RFR Technical Documentation

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

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CHANGES SINCE LAST PUBLISHED VERSION

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This version of the Technical Documentation includes the changes stemming from the update of the reference portfolios for calculating the volatility adjustment for 2026 and the peer country review 2025. All changes will become effective as of March 31st, 2026.

Changes:

- **Table 2 - Swap and government bond RICs used for the derivation of the technical information**
  Inclusion of GVT RICs for Cyprus, Lithuania, and Malta due to these countries no longer using government bond data of a peer country for the calculation of the Long-Term Average Spread (LTAS).
- **Paragraph 11.7.5 is amended with respect to:**
  Table 12 - Peer countries as issuers for the calculation of the long-term average spreads of government bonds
  The peer country for Latvia changes from Ireland to Slovakia as of 31 March 2026, while as of the same date Cyprus, Lithuania, and Malta will no longer use government bond data from a peer country due to the availability of their own government bond data (see change under Table 2).
  A bullet is added regarding the calculation of the long-term average spread following such changes.
- **Table 30 - CIC codes used to allocate assets**
  The following CIC codes and mappings have been added to the table:
  18 (Gov), 42,43,87,88 (Corp)
- **ANNEX F.15 - Historical overview of the government bond- and corporate bond-weights used for the representative portfolios**
  Overview updated with the currency- and country-weights which were applicable from 31 March 2025.

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LETTER OF THE EXECUTIVE DIRECTOR

Solvency II aims at implementing an economic and risk-based supervisory framework in the field of insurance and reinsurance. The framework is built upon three pillars, all equally relevant, that provide for quantitative requirements (Pillar 1), qualitative requirements (Pillar 2) and enhanced transparency and disclosure (Pillar 3).

The starting point in Solvency II is the economic valuation of the whole balance sheet, where all assets and liabilities are valued according to market consistent principles.

The risk-free interest rate term structure (hereafter in this letter, risk-free interest rate) underpins the calculation of liabilities by insurance and reinsurance undertakings. EIOPA is required to publish the risk-free interest rate.

This technical document sets out the basis on which it will do so. It is the result of collaboration between EIOPA's members and its staff.

As a default approach, the risk-free interest rate is primarily derived from the rates at which two parties are prepared to swap fixed and floating interest rate obligations. In the absence of financial swap markets, or where information of such transactions is not sufficiently reliable, the risk-free interest rate is based on the government bond rates of the country. The risk-free interest rates are:

- Calculated for different time periods, reflecting that the liabilities of insurance and reinsurance undertakings stretch years and decades into the future.
- Calculated in respect of the most important currencies for the EU insurance market.
- Adjusted to reflect that a portion of the interest rate in a swap transaction (or a government bond) will reflect the risk of default of the counterparty and hence without adjustment would not be risk-free.
- Based on data available from financial markets. For those periods in the more distant future for which data are not available, the rate is extrapolated from the point at which data are available to a macroeconomic long-term equilibrium rate.

An adjustment (the volatility adjustment) is made to the liquid part of the risk-free interest rate in order to reduce the impact of short-term market volatility on the balance sheet of undertakings. EIOPA is required to provide, both on a currency and country basis, the size of this adjustment for volatility.

A different adjustment (the matching adjustment) is made in respect of predictable portfolios of liabilities. An undertaking can assign to eligible portfolios assets with fixed cash flows that it intends to hold to maturity. EIOPA is required to provide an estimate of what portion of the spread of such assets above the risk-free interest rate reflects risks not faced by those who hold assets to maturity.

Many of the parameters of the risk-free rates are already determined in legislation. Some choices remain however, and in many cases more than one option is possible. The rationale for the key choices made by EIOPA is set out in section 1 (Basis for decision) of this technical documentation. The choices made by EIOPA, always within the limits set by EU legislation, are designed to secure the following objectives.

Replicability

EIOPA intends the risk-free rate interest rate to be capable of replication by undertakings and other interested parties, through this technical documentation. This will benefit undertakings for their own risk management and other purposes. One consequence of replicability is that the use of so-called “expert judgement” i.e., the exercise of discretion in the regular construction of the risk-free interest rate, has been kept to a minimum.

Market consistency

Whenever possible, data from deep, liquid, and transparent financial markets are used to construct the risk-free interest rate. Adopting such a market consistent approach helps foster transparency in insurance markets with a positive impact on understanding and trust, as well as helping create a level playing field by enabling the comparison between undertakings.

Solvency II reporting

The intended frequency of publication of the risk-free interest rate is monthly. Such a frequency will enable undertakings to have a common basis for calculating the value of the financial information they are required to report to their supervisor on a quarterly and annual basis.

Stability for insurance undertakings

EIOPA does not want to exacerbate volatility in the value of liabilities through unwarranted changes to the risk-free interest rate. Changes would naturally have to be justifiable on an EU-wide basis. The experience of those EIOPA members who have already produced risk-free interest rates is however that from time to time the case for change is made. Regardless of any earlier changes, there will also be a more formal stocktake, for example at the point at which the calibration of capital requirements under Solvency II is reviewed.

The risk-free rate interest rate is intended to be published from February 2015, to give undertakings time to prepare. EIOPA does not seek a timescale between publication of the risk-free interest rate and the requirement on undertakings to report that could trigger rapid sale or purchase of assets.

Policyholders

These objectives will not only benefit policyholders, but also replicability, market consistency, Solvency II reporting, and stability for undertakings. Next to that, it will make easier the valuation of undertakings and the work of supervisors.

The key components of the risk-free rate methodology are summarised in Table 1 below. They are explained in much greater detail, alongside other components, in the technical documentation.

Table 1 - The key components of the risk-free rate methodology

Component	Approach adopted by EIOPA
Assessment of deep, liquid, transparent market information	• Assessments by each EIOPA member or (for non-EEA currencies) analysis of market interest rates
Last liquid point (LLP)	• Euro: residual volume criterion • Other EEA currencies: assessment by each EEA member state • Non-EEA currencies: EIOPA assessment
Extrapolation	• Smith-Wilson method as applied in the Long-term Guarantees Assessment
Convergence maturity	• Euro: 60 years • Non-euro currencies: in general max {LLP+40Y; 60Y}
Volatility adjustment: calculation of risk correction	• Calculated in the same manner as the fundamental spread • For government bonds, based on the long-term average spreads over the basic risk-free interest rates term structure • For assets other than government bonds, based on the maximum of: - the long-term average spreads - a probability of default and cost of downgrade based on the projection of an average 1-year transition matrix
Matching adjustment: calculation of fundamental spread	• Separate calculation of a probability of default and cost of downgrade based on the projection of an average 1-year transition matrix

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 (hereinafter "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 with regard to the use that may be made of the information.

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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 to allow 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).

1.2.3. In accordance with recital 23 of the Commission Delegated Regulation (EU) 2015/35[1] (hereinafter “Delegated Regulation”), the present EIOPA technical documentation is published by EIOPA as part of the technical information published pursuant to Article 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.

[1] 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, p. 1)

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3. BASIS FOR DECISION

3.1. METHODOLOGICAL PRINCIPLES & ASSUMPTIONS

3.1.1. The development of the methodology to calculate the relevant risk-free interest rates term structures has required several decisions on the methods, assumptions, and inputs to use in that calculation.

3.1.2. EIOPA has based those decisions on the following principles:

a) respect to the essential elements underpinning the political agreement of Directive 2014/51/EU (Omnibus II Directive).
b) transparency of all the elements of the process of calculation.
c) replicability of the calculations, which has as a direct consequence the restriction of expert judgement to the minimum extent possible, if any,
d) market consistency, prudent assessment of the technical provisions and optimal use of market information.

GENERAL ISSUES

The following items describe the main decisions adopted, following the order of the topics contained in this technical documentation.

3.2. FINANCIAL MARKET DATA USED AS INPUTS

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

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 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 inputs ('direct input provider'), and the other for validation.

3.2.4. EIOPA has decided to use the same direct input provider for swaps and government bonds curves. EIOPA has selected different providers for yields of corporate bonds and for default statistics to reduce the operational risk and the dependence on the data providers.

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 to their needs.

3.3. USE OF MARKET DATA WITH MATURITIES OF LESS THAN ONE YEAR

3.3.1. EIOPA has decided to publish the relevant risk-free interest rates term structure from 1 year maturity onwards. Instruments with a maturity below 1 year are not always swaps and the adjustment of their credit risk, among other features, may add unnecessary complexity to the calculations. Furthermore, below 1-year rates have a negligible impact on the rates extrapolated with the Smith-Wilson method, and hence a negligible impact 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 analyzed the metrics and criteria commonly used for assessments of market liquidity and assessed their applicability for the purposes of setting a conceptual framework for the DLT assessment.

3.4.2. Having in mind that the National Competent Authorities have better knowledge of the financial markets of each currency, the DLT assessment of EEA currencies has been made by each National Competent Authority. All National Authorities applied the same methodology and reported their findings in a common template. Three main findings may be extracted from the set of lessons learnt:

a) The application of the common conceptual framework should not rely on hard thresholds and should not disregard qualitative information. In particular, a number of criteria are inter-linked 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, with the exception of crisis situations, frequent violent changes in the outputs of the DLT assessment do not seem plausible. Rather, a plausible future trend will be the development of financial markets and the extension of the market interest rates meeting DLT requirements (i.e., the use of market consistent information).

BASIC RISK-FREE INTEREST RATES TERM STRUCTURE

3.5. CREDIT RISK ADJUSTMENT (CRA)

3.5.1. The Delegated Regulation only covers the calculation of the CRA for those currencies with DLT swap markets and overnight swaps markets.

3.5.2. For currencies where either swaps or overnight swaps markets do not meet DLT requirements or currencies whose risk-free interest rates term structure is based on government bonds rates, EIOPA has applied the objective criteria described below in section 5, avoiding any margin for expert judgement.

3.5.3. Furthermore, EIOPA is aware of the initiatives in the Union for the development of more transparent financial markets for risk-free financial instruments.

3.6. EXTRAPOLATION METHOD

3.6.1. The interpolation, where necessary, and extrapolation of interest rates have been developed applying the Smith-Wilson method.

3.6.2. This method is of course not the only one possible method for the extrapolation of interest rates. All methods have their pros and cons.

3.6.3. The Smith-Wilson method has been applied during the last years of the development of the Solvency II framework, and in particular in the fifth Quantitative Impact Study (QIS5) and in the Long-term Guarantees Assessment (LTGA) that has underpinned the political agreement of the Omnibus II Directive.

3.6.4. EIOPA will however carefully monitor market developments, and their influence on the implementation of the Smith-Wilson method.

3.7. LAST LIQUID POINT (LLP)

3.7.1. The Delegated Regulation includes a specific recital for the determination of the LLP and the application of DLT requirements for the euro. Its sets out a criterion regarding the residual volume of bonds meeting DLT requirements (residual volume criterion). The criterion is precise except for the very specific market data to be used as input.

3.7.2. For currencies other than the euro, according to recital 30 of the Omnibus II Directive, the choice of the LLP should allow undertakings to match with bonds the cash flows which are discounted with non-extrapolated interest rates in the calculation of the best estimate. The application of this principle is currently challenging due to the limitation of the information available on cash flows from insurance and reinsurance obligations. Therefore, for currencies other than the euro, EIOPA is basing the LLP on the results of the DLT assessment, rather than developing that matching criterion at this stage.

3.8. CONVERGENCE POINT

3.8.1. The Omnibus II Directive explicitly reflects for the euro a convergence period of 40 years and a *LLP* of 20 years, which is equivalent to assuming that the forward rate will be close to its ultimate level from 20 + 40 = 60 years maturity onwards.

3.8.2. For currencies other than the euro, the convergence point is the maximum of (*LLP* + 40 years) and 60 years. This method is considered as the most stable, least influenced by expert judgement and the one with lowest impact on the level playing field between market participants.

3.8.3. In accordance with recital 30 of the Omnibus II Directive, the selected option keeps the allowance of different outcome for specific cases conditional on their adequate justification.

VOLATILITY ADJUSTMENT (VA) AND MATCHING ADJUSTMENT (MA)

3.9. FINANCIAL MARKET INPUTS FOR VA AND MA

3.9.1. The Delegated Regulation states that the manner in which the risk correction for the VA and the fundamental spread for the MA are calculated should be the same. EIOPA understands that the intention of the phrase 'in the same manner' in Article 51 is to cover all the elements of the calculation, including the data underlying it. This means that the same approach should be applied for both the risk correction and the fundamental spread. In particular, EIOPA has not used different market default and transition inputs for these calculations.

3.9.2. EIOPA has gathered inputs on bonds, using the following granularity: currency, credit quality, duration, and economic sector of the issuer. This segmentation is based on Article 77c of the Solvency II Directive.

3.10. FINANCIAL MARKET INPUTS FOR BOND YIELDS

3.10.1. EIOPA has elaborated a conceptual framework to apply to the maximum extent the use of market indices in the calculation of the VA as required in Article 49(3)(b) of the Delegated Regulation.

3.10.2. For this purpose, EIOPA maps the representative portfolios of assets to yields that are derived from yield curves and yield indices.

3.10.3. In the case of the euro currency VA, EIOPA has opted for a simplification in the use of indices for central government bonds: the replacement of the calculation based on all the government curves of the members of the euro area, by a single curve: the ECB yield curve, annual spot rates, with reference to all members of the euro area.

3.10.4. For non-euro currencies and for the purpose of the country-specific increase of the VA, the use of yield curves for each issuer of government bonds is necessary given the materially different degrees of home-bias.

3.10.5. Finally, in the case of other bonds (e.g., corporate bonds and collateralized bonds, etc.), a major challenge has been the availability of the information with the necessary granularity (maturities, ratings, economic sectors) for all relevant currencies.

3.11. INPUTS FOR THE CALCULATION OF THE LONG-TERM AVERAGE SPREAD

3.11.1. Article 54(3) of the Delegated Regulation sets out:

The long-term average referred to in Article 77c(2)(b) and (c) of Directive 2009/138/EC shall be based on data relating to the last 30 years. Where a part of that data is not available, it shall be replaced by constructed data. 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. The constructed data shall be based on prudent assumptions.

3.11.2. There is currently a lack of full 30 years of historical data for swaps and government bonds, for almost all currencies. Furthermore, overnight swap markets (whose short-term rates are necessary for the calculation of the credit risk adjustment), were active only since the end of the last century.

3.11.3. EIOPA has decided to construct the missing spread data for each currency and maturity using the average of the spread data that is available from 1 January 1985 or, failing that, whenever reliable spread data is first available. In practice, the lack of overnight swap rates has led to consider market data only from January 1999.

3.11.4. The same considerations apply to the floor for bonds other than central government and central banks bonds, with two further features that increase the practical difficulties:

a) For most EEA currencies there are no reliable yield term structures for corporate bonds.

b) For the euro, the curves currently provided by financial market data providers have a limited history.

3.11.5. For the selection of market providers, EIOPA has considered a decision process for central governments and central banks bonds and for other bonds (e.g., corporates), taking into account in particular the following:

a) the availability of historical data,

b) the market information and methodology behind the construction of the market indices (e.g., government and corporate bonds),

c) the granularity (e.g., buckets regarding the maturities, ratings, economic sectors, for bonds other than central governments and central banks).

3.12. CENTRAL GOVERNMENTS AND CENTRAL BANKS BONDS - CALCULATION OF THE LONG-TERM AVERAGE SPREAD

3.12.1. Depending on the period of observation, EIOPA has considered whether market data should be weighted for the calculation of the average referred to in Article 77c(2) of the Solvency II Directive.

3.12.2. Both in the LTGA and the EIOPA Stress Test 2014 a simple average was applied.

3.12.3. The allowance of adjustments to the simple average means to disregard market observations and embeds the use of material expert judgement. This option lacks legal basement and has been rejected due to the subjective assumptions required.

3.12.4. Furthermore, EIOPA believes that assuming a flat curve as reconstructed history (e.g., for the euro before 1 January 1999) is the most neutral choice as well as being in line with the Solvency II Directive and in particular the political agreement on the Omnibus II Directive. The level should be equal to the simple and unadjusted average of the available market spreads.

3.13. METHODOLOGY OF CALCULATION OF THE SPREAD BEFORE RISK CORRECTION, FOR CURRENCIES WHERE YIELD TERM STRUCTURES ARE NOT AVAILABLE

3.13.1. For most of the EEA currencies either there are no available interest rate term structures for the assets relevant to determine S_{corp}[2] or the number of potential underlying assets to build such curves is rather low. Market data providers only produce corporate yield curves for a few EAA currencies (just the most developed financial markets).

3.13.2. In absence of empirical data, EIOPA has decided to apply the following formulas which are based on the approach already applied in the LTGA:

$$S_{corp}^{X} = S_{corp}^{€} + \kappa \cdot \left(Y_{rfr}^{X} - Y_{rfr}^{€}\right)$$

$$Y_{corp}^{X} = Y_{corp}^{€} + (1+\kappa) \cdot \left(Y_{rfr}^{X} - Y_{rfr}^{€}\right)$$

[2] According to Article 50 of the Delegated Regulation, S_{corp} denotes the average currency spread on bonds other than governments bonds, loans and securitizations included in the reference portfolio of assets for that currency or country.

where € denotes the euro, X refers to a currency without yield term structures for the assets relevant for the spread S_{corp}, Y_{corp} denotes the yield of the respective corporate bonds of the same credit quality, Y_{rfr} denotes the basic risk-free interest rate and κ is equal to 0.5. The inputs of this formula are maturity dependent according to the information available.

3.13.3. This approach is based on the following rationale: spreads might be better reflected by spreads derived from the basic risk-free rates than using no data. In addition, this method is simple and, where necessary, immediately applicable to all published currencies in a consistent manner.

3.13.4. Further than its simplicity and traceability, this formula guarantees that for each currency their 'notional' yield curves for corporates will behave - compared to the basic risk-free interest rates term structure - similarly to the main currency where corporate yield term structures for the euro are available for a number of years.

3.13.5. Setting $\kappa = 0.5$ seems the best proxy for a formula to be applied to all relevant currencies. This proxy provides a central estimate and ensures that differences with the more accurate and complex calculation are reduced to the maximum extent possible using a simple and implementable approach.

3.14. GRANULARITY OF YIELD INFORMATION FOR BONDS OTHER THAN CENTRAL GOVERNMENT AND CENTRAL BANK BONDS

3.14.1. An appropriate granularity according to maturities, ratings and economic sectors has been adopted in order to adequately capture the different behavior of spreads (e.g. of financial and non-financial bonds).

4. GOVERNANCE AND CONTROLS OF THE PROCESS OF CALCULATION AND PUBLICATION

4.1. ESSENTIAL ELEMENTS OF EIOPA'S OPERATIONAL FRAMEWORK

4.1.1. EIOPA has established internal governance arrangements in order to define the essential elements of the operational framework such as:

a) The period after which the technical information shall be published
b) Definition of the functions involved
c) The resources necessary for running the process and the registers and logs for recording
d) Internal controls to safeguard the process used built on 'four eyes' principle
e) The frequency of activities, in particular audits, reviews, and internal controls
f) Definition in a limitative manner of the areas where expert judgement in the process is allowed (e.g. some areas of the DLT assessment). In that case, the documentation of the expert judgement includes its content, link to the authorized scope, validation, internal control, and log of escalation, to ascertain that, in accordance with the EIOPA regulation, such expert judgement is independently exercised, it acts in the interest of the Union, enhances the protection of policyholders, and fosters a level playing field of the EU insurance market.
g) Definition of the specific process to follow new information might advise the review of the technical information already published. EIOPA rules on public consultation will apply to the review of this technical documentation,
h) Contingency plans for continuing the publication of the technical information in case of unexpected events
i) Rules to record, store and report exceptional events in the development of any of the steps of the process (process events, IT events, financial market data events, etc.)
j) Establishment of an oversight function and of a control function ensuring that the technical information is provided and published or made available in accordance with the methodology, assumptions and inputs approved by EIOPA.

4.1.2. EIOPA's framework regarding code of conduct and conflict of interests applies to all the persons involved in the process in any function. All these persons must declare and sign the relevant documentation at least every year, and as soon as any factual or potential, current or foreseeable, conflict of interest appears or may appear.

4.1.3. EIOPA has not approved and does not envisage approving, the outsourcing of any function or activity of the process for the calculation and publication of the technical information, other than the collection of data of financial markets from generally used financial providers, and the outsourcing applied to some parts of the IT systems of EIOPA.

5. DATA SOURCES FOR THE INPUTS FROM FINANCIAL MARKETS

5.1. FINANCIAL MARKET DATA PROVIDERS

5.1.1. To mitigate the operational risks of a market provider failure, the calculation of the technical information should not over-rely on a single market source.

5.1.2. A first way to ensure this would be to derive each input using data obtained from a range of providers. A second 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.

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

5.1.4. EIOPA has no evidence of the superiority of a concrete market data provider. The choice of market data providers included in this technical documentation are disclosed only for the purposes of transparency (recital 23 of the Delegated Regulation).

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

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

a) Swaps and overnight indexed swaps: Refinitiv
b) Government bonds: Refinitiv and ECB[3]
c) Bonds other than government bonds: Markit – iBoxx indices and, for Danish covered bonds, Refinitiv
d) Default statistics: Standard & Poor's

5.1.7. The market data inputs will be analyzed under the relevant review process according to section 2.

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

5.2. SELECTION OF THE RELEVANT CURRENCIES

5.2.1. EIOPA applies the following criteria to select the currencies (and countries for the country specific increase of the volatility adjustment) for which technical information is published:

- all currencies and countries of the EEA,
- all 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.

5.2.2. The list of relevant currencies and, where applicable, countries can be found in ANNEX A.

5.2.3. 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.

5.3. SELECTION OF MARKET RATES

5.3.1. 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. EIOPA is aware of the initiatives in the Union to develop in the future risk-free instruments traded on deep, liquid, and transparent markets.

5.3.2. EIOPA applies the financial references in the table below from the market data provider selected.

5.3.3. The last column of the table specifies whether the financial instruments applied are either swaps or government bonds. For a clear identification of swaps, the floating leg is also included.

5.3.4. In the process of the calculation of the basic risk-free interest rate term structures, the RICs for government bonds are used only for the currencies with 'GVT' in the 'GVT/SWP' column. The inputs to the process of the calculation of the volatility and matching adjustments regarding government bonds are also based on the information referred to in the table below.

Table 2 - Swap and government bond RICs used for the derivation of the technical information

COUNTRY	ISO 3166	ISO 4217	GVT/SWP/OIS	SWP RIC	SWP FREQ	GVT RIC
Euro	-	EUR	SWP	EURAB6EIRS=	1	ECB (see 5.3.8)
Austria	AT	EUR	SWP	EURAB6EIRS=	1	0#ATXZ=R
Belgium	BE	EUR	SWP	EURAB6EIRS=	1	0#BEXZ=R
Bulgaria	BG	EUR	SWP	EURAB6EIRS=	1	0#BGXZ=R
Croatia	HR	EUR	SWP	EURAB6EIRS=	1	0#HRXZ=R
Cyprus	CY	EUR	SWP	EURAB6EIRS=	1	0#CYXZ=R
Czechia	CZ	CZK	SWP	CZKAM6PRIRS=	1	0#CZXZ=R
Denmark	DK	DKK	SWP	EURAB6EIRS=	1	0#DKXZ=R
Estonia	EE	EUR	SWP	EURAB6EIRS=	1	
Finland	FI	EUR	SWP	EURAB6EIRS=	1	0#FIXZ=R
France	FR	EUR	SWP	EURAB6EIRS=	1	0#FRXZ=R
Germany	DE	EUR	SWP	EURAB6EIRS=	1	0#DEXZ=R
Greece	GR	EUR	SWP	EURAB6EIRS=	1	0#GRXZ=R
Hungary	HU	HUF	GVT	HUFAB6BIRS=	1	0#HUXZ=R
Iceland	IS	ISK	GVT			0#ISXZ=R
Ireland	IE	EUR	SWP	EURAB6EIRS=	1	0#IEXZ=R
Italy	IT	EUR	SWP	EURAB6EIRS=	1	0#ITXZ=R
Latvia	LV	EUR	SWP	EURAB6EIRS=	1	0#LVXZ=R
Liechtenstein	LI	CHF	OIS	CHFOIS=	1	0#CHXZ=R
Lithuania	LT	EUR	SWP	EURAB6EIRS=	1	0#LTXZ=R
Luxembourg	LU	EUR	SWP	EURAB6EIRS=	1	
Malta	MT	EUR	SWP	EURAB6EIRS=	1	0#MTXZ=R
Netherlands	NL	EUR	SWP	EURAB6EIRS=	1	0#NLXZ=R
Norway	NO	NOK	SWP	NOKAB6OIRS=	1	0#NOXZ=R
Poland	PL	PLN	GVT			0#PLXZ=R

COUNTRY	ISO 3166	ISO 4217	GVT/SWP/OIS	SWP RIC	SWP FREQ	GVT RIC
PORTUGAL	PT	EUR	SWP	EURAB6EIRS=	1	0#PTXZ=R
ROMANIA	RO	RON	GVT			0#ROXZ=R
SLOVAKIA	SK	EUR	SWP	EURAB6EIRS=	1	0#SKXZ=R
SLOVENIA	SI	EUR	SWP	EURAB6EIRS=	1	0#SIXZ=R
SPAIN	ES	EUR	SWP	EURAB6EIRS=	1	0#ESXZ=R
SWEDEN	SE	SEK	SWP	SEKAB3SIRS=	1	0#SEXZ=R
SWITZERLAND	CH	CHF	OIS	CHFOIS=	1	0#CHXZ=R
UNITED KINGDOM	GB	GBP	OIS	GBPOIS=	1	0#GBXZ=R
AUSTRALIA	AU	AUD	SWP	AUDSM6ABIRS=	2	0#AUXZ=R
CANADA	CA	CAD	OIS	CADOIS=	2	0#CAXZ=R
CHINA	CN	CNY	SWP	CNYQM7RIRS=	4	0#CNXZ=R
COLOMBIA	CO	COP	GVT			0#COXZ=R
HONG KONG	HK	HKD	SWP	HKDQM3HIRS=	4	0#HKXZ=R
JAPAN	JP	JPY	OIS	JPYOIS=	1	0#JPXZ=R
TAIWAN	TW	TWD	GVT			0#TWXZ=R
UNITED STATES	US	USD	OIS	USDSROIS=	1	0#USXZ=R

5.3.5. These swap and government bond RICs are general RICs describing the specific instruments and their available tenor points within Refinitiv’s data universe. To access specific tenor points, use is made of tenor specific RICs according to the following conventions:

a) for SWP plain vanilla 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 of interest.
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 ISO4217-code and XX is analogue to the SWP IRS tenor coding convention. For example: “JPY10YOIS=” is the Japanese Yen 10 Year TONAR 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 ISO3166-code and XX is analogue to the SWP tenor coding convention. Example: "USGOV5YZ=R" is the RIC for the 5-year USD zero government bond yield of interest.

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

5.3.7. 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.

5.3.8. Although the EUR zero government bond yields are available from Refinitiv (RIC: 0#EUGOVZBMK=ECB), it should be noted that the underlying data are not always perfectly aligned with the ECB Euro-Area-All-Bonds source data available from the ECB statistical data warehouse (SDW). Therefore, the EUR zero government bond yields are being downloaded directly from the ECB SDW.

5.3.9. Specific cases are:

a) For those non-euro countries with contracts where the benefits guaranteed to the policy holders are valued in euro while the payments (including the evolutions of the exchange rate) are in the local currency, the term structure is derived on the basis 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.

6. BASIC RISK-FREE INTEREST RATE TERM STRUCTURES

6.1. IDENTIFICATION AND DLT-ASSESSMENT OF RELEVANT FINANCIAL INSTRUMENTS

6.1.1. 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 recital 21, Article 1(32), (33) and (34), and Articles 43, 44 and 46 of the Delegated Regulation. The identification of the relevant financial instruments is based on a DLT assessment.

6.1.2. The inputs for the DLT assessment are market data on interest rate swap rates, government bond rates and corporate bond rates. These are obtained from market data providers whose services are also available to insurance and reinsurance undertakings.

6.1.3. The output of the DLT assessment is a list, for each currency, of the maturities for which the market of the relevant financial instrument is considered DLT including the identification of the last maturity for which rates can be observed in DLT markets (section 7.B refers to the determination of the last liquid point (*LLP*)).

6.2. CONCEPTUAL FRAMEWORK FOR EEA CURRENCIES

6.2.1. In a first step, an initial DLT assessment for EEA currencies is carried out by the relevant National Competent Authorities except for the selection of the intermediate DLT points for swaps which is performed by EIOPA.

6.2.2. In a second step, EIOPA has a process in place aimed at ensuring homogeneity across national assessments and preserving a level playing field.

6.2.3. The relevant financial instruments for EEA currencies that are currently used to derive the term structures were identified based on a DLT assessment carried out in 2025.

6.2.4. The table below sets out the instruments and tenors used for the derivation of the basic risk-free interest rate term structures. The entries identify the instrument used: S=Interest rate swap, B=government bond, «empty»=no DLT markets for this maturity available. The last non-empty entry defines the *LLP*. No market data beyond the *LLP* is used. Hence, no further entries are shown in the table, even if single maturities beyond the LLP might be considered as meeting DLT criteria.

6.2.5. For the Danish krone no DLT assessment is made. Since this currency is pegged to the euro, its basic risk-free interest rates are based on the DLT assessment for the euro.

6.2.6. The relevant risk-free interest rates are based on market data for integer maturities from one year onwards.

Table 3 - EEA currencies: instruments and tenors used for the derivation of the basic risk-free interest rate term structures

	EUR	CHF	NOK	PLN	ISK	RON	SEK	CZK	HUF
1Y	S	S		B	B	B	S	S	B
2Y	S	S	S	B		B	S	S	B
3Y	S			B	B	B	S	S	B
4Y	S			B		B			B
5Y	S	S	S	B	B	B	S	S	B
6Y	S			B		B			B
7Y	S	S		B		B			B
8Y	S			B		B			B
9Y	S			B	B				B
10Y	S	S	S	B		B	S	S	B
11Y	S								B
12Y	S								B
13Y	S								B
14Y	S								B
15Y	S							S	B
20Y	S								

6.3. CONCEPTUAL FRAMEWORK FOR NON-EEA CURRENCIES

6.3.1. The DLT assessment for non-EEA currencies is carried out using a specific approach based on the empirical evidence provided by market information on the behavior of the relevant rates. The empirical evidence is assessed using a twofold approach (see ANNEX 0 to this subsection for a more detailed explanation):

a) volatility analysis.
b) analysis of the bid-ask spread.

The analysis of bid-ask spread is carried out for all currencies using both the observed bid-ask spread and an approximation of the Roll measure, as applied in EBA's report on high quality liquid assets (HQLA)[4].

6.3.2. The two aforementioned approaches are supported by three toolkits:

a) Chart analysis, consisting of analysis of volatility and analysis of bid-ask spread with the Roll measure.
b) Quantitative analysis.
c) Qualitative analysis.

6.3.3. Where these approaches do not provide conclusive results, the market is not deemed to be DLT. Consequently, the interest rate for the affected maturity and currency is disregarded as input.

6.3.4. The swap markets for two non-EEA currencies do not meet the DLT requirements. For the time being, according to the Delegated Regulations, the risk-free interest rate term structures of those currencies are based on government bond rates.

[4] 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, http://www.eba.europa.eu/documents/10180/16145/EBA+BS+2013+413+Report+on+definition+of+HQLA.pdf

Table 4 - Non-EEA currencies: Tenors of government bonds used for the derivation of the basic risk-free interest rate term structures

Country	Currency	1	2	3	4	5	6	7	8	9	10
COLOMBIA	COP	•	•	•	•	•	•	•	•	•	•
TAIWAN	TWD	•	•	•	•	•	•	•	•	•	•

Table 5 – Non-EEA currencies: tenors of interest rate swaps used for the derivation of the basic risk-free interest rate term structures

Country	Currency	1	2	3	4	5	6	7	8	9	10	11	12	13	15	20	25	30	40	50
AUSTRALIA	AUD	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•		
CANADA	CAD	•	•	•	•	•					•							•		
CHINA	CNY	•	•	•	•	•					•									
HONG KONG	HKD	•	•	•		•					•				•					
JAPAN	JPY	•	•	•		•		•			•					•		•		
UNITED STATES	USD	•	•	•	•	•	•	•	•	•	•		•		•	•	•	•		
UNITED KINGDOM	GBP	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

6.4. UPDATE OF THE DLT ASSESSMENT

6.4.1. 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.

6.4.2. The changes resulting from the DLT assessment will be implemented after a warning period of up to three months. The duration of the warning 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.

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

6.5. CURRENCIES WITHOUT DLT FINANCIAL INSTRUMENTS

6.5.1. 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.

6.5.2. 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.

6.5.3. For that purpose, the use of the basic risk-free interest rate term structures of economies sufficiently similar or inter-linked, 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.

7. CREDIT RISK ADJUSTMENT

7.1. LEGAL FRAMEWORK

7.1.1. The calculation of the credit risk adjustment has been developed in accordance with recital 20 and Article 45 of the Delegated Regulation.

7.2. APPLICATION OF THE ADJUSTMENT

7.2.1. The credit risk adjustment (CRA) is applied as a parallel downward shift of the market rates observed for maturities up to the last liquid point.

7.2.2. Regarding swaps, the CRA is applied to the observed par swap rates before deriving zero coupon rates. In the case of risk-free interest rate term structures based on government bond rates, the input rates are already zero-coupon rates. The credit risk adjustment is applied to those government bonds rates.

7.2.3. The credit risk adjustment may lead to negative interest rates (i.e., there is no floor for the adjusted rates).

7.2.4. In the case of risk-free interest rate term structures based on overnight indexed swaps (OIS), no CRA is applied due to negligible credit risk.

7.3. CALCULATION OF THE CREDIT RISK ADJUSTMENT

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

FIRST SITUATION

7.3.2. In the first situation, the risk-free interest rate term structure is based on swap rates and the relevant overnight indexed swap (OIS) rate meets the DLT requirements.

7.3.3. In this case the approach prescribed in Article 45 of the Delegated Regulation for the credit risk adjustment 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 legs of the swap instruments 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 floating legs that refer to the three month IBOR, and consequently the 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 giving equal weight to all the observations.

7.3.4. In cases where market data is missing for either the interbank offered rate or for the relevant OIS rate, the missing data are 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.

SECOND SITUATION

7.3.5. 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.

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

7.3.7. A second specific case is the Swiss franc. As Liechtenstein is an EEA member, the CHF shall be treated as specified in paragraph 98.

THIRD SITUATION

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

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

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

r_t^{Euro}: the input-rates for calculating the risk-free 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.

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

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

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

7.3.12. As the number of remaining currencies might change from year to year the threshold level of the CRA will be reviewed from year to year depending on the number of remaining currencies for the third situation.

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

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

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

7.4. DATA SOURCES FOR THE CREDIT RISK ADJUSTMENT

7.4.1. The following table lists the currencies for which monthly the criteria set out in paragraph 7.3.4 are checked. In case there are sufficient swap data and overnight indexed swap data, the first situation described above applies and the CRA is calculated with interbank offered rates and OIS rates specified in Table 6.

Table 6 - 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=

Note: 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.

8. CURRENCY RISK ADJUSTMENT FOR CURRENCIES PEGGED TO THE EURO

8.1. LEGAL FRAMEWORK

8.1.1. 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.

8.2. APPLICATION OF THE ADJUSTMENT

8.2.1. The currency risk adjustment is applied in addition to, and in the same way as the credit risk adjustment (see section 5).

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

8.3. CALCULATION OF THE ADJUSTMENT

8.3.1. According to Article 48(2) of the Delegated Regulation, the currency risk adjustment 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.

8.3.2. In line with that provision, the currency risk adjustment for the relevant currency is based on the following formula:

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

where:

- *CurrencyRA* 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 the implementing technical standard with regard to

the adjusted factors to calculate the capital requirement for currency risk for currencies pegged to the euro

- *BE* denotes the best estimate
- *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 currency risk adjustment is calculated with regard to 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.

8.3.3. The rationale of the formula is as follows:

a) 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.
b) 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.
c) 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:

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

d) 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.

8.3.4. The current calibration of the currency risk adjustment for the Danish krone is based on data from EIOPA's 2014 insurance stress test. The following approximation was used for this purpose:

$$CurrencyRA =$$

$$-factor \cdot \left(\frac{BE_L + BE_{NL}}{SCR(0)_L + SCR(0)_{NL}}\right)\left(\frac{BE_L \cdot LAC_L + BE_{NL} \cdot LAC_{NL}}{BE_L \cdot Duration_L + BE_{NL} \cdot Duration_{NL}}\right)\left(\frac{RM_L + RM_{NL}}{TP_L + TP_{NL}}\right)$$

where the subscripts L and NL identify amounts that relate to life and non-life insurance obligations respectively.

8.4. UPDATE OF THE ADJUSTMENT

8.4.1. EIOPA will monitor the currency risk adjustment on an annual basis by means of the formula set out in paragraph 8.3.2. The currency risk adjustment will only be amended where the difference to the formula result is material. When updates are necessary, they will be implemented end-January.

9. EXTRAPOLATION AND INTERPOLATION

9.1. EXTRAPOLATION AND INTERPOLATION METHOD

9.1.1. For each currency the basic risk-free interest rate term structure is constructed from risk-free interest rates for a finite number of maturities. Both the interpolation between these maturities, where necessary, and the extrapolation beyond the last liquid point are based on the Smith-Wilson methodology. This methodology is described in subsections 9.5 to 9.14.

9.1.2. The control input parameters for the interpolation and extrapolation are the last liquid point, ultimate forward rate (UFR), the convergence point and the convergence tolerance. These parameters are specified in subsections 9.2 to 9.4. The control parameters will not be updated on a monthly basis.

9.1.3. To apply the Smith-Wilson method, a cash-flow matrix is derived from the observed market interest rate data. This is further explained in subsection 9.15. The Smith-Wilson method takes care that the present value function of the derived term structure exactly agrees with the empirical data for the observable maturities.

9.1.4. If the reference instruments are swap rates, the market interest rates to be used as inputs are the swap par rates after deduction of the credit and currency risk adjustments described in sections 7 and 8. If the reference instruments are zero coupon government bonds, the market interest rates to be used as inputs are the zero-coupon rates after deduction of the credit and currency risk adjustments.

9.1.5. The derivation of the term structures is based on the rates for the DLT maturities set out in section 5. Where for a certain day one or several of those rates are not available, the term structure is derived based on the remaining rates, provided that not more than 20% of rates are missing and the rate at the last liquid point is available. Otherwise, the market information of the preceding trading day is used to derive the term structure.

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

9.2. LAST LIQUID POINT

9.2.1. Recital 21 of the Delegated Regulation defines a criterion (referred to as the residual volume criterion) to calculate the *LLP*. The residual volume criterion is used to derive the *LLP* for the euro only. For that currency, it gives an *LLP* of 20 years.

9.2.2. For all other currencies, the *LLP* has been chosen according to the results of the DLT assessment. It is the longest maturity for which risk-free interest rates can be derived from DLT markets.

Table 7 - Last liquid points of EEA currencies

CURRENCY	ISO 4217	LLP
Euro	EUR	20
Swiss franc	CHF	10
Czech koruna	CZK	15
Danish krone	DKK	20
Hungarian forint	HUF	15
Icelandic króna	ISK	9
Norwegian krone	NOK	10
Polish zloty	PLN	10
Romanian leu	RON	10
Swedish krona	SEK	10

Table 8 - Last liquid points of non-EEA currencies

CURRENCY	ISO 4217	LLP
AUSTRALIAN DOLLAR	AUD	30
CANADIAN DOLLAR	CAD	30
CHINESE YUAN RENMINBI	CNY	10
COLOMBIAN PESO	COP	10
HONG KONG DOLLAR	HKD	15
JAPANESE YEN	JPY	30
POUND STERLING	GBP	50
NEW TAIWAN DOLLAR	TWD	10
US DOLLAR	USD	30

9.2.3. The *LLP* will be updated together with the DLT assessment.

9.3. ULTIMATE FORWARD RATE

9.3.1. The methodology to derive the UFRs is set out in ANNEX E - *Methodology for the derivation of the UFR*. The UFRs will be calculated in accordance with that methodology on an annual basis and updated when they are sufficiently different from the then applicable UFRs.

9.4. CONVERGENCE POINT AND TOLERANCE

9.4.1. The convergence point is the maximum of (*LLP*+40) and 60 years. Consequently, the convergence period is the maximum of (60-*LLP*) and 40 years.

9.4.2. The parameter alpha that controls the convergence speed is set at the lowest value that produces a term structure reaching the convergence tolerance of the UFR by the convergence point. The convergence tolerance is set at 1 bp. A lower bound for alpha is set at 0.05. The convergence criterion is assessed by EIOPA with a scanning procedure with six decimals precision for alpha. The method for deriving alpha is illustrated in the Excel tool “Smith-Wilson Risk-free Interest Rate Extrapolation” that can be found on EIOPA’s website.

9.4.3. In accordance with recital 30 of the Omnibus II Directive, it is possible to account for specific cases in the derivation of the convergence period, provided they are adequately justified. In view of the characteristics of the Swedish bond market, EIOPA has decided to use a convergence period of ten years for the Swedish krona.

9.5. DESCRIPTION OF THE SMITH-WILSON METHOD WITH INTENSITIES

9.5.1. By way of introduction, an annual interest rate *r* is considered that defines an annual interest factor $R = (1 + r)$. From this a continuous-time interest intensity $\rho = \log{(R)}$ can be defined.[5] Negative interest rates are allowed, but the conditions $r > -1$ or $R > 0$ should be met. Only the interest intensity ρ is unrestricted and this makes it convenient for modelling purposes. In this documentation the concise term intensity instead of instantaneous rate or infinitesimal rate is used to avoid ambiguity with annualized interest rates.

9.5.2. With a constant ρ the present value of an amount of 1 maturing after *v* years would be just $p(v) = \exp{(-v\rho)}$. Since interest intensities usually depend on the term to maturity, it is of interest to analyze present values with changing interest intensity. The yield intensity function is what would be the average flat interest intensity:

$$p(v) = \exp\big(-v \cdot y(v)\big) \Leftrightarrow y(v) = \frac{-\log\, p(v)}{v}$$

9.5.3. The forward intensity function measures the change in the present value function:

$$f(v) = \frac{-\mathrm{d}\log\, p(v)}{dv} = \frac{-p'(v)}{p(v)}$$

9.5.4. The yield function can also be written as an averaged integral of the forward function:

$$y(v) = \frac{1}{v}\int_0^v f(z)dz$$

[5] The “log” function is to be understood as the natural logarithm. This is the case throughout the document.

9.5.5. For the forward and yield curve there holds that $y(0) = f(0)$, the zero-spot intensity. Also in the limit $y(\infty) = f(\infty)$ is obtained, what is the ultimate forward intensity. Furthermore, any turning point of the yield curve will be crossed by the forward curve. This similarity with average and marginal cost curves is mentioned by McCulloch (1971), page 24.[6]

9.5.6. A parallel shock in the forward intensity curve will translate as the same parallel shock in the yield intensity curve. This property does not transpose to annualized interest rates, however.

9.6. A SIMPLE ECONOMETRIC MODEL

9.6.1. Nelson & Siegel (1987)[7] proposed as a model for the forward intensity:

$$f(v) = \beta_1 + \beta_2 e^{-\alpha v} + \beta_3 \alpha v e^{-\alpha v}$$

9.6.2. The implied yield curve follows as an averaged integral using the formula of paragraph 9.5.4:

$$y(v) = \beta_1 + \beta_2 \left(\frac{1 - e^{-\alpha v}}{\alpha v} \right) + \beta_3 \left(\frac{1 - e^{-\alpha v}}{\alpha v} - e^{-\alpha v} \right)$$

and the implied present value function follows using the formula of paragraph 9.5.2:

$$p(v) = exp\left(-\beta_1 v - (\beta_2 + \beta_3) \left(\frac{1 - e^{-\alpha v}}{\alpha} \right) + \beta_3 v e^{-\alpha v} \right)$$

9.6.3. Diebold & Li (2006)[8] extend this Nelson-Siegel model by incorporating a change process through calendar time t. This enables them to forecast future yield curves. Compared with Nelson-Siegel, Smith & Wilson (2001)[9] start the other way around. They propose a model for the present value function, from which the yield and forward intensity function follow. The specification of this present value function

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[6] McCulloch, J Huston, 1971." Measuring the term structure of interest rates". The Journal of Business, University of Chicago Press vol. 44(1) 19-31, January.

[7] Nelson, Charles R & Siegel, Andrew F, 1987." Parsimonious Modelling of yield curves". The Journal of Business, University of Chicago Press vol. 60(4) 473-489, October.

[8] Diebold, Francis X & Li, Canlin (2006)." Forecasting the term structure of government bond yields". Journal of Econometrics vol. 130 337-364.

[9] Smith, A & Wilson, T (2001)." Fitting yield curves with long term constraints". London: Bacon & Woodrow.

needs a special type of function, known as Wilson function, which we will focus on next.

9.7. WILSON FUNCTION

9.7.1. The Wilson function $W(u,v)$ can be specified as:

$$W(u,v) = e^{-\omega(u+v)}H(u,v) = e^{-\omega u}H(u,v)e^{-\omega v}$$

where $H(u,v)$ is the heart of the Wilson function:

$$\begin{aligned} H(u,v) &= \alpha\, min(u,v) - exp(-\alpha\, max(u,v)) \cdot sinh(\alpha\, min(u,v)) \\ &= \alpha\, min(u,v) + \frac{e^{-\alpha(u+v)} - e^{-\alpha|u-v|}}{2} \\ &= \frac{\alpha(u+v) + e^{-\alpha(u+v)} - \alpha|u-v| - e^{-\alpha|u-v|}}{2} \end{aligned}$$

9.7.2. Here α and ω are parameters that have a dimension reciprocal to that of the time duration to maturity *u* and *v* that we take the year and measured as number of days divided by 365.25.

9.7.3. The parameter ω denotes the ultimate forward intensity and takes the value *log(*1.042*)* in case the ultimate forward rate equals 4.2%. The parameter α controls the speed of convergence to this asymptotic level.

9.7.4. This H-function and its first two derivatives happen to be continuous at $u = v$:

$$H(u,v) = \alpha\, min(u,v) - exp(-\alpha\, max(u,v)) \cdot sinh(\alpha\, min(u,v))$$

Differentiation with respect to v gives:

$$\frac{dH(u,v)}{dv} = G(u,v) = \begin{cases} \alpha - \alpha e^{-\alpha u} cosh(\alpha v) & v \le u \\ \alpha e^{-\alpha v} sinh(\alpha u) & u \le v \end{cases}$$

For the second order derivative the following is obtained:

$$\frac{d^2H(u,v)}{dv^2} = \alpha^2 H(u,v) - \alpha^3 min(u,v)$$

However, the third derivative shows a discontinuity at $u = v$.

9.8. MATRICES AND VECTORS

9.8.1. Matrices and vectors will be boldface. Transposition is indicated by a prime and $\circ$ denotes element-wise multiplication of conformable matrices. **1** and **0** will denote column vectors with all components equal to 1 and 0 respectively, and of appropriate order.

9.8.2. A vector u for the *m* observed durations to maturity is introduced, as well as an *m*×*n* matrix ***C*** that for the cash-flows of the *n* financial instruments:

$$\boldsymbol{u} = \begin{bmatrix} u_1 \\ u_2 \\ \vdots \\ u_m \end{bmatrix} \qquad \boldsymbol{C} = \begin{bmatrix} c_{11} & c_{12} & \cdots & c_{1n} \\ c_{21} & c_{22} & \cdots & c_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ c_{m1} & c_{m2} & \cdots & c_{mn} \end{bmatrix} \qquad c_{ij} \geq 0$$

The derivation of these items is explained in the following sub-section 9.15.

9.8.3. Nonlinear functions of vectors will indicate by square brackets the component-wise operation as in:

$$\mathbf{d} = \exp[-\omega\mathbf{u}] = \begin{bmatrix} e^{-\omega u_1} \\ e^{-\omega u_2} \\ \vdots \\ e^{-\omega u_m} \end{bmatrix} \qquad p[\mathbf{u}] = \begin{bmatrix} p(u_1) \\ p(u_2) \\ \vdots \\ p(u_m) \end{bmatrix} \qquad \sinh[\alpha\mathbf{u}] = \frac{1}{2}\begin{bmatrix} e^{\alpha u_1} - e^{-\alpha u_1} \\ e^{\alpha u_2} - e^{-\alpha u_2} \\ \vdots \\ e^{\alpha u_m} - e^{-\alpha u_m} \end{bmatrix}$$

9.8.4. An auxiliary matrix $\boldsymbol{Q} = \boldsymbol{d}_{\Delta}\boldsymbol{C}$ will be needed where the subscript Δ denotes transforming a column vector into a diagonal matrix such that $\boldsymbol{d}_{\Delta}\mathbf{1} = \boldsymbol{d}$. Furthermore, there are the following three column vectors with *n* components:

$$\boldsymbol{b} = \begin{bmatrix} b_1 \\ b_2 \\ \vdots \\ b_n \end{bmatrix} \qquad \mathbf{p} = \begin{bmatrix} p_1 \\ p_2 \\ \vdots \\ p_n \end{bmatrix} \qquad \mathbf{q} = \begin{bmatrix} q_1 \\ q_2 \\ \vdots \\ q_n \end{bmatrix} = \boldsymbol{Q}'\,\mathbf{1} = \boldsymbol{C}'\,\boldsymbol{d}$$

Here **b** is an auxiliary matrix and **p** contains the *n* observed market prices for the *n* financial instruments that will be compared with the *m* components of the present values in $p[\mathbf{u}]$.

9.8.5. The data can be stored in an (*m*+1)×(*n*+1) tableau containing **C** bordered by **u** and the transpose of **p**:

$$\begin{bmatrix} \mathbf{p}' & \\ \mathbf{C} & \mathbf{u} \end{bmatrix}$$

Without loss of generality the rows of this tableau may be ordered according to the components of **u** such that there holds $u_1 < u_2 < \cdots < u_m$. Likewise the columns of this tableau can be ordered such that **C** will be as upper-triangular as possible. Such a canonical format will be useful for validation purposes but is not of any importance for the mathematical formulations.

9.8.6. Zero-rows in **C** can be deleted from the tableau without loss of generality. In case of non-deletion this will imply zero components in the output vector **Qb** at the appropriate places.

9.8.7. The tableau, whether canonical or not, can be normalized by dividing the columns by the appropriate component of **p**, that is post-multiplying with the inverse of $\mathbf{p}_\Delta$:

$$\begin{bmatrix} \mathbf{1}' & \\ \mathbf{C}\mathbf{p}_\Delta^{-1} & \mathbf{u} \end{bmatrix}$$

9.8.8. In case of zero-coupon bonds, the canonical format makes **C** a diagonal matrix that can be normalized to the identity matrix **I**, resulting in a canonical normalized tableau:

$$\begin{bmatrix} \boldsymbol{p}' & \\ \boldsymbol{I} & \boldsymbol{u} \end{bmatrix}$$

9.8.9. Of course, this case does not need a data tableau, but just **u** and **p**. In what follows, data are not assumed to have a canonical or normalized format, such that the exposition holds in full generality.

9.9. WILSON MATRIX AND H-MATRIX

9.9.1. On that basis of the definitions made above, the following can be displayed:

$$\mathbf{v} = \begin{bmatrix} v_1 \\ v_2 \\ \vdots \\ v_k \end{bmatrix} \qquad \mathbf{W}(\mathbf{v},\mathbf{u}) = \begin{bmatrix} W(v_1,u_1) & W(v_1,u_2) & \dots & W(v_1,u_m) \\ W(v_2,u_1) & W(v_2,u_2) & \dots & W(v_2,u_m) \\ \vdots & \vdots & \ddots & \vdots \\ W(v_k,u_1) & W(v_k,u_2) & \dots & W(v_k,u_m) \end{bmatrix}$$
$$= \mathbf{W}'(\mathbf{u},\mathbf{v})$$

$$\mathbf{W}(v,\mathbf{u}) = [W(v,u_1) \quad W(v,u_2) \quad \dots \quad W(v,u_m)] = \mathbf{W}'(\mathbf{u},v)$$

$$\boldsymbol{W}(\boldsymbol{u},\boldsymbol{u}) = \boldsymbol{W} = \boldsymbol{d}_{\Delta}\boldsymbol{H}\boldsymbol{d}_{\Delta} = \boldsymbol{H} \circ \boldsymbol{d}\boldsymbol{d}'$$

9.9.2. The symmetric matrices **W** and **H** will be positive definite as soon as **u** contains distinct positive components. Implementation of the method with **H** is simpler as it only depends on α and not on ω.

9.10. SMITH-WILSON PRESENT VALUE FUNCTION

9.10.1. This function, also known as discount pricing function, can be displayed as:

$$p(v) = e^{-\omega v} + \mathbf{W}(v,\mathbf{u})\mathbf{C}\mathbf{b} = e^{-\omega v} + e^{-\omega v}\mathbf{H}(v,\mathbf{u})\mathbf{Q}\mathbf{b}$$

where the values for *u* correspond to the observed durations to maturity of the financial instruments and *v* is the duration to maturity of the present value function.

9.10.2. A set of equations can be formed by having v the values of u:

$$p[\boldsymbol{u}] = exp[-\omega\boldsymbol{u}] + \boldsymbol{W}\boldsymbol{C}\boldsymbol{b} = \boldsymbol{d} + \boldsymbol{W}\boldsymbol{C}\boldsymbol{b} = \boldsymbol{d} + \boldsymbol{d}_{\Delta}\boldsymbol{H}\boldsymbol{d}_{\Delta}\boldsymbol{C}\boldsymbol{b} = \boldsymbol{d} + \boldsymbol{d}_{\Delta}\boldsymbol{H}\boldsymbol{Q}\boldsymbol{b}$$

Pre-multiplication with the transpose of **C** gives *n* linear equations in **b**:

$$\mathbf{C}'p[\mathbf{u}] = \mathbf{C}'\mathbf{d} + \mathbf{C}'\mathbf{W}\mathbf{C}\mathbf{b} = \mathbf{q} + \mathbf{Q}'\mathbf{H}\mathbf{Q}\mathbf{b}$$

9.10.3. **p** is the market observable counterpart of $\mathbf{C}'p[\mathbf{u}]$

$$\boldsymbol{p} = \boldsymbol{q} + \boldsymbol{Q}'\boldsymbol{H}\boldsymbol{Q}\boldsymbol{b}$$

From this follows the solution for b:

$$\boldsymbol{b} = (\boldsymbol{Q}'\boldsymbol{H}\boldsymbol{Q})^{-1}(\boldsymbol{p} - \boldsymbol{q})$$

This solution depends on ω through **Q** and **q** as well as on α through **H**. The value for α will be determined through convergence requirements.

9.11. SMITH-WILSON FOR ZERO-COUPON BONDS

9.11.1. When m=n, the cash-flow matrix C may be taken as the identity matrix and we are in the zero-coupon bond case. The present value function simplifies as:

$$p(v) = e^{-\omega v}\left(1 + \mathbf{H}(v,\mathbf{u})\tilde{\mathbf{b}}\right) \qquad \text{where } \tilde{\mathbf{b}} = \mathbf{d} \circ \mathbf{b}$$

and the calculation for the coefficient vector: $\widetilde{\boldsymbol{b}} = \boldsymbol{H}^{-1}(\boldsymbol{p} \circ exp[\omega\boldsymbol{u}] - \mathbf{1})$

9.12. SMITH-WILSON YIELD AND FORWARD INTENSITY FUNCTION

9.12.1. From paragraph 9.11.1 the yield intensity function follows as:

$$y(v) = \frac{-\log\, p(v)}{v} = \omega - \frac{\log(1 + \mathbf{H}(v, \mathbf{u})\mathbf{Q}\mathbf{b})}{v}$$

The forward intensity function follows as:

$$f(v) = \frac{-d\log p\,(v)}{dv} = \omega - \frac{d\log(\,1 + \boldsymbol{H}(v, \boldsymbol{u})\boldsymbol{Q}\boldsymbol{b})}{dv} = \omega - \frac{\boldsymbol{G}(v, \boldsymbol{u})\boldsymbol{Q}\boldsymbol{b}}{1 + \boldsymbol{H}(v, \boldsymbol{u})\boldsymbol{Q}\boldsymbol{b}}$$

where the components of the row vector **G**(v,**u**) follow from paragraph 9.7.4.

9.12.2. As *H(u,v)* has a continuous second order derivative, it can be concluded that the Smith-Wilson present value and yield curve are sufficiently smooth at the nodes given by the observed liquid maturities. However, the forward intensity curve is less smooth as it does not have a continuous second order derivative at these nodes.

9.13. ZERO SPOT INTENSITY

9.13.1. When $v \leq \min(\mathbf{u})$, then paragraph 9.7.4 implies:

$$\mathbf{G}'(v, \mathbf{u}) = \mathbf{G}(\mathbf{u}, v) = \alpha\mathbf{1} - \alpha\cosh(\alpha v)\exp(-\alpha\mathbf{u})$$

For $v \downarrow 0$ the following is obtained:

$$\boldsymbol{H}'(0, \boldsymbol{u}) = \boldsymbol{H}(\boldsymbol{u}, 0) = \mathbf{0} \qquad \mathbf{G}(\mathbf{u}, 0) = \alpha\mathbf{1} - \alpha\, exp[-\alpha\mathbf{u}]$$

From this the zero spot intensity follows from paragraph 9.12.1 as:

$$y(0) = f(0) = \omega - \alpha\mathbf{1}'\boldsymbol{Q}\boldsymbol{b} + \alpha\, exp[-\alpha\boldsymbol{u}']\boldsymbol{Q}\boldsymbol{b}$$

9.14. ANALYSIS OF CONVERGENCE TO ULTIMATE FORWARD INTENSITY

9.14.1. When $v \geq U = max(\boldsymbol{u})$, then paragraph 9.7.4 implies:

$$\boldsymbol{H}(\boldsymbol{u}, v) = \alpha\boldsymbol{u} - e^{-\alpha v} sinh[\alpha\boldsymbol{u}] \qquad \mathbf{G}(\mathbf{u}, v) = \alpha e^{-\alpha v} sinh[\alpha\boldsymbol{u}]$$

9.14.2. Now, the upper end of the forward intensity function reduces to:

$$f(v) = \omega + \frac{\alpha}{1 - \kappa \cdot e^{\alpha v}} \qquad v \geq U$$

where κ is a quasi-constant that depends on α (and ω) but not on v:

$$\kappa = \frac{1 + \alpha\boldsymbol{u}'\boldsymbol{Q}\boldsymbol{b}}{sinh[\alpha\boldsymbol{u}']\boldsymbol{Q}\boldsymbol{b}}$$

If α is such that $\kappa = 0$, then $f(v) = \omega + \alpha$, irrespective of the value of *v* and the ultimate forward intensity $f(\infty)$ will not approach ω.

9.14.3. The value of α is determined by requirements on the convergence speed and will automatically be chosen in such a way that $\kappa \neq 0$.

9.14.4. Adopting a convergence period $S = \max(40, 60 - U)$ implies a point of convergence *T* as follows:

$$T = U + S = \max(U + 40, 60)$$

The convergence gap at the point of convergence *T* can be analyzed as a function of α:

$$g(\alpha) = |f(T) - \omega| = \frac{\alpha}{|1 - \kappa e^{\alpha T}|}$$

and the problem of determining α can be formulated as a nonlinear minimization problem:

- Minimize α
  with respect to α and subject to the following two inequality conditions:

  i. $\alpha \geq a$ with the lower bound $a = 0.05$
  ii. $g(\alpha) \leq \tau$

9.14.5. A heuristic solution strategy is the following:

if $\alpha = a$ implies $g(\alpha) \leq \tau$ then $\alpha = a$ is optimal, else search for $\alpha > a$ such that $g(\alpha) = \tau$

9.14.6. Without the lower boundary to alpha, the second inequality $g(\alpha) \leq \tau$ should not be rewritten as $\alpha \leq \tau|1 - \kappa e^{\alpha T}|$, because it might favour a false root for α approaching the value 0.

9.15. FITTING THE TERM STRUCTURE TO BOND AND SWAP RATES

9.15.1. With the Smith-Wilson method the term structure can be fitted to the rates of all the relevant financial instruments.

9.15.2. For each set of instruments, the input for the Smith-Wilson method is defined by:

- the vector of the market prices of the *n* instruments at valuation date,
- the vector of the *m* different cash payment dates up to the last maturity, and
- the $m \times n$ matrix of the cash-flows of the instruments at these dates.

9.15.3. Table 9 gives an overview of how the Smith-Wilson-methodology is applied when the term structure is fitted to zero coupon bond rates, coupon bond rates and par swap rates.

Table 9 - Application of Smith-Wilson for different input instruments

Instruments	Market prices **p**	Cash payment dates **u**	Cash-flow matrix **C**
ZERO-COUPON BONDS	• Market prices of the *n* input instruments, given as the percent amount of the notional amount • The market prices of the zero-coupon input bonds translate at once into spot rates for input maturities	The cash payment dates are the maturity dates of the *n* zero coupon input bonds (i.e., $m = n$)	An $n \times n$ matrix with entries: • $c_{ij} = 1$ for $i = j$, • $c_{ij} = 0$ else. i.e., **C** is the identity matrix.
COUPON BONDS	• Market prices of the *n* coupon input bonds, given as the percent amount of the notional amount of the bond.	The cash payment dates are, in addition to the maturity dates of the input bonds, all coupon dates.	An $m \times n$ matrix with entries: • $c_{ij} = r_c(i)/s$, $i < t(j)$ • $c_{t(j),j} = 1 + r_c(i)/s$, • $c_{ij} = 0$, $i > t(j)$ where $r_c(i)$ is the coupon rate of bond *i*, *s* is the settlement frequency and $t(j)$ the maturity of bond *j*.

PAR SWAP RATES	- The market prices of the *n* par swap input instruments are taken as unit (i.e., 1). - To receive the swap rate, a floating rate must be earned, that can be swapped against the fixed rate. To earn the variable rate a notional amount must be invested. At maturity, the notional amount is de-invested.	The cash payment dates are, in addition to the maturity dates of the swap agreements, all swap rate payment dates.	An m×*n* matrix with entries: - $c_{ij} = r_c(i)/s,\ i < t(j)$ - $c_{t(j),j} = 1 + r_c(i)/s,$ - $c_{ij} = 0,\ i > t(j)$ where $r_c(i)$ is the swap rate of agreement *i*, *s* is the settlement frequency and $t(j)$ the maturity of arrangement *j*.

9.15.4. A numerical illustration is being provided for in ANNEX D - *Numerical illustration of the extrapolation of term structures.*

10. VOLATILITY AND MATCHING ADJUSTMENT

10.1. INTRODUCTION - CONCEPTUAL FRAMEWORK

10.1.1. 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:
[…]
(b) for each relevant duration, credit quality and asset class a fundamental spread for the calculation of the matching adjustment referred to in Article 77c(1)(b);
(c) for each relevant national insurance market a volatility adjustment to the relevant risk-free interest rate term structure referred to in Article 77d(1)

10.1.2. This part of the technical documentation describes how EIOPA derives the technical information mentioned above, in accordance with Articles 77b, 77c and 77d of the Solvency II Directive and Articles 49 to 54 of the Delegated Regulation.

10.1.3. The derivation of the volatility adjustments and fundamental spreads requires decisions on the following:

a) The range and granularity of asset classes, credit quality steps and durations for which the risk corrections of the volatility adjustment and the fundamental spreads are calculated.
b) The source data for the probability of default (PD) calculation.
c) The method of deriving PD from source data.
d) The source data for the cost of downgrade (CoD) calculation.
e) The method of deriving CoD from source data.
f) The source data for the long-term average of spreads (LTAS) calculation.
g) The method of constructing missing data of the 30-year spread history.
h) The treatment of currencies for which source data are not available.

10.1.4. The methodology to derive the volatility adjustment and the fundamental spread, including the decisions from paragraph 10.1.3, are explained in the following sections.

10.2. CONCEPTUAL FRAMEWORK OF THE VOLATILITY ADJUSTMENT

10.2.1. The volatility adjustment (VA) is an adjustment to the relevant risk-free interest rate term structure. The VA is based on 65% of the risk-corrected spread between the interest rate that could be earned from bonds, loans and securitizations included in a reference portfolio for, and the basic risk-free interest rates.

10.2.2. The VA is derived per relevant currency. It is the same for all insurance and reinsurance obligations of a currency unless a country specific increase applies. The following subsection explains the calculation of the VA before application of any country-specific increase (currency volatility adjustment). The subsequent subsection sets out the calculation of the country-specific increase.

10.3. CURRENCY VOLATILITY ADJUSTMENT

10.3.1. To determine a currency volatility adjustment, the following inputs are used:

a) A currency **representative portfolio**[10] of bonds, securitizations, loans, equity, and property covering the best estimate of insurance and reinsurance obligations denominated in that currency, based on insurance market data collected by the means of the regulatory reporting.
b) A currency **reference portfolio** of *yield market indices* based on the representative portfolio from a). In this section, the expression yield market indices cover both yield curves and indices on yields.

10.3.2. Those inputs are used to calculate the following outputs:

a) a **currency spread *S*** between the interest rate derived from the reference portfolio of indices and the rates of the relevant basic risk-free interest rate term structure.
b) a portion of the currency spread *S*, denoted ***RC*** for **risk correction**, which corresponds to "the portion of the spread that is attributable to a realistic assessment of expected losses, unexpected credit risk or any other risk, of the assets" in the reference portfolio (Article 77d of the Solvency II Directive).
c) the **risk-corrected currency spread**, which corresponds to the difference between the currency spread *S* and the risk correction *RC*.

[10] Article 49 of the Delegated Regulation provides that "the [reference] portfolio is based on relevant indices". In order to compose the reference portfolio of indices, EIOPA needs to build first a representative portfolio of assets.

10.3.3. In accordance with Article 50 of the Delegated Regulation, the spread S before risk correction is equal to the following:

$$S = w_{gov} \, . \max(S_{gov}; 0) + w_{corp} . \max(S_{corp}; 0)$$

where:

a) w_{gov} denotes the ratio of the value of government bonds included in the reference portfolio of assets for that currency and the value of all the assets included in that reference portfolio (see also section 11.4).
b) S_{gov} denotes the average currency spread on government bonds included in the reference portfolio of assets for that currency.
c) w_{corp} denotes the ratio of the value of bonds other than government bonds, loans, and securitizations included in the reference portfolio of assets for that currency and the value of all the assets included in that reference portfolio (see also section 11.4).
d) S_{corp} denotes the average currency spread on bonds other than government bonds, loans, and securitizations included in the reference portfolio of assets for that currency.

10.3.4. Here and in the following sections, 'government bonds' means exposures to central governments, central banks and exposures to regional governments and local authorities that are treated as central governments.

10.3.5. The risk correction *RC* is equal to the following:

$$RC = w_{gov} \, . \max\,(RC_{gov}, 0) + w_{corp} \, . \max\,(RC_{corp}, 0)$$

where:

a) w_{gov} and w_{corp} are defined as above.
b) RC_{gov} denotes the risk correction corresponding to the portion of the spread S_{gov} that is attributable to a realistic assessment of the expected losses, unexpected credit risk or any other risk.
c) RC_{corp} denotes the risk correction corresponding to the portion of the spread S_{corp} that is attributable to a realistic assessment of the expected losses, unexpected credit risk or any other risk.

10.3.6. The risk-corrected currency spread S_{crncy}^{RC} is equal to the following:

$$S_{crncy}^{RC} = S - RC$$

The risk-corrected currency spread may be negative when $RC > S$. The zero-floor mentioned in Article 50 of the Delegated Regulation only applies at portfolio level to the spread before the risk correction.

10.3.7. For each relevant currency, the currency VA is equal to the following:

$$VA_{crncy} = 0.65 \cdot S_{crncy}^{RC}$$

Therefore also the currency VA may be negative. Table 10 summarizes the application of floors in the process of calculation of the currency VA:

Table 10 - VA calculation: application of floors

VA CALCULATION: APPLICATION OF FLOORS	Market spread	Risk correction	Risk-corrected spread
FOR EACH INDIVIDUAL BOND	No floor - spread may be either positive or negative	For each individual bond and hence at portfolio level as well, the risk correction cannot be negative	No floor – risk corrected spread may be negative
AT PORTFOLIO LEVEL	Floor at zero - spread cannot be negative		No floor – risk corrected spread may be negative

10.4. COUNTRY SPECIFIC INCREASE OF THE VOLATILITY ADJUSTMENT

10.4.1. For each relevant country, the currency volatility adjustment is increased by the difference between the risk-corrected country spread $S_{country}^{RC}$ and twice the risk-corrected currency spread, whenever that difference is positive, and the risk-corrected country spread is higher than 85 basis points.[11]

10.4.2. To determine the country specific increase of the volatility adjustment, the following inputs are used:

[11] Directive 2019/2177 of 18 December 2019 (recital 6 and art.2)

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2019.334.01.0155.01.ENG&toc=OJ:L:2019:334:TOC

amended SII Directive including a change of threshold for the VA risk-corrected country spread from 100 bps to 85bps.

a) A **country representative portfolio** of bonds, securitizations, loans, equity and property covering the best estimate of obligations sold in that country, based on insurance market data collected by the means of the regulatory reporting.
b) A **country reference portfolio** of indices based on the representative portfolio under a).

10.4.3. Those inputs are used to calculate the following outputs:

a) a **country spread *S*** between the interest rate derived from the reference portfolio of indices and the rates of the relevant basic risk-free interest rate term structure.
b) a portion of the country spread S, denoted ***RC*** for **risk correction**, which corresponds to "the portion of the spread that is attributable to a realistic assessment of expected losses, unexpected credit risk or any other risk, of the assets" in the reference portfolio (Article 77d of the Solvency II Directive).
c) the **risk-corrected country spread**, which corresponds to the difference between the spread *S* and the risk correction *RC*.

10.4.4. The country spread, risk correction and risk-corrected country spread $S_{country}^{RC}$ are calculated in the same way as the currency spread, risk correction and risk-corrected spread S_{crncy}^{RC} for the currency of that country but based on the inputs stemming from the country representative portfolio and the country reference portfolio.

10.4.5. For each relevant country, a country specific increase of the volatility may also apply, in such a manner that the total volatility adjustment is equal to:

$$VA_{total} = 0.65 \cdot \left(S_{crncy}^{RC} + \max\left(S_{country}^{RC} - 2.S_{crncy}^{RC}; 0\right)\right)$$

where $S_{country}^{RC}$ > 85 basis points.

10.4.6. Where $S_{country}^{RC}$ is lower than or equal to 85 basis points, there is no country specific increase of the volatility adjustment. That means we have:

$$VA_{total} = 0.65 \cdot S_{crncy}^{RC}$$

10.5. PUBLICATION OF THE VOLATILITY ADJUSTMENT

10.5.1. According to Article 77d of the Solvency II Directive, the volatility adjustment is not an entity-specific adjustment. Its value should be the same for all the insurance or reinsurance obligations expressed in the same currency or, where the country specific increase applies, relating to the same country.

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

10.6. CONCEPTUAL FRAMEWORK OF THE MATCHING ADJUSTMENT

10.6.1. The matching adjustment (MA) is an adjustment to the basic risk-free interest rate, based on the spread on an undertaking's own portfolio of matching assets, less a fundamental spread that allows for default and downgrade risk.

10.6.2. Undertakings must calculate the MA themselves, based on their own assigned portfolios of eligible assets. Rather than publishing the MA, EIOPA publishes only the fundamental spreads that undertakings should use, together with the following information:

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

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

10.6.4. EIOPA publishes both the probability of default and cost of downgrade for each relevant asset class, duration, and credit quality step.

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

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

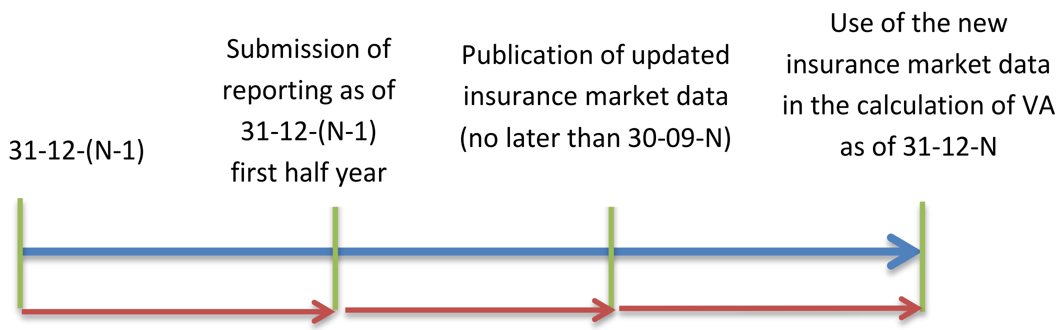
11. DERIVING THE REPRESENTATIVE PORTFOLIOS OF BONDS AND THE REFERENCE PORTFOLIOS OF 'YIELD MARKET INDICES' FOR THE VOLATILITY ADJUSTMENT

11.1. INTRODUCTION

11.1.1. The organization of this section follows the conceptual framework described in the previous section. In subsection 11.2 the relationship among the representative portfolios applied for the currency VA and the country specific increase of the VA is explained. In subsection 11.3 the calculation of the representative portfolio of government bonds and the representative portfolio of other assets is introduced. In subsection 11.4 the weights referred to in Article 50 of the Delegated Regulation are set out. In subsection 11.5 the calculation of the reference portfolios of '*yield market indices*' is specified for the representative portfolio of government bonds and the representative portfolio of other assets.

11.1.2. For the purpose of the preparatory phase in 2015 and the beginning of Solvency II in 2016, the data collected to build the representative portfolios were taken from the EIOPA Stress Test 2014 exercise. In 2016 the representative portfolios were updated based on data reported by insurance and reinsurance undertakings to their supervisory authority during the preparatory phase for Solvency II. In 2017 the updated representative portfolios were derived the first time from the supervisory reporting data of Solvency II. In ANNEX F - *Methodology to update the representative portfolios* the methodology for the update is described.

11.1.3. EIOPA intends to update the representative portfolios at the end of the year, based on the annual supervisory reporting of insurance and reinsurance undertakings and of insurance groups in accordance with the methodology set out in this technical documentation. The insurance market data referred to year end *N*-1 - which undertakings will report in year *N* - will be used for the calculation of the technical information that undertakings should apply with reference to their situation at the end of year *N*. Updated insurance market data will be published at least three months before the year end *N*.



11.1.4. For a limited period, the date of publication of the updated representative portfolio may be deferred from 30 September to a later date, while maintaining a three-month notice period until the updated representative portfolios are used in the calculation of the VA.

11.2. INTRODUCTORY REMARKS ON THE DERIVATION OF THE REPRESENTATIVE PORTFOLIOS

11.2.1. According to Article 77d of the Solvency II Directive, the currency volatility adjustment shall be based on a reference portfolio "*representative for the assets which are denominated in that currency and which insurance and reinsurance undertakings are invested in to cover the best estimate for insurance and reinsurance obligations denominated in that currency*".

11.2.2. According to the same Article, the country specific increase of the volatility adjustment shall be based on a reference portfolio "*representative for the assets which insurance and reinsurance undertakings are invested in to cover the best estimate for insurance and reinsurance obligations sold in the insurance market of that country and denominated in the currency of that country*".

11.2.3. Therefore, the scope of assets to include in the currency and country representative portfolios is different. However, in the Solvency II framework, insurance and reinsurance undertakings are not required to identify the assets covering their best estimate (except in the case of those covering insurance and reinsurance obligations applying the matching adjustment or under a ring-fenced fund regime). It is also not required to classify the assets covering the best estimate of the insurance or reinsurance obligations according to the country where the obligations are sold.

11.2.4. To implement Article 77d of the Solvency II Directive in the simplest possible manner EIOPA applies the following proxies:

a) For the currency representative portfolio: a calculation considering that all assets in a currency X cover liabilities in currency X. Hence, the currency representative portfolio of currency X is based on all assets denominated in that currency X and in which undertakings are invested in.[12]
b) For the country representative portfolio: 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 in.

11.2.5. These assumptions will be monitored in the future and also, they may be removed when there is evidence to the contrary (e.g., for a certain market). The evidence used to remove either or both assumptions will be centrally validated by EIOPA.

11.2.6. The calculation of the two different sets of reference portfolios (currency VA and country specific increase of the VA, respectively) is feasible for the EEA currencies, since the information contained in the individual reporting at solo level provides the data necessary for the purpose.

11.2.7. In the case of non-EEA currencies, the information contained in the reporting at group level allows a proxy only for the calculation of the currency volatility adjustment. Therefore, for non-EEA currencies, the only currently feasible approach is to apply the portfolios used for the calculation of the currency adjustment also for the country specific increase of the volatility adjustment.

11.3. REPRESENTATIVE PORTFOLIOS OF ASSETS REFERRED TO IN ARTICLE 50 OF THE DELEGATED REGULATION

11.3.1. The derivation of the representative portfolios is based on the following information:

a) The **market value** of the assets included in the representative portfolio. Those market values are required to calculate the weights w_{gov} and w_{corp} and the risk-corrected spread S_{RC}.
b) The **duration** of the bonds, loans, and securitizations included in the representative portfolio. Those durations are required to make the spread S maturity-dependent and to select the relevant yield market indices.

[12] Therefore, the representative portfolio for a currency X may include as issuer country Y with a different currency, when country Y issued bonds expressed in currency X and hold by undertakings in country X.

c) The **asset class**, understood as economic sector (financial sector or non-financial sector) of the bonds other than government bonds, loans, and securitizations included in the representative portfolio. Government bonds are distinguished according to issuer to form asset classes. The asset classes are required to select the relevant yield market indices.
d) The **credit quality step** (on a scale from 0 to 6) of the bonds other than government bonds, loans, and securitizations included in the representative portfolio. Those credit quality steps are required to calculate the spread *S* and the risk correction *RC* and to select the relevant yield market indices.

11.3.2. Based on that information, the aggregated market value and the average duration per asset class and credit quality step can be calculated for each currency and country. The weights for the determination of the average duration are the market values of the assets.

11.4. THE PORTFOLIO WEIGHTS REFERRED TO IN ARTICLE 50 OF THE DELEGATED REGULATION

11.4.1. An overview of the weights w_{gov} and w_{corp} applied for the calculation of the volatility adjustments for EEA currencies and countries applicable from 31 March 2024 respectively 31 March 2025 are set out below in Table 11.[13] The derivation of the weights is described in ANNEX F.11 - *Calculation of the weights for the government and corporate portfolios*.

11.4.2. The weights and durations of the underlying currency- and country-parts of the representative portfolios are set out in the Excel files of the respective monthly publication of the risk-free interest rate term structures on EIOPA's website using filenames "EIOPA_RFR_YYYYMMDD_VA_portfolios.xlsx".

11.4.3. The last subsection 11.9 describes the approach for non-EEA currencies during the preparatory phase and the beginning of Solvency II in 2016 and thereafter.

[13] The applicable weights before 31 March 2023 are available in 14.H Annex to subsection 9.D: Methodology to update the representative portfolios under 8. Historical overview of the government bond- and corporate bond-weights used for the representative portfolios.

Table 11 - Weights referred to in Article 50 of the Delegated Regulation

Applicable from 31/03/2024

Based on end of 2022 annual reporting templates

Currency	Govt	Corp
EUR	24.1%	37.7%
BGN	25.0%	6.5%
CZK	44.0%	13.3%
DKK	6.0%	52.2%
HUF	60.4%	5.1%
ISK	23.7%	34.4%
NOK	6.5%	59.2%
PLN	49.6%	15.3%
RON	64.1%	5.8%
SEK	9.4%	32.6%
CHF	24.1%	37.7%
GBP	10.7%	29.7%
AUD	33.8%	42.3%
CAD	20.9%	59.6%
JPY	64.7%	12.7%
USD	15.6%	54.8%
CNY	30.0%	27.4%
HKD	11.4%	7.8%

Country	Govt	Corp
AT	17.7%	34.6%
BE	37.8%	36.5%
BG	46.3%	18.3%
HR	53.4%	10.8%
CY	16.1%	44.3%
CZ	42.8%	23.6%
DK	12.3%	33.4%
EE	22.8%	39.8%
FI	8.9%	30.1%
FR	21.8%	38.3%
DE	15.0%	40.0%
GR	44.2%	27.7%
HU	50.3%	7.4%
IS	22.4%	34.7%
IE	23.5%	37.8%
IT	42.2%	26.8%
LV	34.6%	26.2%
LI	9.0%	28.0%
LT	53.5%	27.3%
LU	8.8%	25.9%
MT	15.1%	34.7%
NL	22.9%	39.5%
NO	6.3%	47.6%
PL	48.6%	18.0%
PT	40.8%	36.4%
RO	64.8%	7.4%
SK	32.5%	41.5%
SI	31.9%	30.8%
ES	34.0%	35.4%
SE	6.8%	23.4%
CH	-	-
UK	-	-
AU	-	-
US	-	-
JP	-	-
US	-	-
CN	-	-
HK	-	-

Applicable from 31/03/2025

Based on end of 2023 annual reporting templates

Currency	Govt	Corp
EUR	24.4%	38.3%
BGN	22.9%	6.9%
CZK	49.1%	11.3%
DKK	7.1%	54.4%
HUF	58.8%	5.8%
ISK	25.4%	33.7%
NOK	5.9%	60.7%
PLN	48.6%	13.7%
RON	67.7%	5.7%
SEK	9.5%	31.7%
CHF	23.5%	41.1%
GBP	16.4%	54.4%
AUD	33.0%	45.8%
CAD	26.2%	60.3%
JPY	66.8%	12.3%
USD	14.8%	56.4%
CNY	32.2%	29.3%
HKD	18.7%	15.4%

Country	Govt	Corp
AT	17.3%	33.6%
BE	36.1%	38.3%
BG	40.8%	23.7%
HR	53.7%	10.9%
CY	21.2%	42.1%
CZ	45.6%	20.8%
DK	12.8%	34.0%
EE	22.3%	40.4%
FI	9.5%	32.1%
FR	20.3%	40.7%
DE	17.4%	36.2%
GR	39.5%	30.4%
HU	51.1%	8.8%
IS	24.3%	34.7%
IE	18.6%	41.2%
IT	41.8%	27.1%
LV	36.8%	23.3%
LI	9.4%	26.6%
LT	50.1%	28.7%
LU	11.6%	33.5%
MT	16.0%	42.1%
NL	21.3%	41.4%
NO	5.4%	46.7%
PL	47.6%	16.4%
PT	39.3%	37.6%
RO	67.5%	8.1%
SK	32.4%	37.7%
SI	32.0%	28.7%
ES	33.1%	37.1%
SE	6.4%	22.1%
CH	-	-
UK	-	-
AU	-	-
US	-	-
JP	-	-
US	-	-
CN	-	-
HK	-	-

11.5. REFERENCE PORTFOLIOS OF 'YIELD MARKET INDICES'

11.5.1. For the calculation of the VA the representative portfolio of bonds needs to be mapped to a given granularity of "*yield market indices*". The expression "*yield market indices"* covers in this section both yield curves and indices on yields.

11.5.2. To be compliant with Articles 77b, 77c and 77d of the Solvency II Directive, the definition of the reference portfolios of "*yield market indices"* needs to be granular enough to reflect the duration, credit quality and asset class of the "*yield market indices"*. This is critical to ascertain an appropriate calibration of the volatility adjustment and the matching adjustment because the spread, the risk correction and the fundamental spread depend to a great extent on those features. Furthermore, such dependence is not linear and therefore the use of simple averages or baskets materially deviates from the relevant calculation

11.5.3. EIOPA uses a reference portfolio for each relevant currency and country to calculate the volatility and matching adjustment according to the following information:

a) **Data from the relevant government bonds yield market indices**. Those data are required to determine the interest rates of government bonds including in the representative portfolio, by duration and country of issuance. Those interest rates are then used to compute the spread S and the risk correction RC for those government bonds. For representative portfolios that could not be updated in 2016 government bond yields are also used to determine the interest rates of separately modelled non-central government bonds.
b) **Data from the relevant corporate bonds yield market indices**. Those data are required to determine the interest rates of corporate bonds including in the representative portfolio, by duration, asset class and credit quality step. Those interest rates are then used to compute the spread S and the risk correction RC for corporate bonds.
c) Currently EIOPA does not use market data to derive the spread *S* and the risk correction *RC* for **loans and securitizations included in the representative portfolios**. The assumption underlying this choice is that the spread *S* and the risk correction *RC* for loans and for securitizations are sufficiently similar to those for corporate bonds with the same credit quality and duration. EIOPA will test this assumption and may remove it in the future to the extent that there are appropriate indices for loans and for securitizations, which are readily available to the public and for which there are published criteria for when and how the constituents of those indices will be changed, in accordance with Article 49 of the Delegated Regulation.

11.5.4. The currency and country reference portfolios are built based on the representative portfolios of the same currency or country. For this purpose, a mapping is made to associate the characteristics of the assets including in the representative portfolios with indices.

11.6. YIELD MARKET INDICES FOR CURRENCY GOVERNMENT BOND PORTFOLIOS

11.6.1. The reference portfolio of "*yield market indices"* used to calculate the VA for a given currency has as many model bonds as government bonds in that currency (and which insurance and reinsurance undertakings are invested in).

11.6.2. The calculations for each issuer are based on its specific yield curve ("*yield market index"*) according to the average duration, at the currency area level, of those issuances where undertakings are invested in. Linear interpolation is used to derive the inter-annual rates corresponding to the average duration.

11.6.3. For the sake of simplicity, exposures are expressed in percentages and rounded to the nearest percentage.[14]

11.6.4. In the case of the euro area, all the issuers of the euro area are mapped with a single "*yield market index*": the relevant maturity of the ECB curve for all government bonds of the euro area (daily observations of annual spot rates). EIOPA provides the necessary information to allow the reconstruction of the LTAS of this curve.

11.7. YIELD MARKET INDICES FOR COUNTRY GOVERNMENT BOND PORTFOLIOS

11.7.1. For each country reference portfolio, EIOPA selects as many "*yield market indices*" as issuers of government bonds in which undertakings of that country are invested in. The market yield for each issuer is derived from the government bond yield curves listed in subsection 5.3, according to the relevant duration. Linear interpolation is used to derive the inter-annual rates corresponding to that duration.

11.7.2. In case of issuances in a currency different than the currency of the issuer, the use of the yield curve in the currency of the issuer is considered to be an acceptable proxy.

11.7.3. Using yield curves allows EIOPA to collect interest rates of government bonds for several maturities. Furthermore, the yield curves should be consistent with those used for the calculation of the basic risk-free interest rates term structures in the case of currencies without DLT swaps.

11.7.4. For the sake of simplicity, exposures are expressed in percentages and rounded to the nearest percentage as for the currency portfolio.

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

- the national increase of the VA for these countries will be zero,
- for countries which do have exposure to a Euro country without a government yield curve, either in their country government bond portfolio or in their matching

[14] In case the total exposure after rounding is not 100%, the rounding differences (positive or negative) are allocated to the largest exposure.

adjustment portfolio, the government yield curve of a peer country will be used to calculate, where applicable:

- the national increase of the volatility adjustment,
- the matching adjustment,

- the long-term average spread of the government bonds to be used for calculating the national increase of the volatility adjustment or the matching adjustment will be approximated with the long-term average spread 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.
- Table 12 below gives an overview of the current and past use of peer countries:

Table 12 - Peer countries as issuers for the calculation of the long-term average spreads of government bonds

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.

- 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 30 March 2026, and on domestic government bond data after that date onward.

11.7.6. EIOPA will continuously monitor the allocation to peer countries. In case the credit quality or level of interest rate 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 functionality of the volatility- and matching adjustment, in particular if the perceived credit quality of an allocated country deteriorates.

11.8. YIELD MARKET INDICES FOR CORPORATE BONDS

11.8.1. Regarding corporate bonds, further than the duration, the following dimensions are considered:

- Assets classes, with a differentiation among 'financial' and 'non-financial exposures',
- Credit quality steps as set out in the Delegated Regulation (from 0 to 6),
- Currencies, with a differentiation where possible for EUR, GBP and USD.

11.8.2. Subsection 14.3 lists the market yield indices used for the implementation of this granularity.

11.8.3. Exposures are expressed in percentages and rounded to the nearest percentage.[15] Therefore, the theoretical 42 model corporate bonds resulting from the granularity mentioned above[16], in practice and for most of markets, are limited to just a few market yield indices.

11.8.4. Table 13 reflects the allocation of the ratings used by the market providers to credit quality steps for the only purposes of this technical documentation. EIOPA states explicitly that this allocation does not pre-empt the work in progress regarding the ratings of ECAIs in relation with the Delegated Regulation.

[15] In case the total exposure after rounding is not 100%, the rounding differences (positive or negative) are allocated to the largest exposure.

[16] 2 assets classes × 7 credit quality steps × 3 currencies

Table 13 - Allocation of ratings to credit quality steps (*)

iBoxx/S&P rating	CQS
AAA	0
AA	1
A	2
BBB	3
BB	4
B	5
CCC, CC, C,…	6

(*) Only for the purpose of the technical information set out in Article 77e of the Solvency II Directive)

11.8.5. For representative portfolios that were not updated in 2016 the portfolio of 'assets other than government bonds' includes separately modelled non-central government bonds. These bonds are not split by economic sectors and credit quality steps. Instead, they are treated in the same way as central government bonds.

11.8.6. For the time being and due to the lack of data, no specific model bonds have been developed specifically for securitizations 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 securitizations and loans (including mortgage loans).

11.9. VOLATILITY ADJUSTMENT FOR NON-EEA CURRENCIES

11.9.1. Due to the incompleteness of the available information, EIOPA has carried out an ad hoc survey based on market data at group level regarding exposures denominated in five non-EEA currencies: Australian dollar, Canadian dollar, Swiss franc, Japanese yen, and US dollar. The selection of these currencies was based on the information available.

11.9.2. EIOPA highlights the possibility of variations in the outputs, once a better set of information becomes available.

11.9.3. EIOPA will assess the relevance of publishing the volatility adjustment for other non-EEA currencies on a case by case and considering, among other factors, the materiality of the currency both at the individual and market level. So far, no other need has been identified.

12. METHODOLOGY FOR THE DETERMINATION OF THE RISK CORRECTIONS AND THE FUNDAMENTAL SPREADS

12.1. INTRODUCTION

12.1.1. In this section the expression "*risk correction"* refers to the volatility adjustment. The expression "*fundamental spread*" refers to the matching adjustment.

12.1.2. Article 51 of Delegated Regulation specifies that the risk correction "shall be calculated **in the same manner** as the fundamental spread" and using the same inputs. Therefore, the methods and source data described in this section are relevant for both the risk correction used for the volatility adjustment and the fundamental spread applied for the matching adjustment.

12.1.3. In the absence of specific reference to the contrary, the content of this section refers to both the risk correction spread and the fundamental spread.

12.2. DETERMINATION OF THE RISK-CORRECTIONS AND THE FUNDAMENTAL SPREADS FOR GOVERNMENT BONDS

12.2.1. According to Article 77c of the Solvency II Directive, the fundamental spread on government bonds is equal to the maximum between:

a) The sum of the credit spread corresponding to the probability of default 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 long-term average of the spread, over the basic risk-free interest rate, 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).

12.2.2. 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 and the* *volatility 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"*.

12.2.3. Therefore, the risk correction of the spread S_{gov} and the fundamental spread on government bonds corresponds only to:

- $RC = FS = 30\% \cdot LTAS$ for exposures to governments of EEA member states
- $RC = FS = 35\% \cdot LTAS$ for exposures to other governments

where *LTAS* is the long-term average of the spread over the risk-free interest rate of assets of the same duration, credit quality and asset class.

12.3. LONG-TERM AVERAGE OF THE SPREAD ON GOVERNMENT BONDS

12.3.1. Article 54(3) of the Delegated Regulation provides the following:

a) The long-term average shall be based on data referring to the last 30 years.
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 referring to the last 30 years. Data that are not reliable shall be replaced by constructed data using that methodology.
d) The constructed data shall be based on prudent assumptions.

12.3.2. To determine the long-term average for each relevant currency and country, EIOPA needs the following inputs:

a) The zero-coupon yield curve of the government bonds in the government bonds representative portfolio, over the last 30 years.
b) The basic risk-free interest rate term structure denominated in the currency of the bonds in the government bonds representative portfolio, over the last 30 years.

12.3.3. However, in most cases there is no historical data over a 30-year period on interest rate swaps and government bonds.

12.3.4. To overcome this issue, EIOPA re-constructs missing data, in accordance with Article 54(3) of the Delegated Regulation, applying the following rule: the missing spread data for each currency and maturity are re-constructed using the average spread calculated with the data available from 1 January 1985 or, failing that, whenever reliable spread data are available.

12.3.5. Nevertheless, since the overnight market have developed only since the end of the last century, the availability of overnight swap rates (necessary to calculate the credit risk adjustment) has been limited, resulting de facto in a calculation of the *LTAS* since 1 January 1999 for all currencies.

12.3.6. Therefore, EIOPA assumes the average spread over the period for which data are missing is not materially different from the average spread that can be calculated with available data.

12.3.7. To illustrate the implementation of this rule, let's take the following example. Suppose that the volatility adjustment is calculated at year end 2015. Suppose further that, for a given currency and maturity, data are only available from 1 January 1999 till 31 December 2015 (i.e., 17 years). The assumption is that the constructed data have the same average as the average obtained from the available market data:

a) From 1986 to 1998: the constructed spread for each year corresponds to the flat average spread calculated on the period 1999-2015.
b) From 1999 to 2015: the available spread data are used.

12.3.8. EIOPA will determine the constructed spread for each currency and maturity where data are missing on the basis of the data available on 31 December 2015. All the calculations are developed using daily data.

12.3.9. The *LTAS* for UK government bonds is a special case because reliable data, to assess the spread of these bonds, in particular pound sterling swap data, are available for the period before 1999. These additional data are taken account by applying the adjustment factors set out in ANNEX 0 to the *LTAS* that are calculated as described in the two paragraphs above.

12.3.10. From 1 January 2016 until having the complete 30-years historical series from January 1999, at each publication the LTAS will be calculated as:

$$\frac{LTAS_{31\_12\_2015} * (7800 - ntd) + \sum^{ntd} Spreads_{from\_1\_1\_2016}}{7800}$$

where:

- *ntd* denotes the number of new trading days from 1 January 2016 onwards where data are available.
- $\sum^{ntd} Spreads\_from\_1\_1\_2016$ means the sum of the spreads during those new dates.

- $LTAS_{31\_12\_2015}$ identifies the LTAS as of 31 December 2015; and it is assumed that a 30-year period is composed of 7800 trading days.

12.3.11. For the sake of transparency EIOPA will publish the long-term average spreads.

12.3.12. The calculations according to the methodology above show that for most of currencies, the markets of government bonds with more than 10 years duration have developed only from the first half of the last decade. As a consequence, the calculation of the LTAS for maturities higher than 10 years lacks representativeness due to the reduced number of observations and to the fact that a major part of the observations refers to the current financial crisis.

12.3.13. To avoid this bias, the calculation of LTAS for government bonds is carried out from 1- to 10-year maturities. The LTAS resulting for maturity 10 years is applied for longer maturities. Even below 10 years, for a few currencies some maturities deliver non plausible results. Table 14 reflects the currencies with some maturities delivering non plausible LTAS (empty cells). To derive the spreads for those maturities, linear interpolation of spreads using neighbor maturities is applied (see also subsection 12.6 where the same linear interpolation is used).

Table 14 - Disregarded maturities for the LTAS- calculation of government bonds

		Tenor in years									
COUNTRY	ISO 4217	1	2	3	4	5	6	7	8	9	10
DENMARK	DKK	•	•		•	•	•		•	•	•
HONG KONG	HKD	•	•	•	•	•		•		•	•
ICELAND	ISK	•		•		•				•	
ROMANIA	RON	•	•	•	•	•	•	•	•		•
SWEDEN	SEK	•	•	•	•	•	•	•	•		•

- This table sets out the maturities used to derive the government bond spreads for current reference dates that enter the calculation of the LTAS. Past changes to the maturities are set out in ANNEX G - *LTAS calculation specifiCities*.
- Empty cells are based on interpolation, non-empty cells on historical data.

12.4. DETERMINATION OF THE RISK-CORRECTIONS AND FUNDAMENTAL SPREADS FOR ASSETS OTHER THAN GOVERNMENT BONDS

12.4.1. The Solvency II Directive and Articles 49 to 54 of the Delegated Regulation set down several aspects of the methodology for calculating the Risk Correction and the Fundamental Spread of assets other than government bonds. The methodology to be used is different depending on whether reliable credit spreads can be determined from long-term default statistics.

12.4.2. Where reliable credit spreads can be derived from such statistics, the risk correction and the fundamental spread can be expressed as:

$$RC = FS = max(PD + CoD, 35\% \cdot LTAS)$$

where:

- *PD* = the credit spread corresponding to the probability of default on the assets.
- *CoD* = the credit spread corresponding to the expected loss resulting from downgrading of the assets.
- *LTAS* = the long-term average of the spread over the risk-free interest rate of assets of the same duration, credit quality and asset class.

12.4.3. Where no reliable credit spreads can be derived from long-term default statistics, the risk correction and fundamental spread can be expressed as $RC = FS = 35\% \cdot LTAS$, where *LTAS* is the long-term average of the spread over the risk-free interest rate of assets of the same duration, credit quality and asset class.

12.4.4. The Delegated Regulation sets the recovery rate assumption in the event of a default at 30% for all asset classes.

12.4.5. The Delegated Regulation also specifies that the *LTAS* should be based on data of the last 30 years.

12.4.6. Where there is not 30 years of complete and reliable information relating to spreads, the Delegated Regulation specifies that the 'missing' data should be constructed using the data that is available, in a prudent manner. The process of reconstruction is consistent with the process described above for government bonds.

12.4.7. Where the fundamental spread is defined by the 35%·*LTAS*, the difference among the fundamental spread and the *PD* will be attributed to the *CoD*.

12.5. METHOD FOR DERIVING THE PROBABILITY OF DEFAULT (PD) AND THE COST OF DOWNGRADE (COD)

12.5.1. The calculation of the *PD* derives an amount that is interpreted as an investor's required compensation for assuming the risk of the expected probability of default of a bond. The expectation of a default (based on historical default probabilities derived from the transition matrices) is thus combined with an assumption on the recovery value in case of default, which is assumed to be 30% of the market value as set out in Article 54(2) of the Delegated Regulation.

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

- For the *PD*, EIOPA assumes a "buy and hold" strategy: assets are not sold after downgrade.
- For the CoD, EIOPA assumes a "buy and replace" strategy: assets downgraded are replaced by an asset of the same credit quality step as before downgrade, or higher. 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 or equal to zero.

12.5.3. 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 rates term structure and for each credit quality step a vector of relevant portions of the market value of a risk-free benchmark instrument. These portions have been designed to be analogous to the recovery rate for the *PD*.

Table 15 - Scaling factors used in the calculation of the Cost of Downgrade

CQS	Scaling factor
AAA	98%
AA	97%
A	95%
BBB	85%
BB	70%
B	50%
CCC	40%

12.5.4. In case of a rating migration to a credit quality step of lower quality (downgrades), the cost is defined as 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 did not default, the cost is reduced so that it takes account of that information.

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

12.5.6. 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 spread over the basic risk-free interest rate in basis points.

12.5.7. The annex to this subsection contains a detailed description of this method. Subsection 14.3 describes the transition matrices used for the calculations described in this subsection.

12.5.8. For the calculation of the volatility adjustment, the value of the *PD* and *CoD* expressed in basis points are rounded to the nearest basis point. This rounded value is used as input in the relevant step of the calculation of the volatility adjustment.

12.5.9. For the matching adjustment, the *PD* that EIOPA publishes is the probability to apply for the de-risking of cash flows as follows:

$$\begin{aligned}&\text{de-risked cash flow}\\&\qquad= \text{cashflow} * (1 - PD_{EIOPA}) + \text{recovery\_rate} * \text{cashflow} * PD_{EIOPA}\end{aligned}$$

12.5.10. The *PD* probability for de-risking cash flows expected at time '*t*' is derived from a Markov matrix as the last column obtained when powering '*t*' times the one-year average transition matrices (see ANNEX H.6.3).

12.5.11. The probability of default, cost of downgrade and fundamental spread are published until 30 years maturity. From that maturity onwards the value of those magnitudes for the 30 years maturity will apply.

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

12.6. LONG-TERM AVERAGE OF THE SPREAD ON OTHER ASSETS

12.6.1. The long-term average of the spread on other assets is calculated in the same manner as the long-term average spread on government bonds described in the subsection 12.3, with the following specificities.

12.6.2. A linear interpolation is performed to obtain complete corporate yield curves where there is missing data.[17] Where there are no market data or only market data for a single maturity, then the yields are set to zero. All yields below the first maturity available are equal to the first yield available.

12.6.3. As explained in sub-section 14.3, the CQS 0 corporate yields are equal to 85% of the CQS 1 corporate yields where those yields are positive or zero, and otherwise equal to 115% of those yields. This operation is performed for financial and non-financial bonds and for all currencies.

12.6.4. The long-term average spread is calculated for those dates where neither the basic risk-free rate term structures nor the corporate yields of the same currency[18] are nil. The calculation is performed in the same manner as the long-term average spread on government bonds, i.e., assuming that the average spread over the period for which data is missing, is not materially different from the average spread that can be calculated with available data.

12.6.5. Having in mind the content of the market input data as described in section 14, the value of the 2-year *LTAS* is used also as value of the 1-year *LTAS*.

12.6.6. The *LTAS* on other assets is kept constant from the last maturity available of the market source onwards.

12.6.7. For GBP non-financial bonds rated CQS 1, the *LTAS* for maturities 4 to 9 years calculated before 1st January 2016 is obtained by linear interpolation of the *LTAS* using 3- and 10-year maturities, because the history of the indices available in the range of 4- to 9-year does not allow a reliable calculation of those *LTAS*. From 1st January onwards, the new data to be used in the *LTAS* calculation is of better quality and one does not need to interpolate anymore.

12.6.8. As for UK government bonds, there are adjustment factors for the *LTAS* of corporate bonds denoted in pound sterling in order to take account of reliable data for the

[17] This linear interpolation is performed for each 10th of a year. See also subsection 14.2.2.

[18] Currencies for which a LTAS on other assets is calculated are EUR, GBP and USD.

period before 1999. The adjustment factors are set out in ANNEX G - *LTAS calculation specifiCities*.

12.6.9. For GBP and USD corporate bonds rated CQS 4 or CQS 5, the *LTAS* are calculated using the approach described in subsection 12.7. This means that first the spread of the GBP/USD basic risk-free term structures over the EUR basic risk-free term structure is calculated. Secondly, the average of the above calculation over all relevant dates is calculated. Thirdly, this long-term average is multiplied by $\kappa = 0.5$. Finally, this result is added to the corresponding *LTAS* of the EUR.

12.6.10. The *LTAS* of CQS 6 corporate bonds is equal to the *LTAS* of CQS 5 corporate bonds.

12.7. CURRENCIES WITHOUT YIELD MARKET INDICES FOR CORPORATES, LOANS AND SECURITIZATIONS

12.7.1. For currencies for which there are no yield market indices satisfying the calculation needs, the spread on corporate bonds denominated in euro is used with an adjustment proportionate to the difference between the basic risk-free interest rate term structure of the concerned currency and the euro. In such case, the following formulas applies:

$$S_{corp}^{X} = S_{corp}^{€} + \kappa \cdot \left(Y_{rfr}^{X} - Y_{rfr}^{€}\right)$$

$$Y_{corp}^{X} = Y_{corp}^{€} + (1+\kappa) \cdot \left(Y_{rfr}^{X} - Y_{rfr}^{€}\right)$$

where € denotes the euro, *X* refers to a currency without interest rates term structures for the assets relevant for the spread S_{corp}, Y_{corp} denotes the yield of the respective corporate bonds of the same credit quality, Y_{rfr} denotes the basic risk-free interest rate and $\kappa = 0.5$. The inputs of this formula are maturity dependent according to the information available.

12.7.2. EIOPA may also consider the specific case of covered bonds once the current limitations in the information available are solved.

12.7.3. For the time being an operational solution has been identified for the Danish market of covered bonds based on the following formula:

$$S_{covered}^{DKK} = R_{covered}^{DKK} - Y_{rfr}^{DKK}$$

where DKK denotes Danish krone and:

- $R_{covered}^{DKK}$ shall be based on the option-adjusted yield from Nykredits Realkreditindeks (RIC ".NYKROAY2").
- The maturity used for Y_{rfr}^{DKK} shall correspond to the option-adjusted duration of the Nykredits Realkreditindeks (RIC ".NYKROAD2").

12.7.4. The resulting $S_{covered}^{DKK}$ is relevant for AAA Financials in the calculation for DKK.

12.7.5. Nykredits Realkreditindeks includes a representative extract of the Danish covered bond market. The index includes both covered bonds with short and long maturities. See also *ANNEX I* - Background on the treatment of Danish covered bonds to this section.

12.8. INPUTS USED TO DETERMINE S_{GOV} AND S_{CORP}

12.8.1. For determining the spread S_{gov} on government bonds, the starting point is the information of insurance market data relevant for the currency (or country) whose VA is calculated. This information is composed of two elements:

a) The composition of the reference portfolio of yield market indices of government bonds for the currency (or country). This composition is applied considering for each component of the portfolio (i.e., each issuer) its relative market value (the percentage of the total market value of the portfolio).
b) It is also necessary to know the duration of each component of the reference portfolio.

Each relative market value and its corresponding duration build a model bond (i.e., a model bond is a government bond with the duration for such bond in the currency or country where the VA is calculated).
Since in the case of government bonds the selected yield market indices are yield curves, this means that each model bond is the value of the yield curve for each issuer at the relevant maturity.

12.8.2. The following financial market inputs are also necessary:

a) The market yields corresponding to the currency and duration of each model point representing the government bonds as referred above and in section 11.
b) The basic risk-free interest rates corresponding to the currency and durations of each model point representing the government bonds as referred above and in section 11.
c) The risk corrections corresponding to the currency and durations of each model point representing the government bonds as referred above and in section 11.

12.8.3. Where the average duration of the relevant government bond in which the insurance and reinsurance undertakings of a given market are invested in does not coincide with one of the maturities of the yield curve, EIOPA uses a linear interpolation to find the interest rate of the government bond and/or the basic risk-free rate and/or the risk correction that corresponds to the average duration. In case the average duration of the relevant government bond is greater than the highest available maturity of the corresponding yield curve, the interest rate of the highest available maturity is used.

12.8.4. For determining the spread S_{corp} on assets other than government bonds, the same approach applies *mutatis mutandis*.

12.8.5. Table 16 summarizes the inputs for the calculations per sub portfolio underlying the VA:

Table 16 - Specification of the input for the calculation of the VA

Calculation Inputs VA			Yield	Risk-free rate	Risk correction
Government part of the VA	Currency VA	Govt bonds	**Euro VA:** ECB curve for all euro area issuers, government bond of the issuer for all non-euro area issuers **VAs for other currencies:** Government bond of the issuer	Currency of the issuer	**Euro VA:** ECB curve FS for all euro area issuers, government bond FS of the issuer for all non-euro area issuers **VAs for other currencies:** Government bond FS of the issuer
	Country VA	Govt bonds	Government bond of the issuer	Currency of the issuer	Government bond FS of the issuer
Corporate part of the VA	Currency VA	Corp bonds	Corporate bonds in the currency for which a VA is calculated (if needed with K factor approach)	Currency for which a VA is calculated	Corporate bond FS in the currency for which a VA is calculated (if needed with K factor approach)
		RGLA bonds	**Euro VA:** ECB curve for all euro area issuers, government bond of the issuer for all non-euro area issuers **VAs for other currencies:** Government bond of the issuer	Currency of the issuer	**Euro VA:** ECB curve FS for all euro area issuers, government bond FS of the issuer for all non-euro area issuers **VAs for other currencies:** Government bond FS of the issuer
	Country VA	Corp bonds	Corporate bonds in the currency of the country for which a VA is calculated (if needed with K factor approach)	Currency of the country for which a VA is calculated	Corporate bond FS in the currency of the country for which a VA is calculated (if needed with K factor approach)

		RGLA BONDS	Government bond of the country of the issuer	Currency of the issuer	Government bond FS of the issuer

13. PROCESS OF CALCULATION OF THE RISK-CORRECTED SPREAD AT PORTFOLIO LEVEL

13.1. PROCESS OF CALCULATION OF THE CURRENCY VOLATILITY ADJUSTMENT

13.1.1. The process applies *mutatis mutandis* to the calculation of the country specific increase of the volatility adjustment.

13.1.2. The following steps describe the process in detail:

- Step 1: For each currency, identify the model bonds (and their duration) included in the representative portfolio.
- Step 2: For each model bond, identify the market yield at the date of calculation, according to the information in section 12 and the corresponding duration of the model bond.[19] This yield is referred to in the process as 'yield before risk correction'.
- Step 3: For each model bond, identify the basic risk-free interest rates curve at the date of calculation, according to the duration of the model bond.[20]
- Step 4: For each model bond, calculate the risk correction as the maximum of the relevant percentage of the long-term average spread (30% or 35% as described in subsection 12.2), and the *PD+CoD* (probability of default and cost of downgrade, as referred to in subsection 12.4 and ANNEX H). In the case of government bonds, the risk correction is the relevant percentage of the long-term average spread (i.e., the *PD+CoD* component does not apply). Where the *LTAS* is negative, a zero floor is applied as mentioned in section 10.
- Step 5: Once completed the previous steps, a single cash flow is projected for each model bond according to the duration of the model bond, and using as capitalization rate the market 'yield before risk correction' referred to in step 2. This means a cash flow projection with the features of each model bond.
- Step 6: The projection of single cash flows for each model bond made in step 5 is repeated but using as capitalization rate the basic risk-free rate referred to in step 3.

[19] Where the market yield is given for a maturity that does not fit exactly the weighted average duration of the model bond, a linear interpolation of yields of the same index or the same curve is performed.

[20] The same linear interpolation as in step 2 applies if necessary.

- Step 7: A third projection is necessary but using this time, as capitalization rate, the 'yield before risk correction' reduced with the risk correction derived in step 4.
- Steps 8, 9 and 10: Calculation of the three following internal effective rates (IER[21]) for the overall reference portfolio:
  - Step 8: "IER_yield_before" is equal to the internal effective rate, calculated as a single discount rate that, where applied to the cash-flows calculated in step 5, results in a value that is equal to the aggregated value of the whole portfolio (since relative percentages are used, this aggregated value is 1).
  - Step 9: "IER_basic_RFR" is equal to the internal effective rate, calculated as a single discount rate that, where applied to the cash-flows calculated in step 6, results in a value that is equal to the aggregated value of the whole portfolio (since relative percentages are used, this aggregated value is 1).
  - Step 10: "IER_yield_corrected" is equal to the internal effective rate, calculated as a single discount rate that, where applied to the cash-flows calculated in step 7, results in a value that is equal to the aggregated value of the whole portfolio (since relative percentages are used, this aggregated value is 1).

13.1.3. Next, for each relevant currency, the spreads S_{gov} (the same applies for S_{corp}) before the risk correction is equal to the following, in accordance to Article 50 of the Delegated Regulation:

$$S_{gov} = max\left(0\,;\ IER_{yield\ before\ RC} - IER_{Basic\ RFR}\right)$$

while the risk correction RC_{gov} (the same applies to RC_{corp}) is equal to the following[22]:

$$RC_{gov} = \ max\ (\ 0\,;\ IER_{yield\ before\ RC} - IER_{yield\ corrected}\ )$$

13.1.4. Finally, for each relevant currency and country the VA is calculated using these four values (S_{gov}, S_{corp}, RC_{gov}, RC_{corp}) as inputs to the formulas referred to in subsections 10.3 and 10.4 .

[21] The IER is calculated by EIOPA using a pre-defined Matlab function: "xirr" with the following parameters: "GUESS" = 0.05 and "MAXITER" = 200.

[22] The risk correction at portfolio level cannot be negative because, as mentioned in section 10, the risk correction for each individual model bond cannot be negative.

13.1.5. The volatility adjustment is rounded at the nearest integer basis point. This rounding is applied only at the end of the calculation process.

13.1.6. Illustrative example (dummy data)

W_{GOV}	62,00%	
W_{CORP}	25,10%	
S_{GOV}	0,85%	= IER 1(step 8) - IER 2 (step 9)
S_{CORP}	1,20%	= IER 1(step 8) - IER 2 (step 9)
RC_{GOV}	0,20%	= IER 1(step 8) - IER 3 (step 1)
RC_{CORP}	0,35%	= IER 1(step 8) - IER 3 (step 1)
S	0,83%	
RC	0,21%	
S_RC_{CRNCY}	0,62%	
CURRENCY VA	0,40%	

13.1.7. Detailed examples of the VA calculation can be found in the two Excel files "VA calculation example IT" and "VA calculation example UK" available at EIOPA's website.

14. FINANCIAL MARKET DATA APPLIED FOR VA AND MA CALCULATION

14.1. MARKET DATA FOR GOVERNMENT BONDS

14.1.1. The calculation of the *LTAS* is based on the basic risk-free interest rates term structures and the government yield curves described in section 5.

14.2. MARKET DATA FOR CORPORATE BONDS

14.2.1. The market yields for corporate bonds are those provided by the Markit – iBoxx indices listed in the tables below in this subsection. The yield is the 'Annual Yield' and the duration is the 'Duration' (rounded to the first decimal).[23]

14.2.2. The relevant yield curve is calculated by linear interpolation for those maturities provided by the source. For shorter and longer maturities, the interest rate published for the nearest duration is applied. An example for the interpolation is as follows: to calculate the yield for a bond of duration 8.8, a linear interpolation is performed using the closest data available. For instance, this could be, on the one hand the market yield of the bucket 7-10Y and its duration (e.g. 8.3 years) and, on the other hand, the market yield of the bucket 10-15Y and its duration (e.g. 12.1 years).

14.2.3. Having in mind the availability of both the current value of market yield indices for exposures to corporate bonds, and of their historical series (necessary to calculate the long-term average spreads), the following decisions have been adopted for pragmatic reasons:

a) CQS0 (AAA) corporate yield indices for the euro and GBP have not been available during the last two years for a major part of the maturity buckets, and even for those maturity buckets where yields are available, the number of constituents of the index is very low. Furthermore, availability of buckets has continuously changed during the last years (i.e., not always the same buckets of duration have been available).
To solve the current lack of data and avoid the exposure of the calculation to likely business contingencies, the market yields of CQS0 exposures will be 85% of CQS1

[23] The names of the yield and duration concepts relate to the field names of the data files from the Markit FTP server. Before 7 October 2019, the yield and duration for the high-yield indices were called 'Annual Yield to worst' and 'Duration to worst' respectively in the CSV files.

yields for the euro and for the GBP. The 0.85 reduction factor is based on the historical experience of those periods where both CQS0 and CQS1 yields have been simultaneously available. In case CQS1 yields are negative the market yields of CQS0 exposures will be 115% of CQS1 yields.

b) Regarding CQS1 non-financial bonds expressed in GBP, the available historical series of market yield indices for maturities from 4- to 9-year are incomplete and a reliable calculation of the long-term average spread (LTAS) is not possible before 1st January 2016.

   Therefore for GBP non-financial bonds, credit quality step 1, the LTAS for maturities 4- to 9-year is obtained by linear interpolation of 3- and 10-year maturities LTAS. This interpolation is performed for all data before the 31 December 2015. It won't be performed for the data afterwards as reliable data is available. This rule does not apply to the current market yields, because for the time being it is possible to use the indices GBP CQS1 Non-financial.

c) The currently available indices for CQS4 and CQS5 do not discriminate by duration. Therefore, the market yield of sub-investment grade assets CQS4 and CQS5 is used for all maturities (i.e., a flat curve is used).

d) The market yield indices available for CQS6 are based on a limited number of constituents and the historical information available is not complete enough. For these exposures the market yield indices of CQS5 are applied.

14.2.4. EIOPA will monitor the effect of these criteria and the improvements of the available financial market data

14.3. MARKET DATA FOR THE CALCULATION OF THE PD AND COD

14.3.1. The inputs necessary for the calculation of the probability of default and cost of downgrade are the benchmark curve used to calculate the spreads, the corporate bonds spreads to the benchmark curve, and the relevant transition matrices:

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

   - the transition probabilities refer to the 1-year average calculated along the last 30 years, until 1 January 2016.

- having in mind the limited number of exposures per geographical area, credit quality step and economic sector, the geographical area considered refers to all countries.
- the withdrawn exposures are excluded (i.e., not considered in the initial population of names).
- the statistics refer to issuers (i.e. names).
- having in mind the definition of the market source for ratings below CCC, those categories are included as defaults. Therefore, matrices used as input have seven credit quality steps (i.e. eight rows and columns, including the situation of being defaulted, which is considered to be an absorbing state – no return to rated categories).

14.3.2. The input data for the transition matrices are specified in ANNEX J.

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

Table 17 - Markit: EUR iBoxx indices

Markit iBoxx Indices	1-3yr	3-5yr	5-7yr	7-10yr	10+yr
EUR Financials AAA	85% of the EUR financials AA yields if those yields are positive or zero, otherwise 115% of those yields				
EUR Financials AA	DE000A0JZBB2	DE000A0JZBD8	DE000A0JZBF3	DE000A0JZBH9	DE000A0JZA95
EUR Financials A	DE000A0JZA12	DE000A0JZA38	DE000A0JZA53	DE000A0JZA79	DE000A0JZAZ3
EUR Financials BBB	DE000A0JZBX6	DE000A0JZBZ1	DE000A0JZB11	DE000A0JZB37	DE000A0JZBV0
EUR Financials BB	iBoxx EUR High Yield curve Financials ex crossover LC BB (GB00B1CQYN32)				
EUR Financials B	iBoxx EUR High Yield curve Financials ex crossover LC B (GB00B1CQYW23)				
EUR Financials CCC	iBoxx EUR High Yield curve Financials ex crossover LC B (GB00B1CQYW23)				
EUR Non-Financials AAA	85% of the EUR Non-financials AA yields if those yields are positive or zero, otherwise 115% of those yields				
EUR Non-Financials AA	DE000A0JZCH7	DE000A0JZCK1	DE000A0JZCM7	DE000A0JZCP	DE000A0JZCF1
EUR Non-Financials A	DE000A0JZB78	DE000A0JZB94	DE000AJ0ZCB0	DE000A0JZCD6	DE000A0JZB52
EUR Non-Financials BBB	DE000A0JZC36	DE000A0JZC51	DE000A0JZC77	DE000A0JZC93	DE000A0JZC10
EUR Non-Financials BB	iBoxx EUR High Yield curve non-financials ex crossover LC BB (GB00B1CR1Z75)				
EUR Non-Financials B	iBoxx EUR High Yield curve non-financials ex crossover LC B (GB00B1CR2653)				
EUR Non-Financials CCC	iBoxx EUR High Yield curve non-financials ex crossover LC B (GB00B1CR2653)				

Table 18 - Markit: GBP iBoxx indices

Markit iBoxx Indices	1-3yr	3-5yr	5-7yr	7-10yr	10-15yr	15+yr
GBP Financials AAA	85% of the GBP financials AA yields if those yields are positive or zero, otherwise 115% of those yields					
GBP Financials AA	DE000A0JY7T1	DE000A0JY7X3	DE000A0JY7Z8	DE000A0JY712	DE000A0JY7R5	DE000A0JY7V7
GBP Financials A	DE000A0JY7B9	DE000A0JY7F0	DE000A0JY7H6	DE000A0JY7K0	DE000A0JY696	DE000A0JY7D5
GBP Financials BBB	DE000A0JY8R3	DE000A0JY8V5	DE000A0JY8X1	DE000A0JY8Z6	DE000A0JY8P7	DE000A0JY8T9
GBP Non-Financials AAA	85% of the GBP non-financials AA yields if those yields are positive or zero, otherwise 115% of those yields					
GBP Non-Financials AA	DE000A0JY9P5	DE000A0JY9T7	DE000A0JY9V3	DE000A0JY9X9	DE000AJ0Y9M2	DE000A0JY9R1
GBP Non-Financials A	DE000A0JY878	DE000A0JY9B5	DE000A0JY9D1	DE000A0JY9F6	DE000A0JY852	DE000A0JY894
GBP Non-Financials BBB	DE000A0JZAM1	DE000A0JZAR0	DE000A0JZAT6	DE000A0JZAV2	DE000A0JZAK5	DE000A0JZAP4

Table 19 - Markit: USD iBoxx indices

Markit iBoxx Indices	1-3yr	3-5yr	5-7yr	7-10yr	10-15yr	15+yr
USD Financials AAA	85% of the USD financial AA yields if those yields are positive or zero, otherwise 115% of those yields					
USD Financials AA	GB00B05DN483	GB00B05DN590	GB00B05DN608	GB00B05DN715	GB00B05DN822	GB00B05DNB55
USD Financials A	GB00B05DMS57	GB00B05DMT64	GB00B05DMV86	GB00B05DMW93	GB00B05DMX01	GB00B05DN046
USD Financials BBB	GB00B05DNS23	GB00B05DNT30	GB00B05DNV51	GB00B05DNW68	GB00B05DNX75	GB00B05DNZ99
USD Non-Financials AAA	85% of the USD Non-financials AA yields if those yields are positive or zero, otherwise 115% of those yields					
USD Non-Financials AA	GB00B05DQD84	GB00B05DQF90	GB00B05DQG16	GB00B05DQH23	GB00B05DQJ47	GB00B05DQL68
USD Non-Financials A	GB00B05DQ270	GB00B05DQ387	GB00B05DQ494	GB00B05DQ502	GB00B05DQ619	GB00B05DQ833
USD Non-Financials BBB	GB00B05DR245	GB00B05DR351	GB00B05DR468	GB00B05DR575	GB00B05DR682	GB00B05DR807

14.3.4. Yields for sub-investment grade bonds denominated in pound sterling and US dollar are derived from yields of corresponding bonds denominated in euro by applying the factor described in subsection 12.7

15. CALCULATION OF THE RISK-FREE INTEREST RATES TERM STRUCTURES AT A GLANCE.

15.1. SUMMARY OF THE COMPLETE PROCESS OF CALCULATION

15.1.1. Basic risk-free interest rates term structure

- Step A: Use as input for the market interest rates of the relevant financial instrument the data specified in Table 2.
- Step B: According to Table 3, Table 4, and Table 5 removal of the rates for the tenors either not meeting the DLT requirements or higher than the LLP.
- Step C: Calculation of the credit risk adjustment as described in section 7.
- Step D: Reduction of all the market rates remaining after step B by the amount of the credit risk adjustment (and the currency adjustment in the case of the Danish currency).
- Step E: Construction of the matrix of cash flows corresponding to the credit risk adjusted rates after step D.
  One of the dimensions of this matrix reflects the maturities corresponding to DLT rates (e.g. 1 to 15 and 20 years in the case of the euro), while the other dimensions reflects the future terms with payments of the underlying financial instrument, according to the frequency of the financial instrument (e.g. annualized rates in the case of the euro curve). For simplicity, market conventions are not used since its effect is negligible.
- Step F: Selection of the rest of inputs to the method of extrapolation in accordance with sections 6 and 9: LLP (subsection 9.2), ultimate forward rate (subsection 9.3), convergence period, tolerance (1 basis point) and lower bound of alpha parameter (0.05) (subsection 9.4).
- Step G: Application of the method of extrapolation (subsection 9.5).

15.1.2. Risk-free interest rates term structure with the volatility adjustment

- Step H: Calculation of the volatility adjustment. This subprocess has been described in section 10.2. For each relevant currency and each relevant country, the volatility adjustment is a fixed number, expressed in basis points and rounded to the nearest integer basis point, and applied to all maturities till the last liquid point.
- Step I: Construction of the matrix of cash flows corresponding to the zero-coupon annualized rates resulting from step G. All integer maturities until the last liquid point, included, will be used to build this matrix. Furthermore, for each maturity a single payment will be considered. Therefore, the matrix of this step will usually have different dimensions than the one built in step E.
- Step J: Addition of the annualized volatility adjustment to the matrix of cash flows obtained in step I.
- Step K: Application of the method of extrapolation with the same inputs used in step F and according to the method mentioned in step G.

15.1.3. The volatility adjustment is not added directly to the par swap rates adjusted for credit risk but is added to the zero-coupon spot rates of the basic risk-free interest rate term structure obtained after using the Smith-Wilson method (as described in an earlier part of this technical documentation).

15.1.4. In accordance with Article 46 of the Delegated Regulation, the volatility adjustment is added to the zero-coupon spot rates from paragraph 15.1.3 only for the liquid part of the curve.

15.1.5. The resulting rates are the relevant risk-free interest rates including the volatility adjustment to which the extrapolation is applied, using again the Smith-Wilson method.

15.1.6. Because the volatility adjustment is applied to the liquid zero-coupon rates of the basic risk-free interest rate term structure, the relevant risk-free interest rate term structure including the VA is a parallel shift of the basic risk-free interest rate term structure until the LLP. There is no parallel shift after the LLP since both the basic and relevant risk-free curves ultimately converge to the same UFR.

ANNEXES

ANNEX A RELEVANT CURRENCIES

A.1 ANNEX TO SECTION 5 - DATA SOURCES FOR THE INPUTS FROM FINANCIAL MARKETS

A.1.1 EEA Currencies

Table 20 - 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	Hungarian forint	Hungary
ISK	Icelandic króna	Iceland
NOK	Norwegian krone	Norway
PLN	Polish zloty	Poland
RON	Romanian leu	Romania
SEK	Swedish krona	Sweden

A.1.2 Other currencies

Table 21 - Other currencies

ISO 4217	Currency	Countries where the currency is used
AUD	Australian dollar	Australia
CAD	Canadian dollar	Canada
CNY	Chinese yuan renminbi	China
COP	Colombian peso	Colombia
GBP	Pound sterling	United Kingdom
HKD	Hong Kong dollar	Hong Kong
JPY	Japanese yen	Japan
TWD	New Taiwan dollar	Taiwan
USD	US dollar	United States

ANNEX B IDENTIFICATION OF REFERENCE INSTRUMENTS AND DLT ASSESSMENT

B.1 ANNEX TO SECTION 6 - BASIC RISK-FREE INTEREST RATE TERM STRUCTURES

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.[24] 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 upon up-to-date and credible information.[25]

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 DLT requirements are met, the DLT assessment should foster the optimal use of the information provided by financial markets.[26]

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

B.1.4 As part of the preparation and follow-up of the Long-term Guarantees Assessment, EIOPA developed a conceptual framework for DLT assessment based on the aforementioned analysis in 2013. This conceptual framework was put into practice on a tentative basis for the EIOPA Stress Test 2014.

B.1.5 EIOPA's work and lessons learnt during 2013 are in line with EBA's report on high quality liquid assets (HQLA).[27]

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

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

[26] Recital 45 of the Solvency II Directive.

[27] 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, http://www.eba.europa.eu/documents/10180/16145/EBA+BS+2013+413+Report+on+definition+of+HQLA.pdf

B.1.6 While acknowledging the differences between the banking and insurance sectors, EIOPA recognizes 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.1.7 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.1.8 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 (LCR) in the banking sector is quite 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.1.9 There are several factors influencing the liquidity (and depth) of financial markets. Further, the influence of these factors varies across markets (e.g., according to their practices, conventions, and operational rules) and also varies over time within the same market (e.g., according to changes in the environment). Finding a generalized way to measure the level of these factors is the subject of continuing research.

B.1.10 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).[28]

B.1.11 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. In particular for the swap market, the lack of information on real trading volumes means that it is not possible to use some of the main indicators generally used when making DLT assessments of other types of instruments. This limitation has particular importance because Solvency II prescribes swaps as the first choice of instrument for deriving the relevant risk-free interest rate term structure.

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

B.1.12 Finally, practitioners, academics and supervisors acknowledge the relevance of supplementing quantitative metrics with qualitative or expert judgement. EIOPA supports the appropriate consideration of qualitative information, and this view is also reflected in the EBA report on HQLA.[29] 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.1.13 The following annexes describe EIOPA's approach to the DLT assessment, separately for the following two cases:

a) EEA currencies, for which it is feasible to obtain ad-hoc information on pricing and trading (except for traded volumes for swaps, as mentioned above).
b) Non-EEA currencies, for which EIOPA has adapted its methodology to account for data limitations. In particular this approach includes those metrics used by EBA that do not rely on either traded volumes or on any other information that is not generally available.

B.1.14 In both cases, 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. Therefore, as a general rule, hard thresholds and the automatic use of benchmarks have not been considered appropriate. For example, comparing the bid-ask spreads of one currency against another does not necessarily provide conclusive evidence for a DLT assessment, not only because of the specifics of each financial market (level of interest rates, trends, etc.), but also because experience shows that the relative positions of two currencies may change over time.

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

ANNEX C DLT ASSESSMENT

C.1 ANNEX TO SUBSECTION 6.2 - CONCEPTUAL FRAMEWORK FOR EEA CURRENCIES

C.1.1 The DLT assessment for EEA currencies is based on the conceptual framework that EIOPA developed for the purposes of the Long-term Guarantees Assessment in 2013.

C.1.2 As mentioned in the general ANNEX B above, each of the depth, liquidity and transparency criteria lacks a globally accepted clear definition that is of practical use. Even in academic literature a wide range of measures for depth and liquidity exist; however, none of those measures is considered authoritative and applicable in all markets.

C.1.3 Therefore, the list of criteria mentioned below should be considered as non-exhaustive. EIOPA has focused on criteria that may be helpful in assessing the credibility of market data for interest rate swaps and government bonds. Additional criteria consider the general bond market. The criteria are as follows:

a) Bid-ask spread: the price difference between the highest price a buyer would pay and the lowest price for which a seller would sell.
b) Trade frequency: number of trades that take place within a defined period of time.
c) Trade volume.
d) Trader quotes/dealer surveys (incl. dispersion of answers).
e) Quote counts (1): number of dealer quotes within a window of a few days.
f) Quote counts (2): number of dealers quoting.
g) Number of pricing sources.
h) Assessment of large trades and movement of prices (depth).
i) Only applicable to the euro: residual volume approach for bonds.

Annex to subsection 0 -

C.2 CONCEPTUAL FRAMEWORK FOR NON-EEA CURRENCIES

C.2.1 The DLT assessment of non-EEA currencies is based, in addition to qualitative analysis, on the joint consideration of three main methodologies:

a) volatility analysis.
b) analysis of bid-ask spreads (both direct observations and also using the Roll measure, as described below).
c) quantitative analysis.

C.2.2 The DLT assessment methodology presented in this annex is going to be applied to non-EEA currencies. Results of that methodology for EEA currencies are presented only for illustration purposes. The DLT assessment for EEA currencies will be conducted according to methodology described in subsection 0.

C.3 VOLATILITY ANALYSIS

C.3.1 For the volatility analysis, the behavior of the available interest rates for each maturity and non-EEA currency over the past 105 business days is analyzed (this is approximately a chronological period of five months).

C.3.2 The analysis is conducted for rates directly observed in markets (e.g., par swap rates where swaps are the financial instrument used as reference), for zero-coupon spot rates, and finally for the 1-year forward rate term structure.

C.3.3 For each of the three sets of rates above, and for each currency and maturity, the analysis considers both the values of the rate and the behavior of the volatility calculated considering the last 21 days[30] (approximately one chronological month). Therefore, 84 values of the volatility for each rate are calculated, with rolling windows referring to the last 105 trading days (i.e., for the oldest 21 dates in the series, no volatility is calculated, as these dates do not have the 21-day period of reference necessary for the calculation).

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[30] The following formula is used:

Volatility = standard deviation of natural logarithms of variations =

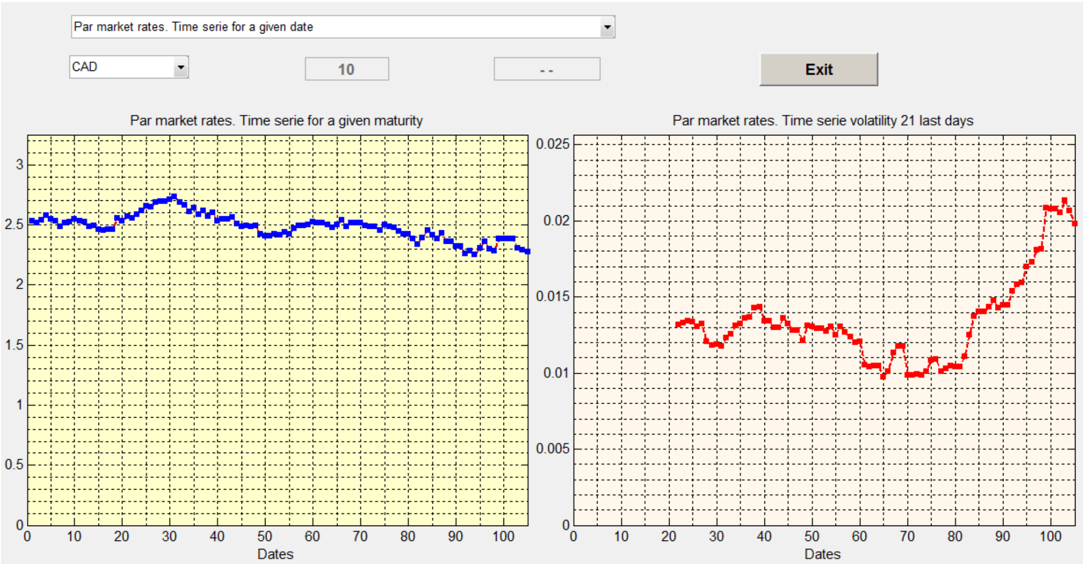
= $\sqrt{\sum \frac{(\ell n(c_i) - \overline{\ell n c})^2}{n-1}}$ where $ln\, c_k = ln \frac{rate_k}{rate_{k-1}}$ and $\overline{\ell n c}$ denotes the simple average of the last 21 daily logarithmic changes.

Note that no $\sqrt{t}$ adjustment is applied in order to derive annual volatilities. This has no impact on the conclusions to the extent the DLT analysis aims at comparing volatilities, not at assessing its values on an annual basis.

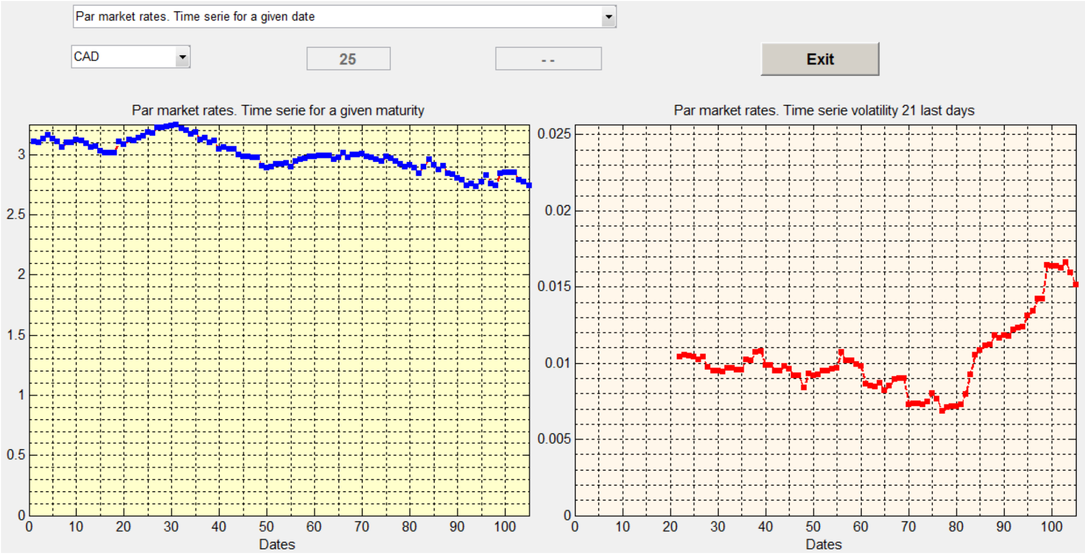
C.3.4 The analysis described in the paragraphs above is used to conduct three tests and to produce the set of statistics described below.

C.3.5 The first test focuses on how the rate for a given maturity behaves during the 105 day window (both the level of the rate itself and its 21-day volatility).

C.3.6 As an example, the charts below show the behavior of the 10-year (first two charts) and 25-year rates and volatilities (second two charts) for the Canadian dollar, as of 31 December 2014, using the par swap market rates.

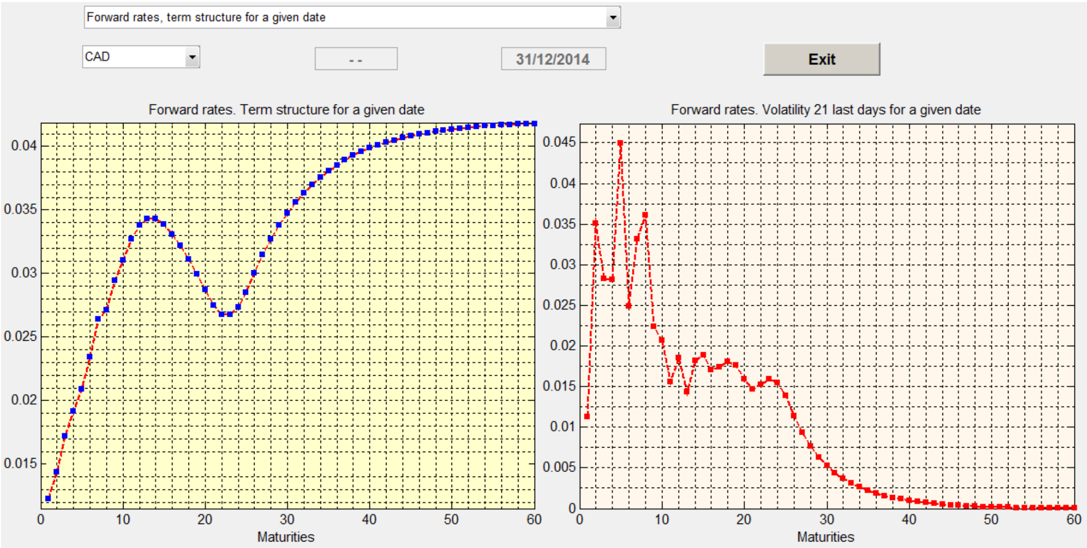


C.3.7 There are several ways of inferring an empirical view on the behavior of the interest rates. For example, by considering the values of the rates (y-axis in the left chart) and the level of the volatility (y-axis on the right-hand side), by considering the lack of/presence of repeated sudden changes in the level of the volatility, or by examining the range of variation in both charts. From these perspectives the rates for both maturities show a similar pattern, and do not convey abnormal features.



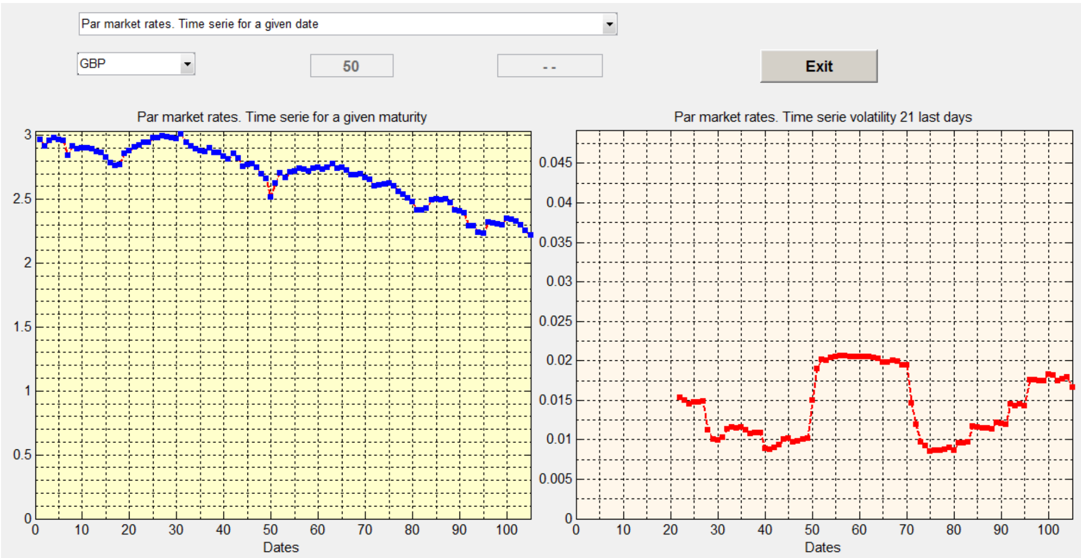
C.3.8 The second test aims to detect whether the rate for a given maturity produces humps or hollows in the term structure curve (i.e., by comparing with the behavior of neighboring maturities).

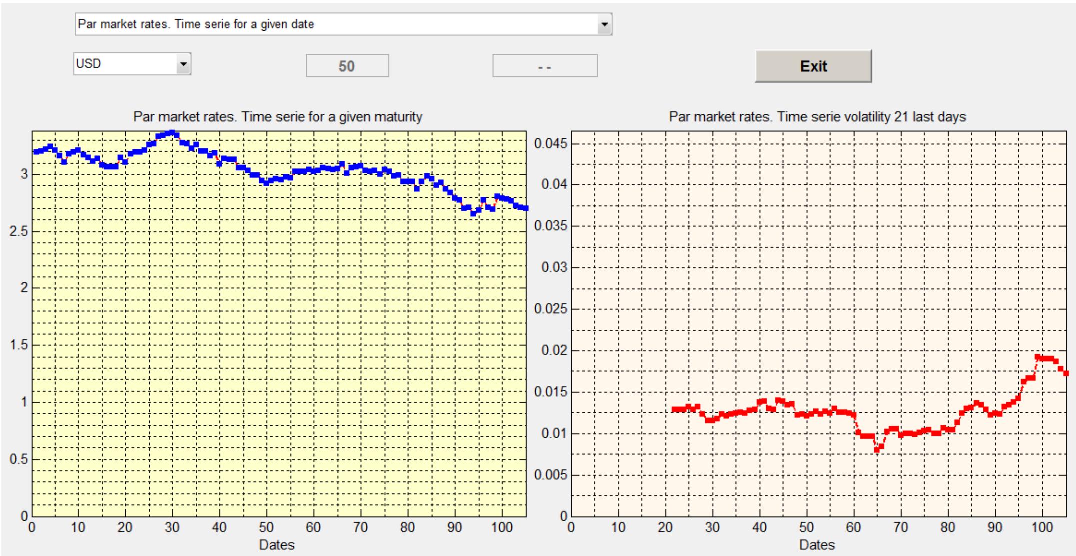
C.3.9 Again, using the example of the Canadian curve as at 31 December 2014, it can be seen that the curve does not present abnormal features and the 21-days volatility of all observable maturities is in a reasonable range (note the LLP for the Canadian currency is 25 years, therefore the part of the curve for maturities longer than 25 years does not represent market data, but the Smith-Wilson extrapolation).



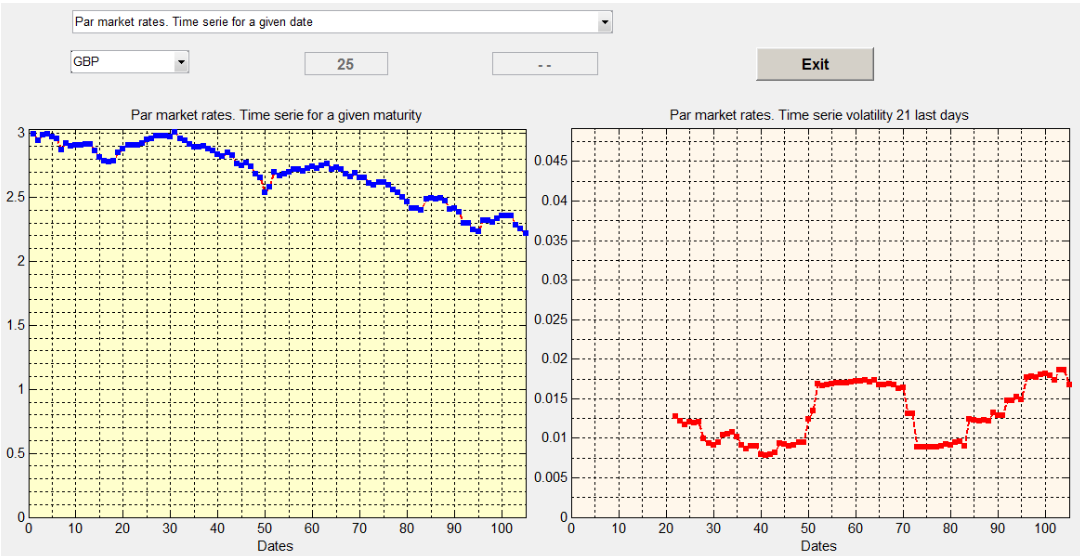
C.3.10 For the third analysis, a comparison across currencies has been developed. The comparison is used in situations where there is an adequate relationship between the non-EEA currency now being analyzed and an EEA currency whose DLT nature has been tested as described in section 4.B. This third test aims to verify whether the behavior of the non-EEA rate is sufficiently similar to its 'peer' EEA rate.

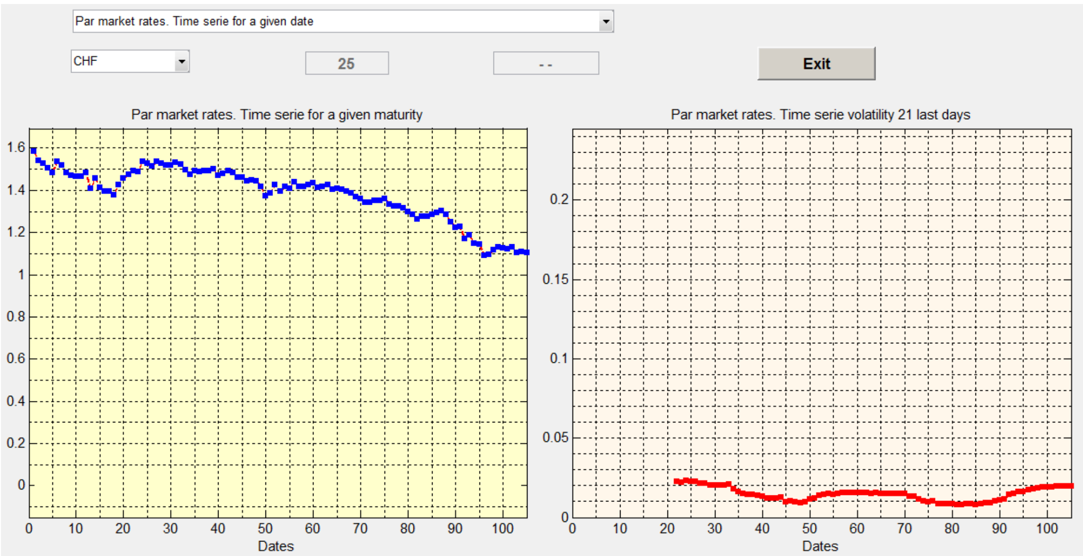
C.3.11 For example, the charts below compare the behavior of 50-year maturities for GBP and USD as at 31 December 2014 using par swap rates (note that the similarity of behaviors between these currencies is also observed when using zero-coupon rates and forward rates).





C.3.12 The charts below compare the behavior of 25-year maturities for GBP and CHF as at 31 December 2014 using 1-year forward rates (note that the similarity of behaviors is also observed when using par swap rates and zero-coupon rates).





C.4 THE ANALYSIS OF BID-ASK SPREADS: DIRECT OBSERVATION

C.4.1 For all currencies where a 'likely' longest DLT maturity has been established, a direct investigation of the specific bid-ask spreads at these maturities is also carried out. The following metrics are obtained for the month prior to the reference date and also for the last quarter:

a) Median of bid-ask spreads during the last month.
b) 80th Percentile of bid-ask spreads during the last month.
c) Maximum of bid-ask spreads during the last month.
d) Simple Average of bid-ask spreads during the last month.
e) Last spread (at the date of reference of the curve).
f) Number of days with zero spreads.

C.4.2 The tables below summarize some findings for long-term maturities of swaps as of 31 December 2014 (currencies identified according to ISO 4217 in all tables):

Table 22 - Analysis of bid-ask spread for 15-year interest rates swaps IBOR

	Last 64 days with trading						*Last 21 days with trading*					
	Zero observations	*Median non-zero spreads*	*Percentile 80 non-zero spreads*	*Maximum spread*	*Average non-zero spreads*	*Last non-zero spread*	*Zero observations*	*Median non-zero spreads*	*Percentile 80 non-zero spreads*	*Maximum spread*	*Average non-zero spreads*	*Last non-zero spread*
EUR	0	2.25	4.00	4.00	2.34	2.40	0	3.00	4.00	4.00	2.58	2.40
BGN	48	260.00	260.00	260.00	260.00	260.00	5	260.00	260.00	260.00	260.00	260.00
CZK	0	4.00	4.00	7.00	4.22	4.00	0	4.00	4.00	4.00	3.86	4.00
DKK	0	3.00	3.00	7.00	3.06	7.00	0	3.00	4.73	7.00	3.70	7.00
HUF	3	6.00	7.45	10.00	5.93	10.00	0	6.00	6.00	10.00	5.21	10.00
LIC	0	4.00	4.00	10.00	3.61	4.00	0	4.00	4.00	10.00	3.62	4.00
NOK	0	10.00	10.00	10.00	7.54	4.00	0	5.00	10.00	10.00	6.44	4.00
PLN	0	3.00	4.00	6.00	3.37	3.00	0	3.00	3.00	3.00	3.00	3.00
RON	0	140.00	140.00	140.00	140.00	140.00	0	140.00	140.00	140.00	140.00	140.00
RUB	0	14.00	14.00	14.00	14.00	14.00	0	14.00	14.00	14.00	14.00	14.00
SEK	0	3.00	3.10	6.00	3.17	3.00	0	3.00	3.00	3.10	2.88	3.00
CHF	0	4.00	4.00	10.00	3.61	4.00	0	4.00	4.00	10.00	3.62	4.00
GBP	0	1.00	1.00	1.90	1.00	1.80	0	1.00	1.56	1.90	1.13	1.80
AUD	0	3.00	4.00	8.50	3.45	4.00	0	3.00	4.00	8.50	3.60	4.00
CAD	0	3.17	4.00	6.10	3.09	4.00	0	3.42	4.00	5.90	3.06	4.00
CLP	2	4.00	5.00	5.00	4.21	4.00	2	4.00	4.70	5.00	4.21	4.00
CNY	3	40.00	40.00	59.00	40.51	40.00	0	39.00	40.00	59.00	40.33	40.00
HKD	2	7.00	7.10	10.00	7.25	10.00	2	7.00	7.10	10.00	7.48	10.00
JPY	0	2.00	2.00	8.00	2.20	2.00	0	2.00	2.00	8.00	2.24	2.00
MYR	0	10.00	10.00	10.00	9.94	10.00	0	10.00	10.00	10.00	10.00	10.00
MXN	0	4.00	4.00	6.00	4.00	4.00	0	4.00	4.60	6.00	4.27	4.00
NZD	3	1.00	1.74	8.00	2.00	0.75	1	0.75	1.00	8.00	1.39	0.75
SGD	0	7.00	7.00	7.10	5.88	7.00	0	7.00	7.00	7.00	6.12	7.00
ZAR	0	8.00	10.00	10.00	8.06	8.00	0	8.00	10.00	10.00	8.25	8.00
KRW	0	3.00	3.50	3.50	3.20	3.00	0	3.00	3.50	3.50	3.17	3.00
THB	0	9.00	10.00	12.00	8.84	9.00	0	9.00	10.00	10.00	8.71	9.00
TRY	0	40.00	40.00	42.00	40.08	40.00	0	40.00	40.00	41.00	40.05	40.00
USD	2	0.40	0.51	0.80	0.39	0.50	-	0.45	0.56	0.80	0.43	0.50

Table 23 - Analysis of bid-ask spread for 20-year interest rates swaps IBOR

	Last 64 days with trading						Last 21 days with trading					
	Zero observations	Median non-zero spreads	Percentile 80 non-zero spreads	Maximum spread	Average non-zero spreads	Last non-zero spread	Zero observations	Median non-zero spreads	Percentile 80 non-zero spreads	Maximum spread	Average non-zero spreads	Last non-zero spread
EUR	0	2.18	4.00	4.00	2.28	2.40	0	2.66	4.00	4.00	2.52	2.40
BGN	48	260.00	260.00	260.00	260.00	260.00	5	260.00	260.00	260.00	260.00	260.00
CZK	0	4.00	4.00	7.00	4.20	4.00	0	4.00	4.00	4.00	3.86	4.00
DKK	0	3.00	3.00	7.00	3.12	7.00	0	3.00	4.80	7.00	3.63	7.00
HUF	4	6.00	10.00	10.00	6.67	6.00	1	6.00	6.00	6.00	5.73	6.00
LIC	0	4.00	4.00	10.00	3.66	5.00	0	3.00	4.30	10.00	3.33	5.00
NOK	0	15.50	15.50	15.50	14.66	3.70	0	15.50	15.50	15.50	12.94	3.70
PLN	1	3.00	3.97	6.00	3.25	3.00	0	3.00	3.00	3.00	2.89	3.00
RON	0	140.00	140.00	140.00	140.00	140.00	0	140.00	140.00	140.00	140.00	140.00
RUB	2	10.00	60.00	61.00	24.53	60.00	2	60.00	60.70	61.00	55.42	60.00
SEK	0	3.00	3.10	8.00	3.57	3.00	0	3.00	3.10	6.00	3.15	3.00
CHF	0	4.00	4.00	10.00	3.66	5.00	0	3.00	4.30	10.00	3.33	5.00
GBP	0	1.18	1.33	13.10	1.69	1.16	0	1.18	1.45	13.10	2.68	1.16
AUD	0	3.68	4.00	4.00	3.67	4.00	0	3.62	4.00	4.00	3.65	4.00
CAD	0	3.38	4.00	6.10	3.10	4.00	0	3.93	4.05	6.10	3.28	4.00
CLP	2	4.00	5.00	5.00	4.21	4.00	2	4.00	5.00	5.00	4.26	4.00
JPY	0	2.00	2.00	8.00	2.20	2.00	0	2.00	2.00	8.00	2.24	2.00
MYR	0	10.00	10.00	10.00	9.97	10.00	0	10.00	10.00	10.00	10.00	10.00
MXN	20	3.00	3.00	3.00	3.00	3.00	14	3.00	3.00	3.00	3.00	3.00
NZD	0	1.00	5.73	8.00	2.36	8.00	0	1.00	3.10	8.00	2.25	8.00
SGD	0	7.00	7.00	7.70	6.10	7.00	0	7.00	7.00	7.70	6.39	7.00
ZAR	0	8.00	8.00	11.00	7.24	8.00	0	8.00	8.00	11.00	8.00	8.00
KRW	0	3.25	3.50	3.50	3.24	3.50	0	3.50	3.50	3.50	3.31	3.50
THB	0	15.00	15.00	31.50	13.01	6.00	0	15.00	15.00	15.00	12.00	6.00
TRY	0	20.00	20.00	21.00	20.02	20.00	0	20.00	20.00	21.00	20.05	20.00
USD	0	0.40	0.55	0.80	0.41	0.50	-	0.48	0.57	0.80	0.44	0.50

Table 24 - Analysis of bid-ask spread for 25-year interest rates swaps IBOR

	Last 64 days with trading						Last 21 days with trading					
	Zero observations	Median non-zero spreads	Percentile 80 non-zero spreads	Maximum spread	Average non-zero spreads	Last non-zero spread	Zero observations	Median non-zero spreads	Percentile 80 non-zero spreads	Maximum spread	Average non-zero spreads	Last non-zero spread
EUR	0	2.46	4.00	4.00	2.43	2.40	0	3.00	4.00	4.00	2.56	2.40
CZK	0	4.00	4.00	7.00	4.45	4.00	0	4.00	4.00	4.00	4.00	4.00
DKK	0	3.00	3.00	7.00	3.25	7.00	0	3.00	4.20	7.00	3.76	7.00
LIC	0	6.00	6.00	10.00	4.48	5.00	0	3.00	5.30	10.00	3.41	5.00
NOK	0	17.50	17.50	21.30	16.94	3.70	0	17.50	17.50	17.50	15.60	3.70
SEK	1	3.00	5.00	8.00	3.77	3.00	1	3.00	5.00	8.00	3.56	3.00
CHF	0	6.00	6.00	10.00	4.48	5.00	0	3.00	5.30	10.00	3.41	5.00
GBP	0	1.00	1.00	1.70	1.00	1.00	0	1.00	1.00	1.70	1.02	1.00
AUD	0	3.56	4.00	4.00	3.66	4.00	0	3.62	4.00	4.00	3.65	4.00
CAD	0	3.00	4.00	6.10	3.04	4.00	0	3.45	4.00	6.00	3.25	4.00
JPY	0	2.00	2.00	8.00	2.39	8.00	0	2.00	2.00	8.00	2.47	8.00
MYR	0	10.00	10.00	10.00	9.97	10.00	0	10.00	10.00	10.00	10.00	10.00
NZD	7	1.00	1.00	1.00	1.00	1.00	0	1.00	1.00	1.00	1.00	1.00
ZAR	0	8.00	10.00	10.00	7.95	8.00	0	8.00	10.00	10.00	8.40	8.00
KRW	0	3.50	3.50	3.50	3.26	3.50	0	3.50	3.50	3.50	3.33	3.50
USD	0	0.40	0.60	0.85	0.45	0.60	0	0.50	0.60	0.69	0.48	0.60

Table 25 - Analysis of bid-ask spread for 30-year interest rates swaps IBOR

	Last 64 days with trading						Last 21 days with trading					
	Zero observations	Median non-zero spreads	Percentile 80 non-zero spreads	Maximum spread	Average non-zero spreads	Last non-zero spread	Zero observations	Median non-zero spreads	Percentile 80 non-zero spreads	Maximum spread	Average non-zero spreads	Last non-zero spread
EUR	0	3.00	3.00	3.00	2.28	1.00	0	3.00	3.00	3.00	2.39	1.00
CZK	0	4.00	4.00	7.00	3.95	4.00	0	4.00	4.00	4.00	3.81	4.00
DKK	0	3.00	3.00	7.00	2.94	7.00	0	3.00	4.80	7.00	3.43	7.00
LIC	0	6.00	6.00	10.00	4.91	6.00	0	6.00	6.00	10.00	4.66	6.00
NOK	0	17.50	17.50	17.50	16.55	3.70	0	17.50	17.50	17.50	15.77	3.70
PLN	0	4.00	4.00	6.00	4.08	4.00	0	4.00	4.00	4.00	4.00	4.00
SEK	0	5.37	6.00	10.00	5.05	3.00	0	3.00	6.00	10.00	4.57	3.00
CHF	0	6.00	6.00	10.00	4.91	6.00	0	6.00	6.00	10.00	4.66	6.00
GBP	0	0.95	1.00	2.00	0.98	1.80	0	1.00	1.83	2.00	1.17	1.80
AUD	0	3.75	4.00	5.00	3.64	4.00	0	3.75	4.00	4.00	3.68	4.00
CAD	0	4.00	4.00	6.10	3.92	4.00	0	4.00	4.00	6.10	4.00	4.00
JPY	0	2.00	2.00	8.00	2.40	8.00	0	2.00	2.00	8.00	2.52	8.00
SGD	0	5.00	6.00	8.00	5.24	6.00	0	5.00	6.00	8.00	5.33	6.00
ZAR	0	8.00	8.00	10.00	7.53	8.00	0	8.00	8.00	10.00	7.86	8.00
KRW	0	3.50	3.50	3.50	3.26	3.50	0	3.50	3.50	3.50	3.33	3.50
USD	1	0.44	0.70	1.45	0.47	0.72	0	0.48	0.71	0.92	0.49	0.72

Table 26 - Analysis of bid-ask spread for 50-year interest rates swaps IBOR

	Last 64 days with trading						Last 21 days with trading					
	Zero observations	Median non-zero spreads	Percentile 80 non-zero spreads	Maximum spread	Average non-zero spreads	Last non-zero spread	Zero observations	Median non-zero spreads	Percentile 80 non-zero spreads	Maximum spread	Average non-zero spreads	Last non-zero spread
EUR	0	3.00	3.00	3.00	2.39	2.00	0	3.00	3.00	3.00	2.49	2.00
LIC	0	10.00	10.00	10.00	10.00	10.00	0	10.00	10.00	10.00	10.00	10.00
CHF	0	10.00	10.00	10.00	10.00	10.00	0	10.00	10.00	10.00	10.00	10.00
GBP	0	1.00	1.00	2.00	1.07	1.80	0	1.00	1.52	2.00	1.21	1.80
USD	0	1.20	2.00	2.10	1.36	2.00	0	1.20	2.00	2.00	1.45	2.00

C.5 THE ANALYSIS OF BID-ASK SPREADS: ROLL MEASURE

C.5.1 For this analysis, EIOPA has followed the approach used in the EBA report on HQLA. Roll (1984)[31] shows that under certain conditions, the percentage bid/ask spread equals two times the square root of minus the covariance between consecutive returns:

$$Roll_t = 2 \cdot \sqrt{- cov(r_k, r_{k-1})},$$

where t is the time period over which the measure is calculated and $r_k = price_k - price_{k-1}$.

The higher value of Roll measure, the lower liquidity of the analyzed interest rate.

[31] Richard Roll (1984), A Simple Implicit Measure of the Effective Bid-Ask Spread in an Efficient Market. The Journal of Finance, 39: 1127-1139.

C.5.2 EIOPA's analysis considers a daily Roll measure, using a 21-trading day rolling window in the computation of the covariance. In cases where a positive covariance is found, the Roll measure is set to zero.

C.5.3 The set of analytical tests described for the volatility analysis are also applied for the Roll measure, although in this case only the zero-coupon rates are examined. This approach (examining only the zero-coupon rates) does not have a material influence on the outcome of the assessment, because all the information is already captured in the chart analysis for both the volatility and the Roll measurement.

C.6 QUANTITATIVE ANALYSIS

C.6.1 As mentioned in section B.1.14, EIOPA does not consider it appropriate to apply hard thresholds purely based on quantitative metrics, because it is necessary to make an appropriate allowance for the characteristics of each individual market and for prevailing financial conditions.

C.6.2 For the same reasons, metrics that can be calculated as at a specific date should be supplemented by examining the behavior of these metrics during the rolling windows of the period of observation mentioned above (105 days).

C.6.3 Thus, additional relevant metrics are as follows:

a) Number of days without any available data.
b) Median of spot zero coupon rates during the 105-day period of observation. This provides a metric to measure the 'size effect', which is currently material both across currencies and across maturities within the same currency.
c) Trend of interest rates during the period (obtained as the first-degree coefficient of a linear fitting with LSM). This metric is necessary for an appropriate assessment of other metrics, to the extent that the existence of a clear and strong trend in interest rates, influences other metrics (e.g., the Roll measure).
d) For the series of zero-coupon rates, the interquartile range (Q75 – Q25) relative to the median.
e) For the series of zero-coupon rates, the number of outliers, calculated as the number of interest rates falling outside of the interval (mean - 1.5 standard deviations; mean + 1.5 standard deviations). Note that these statistics are calculated using only the interest rates between the 12.5th and 87.5thpercentiles (thus avoiding any influence on the mean or standard deviation of 'large' outliers).
f) Last 21-day volatility observed in the 105-day period.

g) For the series of first order differences of zero-coupon rates, the interquartile range (Q75 - Q25) relative to the median.

h) For the series of first order differences of zero-coupon rates, the number of outliers as described above.

i) Last observed Roll measure.

j) 90th Percentile for the series of Roll-measurements.

k) 90th Percentile of logarithmic returns.

C.6.4 The table below provides an illustrative example of the outputs of these metrics, for those non-EEA currencies where it has been possible to obtain interest rates for 40-year maturities.

	Zero observations	*Median zero spot rate*	*Linear growth*	*Interquartile range / Median for rates*	*Num. Rates Outliers*	*Last 21-days volat*	*Interquartile range / Median for diffs*	*Num. Diffs Outliers*	*Last Roll measure*	*Perctile 90 Roll*	*Perctile 90 log returns*
EUR	0	2.20	- 0.47	12.61	10.00	2.00	- 5.95	18.00	34.41	47.00	1.72
CHF	0	1.77	- 0.25	10.13	14.00	1.65	- 7.93	16.00	28.70	5.17	1.25
GBP	0	3.21	- 0.46	9.10	1.00	1.21	- 24.80	11.00	-	62.20	1.42
AUD	0	4.52	- 0.18	5.87	12.00	1.90	- 21.41	15.00	62.50	68.79	3.38
JPY	0	2.02	- 0.10	3.40	6.00	1.16	- 14.12	13.00	18.97	36.74	0.80
USD	0	3.49	- 0.28	5.25	16.00	1.43	19.69	15.00	33.26	41.08	2.29

C.6.5 As mentioned above, this quantitative analysis is supplemented with the other analysis mentioned in this annex.

C.7 ANNEX TO SECTION 6: 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 3,

Table 4, and

Table 5 of the main text. Market data until (and including) 31 December 2019 was received from Bloomberg.

C.7.1 EEA currencies

Table 27 - History of financial instruments used for EEA currencies

	Financial instruments used **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 1-12,15,20Y	1 April 2021– 31 December 2024
	SWP 1-13,15,19,20Y	1 January 2025 – 29 June 2025
	SWP 1-13,15,20Y	30 June – 31 December 2025
CHF	SWP 1-15, 20, 25	1 January 2016 – 31 March 2021
	SWP 2,5,10,25	1 April 2021 – 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
NOK	SWP 1-10	1 January 2016 – 31 December 2019
	SWP 1-5, 10	1 January 2020 – 31 March 2021
	SWP 1, 2, 5 and 10	1 April 2021 – 31 December 2021
SEK	SWP 1-10	1 January 2016 – 31 December 2019
	SWP 1-7, 10	1 January 2020 – 31 March 2021
	SWP 1-5 and 10	1 April 2021 – 31 December 2021
	SWP 2, 5 and 10	1 January – 31 December 2022
	SWP 2-3,5,10	1 January 2023 – 31 December 2025

	Financial instruments used SWP=swaps, GVT=government bonds. All maturities in years.	Period
CZK	SWP 1-10, 12, 15	1 January 2016 – 31 March 2021
	SWP 1-2-5-10-15	1 April 2021 – 31 December 2021
	SWP 2,5,10,15	1 January – 31 December 2022
	SWP 1,2,5,10,15	1 January – 31 December 2023
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 2021 – 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.	
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 and 8	1 April 2021 – 31 December 2021
	GVT 1,2,4 and 8	1 January – 31 December 2022
	GVT 1-4 and 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
HUF	GVT 1-10, 15	1 January 2016 – 31 March 2021
RON	GVT 1-5, 7, 8, 9, 10	1 January 2016 – 31 March 2021
	GVT 1-6 and 8-10	1 April 2021 - 31 December 2021
	GVT 1-7 and 10	1 January – 31 December 2022
	GVT 1-10	1 January 2023 – 31 December 2025

C.7.2 Non-EEA currencies

Table 28 - History of financial instruments used for non-EEA currencies

	Financial instruments used **SWP=IBOR-swaps, OIS=OIS-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
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 2024 – 31 December 2024
CLP	SWP 1-10	1 January – 30 December 2016
	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
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

	Financial instruments used SWP=IBOR-swaps, OIS=OIS-swaps, GVT=government bonds. All maturities in years.	Period
	GVT 1-6,8-10	1 January – 31 December 2023
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
HKD	SWP 1-5, 7, 10, 12, 15	1 January 2016 – 31 December 2019
	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
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 2021 – 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
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	

	Financial instruments used **SWP=IBOR-swaps, OIS=OIS-swaps, GVT=government bonds. All maturities in years.**	Period
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
	SWP 1-5, 7, 10, 20	1 January 2020 – 31 March 2021
	SWP 1-5, 10,20	1 April 2021 – 31 December 2021
	SWP 1-5, 10	1 January 2022 – 31 December 2023
	SWP 1-5,7,10Y	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 2021 – 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

	Financial instruments used SWP=IBOR-swaps, OIS=OIS-swaps, GVT=government bonds. All maturities in years.	Period
	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 and 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
	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 2021 – 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	
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

	Financial instruments used **SWP=IBOR-swaps, OIS=OIS-swaps, GVT=government bonds. All maturities in years.**	Period
	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 D NUMERICAL ILLUSTRATION OF THE EXTRAPOLATION OF TERM STRUCTURES

D.1 ANNEX TO SECTION 9 - EXTRAPOLATION AND INTERPOLATION

D.1.1 With the data in the canonical normalized format as given on the next page and where the ultimate forward intensity $\omega = log(1.042)$ and convergence period S = 40, the following results are obtained for the key parameters of the Smith-Wilson method:

UFR	4,2%	ultimate forward rate	**u**	**Qb**
ω	0,0411	ultimate forward intensity	1	-2,045
			2	-0,528
κ	0,7379		3	3,375
			4	-4,119
U	20	last liquid point	5	3,831
S	40	convergence period	6	-1,583
T	60	convergence point	7	-1,036
			8	5,910
$\lvert f(T) - \omega \rvert$	0,0001	gap at convergence	9	-11,183
τ	0,0001	convergence tolerance	10	19,266
			11	-28,567
target	0,123760	minimize with respect to α	12	27,689
α	0,123760		13	-12,632
a	0,05	lowerbound α	14	-2,724
			15	2,212
			16	10,182
			17	-17,203
			18	10,943
			19	-4,674
			20	2,314

D.1.2 With α, ω, **u** and **Qb** the Smith-Wilson present value function can be evaluated for any maturity *v*:

$$p(v) = e^{-\omega v}(1 + H(v, \boldsymbol{u})\boldsymbol{Qb})$$

D.1.3 The yield intensity follows as:

$$y(v) = \frac{-\log p\,(v)}{v}$$

and the annualized yield rate can be calculated as a fractional power of the present value function or as the exponential of the yield intensity:

$$(p(v))^{-\frac{1}{v}} - 1 = exp\big(y(v)\big) - 1$$

D.1.4 Besides the data tableau in canonical normalized format below, also a graph of the yield and forward intensity curve is displayed and a tabulation of yield intensity together with annualized yield rate for maturities from 0 up to 120 years.

transpose of market observed p

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

cash-flow matrix C

																				u
1,002	0,00225	0,003	0,00425	0,0055	0,007	0,0085	0,01	0,0115	0,01275	0,014	0,01475	0,01575	0,0165	0,017	0,0175	0,018	0,01825	0,0185	0,01875	1
0	1,00225	0,003	0,00425	0,0055	0,007	0,0085	0,01	0,0115	0,01275	0,014	0,01475	0,01575	0,0165	0,017	0,0175	0,018	0,01825	0,0185	0,01875	2
0	0	1,003	0,00425	0,0055	0,007	0,0085	0,01	0,0115	0,01275	0,014	0,01475	0,01575	0,0165	0,017	0,0175	0,018	0,01825	0,0185	0,01875	3
0	0	0	1,00425	0,0055	0,007	0,0085	0,01	0,0115	0,01275	0,014	0,01475	0,01575	0,0165	0,017	0,0175	0,018	0,01825	0,0185	0,01875	4
0	0	0	0	1,0055	0,007	0,0085	0,01	0,0115	0,01275	0,014	0,01475	0,01575	0,0165	0,017	0,0175	0,018	0,01825	0,0185	0,01875	5
0	0	0	0	0	1,007	0,0085	0,01	0,0115	0,01275	0,014	0,01475	0,01575	0,0165	0,017	0,0175	0,018	0,01825	0,0185	0,01875	6
0	0	0	0	0	0	1,0085	0,01	0,0115	0,01275	0,014	0,01475	0,01575	0,0165	0,017	0,0175	0,018	0,01825	0,0185	0,01875	7
0	0	0	0	0	0	0	1,01	0,0115	0,01275	0,014	0,01475	0,01575	0,0165	0,017	0,0175	0,018	0,01825	0,0185	0,01875	8
0	0	0	0	0	0	0	0	1,0115	0,01275	0,014	0,01475	0,01575	0,0165	0,017	0,0175	0,018	0,01825	0,0185	0,01875	9
0	0	0	0	0	0	0	0	0	1,01275	0,014	0,01475	0,01575	0,0165	0,017	0,0175	0,018	0,01825	0,0185	0,01875	10
0	0	0	0	0	0	0	0	0	0	1,014	0,01475	0,01575	0,0165	0,017	0,0175	0,018	0,01825	0,0185	0,01875	11
0	0	0	0	0	0	0	0	0	0	0	1,01475	0,01575	0,0165	0,017	0,0175	0,018	0,01825	0,0185	0,01875	12
0	0	0	0	0	0	0	0	0	0	0	0	1,01575	0,0165	0,017	0,0175	0,018	0,01825	0,0185	0,01875	13
0	0	0	0	0	0	0	0	0	0	0	0	0	1,0165	0,017	0,0175	0,018	0,01825	0,0185	0,01875	14
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,017	0,0175	0,018	0,01825	0,0185	0,01875	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,0175	0,018	0,01825	0,0185	0,01875	16
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,018	0,01825	0,0185	0,01875	17
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,01825	0,0185	0,01875	18
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,0185	0,01875	19
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,01875	20

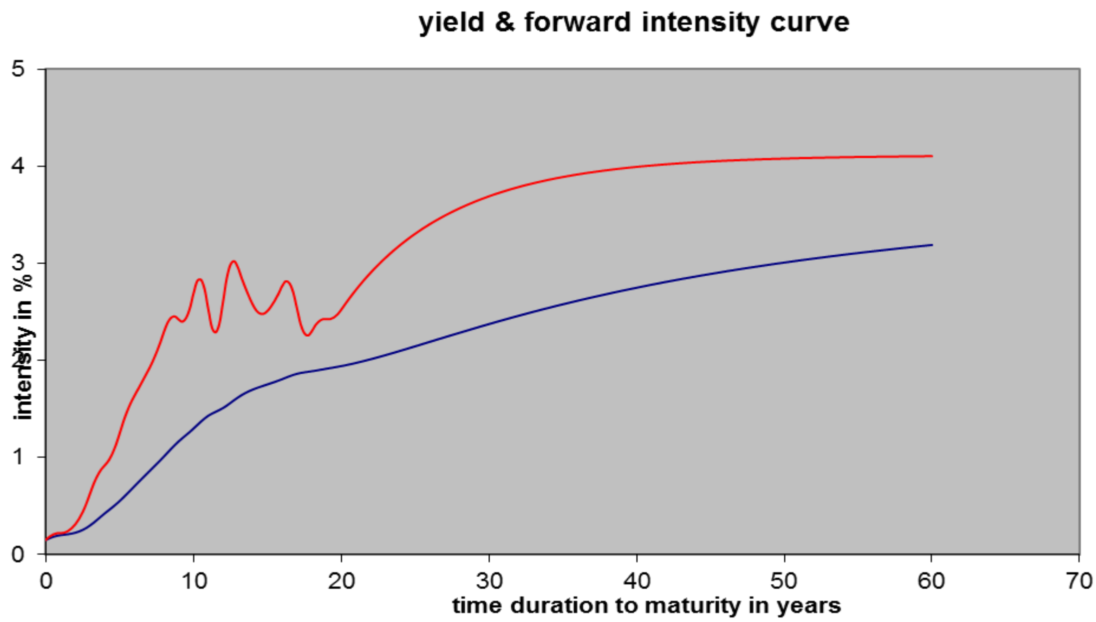


Table 29 - Spot yield intensities (continuous curve)

maturity in years	yield **intensity** in %	yield **rate** in %	maturity in years	yield **intensity** in %	yield **rate** in %	maturity in years	yield **intensity** in %	yield **rate** in %
0	0,15043	0,15054						
1	0,19980	0,20000	41	2,77975	2,81875	81	3,42830	3,48774
2	0,22478	0,22503	42	2,80915	2,84898	82	3,43665	3,49639
3	0,29980	0,30025	43	2,83746	2,87810	83	3,44481	3,50483
4	0,42516	0,42607	44	2,86472	2,90614	84	3,45277	3,51307
5	0,55098	0,55250	45	2,89096	2,93315	85	3,46055	3,52112
6	0,70286	0,70533	46	2,91624	2,95918	86	3,46814	3,52898
7	0,85583	0,85951	47	2,94059	2,98425	87	3,47556	3,53667
8	1,01017	1,01529	48	2,96406	3,00842	88	3,48282	3,54418
9	1,16615	1,17298	49	2,98668	3,03173	89	3,48991	3,55152
10	1,29724	1,30569	50	3,00850	3,05421	90	3,49684	3,55870
11	1,43000	1,44027	51	3,02954	3,07590	91	3,50362	3,56572
12	1,50925	1,52070	52	3,04985	3,09683	92	3,51026	3,57260
13	1,61761	1,63077	53	3,06945	3,11704	93	3,51675	3,57932
14	1,69901	1,71353	54	3,08838	3,13657	94	3,52310	3,58590
15	1,75260	1,76805	55	3,10667	3,15543	95	3,52933	3,59235
16	1,80701	1,82343	56	3,12435	3,17367	96	3,53542	3,59866
17	1,86227	1,87972	57	3,14145	3,19131	97	3,54138	3,60484
18	1,88810	1,90604	58	3,15798	3,20838	98	3,54723	3,61089
19	1,91447	1,93291	59	3,17399	3,22490	99	3,55295	3,61682
20	1,94136	1,96032	60	3,18948	3,24089	100	3,55856	3,62264
21	1,97401	1,99362	61	3,20449	3,25638	101	3,56406	3,62834
22	2,01239	2,03278	62	3,21902	3,27139	102	3,56946	3,63393
23	2,05459	2,07584	63	3,23312	3,28595	103	3,57475	3,63941
24	2,09920	2,12139	64	3,24678	3,30006	104	3,57993	3,64478
25	2,14517	2,16834	65	3,26004	3,31376	105	3,58502	3,65006
26	2,19172	2,21591	66	3,27290	3,32705	106	3,59001	3,65523
27	2,23826	2,26350	67	3,28539	3,33996	107	3,59491	3,66031
28	2,28439	2,31068	68	3,29752	3,35249	108	3,59972	3,66529
29	2,32977	2,35712	69	3,30931	3,36468	109	3,60444	3,67019
30	2,37419	2,40260	70	3,32076	3,37652	110	3,60907	3,67499
31	2,41750	2,44696	71	3,33190	3,38803	111	3,61362	3,67971
32	2,45959	2,49009	72	3,34273	3,39923	112	3,61809	3,68434
33	2,50039	2,53192	73	3,35327	3,41013	113	3,62248	3,68889
34	2,53988	2,57240	74	3,36353	3,42073	114	3,62679	3,69337
35	2,57802	2,61154	75	3,37351	3,43106	115	3,63103	3,69776
36	2,61483	2,64932	76	3,38324	3,44112	116	3,63520	3,70208
37	2,65033	2,68576	77	3,39272	3,45093	117	3,63929	3,70633
38	2,68453	2,72089	78	3,40195	3,46048	118	3,64332	3,71050
39	2,71748	2,75474	79	3,41095	3,46979	119	3,64727	3,71460
40	2,74921	2,78735	80	3,41973	3,47888	120	3,65116	3,71864

ANNEX E METHODOLOGY FOR THE DERIVATION OF THE UFR

E.1 ANNEX TO SECTION 9.3 - ULTIMATE FORWARD RATE

E.2 INTRODUCTION

E.2.1 This annex sets out the methodology to derive the (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 on Solvency II[32] 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.

E.3 METHODOLOGY TO DERIVE THE UFR

E.3.1 Update of the UFR: EIOPA will annually calculate the UFRs 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 for the term structures of 1 January of the following year.

E.3.2 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:

[32] 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, p. 1)

- UFR_t^L denotes the *UFR* of year t, after limitation of the annual change,
- UFR_{t-1}^L denotes the *UFR* of year *t-1*, after limitation of the annual change,
- UFR_t denotes the *UFR* of year t, before limitation of the annual change.

E.3.3 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.

E.4 CALCULATION OF THE EXPECTED REAL RATE

E.4.1 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:

- *R* is the expected real rate,
- *n* is the number of years since end of 1960,
- r_i is the annual real rate for the year 1960+*i*,

E.4.2 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.

E.4.3 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*).

E.4.4 The short-term nominal rates are taken from the annual macro-economic database of the European Commission (AMECO database).[33] The inflation rates are taken from the Main Economic Indicators database of the OECD.[34]

E.4.5 The expected real rate is rounded to full five basis points as follows:

- When the unrounded rate is lower than the rounded rate of the previous year, the rate is rounded upwards.
- When the unrounded rate is higher than the rounded rate of the previous year, the rate is rounded downwards.

E.5 CALCULATION OF THE EXPECTED INFLATION RATE

E.5.1 For currencies where the central bank has announced an inflation target, the expected inflation is based on that inflation target according to the following rules:

- The expected inflation rate is:
  - 1%, where the inflation target is lower than or equal to 1%,
  - 2%, where the inflation target is higher than 1% and lower than 3%,
  - 3%, where the inflation target is higher or equal to 3% and lower than 4%,
  - 4%, where the inflation target is 4% or higher.
- 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.

E.5.2 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

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[33] Short-term nominal rates used for deriving the expected real rate can be found in the annual macro-economic database of the European Commission's Directorate General for Economic and Financial Affairs, "AMECO". On AMECO online, select 13-Monetary variables, select Interest Rates and then tick the box Short-term nominal (ISN). (http://ec.europa.eu/economy_finance/ameco/user/serie/ResultSerie.cfm)

[34] Inflation rates used for deriving the expected real rate can be found on the website of the Organization for Economic Co-operation and Development (OECD): go to the OECD Main Economic Indicators (MEI) and select consumer price indices. When accessing the database, choose consumer prices – all items for the subject, percentage change on the same period of the previous year for the measure and percentage for the unit. (http://stats.oecd.org/Index.aspx?DataSetCode=MEI_PRICES). OECD data used in this document were accessed in March 2016.

inflation rate will be chosen in accordance with those indications. The expected inflation rate will be rounded downwards to full percentage points.

E.5.3 The past inflation experience will be assessed against the average of 10 years annual inflation rates. The projection of inflation rates will be derived on the basis of an autoregressive–moving-average model.

E.6 IMPLEMENTATION OF THE METHODOLOGY

E.6.1 The methodology to derive the UFR should be implemented in 2018. The first UFRs calculated according to the methodology should be announced at the beginning of April 2017. Those UFRs should be applied for the first time to calculate the risk-free interest rate term structures for 1 January 2018.

E.6.2 The initial application of the methodology in 2018 should be based on the following additional specification:

- The UFR of 2017, denoted UFR_{t-1}^{L} in paragraph E.3.2, is:
  - 3.2% for the Swiss franc and the Japanese yen,
  - 5.2% for the Brazilian real, the Indian rupee, the Mexican peso, the Turkish lira and the South African rand,
  - 4.2% for all other relevant currencies.
- The rounded expected real rate of the previous year referred to in paragraph E.4.5 is equal to 2.2%.

ANNEX F METHODOLOGY TO UPDATE THE REPRESENTATIVE PORTFOLIOS

F.1 ANNEX TO SECTION 11 - DERIVING THE REPRESENTATIVE PORTFOLIOS OF BONDS AND THE REFERENCE PORTFOLIOS OF 'YIELD MARKET INDICES' FOR THE VOLATILITY ADJUSTMENT

F.2 INTRODUCTION

F.2.1 The calculation of the volatility adjustment is based on representative portfolios of assets for each currency and country. The initially used representative portfolios were based on asset data for the reference date end of 2013 collected for the 2014 insurance stress test of EIOPA.

F.2.2 It is important for the accuracy and well-functioning of the volatility adjustment that the representative portfolios are based on up-to-date data. EIOPA has therefore updated the representative portfolio in 2016 and 2017. The last updated representative portfolios have been applied since 31 March 2018.

F.2.3 This annex describes the methodology to derive the updated representative portfolios.

F.3 DATABASE

F.3.1 The updated representative portfolios were derived from the following templates of the supervisory reporting for Solvency II. The date of reference of those data is 31 December 2016.

- List of assets (S.06.02.01).
- Balance sheet (S.02.01.02).
- Collective investment undertakings — look-through approach (S.06.03.04).

F.3.2 Article 77d of the Solvency II Directive distinguishes two different types of representative portfolios:

- **The currency representative portfolio**: a portfolio "*representative for the assets which are denominated in that currency and which insurance and reinsurance* *undertakings are invested in to cover the best estimate for insurance and reinsurance obligations denominated in that currency*".

- **The country representative portfolio**: a portfolio "*representative for the assets which insurance and reinsurance undertakings are invested in to cover the best estimate for insurance and reinsurance obligations sold in the insurance market of that country and denominated in the currency of that country*".

F.3.3 To allow for the calculation of the representative portfolios, assets from all relevant solo undertakings are aggregated line by line to create a database for each country and each currency representative portfolio. This database is enriched by several calculations and indicators to allocate the assets in the relevant portfolio and perform the calculations.

F.4 COMPOSITION OF THE REPRESENTATIVE PORTFOLIOS

F.4.1 Each representative portfolio provides the following information:

- Weights (in percentages) of the
  - central government and central banks bonds – called "government portfolio"; and
  - bonds other than above, loans and securitisations – called "corporate portfolio".
- For the government portfolio, weight of and duration of the following relevant issuers:
  - AT, BE, BG, HR, CY, CZ, DK, EE, FI, FR, DE, GR, HU, IE, IT, LV, LT, LU, MT, NL, NO, PL, PT, RO, SK, SI, ES, SE, UK, US, IS, LI, AU, CA, CH, JP, CN, HK.
- For the corporate portfolio, weight of and duration for each of the following issuers:
  - Financial entities categorised in seven credit quality steps.
  - Non-financial entities categorised in seven credit quality steps.

F.4.2 Regional government and local authorities (RGLA): in the initial representative portfolio, exposures to RGLA were allocated to the corporate portfolio in their quality of "non-central government bonds" and their spreads were modelled on the basis of the corresponding government bond indices.

F.4.3 Because of the adoption of the Commission Implementing Regulation (EU) 2015/2011 on the list of regional governments and local authorities' exposures to whom are to be treated as exposures to central government[35], this allocation was changed as follows:

- the RGLA listed in the Regulation are allocated to the government portfolio.
- the remaining RGLA are allocated to the corporate portfolio and classified as non-financial assets taking into account their credit quality step.

F.5 ASSUMPTIONS

F.5.1 Given the information available in the preparatory phase reporting, assumptions were needed to calculate the representative portfolios. Those assumptions, as explained below, are unchanged compared to the initial representative portfolios.

F.5.2 **Currency representative portfolios**
As in Solvency II reporting undertakings are not required to identify the assets covering their best estimate, an assumption is needed to calculate the currency representative portfolios: all assets in currency X cover liabilities in the same currency X. Therefore, the database used for the calculation of a given currency representative portfolio was composed of all the assets denominated in that same currency held by all solo undertakings which participated in the preparatory phase reporting.

F.5.3 **Country representative portfolios**
A calculation taking into account in which countries insurance obligations were sold would have been most precise. However, in absence of reliable information about the country of sale, the assumption was made that all liabilities are sold in the country of the undertaking and denominated in the currency of that country. Therefore, the database used for the calculation of a given country representative portfolio was composed of all the assets held by all solo undertakings of that same country which participated in the preparatory phase reporting.

[35] See http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015R2011&from=EN.

CALCULATION OF THE WEIGHTS FOR THE GOVERNMENT AND CORPORATE PORTFOLIOS

F.6 ASSET VALUES USED IN THE CALCULATION

F.6.1 The weights were calculated with the value of assets as reported in the reporting field "Total SII amount", expressed in the currency of the reporting (specific to each undertaking). The asset value was converted to euro so that all assets can be compared. ECB exchange rates were used for that purpose.

F.6.2 The converted asset values could not be used directly as the representative portfolios needs to be representative of the assets covering the best estimate of the insurance and reinsurance obligations where the matching adjustment does not apply.

F.7 REDUCTION OF THE ASSET VALUES IN PROPORTION TO THE BEST ESTIMATE

F.7.1 The value of the assets was reduced by ratios calculated with the information reported in the "balance-sheet" reporting template.

F.7.2 Two reduction factors per undertaking were 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.[36]

F.7.3 The first ratio was applied to assets held in unit-linked/index-linked funds only. All relevant assets have been identified line by line, and their Solvency II value has been multiplied by the ratio: (best estimate for unit-linked/index-linked products)/(overall technical provisions for unit-linked/index-linked products).

F.7.4 The second ratio was applied to all other assets. All relevant assets have been identified line by line, and their Solvency II value has been multiplied by the ratio: (best estimate for all products excluding unit-linked/index-linked products)/(overall technical provisions for all products excluding unit-linked/index-linked products).

[36] 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.

F.8 EXCLUSION OF MATCHING ADJUSTMENT ASSETS

F.8.1 As the legislation does not allow cumulating the matching adjustment (MA) with the volatility adjustment, assets held in a matching adjustment portfolio should be excluded from the calculation. For that purpose, the matching adjustment assets were identified on the basis of the matching portfolio number reported in the list of assets template for each asset that belongs to a matching adjustment portfolio.

F.9 ALLOCATION OF THE ASSETS TO THE GOVERNMENT AND CORPORATE PORTFOLIOS

F.9.1 CIC codes (as reported in the field "CIC") were used to allocate the assets to the government or corporate portfolio as set out in the following table:

Table 30 - 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

(*) The CIC codes 13 and 14 were used to identify bonds issued by RGLA. For those assets, the allocation to the government or corporate portfolio depends on the issuer (identified with the field "Issuer Country"). Where no issuer was reported, those assets were allocated to the corporate portfolio.

F.10 LOOK THROUGH

F.10.1 In the update of representative portfolios, the collective investment undertakings (CIUs) reported in the list of assets were replaced, where possible, by the assets reported in the look-through templates. The replacement was possible where the look-through template was available and the reported value of the CIU and the reported value of the look-through assets matched. Differences up to 1% with regard to that match were accepted.

F.10.2 The look-through template provides less detailed asset information than the list of assets. The allocation of assets to the government or corporate portfolio was based on the following correspondence:

Table 31 - CIU look through correspondence

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

F.10.3 The look-through template provides with regard to the currency of the assets only whether it is equal to the reporting currency of the undertaking or not. In the latter case the currency different from the reporting currency is not specified. In case the currency of the asset was equal to the reporting currency that information was used in the calculation. Assets not in the reporting currencies were treated like assets without currency information in the list of assets template.

F.10.4 The look-through template provides no information about the credit quality step and the sector of an asset. Also, with regard to that information the look-through assets were treated like assets from the list of assets where credit quality step and the sector information was not filled in.

F.10.5 For the duration of assets allocated to government or corporate bonds the duration of the CIU was used.

F.11 CALCULATION OF THE WEIGHTS FOR THE GOVERNMENT AND CORPORATE PORTFOLIOS

F.11.1 The calculation of the weights w_{gov} and w_{corp} for government and corporate bonds was done in accordance with the following formulas:

$$w_{gov} = \frac{MV_{gov}}{MV_{gov} + MV_{corp} + MV_{other}}$$

$$w_{corp} = \frac{MV_{corp}}{MV_{gov} + MV_{corp} + MV_{other}}$$

where:

- MV_{gov} denotes the market value of assets with CIC codes that are allocated to the government bond portfolio,
- MV_{corp} denotes the market value of assets with CIC codes that are allocated to the corporate bond portfolio,
- MV_{other} denotes the market value of all assets with CIC codes that are not allocated to the government or corporate bond portfolio.

F.11.2 The market values were reduced in proportion to the best estimate and to take into account the matching adjustment, as described earlier in this section.

F.12 CALCULATION OF THE GOVERNMENT PORTFOLIO

F.12.1 Identification of issuers: the country of the issuer is reported in the list of assets template with the field “Issuer Country”. Only assets of the following issuers were taken into account: AT, BE, BG, HR, CY, CZ, DK, EE, FI, FR, DE, GR, HU, IE, IT, LV, LT, LU, MT, NL, NO, PL, PT, RO, SK, SI, ES, SE, UK, US, IS, LI, AU, CA, CH, JP, CN, HK.

F.12.2 Duration: the assets where no duration, zero duration or a duration greater than 50 years had been reported were excluded for the determination of the average durations. The average durations were calculated by means of a weighted average, using the reduced asset values as weights.

F.13 CALCULATION OF THE CORPORATE PORTFOLIO

F.13.1 Identification of issuers: two allocations needed to be made to calculate the corporate portfolio: the allocation according to the sector of issuer (financial or non-financial) and according to credit quality steps.

F.13.2 Determination of the sector: the sector was determined on the basis of the field “Issuer Sector”. This field corresponds to the NACE code from EUROSTAT Statistical Classification of Economic Activities in the European Community.[37]

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37 http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_NOM_DTL&StrNom=NACE_REV2&StrLanguageCode=EN&IntPcKey=&StrLayoutCode=HIERARCHIC&CFID=12721637&CFTOKEN=9fa1f017d5f2811e-C999B956-E7EA-A517-3AB8BA746C9C60F5&jsessionid=f90060eefcba131dc3c6

F.13.3 Section K is used to identify "Financial and Insurance activities". The code can be:

- 64: financial service activities, except insurance and pension funding.
- 65: insurance, reinsurance, and pension funding, except compulsory social security.
- 66: activities auxiliary to financial services and insurance activities.

F.13.4 All those assets where the issuer sector field starts with a "K" were allocated to the financial part of the corporate portfolio. All other assets were allocated to the non-financial part of the corporate portfolio, except for those where no information on the sector was reported: those were excluded from the calculations.

F.14 DETERMINATION OF THE CREDIT QUALITY STEP

F.14.1 The preparatory phase template gives information on the rating agency and on the external rating (fields "Rating agency" and "External rating"). Using the field "External rating" and the implementing technical standards on ECAI mappings for Solvency II[38], assets were allocated a credit quality step.

F.14.2 Assets where no external rating had been reported ("unrated assets") were excluded from the allocation to credit quality steps (CQS) by distributing the respective share across the seven CQS of both the "financial" and "non-financial" asset category.[39]

F.14.3 Duration: the assets where no duration, zero duration or a duration greater than 50 years had been reported were excluded for the determination of the average durations. The average durations were calculated by means of a weighted average, using the reduced asset values as weights.

[38] See https://eur-lex.europa.eu/eli/reg_impl/2016/1800/oj.

[39] For the Danish krone (DKK) representative portfolio, unrated assets were distributed to CQS0-6 within the financial/non-financial category they are reported to belong to. The distribution is in accordance with the weights of assigned assets found for each CQS within that category.

F.15 HISTORICAL OVERVIEW OF THE GOVERNMENT BOND- AND CORPORATE BOND-WEIGHTS USED FOR THE REPRESENTATIVE PORTFOLIOS

Applicable from 31/12/2015

Initial weights

Currency	Govt	Corp
EUR	38.7%	48.2%
BGN	54.4%	23.8%
HRK	74.3%	9.4%
CZK	52.6%	29.2%
DKK	19.3%	61.9%
HUF	83.4%	9.7%
ISK	77.2%	9.3%
NOK	18.4%	53.8%
PLN	44.8%	11.8%
RON	74.5%	12.2%
SEK	20.6%	31.6%
CHF	23.8%	51.4%
GBP	16.7%	30.3%
AUD	76.5%	18.2%
CAD	51.9%	41.1%
JPY	85.2%	11.4%
USD	18.2%	76.1%

Country	Govt	Corp
AT	31.6%	46.4%
BE	55.3%	34.3%
BG	54.4%	23.8%
HR	74.3%	9.4%
CY	20.2%	63.9%
CZ	52.6%	29.2%
DK	19.3%	61.9%
EE	64.0%	27.3%
FI	18.0%	46.0%
FR	37.1%	47.6%
DE	22.4%	68.5%
GR	54.4%	35.3%
HU	83.4%	9.7%
IS	77.2%	9.3%
IE	40.9%	52.5%
IT	62.0%	25.1%
LV	89.7%	9.4%
LI	23.8%	51.4%
LT	69.1%	25.7%
LU	40.2%	49.8%
MT	49.7%	35.7%
NL	41.1%	48.5%
NO	18.4%	53.8%
PL	44.8%	11.8%
PT	47.1%	44.8%
RO	74.5%	12.2%
SK	53.6%	39.8%
SI	46.0%	38.1%
ES	50.1%	37.7%
SE	20.6%	31.6%
CH	23.8%	51.4%
UK	16.7%	30.3%
AU	76.5%	18.2%
CA	51.9%	41.1%
JP	85.2%	11.4%
US	18.2%	76.1%

Applicable from 30/09/2016

Based on 2015 Stress Test Data

Currency	Govt	Corp
EUR	27.4%	43.8%
BGN	23.5%	2.3%
HRK	29.6%	6.7%
CZK	50.8%	15.6%
DKK	19.3%	61.9%
HUF	55.4%	15.1%
ISK	77.2%	9.3%
NOK	12.0%	59.5%
PLN	38.4%	20.7%
RON	64.8%	6.7%
SEK	12.1%	31.1%
CHF	23.8%	51.4%
GBP	19.4%	33.1%
AUD	76.5%	18.2%
CAD	51.9%	41.1%
JPY	85.2%	11.4%
USD	18.2%	76.1%

Country	Govt	Corp
AT	18.3%	46.5%
BE	48.7%	34.2%
BG	53.3%	18.5%
HR	58.9%	11.4%
CY	5.5%	42.5%
CZ	52.3%	27.4%
DK	19.3%	61.9%
EE	24.2%	42.4%
FI	8.2%	38.3%
FR	27.0%	46.9%
DE	15.6%	55.2%
GR	32.9%	33.1%
HU	52.7%	19.5%
IS	77.2%	9.3%
IE	17.9%	27.9%
IT	45.5%	22.9%
LV	49.3%	18.9%
LI	2.5%	32.6%
LT	59.3%	23.7%
LU	40.2%	49.8%
MT	16.6%	25.7%
NL	30.3%	38.9%
NO	11.8%	54.3%
PL	37.2%	22.0%
PT	37.8%	37.6%
RO	46.9%	29.6%
SK	41.6%	38.1%
SI	31.9%	27.0%
ES	43.3%	33.2%
SE	10.9%	29.0%
CH	23.8%	51.4%
UK	17.2%	31.3%
AU	76.5%	18.2%
CA	51.9%	41.1%
JP	85.2%	11.4%
US	18.2%	76.1%

Applicable from 31/03/2018

Based on end of 2016 annual reporting templates

Currency	Govt	Corp
EUR	32.8%	40.5%
BGN	37.3%	8.2%
HRK	28.3%	9.3%
CZK	51.3%	15.9%
DKK	19.3%	61.9%
HUF	62.9%	3.7%
ISK	28.0%	22.0%
NOK	12.6%	59.1%
PLN	51.6%	10.8%
RON	63.9%	8.3%
SEK	13.3%	36.1%
CHF	27.7%	28.5%
GBP	23.2%	31.0%
AUD	27.5%	19.9%
CAD	34.8%	30.0%
JPY	51.3%	6.7%
USD	17.0%	55.8%

Country	Govt	Corp
AT	23.0%	41.2%
BE	47.0%	36.6%
BG	48.5%	19.4%
HR	59.0%	10.5%
CY	13.8%	35.6%
CZ	46.4%	27.8%
DK	19.3%	61.9%
EE	18.7%	45.2%
FI	11.7%	42.2%
FR	27.2%	43.7%
DE	23.2%	46.9%
GR	47.5%	26.7%
HU	58.0%	7.6%
IS	27.4%	22.9%
IE	29.7%	27.8%
IT	50.2%	24.6%
LV	47.5%	14.6%
LI	6.6%	39.4%
LT	64.5%	21.7%
LU	17.1%	33.4%
MT	21.3%	27.8%
NL	33.9%	38.2%
NO	12.8%	56.5%
PL	46.0%	13.5%
PT	45.4%	33.1%
RO	60.4%	12.4%
SK	43.2%	34.7%
SI	32.7%	32.2%
ES	49.9%	27.3%
SE	11.0%	29.3%
CH	-	-
UK	17.1%	25.2%
AU	-	-
CA	-	-
JP	-	-
US	-	-

Applicable from 01/01/2019

Specific update for Denmark weights only

Currency	Govt	Corp
EUR	32.8%	40.5%
BGN	37.3%	8.2%
HRK	28.3%	9.3%
CZK	51.3%	15.9%
DKK	9.8%	61.5%
HUF	62.9%	3.7%
ISK	28.0%	22.0%
NOK	12.6%	59.1%
PLN	51.6%	10.8%
RON	63.9%	8.3%
SEK	13.3%	36.1%
CHF	27.7%	28.5%
GBP	23.2%	31.0%
AUD	27.5%	19.9%
CAD	34.8%	30.0%
JPY	51.3%	6.7%
USD	17.0%	55.8%

Country	Govt	Corp
AT	23.0%	41.2%
BE	47.0%	36.6%
BG	48.5%	19.4%
HR	59.0%	10.5%
CY	13.8%	35.6%
CZ	46.4%	27.8%
DK	15.4%	43.4%
EE	18.7%	45.2%
FI	11.7%	42.2%
FR	27.2%	43.7%
DE	23.2%	46.9%
GR	47.5%	26.7%
HU	58.0%	7.6%
IS	27.4%	22.9%
IE	29.7%	27.8%
IT	50.2%	24.6%
LV	47.5%	14.6%
LI	6.6%	39.4%
LT	64.5%	21.7%
LU	17.1%	33.4%
MT	21.3%	27.8%
NL	33.9%	38.2%
NO	12.8%	56.5%
PL	46.0%	13.5%
PT	45.4%	33.1%
RO	60.4%	12.4%
SK	43.2%	34.7%
SI	32.7%	32.2%
ES	49.9%	27.3%
SE	11.0%	29.3%
CH	-	-
UK	17.1%	25.2%
AU	-	-
CA	-	-
JP	-	-
US	-	-

Applicable from 31/03/2019

Based on end of 2017 annual reporting templates

Currency	Govt	Corp
EUR	31.3%	39.5%
BGN	34.7%	5.4%
HRK	37.6%	9.5%
CZK	47.0%	19.9%
DKK	9.5%	59.0%
HUF	65.0%	4.0%
ISK	30.9%	21.1%
NOK	13.8%	58.7%
PLN	52.2%	13.7%
RON	62.1%	9.1%
SEK	13.9%	34.7%
CHF	20.0%	41.1%
GBP	26.8%	28.1%
AUD	18.8%	28.3%
CAD	17.3%	47.8%
JPY	44.4%	4.7%
USD	17.0%	55.0%

Country	Govt	Corp
AT	24.3%	39.0%
BE	45.0%	36.4%
BG	50.3%	19.0%
HR	62.9%	10.4%
CY	22.2%	32.5%
CZ	41.6%	30.9%
DK	15.3%	40.5%
EE	22.3%	44.8%
FI	14.8%	32.9%
FR	27.5%	41.1%
DE	22.1%	45.9%
GR	50.9%	25.2%
HU	59.3%	8.0%
IS	29.2%	21.1%
IE	29.0%	27.9%
IT	47.0%	24.7%
LV	52.2%	17.6%
LI	7.2%	30.2%
LT	66.4%	21.0%
LU	16.5%	32.6%
MT	23.3%	31.6%
NL	32.3%	41.0%
NO	14.5%	55.4%
PL	49.9%	15.3%
PT	45.9%	32.6%
RO	59.9%	12.0%
SK	42.6%	36.8%
SI	31.8%	33.3%
ES	39.7%	31.9%
SE	10.5%	28.1%
CH	-	-
UK	21.4%	26.7%
AU	-	-
CA	-	-
JP	-	-
US	-	-

Applicable from 31/03/2020

Based on end of 2018 annual reporting templates

Currency	Govt	Corp
EUR	31.6%	40.5%
BGN	34.7%	5.3%
HRK	46.6%	9.0%
CZK	43.1%	20.7%
DKK	5.4%	67.3%
HUF	63.3%	6.8%
ISK	25.8%	29.3%
NOK	10.0%	64.4%
PLN	50.3%	15.4%
RON	67.7%	8.9%
SEK	11.6%	39.7%
CHF	26.0%	38.5%
GBP	21.2%	36.1%
AUD	20.2%	32.9%
CAD	23.6%	48.9%
JPY	53.7%	9.4%
USD	15.6%	59.7%
CNY	29.2%	45.5%
HKD	9.7%	14.6%

Country	Govt	Corp
AT	22.6%	43.2%
BE	47.3%	34.0%
BG	52.5%	23.2%
HR	71.9%	11.0%
CY	16.8%	40.5%
CZ	39.3%	32.4%
DK	12.1%	46.7%
EE	24.4%	40.8%
FI	9.9%	35.6%
FR	29.1%	43.2%
DE	22.2%	46.1%
GR	53.7%	26.0%
HU	58.4%	10.5%
IS	24.5%	29.1%
IE	29.8%	32.9%
IT	48.0%	25.5%
LV	58.2%	21.6%
LI	9.1%	26.9%
LT	68.0%	22.9%
LU	11.2%	35.0%
MT	22.1%	30.5%
NL	34.9%	36.5%
NO	10.4%	58.7%
PL	48.4%	16.6%
PT	44.8%	33.7%
RO	64.4%	12.0%
SK	43.5%	36.2%
SI	33.9%	35.2%
ES	44.1%	34.8%
SE	8.5%	31.5%
CH	-	-
UK	20.0%	33.3%
AU	-	-
CA	-	-
JP	-	-
US	-	-

Applicable from 31/03/2021

Based on end of 2019 annual reporting templates

Currency	Govt	Corp
EUR	31.3%	40.0%
BGN	37.1%	6.1%
HRK	50.8%	7.4%
CZK	47.2%	17.7%
DKK	5.8%	63.2%
HUF	62.3%	6.7%
ISK	21.7%	32.0%
NOK	8.4%	61.5%
PLN	52.3%	15.0%
RON	67.4%	8.5%
SEK	9.6%	38.4%
CHF	17.2%	47.5%
GBP	15.7%	35.0%
AUD	28.7%	43.4%
CAD	17.2%	68.7%
JPY	41.7%	18.0%
USD	15.3%	61.3%
CNY	28.6%	39.0%
HKD	11.8%	5.1%

Country	Govt	Corp
AT	23.1%	42.6%
BE	47.1%	33.8%
BG	52.2%	24.2%
HR	72.2%	10.1%
CY	15.2%	40.6%
CZ	43.8%	27.7%
DK	13.4%	42.7%
EE	21.4%	46.6%
FI	9.3%	35.9%
FR	28.0%	42.3%
DE	22.5%	44.4%
GR	53.6%	26.1%
HU	57.9%	10.4%
IS	20.9%	31.6%
IE	26.6%	33.4%
IT	48.4%	25.6%
LV	43.1%	26.5%
LI	8.6%	31.8%
LT	69.7%	21.6%
LU	11.7%	34.6%
MT	20.1%	43.3%
NL	34.5%	37.4%
NO	8.6%	53.5%
PL	49.9%	17.7%
PT	45.4%	36.6%
RO	64.1%	11.6%
SK	39.6%	39.8%
SI	35.7%	32.6%
ES	44.3%	33.8%
SE	7.0%	27.8%
CH	-	-
UK	-	-
AU	-	-
CA	-	-
JP	-	-
US	-	-
CN	-	-
HK	-	-

Applicable from 31/03/2022

Based on end of 2020 annual reporting templates

Currency	Govt	Corp
EUR	31.6%	39.4%
BGN	34.0%	6.7%
HRK	44.9%	9.7%
CZK	46.2%	17.5%
DKK	9.6%	55.9%
HUF	65.3%	5.5%
ISK	19.9%	31.9%
NOK	7.9%	61.1%
PLN	56.1%	13.3%
RON	68.5%	6.2%
SEK	10.5%	33.5%
CHF	26.2%	51.6%
GBP	14.3%	36.6%
AUD	30.8%	45.8%
CAD	19.8%	67.0%
JPY	68.9%	11.8%
USD	17.1%	62.7%
CNY	28.0%	32.2%
HKD	10.6%	10.1%

Country	Govt	Corp
AT	25.0%	41.2%
BE	46.9%	35.1%
BG	51.6%	24.6%
HR	67.3%	12.0%
CY	16.6%	41.4%
CZ	43.3%	28.1%
DK	15.0%	40.4%
EE	20.1%	43.8%
FI	9.3%	33.3%
FR	28.3%	41.5%
DE	23.8%	42.9%
GR	54.1%	25.2%
HU	58.4%	9.5%
IS	19.1%	31.1%
IE	28.5%	37.1%
IT	47.8%	25.6%
LV	39.8%	29.0%
LI	8.6%	32.3%
LT	64.0%	26.7%
LU	12.1%	33.4%
MT	25.0%	35.9%
NL	31.0%	40.3%
NO	7.7%	53.5%
PL	54.8%	16.5%
PT	44.0%	38.8%
RO	67.5%	8.9%
SK	36.3%	44.3%
SI	37.8%	31.0%
ES	42.2%	35.7%
SE	7.5%	24.4%
CH	-	-
UK	-	-
AU	-	-
CA	-	-
JP	-	-
US	-	-
CN	-	-
HK	-	-

Applicable from 31/03/2023

Based on end of 2021 annual reporting templates

Currency	Govt	Corp
EUR	29.2%	36.6%
BGN	28.4%	6.4%
HRK	-	-
CZK	44.8%	13.7%
DKK	6.8%	58.2%
HUF	59.4%	4.9%
ISK	21.7%	34.6%
NOK	6.2%	59.4%
PLN	50.9%	13.9%
RON	55.4%	13.5%
SEK	8.9%	27.7%
CHF	21.7%	37.6%
GBP	10.5%	28.6%
AUD	31.7%	42.6%
CAD	18.5%	64.1%
JPY	64.4%	12.0%
USD	16.0%	57.4%
CNY	26.2%	29.6%
HKD	10.5%	8.6%

Country	Govt	Corp
AT	20.4%	37.2%
BE	42.6%	33.6%
BG	45.4%	22.1%
HR	57.7%	11.9%
CY	15.2%	41.1%
CZ	43.1%	24.2%
DK	12.8%	37.3%
EE	19.6%	39.3%
FI	8.0%	28.7%
FR	26.1%	39.1%
DE	21.9%	38.5%
GR	44.5%	25.5%
HU	51.6%	8.2%
IS	20.8%	35.4%
IE	25.1%	35.2%
IT	42.7%	24.0%
LV	32.3%	29.0%
LI	8.9%	26.6%
LT	61.3%	28.1%
LU	10.9%	30.4%
MT	17.4%	35.2%
NL	28.8%	38.2%
NO	5.8%	47.7%
PL	49.1%	17.1%
PT	40.9%	37.9%
RO	55.2%	16.8%
SK	35.0%	41.2%
SI	33.8%	29.6%
ES	37.0%	34.3%
SE	5.8%	19.8%
CH	-	-
UK	-	-
AU	-	-
CA	-	-
JP	-	-
US	-	-
CN	-	-
HK	-	-

Applicable from 31/03/2024

Based on end of 2022 annual reporting templates

Currency	Govt	Corp
EUR	24.1%	37.7%
BGN	25.0%	6.5%
CZK	44.0%	13.3%
DKK	6.0%	52.2%
HUF	60.4%	5.1%
ISK	23.7%	34.4%
NOK	6.5%	59.2%
PLN	49.6%	15.3%
RON	64.1%	5.8%
SEK	9.4%	32.6%
CHF	24.1%	37.7%
GBP	10.7%	29.7%
AUD	33.8%	42.3%
CAD	20.9%	59.6%
JPY	64.7%	12.7%
USD	15.6%	54.8%
CNY	30.0%	27.4%
HKD	11.4%	7.8%

Country	Govt	Corp
AT	17.7%	34.6%
BE	37.8%	36.5%
BG	46.3%	18.3%
HR	53.4%	10.8%
CY	16.1%	44.3%
CZ	42.8%	23.6%
DK	12.3%	33.4%
EE	22.8%	39.8%
FI	8.9%	30.1%
FR	21.8%	38.3%
DE	15.0%	40.0%
GR	44.2%	27.7%
HU	50.3%	7.4%
IS	22.4%	34.7%
IE	23.5%	37.8%
IT	42.2%	26.8%
LV	34.6%	26.2%
LI	9.0%	28.0%
LT	53.5%	27.3%
LU	8.8%	25.9%
MT	15.1%	34.7%
NL	22.9%	39.5%
NO	6.3%	47.6%
PL	48.6%	18.0%
PT	40.8%	36.4%
RO	64.8%	7.4%
SK	32.5%	41.5%
SI	31.9%	30.8%
ES	34.0%	35.4%
SE	6.8%	23.4%
CH	-	-
UK	-	-
AU	-	-
US	-	-
JP	-	-
US	-	-
CN	-	-
HK	-	-

Applicable from 31/03/2025

Based on end of 2023 annual reporting templates

Currency	Govt	Corp
EUR	24.4%	38.3%
BGN	22.9%	6.9%
CZK	49.1%	11.3%
DKK	7.1%	54.4%
HUF	58.8%	5.8%
ISK	25.4%	33.7%
CHF	23.5%	41.1%
NOK	5.9%	60.7%
PLN	48.6%	13.7%
RON	67.7%	5.7%
SEK	9.5%	31.7%
GBP	16.4%	54.4%
AUD	33.0%	45.8%
CAD	26.2%	60.3%
CNY	32.2%	29.3%
HKD	18.7%	15.4%
JPY	66.8%	12.3%
USD	14.8%	56.4%

Country	Govt	Corp
AT	17.3%	33.6%
BE	36.1%	38.3%
BG	40.8%	23.7%
HR	53.7%	10.9%
CY	21.2%	42.1%
CZ	45.6%	20.8%
DK	12.8%	34.0%
EE	22.3%	40.4%
FI	9.5%	32.1%
FR	20.3%	40.7%
DE	17.4%	36.2%
GR	39.5%	30.4%
HU	51.1%	8.8%
IS	24.3%	34.7%
IE	18.6%	41.2%
IT	41.8%	27.1%
LV	36.8%	23.3%
LI	9.4%	26.6%
LT	50.1%	28.7%
LU	11.6%	33.5%
MT	16.0%	42.1%
NL	21.3%	41.4%
NO	5.4%	46.7%
PL	47.6%	16.4%
PT	39.3%	37.6%
RO	67.5%	8.1%
SK	32.4%	37.7%
SI	32.0%	28.7%
ES	33.1%	37.1%
SE	6.4%	22.1%

F.15.1 The underlying currency and country specific portfolios are available here as part of the regular monthly VA-portfolio-files with filename “*EIOPA_RFR_YYYYMMDD_VA_portfolios.xlsx*“.

ANNEX G LTAS CALCULATION SPECIFICITIES

G.1 ANNEX TO SUBSECTION 12.3 – HISTORY OF GOVERNMENT BOND RATES FOR CALCULATING THE LTAS

G.1.1 Table 32 specifies the government bond maturities that were used to derive spreads for the government bond *LTAS* in the past since 1 January 2016. For currencies that do not appear in those tables the maturities are unchanged since 1 January 2016. The currently used maturities are set out in table 14 of the main text. Market data until (and including) 31 December 2019 was received from Bloomberg.

Table 32 - 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
BGN	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 – 31 December 2025
HRK	1-4, 10	1 January – 30 December 2016
	1,3,4,8,9	31 December 2016 – 31 March 2021
	1-5 and 7-10	1 April 2021 – 31 December 2021
	1-7, 9	1 January – 31 December 2022
ISK	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
CLP	1-7, 9-10	1 January 2016 – 31 December 2019
	1-5, 7, 10	1 January 2020 – 31 December 2021

	Government bond maturities used All maturities in years	Period
	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	
COP	1-6, 8, 10	1 January 2016 – 31 December 2022
	1-6, 8-10	1 January – 31 December 2023
CY	1-5, 7-10	1 January 2016 – 31 March 2021
HKD	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
DKK	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
GR	1-2, 4-5, 7-10	1 January 2016 – 31 March 2021
	1-5, 10	1 April 2021 – 31 December 2022
RUB	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	
MXN	1-6, 8, 10	1 April 2021 – 31 December 2022
	1-5, 7	1 January – 31 December 2023

	Government bond maturities used All maturities in years	Period
	1-4,6,8,10	1 January – 31 December 2024
	Removed from list of relevant currencies as of 1 January 2025	
MYR	1-9	1 January 2016 – 31 December 2019
	Removed from list of relevant currencies as of 1 January 2025	
THB	1-5,7-10	1 January 2016 – 31 December 2019
	Removed from list of relevant currencies as of 1 January 2025	
CZK	1-8, 10	1 January 2016 – 31 March 2021
NOK	1-9	1 January 2016 – 31 December 2021
RON	1-5, 7-10	1 January 2016 – 31 March 2021
	1-6 and 8-10	1 April 2021 – 31 December 2021
	1-7, 10	1 January – 31 December 2022
	1-10	1 January 2023 – 31 December 2025
SEK	1-8, 10	1 January 2016 – 31 March 2021
	1-10	1 April 2021 – 31 December 2025
CHF	2-8,10	1 January 2016 – 31 March 2021
SI	1-2, 4-10	1 January 2016 – 31 March 2021
SK	1-3, 5-10	1 January 2016 – 31 March 2021
TRY	1-5, 7, 9	1 January 2016 – 31 March 2021
	1-5, 7, 8	1 April 2021-31 December 2021
	1-9Y	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	
	1-4, 6-10	1 January – 31 December 2022

	Government bond maturities used All maturities in years	Period
ZAR	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	

G.2 ANNEX TO SUBSECTIONS 12.3 AND 12.6: ADJUSTMENT FACTORS FOR THE POUND STERLING LTAS

G.2.1 The adjustment factors applied to LTAS31_12_2015 of UK government bonds are as follows:

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

G.2.2 The adjustment factors applied to LTAS31_12_2015 of pound sterling corporate bonds are as follows:

Maturity	CQS 0, CQS 1	CQS 2	CQS 3
1 TO 4 YEARS	82%	88%	97%
5 TO 8 YEARS	80%	84%	93%
9 TO 30 YEARS	95%	93%	93%

The adjustment factors apply to financial and non-financial bonds. There are no adjustments to corporate bonds of CQS 4 to 6.

ANNEX H CALCULATION OF THE COST OF DOWNGRADE (COD) AND PROBABILITY OF DEFAULT (PD)

H.1 ANNEX TO SUBSECTION 12 - METHODOLOGY FOR THE DETERMINATION OF THE RISK CORRECTIONS AND THE FUNDAMENTAL SPREADS

H.2 LEGAL CONTEXT

H.2.1 The two components Cost of Downgrade (CoD) and Probability of Default (PD) are required by Article 77c(2)(a) (Calculation of the matching adjustment) of the Solvency II Directive, supplemented by Article 51 (Risk-corrected spread, for volatility adjustment) and 54(4) (Calculation of the fundamental spread) of the Delegated Regulation. Furthermore, recital 31 of the Omnibus II Directive and the recitals 22 and 23 of the Delegated Regulation apply.

H.2.2 The Cost of Downgrade (CoD) is defined as the present value of costs resulting from future downgrade, expressed as spreads in base 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 or a better one as the replaced asset.

H.2.3 As described below, the same approach applies to the Probability of Default (PD) with the appropriate modifications.

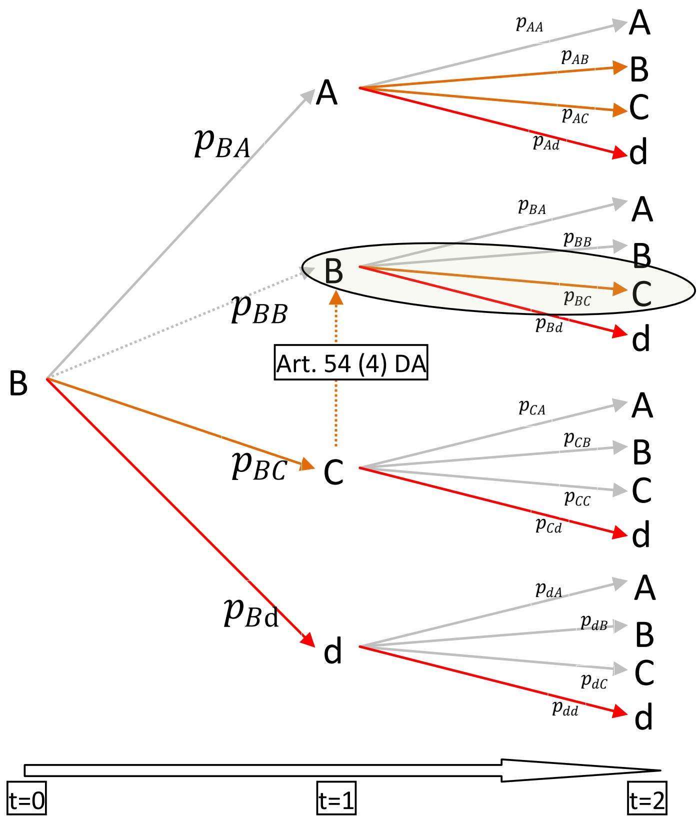
H.2.4 The three components of a present value:

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

H.3 PROBABILITY

H.3.1 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



H.3.2 The probability for 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 $B \rightarrow B \rightarrow C$. 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 $B \rightarrow C \left(\xrightarrow{Art.54\ (4)} B \right) \rightarrow B$. So, the total probability to have a downgrade event between $t = 1$ and $t = 2$ is given by $(P_{BB} + P_{BC}) \cdot P_{BC}$.

H.3.3 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 credit quality step for the year in which the cost of the downgrading event is accounted:

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

H.3.4 The original transition matrix T is retained for those probabilities regarding the transitions in the year the cost accounting is done.

H.3.5 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 credit quality step B at $t = 1$ (regarding 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 credit quality step 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 $t = 2$.

H.3.6 More general, 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 the first m times and then once the matrix T. 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 $Q^m T$.

H.4 ZERO BOND CASH FLOWS

H.4.1 By Article 54(4) of the Delegated Regulation, the cash flow in case of downgrade is defined as the difference in market values of the original (higher) credit quality and the new (lower) credit quality. There is no specific requirement for the case of upgrade, the case of staying in the same credit quality or for the case of defaulting. The defaulting case is considered in the separate component for PD (probability of default).

H.4.2 The corresponding market values change over time. The cash flows are derived from zero 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.

H.5 DISCOUNT FACTOR

H.5.1 The discount factor $1/(1 + \text{InterestRate}_t)^t$ considers the risk-free spot rate.

H.5.2 The above considerations give rise to the following nutshell description.

H.6 COST OF DOWNGRADE AND PROBABILITY OF DEFAULT IN A NUTSHELL

H.6.1 **Input Data**

Transition Matrix $T = (p_{X,Y})_{X,Y \in CQS}$ for the n-element set CQS of credit quality steps including default state denoted by "d" (note that $p_{dX} = 0$ 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.

H.6.2 **Cost of Downgrade, step 1**

Based on the basic risk-free interest rate term structure$(r_M)_{M=1\dots3}$, the market value of a zero 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 having in mind 15 years maturity as an approximation of the highest duration observed.

A downgrade at time m from credit quality step 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):

$$C_M^{(m)} \coloneqq \left(\left\{ \begin{matrix} CoD_{(X,Y),M}(m) \cdot p_{X,Y} & \text{for } Y \neq \text{default} \\ (1 - \text{RecoveryRate}) \cdot MV_{X,M}(m) \cdot p_{X,Y} & \text{for } Y = \text{default} \end{matrix} \right\} \right)_{(X<Y) \in CQS}.$$

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.

$$(q_{XY})_{X,Y \in CQS} \coloneqq \left\{ \begin{matrix} p_{XY} & \text{for } X > Y \text{ and } Y = \text{n (lower triangle and rightmost column)} \\ \sum_{k=i}^{n-1} p_{i,k} & \text{for } X = Y \leq n \text{ (Art. 54 (4) DA) (main diagonal)} \\ 0 & \text{for } X < Y < n \text{ (upper triangle except rightmost column)} \end{matrix} \right\}$$

$$= \begin{pmatrix} \sum_{k=1}^{n-1} p_{1,k} & \leftarrow 0 & \cdots & \leftarrow 0 & p_{1d} \\ p_{21} & \sum_{k=2}^{n-1} p_{2,k} & \leftarrow 0 & \vdots & p_{2d} \\ p_{31} & p_{32} & \sum_{k=3}^{n-1} p_{3,k} & \leftarrow 0 & p_{3d} \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ p_{n-1,1} & \cdots & p_{n-2,n-1} & p_{n-1,n-1} & p_{n-1,d} \\ p_{d1} = 0 & p_{d2} = 0 & \cdots & p_{d,n-1} = 0 & p_{dd} = 1 \end{pmatrix}.$$

The following matrix contains the expected cash flows representing the expected cost of downgrade for bonds in the credit quality step in CQS of original maturity M at times $m = 1, \dots, M$.

$$\begin{pmatrix} CoD_{\text{best quality},M}(1) & \cdots & CoD_{\text{best quality},M}(M) \\ \vdots & \ddots & \vdots \\ CoD_{\text{lowest quality},M}(1) & \cdots & CoD_{\text{lowest quality},M}(M) \\ CoD_{\text{default},M}(1) = 0 & \cdots & CoD_{\text{default},M}(1) = 0 \end{pmatrix} := \bigcup_{m=1}^{M} \underbrace{\left(Q^{m-1} C_M^{(m)} \begin{pmatrix} 1 \\ \vdots \\ 1 \\ 0 \end{pmatrix} \right)}_{\text{colum vector}},$$

where $\cup_{m=1}^{M}(\vdots)$ shall denote the concatenation (to the right) of column vectors into a matrix. In base 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.

H.6.3 Probability of Default in a nutshell

The computation of the probability of default 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 probability of default is the total probability for a zero 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.

H.6.4 Cost of Downgrade, step 2

Using the same notation as before, we have now calculated:

- $CoD_{c,M}^{(bp)}$
- $PD_{c,M}^{(bp)}(T)$ using the original transition matrix T.

We need to calculate $PD_{c,M}^{(bp)}(Q)$: for that purpose, we proceed as before, while using the "twisted Article 54(4) matrix" Q instead of the original transition matrix T.
The final cost of downgrade becomes:

$$CoD_{c,M}^{(bp)} = max\left[0, CoD_{c,M}^{(bp)} - \left(PD_{c,M}^{(bp)}(T) - PD_{c,M}^{(bp)}(Q)\right)\right]$$

H.7 REDUCING COMPUTATIONAL AND NUMERICAL COMPLEXITY

H.7.1 Please note that $C_M^{(m)}$ is strictly upper triangular. This might help to further reduce complexity if needed. One can setup an internal table of all the values $(1+r_m)^m$ and R_c^m for $m = 1, \ldots, M$. The market values are then just given by the product of two entries of this fixed-value table.

H.7.2 Furthermore, the matrix powers Q^m and T^m can be saved in an internal (three-dimensional) array.

H.7.3 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.

H.8 A REMARK ABOUT PROBABILITY IN CONTINUOUS TIME AND WHY IT HAS NOT BEEN USED HERE

H.8.1 In this notation, one could – in theory – also define matrix powers for non-integral times t by:

$$Q^t \coloneqq S^{-1}\text{diag}(\lambda_c^t)S.$$

H.8.2 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.

H.9 A REMARK ABOUT INTRA-YEAR CHAINS OF RATING CHANGES

H.9.1 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 $t = 0, t = 1, \ldots, t = M$.

H.9.2 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 recognized 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.

H.9.3 If the chain consists of only downgrading events, there is almost no difference at all, because the CoD cashflows are defined as differences between market values:

$$CoD_{X\to Y} + CoD_{Y\to Z} = (MV_X - MV_Y) + (MV_Y - MV_Z) = MV_X - MV_Z = CoD_{X\to Z}.$$

H.9.4 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 recognized within this model.

ANNEX I BACKGROUND ON THE TREATMENT OF DANISH COVERED BONDS

I.1 ANNEX TO SUBSECTION 12.7 - CURRENCIES WITHOUT YIELD MARKET INDICES FOR CORPORATES, LOANS AND SECURITIZATIONS

I.1.1 Nykredits Realkreditindeks includes a representative extract of the Danish covered bond market. The index includes both covered bonds with short and long maturities.

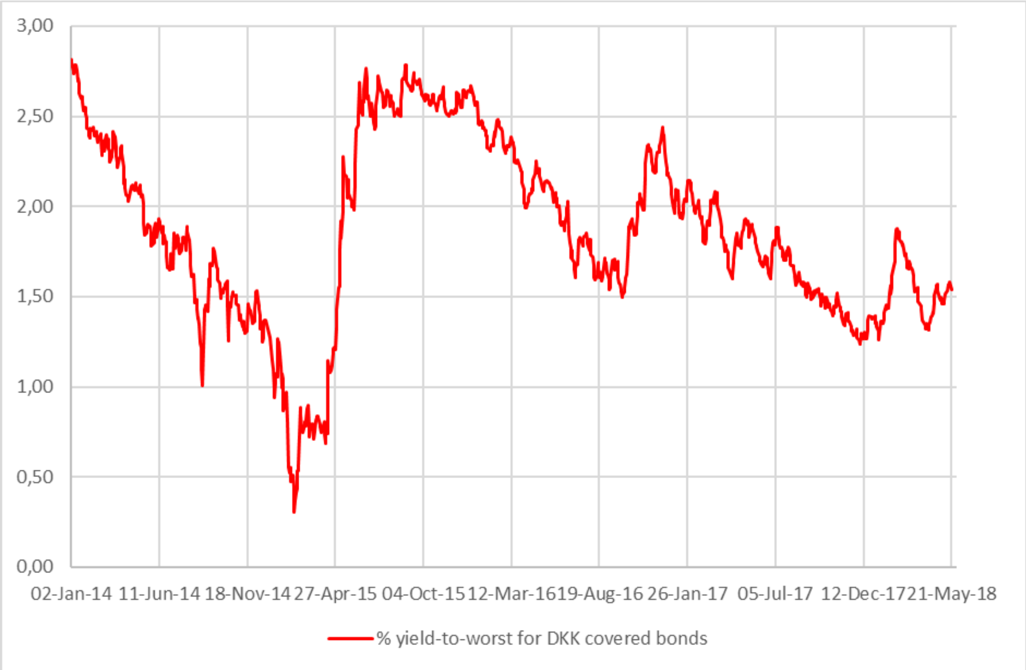
I.1.2 A single index which covers all maturities is preferred over a more granular approach e.g., mapping exposures to two indices with maturity 3 years and 30 years. Such a mapping will include major expert judgement on the split of insurance undertakings holdings of short and long duration covered bonds.

I.1.3 The use of a single index reflects better the exposures of the Danish insurance sector as a whole, than an attempt to map exposures in to two buckets. It should also be noted that the Nykredits Realkreditindeks is the index used as input for the covered bond component in the current Danish interest rate curve.

I.1.4 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 are allowed to opt for early repayment of their loan. In order to account for such embedded call option, an option-adjusted version of the Nykredit Realkreditindeks was analyzed for its modelling approach of the optionality, found eligible and subsequently adopted for calculation of the Danish krone VA.

I.1.5 Historical data for the option-adjusted yield (“yield to worst”) of Nykredits Real-kreditindeks is given in Figure 2 below. This data corresponds to the input $R_{covered}^{DKK}$.

Figure 2 – Historical data of Nykredits Realkreditindeks



ANNEX J SPECIFICATION OF THE INPUT DATA FOR THE TRANSITION MATRICES

J.1 ANNEX TO SUBSECTION 12.5 - METHOD FOR DERIVING THE PROBABILITY OF DEFAULT (PD) AND THE COST OF DOWNGRADE (COD)

J.1.1 This annex sets out the input data of Standard & Poor's (S&P) for the transition matrices used to calculate the probabilities of default and the cost of downgrading. The specific time period of the data used, and the timing of the data download are specified in the monthly publication of the probabilities of default and the cost of downgrading.

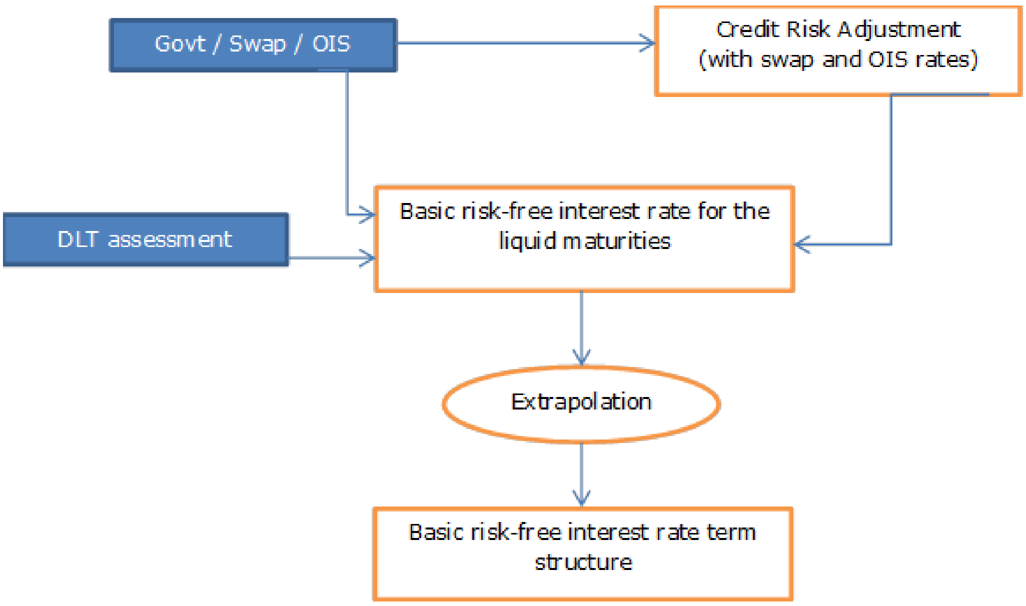
J.1.2 Financial bonds

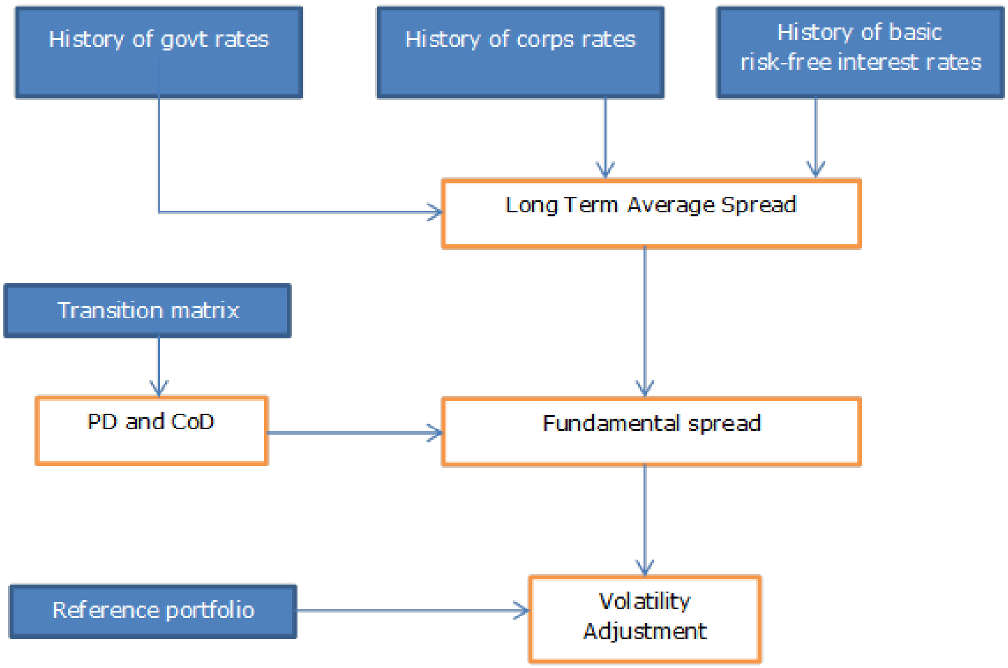
S&P Report Type	Transition Matrices (Percent, NR Excluded)
CALCULATION BASE	Number of Issuers (All)
HORIZON	1Year
INDUSTRY SELECTION	GICS -40 -- Financials
COUNTRY SELECTION	All
VINTAGE YEARS SELECTION	All
NUMBER OF POOLS	30

J.1.3 Non-financial bonds

S&P Report Type	Transition Matrices (Percent, NR Excluded)
Calculation Base	Number of Issuers (All)
Horizon	1Year
Industry Selection	GICS -10 – Energy, 15 -- Materials, 20 -- Industrials, 25 -- Consumer Discretionary, 30 -- Consumer Staples, 35 -- Health Care, 45 -- Information Technology, 50 -- Telecommunication Services, 55 – Utilities, 60 -- Real Estate
Country Selection	All
Vintage Years Selection	All
Number of Pools	30

ANNEX K DIAGRAM OF CALCULATIONS





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