D.5.6 Now, using:

$$d_{t_k, t_k + \frac{1}{m_1}} = \left(1 + f_{t_k, t_k + \frac{1}{m_1}}\right)^{-1},$$

results in:

$$= \frac{s_{t_{k+1}}^{(m_1)}}{s_{t_k}^{(m_1)}} \cdot \left(1 - d_{t_k}\right) + s_{t_{k+1}}^{(m_1)} \cdot d_{t_k} \cdot \left(1 - d_{t_k,t_{k+1}}\right) \cdot f_{t_k,t_k+\frac{1}{m_1}}{}^{-1}.$$

D.5.7 And hence, using $V_{t_{k+1}}^{fixed} = V_{t_{k+1}}^{float}$ it follows that:

$$\frac{s_{t_{k+1}}^{(m_1)}}{s_{t_k}^{(m_1)}} \cdot \left(1 - d_{t_k}\right) + s_{t_{k+1}}^{(m_1)} \cdot d_{t_k} \cdot \left(1 - d_{t_k,t_{k+1}}\right) \cdot f_{t_k,t_k+\frac{1}{m_1}}{}^{-1} = 1 - d_{t_{k+1}}.$$

D.5.8 Now, the right-hand term can be written as:

$$1 - d_{t_{k+1}} = 1 - d_{t_k} + d_{t_k} - d_{t_{k+1}}$$
$$= 1 - d_{t_k} + d_{t_k} \cdot \left(1 - d_{t_k,t_{k+1}}\right).$$

D.5.9 Substituting results in:

$$s_{t_{k+1}}^{(m_1)} \cdot \frac{1 - d_{t_k,t_{k+1}}}{f_{t_k,t_k+\frac{1}{m_1}}} + d_{t_k,t_{k+1}} + \frac{s_{t_{k+1}}^{(m_1)} - s_{t_k}^{(m_1)}}{s_{t_k}^{(m_1)}} \cdot \frac{1 - d_{t_k}}{d_{t_k}} - 1 = 0,$$

with:

$$d_{t_k,t_{k+1}} = \left(1 + f_{t_k,t_k+\frac{1}{m_1}}\right)^{-m_1 \cdot (t_{k+1} - t_k)}.$$

D.5.10 Hence, we have a non-linear equation with one unknown $f_{t_k,t_k+\frac{1}{m_1}}$, which can be solved numerically.

D.5.11 To solve for the unknown forward rate, one can use any of the root-finding algorithms which come with modern programming languages, provided that the correctness of the solution is verified.

D.5.12 The RFR production code is written in MATLAB in which use is made of the *fzero*-function to solve for the unknow forward rate. In EIOPA's Excel VA-demonstration workbook use is made of the Newton-Raphson root finding algorithm implemented in VBA-code. This algorithm is further described in Annex D.6 for information only.

D.5.13 Now, let the numerical solution be denoted by f^*. Subsequently, the discount factors up to and including t_{k+1} follow from:

$$d_{t_k+\frac{j}{m_1}} = d_{t_k} \cdot (1 + f^*)^{-j} \quad for\ j = 1, \ldots, m_1 \cdot (t_{k+1} - t_k),$$

and

$$z_{t_k+\frac{j}{m_1}} = d_{t_k+\frac{j}{m_1}}{}^{-\frac{1}{t_k+\frac{j}{m_1}}} - 1 \quad for\ j = 1,2, \ldots, m_1 \cdot (t_{k+1} - t_k).$$

Together with the previous calculated zero rates up to and including t_k, this will form the full set of risk-free zero rates up to and including t_{k+1}.

D.5.14 Now, repeat paragraphs D.5.9, D.5.10, and D.5.13 for the next pair of non-consecutive tenor points until all pairs of non-consecutive tenor points have been passed.

D.6 NEWTON-RAPHSON ALGORITHM IN EIOPA'S EXCEL VA-TOOL

D.6.1 With reference to paragraph D.5.9 the formula $g(f^*)$ specifying the difference of a par swap value as function of an unknown forward rate f^* and a par swap value of one is according to the following:

$$g(f^*) = s_{t_{k+1}}^{(m_1)} \cdot \frac{1-d^*}{f^*} + d^* + \frac{s_{t_{k+1}}^{(m_1)} - s_{t_k}^{(m_1)}}{s_{t_k}^{(m_1)}} \cdot \frac{1-d_{t_k}}{d_{t_k}} - 1,$$

with:

$$d^* = (1+f^*)^{-m_1 \cdot (t_{k+1}-t_k)}.$$

D.6.2 Now, the first order derivative with respect to the unknown forward rate f^* equals:

$$g'(f^*) = s_{t_{k+1}}^{(m_1)} \cdot \left(\frac{-d^{*\prime} \cdot f^* - (1-d^*)}{f^{*2}} \right) + d^{*\prime},$$

with:

$$d^{*\prime} = -m_1 \cdot (t_{k+1} - t_k) \cdot (1+f^*)^{-m_1 \cdot (t_{k+1}-t_k)-1} = -m_1 \cdot (t_{k+1} - t_k) \cdot \frac{d^*}{1+f^*}.$$

D.6.3 To start the Newton-Raphson algorithm the unknown forward is set to

$$f^* = f_{t_{k-1}, t_{k-1}+\frac{1}{m_1}}.$$

D.6.4 Subsequently calculate $g(f^*)$: if $|g(f^*)| < 10^{-15}$ then go to D.5.13, else go to D.6.5.

D.6.5 Calculate $g'(f^*)$ and set the next f^* equal to: $f^* = f^* - \frac{g(f^*)}{g'(f^*)}$ and go to D.6.4.

D.7 USING ZERO-COUPON GOVERNMENT BOND RATES AS INPUTS

D.7.1 Assume we observe according to EIOPA's DLT criteria the following L zero-coupon government bond rates, corrected for a CRA and a CURA where applicable, denoted by:

$$r_{t_k}:\ k = 1,2,\dots,L \ with\ t_k \in \mathbb{N}\,.$$

D.7.2 The full set of available DLT tenor-points is given by:

$$DLT = \{t_k | k = 1,2, \dots, L\}.$$

D.7.3 The missing DLT tenor points follow from:

$$nonDLT = \{t \in \mathbb{N} | t \notin DLT \ \wedge t < t_L\}.$$

Hence, missing tenor points $t \in \mathbb{N}$ can only be observed:

1. before the start of the series of DLT points: $t < t_1$, or
2. within the series of DLT points: $t_k < t < t_{k+1}$, where $t_{k+1} - t_k > 1$.

D.8 STEP 1 FOR ZERO-COUPON GOVERNMENT BOND RATES

D.8.1 Start with the zero-coupon government bond rate having the smallest observed maturity: r_{t_1}

As the input rate is already a risk-corrected zero rate, the discount factor for horizon t_1 follows directly from:

$$d_{t_1} = \left(\frac{1}{1+r_{t_1}}\right)^{t_1}.$$

D.8.2 Now, the constant forward assumption implies the following relation:

$$f_{j-1,j} = f_j = f_1 \quad for\ j = 1,2, \dots, t_1,$$

while:

$$d_{t_1} = \prod_{j=1}^{t_1} \frac{1}{1 + f_{j-1,j}} = \prod_{j=1}^{t_1} \frac{1}{1 + f_1} = \left(\frac{1}{1 + f_1}\right)^{t_1}$$

and hence:

$$f_{j-1,j} = f_j = f_1 = r_{t_1} \quad for\ j = 1,2, \dots, t_1.$$

D.8.3 From which it follows that:

$$d_j = \left(\frac{1}{1+r_{t_1}}\right)^j \Leftrightarrow z_j = r_{t_1} \quad for\ j = 1,2, \dots, t_1.$$

D.9 STEP 2 FOR ZERO-COUPON GOVERNMENT BOND RATES

D.9.1 Assume we have calculated zero rates up to and including tenor t_k. Now, for the next non-consecutive DLT tenor t_{k+1} we know the following relations holds:

$$d_{t_k} = \left(\frac{1}{1+r_{t_k}}\right)^{t_k},\ d_{t_{k+1}} = \left(\frac{1}{1+r_{t_{k+1}}}\right)^{t_{k+1}},$$

$$d_{t_{k+1}} = d_{t_k} \cdot d_{t_k,t_{k+1}},$$

$$d_{t_k,t_{k+1}} = \prod_{j=t_k+1}^{t_{k+1}} \frac{1}{1+f_{j-1,j}}$$

D.9.2 The constant forward assumption implies that:

$$f_{j-1,j} = f_{t_k,j} = f_{t_k,t_k+1} \quad for\ j = t_k+1, \dots t_{k+1},$$

$$d_{t_k,t_{k+1}} = \prod_{j=t_k+1}^{t_{k+1}} \frac{1}{1+f_{j-1,j}} = \prod_{j=t_k+1}^{t_{k+1}} \frac{1}{1+f_{t_k,t_k+1}} = \left(\frac{1}{1+f_{t_k,t_k+1}}\right)^{t_{k+1}-t_k}$$

D.9.3 Using the previous relations, we can derive the following:

$$d_{t_k,t_{k+1}} = \frac{d_{t_{k+1}}}{d_{t_k}} \Leftrightarrow \left(\frac{1}{1+f_{t_k,t_k+1}}\right)^{t_{k+1}-t_k} = \frac{d_{t_{k+1}}}{d_{t_k}}$$

$$\Leftrightarrow f_{t_k,t_k+1} = \left(\frac{d_{t_k}}{d_{t_{k+1}}}\right)^{\frac{1}{t_{k+1}-t_k}} - 1$$

D.9.4 The discount factors for horizon $j = t_k, \dots t_{k+1}$ follow from:

$$d_j = d_{t_k} \cdot\ d_{t_k,j} = \left(\frac{1}{1+r_{t_k}}\right)^{t_k} \cdot \left(\frac{1}{1+f_{t_k,t_k+1}}\right)^{j-t_k}$$

D.9.5 From which the risk-free zero rates follow immediately:

$$z_j = {d_j}^{-\frac{1}{j}} - 1 \quad for\ j = t_k, \dots t_{k+1}.$$

ANNEX E REPRESENTATIVE PORTFOLIOS

E.1 INTRODUCTION

E.1.1 This annex describes the methodology to construct the representative portfolios of assets underlying the reference portfolios of assets for calculating the risk-corrected spread (RCS).

E.1.2 Each year, the representative portfolios of assets are updated based on the methodology described in this annex. Updates are based on the annual supervisory reporting data of insurance and reinsurance undertakings, as well as of insurance groups.

E.1.3 Updates in year *N* are based on the reporting data relating to the end of year *N-1*. The deadline for reporting this data is the end of July of year *N*, while each update should be published at least three months before becoming applicable. Ideally, an update should become applicable at the start of year *N+1*. Hence, considering the three-month notice period it must be published before the end of September of year *N*. This leaves effectively two months lead time to prepare the updates, impact assessments, validations, reports, and approval. Due to this short lead time, all updates since the start of Solvency II have been published in December of year *N*, to become applicable on the 31st of March of year *N+1*.

E.2 PRACTICAL ASSUMPTIONS MADE

E.2.1 A representative portfolio describes an investment portfolio in terms of type of investments with associated exposures in terms of relative size (weight) and duration.

E.2.2 A reference portfolio is a representative portfolio supplemented with suitable yield proxies. As detailed in paragraph 9.1.11, there are two types of reference portfolios, namely currency reference portfolios and country reference portfolios. Furthermore, as stated in paragraph 9.1.14 both these currency and country reference portfolios contain a government bond reference portfolio and a corporate bond reference portfolio. Hence, to construct these reference portfolios we need to construct the respective representative portfolios first.

E.2.3 According to paragraph 9.1.11, the scope of assets to include in the currency and country representative portfolios is different. Moreover, in the Solvency II framework, insurance and reinsurance undertakings are not required to identify the assets covering their best estimates of liabilities (except in the case of those covering insurance and reinsurance obligations applying the matching adjustment (MA) or under a ring-fenced

fund regime). It is also not required to classify the assets covering the best estimates of liabilities according to the country where the liabilities are sold. Therefore, to be able to implement Article 77d of the Solvency II Directive, EIOPA made the following practical assumptions.

(a) For the currency representative portfolios: a calculation considering that all assets in currency *X* cover liabilities in currency *X*. Hence, the currency representative portfolio of currency *X* is based on all assets denominated in that currency and in which undertakings are invested.
(b) For the country representative portfolios: a calculation considering that all liabilities are sold in the country of the undertaking and denominated in the currency of that country. Hence, the country representative portfolio of a country is based on all assets in which undertakings established in that country are invested.

E.3 SOURCE DATA AND ADJUSTMENTS

E.3.1 The representative portfolios are derived from the following Solvency II annual reporting templates:

- Basic information – General (S.01.02)
- Balance sheet (S.02.01).
- List of assets (S.06.02).
- Collective investment undertakings — look-through approach (S.06.03).

E.3.2 As the legislation does not allow cumulating the matching adjustment (MA) with the volatility adjustment (VA), assets held in a MA portfolio are to be excluded. For that purpose, the matching portfolio assets are identified based on the field 'Matching portfolio number' as reported in the list of assets and are subsequently excluded.

E.3.3 Collective investment undertakings (CIU) reported in the list of assets are replaced, where possible, by the assets reported in the look-through templates. The replacement is made when the look-through template is available and the reported asset value of the CIU and the aggregated reported asset values of the look-through assets match. Differences up to 1% regarding that match are accepted.

E.3.4 The look-through template provides less detailed asset information than the list of assets. Annex E.4 describes the additional assumptions made to include the look-through assets in the construction of representative portfolios.

E.3.5 For each remaining asset, its exposure in terms of relative size (weight) and duration are initially based on the following.

(a) Relative size (weight): asset market values as reported under the field 'Total Solvency II amount' in the list of assets. Where applicable, asset market values are converted into euro-equivalents for comparability. Such conversions are based on ECB exchange rates.
(b) Duration: duration as reported under the field 'Duration' in the list of assets. An asset for which no duration is reported is excluded from the calculation of its portfolio's weighted duration.

E.3.6 As stated in paragraph 9.1.11, assets should only be considered to the extent that they cover the best estimate of liabilities. To allow for this, for each undertaking the market value of their assets is reduced based on liability information as reported in their balance sheet according to the following.

(a) Two reduction factors per undertaking are calculated: one reduction factor for assets held in unit-linked/index-linked funds and another one for assets not held in unit-linked/index-linked funds.[22]
(b) The first ratio is applied to assets held in unit-linked/index-linked funds only. All relevant assets are identified line by line, and their Solvency II value is multiplied by the ratio:

$$\frac{\text{best estimate for UL/IL products}}{\text{overall technical provisions for UL/IL products}}$$

In case the best estimate is negative, the corresponding assets are excluded.
(c) The second ratio is applied to all other assets. All relevant assets are identified line by line, and their Solvency II value is multiplied by the ratio:

$$\frac{\text{best estimate for all products excluding UL/IL products}}{\text{overall technical provisions for all products excluding UL/IL products}}$$

In case the best estimate is negative the corresponding assets are excluded.

E.3.7 Next, the assets with their adjusted asset values are classified line-by-line based on the field 'CIC' of the template 'List of assets (S.06.02)'. CIC codes are used to classify each asset as either a 'government bond', a 'corporate bond', or 'other' according to Table 9.

[22] Some unit-linked/index-linked insurance obligations are not or only partly valued as a whole, as referred to in the second subparagraph of Article 77(4) of the Solvency II Directive, but a risk margin and a best estimate is calculated for them.

Table 9 - CIC codes used to allocate assets

	CIC codes
GOVERNMENT PORTFOLIO	11, 13*, 14*, 15, 16, 17, 18, 19
CORPORATE PORTFOLIO	12, 13*, 14*, 21, 22, 23, 24, 25, 26, 27, 28, 29, 42, 43, 52, 54, 62, 64, 81, 82, 84, 85, 86, 87, 88, 89
OTHER	All other CIC codes

(*) CIC codes 13 and 14 include regional government and local authorities' (RGLA) bonds. The classification of RGLA bonds is based on the provisions of paragraph 9.1.13.

E.4 LOOK-THROUGH MAPPING

E.4.1 The allocation of assets to the government or corporate bond portfolio is based on the following correspondence:

Table 10 - CIU look through mapping

Representative portfolio type	Category of assets included in CIUs
GOVERNMENT PORTFOLIO	Government bonds
CORPORATE PORTFOLIO	Corporate bonds, structured notes, collateralised securities and mortgages and loans
OTHER	All other asset categories

E.4.2 The look-through template only indicates whether the currency of the assets is equal to the undertaking's reporting currency. Where it is not equal, the specific currency is not identified. If the asset currency matches the reporting currency, this information is used in the calculation. Assets not denominated in the reporting currency are treated in the same way as non-look-through assets with missing currency information (see section E.5.4).

E.4.3 The look-through template does not provide information on the issuing sector or credit quality step (CQS) of look-through assets. If this information is available at the CIU-level then it is assumed that the value of these fields at the look-through level is equal to the available information at the CIU-level. If this information is not available at the CIU-level then look-through assets are treated in the same manner as non-look-through assets for which the issuing sector and CQS are missing (see section E.5.4).

E.4.4 The duration of look-through assets is assumed to be equal to the duration of the CIU they originate from. If no duration is reported at CIU-level then its look-through assets

will not have a duration either. According to E.3.5 (b) such assets are excluded from the calculation of its portfolio's weighted duration.

E.5 WEIGHTS AND DURATIONS FOR CURRENCY AND COUNTRY PORTFOLIOS

E.5.1 The line-by-line asset classification allows for grouping the assets and aggregating their adjusted market values to produce for each currency portfolio (cu) and each country portfolio (co) the total adjusted market values and their corresponding durations when applicable:

$AMV_{c,gov}$: the adjusted market value of the total government bond portfolio in representative portfolio c (see paragraph E.6.9);

$d_{c,gov}$: the duration of the total government bond portfolio in representative portfolio c (see Annex E.6);

$AMV_{c,corp}$: the adjusted market value of the total corporate bond portfolio in representative portfolio c (see paragraph E.6.9);

$d_{c,corp}$: the duration of the total corporate bond portfolio in reference representative c (see paragraph E.6.9);

$AMV_{c,other}$: the adjusted market value of the total portfolio of other assets in representative portfolio c (see paragraph E.6.9);

With: $c \in \{cu, co\}$.

E.5.2 Now, this allows for defining the following exposures in terms of portfolio weights (in % of total adjusted market values) and durations:

- Government bond exposure: $(w_{c,gov}, d_{c,gov})$
  With:
  $$w_{c,gov} = \frac{AMV_{c,gov}}{AMV_{c,gov} + AMV_{c,corp} + AMV_{c,other}}$$
- Corporate bond exposure: $(w_{c,corp}, d_{c,corp})$
  With:
  $$w_{c,corp} = \frac{AMV_{c,corp}}{AMV_{c,gov} + AMV_{c,corp} + AMV_{c,other}}$$

E.5.3 This allows for defining similar exposures in terms of conditional portfolio weights (in % of total bonds B) and durations:

- Government bond exposure: $\left(w_{c,gov|B}, d_{c,gov}\right)$
  With:
  $$w_{c,gov|B} = \frac{AMV_{c,gov}}{AMV_{c,gov} + AMV_{c,corp}} = \frac{w_{c,gov}}{w_{c,gov} + w_{c,corp}}$$
- Corporate bond exposure: $\left(w_{c,corp|B}, d_{c,corp}\right)$
  With:
  $$w_{c,corp|B} = \frac{AMV_{c,corp}}{AMV_{c,gov} + AMV_{c,corp}} = \frac{w_{c,corp}}{w_{c,gov} + w_{c,corp}}$$
- Note: $w_{c,gov|B} + w_{c,\mathrm{corp}|B} = 1$

E.5.4 Currency portfolios are grouped based on two dimensions.

1. The first dimension is the issuing currency as reported in field 'Currency' of the template 'List of assets - (S.06.02)'. The set of issuing currencies (ICU) considered is equal to the list of relevant currencies according to ANNEX A which are the unique values of the column 'ISO 4217' of Table 1.
   If the field 'Currency' is missing then the bond is excluded from this grouping.

The second dimension depends on the type of bond according to the following.

2. For government bonds, the second dimension is the issuing country as reported in field 'Issuer Country' of the 'List of assets - (S.06.02)'. The set of issuing countries (ICO) considered is equal to the countries of the relevant currencies, i.e. the issuing countries are the values of the column 'Country Code' of Table 1 except the 'Country Code' equal to 'EA'. This latter 'Country Code' serves a special purpose as explained in Annex G.2.2.
   If the field 'Issuer Country' is missing then the government bond is excluded from this grouping.
3. For corporate bonds, the second dimension is each combination of the issuing domain within $D = \{Financial, NonFinancial\}$ based on the field 'Issuer Sector' and the issued CQS within $Q = \{0,1,2,..,6\}$ based on the field 'Credit quality step', both of the template 'List of assets - (S.06.02)'.
   If the field 'Issuer Sector' is according to NACE 2.0 and starts with "K" then the corporate bond is classified as "Financial" else "Non-Financial".
   If the field 'Issuer Sector' is according to NACE 2.1 and starts with "L" then the corporate bond is classified as "Financial" else "Non-Financial".
   If the field 'Issuer Sector' is missing then the corporate bond is excluded from this grouping.

If the field 'Credit quality step' is missing then the corporate bond is classified as 'Unrated' (see also section E.6.3.).

E.5.5 Country portfolios are grouped based on two dimensions as well.

1. The first dimension is the home country code of the undertaking based on the field 'Country of authorisation' of the template 'Basic information – General (S.01.02)'. The set of home country codes (HCO) is equal to the country codes of the euro area, i.e. the set HCO is a subset of the set ICO.
   If the field 'Home Country' is missing the bond is excluded from this grouping.

The second dimension depends on the type of bond and is like the provisions of paragraph E.5.4 points 2 and 3.

E.5.6 Based on E.5.4 and E.5.5, it follows that the subscript c representing the type of representative portfolio, i.e. $c \in \{cu, co\}$, can either take a value out of the set of issuing currencies (ICU) or take a value out of the set of home countries (HCO). Therefore, it holds that:

$$c \in C = \{cu, co\} = \{ICU | c = cu\} \cup \{HCO | c = co\}.$$

E.6 WEIGHT AND DURATIONS FOR GOVERNMENT AND CORPORATE BOND PORTFOLIOS

E.6.1 Within the government bond portfolios, the following exposures in terms of weight and duration are defined:

$$\left(w_{c,gov,i}, d_{c,gov,i}\right), \quad c \in C\ , i \in ICO.$$

E.6.2 Within the corporate bond portfolios, the following exposures in terms of weight and duration are defined:

$$\left(w_{c,corp,s}, d_{c,corp,s}\right) \quad c \in C, s \in S,$$

with:

$$S = D \times Q = \{(d, q) | d \in D \wedge q \in Q\}.$$

E.6.3 To ensure that all corporate bonds are included when deriving the weights, the unrated corporate bonds within each issuing sector are proportionally redistributed across the rated bonds, implicitly assuming they follow the same rating distribution.

E.6.4 Now, both types of bond reference portfolios will be denoted by the following uniform notation of exposures:

$$(w_{c,b,i}, d_{c,b,i}),$$

with:

$$c \in C = \{ICU | c = cu\} \cup \{HCO | c = co\},$$

$$b \in B = \{government\ bond, corporate\ bond\},$$

$$i \in I_b = \{ICO | b = government\ bond\} \cup \{S | b = corporate\ bond\},$$

and:

$$\sum_{i \in I_b} w_{c,b,i} = 1 \quad \forall\ c, b.$$

E.6.5 Now, let for all c, b, and i according to E.6.4:

$N_{c,b,i}$: the number of bonds of type b of issuance type i in representative portfolio c;

$AMV_{c,b,i,j}$: the adjusted market value of bond j of type b of issuance type i in representative portfolio c, with $j = 1, \dots, N_{c,b,i}$;

$w_{c,b,i,j}$: the weight of bond j of type b of issuance type i in representative portfolio c, with $j = 1, \dots, N_{c,b,i}$;

$d_{c,b,i,j}$: the duration of bond j of type b of issuance type i in representative portfolio c, with $j = 1, \dots, N_{c,b,i}$.

E.6.6 Then the adjusted market value of the bond portfolio of type b of issuance type i in representative portfolio c is equal to:

$$AMV_{c,b,i} = \sum_{j=1}^{N_{c,b,i}} AMV_{c,b,i,j},$$

which allows for calculating the weight of bond j of type b of issuance type i in representative portfolio c according to:

$$w_{c,b,i,j} = \frac{AMV_{c,b,i,j}}{AMV_{c,b,i}} \cdot 100\%,$$

and subsequently the weighted duration of the bond portfolio of type b of issuance type i in representative portfolio c:

$$d_{c,b,i} = \sum_{j=1}^{N_{c,b,i}} w_{c,b,i,j} \cdot d_{c,b,i,j}.$$

E.6.7 For government bonds and corporate bonds reported with a duration exceeding 50 years and 15 years, respectively, the duration may be capped at those upper thresholds (i.e. 50 years and 15 years, respectively) where, based on expert judgement, the weighted portfolio duration would otherwise appear unrealistically high. In most such cases observed historically, the reported durations proved to be incorrect.

E.6.8 In exceptional cases where the reported data allow the calculation of a weight but not a duration, the exposure will be assigned the duration of the portfolio comprising exposures of the same issuer type for which both weights and durations have been reported. This approach ensures that the exposure is included without distorting the duration of the portfolio to which it belongs.

E.6.9 Similarly, the adjusted market value of the total bond portfolio of type b in representative portfolio c is equal to:

$$AMV_{c,b} = \sum_{i \in I_b} AMV_{c,b,i},$$

which allows for calculating the weight of the bond portfolio of type b of issuance type i in representative portfolio c according to:

$$w_{c,b,i} = \frac{AMV_{c,b,i}}{AMV_{c,b}} \cdot 100\%,$$

and subsequently the weighted duration of the total bond portfolio of type b in representative portfolio c:

$$d_{c,b} = \sum_{i \in I_b} w_{c,b,i} \cdot d_{c,b,i}.$$

E.6.10 Final durations are rounded to one decimal place.

ANNEX F REFERENCE PORTFOLIOS

F.1 INTRODUCTION

F.1.1 Reference portfolios are representative portfolios supplemented with suitable yield proxies. Reference portfolios are used for calculating the risk-corrected spread (RCS) of bond returns.

F.1.2 An RCS equals a bond spread minus a risk correction, while a bond spread equals a bond return minus a risk-free return.

F.1.3 Reference portfolios are established for all relevant currencies and all countries of the euro area and do consist of a government bond reference portfolio and a corporate bond reference portfolio.

F.2 BOND REFERENCE PORTFOLIOS

F.2.1 According to paragraph E.6.4, the exposures of bond representative portfolios for currency and country portfolios are given by:

$$\left(w_{c,b,i}, d_{c,b,i}\right), \qquad c \in C, b \in B, i \in I_b$$

with:

$$\sum_{i \in I_b} w_{c,b,i} = 1 \quad \forall\, c, b.$$

To be able to calculate the risk-corrected spreads, these exposures are supplemented with suitable yield proxies.

F.2.2 Suitable yield proxies in this context are zero-coupon yield proxies for either a bond return, a risk-free return, or a risk correction. Using these yield proxies the following reference portfolios of zero-coupon model bonds at time t can be constructed:

$$\left(w_{c,b,i}, d_{c,b,i}, y^{x}_{c,b,i}(t, d_{c,b,i})\right), \qquad x \in X = \{my, rfy, rcy\}$$

with for each zero-coupon model bond with maturity T of issuant type i in the reference bond portfolio of type b in reference portfolio c:

$y^{my}_{c,b,i}(t,T)$: the proxy for the market yield at time t of the bond;

$y^{rfy}_{c,b,i}(t,T)$: the proxy for the risk-free yield at time t of the bond;

$y^{rcy}_{c,b,i}(t,T)$: the proxy for the risk-corrected market yield at time t of the bond.

F.3 INTERNAL RATE OF RETURNS FOR BOND REFERENCE PORTFOLIOS

F.3.1 For each zero-coupon model bond with yield proxy x of issuant type i as part of bond reference portfolio of type b in reference portfolio c, its cash flow $CF^{x}_{c,b,i}$ at time t at horizon $d_{c,b,i}$ follows from the following definition:

$$CF^{x}_{c,b,i}(t) = \boldsymbol{w_{c,b,i}} \cdot \left(1 + y^{x}_{c,b,i}(t, \boldsymbol{d_{c,b,i}})\right)^{\boldsymbol{d_{c,b,i}}},\ c \in C, b \in B, i \in I_b, x \in X,$$

with:

$y^{x}_{c,b,i}(t, \boldsymbol{d_{c,b,i}})$: yield proxy x at time t for a zero-coupon model bond with maturity $\boldsymbol{d_{c,b,i}}$ of issuant type i as part of the bond reference portfolio of type b in reference portfolio c.

Note: According to paragraph E.1.3 the exposures $\left(\boldsymbol{w_{c,b,i}}, \boldsymbol{d_{c,b,i}}\right)$ are derived in year *N* based on the reporting data relating to the end of year *N-1*. To keep the definition of the cash flow consistent with the definition of the exposures, the cash flows are based on the respective yield proxies at the end of year *N-1* as well.

F.3.2 Based on the definition of the cash flow in paragraph F.3.1 and letting time t_0 be the end of year *N-1*, the 'frozen cash flow' for the zero-coupon model bond as derived in year *N* can be written as:

$$\mathbf{CF^{x}_{c,b,i}}(t_0) = \boldsymbol{w_{c,b,i}} \cdot \left(1 + \boldsymbol{y^{x}_{c,b,i}}\left(t_0, \boldsymbol{d_{c,b,i}}\right)\right)^{\mathbf{d_{c,b,i}}}.$$

The bold notation indicates that all values are fixed until the next update of the representative portfolios.

Now, by construction of the weights at time t_0 (paragraph E.6.9), it follows that:

$$\sum_{i \in I_b} \boldsymbol{w_{c,b,i}}(t_0) = \sum_{i \in I_b} \mathbf{CF^{x}_{c,b,i}}(t_0) \cdot \left(1 + \boldsymbol{y^{x}_{c,b,i}}(t_0, \boldsymbol{d_{c,b,i}})\right)^{-\mathbf{d_{c,b,i}}} = 1.$$

F.3.3 Both the cash flow and the duration are fixed until the next update of the representative portfolios. This does not hold for the yield proxy. Hence, at an arbitrary time $t > t_0$ the sum can be written as a function of the yield proxy at time t:

$$\sum_{i \in I_b} \mathbf{CF^{x}_{c,b,i}}(t_0) \cdot \left(1 + y^{x}_{c,b,i}\left(t, \boldsymbol{d_{c,b,i}}\right)\right)^{-\mathbf{d_{c,b,i}}}.$$

F.3.4 Now, let:

$Y_{c,b}^{x}(t)$: the yield of type x at time t of reference portfolio of type b in reference portfolio c.

$Y_{c,b}^{x}(t)$ is a single yield at time *t* at the level of reference portfolio of type *b* in reference portfolio *c* which is calculated as an 'internal rate of return' (IRR). Using an IRR for discounting results in the same sum of present values of cash flows. From this it follows that $Y_{c,b}^{x}(t)$ is the solution of the following equation:

$$\sum_{i\in I_b} \mathbf{CF}_{\mathbf{c,b,i}}^{\mathbf{x}}(t_0)\cdot\left(1+Y_{c,b}^{x}(\mathrm{t})\right)^{-\mathbf{d}_{\mathbf{c,b,i}}} = \sum_{i\in I_b} \mathbf{CF}_{\mathbf{c,b,i}}^{\mathbf{x}}(t_0)\cdot\left(1+y_{c,b,i}^{x}\left(t,\boldsymbol{d}_{\boldsymbol{c,b,i}}\right)\right)^{-\mathbf{d}_{\mathbf{c,b,i}}}.$$

This solution can be solved numerically. To solve for the unknown $Y_{c,b}^{x}(t)$, one can use any of the root-finding algorithms which come with modern programming languages, provided that the correctness of the solution is verified.

Note: The duration $d_{c,b}$ of reference portfolio of type b in reference portfolio c is according to the provisions of paragraph E.6.9.

F.4 MAPPING IRRS TO SPREADS AND RISK CORRECTIONS

F.4.1 Now, with reference to paragraph 9.2.7, the risk-corrected spread RCS_c at time t is defined as:

$$RCS_c(t) = S_c(t) - RC_c(t), \qquad c \in C.$$

F.4.2 While with reference to paragraph 9.2.5, the spread of reference portfolio c at time t is defined as:

$$S_c(t) = \boldsymbol{w_{c,gov|B}}\cdot S_{c,gov}(t) + \boldsymbol{w_{c,corp|B}}\cdot S_{c,corp}(t)$$

$$= \boldsymbol{w_{c,gov|B}}\cdot\left(Y_{c,gov}^{my}(t) - Y_{c,gov}^{rfy}(t)\right) + \boldsymbol{w_{c,corp|B}}\cdot\left(Y_{c,corp}^{my}(t) - Y_{c,corp}^{rfy}(t)\right)$$

F.4.3 And with reference to paragraph 9.2.5, the risk correction of reference portfolio c at time t is defined as:

$$RC_c(t) = \boldsymbol{w_{c,gov|B}}\cdot RC_{c,gov}(t) + \boldsymbol{w_{c,corp|B}}\cdot RC_{c,corp}(t)$$

$$= \boldsymbol{w_{c,gov|B}}\cdot\left(Y_{c,gov}^{my}(t) - Y_{c,gov}^{rcy}(t)\right) + \boldsymbol{w_{c,corp|B}}\cdot\left(Y_{c,corp}^{my}(t) - Y_{c,corp}^{rcy}(t)\right).$$

F.4.4 Hence, calculating the RCS for both the currency and country reference portfolios requires calculating all 12 yields $Y_{c,b}^{x}(t), for\ c \in C, b \in B, x \in X$, i.e. IRRs for 2 types of reference portfolios (currency, country), each having 2 types of reference bond portfolios

(government, corporate), each with 3 types of yields (market yield, risk-free yield, and risk-corrected yield) or $2 \times 2 \times 3 = 12$.

ANNEX G YIELD PROXIES

G.1 INTRODUCTION

G.1.1 In general, yield proxies refer to a yield curve or a yield index sourced from market data providers, but they could also refer to derived data like, for instance, the basic risk-free rate term structures. Yield curves and yield indices are generally available for a limited list of maturities or for a limited list of buckets of maturities.

G.1.2 Durations of model bonds in reference portfolios are rounded to one decimal place. If the duration of a model bond falls within the range of available maturities of a yield curve, then linear interpolation is used to derive the corresponding yield. If the duration of a model bond falls outside the range of available list of maturities or of buckets of maturities, then flat extrapolation is used to derive the corresponding yield.

G.1.3 For the time being and due to the lack of data, no specific model bonds have been developed specifically for securitisations and loans. Once the relevant information is available, it will be necessary to assess the impact on the number of model points of a specific consideration of securitisations and loans (including mortgage loans).

G.2 GOVERNMENT BOND YIELDS

G.2.1 Proxies for the market yield at time t on government bonds with maturity T in the currency reference portfolio are denoted by:

$$y^{my}_{cu,gov,i}(t,T), \quad cu \in ICU, i \in ICO.$$

G.2.2 These yields are derived from the 'GVT RIC' column in Table 1 as follows. For the euro currency portfolio, the yield proxy for issuers located within the euro area is taken from the row where the 'COUNTRY CODE' equals 'EA', i.e. the ECB curve is applied as the yield proxy for all euro area issuers within the euro currency portfolio. For all other issuers within the euro currency portfolio, as well as for all other currency portfolios, the yield proxy is taken from the row where the 'COUNTRY CODE' corresponds to the respective issuing country. Hence:

$$y^{my}_{cu,gov,i}(t,T) = \begin{cases} y^{my}_{EUR,gov,EA}(t,T) & cu = EUR, \quad i \in HCO \\ y^{my}_{*,gov,i}(t,T) & elsewhere \end{cases}$$

G.2.3 This setup implicitly assumes that, where countries issue bonds in a currency other than their local currency, the corresponding market yield is equivalent to the proxy used for bonds issued in their local currency.

G.2.4 Proxies for the market yield at time t on government bonds with maturity T in the country reference portfolio are denoted by:

$$y^{my}_{co,gov,i}(t,T), \quad co \in HCO, i \in ICO.$$

G.2.5 These returns are based on the column 'GVT RIC' of Table 1 according to the following: for all issuing countries, their yield proxy is equal to the 'GVT RIC' from the row where the column 'COUNTRY CODE' is equal to the respective issuing country. Hence:

$$y^{my}_{co,gov,i}(t,T) = y^{my}_{*,gov,i}(t,T), \quad i \in ICO$$

G.3 PEER COUNTRY GOVERNMENT BOND YIELDS

G.3.1 In case the issuing country has been assigned to a peer country according to column 'GVT RIC', then the 'GVT RIC' of the respective peer country is used as yield proxy.

G.3.2 EIOPA monitors the allocation to peer countries on an annual basis. In case the credit quality or interest rate level of an allocated country or of a peer country significantly changes, the allocation may be changed. Changes may be implemented at short notice to ensure the suitability of the yield proxy, especially when the perceived credit quality of an allocated country deteriorates.

Table 11 below gives an overview of the current and past use of peer countries.

Table 11 - Current and past use of peer countries

COUNTRY WITHOUT GOVERNMENT BOND YIELD CURVE	Peer country
ESTONIA	Belgium
LATVIA	Slovakia*
LIECHTENSTEIN	Switzerland
LUXEMBURG	Netherlands**

* For Latvia for reference dates until 30 January 2017: Spain; for reference dates until 30 March 2026: Ireland.
** For Luxembourg for reference dates until 31 May 2017: France.

Note: **From 31 March 2026 Cyprus, Lithuania and Malta will no longer use peer country government bond data. The time-series of the underlying government bond data used to calculate the long-term average spread for Cyprus, Malta and Lithuania is based on the respective peer-country government bond data up to 31 March 2026, and on domestic government bond data from that date onward.**

G.4 RISK-FREE YIELDS

G.4.1 Proxies for risk-free yields associated with either bond type in either reference portfolio are only dependent on the issuing country of the bond as the issuing country defines the currency of the bond. Hence:

$$y^{rfy}_{c,b,i}(t,T) = y^{rfy}_{*,*,i}(t,T), \qquad i \in ICO \cup 'EA', \qquad T = 1, \dots, 150$$

If $i = 'EA'$ then $y^{rfy}_{*,*,'EA'}(t,T)$ represents the euro risk-free rate yield. This particular notation is used in the definition of the corporate yield proxy (see Annex G.5.3).

G.4.2 These risk-free yields $y^{rfy}_{*,*,i}(t,T)$ are sourced from the corresponding unrounded basic risk-free rate term structures calculated according to the provisions of Section 8.

G.5 CORPORATE BOND YIELDS

G.5.1 Proxies for the market yield at time t on corporate bonds with maturity T in reference portfolio c are denoted by:

$$y^{my}_{c,corp,s}(t,T), \quad c \in C, s \in S.$$

G.5.2 Due to the lack of suitable yield proxies sourced by market data providers all proxies for the yields on corporate bonds will be based on the iBoxx® indices for either EUR, GBP, or USD.

G.5.3 As a country defines the currency, it follows that if for countries for which there are no suitable corporate yield proxies available, or they are only partially available as indicated in Annexes G.5.5 and G.5.6, the missing yield proxies are derived from the risk-free yields of the respective country, the market yields of corporate bonds issued in euro, and the risk-free euro yield, according to the following formula:

$$y^{my}_{i,corp,s}(t,T) = y^{rfy}_{*,*,i}(t,T) + \max\left\{0;\ y^{my}_{EA,corp,s}(t,T) - y^{rfy}_{*,*,EA}(t,T) + \kappa \cdot \left(y^{rfy}_{*,*,i}(t,T) - y^{rfy}_{*,*,EA}(t,T)\right)\right\},$$

with: $\kappa = 0.5, i \in ICO$

or equivalently:

$$S_{i,corp,s}(t,T) = \max\left\{0;\ S_{EA,corp,s}(t,T) + \kappa \cdot \left(y^{rfy}_{*,*,i}(t,T) - y^{rfy}_{*,*,EA}(t,T)\right)\right\}$$

The underlying assumption of this formula is that the spread on a corporate bond

denominated in the currency of country i is linked to the spread on a comparable corporate bond denominated in euro, adjusted for the difference between the risk-free yield of both currencies. In addition, the formulation ensures that the constructed market yield on a corporate bond denominated in the currency of country i cannot fall below the corresponding risk-free yield for that country.

G.5.4 For the euro currency reference portfolio and the country reference portfolios of all countries in the euro area, i.e. the set HCO, corporate bond market yields are sourced from the iBoxx® EUR indices in Table 12 below.

Table 12 - EUR iBoxx® indices

EUR - $S \times Q$	1-3yr	3-5yr	5-7yr	7-10yr	10+yr
FIN CQS 0	85% of the EUR FIN CQS1 yields if those yields are positive or zero, otherwise 115% of those yields				
FIN CQS 1	DE000A0JZBB2	DE000A0JZBD8	DE000A0JZBF3	DE000A0JZBH9	DE000A0JZA95
FIN CQS 2	DE000A0JZA12	DE000A0JZA38	DE000A0JZA53	DE000A0JZA79	DE000A0JZAZ3
FIN CSQ 3	DE000A0JZBX6	DE000A0JZBZ1	DE000A0JZB11	DE000A0JZB37	DE000A0JZBV0
FIN CQS 4	GB00B1CQYN32				
FIN CQS 5	GB00B1CQYW23				
FIN CQS 6	GB00B1CQYW23				
NONFIN CQS 0	85% of the EUR NONFIN CQS1 yields if those yields are positive or zero, otherwise 115% of those yields				
NONFIN CQS 1	DE000A0JZCH7	DE000A0JZCK1	DE000A0JZCM7	DE000A0JZCP0	DE000A0JZCF1
NONFIN CQS 2	DE000A0JZB78	DE000A0JZB94	DE000A0JZCB0	DE000A0JZCD6	DE000A0JZB52
NONFIN CQS 3	DE000A0JZC36	DE000A0JZC51	DE000A0JZC77	DE000A0JZC93	DE000A0JZC10
NONFIN CQS 4	GB00B1CR1Z75				
NONFIN CQS 5	GB00B1CR2653				
NONFIN CQS 6	GB00B1CR2653				

For issuances with credit quality step CQS4 or CQS5, the respective indices do not discriminate by duration. Therefore, these indices are used for the corporate bond yields of such issuances irrespective of their duration, i.e. the flat extrapolation according to G.1.2 is applied.

Finally, due to the lack of a suitable yield proxy for issuances with credit quality step CQS6, the yield proxy for issuance with credit quality step CQS5 is used for this category.

G.5.5 If the issuing currencies are either GBP or USD, then their corporate bond market yields are sourced from the iBoxx® indices in Table 13 and Table 14 below, respectively. Market yields for missing issuances of type $s \in S \times Q$ for either GBP or USD are constructed according to the provisions of paragraph G.5.3. Missing issuances of type $s \in S \times Q$ are the entries present in the first column of Table 12, which are not present in either the first column of Table 13 or the first column of Table 14.

Table 13 - GBP iBoxx® indices

GBP - $S \times Q$	1-3yr	3-5yr	5-7yr	7-10yr	10-15yr	15+yr
FIN CQS 0	85% of the GBP FIN CQS1 yields if those yields are positive or zero, otherwise 115% of those yields					
FIN CQS 1	DE000A0JY7T1	DE000A0JY7X3	DE000A0JY7Z8	DE000A0JY712	DE000A0JY7R5	DE000A0JY7V7
FIN CQS 2	DE000A0JY7B9	DE000A0JY7F0	DE000A0JY7H6	DE000A0JY7K0	DE000A0JY696	DE000A0JY7D5
FIN CSQ 3	DE000A0JY8R3	DE000A0JY8V5	DE000A0JY8X1	DE000A0JY8Z6	DE000A0JY8P7	DE000A0JY8T9
NONFIN CQS 0	85% of the GBP NONFIN CQS1 yields if those yields are positive or zero, otherwise 115% of those yields					
NONFIN CQS 1	DE000A0JY9P5	DE000A0JY9T7	DE000A0JY9V3	DE000A0JY9X9	DE000A0JY9M2	DE000A0JY9R1
NONFIN CQS 2	DE000A0JY878	DE000A0JY9B5	DE000A0JY9D1	DE000A0JY9F6	DE000A0JY852	DE000A0JY894
NONFIN CQS 3	DE000A0JZAM1	DE000A0JZAR0	DE000A0JZAT6	DE000A0JZAV2	DE000A0JZAK5	DE000A0JZAP4

Table 14 - USD iBoxx® indices

USD - $S \times Q$	1-3yr	3-5yr	5-7yr	7-10yr	10-15yr	15+yr
FIN CQS 0	85% of the USD FIN CQS1 yields if those yields are positive or zero, otherwise 115% of those yields					
FIN CQS 1	GB00B05DN483	GB00B05DN590	GB00B05DN608	GB00B05DN715	GB00B05DN822	GB00B05DNB55
FIN CQS 2	GB00B05DMS57	GB00B05DMT64	GB00B05DMV86	GB00B05DMW93	GB00B05DMX01	GB00B05DN046
FIN CSQ 3	GB00B05DNS23	GB00B05DNT30	GB00B05DNV51	GB00B05DNW68	GB00B05DNX75	GB00B05DNZ99
NONFIN CQS 0	85% of the USD NONFIN CQS1 yields if those yields are positive or zero, otherwise 115% of those yields					
NONFIN CQS 1	GB00B05DQD84	GB00B05DQF09	GB00B05DQG16	GB00B05DQH23	GB00B05DQJ47	GB00B05DQL68
NONFIN CQS 2	GB00B05DQ270	GB00B05DQ387	GB00B05DQ494	GB00B05DQ502	GB00B05DQ619	GB00B05DQ833
NONFIN CQS 3	GB00B05DR245	GB00B05DR351	GB00B05DR468	GB00B05DR575	GB00B05DR682	GB00B05DR807

G.5.6 If the issuing currency is DKK, then the corporate bond market yield for issuance of type FIN×CQS0 is sourced from the Nykredit's Realkreditindeks. The Nykredit's Realkreditindeks includes a representative extract of the Danish covered bond market. A single index is used as it better reflects the exposures of the Danish insurance sector. During the 2018 analysis of the Danish covered bond market, it was found that in a substantial part of the issued covered bonds, debtors of the underlying residential mortgages were allowed to opt for early repayment of their loan. To account for such an embedded call option, an option-adjusted version of the Nykredit Realkreditindeks was analysed for its modelling approach of the optionality, found eligible and subsequently adopted resulting in an option-adjusted corporate bond market yield and an option-adjusted duration for DKK issuances of type FIN×CQS0. They are sourced from the following RICs:

$y^{yld}_{DKK,corp,FIN\times CQS0}(t)$: '.NYKROAY2'

$d_{DKK,corp,FIN\times CQS0}(t)$: '.NYKROAD2'

The corporate bond market yields for all other DKK issuances are according to the provisions of G.5.3.

G.6 RISK CORRECTIONS

G.6.1 According to paragraph F.4.3, the risk correction of reference portfolio c at time t is defined as:

$$RC_c(t) = \boldsymbol{w_{c,gov|B}} \cdot \left(Y^{my}_{c,gov}(t) - Y^{rcy}_{c,gov}(t)\right) + \boldsymbol{w_{c,corp|B}} \cdot \left(Y^{my}_{c,corp}(t) - Y^{rcy}_{c,corp}(t)\right),$$

with:

$Y^{my}_{c,b}(t)$: the market yield at time t for a reference portfolio of type b in reference portfolio c;

$Y^{rcy}_{c,b}(t)$: the risk-corrected market yield at time t for a reference portfolio of type b in reference portfolio c.

According to paragraph F.4.4, both $Y^{my}_{c,b}(t)$ and $Y^{rcy}_{c,b}(t)$ are internal rate of returns (IRRs) which require the respective underlying yields at the zero-coupon model bond level for each type of issuance i to get calculated.
Hence, to calculate $Y^{my}_{c,b}(t)$ one needs the underlying $y^{my}_{c,b,i}(t, \boldsymbol{d_{c,b,i}})$, while for calculating $Y^{rcy}_{c,b}(t)$ one needs the underlying $y^{my}_{c,b,i}(t, \boldsymbol{d_{c,b,i}}) - y^{rc}_{c,b,i}(t, \boldsymbol{d_{c,b,i}})$.

G.6.2 With reference to Article 51(2) of the Delegated Regulation, the risk correction at time t for government bonds with maturity T in reference portfolio $c \in C$ as issued by issuing country $i \in ICO$ and being a Member State of the EEA, is defined according to the following formula:

$$y^{rc}_{c,gov,i}(t,T) = \min\Big\{$$

$$65\% \cdot LTAS^{+}_{c,gov,i}(t,T);$$
$$30\% \cdot \min\{S^{+}_{c,gov,i}(t,T); LTAS^{+}_{c,gov,i}(t,T)\} +$$
$$20\% \cdot \max\Big\{0; \min\{S^{+}_{c,gov,i}(t,T) - LTAS^{+}_{c,gov,i}(t,T); LTAS^{+}_{c,gov,i}(t,T)\}\Big\} +$$
$$15\% \cdot \max\{0; S^{+}_{c,gov,i}(t,T) - 2 \cdot LTAS^{+}_{c,gov,i}(t,T)\}\Big\},$$

with:

$F^{+}(t,T) = \max\{0; F(t,T)\}$, and F being either S or long-term average spread (LTAS);

$$S_{c,gov,i}(t,T) = \begin{cases} y^{my}_{EUR,gov,EA}(t,T) - y^{rfy}_{*,*,EA}(t,T) = S_{gov,EA}(t,T) & c = EUR, \quad i \in HCO \\ y^{my}_{*,gov,i}(t,T) - y^{rfy}_{*,*,i}(t,T) = S_{gov,i}(t,T) & elsewhere \end{cases}$$

$$LTAS_{c,gov,i}(t,T) = \frac{1}{\#N(t)} \sum_{u \in N(t)} S_{c,gov,i}(u,T)$$

And hence:

$$LTAS_{gov,i}(t,T) = \frac{1}{\#N(t)} \sum_{u \in N(t)} S_{gov,i}(u,T), \qquad i \in ICO \cup 'EA' \text{ and EEA}$$

additionally, with:

$N(t)$: the set of relevant trading days at time t;
$\#N(t)$: the number of trading days in set $N(t)$.

See paragraph G.6.5 for more details on the set $N(t)$.

This allows for calculating the risk-corrected market yields according to:

$$y^{my}_{c,b,i}(t, \boldsymbol{d_{c,b,i}}) - y^{rc}_{c,b,i}(t, \boldsymbol{d_{c,b,i}}) = y^{my}_{*,gov,i}(t, \boldsymbol{d_{c,b,i}}) - y^{rc}_{*,gov,i}(t, \boldsymbol{d_{c,b,i}})$$

which subsequently allows for calculating the IRRs $Y^{rcy}_{c,b}(t)$ needed for calculating the risk correction of reference portfolio c of government bonds at time t according to paragraph G.6.1.

G.6.3 With reference to Article 51(3) of the Delegated Regulation, the risk correction for bonds other than government bonds issued by an EEA Member State are either:

1) government bonds issued by a country $i \in ICO$ not being an EEA Member State;
2) corporate bonds of issuance type $s \in S$

G.6.4 The risk correction at time t for bonds with maturity T of type $b \in B$ in reference portfolio $c \in C$ according to the provisions of Annex 0 is defined according to the following formula:

$$y^{rc}_{c,b,i}(t,T) = \min\Big\{$$

$$125\% \cdot LTAS^{+}_{c,b,i}(t,T);$$

$$50\% \cdot \min\left\{S^{+}_{c,b,i}(t,T); LTAS^{+}_{c,b,i}(t,T)\right\} +$$

$$40\% \cdot \max\left\{0; \min\left\{S^{+}_{c,b,i}(t,T) - LTAS^{+}_{c,b,i}(t,T); LTAS^{+}_{c,b,i}(t,T)\right\}\right\} +$$

$$30\% \cdot \max\left\{0; S^{+}_{c,b,i}(t,T) - 2 \cdot LTAS^{+}_{c,b,i}(t,T)\right\}\Big\},$$

with:
$F^{+}(t,T) = \max\{0; F(t,T)\}$, and F being either S or long-term average spread (LTAS);

$$S_{c,b,i}(t,T) =$$
$$\begin{cases} y^{my}_{*,gov,i}(t,T) - y^{rfy}_{*,*,i}(t,T) = S_{gov,i}(t,T) & b = gov \text{ and } i \in ICO \text{ and not EEA} \\ y^{my}_{i,corp,s}(t,T) - y^{rfy}_{*,*,i}(t,T) = S_{corp,i}(t,T) & b = corp \text{ and } i \in ICO \end{cases}$$

with $y^{my}_{i,corp,s}(t,T)$ according to paragraph G.5.3., and

$$LTAS_{c,b,i}(t,T) = \frac{1}{\#N(t)} \sum_{u \in N(t)} S_{c,b,i}(u,T)$$

And hence:

$$LTAS_{gov,i}(t,T) = \frac{1}{\#N(t)} \sum_{u \in N(t)} S_{gov,i}(u,T), \qquad i \in ICO \text{ and EEA}$$

$$LTAS_{corp,i}(t,T) = \frac{1}{\#N(t)} \sum_{u \in N(t)} S_{corp,i}(u,T), \qquad i \in ICO$$

For $LTAS_{gov,i}(t,T)$ when combined with Annex G.6.2 it follows that:

$$LTAS_{gov,i}(t,T) = \frac{1}{\#N(t)} \sum_{u \in N(t)} S_{gov,i}(u,T), \qquad i \in ICO$$

i.e. the long term average spread for government bonds is not dependent on the issuing country being a member state of the EEA.

with:

$N(t)$: the set of relevant trading days at time t;
$\#N(t)$: the number of trading days in set $N(t)$.

See paragraph G.6.5 for more details on the set $N(t)$.

G.6.5 Delegated Regulation's Article 51(4) on the calculation of the risk correction for the volatility adjustment as well as Article 54(3) on the calculation of the fundamental spread for the matching adjustment provide the following.

(a) The LTAS shall be based on data relating to the last 30 years.
Hence, let the function $date(t) = (year(t), month(t), day(t))$, then the first trading day of the set $N(t)$ in G.6.2 and G.6.4 is the trading day with the smallest date greater than $(year(t) - 30, month(t), day(t))$. The last trading day of the set $N(t)$ is the trading day with the highest date smaller than or equal to $date(t)$.
(b) Where a part of that data is not available, it shall be replaced by constructed data.
(c) The constructed data shall be based on the available and reliable data relating to the last 30 years. Data that is not reliable shall be replaced by constructed data using that methodology.
(d) The constructed data shall be based on prudent assumptions.

G.6.6 In most cases, historical data spanning a 30-year period are not available for the proxies used for government bond yields, corporate bond yields and the corresponding risk-free yields required for the calculation of either type of LTAS. To address this limitation, EIOPA reconstructs the missing data in accordance with paragraph G.6.5 by applying the following rule: missing spread observations are reconstructed using the average spread calculated from the data available from 1 January 1985 onwards or, where such data are unavailable, from the earliest point in time for which reliable spread data exist.

G.6.7 Proxies for risk-free yields are sourced from the basic risk-free rates as specified in G.4.1. For currencies where the basic risk-free rates include a credit risk adjustment according to Subsection 6.4 - First situation, the construction of historical yield proxies requires the availability of the corresponding underlying overnight indexed swap (OIS) rates. As the underlying OIS rates are only available from 1 January 1999 onwards, the historical series of yield proxies for those currencies is effectively limited to that date. Consequently, EIOPA has, in practice, calculated the LTAS for all currencies based on data available from 1 January 1999.

G.6.8 Consequently, and considering the Solvency II application date of 1 January 2016, EIOPA calculated the constructed spread, for each currency and maturity where observations are unavailable, based on the time series covering the period from 1 January 1999 to

31 December 2015. The calculation is performed using daily observations throughout the reference period in accordance with the provisions of G.6.13.

G.6.9 It should be noted that government bond markets for maturities exceeding 10 years have only developed from the first half of the previous decade onwards. Consequently, the estimation of the LTAS for maturities beyond 10 years is subject to limited representativeness, reflecting the relatively low number of available observations. To avoid this bias, the calculation of LTAS for government bonds is only carried out for maturities 1-10Y. The LTAS for maturities greater than 10Y are equal to the LTAS for maturity 10Y.

G.6.10 Even below 10 years, for a few currencies some maturities deliver non-plausible results. Table 15 reflects the currencies where empty maturity cells deliver non-plausible LTAS values. To derive the spreads for the disregarded maturities, linear interpolation of spreads using neighbouring maturities is applied.

Table 15 - Disregarded maturities for the LTAS calculation of government bonds

	Tenor in years									
Country	1	2	3	4	5	6	7	8	9	10
Bulgaria	•	•	•	•	•	•		•	•	•
Cyprus	•	•	•		•		•	•	•	•
Denmark	•	•	•	•	•		•	•	•	
Iceland	•	•		•					•	
Romania	•	•	•	•	•	•	•	•		•
Sweden	•	•	•	•	•	•	•		•	•

Notes: This table sets out the maturities used to derive the government bond spreads for current reference dates that enter the calculation of the LTAS, only for those countries for which the calculation does not cover the entire set of 1- to 10-year maturities. Past changes to the maturities are set out in ANNEX H. Empty cells are based on interpolation, non-empty cells on historical data.

Table 18 in ANNEX H reports the history of disregarded maturities for the LTAS calculation of government bonds.

G.6.11 The LTAS for corporate bonds is calculated for those dates where neither the basic risk-free interest rate term structures nor the corporate yields are nil. The calculation of LTAS for corporate bonds is only carried out for integer maturities smaller than or equal to the last maturity available from the market source. For integer maturities greater than the longest maturity of the previous step the LTAS equals the LTAS of this longest maturity.

G.6.12 Linear interpolation is used to obtain complete corporate yield returns for maturities with missing data. Where there is no market data or only market data for a single maturity, then the yields are set to zero. All yields below the available first maturity are equal to the first yield available.

G.6.13 Now, for the period prior to 1 January 1999, EIOPA assumes that the average spread over the missing period does not materially differ from the average spread observed over the period 1 January 1999 to 31 December 2015:

- calculate the average spread over the period 1999-2015 (17 years);
- now, for each year in the period 1986-1998 (13 years) the constructed spread corresponds to the average spread over the period 1999-2015.

G.6.14 Due to the provisions of paragraphs G.6.8 and G.6.13, EIOPA has effectively calculated for all maturities $LTAS_{c,b,i}(31_12_2015, T)$, being the LTAS as of 31 December 2015 for $c \in C, b \in B, i \in I_b, T = 1,..,30$.

G.6.15 From 1 January 2016 until 1 January 2029 the $LTAS_{c,b,i}(t, T)$ will be calculated as:

$$\frac{LTAS_{c,b,i}(31_12_2015,T)\cdot(7800-\#N_{01_01_2016}(t))+\sum_{u\in N_{01_01_2016}(t)} S_{c,b,i}(u,T)}{7800},$$

with:

- $LTAS_{c,b,i}(31_12_2025, T)$ is the LTAS for maturity *T* as of 31 December 2015;
- $N_{01_01_2016}(t)$: the set of trading days in period [01-01-2016; t];
- $\#N_{01_01_2016}(t)$: the number of trading days in set $N_{01_01_2016}(t)$;
- it is assumed that a 30-year period is composed of 7800 trading days.

G.6.16 The $LTAS_{GBP,b,i}(31_12_2015, T)$ is a special case because of market data being available for the period before 1999. The impact of this additional data is modelled through the following adjustment factors:

Table 16 - Adjustment factors applied to $LTAS_{GBP,gov,i}(31_12_2015, T)$

Maturity	Adjustment Factor	Maturity	Adjustment Factor
1Y	103%	6Y	103%
2Y	95%	7Y	99%
3Y	94%	8Y	104%
4Y	94%	9Y	105%
5Y	95%	10-30Y	105%

Table 17 - Adjustment factors applied to $LTAS_{GBP,corp,i}(31_12_2015, T)$

Maturity	Adjustment Factor		
	CQS1	CQS2	CQS3
1-4Y	82%	88%	97%
5-8Y	80%	84%	93%
9-30Y	95%	93%	93%

G.6.17 For the sake of transparency EIOPA will publish the LTAS.

ANNEX H LTAS CALCULATION SPECIFICITIES

H.1 HISTORY OF LTAS GOVERNMENT BOND RATES

H.1.1 Table 18 specifies the government bond maturities that were used to derive spreads for the government bond long-term average spreads (LTAS) in the past since 1 January 2016. For currencies that do not appear in the table the maturities are unchanged since 1 January 2016. The currently used maturities are set out in Table 15 of the main text. Market data until (and including) 31 December 2019 was received from Bloomberg.

Table 18 - History of LTAS government bond maturities

	Government bond maturities used All maturities in years	Period
AT	1-3, 5-10	1 January 2016 – 31 March 2021
BG	1-7, 9	1 January 2016 – 31 December 2022
	1-5, 7, 9	1 January – 31 December 2023
	1-6, 8	1 January – 31 December 2024
	1-7	1 January – 29 January 2027
CH	2-8, 10	1 January 2016 – 31 March 2021
CL	1-7, 9, 10	1 January 2016 – 31 December 2019
	1-5, 7, 10	1 January 2020 – 31 December 2021
	1-4, 7, 9, 10	1 January – 31 December 2022
	1-4, 6, 8, 10	1 January – 31 December 2023
	1-3, 5, 7, 8, 10	1 January – 31 December 2024
	Removed from list of relevant currencies as of 1 January 2025	
CO	1-6, 8, 10	1 January 2016 – 31 December 2022
	1-6, 8-10	1 January – 31 December 2023
	1-10	1 January 2024 – 29 January 2027
	Removed from list of relevant currencies as of 30 January 2027	
	1-5, 7-10	1 January 2016 – 31 March 2021

	Government bond maturities used All maturities in years	Period
CY	1-10	1 April 2021 – 29 January 2027
CZ	1-8, 10	1 January 2016 – 31 March 2021
	1-5, 7, 9, 10	1 April 2021 – 31 December 2022
	1-3, 5, 7-9	1 January – 31 December 2023
	1, 2, 4, 6-8, 10	1 January – 31 December 2024
	1-3, 5-7, 9, 10	1 January – 31 December 2025
DK	1-2,4-6,8-10	1 January 2016 – 29 January 2027
EL	1, 2, 4, 5, 7-10	1 January 2016 – 31 March 2021
	1-5, 10	1 April 2021 – 31 December 2022
HK	1-10	1 January 2016 – 31 December 2022
	1-5, 7, 10	1 January – 31 December 2023
	1-6, 8, 10	1 January 2024 – 31 December 2025
	1-5, 7, 9-10	1 January 2026 – 29 January 2027
	Removed from list of relevant currencies as of 30 January 2027	
HR	1-4, 10	1 January – 30 December 2016
	1, 3, 4, 8, 9	31 December 2016 – 31 March 2021
	1-5, 7-10	1 April 2021 – 31 December 2021
	1-7, 9	1 January – 31 December 2022
IS	1-4, 9	1 January – 31 December 2023
	1, 2, 6, 8, 9	1 January – 31 December 2024
	1-4, 7, 9	1 January – 31 December 2025
	1,3,5,9	1 January 2026 – 29 January 2027
MX	1-6, 8, 10	1 April 2021 – 31 December 2022
	1-5, 7	1 January – 31 December 2023
	1-4, 6, 8, 10	1 January – 31 December 2024
	Removed from list of relevant currencies as of 1 January 2025	

	Government bond maturities used All maturities in years	Period
MY	1-9	1 January 2016 – 31 December 2019
	Removed from list of relevant currencies as of 1 January 2025	
NO	1-9	1 January 2016 – 31 December 2021
RO	1-5, 7-10	1 January 2016 – 31 March 2021
	1-6, 8-10	1 April – 31 December 2021
	1-7, 10	1 January – 31 December 2022
	1-10	1 January 2023 – 31 December 2025
RU	1-9	1 January 2016 – 31 December 2019
	1-5, 7, 9, 10	1 January 2020 – 31 December 2021
	1-10	1 January – 31 December 2022
	1-9	1 January – 31 December 2023
	Removed from list of relevant currencies as of June 2024	
SE	1-8, 10	1 January 2016 – 31 March 2021
	1-10	1 April 2021 – 31 December 2025
	1-8, 10	1 January 2026 – 29 January 2027
SI	1, 2, 4-10	1 January 2016 – 31 March 2021
SK	1-3, 5-10	1 January 2016 – 31 March 2021
TH	1-5, 7-10	1 January 2016 – 31 December 2019
	Removed from list of relevant currencies as of 1 January 2025	
TR	1-5, 7, 9	1 January 2016 – 31 March 2021
	1-5, 7, 8	1 April 2021 – 31 December 2021
	1-9	1 January – 31 December 2022
	1-6, 8, 9	1 January – 31 December 2023
	1-5, 7-9	1 January – 31 December 2024
	Removed from list of relevant currencies as of 1 January 2025	
	1-10	1 January 2016 – 29 January 2027

	Government bond maturities used All maturities in years	Period
TW	Removed from list of relevant currencies as of 30 January 2027	
ZA	1-4, 6-10	1 January – 31 December 2022
	1, 3, 4, 6-10	1 January – 31 December 2023
	1-3, 5-10	1 January – 31 December 2024
	Removed from list of relevant currencies as of 1 January 2025	

ANNEX I CALCULATION OF THE COD AND PD

I.1 LEGAL CONTEXT

I.1.1 The two components cost of downgrade (CoD) and probability of default (PD) are required by Article 77c(2)(a) of the Solvency II Directive, supplemented by Article 54 of the Delegated Regulation. Furthermore, recital 31 of the Omnibus II Directive and recitals 22 and 23 of the Delegated Regulation apply.

I.1.2 The CoD is defined as the present value of costs resulting from a future downgrade, expressed as spreads in basis points over the risk-free interest rates. According to Article 54(4)(a) the cash flow pattern does not change, according to point (b) the replacing asset belongs to the same asset class as the replaced asset and according to point (c) the replacing asset has the same credit quality step (CQS) as the replaced asset or a better one.

I.2 METHOD FOR DERIVING THE PD AND THE COD

I.2.1 The calculation of the credit spread corresponding to the PD derives an amount that is interpreted as an investor's required compensation for assuming the risk of the expected PD of a bond. The expectation of default (based on historical default probabilities derived from 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 as set out in Article 54(2) of the Delegated Regulation.

I.2.2 For the sake of consistency, EIOPA applies the same method to calculate both the PD and CoD, with the following difference.

(a) For the PD, EIOPA assumes a 'buy and hold' strategy: assets are not sold after downgrade.
(b) For the CoD, EIOPA assumes a 'buy and replace' strategy: downgraded assets are replaced by an asset of the same CQS as before downgrade, or higher, as specified in Article 54(4) of the Delegated Regulation. This difference in calculation of PD and CoD may give rise to the double-counting of risks. To avoid that, the CoD calculation is reduced by the following difference: the PD calculated with the 'buy and hold' strategy minus the PD calculated with the 'buy and replace' strategy. EIOPA ensures that the final outcome stays greater than or equal to zero.

I.2.3 Both computations use the transition matrix adjusted for cost accounting and are based on the same inputs: empirical one-year transition matrices, the relevant basic risk-free

interest rate term structure and for each CQS a vector of relevant portions of the market value of a risk-free benchmark instrument, as set out in Table 19. These portions have been designed to be analogous to the recovery rate for the PD.

Table 19 - Scaling factors used in the calculation of the Cost of Downgrade

CQS	Scaling factor
0	98%
1	97%
2	95%
3	85%
4	70%
5	50%
6	40%
Note: CQS6 category in this table does not include ratings lower than CCC, as those categories are treated as default (See Subsection I.3).	

I.2.4 In case of a rating migration to a CQS of lower quality (i.e. a downgrade), the cost is defined as the difference between the two market values. This cost reflects the cost of replacing the downgraded asset with an asset of the same credit quality it was downgraded from and preserving the original cash flow pattern. Knowing that the asset has not defaulted, the cost is lower compared to a case of default.

I.2.5 For the next year of projection, the asset is supposed to start from the CQS of the replaced bond. This cost accounting and rebalancing procedure is applied until the maturity of the original bond. This procedure implements the rebalancing requirement as set out in Article 54(4) of the Delegated Regulation.

I.2.6 The total loss is defined as the loss in market value by subtracting the present value of future downgrading cost cash flows. Finally, the loss in market value is transformed into an implied (higher) yield and the result is expressed as a spread over the basic risk-free interest rate in basis points.

I.2.7 In addition to publishing PD and CoD expressed in basis points, EIOPA also publishes the PD as a probability, to be applied for the de-risking of cash flows as follows:

$$\text{de-risked cash flow} = \text{CashFlow} \cdot (1 - PD_{EIOPA}) + \text{recovery_rate} \cdot \text{CashFlow} \cdot PD_{EIOPA}.$$

I.2.8 The PD used to de-risk cash flows expected at time t is derived within a Markov transition framework. Specifically, it is obtained from the last column (i.e. the column corresponding to the state of default) in the matrix resulting from raising the one-year average transition matrix to the power of t (see paragraph I.7.3).

I.2.9 The PD, CoD and fundamental spread are published for maturities up to 30 years. For longer maturities, the values corresponding to the 30-year maturity apply.

I.2.10 The calculation of PD and CoD is set out in the Excel tool 'CoD & PD Calculation' that can be found on EIOPA's website.

I.3 MARKET DATA FOR THE CALCULATION OF THE PD AND COD

I.3.1 The inputs necessary for the calculation of the PD and the CoD are the benchmark curve used to calculate the spreads, market yields for corporate bonds and the relevant transition matrices, as indicated below.

(a) The benchmark curve is the basic risk-free interest rate term structure.
(b) The spreads are calculated as the difference between the market yields for corporate bonds and the basic risk-free interest rate term structure.
(c) Two transition matrices are used as inputs: financial and non-financial issuers. Both transition matrices have been obtained according to the following criteria.

i. Transition probabilities refer to the 1-year average calculated over the last 30 years.
ii. Given the limited number of exposures per geographical area, CQS and economic sector, the geographical area considered refers to all countries.
iii. Issuers whose rating has been withdrawn are excluded (i.e. not considered in the initial population of issuers).
iv. The statistics refer to issuers.
v. Considering the definition of the data provider for ratings below CCC, those categories are treated as defaults. Therefore, matrices used as input have seven credit quality steps (i.e. eight rows and columns, including the state of being in default, which is considered to be an absorbing state, i.e. no return to rated categories).

I.3.2 The filtering criteria applied when extracting the transition matrices are specified in Annex I.11

I.3.3 EIOPA will update the transition matrices on an annual basis in mid-January. The updated matrices will first be applied in the calculation of end-of-January technical information.

I.3.4 As described below, the same approach applies to the PD with the appropriate modifications.

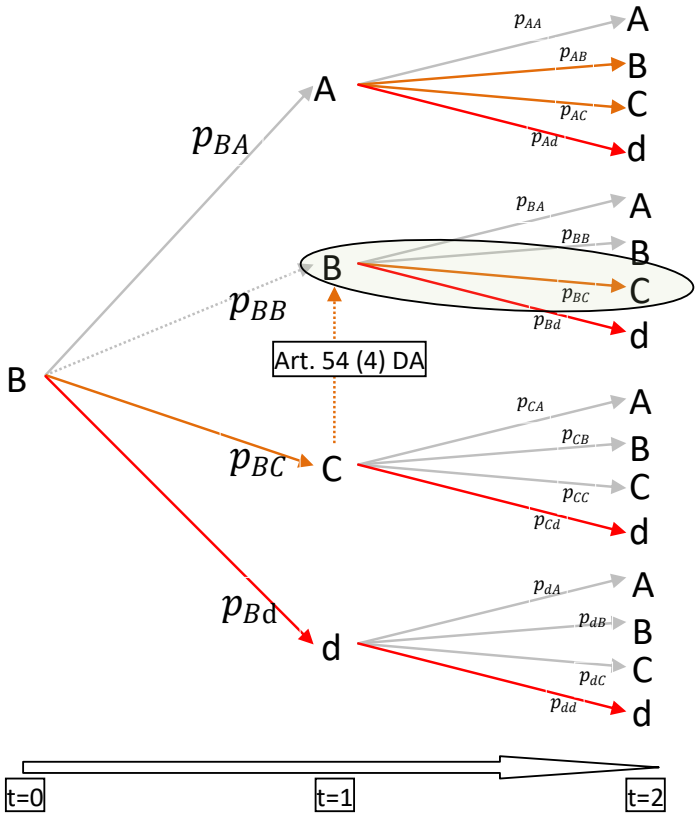
I.3.5 The three components of a present value:

$$PV = \sum_{t=1}^{T} \frac{\text{CashFlow}_t \cdot \text{Probability}(CashFlow_t)}{(1+\text{InterestRate}_t)^t}.$$

I.4 PROBABILITY

I.4.1 Looking from $t = 0$ ('today'), the probability for a downgrade event from X to Y to occur between time $t = t_0$ and $t = t_1$ is given as the probability for the bond to be in CQS X at time $t = t_0$ and then to end in CQS Y at time $t = t_1$.

Figure 1 - Example: Downgrade from B to C between t=1 and t=2 for a B bond at inception t=0



I.4.2 The probability of being in CQS B at time $t = 1$ is determined by all the paths leading to B in $t = 1$. For the above example, where we only consider the initial CQS B, the path without replacement would be $B \to B \to C$. However, due to the requirement of Article 54(4) of the Delegated Regulation to replace bonds that have been downgraded by a bond of the CQS it was in before the downgrade event, we could have also come to B at time $t = 1$ via the path $B \to C \left(\xrightarrow{Art.54\ (4)} B\right) \to B$. So, the total probability of a downgrade from B to C between $t = 1$ and $t = 2$ for a bond with CQS B at $t = 0$ is given by $(P_{BB} + P_{BC}) \cdot P_{BC}$.

I.4.3 Hence, the replacement requirement of Article 54(4) of the Delegated Regulation leads to the following change in that transition matrix which determines the starting CQS for the year in which the cost of the downgrade event is accounted:

$$T = \begin{pmatrix} P_{AA} & P_{AB} & P_{AC} & P_{Ad} \\ P_{BA} & P_{BB} & P_{BC} & P_{Bd} \\ P_{CA} & P_{CB} & P_{CC} & P_{Cd} \\ P_{dA} & P_{dB} & P_{dC} & P_{dd} \end{pmatrix}$$

$$\xrightarrow{\text{Art. 54 (4) Delegated Regulation}} \begin{pmatrix} P_{AA} + P_{AB} + P_{AC} & \xleftarrow{\text{Art. 54 (4) DR}} & \xleftarrow{\text{Art. 54 (4) DR}} & P_{Ad} \\ P_{BA} & P_{BB} + P_{BC} & \xleftarrow{\text{Art. 54 (4) DR}} & P_{Bd} \\ P_{CA} & P_{CB} & P_{CC} & P_{Cd} \\ P_{dA} & P_{dB} & P_{dC} & P_{dd} \end{pmatrix} = Q$$

I.4.4 The original transition matrix T is retained for those probabilities regarding the transitions in the year the cost accounting is done.

I.4.5 This means, the probability for a downgrade from B at $t = 1$ to C at $t = 2$ is given by the probability of being in CQS B at $t = 1$ (accounting for possible upgrading events due to Art. 54 (4) of the Delegated Regulation between $t = 0$ and $t = 1$), multiplied by the probability P_{BC} of transitioning from CQS B at $t = 1$ to C at $t = 2$. In matrix notation, this can be expressed by the matrix multiplication of Q for the possible paths from $t = 0$ to $t = 1$ with T for the possible paths from $t = 1$ to $t = 2$.

I.4.6 More generally, for a downgrade event to be accounted for in year m (i.e. between $t = m$ and $t = m + 1$), we consider the matrix Q for the first m periods and then apply the matrix T once. Thus, the probabilities to be used for a downgrade event in year m (i.e. between $t = m$ and $t = m + 1$) are all contained in the matrix $Q^m T$.

I.5 ZERO-COUPON BOND CASH FLOWS

I.5.1 By Article 54(4) of the Delegated Regulation, the cash flow in case of a downgrade is defined as the difference between the market values of the original (higher) and the new (lower) CQS. There is no specific requirement for the case of an upgrade, the case of staying in the same credit quality or for the event of default. The default case is considered in the separate component for PD.

I.5.2 The corresponding market values change over time. The cash flows are derived from zero-coupon bonds with investment (-1) at inception $t = 0$ and final payment $(1 + r_T)^T$ at maturity $t = T$, i.e. the zero-coupon bond cash flow pattern is given by:

$$(-1),\ 0,\ \dots,\ 0,\ (1+r_T)^T$$

The compound interest rate r_t is based on the financial instrument considered to be risk-free once adjusted. For Solvency II purposes, this is considered to be the basic risk-free interest rate structure.

I.6 DISCOUNT FACTOR

I.6.1 The discount factor $1/(1+\text{InterestRate}_t)^t$ considers the risk-free spot rate.

I.6.2 The above considerations give rise to the following nutshell description.

I.7 COST OF DOWNGRADE AND PROBABILITY OF DEFAULT IN A NUTSHELL

I.7.1 **Input Data**

Transition Matrix $T = (p_{X,Y})_{X,Y \in CQS}$ for the n-element set CQS of credit quality steps including the default state denoted by 'd' (note that $p_{dX} = 0$ for all X ≠ d and $p_{dd} = 1$ because d is considered an absorbing state) and relevant portions R_c for credit quality steps $c \in CQS$. Any explicit reference to economic sectors or other granularity buckets is dropped, because Article 54(4) of the Delegated Regulation does not require costs of transitions between economic sectors or other granularity buckets to be considered. However, the following calculation needs to be done within each of those buckets not explicitly mentioned here.

I.7.2 **CoD, step 1**

Based on the basic risk-free interest rate term structure $(r_M)_{M=1,\dots,30}$, the market value of a zero-coupon bond of maturity M at time m is given by:

$$MV_M(m) = \frac{(1+r_M)^M}{\left(1+f_{m,M}\right)^{M-m}},$$

where the forward rates $f_{m,M}$ are derived on an arbitrage-free basis:

$$(1+r_m)^m\left(1+f_{m,M}\right)^{M-m} = (1+r_M)^M.$$

This provides the following closed formula for the market value of the risk-free reference instrument:

$$MV_M(m) = (1 + r_m)^m \,.$$

The market value of the risky instruments in CQS c is defined based on a fixed portion R_c as a portion of the risk-free instrument and given by:

$$MV_{c,M}(m) = R_c^{\frac{M-m}{15}} \cdot (1 + r_m)^m.$$

The portion is a certain percentage R_c^M of the market value of the risk-free reference instrument at inception and increases to 100% at maturity. The factors are applied taking a 15-year maturity as an approximation of the highest duration observed.

A downgrade at time m from CQS X to $Y > X$ results in the following cost:

$$CoD_{(X,Y),M}(m) \coloneqq MV_{X,M}(m) - MV_{Y,M}(m) > 0.$$

Define the following strictly upper triangular matrix (an upgrade or stay is not accounted for):

$$C_M^{(m)} \coloneqq \left(\begin{cases} CoD_{(X,Y),M}(m) \cdot p_{X,Y} & \text{for } Y \neq \text{default} \\ (1 - \text{RecoveryRate}) \cdot MV_{X,M}(m) \cdot p_{X,Y} & \text{for } Y = \text{default} \end{cases} \right)_{(X<Y)\in CQS}.$$

Define the lower triangular matrix Q according to the replacement requirement of Article 54(4) of the Delegated Regulation, i.e. the matrix Q represents the transition matrix implementing the rebalancing requirement after a downgrade.

$$(q_{XY})_{X,Y\in CQS} \coloneqq \begin{cases} p_{XY} & \text{for } X > Y \text{ and } Y = \text{n (lower triangle and rightmost column)} \\ \sum_{k=i}^{\text{n}-1} p_{i,k} & \text{for } X = Y \leq n \text{ (Art. 54 (4) DA) (main diagonal)} \\ 0 & \text{for } X < Y < n \text{ (upper triangle except rightmost column)} \end{cases} =$$

$$\begin{pmatrix} \sum_{k=1}^{\text{n}-1} p_{1,k} & \leftarrow 0 & \cdots & \leftarrow 0 & p_{1d} \\ p_{21} & \sum_{k=2}^{\text{n}-1} p_{2,k} & \leftarrow 0 & \vdots & p_{2d} \\ p_{31} & p_{32} & \sum_{k=3}^{\text{n}-1} p_{3,k} & \leftarrow 0 & p_{3d} \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ p_{n-1,1} & \cdots & p_{n-2,n-1} & p_{n-1,n-1} & p_{n-1,d} \\ p_{d1} = 0 & p_{d2} = 0 & \cdots & p_{d,n-1} = 0 & p_{dd} = 1 \end{pmatrix}.$$

The following matrix contains the expected cash flows representing the expected CoD for bonds in the credit quality step in CQS of original maturity M at times $m = 1, \ldots, M$.

$$\begin{pmatrix} CoD_{\text{best quality},M}(1) & \cdots & CoD_{\text{best quality},M}(M) \\ \vdots & \ddots & \vdots \\ CoD_{\text{lowest quality},M}(1) & \cdots & CoD_{\text{lowest quality},M}(M) \\ CoD_{\text{default},M}(1) = 0 & \cdots & CoD_{\text{default},M}(M) = 0 \end{pmatrix} := \bigcup_{m=1}^{M} \underbrace{\left(Q^{m-1} C_M^{(m)} \begin{pmatrix} 1 \\ \vdots \\ 1 \\ 0 \end{pmatrix} \right)}_{\text{colum vector}},$$

where $\bigcup_{m=1}^{M}(\vdots)$ shall denote the concatenation (to the right) of column vectors into a matrix. In basis points, $CoD_{c,M}^{(bp)}$ is solved from the following equation.

$$\frac{1}{\left(1 + r_M + CoD_{c,M}^{(bp)}\right)^M} = \frac{1}{(1 + r_M)^M} \left(1 - \sum_{m=1}^{M} \frac{CoD_{c,M}(m)}{(1 + r_m)^{m-0.5}} \right).$$

Note: $CoD_{c,M}^{(bp)} = 0$ if $CoD_{c,M}(m) = 0$ for all c, m.

I.7.3 Probability of Default in a nutshell

The computation of the PD in base points as spread over the basic risk-free rate is done completely consistently with the above approach. There is no Article 54(4) requirement to replace downgraded bonds along the way. Hence, the only difference is to use the original transition matrix T instead of the 'twisted Article 54(4) matrix' Q and to use the column vector $\begin{pmatrix} 0 \\ \vdots \\ 0 \\ 1 \end{pmatrix}$ instead of $\begin{pmatrix} 1 \\ \vdots \\ 1 \\ 0 \end{pmatrix}$.

Rename CoD to PD in this case. The other special case corresponds to the RecoveryRate term, which is given by Article 54(2) of the Delegated Regulation as 30% of the market value of the bond.

For the risk correction of cash flows to be considered in the matching adjustment, the PD is the total probability for a zero-coupon bond's final payment at maturity not to occur. This probability is independent of market values and is just given by the rightmost column of the matrix powers T^m.

I.7.4 CoD, step 2

Using the same notation as before, we have now calculated:

(a) $CoD_{c,M}^{(bp)}$;

(b) $PD_{c,M}^{(bp)}(T)$ using the original transition matrix T.

We need to calculate $PD_{c,M}^{(bp)}(Q)$: for that purpose, we proceed as before, but use the 'twisted Article 54(4) matrix' Q instead of the original transition matrix T.

The final CoD becomes:

$$CoD_{c,M}^{(bp),final} = max\left[0, CoD_{c,M}^{(bp)} - \left(PD_{c,M}^{(bp)}(T) - PD_{c,M}^{(bp)}(Q)\right)\right].$$

I.8 REDUCING COMPUTATIONAL AND NUMERICAL COMPLEXITY

I.8.1 Please note that $C_M^{(m)}$ is strictly upper triangular. This might help to further reduce complexity if needed. One can set up an internal table of all the values $(1 + r_m)^m$ and R_c^m for $m = 1, \dots, M$. The market values are then just given by the product of two entries of this fixed-value table.

I.8.2 Furthermore, the matrix powers Q^m and T^m can be saved in an internal (three-dimensional) array.

I.8.3 The matrix Q excluding the last row and column is lower triangular with non-zero values on the main diagonal (unless 'stay or upgrade' would both be impossible for any CQS). That is, the diagonal consists of the Eigenvalues λ_c of the matrix Q which is immediate from the characteristic polynomial decomposing into linear terms of the form $(\lambda - \lambda_c)$. Write $Q = S^{-1} * \text{diag}(\lambda_c)_{c \in CQS} * S$, then $Q^m = S^{-1}\text{diag}(\lambda_c^m,)_{c \in CQS} S$, where the columns of S are the corresponding left-Eigenvectors.

I.9 A REMARK ABOUT PROBABILITY IN CONTINUOUS TIME AND WHY IT HAS NOT BEEN USED HERE

I.9.1 In this notation, one could – in theory – also define matrix powers for non-integral times t by:

$$Q^t := S^{-1}\text{diag}(\lambda_c^t)S.$$

I.9.2 However, the use of the continuous version of powers of Q should carefully consider whether continuous downgrade events with immediate upgrade make sense in the specific application context. Even if one would consider integrals instead of sums, downgrades would still be discrete jumps between a finite number of rating classes or credit quality steps. This could be different if spreads were considered to continuously change without regard to a rather limited number of rating categories or credit quality steps. The choice taken in this approach stays away from this complexity in order to create consistency with the mechanics behind the creation of transition matrices.

I.10 A REMARK ABOUT INTRA-YEAR CHAINS OF RATING CHANGES

I.10.1 In real life, if a financial instrument receives a downgrade with negative forecast, it is not unlikely that the same instrument receives a second downgrade within the same year. The approach taken here would not 'see' this chain of rating changes, because it only looks at discrete points $t = 0, t = 1, \dots, t = M$.

I.10.2 However, this would only be influential on the result if there is an upgrade event followed by a downgrade event in that chain of rating changes because this downgrade event would have to be accounted for. But it is not accounted for, because it would not be recognised if one only opens the 'black box' at the next point in time. Since these events are quite unlikely to occur, we disregard the difference stemming from this simplified view.

I.10.3 If the chain consists of only downgrading events, there is almost no difference at all, because the CoD cash flows are defined as differences between market values:

$$CoD_{X\to Y} + CoD_{Y\to Z} = (MV_X - MV_Y) + (MV_Y - MV_Z) = MV_X - MV_Z = CoD_{X\to Z}.$$

I.10.4 The only difference would stem from the different points in time and therefore the different interest/forward rates concerned. But again, this simplification has been considered to be of negligible materiality. However, in theory, this can be recognised within this model.

I.11 TRANSITION MATRICES FOR COD AND PD

I.11.1 This annex sets out the filtering criteria for extracting Standard & Poor's (S&P) transition matrices, which are used to calculate the PD and the CoD. The specific time period of the data used, and the date of the data download are specified in the monthly publication of the PD and the CoD.

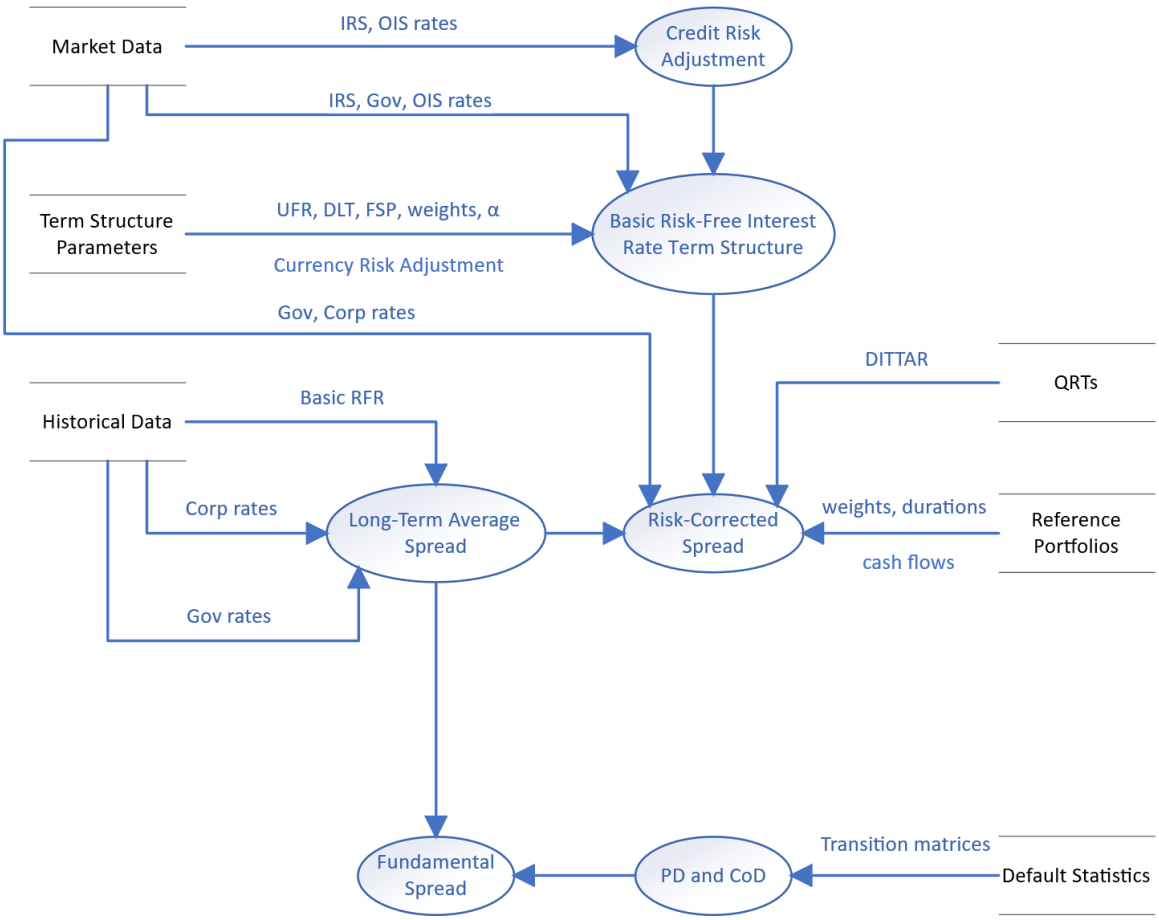
Table 20 – Financial issuers

S&P Report Type	Transition Matrices (Percent, NR Excluded)
CALCULATION BASE	Number of Issuers (All)
HORIZON	1 Year
INDUSTRY SELECTION	GICS -40 -- Financials
COUNTRY SELECTION	All
VINTAGE YEARS SELECTION	All
NUMBER OF POOLS	30
POOL START DATES	01/01/(YYYY-30) to 01/01/(YYYY-1)

Table 21 – Non-financial issuers

S&P Report Type	Transition Matrices (Percent, NR Excluded)
CALCULATION BASE	Number of Issuers (All)
HORIZON	1 Year
INDUSTRY SELECTION	GICS -10 – Energy, 15 -- Materials, 20 -- Industrials, 25 -- Consumer Discretionary, 30 -- Consumer Staples, 35 -- Health Care, 45 -- Information Technology, 50 -- Communication Services, 55 – Utilities, 60 -- Real Estate
COUNTRY SELECTION	All
VINTAGE YEARS SELECTION	All
NUMBER OF POOLS	30
POOL START DATES	01/01/(YYYY-30) to 01/01/(YYYY-1)

ANNEX J DIAGRAM OF CALCULATIONS



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