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MASTER'S THESIS

A REVIEW OF LONG-TERM GUARANTEES MEASURES UNDER SOLVENCY II: APPLYING VOLATILITY ADJUSTMENT IN THE SLOVENIAN INSURANCE MARKET

Ljubljana, June 2025 RIA DAVKOVSKA

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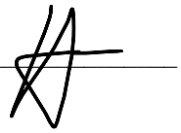

ABSTRACT

The thesis examines the non-transitional long-term guarantees measures under Solvency II in light of their revision introduced by the 2020 Solvency II Review. It investigates the reasons behind the underutilization of the optional measures, with a particular focus on the volatility adjustment in the Slovenian insurance market. Combining both qualitative and quantitative analyses, it assesses the impact of the current and revised volatility adjustment on the solvency position of a Slovenian insurance undertaking. The results show that the application of the volatility adjustment, current or revised, for the Slovenian insurance undertaking leads to a disproportionate capital relief, i.e. overshooting. The revised mechanism is smoother and tailored to the undertaking's specific risk profile, but its effectiveness still depends on the alignment between the undertaking's asset and liability characteristics and the assumptions behind the reference portfolio. The insights of the thesis have practical implications for undertakings aiming to better understand the mechanisms behind the revised long-term guarantees measures and evaluate the cost-benefit of applying the volatility adjustment.

KEY WORDS: Solvency II, Long-term guarantees measures, Volatility Adjustment, Slovenian insurance market

SUSTAINABLE DEVELOPMENT GOALS

POVZETEK

Magistrska naloga preučuje stalne ukrepe dolgoročnih jamstev po Solventnosti II v luči njihove revizije, ki jo je prinesel Pregled Solventnosti II 2020. Naloga raziskuje vzroke za premajhno izkoriščenost teh ukrepov, s posebnim poudarkom na prilagoditvi za nestanovitnost na slovenskem zavarovalniškem trgu. S kombinacijo kvalitativne in kvantitativne analize ocenjuje vpliv trenutne in revidirane prilagoditve za nestanovitnost na solventnostni položaj slovenske zavarovalnice. Rezultati kažejo, da uporaba prilagoditve za nestanovitnost, trenutne ali revidirane, za slovensko zavarovalnico vodi v nesorazmerno kapitalsko razbremenitev tj. prekomerno prilagajanje. Revidirani mehanizem je bolj gladek in prilagojen posebnemu profilu tveganja podjetja, vendar je njegova učinkovitost še vedno odvisna od usklajenosti med značilnostmi sredstev in obveznostmi podjetja ter predpostavkami v ozadju referenčnega portfelja. Spoznanja magistrske naloge imajo praktične implikacije za podjetja, ki želijo bolje razumeti mehanizme, ki stojijo za revidiranimi ukrepi dolgoročnih jamstev in oceniti stroške in koristi uporabe prilagoditve za nestanovitnost.

KLJUČNE BESEDE: Solventnost II, ukrepi dolgoročnih jamstev, prilagoditev za nestanovitnost, slovenski zavarovalniški trg

CILJI TRAJNOSTNEGA RAZVOJA

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LIST OF ABBREVIATIONS

sl. – Slovene

BE – (sl. najboljša ocena); Best Estimate

bps – (sl. bazične točke); Basis points

CIC – (sl. dopolnilna identifikacijska koda); Complementary Identification Code

CoD – (sl. strošek znižanja bonitetne ocene); Cost of Downgrade

CSSR – (sl. razmerje občutljivosti na kreditni razmik); Credit Spread Sensitivity Ratio

CQS – (sl. stopnje kreditne kakovosti); Credit Quality Steps

ECB – (sl. Evropska centralna banka); European Central Bank

EEA – (sl. Evropski gospodarski prostor); European Economic Area

EIOPA – (sl. Evropski organ za zavarovanja in poklicne pokojnine); European Insurance and Occupational Pensions Authority

EU – (sl. Evropska unija); European Union

FSP – (sl. prva točka zglajevanja); First Smoothing Point

GAR – (sl. razmerje splošne uporabe); General Application Ratio

i.e. – (sl. tj. - to je) id est

IRR – (sl. notranja stopnja donosa); Internal Rate of Return

LLP – (sl. zadnja likvidna točka); Last Liquid Point

LTAS – (sl. dolgoročno povprečje razpona); Long-term Average Spread

LTG – (sl. dolgoročna jamstva); Long-term guarantees

MA – (sl. uskladitvena prilagoditev); Matching adjustment

OF – (sl. lastna sredstva); Own Funds

ORSA – (sl. lastna ocena tveganj in solventnosti); Own Risk and Solvency Assessment

PD – (sl. verjetnost neplačila); Probability of Default

RFR – (sl. netvegane obrestne mere); Risk-free interest rates

RM – (sl. dodatek za tveganje); Risk Margin

SCR – (sl. zahtevani solventnostni kapital); Solvency Capital Requirement

SFCR – (sl. poročilo o solventnosti in finančnem položaju); Solvency and Financial Condition Report

TRFR – (sl. prehodni ukrep glede krivulje neobrestne mere); Transitional measure on the risk-free interest rates

TTP – (sl. prehodni ukrep glede zavarovalno-tehničnih rezervacij); Transitional measure on technical provisions

UFR – (sl. končna terminska obrestna mera); Ultimate Forward Rate

UK – (sl. Združeno Kraljevstvo); United Kingdom

VA – (sl. prilagoditev za nestanovitnost); Volatility Adjustment

1 INTRODUCTION

The insurance industry is a crucial component of the financial system, providing risk management and protection to individuals, businesses and society. To ensure its stability and resilience, regulatory frameworks have evolved over time to address emerging risks. Solvency II, implemented in 2016, is the risk-based comprehensive regulatory framework for insurance and reinsurance undertakings in the European Union (EU). Its purpose is to enhance risk management standards and ensure adequate protection of policyholders and beneficiaries, by combining both qualitative and quantitative measures.

Market consistency is one of the core principles of Solvency II, requiring assets and liabilities to be valued at their market value. However, complete market consistency was recognized as inadequate for undertakings providing long-term guarantees (LTG) products, where liabilities are less sensitive to short-term market volatility. For this reason, LTG measures were incorporated into the framework. The measures include extrapolation of the risk-free interest rates (RFR), the matching adjustment (MA), the volatility adjustment (VA), the extension of the recovery period in case of non-compliance with the Solvency Capital Requirement (SCR), the transitional measure on the risk-free interest rates (TRFR) and the transitional measure on technical provisions (TTP).

According to the European Insurance and Occupational Pensions Authority's (EIOPA) (2020a) last report, in 2019, 650 undertakings, representing 79% of technical provisions (TP) in the European Economic Area (EEA), applied at least one measure. The VA was the most applied measure, employed by 631 undertakings, representing 79% of the EEA's TP (EIOPA, 2020c). Despite its dominance, its utilization has been declining, and the measure has not been applied by Slovenian insurance or reinsurance undertakings until 2020 (EIOPA, 2020c).

The effectiveness of the LTG measures in fulfilling their regulatory objectives was subject of research both before and after their implementation. Studies concentrated on the non-transitional measures have raised several concerns:

- The Smith-Wilson term structure model may overestimate the extrapolated part of the RFR curve, which might result in an undervaluation of liabilities, significantly affecting undertakings with LTG products (Jørgensen, 2018; Rae et al., 2018; Gosden et al., 2012).
- The MA, built on the illiquidity premium concept, allows an assets' premium to artificially reduce the value of liabilities, conflicting with market consistency (Ayadi et al., 2012; Wüthrich, 2011). Its strict application requirements increase operational risk, costs and complexity for undertakings and national differences in implementation create an uneven playing field across the EEA (Rae et al., 2018).

- The VA may lead to over- or undershooting effects due to mismatches between undertakings' actual portfolios and the reference portfolio used in its calculation. Undertakings with conservative or short duration portfolios benefit disproportionately from the VA, potentially misrepresenting their financial health (Barucci et al., 2023; Plat, 2016). Garston et al. (2018) highlighted flaws in the euro representative and reference portfolio, such as delayed updates and lack of sensitivity to EEA country-specific bond spreads, which can lead to inaccurate liability valuations. Country-specific VA exists, but its application criteria cause inconsistent activation, further increasing capital volatility during times of market stress (Barruci et al., 2023; Gosden et al., 2012).

These concerns contributed to the 2020 Solvency II Review, which among its key features had the goal of better aligning the LTG measures' design with their objective. The revised extrapolation methodology allows the use of market information from additional financial instruments. The MA methodology remained unchanged, only removing the diversification limits for MA portfolios. In contrast, the revision of the VA was the most significant, and it included an undertaking-specific adjustment replacing the country-specific VA for non-euro member states and a macro VA with a smooth activation mechanism for euro member states, an undertaking-specific credit spread sensitivity ratio and an increased general application ratio (GAR).

The thesis examines the mandatory extrapolation mechanism and the optional MA and VA, as these measures help stabilize undertakings' balance sheets by limiting short-term market impacts and procyclical risks. It investigates the reasons behind the underutilization of the optional measures, with a particular focus on the VA in the Slovenian insurance market. It aims to provide a clearer understanding of the functioning of the VA, assess whether it meets its regulatory objectives, and analyze its impact on undertakings' solvency ratios. The analysis considers both the current and revised measures' methodologies, highlighting the expected improvements and remaining challenges in its practical implementation. The empirical analysis assesses the impact of the current and revised VA on the SCR ratio of a Slovenian insurance undertaking in the period from 31.12.2015 to 31.12.2023. Moreover, to highlight how country- and undertaking-specific factors affect the calculated VA values, the adjustment is recalculated on the undertaking's actual portfolio on 31.12.2023.

The thesis aims to answer the following research questions:

1. How do the LTG measures influence the valuation of insurance liabilities during short-term market volatility?
2. What are the primary factors contributing to the underutilization of the LTG measures, particularly VA, by Slovenian insurance undertakings?
3. How do the current and revised VA methodologies impact the SCR ratio of a Slovenian insurance undertaking compared to using no VA?

4. What structural differences exist between the euro representative portfolio and Slovenian insurance portfolios, and how do they influence the effectiveness of the VA?
5. How do the revised LTG measures address or exacerbate short-term market volatility issues?

The thesis is structured in five main chapters. After the introduction, Chapter 2 reviews the non-transitional LTG measures under Solvency II, presents the academic perspectives on their limitations and introduces the recent changes to their methodologies. Chapter 3 describes the data sources, and the methodology employed in the application of the VA for a Slovenian insurance undertaking. In Chapter 4, the impact of the VA on the Slovenian insurance undertaking's liabilities and solvency position is presented and discussed, along with the limitations of the thesis and further research recommendations. The last Chapter 5 concludes the thesis.

2 REVIEW OF LONG-TERM GUARANTEES MEASURES UNDER SOLVENCY II

This chapter outlines the regulatory background relevant to the LTG measures under Solvency II. It provides an overview of the extrapolation of the RFR, the MA and VA in the context of the current framework and the recent changes introduced by the 2020 Solvency II Review. Moreover, it sets the theoretical foundation for the later empirical analysis of the VA in the Slovenian insurance market.

2.1 The Solvency II Framework

Solvency II is a risk-based regulatory framework for insurance and reinsurance undertakings in the EU aiming to enhance risk management standards and ensure adequate protection of policyholders and beneficiaries (EIOPA, n.d.-a). The Directive 2009/138/EC of the European Parliament and of the Council of 25 November 2009 on taking-up and pursuit of the business of Insurance and Reinsurance (Solvency II Directive) was adopted in 2009 but implemented in 2016. Its implementation was delayed due to various challenges, among which was the treatment of LTG products and their impact on undertakings' solvency positions.

The framework is based on market consistent valuation of assets and liabilities, requiring them to be valued at the amount for which they can be exchanged, transferred, or settled in the market (EIOPA, n.d.-a). However, complete market consistency was recognized as inadequate for undertakings providing LTG products, because they manage long-term illiquid liabilities backed by long-term assets held to maturity. These undertakings are often able to invest in illiquid assets and realise an illiquidity premium, not affected by any short-term market volatility. Since both their assets and liabilities are insensitive to short-term market fluctuations, market based valuation can overestimate volatility and misrepresent solvency positions. As a result, the inclusion of an illiquidity premium became one of the central points of debate during the development of the

framework. Political lobbying played a key role in shaping the final framework, since member states and industry stakeholders advocated for adjustments that would protect their domestic markets and prevent excessive capital requirements on long-term business models (Gosden et al., 2012). United Kingdom (UK) was the biggest advocate for the inclusion of an illiquidity premium, since its life insurance market is predominantly composed of annuity and pension products (Bank of England, 2025, Gosden et al., 2012). Since such liabilities are typically backed by assets producing matching cash flows, an illiquidity premium would significantly reduce capital requirements and improve solvency positions. These discussions ultimately led to the adoption of two different variations of the illiquidity premium: the MA and the VA.

The LTG measures were introduced through the Omnibus II Directive to ensure an appropriate treatment of LTG products (Barucci et al., 2023). To stabilize undertakings' balance sheets by limiting short-term market volatility and procyclical risks, three non-transitional LTG measures were introduced: the extrapolation of the RFR, the MA and the VA. While the MA and VA are optional measures, the extrapolation is a mandatory component of the Solvency II framework, but it is considered an LTG measure due to its role in improving the valuation of long-term liabilities.

The Solvency II Directive required a review of certain areas of the framework, including the LTG measures, by 1 January 2021. As part of this review, which became known as the 2020 Solvency II Review, EIOPA was requested to provide technical advice to the European Commission, which then proposed amendments to the framework (EIOPA, 2020a). In January 2025, the Directive (EU) 2025/2 of the European Parliament and of the Council of 27 November 2024 amending Directive 2009/138/EC as regards proportionality, quality of supervision, reporting, long-term guarantee measures, macro-prudential tools, sustainability risks and group and cross-border supervision, and amending Directives 2002/87/EC and 2013/34/EU (Directive amending Solvency II), entered into force. The Directive requires member states to transpose the amendments into national laws by 29 January 2027.

2.2 Long-term guarantees measures

Although Solvency II does not provide a legal definition of long-term guarantees, the concept is commonly understood to refer to insurance products that include guarantees linked to either contract duration or type of financial commitments provided (EIOPA, 2016). LTG are primarily associated with life insurance but can also be found within annuities stemming from third party liability non-life insurance. EIOPA's annual reports (2016, 2017, 2018a, 2020c, 2019) show a decrease in the duration and level of guarantees, as well as an overall decline in the availability of LTG products throughout the EU in the last years. The majority of those currently in the market are in run-off, while very few, such as guaranteed annuity benefits products, are still commercialized.

2.2.1 Extrapolation of the relevant risk-free interest rate term structure

Article 77 of the Solvency II Directive states that the value of TP should be equal to the sum of the best estimate (BE) and risk margin (RM), where the BE is based on discounting the probability-weighted average of future cash flows using the relevant RFR term structure.

According to Article 77a of the Solvency II Directive, the determination of the relevant RFR term structure should take into account observable market data from relevant financial instruments, where markets are considered deep, liquid and transparent (DLT). Beyond the last liquid point (LLP), which is the longest maturity where these instruments trade in DLT markets, the term structure should be extrapolated. The extrapolation is of mandatory application and is performed using the Smith-Wilson model, providing smooth convergence of forward rates from the LLP to a predefined ultimate forward rate (UFR). For euro, the LLP was set at 20 years, with the extrapolated curve converging toward a UFR of 4.2% over a 40-year period. However, after the implementation of Solvency II, the persisting low interest rate environment pressured for a lower UFR and in 2018, EIOPA started gradually reducing it (EIOPA, 2017).

2.2.1.1 Academic perspectives on the limitations of the extrapolation of the relevant risk-free interest rate term structure

Changes in the extrapolation parameters or term structure models can significantly impact the liability valuations and the undertaking' solvency positions. This was shown in Jørgensen's (2018) analysis of the sensitivity of liability valuations to different extrapolation models and assumptions under the Smith-Wilson model. When compared to the extended Nelson-Siegel model and the method of bootstrapping and horizontal extrapolation, the Smith-Wilson model results in the lowest liability valuations (Jørgensen, 2018). When the VA is added, liability values decrease further, resulting in a 25% lower present value compared to the benchmark method of bootstrapping and horizontal extrapolation (Jørgensen, 2018). His findings also indicate that variations in the values chosen for the parameters in the Smith-Wilson model, such as the UFR, significantly affect the extrapolated part of the yield curve.

The Smith-Wilson model precisely matches market rates for shorter maturities, while disregarding available market data beyond the LLP (Jørgensen, 2018). This limits the sensitivity of liabilities to real market movements beyond the LLP, which reduces incentives for proper risk management and duration matching (Rae et al., 2018). On the other hand, liabilities become highly sensitive to the interest rate at the LLP maturity. This can lead to increased demand for fixed income hedging assets at that point, potentially depressing corresponding market rates (Jørgensen, 2018).

Moreover, the convergence period parameter in the Smith-Wilson model determines the steepness of the transition to the UFR. For euro, it was set at 60 years, although the fifth Quantitative Impact Study conducted during the preparation of the Solvency II technical standards specifically

recommended a convergence point between 70 and 120 years (Jørgensen, 2018). A shorter convergence period results in a steeper transition to the UFR, which raises the discount rates and reduces the present value of long-term liabilities.

The chosen Smith-Wilson model and the parameter assumptions behind it appear systematically designed to 'raise' the RFR term structure above its market-consistent level, which could lead to a systematic undervaluation of liabilities (Jørgensen, 2018). As a result, significant revisions of the methodology can result in material systematic shifts in solvency positions. This conflicts with the Solvency II's objectives of financial stability, policyholders protection and prudent liability valuations.

2.2.1.2 Revised methodology

The Directive amending Solvency II states that the extrapolation should begin at the first smoothing point (FSP) for each currency. This point is defined as the longest maturity for which markets are DLT, and the proportion of outstanding bonds of that and longer maturities is sufficiently high in the currency's bond market (Directive amending Solvency II). For euro, the FSP remains at 20 years. The Directive amending Solvency II further states that the extrapolated part of the term structure should incorporate market information from financial instruments other than bonds, if their markets are DLT. Lastly, to avoid material systematic shifts in solvency positions and market disruption, the Directive amending Solvency II introduces a phasing-in mechanism, allowing undertakings to gradually transition to the new extrapolation methodology until 2032.

2.2.2 The matching adjustment

The second LTG measure is the MA, designed to reflect the reduced credit spread volatility faced by undertakings holding long-term assets that match their liability cash flows to maturity. To prevent short-term credit spread volatility from affecting their solvency positions, Article 77b (1) of the Solvency II Directive allows for the application of the MA to the relevant RFR term structure to calculate the BE of a portfolio of liabilities. The article further states that the application of the MA is subject to prior approval, where specific requirements must be met. For the list of specific requirements, see Appendix 1.

Article 77b (2) states that undertakings applying the MA cannot go back to an approach that excludes it. If requirements for its application are no longer met, undertakings must notify the supervisory authority and either restore compliance within two months or stop applying the MA for at least 24 months (Article 77b (2) of the Solvency II Directive). The MA cannot be combined with the VA or the TRFR for the same portfolio of liabilities.

According to Article 77c (1) of the Solvency II Directive, the MA is calculated as the difference between the annual effective rate that, when applied to the liability cash flows, equates their present value to the market value of the assigned assets and the annual effective rate using the basic RFR term structure. The MA should not include the fundamental spread, which is the sum of the credit spread reflecting the probability of default of the assets and the credit spread capturing the expected losses from credit rating downgrades (Article 77c (1) of the Solvency II Directive).

2.2.2.1 Academic perspectives on the limitations of the matching adjustment

During the development of Solvency II, there was considerable debate regarding the appropriate application of the previous illiquidity premium (current MA). Some researchers and academics argued that the illiquidity premium is an assets' feature and should therefore be reflected in the valuation of assets, not liabilities (Ayadi et al., 2012). Wütrich (2011) supported this position by emphasizing that market consistent valuation is based on replicating portfolios and arbitrage-free pricing. However, because liabilities are inherently non-tradeable and non-headgeable, in practice no perfectly replicating portfolio exists (Wüthrich, 2011). As a result, discounting liabilities at a premium may lead to inconsistencies with the principle of market consistency and artificially reduce liability valuations.

The Solvency II Directive established strict and hard to meet requirements for cash flow matching and asset admissibility but left some space for national supervisory agencies to interpret them as they see fit for their markets. As noted by Rule (2017), the Executive Director for Insurance Supervision at the Bank of England, in his speech one year after Solvency II's implementation, UK's undertakings were allowed to restructure portfolios of illiquid assets, such as mortgages, using special purpose vehicles and internal securitization to meet the MA requirements. Additionally, they were allowed to pair and group assets, such as combining floating rate notes with interest rate swaps (Rule, 2017). These flexibilities together with the low interest environment at the time of Solvency II's implementation, increased the demand for illiquid assets. UK's supervisory authority projected that, in the coming years, up to 40% of annuities could be backed up by illiquid assets (Rae et al., 2018).

The shift from government and corporate bonds to illiquid assets increases liquidity and concentration risk. A simultaneous shift toward illiquid assets could also lead to asset price inflation and a bubble effect in these markets. Additionally, in the process of restructuring, undertakings often must conduct internal assessments of credit ratings which can be extremely material, as they determine levels of fundamental spreads applied to assets (Forrester & McNeill, 2016). This adds subjectivity and model risk, as misjudging credit quality can lead to underestimating default risk and mispricing liabilities.

Applying the MA has increased complexity, operational risk and costs for undertakings. They have to establish MA compliance committees, integrate it within internal models, validate asset data, adjust trading criteria, enhance cash flow monitoring and meet stricter reporting requirements (Forrester & McNeill, 2016). However, undertakings lacking internal expertise, financial or operational resources are unable to benefit from the MA, which creates an uneven playing field across undertakings. Looking at a broader level, the UK's more flexible implementation of the MA creates an uneven playing field across the EU and UK, since undertakings in member states with stricter implementations find it harder to comply with the requirements for its' application.

Lastly, the SCRs for different MA portfolios must be calculated separately, without diversification benefits between portfolios or other business activities, meaning that as undertakings increase the number of MA portfolios, diversification benefits decrease (Rae et al., 2018). This can disincentivize undertakings from applying the MA, despite its potential to better align with the structure of their liabilities and stabilize their balance sheets.

2.2.2.2 Revised methodology

The Directive amending Solvency II does not introduce changes to the MA methodology that would affect the calculation of TP or own funds (OF). The only amendment specifically concerning the MA is to Article 111 of the Solvency II Directive, clarifying that limitations on diversification related to ring-fenced funds do not apply to assigned portfolios covering liabilities under the MA.

2.2.3 The volatility adjustment

The last non-transitional LTG measure is the VA, a mechanism that modifies the relevant RFR term structure to account for temporary fluctuations in credit spreads. It aims to reduce balance sheet volatility caused by short-term market movements, that do not reflect a fundamental change in the undertakings' long-term financial position. While the MA is a more precise solution for capturing the illiquidity premium, as it is based on strict asset-liability matching, the VA represents a broader and less granular approach. It provides a practical and operationally simpler adjustment which does not take into account the asset-liability composition of individual undertakings.

Article 77d of the Solvency II Directive states that the application of the VA may be subject to prior approval by supervisory authorities and should be applied only to the non-extrapolated part of the RFR term structure and extrapolation should be based on the adjusted rates.

According to Article 77d (2) and (3), the currency VA is calculated as 65% of the risk-corrected currency spread, which is the difference between the spread of the observed asset in the reference portfolio and the portion attributed to the expected losses or other credit risks. The reference portfolio per currency is representative of the assets insurance and reinsurance undertakings hold

to cover the best estimate of liabilities (BEL) in that currency (Article 77d (2) of the Solvency Directive).

In addition to the currency VA, Article 77d (4) allows for a country-specific VA when credit spreads in a particular country deviate significantly from the broader currency-wide spreads due to local market conditions, economic stress, or sovereign risk. The risk-corrected currency spread is increased for the difference between the risk-corrected country spread and twice the risk-corrected currency spread, only when their difference is positive, and the risk-corrected country spread is higher than 85 basis points (bps) (Article 77d (4) of the Solvency II Directive). The risk-corrected country spread is calculated in the same manner as the risk-corrected currency spread, but on a reference portfolio representative of the assets insurance and reinsurance undertakings hold to cover the BEL from products sold in the insurance market and currency of that country (Article 77d (4) of the Solvency II Directive).

Moreover, the Solvency II Directive provides the option of a dynamic VA when calculating SCR with internal models but leaves at the discretion of national supervisory authorities to decide whether they allow its application. The dynamic VA can change during the 1-year forecast due to spread or risk correction, or changes in the undertakings' investment behavior. The dynamic VA is not in the scope of this thesis, as it is exclusively used in internal models, which are not currently utilized by Slovenian insurance undertakings.

2.2.3.1 Academic perspectives on the limitations of the volatility adjustment

Overshooting and undershooting effects

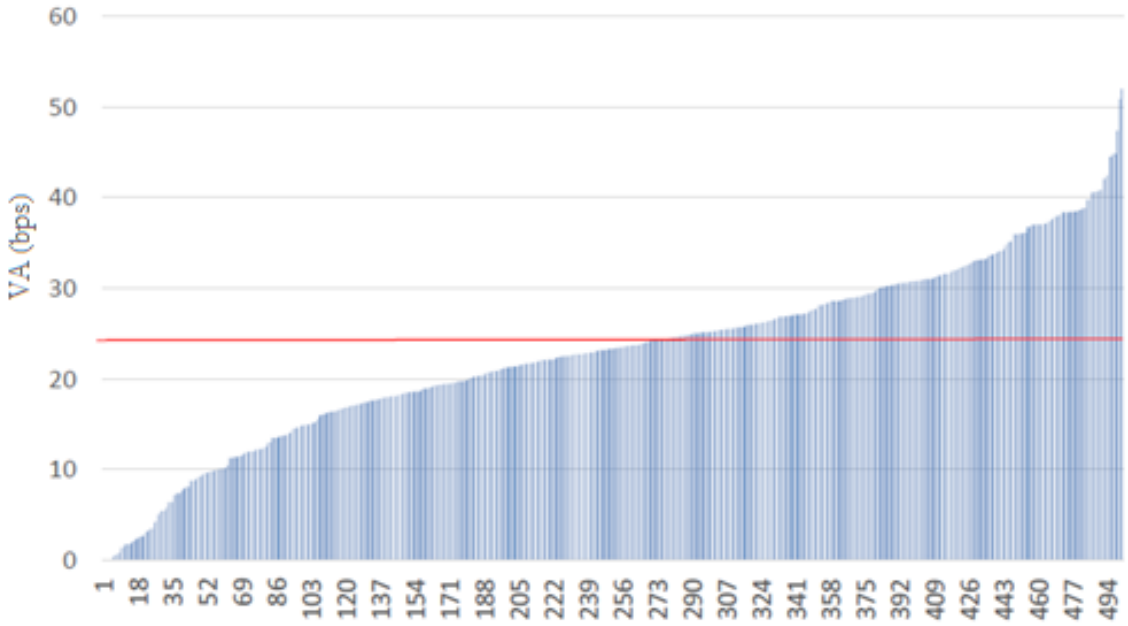
The VA intends to stabilize the balance sheet by compensating for non-credit-related increases in bond spreads on the asset side. However, it may over- or undershoot the intended adjustment due to mismatches in asset allocation, credit quality or duration of undertakings' portfolios and the representative portfolio.

For undertakings with relatively long-term liabilities that hold relatively little and relatively less-risky fixed income assets, the application of the VA implies a disproportionate decrease in the BEL (EIOPA, 2018a). When credit spreads widen, the VA increases the discount rates and reduces the present value of liabilities. Although the value of assets also decreases, their lower credit spread sensitivity means the reduction is relatively small. This leads to an artificial increase in OF, as the decrease in liabilities outweighs the decrease in asset values. Consequently, undertakings may report higher solvency positions during times of market stress, potentially misrepresenting their financial health. When credit spreads normalize, the VA effect reverses, worsening solvency positions and contributing to procyclicality instead of mitigating it. Plat (2016) demonstrated this issue by applying the euro VA to the liability portfolio of a Dutch undertaking over the period from 2000 to 2015. The analysis showed that during the 2008 financial crisis, the VA would have led to

an increase in OF, primarily due to two factors (Plat, 2016). First, the assets portfolio of the Dutch undertaking was less risky than the euro representative portfolio, which contained a higher share of corporate bonds and government bonds from countries with higher credit risk. Second, the liabilities of the Dutch undertaking had a longer duration compared to its assets. The duration gap between assets and liabilities is implicitly included in the 65% GAR of the VA, which is fixed but can deviate significantly from the undertaking-specific duration gap (Garston et al., 2018). Since the VA is applied uniformly to all liabilities, regardless of the asset duration, the reduction in the value of liabilities may be more pronounced. Barucci et al. (2023) investigated this issue, with both the current and proposed VA methodology as revised by EIOPA. The analysis revealed a positive correlation between the duration gap and the benefit derived from the VA, measured as the difference between assets and discounted liabilities (Barucci et al., 2023). This suggests that undertakings with a greater duration gap, where liabilities have a longer duration than assets, may experience more significant capital relief i.e. overshooting effects from the VA.

EIOPA's annual report on the LTG measures assessed the exposure of undertakings applying the VA to credit spread volatility, as low proportion of credit spread sensitive assets would indicate overshooting (EIOPA, 2018a). In 2017, an analysis of 596 undertakings showed that 78% of their assets were credit spread sensitive, while in 2018, the average share of credit spread sensitive assets of 159 undertakings was 56% (EIOPA, 2018a, 2019). Both years there was a really high diversity of the per undertaking results, ranging from undertakings nearly exclusively invested in credit spread sensitive assets to undertakings with very low amounts (EIOPA, 2018a).

Figure 1: Undertaking-specific VA for undertakings applying the VA – EUR



Source: EIOPA (2019).

Moreover, EIOPA (2019) analyzed the undertakings' potential to earn the VA by comparing their undertaking-specific VA with the euro VA. Figure 1 shows the undertaking-specific VA (in bps) where each bar represents one undertaking, with a high diversity of results. However, the mean undertaking-specific VA was 22 bps, while the actual euro VA on 31 December 2018 was 23 bps (EIOPA, 2019). When analyzed by country, the Slovenian average undertaking-specific VA was 22 bps, while results between countries varied from 18 to 28 bps (EIOPA, 2019).

Another indicator of overshooting was, if undertaking's asset portfolio significantly differed from the reference portfolio and its risk-corrected spread was lower than the risk-corrected spread of the reference portfolio (EIOPA, 2018). EIOPA's report (2017) shows that Slovenia's risk-corrected country spread was much lower than the euro risk-corrected spread, meaning that the spreads deriving from assets held by Slovenian undertakings were much lower than the level of spread in the euro reference portfolio.

With regard to the euro VA, EIOPA's report (2018a) also highlighted its potential undershooting in cases where spread widenings affect a single member state, but the activation of the country-specific VA is not triggered. For the affected member state, the VA may not provide the intended stabilization, if the country-specific VA is below the trigger point or creates a cliff-edge effect, if it fluctuates around it. Since the implementation of Solvency II, the country-specific VA was activated only for Greece and Italy (Barucci et al., 2023). The inconsistent activation increases the volatility of the BEL furthermore, making it more difficult for undertakings to manage their solvency positions in times of market volatility (Barucci et al., 2023).

Lack of incentives for proper risk management

The misalignment between the undertakings' actual portfolios and the reference portfolio may create an incentive for conservative undertakings to take on additional credit risk to maximize the VA's capital relief, rather than align investments with their risk profiles. As seen in Plat's (2016) analysis, the Dutch insurer's conservative portfolio did not experience the same level of credit spread widening as the euro reference portfolio during the crisis, yet it still benefited from the full adjustment. The analysis highlighted that the Dutch insurer, under the current VA framework, could reduce its risk by increasing its exposure to riskier long-term financial bonds and lower rated government bonds (Plat, 2016). A similar concern was raised by Barucci et al. (2023), who noted that although a duration gap is typical for life insurance undertakings, the VA may further incentivize its increase for the benefit of a larger capital relief.

Asymmetry

The mechanism behind the VA is not symmetric because it produces only positive adjustments, only reducing the volatility in times of distress. But excessive volatility goes both ways, meaning

that asset prices can also become inflated in times of expansion. Ayadi et al. (2012) explain how in times of expansion, this leads to the risk not being reduced but simply shifted between sectors. Basel III forces the banking sector to hold more capital, making risk-taking more expensive, while the insurance sector not facing equivalent countercyclical requirements may take on more risky credit exposures (Ayadi et al., 2012). A more appropriate approach would be a symmetrical mechanism that also incentivizes the buildup of additional capital reserves in times of expansion.

Representative and reference portfolio

The weights of the government and corporate assets in the fixed income representative portfolio are updated annually once aggregated reporting templates of the previous year are submitted to EIOPA. This time lag between the data used for calibration and their effective use in the VA could potentially lead to outdated calculation if asset allocations or relative market values change significantly in the meantime (Garston et al., 2018). Moreover, the weights do not sum up to 100% because the representative portfolio includes only fixed income assets.

The currency VA does not account for differences between the euro government bonds as their market yield and long-term average spread (LTAS) in the reference portfolio are based on average ECB spreads and aggregated euro LTAS rather than on national government bonds spreads (Garston et al., 2018). As a result, liquidity differences between different national euro government bond markets are overlooked.

Competition and level playing field

The application of the VA can be subject to prior approval, and the national supervisory authorities that introduced such processes may differ in their strictness, as the Solvency II Directive does not set any clear requirements. In 2016, 10 member states, including Slovenia, imposed approval processes in their national markets (EIOPA, 2016). Regardless of whether prior approval is required, the written policy on risk management of undertakings applying the VA must include a policy on the criteria for its application (Article 44 (2a) of the Solvency II Directive). While the policies differ considerably, they all include one or more of the following criteria (EIOPA, 2016, 2018a):

- The asset portfolio or own specific VA must be sufficiently similar to the representative portfolio or the standard VA.
- The undertaking fulfills the prudent person principle when applying the VA and is able to manage the risks introduced or affected by the VA, such as liquidity risk.
- The undertaking can earn a minimum interest rate on its asset portfolio equal to the RFR plus the VA.
- The duration of the undertakings' assets and liabilities is similar.

- The application of the VA does not lead to or encourage procyclical investment behavior but rather prevents it.
- The undertaking's risk profile is in line with the assumptions underlying the VA i.e. they face the risk of a forced sale of assets.

The different criteria for the application of the VA create inconsistencies in how the measure is implemented, both across undertakings and member states. Combined with varying supervisory practices, it creates an uneven playing field across the EU and weakens regulatory harmonization.

2.2.3.2 Revised methodology

To ensure fair competition and level playing field the Directive amending Solvency II introduces a prior approval process for the application of the VA, in which undertakings demonstrate to the satisfaction of the national supervisory authority, that they are able to calculate the revised VA.

The revised Article 77d (3) introduces an undertaking-specific credit spread sensitivity ratio (CSSR) in the calculation of the currency VA, in order to mitigate over- and under-shooting effects. The CSSR cannot be negative or higher than one and shall take values lower than one when the sensitivity of the undertakings' assets to changes in credit spreads is lower than the sensitivity of its liabilities. The article further introduces a non-linear risk-correction which decreases as spreads increase but shall not exceed an appropriate percentage of the LTAS (Directive amending Solvency II). This change increases the countercyclicality of the VA by allowing more of the spread to enter the adjustment in times of market stress.

Additionally, to offset the overshooting effects for undertakings holding better credit quality bonds than contained in the representative portfolio, the Directive amending Solvency II introduces the option of applying an undertaking-specific adjustment to the currency risk-corrected spread. The adjustment is applied when the risk-corrected spread of the reference portfolio exceeds the risk-corrected spread calculated from the undertaking's own asset portfolio for four quarterly reporting periods (Directive amending Solvency II).

The country-specific VA is replaced with a macro VA in order to mitigate exaggerations of bond spreads in specific member states using the euro. According to the Directive amending Solvency II, the macro VA is activated when the country risk-corrected spread is 1.3 times larger than the euro risk-corrected spread. To ensure gradual and smooth activation and mitigate cliff-edge effects, the macro VA is scaled by a country adjustment factor, which reflects the relative exposure of undertakings to debt instruments in the country. The macro VA cannot be combined with the undertaking-specific adjustment to the currency risk-corrected spread (Directive amending Solvency II).

Lastly, the Directive amending Solvency II addresses the issue of the weights in the representative portfolio by defining them as ratios of the initial weight to the total value of fixed income assets in the portfolio.

2.2.4 Risk management and disclosure requirements on long-term guarantees measures

The Solvency II Directive imposes additional risk management and disclosure requirements on undertakings applying the LTG measures.

Article 44 of the Solvency II Directive sets out the risk management requirements, including specific obligations for undertakings applying the MA or the VA. Undertakings must set up a liquidity plan projecting the incoming and outgoing cash flows in relation to the assets and liabilities to which these adjustments are applied (Article 44 of the Solvency II Directive).

Article 44 (2a) states that undertakings must annually assess the sensitivity of their TP and eligible OF to the assumptions underlying: the extrapolation of the RFR term structure, the calculation of the MA, the VA and the fundamental spread, as well as the sensitivity to changes on the composition of the MA portfolio. Undertakings applying the MA or the VA should additionally assess the possible effects of a forced sale of assets, as well as the impact of a reduction of the adjustments to zero (Article 44 of the Solvency II Directive). Article 44 (2a) additionally states that the written policy on risk management of undertakings applying the VA must include a policy on the criteria for its application.

Article 45 (2a) requires undertakings applying the MA, the VA or any transitional measure to assess in their own risk and solvency assessment (ORSA) their compliance with the SCR, with and without considering those adjustments and measures. Furthermore, undertakings applying the MA or the VA must publicly disclose in their solvency and financial condition reports (SFCR) a quantification of the impact on their solvency position if the measures were reduced to zero (Article 51 (1a) of the Solvency II Directive). Those applying the MA must also describe the adjustment and the portfolio to which it is applied.

2.2.4.1 Limitations

Solvency II lacks consistency in the disclosure requirements regarding the LTG measures. While the effect of the MA and VA are explicitly disclosed, the impact of the extrapolation to the UFR is not. This creates an information gap, where analysts can assess the balance sheet strength of undertakings benefiting from the MA or VA, but lack comparable insights for those relying solely on the extrapolation (Rae et al., 2018). As a result, transparency is reduced, and cross-company comparisons are more challenging. Moreover, the additional risk management and disclosure requirements for undertakings applying the MA or VA are vaguely defined, leading to differences

in their implementation across undertakings. Lastly, they are an additional costly and time-consuming burden on an already extensive reporting framework.

2.2.4.2 Revised methodology

Regarding risk management, the Directive amending Solvency II supplements Article 44 with further clarifications of the requirements for liquidity planning and no longer requires the sensitivity analysis to include the effects of a forced sale of assets or the impact of a reduction of the adjustments to zero. The revised Article 45 (2a) still requires an ORSA assessment with and without the MA, VA and transitional measures, but introduces an exemption for currencies which are immaterial or marginally affected by extrapolation (Directive amending Solvency II). The article further introduces an additional assessment for undertakings applying the VA, where they must assess the deviation of their risk profile from assumptions underlying the adjustment. Article 51 is amended so that reporting on the impact of not applying the MA, VA or phasing-in mechanism for extrapolation is required only in the SFCR targeted at market participants and not in the part addressed to policyholders and beneficiaries (Directive amending Solvency II). Undertakings applying the VA should additionally disclose the calculated VA values for each relevant currency and the corresponding BEL (Directive amending Solvency II).

2.3 Utilization and impact of long-term guarantees measures

As part of its regulatory responsibilities under the Solvency II Directive, EIOPA was required to conduct an annual review of the LTG measures and report on their impact and effectiveness until 1 January 2021. To conduct these reviews, national supervisory authorities provided detailed information on the availability of LTG products in their markets, number of undertakings applying the LTG measures and their impact on undertakings' solvency positions and investment behaviors.

According to EIOPA's (2020c) last available annual report on LTG measures, in 2019, 650 insurance and reinsurance undertakings in 21 countries, representing 80% of TP in the EEA, were using at least one of the optional measures. The LTG measures were used mostly by life and composite undertakings, especially the VA, which was applied by more than half of all life undertakings in 2019 (EIOPA, 2019).

Table 1 provides an overview of the number of undertakings using each LTG measure and their EEA market share in TP. For each measure, the first value refers to the number of undertakings applying it while the percentage in brackets represents the share of total EEA TP they cover. Since it is possible to use certain combinations of LTG measures, the total number of users and non-users exceeds the total number of undertakings. It can be observed that the number of undertakings using at least one LTG measure has steadily declined. At the same time, the share of TP held by these undertakings has increased. The decline in the number of undertakings applying LTG measures is consistent with the broader trend of consolidation in the EEA market, where the total number of

insurance and reinsurance undertakings has been decreasing over the years. Additionally, it is important to emphasize that the data for 2019 shown in Table 1 does not include UK data due to Brexit. Given the UK's strong insurance market, its exclusion likely contributes to the observed decline in the number of undertakings using LTG measures in 2019. Despite fewer undertakings using the LTG measures, the increased share of TP covered suggests that the measures are primarily utilized by larger and/or more systematically significant undertakings managing substantial amounts of long-term liabilities.

Table 1: Number of undertakings applying the LTG measures and their EEA market share in TP

LTG measure	2016*	2016	2017	2018	2019
VA (TP Share)	852 (61%)	730 (66%)	696 (66%)	660 (67%)	631 (79%)
TTP (TP Share)	154 (24%)	163 (25%)	162 (24%)	159 (25%)	136 (19%)
MA (TP Share)	38 (16%)	38 (15%)	34 (14%)	34 (15%)	14 (2%)
TRFR (TP Share)	5 (0%)	6 (0%)	7 (0%)	6 (0%)	8 (0%)
No measure	2149	2162	2175	2098	1807
Total number of undertakings	3050	2945	2912	2797	2458

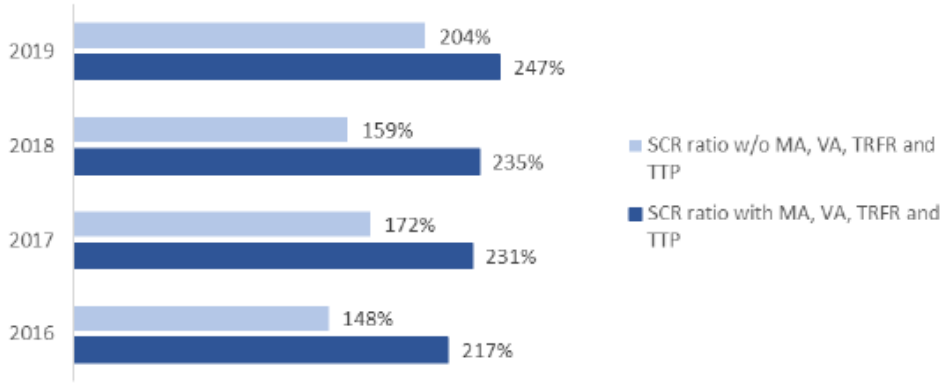
* Data from 1 January 2016, while all other data is with year-end reference date

Source: Adapted from EIOPA (2016), EIOPA (2017), EIOPA (2018a), EIOPA (2019), EIOPA (2020c).

Between 2016 and 2019, the VA remained the most widely applied LTG measure, in terms of number of member states, number of undertakings and amount of TP covered. Despite the decline in the total number of undertakings, the proportion of those relying on the VA remained significant. In 2019, 25% of undertakings applied the VA, covering 79% of EEA's TP. In contrast to the VA, the TTP and TRFR are temporary measures intended to be phased out by 2032 and are not expected to play a long-term role in Solvency II. While the TTP was the second most utilized measure, applied by 136 undertakings in 2019, the TRFR was the least used one, with only a small number of undertakings applying it. Lastly, the MA is unique in its application, and it has been applied only in the UK and Spain, due to their specific life insurance market structures, primarily consisting of retirement savings and annuity products.

Figure 2 shows the impact of removing the optional LTG measures on the SCR ratio of undertakings applying at least one measure. The impact varied significantly across member states and undertakings. In 2019, removing the optional measures would reduce the SCR ratio by an average of 43%, with the largest impact in Germany and Netherlands at 78% and 53% respectively (EIOPA, 2020c).

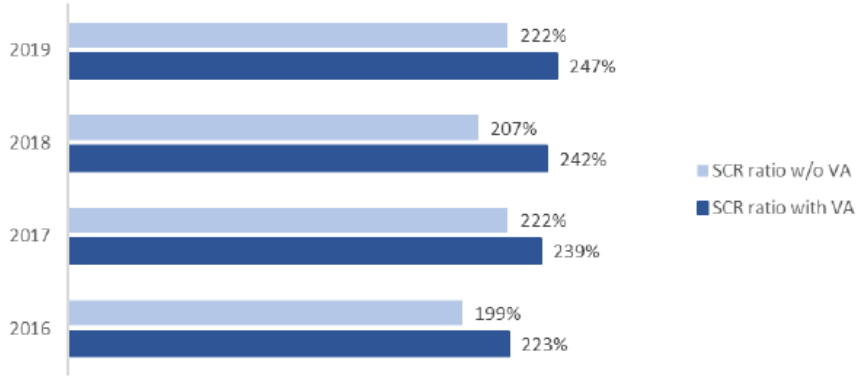
Figure 2: Impact of removing MA, VA, TRFR and TTP on the SCR ratio of undertakings using at least one measure



Source: EIOPA (2020c).

Figure 3 shows the impact of removing the VA on the SCR ratio of undertakings applying it. It can be concluded that undertakings applying the VA tend to be better capitalized, as reflected in the higher SCR ratio compared to the overall group of undertakings using the optional LTG measures. Moreover, the impact of removing the VA depends on the value of the VA in a given year. A higher VA generally provides greater capital relief and leads to a more significant drop in the SCR ratio when removed. This was the case in 2018, when the VA was 24 bps, whereas in 2017, it was only 4 bps (EIOPA, 2019).

Figure 3: Impact of removing VA on the SCR ratio of undertakings using the measure



Source: EIOPA (2020c).

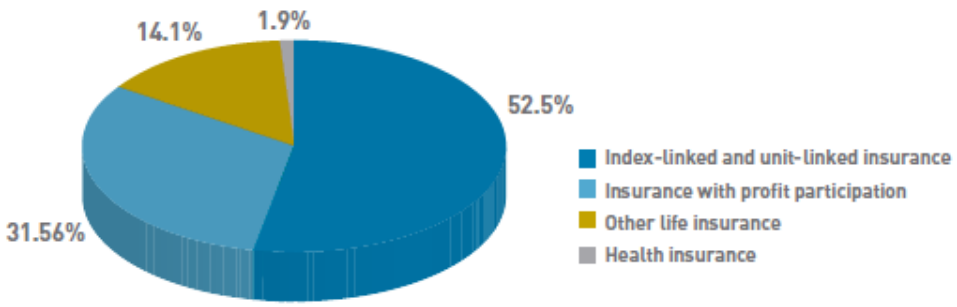
2.4 Slovenian insurance market

In 2023, in the Slovenian market there were 11 insurance and 2 reinsurance Slovenian undertakings (Insurance Supervisory Agency, 2024a). Out of the 11 insurance undertakings, 4 were composite, 4 life and 3 non-life undertakings (Insurance Supervisory Agency, 2024a). Slovenia is among the 7 EEA countries where until 2020 none of the LTG measures has been applied by any national

undertaking (EIOPA, 2020c). From 2020, one Slovenian life insurance undertaking has been applying the VA and one composite insurance undertaking the TTP (Insurance Supervisory Agency, 2024b).

In 2016, LTG products represented 90% of Slovenian life insurance TP, with material volumes in traditional life, unit-linked with guaranteed return, variable annuities and health insurance (EIOPA, 2017). According to EIOPA's (2018a) latest available data, in 2017, products with at least one guarantee made up 95% of the Slovenian market. Nevertheless, due to the prolonged period of low interest rates insurance undertakings could no longer achieve the guaranteed return on life insurance policies and as a result, the duration of the guarantee decreased, and some products even ceased to be commercialized. At the same time, index- and unit-linked life insurance products, where the investment risk is borne by the policyholders, came to the forefront and in 2023 represented more than half of the life insurance gross written premium on the Slovenian market (Insurance Supervisory Agency, 2024a). Figure 4 shows the shares of gross insurance premium written by line of business for life insurance in 2023. Insurance with profit participation accounted for 31.56% and compared to 2022, it decreased by 2.1 percentage points (Insurance Supervisory Agency, 2024a). The volume of index- and unit-linked insurance was 21 percentage points higher than the level of insurance with profit participation, while in 2019, this difference was only 3.6 percentage points (Insurance Supervisory Agency, 2024a).

Figure 4: Shares of gross insurance premium written by line of business for life insurance in 2023



Source: Insurance Supervisory Agency (2024a).

On 31.12.2023, the aggregated asset portfolio of Slovenian insurance and reinsurance undertakings consisted of 41.3% government and 23.5% corporate bonds, with nearly one third of assets issued by Slovenian entities (Insurance Supervisory Agency, 2024a). Regarding credit quality, the largest share of assets was lower or upper medium grade or not rated (Insurance Supervisory Agency, 2024a). Table 2 shows the structure of basic OF and capital adequacy of Slovenian insurance and reinsurance undertakings on 31.12.2023. The SCR ratios are significantly above the minimum 100%, suggesting that Slovenian undertakings are highly capitalized. This could be one of the

reasons behind the underutilization of LTG measures on the Slovenian insurance and reinsurance market.

Table 2: Structure of basic OF and capital adequacy of Slovenian insurance and reinsurance undertakings on 31.12.2023

	Insurance companies	Reinsurance companies
The total amount of basic own funds	2,253.0	794.8
Of which, subordinated liabilities	91.7	58.7
The total amount of ancillary own funds	0.0	0.0
Total eligible amount of own funds to cover the solvency capital requirement	2,253.0	794.8
Tier 1 unrestricted	2,147.3	732.9
Tier 1 restricted	15.0	0.0
Tier 2	76.7	58.7
Tier 3	14.0	3.2
The total eligible amount of basic own funds to cover the minimum capital requirement	2,198.6	744.2
Tier 1 unrestricted	2,147.3	732.9
Tier 1 restricted	15.0	0.0
Tier 2	36.3	11.3
The total amount of the solvency capital requirement (SCR)	977.8	293.5
The total amount of the minimum capital requirement (MCR)	338.6	83.3
Ratio of eligible own funds to SCR	230.4%	270.8%
Ratio of eligible own funds to MCR	649.4%	893.2%

Source: Insurance Supervisory Agency (2024a).

3 DATA AND METHODOLOGY

This chapter provides a detailed description of the data sources and methodology used to evaluate the impact of applying the VA on a Slovenian insurance undertaking's solvency position. The empirical analysis focuses solely on the currency VA, as the country-specific VA for Slovenia has not been activated since the implementation of the Solvency II framework. It includes both the current and revised methodologies of the currency VA, as well as both the standard and undertaking-specific approach to its calculation.

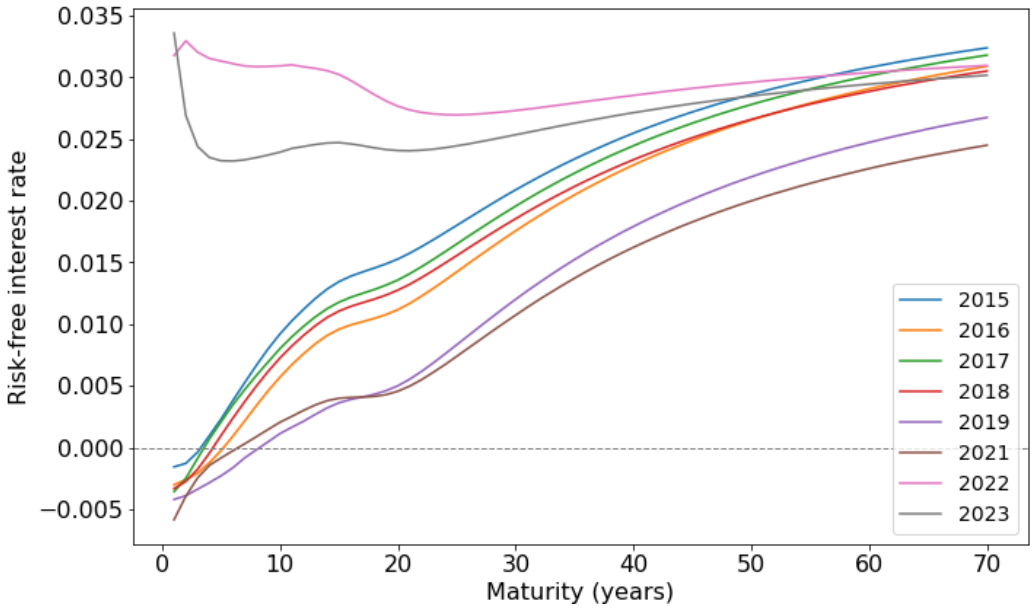
3.1 Data sources

3.1.1 Risk-free interest rate term structure and current volatility adjustment values

EIOPA publishes monthly technical information, including the relevant RFR term structure, VA for each national market and relevant currency, LTAS of government and corporate bonds, probability of default (PD), cost of default (CoD) and fundamental spreads for different durations, credit qualities, and asset classes. This analysis uses the monthly euro RFR term structure, both with and without the current VA, as published by EIOPA in the period from 31.12.2015 to

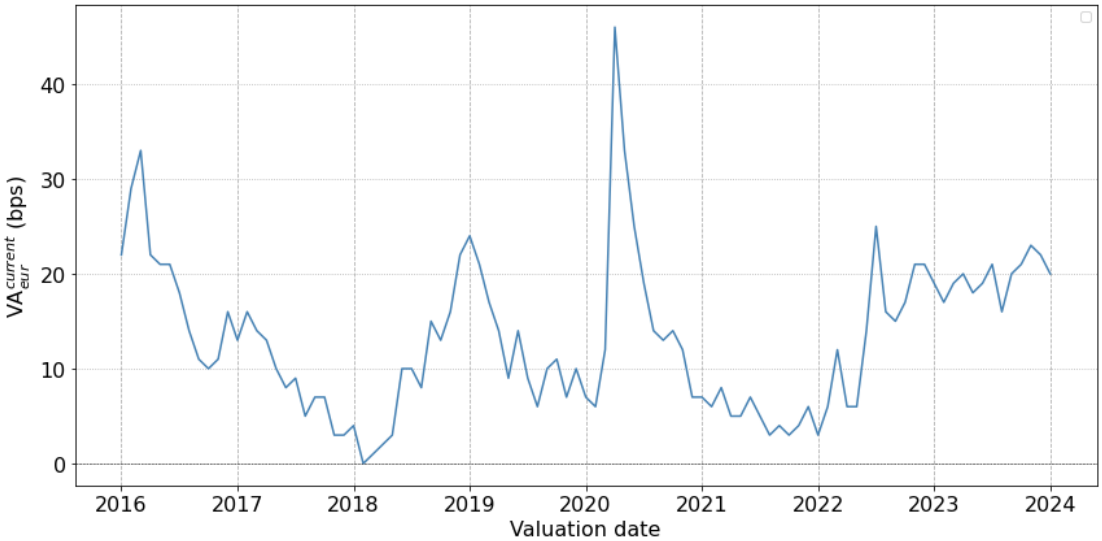
31.12.2023. The euro RFR term structure is based on 6 month EURIBOR swap rates up to the LLP of 20 years, beyond that, the rate curve is extrapolated toward the UFR (EIOPA, 2024a). Figure 5 shows the evolution of the euro RFR term structure without VA for year-end dates in the period from 31.12.2015 to 31.12.2023.

Figure 5: Euro RFR term structures without VA on year-end dates



Source: Own work based on EIOPA (2025).

Figure 6: Current VA values in the period from 31.12.2015 to 31.12.2023



Source: Own work based on EIOPA (2025).

The current euro VA values are shown in Figure 6, while the revised VA values are calculated using the methodology described in Chapter 3.2.2. EIOPA obtains the RFR term structure with the

current VA by adding the current VA values on the non-extrapolated part of the term structure (maturities up to the LLP of 20 years) and extrapolating using the Smith-Wilson model.

3.1.2 'Yield market indices' data

The data on 'yield market indices' used in the calculation of the undertaking-specific currency VA for the Slovenian insurance undertaking on 31.12.2023 was obtained from the data provider Bloomberg, as described in Chapter 3.2.1. The data for the European Central Bank (ECB) yield curve on 31.12.2023 was obtained directly from the ECB's website (ECB, 2024).

3.1.3 Slovenian insurance undertaking data

The remaining data used in the analysis was obtained from a Slovenian insurance undertaking and includes the following, all denominated in euros:

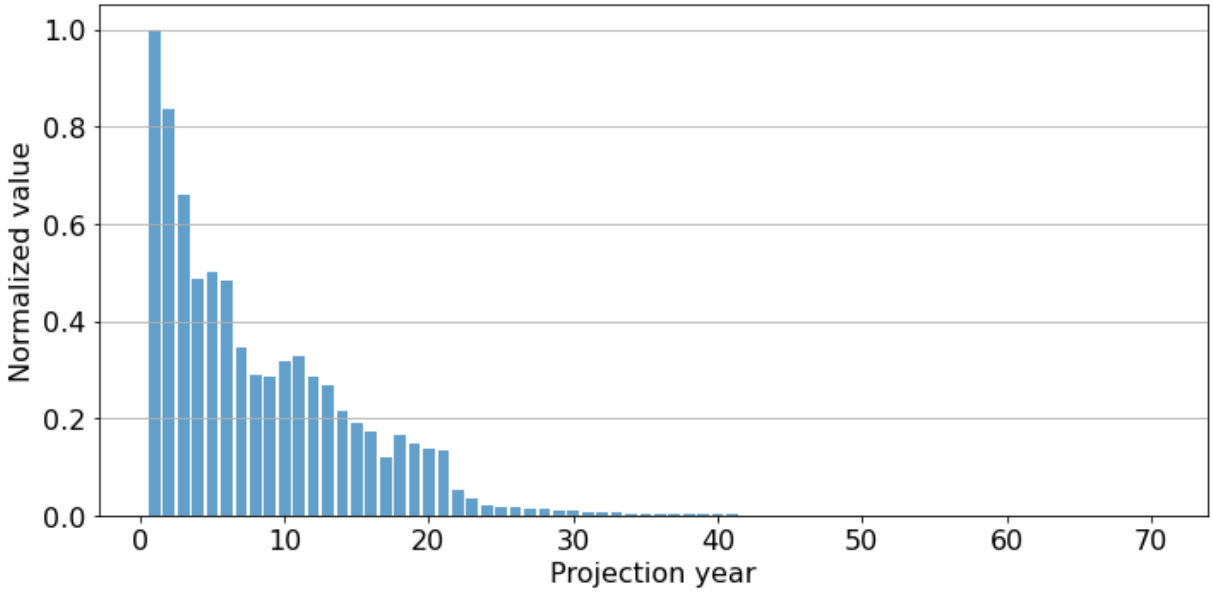
- Projected annual liability cash flows for an annuity life insurance portfolio on 31.12.2023.

- Market value of assets covering liabilities from the annuity life insurance portfolio on 31.12.2023.

- Projected annual cash flows of fixed income assets, including all projected coupon and redemption cash flows per asset.

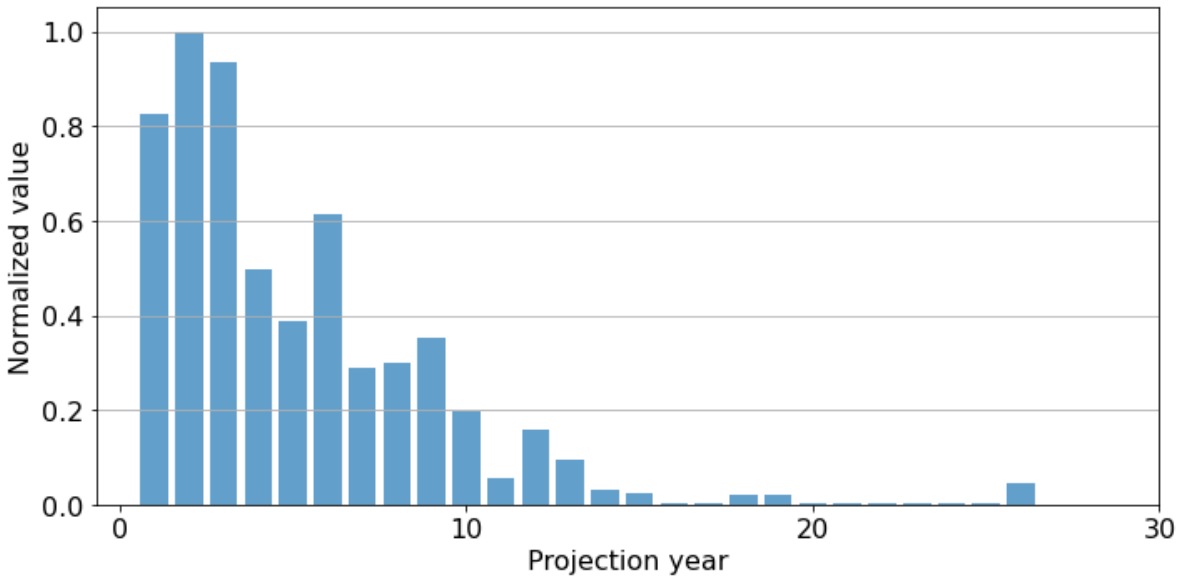
- Value of TP, eligible OF, SCR and SCR ratio under Solvency II on 31.12.2023.

Figure 7: Projected liability cash flows for an annuity life insurance portfolio of the Slovenian insurance undertaking on 31.12.2023



Source: Own work.

Figure 8: Projected cash flows of fixed income assets of the Slovenian insurance undertaking on 31.12.2023



Source: Own work.

The figures above show normalized data, since absolute cash flow data cannot be disclosed due to confidentiality reasons. Figure 7 shows the normalized data of projected annual liability cash flows for an annuity life insurance portfolio over a period of 70 years. The annuity life insurance portfolio is in run-off, meaning that no new policies are being sold and the existing ones are being paid out. As a result, the projected cash flows are more heavily concetrated in the initial projection years, reflecting the limited remaining duration of the liability portfolio. Figure 8 shows the normalized data of projected annual cash flows of fixed income assets over a period of 26 years, in the asset portfolio covering the liability cash flows from the annuity life insurance portfolio.

3.2 Methodology

3.2.1 Currency representative portfolio and reference portfolio of 'yield market indices'

The currency representative portfolio is representative of the assets insurance and reinsurance undertakings hold to cover the BEL denominated in that currency (Article 77d (2) of the Solvency Directive). However, under the Solvency II Directive, undertakings are not required to identify the assets covering their BEL. That is why, in the process of constructing the currency representative portfolio, EIOPA assumes that all assets in each currency cover liabilities in the same currency (EIOPA, 2024b). The currency representative portfolio consists of a government and corporate bond portfolio with their respective weights. The allocation of assets to the government and corporate bond portfolios is based on complementary identification codes (CIC) of the asset classes, shown in Table 3 (EIOPA, 2024b). The weights are calculated using the total Solvency II

value of assets reported by undertakings, adjusted in proportion to their BE and excluding the assets from MA portfolios (EIOPA, 2024b). They are calculated based on the market value of assets allocated to each portfolio, using equations (EIOPA, 2024b):

$$w_{cu,gov} = \frac{MV_{gov}}{MV_{gov}+MV_{corp}+MV_{other}} \text{ and } w_{cu,corp} = \frac{MV_{corp}}{MV_{gov}+MV_{corp}+MV_{other}} \quad (1)$$

where MV is the market value of assets.

Table 3: CIC codes used to allocate assets in the representative portfolio

	CIC codes
GOVERNMENT PORTFOLIO	11, 13*, 14*, 15, 16, 17, 19
CORPORATE PORTFOLIO	12, 13*, 14*, 21, 22, 23, 24, 25, 26, 27, 28, 29, 52, 54, 62, 64, 81, 82, 84, 85, 86, 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.	

Source: EIOPA (2024b).

The government portfolio provides the composition and duration of central government and central banks bonds by issuer country. The corporate portfolio includes the composition and duration of corporate bonds, structured notes, collateralized securities and mortgages and loans, allocated according to their sector of issuer and credit quality steps (CQS). The allocation to asset classes in the corporate bond portfolio is based on the NACE codes of assets, where those starting with 'K' are allocated to the financial asset class, all others to the non-financial asset class of the portfolio (EIOPA, 2024b). The allocation to CQS is based on the external ratings of the assets, as shown in Table 4. Assets with no external ratings are excluded from the allocation to CQS and are respectively distributed across all CQS of both financial and non-financial asset classes (EIOPA, 2024b).

The durations of the assets in both the government and corporate portfolio are calculated by means of a weighted average, excluding the assets with no duration, zero duration or duration greater than 50 years (EIOPA, 2024b).

The reference portfolio used in the calculation of the VA is built on the representative portfolio but mapped to 'yield market indices' to ensure appropriate calibration of spreads and risk corrections. The expression 'yield market indices' covers both yield curves and indices on yields. For government bonds, specific yield curves are used for each issuer, according to the bonds' average

duration (EIOPA, 2024b). Linear interpolation is used to derive the interannual rates corresponding to the average duration. For the euro VA, all issuers from the Eurozone are mapped with the relevant maturity of the ECB yield curve (EIOPA, 2024b). For non-euro area issuers government bond yield curves are used. The market yields for corporate bonds are provided by Markit iBoxx indices for each asset class and CQS, according to their average duration. The specific Bloomberg and Markit tickers used by EIOPA are given in Appendix 2.

Table 4: 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

Source: EIOPA (2024b).

3.2.2 Current methodology of the currency volatility adjustment

The current currency VA is given by the following equation (EIOPA, 2024b):

$$VA_{cu}^{current} = 65\% * S\_RC_{cu} \tag{2}$$

where the risk-corrected spread S_RC_{cu} is calculated as the difference between the observed spread in the reference portfolio and the related risk-correction:

$$S\_RC_{cu} = S_{cu} - RC_{cu} \tag{3}$$

The reference portfolio spread S_{cu} and risk-correction RC_{cu} are calculated as the weighted sum of the government and corporate components in the reference portfolio for currency ***cu***, derived separately for each asset class (EIOPA, 2024b):

$$S_{cu} = w_{cu,gov} * \max\left(S_{gov}, 0\right) + w_{cu,corp} * \max\left(S_{corp}, 0\right) \tag{4}$$

$$RC_{cu} = w_{cu,gov} * \max\left(RC_{gov}, 0\right) + w_{cu,corp} * \max\left(RC_{corp}, 0\right) \tag{5}$$

To calculate the spread S and risk-correction RC for government bonds in the currency representative portfolio, for each bond issuer, a model zero-coupon bond is defined with a maturity

corresponding to its duration. The defined model bonds are then valued using three different yields, resulting in distinct valuations (EIOPA, 2024b):

1. A market yield based on the market interest rate curve as described in Chapter 3.2.1.
2. A risk-free yield based on the risk-free interest rate curve provided by EIOPA.
3. A risk-corrected yield based on the risk-corrected curve, obtained by subtracting the risk-correction from the market interest rate curve.

The risk-correction accounts for the fundamental risks of bonds such as expected losses or unexpected credit risk. For each government bond, the risk-correction for governments of EEA countries is 30% of the *LTAS* and for other governments is 35% of the *LTAS* (EIOPA, 2024b). The *LTAS* is calculated as the 30 year average of the spread over the RFR of assets of the same duration, credit quality and asset class (EIOPA, 2024b).

The obtained valuations are then weighted by the model bonds' weight in the government representative portfolio, resulting in three separate portfolios and corresponding projected cash flows. Then, the internal rate of return (*IRR*) is calculated for each portfolio and corresponding cash flow projection (EIOPA, 2024b):

1. $IRR_{yield\ before\ rc}$ for the market yield portfolio.
2. IRR_{rfr} for the risk-free yield portfolio.
3. $IRR_{yield\ rc}$ for the risk-corrected market yield portfolio.

Then S_{gov} and RC_{gov} are calculated as follows (EIOPA, 2024b):

$$S_{gov} = max\left(IRR_{yield\ before\ rc} - IRR_{rfr}, 0\right) \tag{6}$$

$$RC_{gov} = max\left(IRR_{yield\ before\ rc} - IRR_{yield\ rc}, 0\right) \tag{7}$$

For the corporate bonds portfolio, S_{corp} and RC_{corp} are calculated in the same manner as for the government bond portfolio, with the risk-correction for each corporate bond being (EIOPA, 2024b):

$$\max\ (PD + CoD, 35\% * LTAS) \tag{8}$$

where *PD* is the credit spread corresponding to the probability of default and *CoD* is the credit spread corresponding to the expected loss resulting from downgrade of the asset. If no reliable credit spreads can be obtained from long-term default statistics, the risk-correction is 35% of *LTAS*.

3.2.3 Revised methodology of the currency volatility adjustment

The Directive amending Solvency II presents the revised formula for the currency VA:

$$VA_{cu}^{revised} = 85\% * CSSR_{cu} * RCS_{cu} \quad (9)$$

where $CSSR_{cu}$ is the credit spread sensitivity ratio of an insurance or reinsurance undertaking for currency ***cu*** and RCS_{cu} is the risk-corrected spread for the same currency. Since the Directive amending Solvency II does not specify the exact calculation method for the credit spread sensitivity ratio, the approach proposed in EIOPA's technical advice for the 2020 Solvency II Review will be used (EIOPA, 2020b):

$$CSSR_{cu} = max\left\{min\left\{\frac{PVBP(MV_{cu}^{FI})}{PVBP(BEL_{cu})}, 1\right\}, 0\right\} \quad (10)$$

where MV_{cu}^{FI} is the market value of the undertaking's fixed income assets in currency ***cu*** and $PVBP(MV_{cu}^{FI})$ is the price value of a basis point of those assets, calculated as the difference between the market value against current spreads and the market value when spreads would increase by the part of the VA_{cu} that does not depend on the undertaking-specific's *CSSR*, i.e. $85\% * RCS_{cu}$ (EIOPA, 2020b):

$$PVBP(MV_{cu}^{FI}) = \frac{MV_{cu}^{FI}(CS) - MV_{cu}^{FI}(CS + 85\% * RCS_{cu})}{85\% * RCS_{cu}} \quad (11)$$

The allocation of the assets to the fixed income portfolio used to calculate $PVBP(MV_{cu}^{FI})$ is based on CIC codes of the asset classes (EIOPA, 2020b). The detailed allocation by CIC codes is provided in Appendix 3.

$PVBP(BEL_{cu})$ is the price value of a basis point of the undertaking's BEL in the same currency, calculated as a sensitivity in the value of the VA (EIOPA, 2020b):

$$PVBP(BEL_{cu}) = \frac{BEL_{cu}(RFR_{cu}) - BEL_{cu}(RFR_{cu} + 85\% * RCS_{cu})}{85\% * RCS_{cu}} \quad (12)$$

where RFR_{cu} denotes the RFR term structure for currency ***cu***.

The calculation of the risk-corrected spread for currency ***cu*** RCS_{cu} in the revised methodology differs from the calculation of the risk-corrected spread for currency S_RC_{cu} in the $VA_{cu}^{current}$ with respect to the division by the term $w_{cu,gov} + w_{cu,corp}$, allowing for a full normalization of the reference portfolio (Directive amending Solvency II):

$$RCS_{cu} = Scale_{cu} * (S_{cu} - RC_{cu}) \quad (13)$$

where:

$$Scale_{cu} = \frac{1}{w_{cu,gov} + w_{cu,corp}} \quad (14)$$

S_{cu}, S_{gov}, S_{corp}, RC_{cu}, RC_{gov}, and RC_{corp} are calculated in the same manner as in $VA_{cu}^{current}$ described in Chapter 3.2.2, the only difference being in the risk-correction applied in the

computation of the risk-corrected interest rate curve. Since the Directive amending Solvency II does not specify the exact calculation method for the revised risk-correction, the approach proposed in EIOPA's technical advice for the 2020 Review of Solvency II is presented. For each government bond (EIOPA, 2020b):

$$30\% * min(S^+, LTAS^+) + 20\% * max(S^+ - LTAS^+, 0) \tag{15}$$

For corporate bonds in the reference portfolio (EIOPA, 2020b):

$$50\% * min(S^+, LTAS^+) + 40\% * max(S^+ - LTAS^+, 0) \tag{16}$$

where $S^+ = \max(S, 0)$, $LTAS^+ = \max(LTAS, 0)$.

To simplify the calculation of $VA_{cu}^{revised}$ for the empirical analysis of the thesis it will be assumed that the values of RC_{cu}, RC_{gov}, and RC_{corp} are calculated in the same manner as those under the current framework. Then, the RCS_{cu} and the $VA_{cu}^{revised}$ become:

$$RCS_{cu} = Scale_{cu} * \frac{VA_{cu}^{current}}{65\%} \tag{17}$$

$$VA_{cu}^{revised} = 85\% * CSSR_{cu} * RCS_{cu} \tag{18}$$

Then, the part of the $VA_{cu}^{revised}$ that does not depend on the undertaking-specific *CSSR* in equations *(11)* and *(12)* becomes:

$$85\% * RCS_{cu} \tag{19}$$

3.2.4 Duration analysis

The weighted average durations of the projected annual cash flows of fixed income assets and liabilities are calculated using the equation (Fooladi et al., 2006):

$$Dur = \frac{\sum_{t=1}^{T} t * \frac{CF_t}{(1+r)^t}}{\sum_{t=1}^{T} \frac{CF_t}{(1+r)^t}} \tag{20}$$

where CF_t is the projected cash flow at time *t*, *r* is interest rate at time *t* and *T* is the final projection year. Then, the duration gap is calculated as follows (Fooladi et al., 2006):

$$Dur_{gap} = Dur_{FI\ assets} - Dur_{liabilities} * \frac{total\ liability}{total\ FI\ assets} \tag{21}$$

3.2.5 Solvency capital requirement ratio

The Solvency II Directive defines the SCR ratio as:

$$SCR_{ratio} = \frac{Eligible\ Own\ Funds}{SCR} \quad (22)$$

The $Eligible\ Own\ Funds$ are the OF items that meet the criteria and quantitative limits set out under the Solvency II Directive to cover the SCR. They include Tier 1, eligible Tier 2 and eligible Tier 3 OF items. The OF and their classification are defined in Articles 87 to 99 of the Solvency II Directive.

The SCR reflects the capital needed to ensure that the undertaking can meet its obligations over a one-year period with a 99.5% confidence level. It captures all quantifiable risks to which the undertaking is exposed. The structure and calculation of the SCR with the standard formula are set out in Articles 103 to 111 of the Solvency II Directive.

3.3 Empirical approach

3.3.1 Calculating the best estimate of liabilities

To evaluate the effects of the VA on the solvency position of the Slovenian insurance undertaking, a simulation of the effects of the VA on the BEL is conducted. The BEL was calculated by discounting the projected annual liability cash flows with the euro RFR term structure without the VA, with the current VA and with the revised VA, in the period from 31.12.2015 to 31.12.2023.

To isolate the effect of the VA on the solvency position of the Slovenian insurance undertaking, the following assumptions were made:

- The portfolio of assets as of 31.12.2023 remains constant over the calculation period from 31.12.2015 to 31.12.2023.
- The value of projected annual liability cash flows from the annuity life insurance portfolio as of 31.12.2023 remains constant over the calculation period from 31.12.2015 to 31.12.2023, with a constant profit participation that does not vary with interest rate term structures.

The calculation of BEL was done in the following steps:

1. To calculate the BEL without the application of the VA, liability cash flows were discounted using the euro RFR term structure without the adjustment, for each valuation date in the period from 31.12.2015 to 31.12.2023.
2. To calculate the BEL with the application of the current VA, liability cash flows were discounted using the euro RFR term structure with the current VA, for each valuation date in the period from 31.12.2015 to 31.12.2023.
3. To calculate the BEL with the application of the revised VA, liability cash flows were discounted using the euro RFR term structure with the revised VA, for each valuation date in the period from 31.12.2015 to 31.12.2023.

To calculate the revised VA, the undertaking-specific *CSSR* had to be obtained first. The undertaking-specific *CSSR* was calculated using equations *(10), (11)* and *(12),* for each valuation date in the period from 31.12.2015 to 31.12.2023. First, the revised VA values without the undertaking-specific *CSSR* were obtained from the current VA values using equation *(19).* The euro RFR term structures with the revised VA without the undertaking-specific *CSSR* were obtained by adding the values from equation *(19)* to the non-extrapolated part of the term structure and extrapolating using the Smith-Wilson model.

Equation *(12)* was used to calculate the price value of a basis point of BEL. Liability cash flows were discounted using the euro RFR term structure without the VA and the euro RFR term structure with the revised VA without the undertaking-specific *CSSR,* for each valuation date in the period from 31.12.2015 to 31.12.2023. The difference in the present values was then divided by the revised VA without the undertaking-specific *CSSR*.

Equation *(11)* was used to calculate the price value of a basis point of the fixed income assets. The calculation was done using an interest rate risk model internally developed by the Slovenian insurance undertaking. The model calculates the sensitivity of fixed income assets to changes in interest rates based on each assets' modified duration and convexity. To obtain the first term of equation *(11)*, $MV_{cu}^{FI}(CS)$, market prices of the fixed income assets on 31.12.2023 were shocked backward in time, applying an interest rate curve shock. The shock was based on the differences in the euro RFR term structures between 31.12.2023 and each valuation date in the period from 31.12.2015 to 30.11.2023. Based on this, a theoretical market value of the fixed income assets was obtained for each valuation date in the period from 31.12.2015 to 31.12.2023. The credit spread (or Z-spread) was then calculated for each fixed income asset for each valuation date in the period from 31.12.2015 to 31.12.2023. The Z-spread denotes the number of basis points that need to be added to the RFR, so that present value of an assets' cash flows equals its current market value. Then, to obtain the second term of equation *(11)*, $MV_{cu}^{FI}(CS + 85\% * RCS_{cu})$, cash flows for each asset were discounted using the euro RFR term structure with the revised VA without the undertaking-specific *CSSR* plus the Z-spread. Lastly, to obtain $PVBP(MV_{cu}^{FI})$, the difference in the market values was divided by the revised VA without the undertaking-specific *CSSR*.

The revised VA was then calculated using equation *(18)* for each valuation date in the period from 31.12.2015 to 31.12.2023. The euro RFR term structure with the revised VA was obtained by adding the revised VA values to the non-extrapolated part of the term structure and extrapolating using the Smith-Wilson model described in Chapter 2.2.1.

3.3.2 Calculating the undertaking-specific currency volatility adjustment

To assess how undertaking-specific characteristic influence the amount of the calculated VA, the undertaking-specific currency VA for the Slovenian insurance undertaking was computed. To

calculate the undertaking-specific euro VA on 31.12.2023, the euro representative portfolio was replaced with the actual undertaking's asset portfolio on 31.12.2023. The allocation of the assets to the government and corporate bond representative portfolios was based on CIC codes of the asset classes given in Table 3. Then, the weights of the government and corporate bond representative portfolio were calculated using equation *(1).* Further allocation of the assets within the government and corporate bond representative portfolio was based on the methodology described in Chapter 3.2.1.

The reference portfolio was constructed on the basis of the undertaking's representative portfolio mapped on 'yield market indices', as described in Chapter 3.2.1. The remaining data needed to calculate the VA was taken as published by EIOPA on 31.12.2023: the RFR term structure, LTAS for government and corporate bonds, PD, CoD and fundamental spreads for different durations, credit qualities, and asset classes.

The undertaking-specific value for the current VA was calculated using the methodology described in Chapter 3.2.2. Based on the obtained value for the current VA, the revised VA value was calculated using equations *(14), (17)* and *(18)*. The undertaking-specific *CSSR* value on 31.12.2023 was already calculated in Chapter 3.3.1.

Lastly, to calculate the BEL with the application of both undertaking-specific current and revised VA, liability cash flows were discounted using the euro RFR term structure with the current and revised VA on 31.12.2023. The euro RFR term structure with the current and revised VA was obtained by adding the VA values to the non-extrapolated part of the term structure and extrapolating using the Smith-Wilson model described in Chapter 2.2.1.

3.3.3 Calculating the solvency capital requirement ratio

To calculate the new SCR ratio of the Slovenian insurance undertaking with the VA on 31.12.2023, the *Eligible Own Funds* were increased by the difference between the BEL calculated without VA and with VA. The value obtained for the *Eligible Own Funds* was then divided by the undertakings SCR on 31.12.2023, as shown in equation *(22).* The new SCR ratio was calculated for the current, the revised, the undertaking-specific current and the undertaking-specific revised VA.

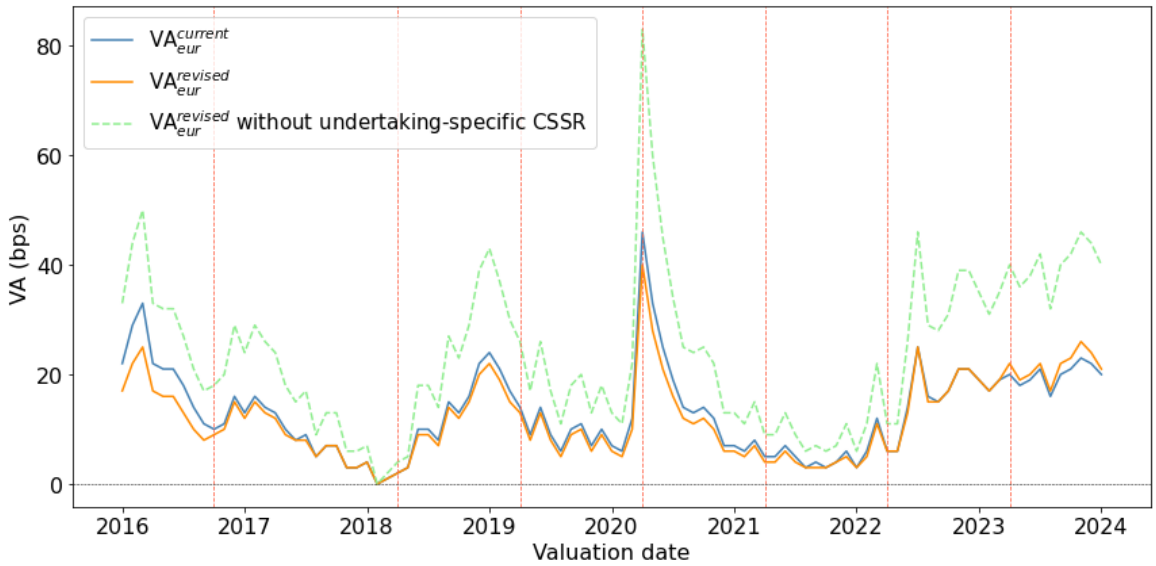
4 RESULTS AND DISCUSSION

4.1 Impact of the volatility adjustment on best estimate of liabilities

Figure 9 presents the values of the current VA, the revised VA and revised without the undertaking-specific *CSSR* in the period from 31.12.2015 to 31.12.2023. The red vertical lines correspond to the dates on which EIOPA updated the representative portfolios (September 2016 and March 2018,

2019, 2020, 2021, 2022 and 2023). The mean value of the current VA is 13 bps, with a variance of 64.5, while the revised VA has a mean of 12 bps and a variance of 55.0. The revised VA values are consistently slightly lower or equal to those of the current VA until March 2023. After March 2023, the values are slightly higher than those of the current VA. This increase is a combination of an increase in all components in equation *(18)* of the revised VA. First, the current VA values, which are the starting point for the calculation of the revised VA, were higher than average. Second, the *Scale* factor introduced to obtain a full normalization of the weights in the reference portfolio increased. As marked by the vertical red lines in Figure 9, the most recent update of the reference portfolio in March 2023 lowered the weights of government and corporate bonds, from 31.6% and 39.4% to 29.2% and 36.6%, respectively. This increased the *Scale* factor value from 1.41 to 1.52. Lastly, the undertaking-specific *CSSR* introduced to mitigate under- or overshooting effects of the VA was higher than average, due to the rise in the RFR from 2022 on.

Figure 9: VA values in the period from 31.12.2015 to 31.12.2023



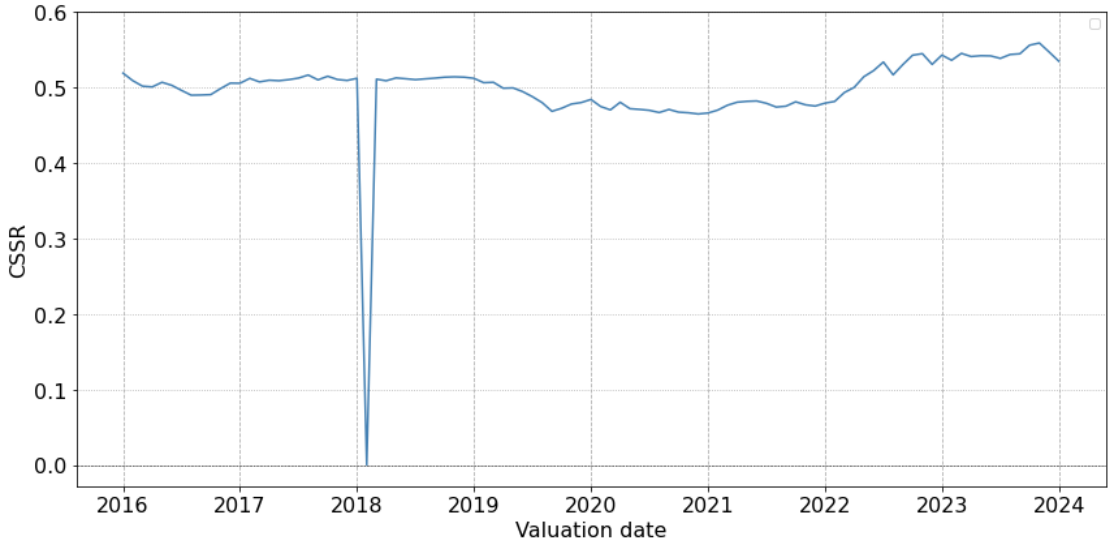
The red vertical lines correspond to the dates on which EIOPA updated the representative portfolios (September 2016 and March 2018, 2019, 2020, 2021, 2022 and 2023).

Source: Own work.

Figure 10 shows the calculated values for the Slovenian insurance undertaking's *CSSR* ranging from 0.465 to 0.559, with a mean value of 0.498. The *CSSR* value on 31.1.2018 was zero because both the current and revised VA values were zero. The *CSSR* results indicate that the liabilities are more credit spread sensitive than the fixed income assets. For each basis point change in credit spreads, the average impact on the liabilities is more than twice that on the fixed income assets. From 2022, the CSSR increases, due to the rise in the RFR shown in Figure 5. The higher RFR term structure, particularly at short and medium maturities, reduces the present value of projected cash flows and their marginal credit spread sensitivity due to exponential discounting. As a result,

the *PVBP* of both liabilities and fixed income assets decreases, but the effect on liabilities is more pronounced due to their longer duration. This results in an increase of the *CSSR*.

Figure 10: Credit spread sensitivity ratio of the Slovenian insurance undertaking in the period from 31.12.2015 to 31.12.2023



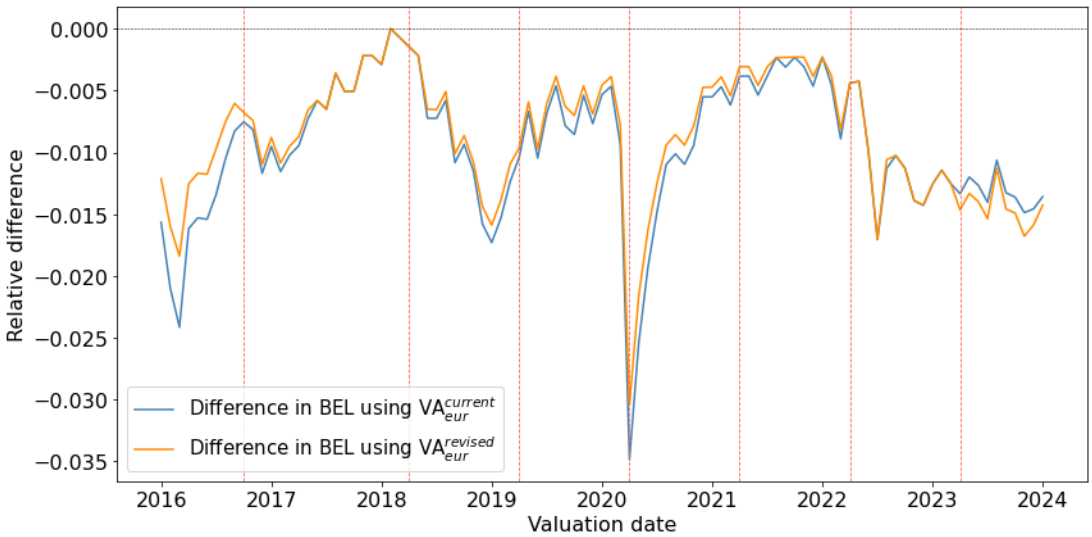
Source: Own work.

To understand the difference in the credit spread sensitivity between the liabilities and the fixed income assets, additional duration analysis was conducted. The duration gap between the liabilities and fixed income assets becomes evident by simply analyzing the projected annual cash flows in Figure 7 and Figure 8. The projected annual liability cash flows extend over a significantly longer time period of 70 years and decrease more gradually, while the projected annual fixed income assets cash flows extend over 26 years and decrease more sharply. The duration analysis showed that the average weighted duration of liabilities is 7.1 years, and of fixed income assets, 4.7 years. Thereby, the duration gap is 2.6 years. As presented in Chapter 2.2.3.1, a positive duration gap has been associated with overshooting effects of the VA. Moreover, one criterion for the application of the VA mentioned in risk management policies of undertakings applying it, was a similar duration of assets and liabilities. Based on the analysis, the Slovenian insurance undertaking does not meet this criterion. This suggests that the application of the VA, current or revised, for the Slovenian insurance undertaking on 31.12.2023 would have resulted in a disproportionate decrease in the BEL.

Figure 11 shows the impact of the current and revised VA on the Slovenian insurance undertaking's BEL in the period from 31.12.2015 to 31.12.2023. Due to confidentiality, only the relative difference in the calculated BEL compared to the BEL without the VA is shown. As expected, the application of the VA reduces the BEL throughout the whole calculation period, except on 31.1.2018, when both the current and revised VA values were 0. The impact of the VA is

proportional with the VA values in Figure 9. It is more pronounced during market stress periods, when credit spreads widen and the calculated VA values, both current and revised, are higher.

Figure 11: Impact of the current and revised VA on the BEL of the Slovenian insurance undertaking in the period from 31.12.2015 to 31.12.2023



The red vertical lines correspond to the dates on which EIOPA updated the representative portfolios (September 2016 and March 2018, 2019, 2020, 2021, 2022 and 2023).

Source: Own work.

4.2 Comparison between the undertaking-specific and euro reference portfolio volatility adjustment

Table 5 summarizes the key differences between EIOPA's euro representative portfolio and the Slovenian insurance undertaking's asset portfolio, along with their impact on the calculated undertaking-specific VA value. Due to confidentiality, the detailed portfolio characteristics of the Slovenian insurance undertaking are not disclosed, instead, relative comparisons to EIOPA's euro representative portfolio are given. The impact of the undertaking's asset portfolio characteristics on the own specific VA is mixed. The higher share of fixed income assets and high-yield corporate bonds increases the VA, whereas the lower duration of the portfolio decreases it.

Nevertheless, the values calculated for the Slovenian insurance undertaking's own specific current and revised VA on 31.12.2023 are 11 and 8, respectively. Table 6 presents the VA values calculated in EIOPA's euro reference portfolio and the calculated undertaking-specific VA values on 31.12.2023. The lowest value calculated is the undertaking-specific revised VA, as under the revised framework the undertaking-specific *CSSR* further lowers the adjustment.

Table 5: Comparison of portfolio characteristics and their impact on the VA value

Portfolio characteristics	EIOPA's euro representative portfolio	Slovenian insurance undertaking's portfolio	Impact on the VA
% of Fixed income assets	65.8%	Higher	Higher VA
Portfolio duration in years	8.7	Lower	Lower VA
Government portfolio	10.3	Lower	Lower VA
- Euro government bonds	10.2	Lower	Lower VA
Corporate portfolio	6.9	Lower	Lower VA
Corporate portfolio credit quality - % of High-yield	2.0%	Higher	Higher VA

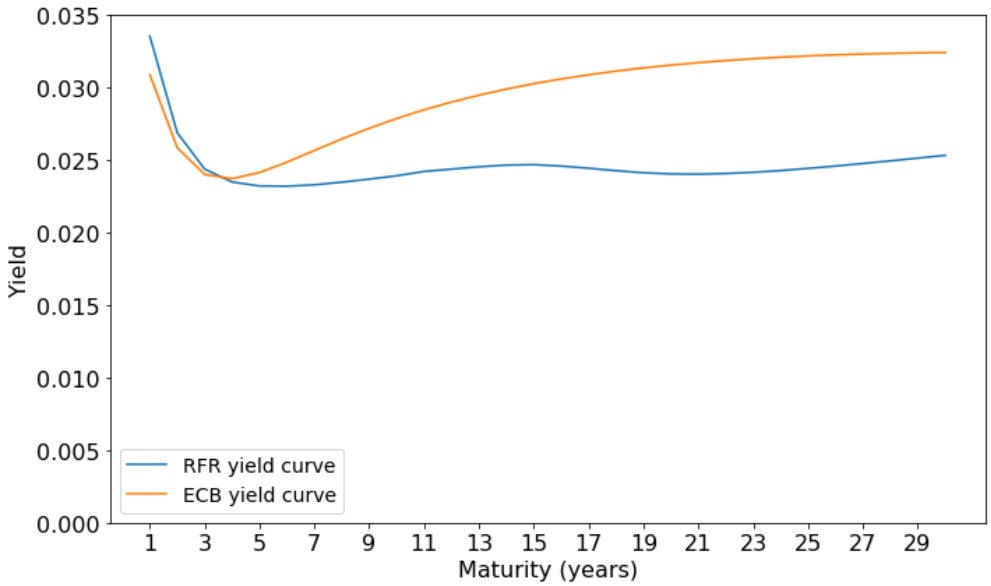
Source: Own work, EIOPA (2024a).

Table 6: Euro reference portfolio and undertaking-specific VA values on 31.12.2023

Current VA	Revised VA	Undertaking-specific current VA	Undertaking-specific revised VA
20	21	11	8

Source: Own work, EIOPA (2024a).

Figure 12: Euro RFR term structure and ECB yield curve on 31.12.2023



Source: Own work based on EIOPA (2024a) and ECB (2024).

The relatively low undertaking-specific VA values are mainly a result of the low spread of the government bond portfolio S_{gov}, calculated as the difference between the IRR of the market yield and the risk-free yield portfolio, given in equation *(6)*. Since the majority of bonds in the Slovenian insurance undertaking' government portfolio are euro government bonds, their market yield was

taken from the ECB yield curve. As shown in Figure 12, on 31.12.2023 the ECB yield curve was lower than the euro RFR yield curve for short maturities. A similar observation was made in most of the government bond yield curves of non-EEA issuers in the undertaking's portfolio. This means that the calculated spread of each government bond is negative or positive, but relatively low, depending on the bond's duration. As a result, the overall spread of the government portfolio S_{gov} is also low, meaning that the calculated undertaking-specific VA value is mainly driven by the spread of the corporate bond portfolio S_{corp}.

EIOPA's (2016, 2017, 2018a, 2020c, 2019) reports show that the average VA user's asset portfolio structure and duration are very similar to the entire market, the most significant difference being the higher proportion of bonds and a slightly lower credit quality. A similar structure can be observed in the Slovenian insurance undertaking's asset portfolio in Table 5, but with a lower average duration and an even lower credit quality of corporate bonds than the average VA user. When an undertaking's asset portfolio significantly differs from the representative portfolio and its risk-corrected spread is lower than the risk-corrected spread of the reference portfolio, the application of the VA leads to overshooting. As discussed in Chapter 2.2.3.1, the spreads derived from assets held by Slovenian undertakings are much lower than the level of spreads in the euro reference portfolio. The analysis of the Slovenian insurance undertaking confirms that, as the low undertaking-specific risk-corrected spread on 31.12.2023, led to lower undertaking-specific VA values. A sufficient similarity of the undertaking's asset portfolio or own specific VA to the representative portfolio or the standard VA, is another criterion for its application, mentioned in the risk management policies of undertakings applying it. Based on the results presented in Table 5 and Table 6, the Slovenian insurance undertaking does not meet this criterion. This supports the earlier conclusion that the application of the VA, current or revised, for the Slovenian insurance undertaking on 31.12.2023 would have led to a disproportionate decrease in the BEL.

4.3 Impact of the volatility adjustment on the solvency capital requirement ratio

Table 7: Impact of the VA on the Slovenian insurance undertaking's SCR ratio on 31.12.2023

	Current VA	Revised VA	Undertaking-specific current VA	Undertaking-specific revised VA
VA Value	20	21	11	8
Impact on BEL	-1.36%	-1.43%	-0.75%	-0.55%
Impact on SCR ratio	1.97%	2.07%	1.09%	0.80%

Source: Own work.

Table 7 provides a summary of the impact of the VA on the Slovenian insurance undertaking's SCR ratio on 31.12.2023. Due to confidentiality, the table provides the relative difference compared to the BEL and SCR ratio without the VA. The results are in line with expectations, the application of the VA reduces the BEL and increases the SCR ratio, however, the extent of the

impact varies depending on the VA calculation methodology. As previously discussed, the current and revised VA values are much higher than the undertaking-specific values, suggesting that their application would overstate the adjustment for the Slovenian insurance undertaking on 31.12.2023. Consequently, they have the largest impact on the undertaking's BEL and SCR ratio. Nevertheless, even with the application of the revised VA, leading to overshooting effects, the increase in the SCR ratio is 2.07%. Such relatively small capital relief can be easily overweighted by the additional operational burden the application of the VA introduces for the undertaking.

4.4 Discussion

The non-transitional LTG measures stabilize undertakings' balance sheets by limiting short-term market volatility, but they can also lead to improper liability valuations and incentivize risk-taking, especially in cases of disproportionate capital relief. The 2020 Solvency II Review improves the design of the LTG measures to fit their purpose by mitigating some of their limitations under the current framework.

The Smith-Wilson method used for extrapolation of the RFR reduces long-term interest rate volatility in liability valuations by smoothing the yield curve beyond the LLP, however, this comes at a cost of reduced sensitivity to real market movements in the extrapolated part of the yield curve. The revised extrapolation methodology incorporates market information from financial instruments other than bonds, into the extrapolation beyond the FSP, if their markets are DLT. This may lower the smoothness of the extrapolated curve but will certainly make it more market consistent. The increased sensitivity to real market movements beyond the FSP will increase incentives for proper risk management and duration matching and will lower the probability of under- or overestimation of liability valuations.

With regard to the MA, the revised Solvency II framework does not introduce any changes to its methodology but allows for diversification benefits between the MA portfolios and other business activities. The undertakings already applying the MA will be able to access diversification benefits further lowering their SCR and may be incentivized to increase the number of MA portfolios. This change alone is not likely to incentivize new undertakings outside of the UK and Spain to start applying the MA, since fulfilling the requirements for its application remains quite a challenge. The specific characteristics of assets eligible for the MA would require changes to undertakings' asset allocation, which increases complexity and operational costs.

Among all measures, the VA has undergone the most significant change in methodology. The introduction of a prior approval process for its application in all member states will certainly contribute to improving the level playing field and ensuring fair competition across the EU. However, differences in national supervisory approval processes may still occur, as the revised Solvency II framework does not set any clear requirements for its application, as it does for the MA.

As shown in Figure 9, the revised VA without the undertaking-specific *CSSR* has the largest values throughout the calculation period. This is a result of the increased GAR, from 65% to 85%, and the newly introduced *Scale* factor. Since the representative portfolio contains only fixed income assets, the sum of its weights will always be less than 1, resulting in a Scale factor always greater than 1. The higher value of the revised VA without the undertaking-specific *CSSR* allows undertakings to benefit from the partial or full adjustment, based on their credit spread sensitivity. Since the value of the *CSSR* is capped at 1, undertakings with more credit spread sensitive assets than liabilities, will benefit from the full adjustment. On the other hand, those with more credit spread sensitive liabilities will have to proportionally lower the adjustment. In this way, the VA becomes tailored to the specific risk profile of undertakings, reducing the probability of over- or undershooting effects. Even when the VA is calculated directly on the undertaking's portfolio, reflecting its structure, duration and credit quality, the undertaking-specific *CSSR* adds an important dimension, explaining how much of the spread risk actually affects the undertaking's solvency position. Undertakings with similar portfolios, but different liability structures or risk profiles, have different sensitivity to spread risk. The *CSSR* connects the liability side to the asset side spread risk, further preventing over- or undershooting effects.

Nevertheless, as seen in the analysis of the Slovenian insurance undertaking, under the revised methodology, overshooting effects can still occur if the undertaking's asset portfolio is not sufficiently similar to the representative portfolio. The euro representative portfolio includes a large number of insurance and reinsurance undertakings from all Eurozone member states, each with different national- and own-specific characteristics. As a result, the likelihood that an individual undertaking's asset portfolio differs significantly from the euro representative portfolio is higher, especially in smaller markets such as the Slovenian.

The revised euro country-specific component, the macro VA, was not in the scope of the empirical analysis of the thesis, but its impact was already analyzed by Barucci et al. (2023). The results of their analysis showed that the macro VA would have been activated more frequently than the current country-specific VA in the period from 30.11.2015 to 31.12.2021 (Barucci et al., 2023). Besides from Greece and Italy, the macro VA would have been activated also for Portugal and Spain (Barucci et al., 2023). This suggests that the revised activation mechanism of the macro VA is smoother with a lower probability of undershooting or cliff-edge effects.

On the downside, the revised VA methodology increases the operational complexity for undertakings applying it, since they will now need to calculate the adjustment themselves. To obtain the VA value on a given valuation date, undertakings will need to calculate their own specific *CSSR* first, then add the VA values to the non-extrapolated part of the RFR term structure and extrapolate using the revised extrapolation methodology. This adds another layer of complexity to the already overly burdensome process of calculation of solvency positions under the Solvency II framework.

Looking specifically at Slovenia, as shown in Table 2, the Slovenian insurance and reinsurance market is highly capitalized, with undertakings holding capital well above the regulatory requirements set by Solvency II. In such cases of compliance with the SCR without any optional or transitional LTG measures, undertakings are able to 'absorb' the fluctuations in their solvency positions caused by short-term market volatility, without any significant implications. In the case of the Slovenian insurance undertaking, even with the application of the revised VA, leading to overshooting effects on 31.12.2023, the increase in the SCR ratio is 2.07%. Such relatively small capital relief can be easily overweighted by the additional operational burden the VA introduces for undertakings. Moreover, taking into account that almost half of the Slovenian insurance undertakings are composite, the operational burden of applying the VA can be even larger, since they manage both life and non-life portfolios with different characteristics. Lastly, the declining presence of traditional life insurance and the overall decline in the availability of LTG products on the Slovenian market limit the relevance of applying the VA.

With regard to the revised risk management and disclosure requirements on LTG measures, the 2020 Solvency II Review adds some clarification, but there is no significant reduction in the reporting or operational burden for undertakings. On the contrary, the revision introduced additional disclosures for undertakings applying the VA. The assessment of the deviation of their risk profile from the assumptions underlying the adjustment and the disclosure of calculated VA values and corresponding BEL, further burden undertakings. The Solvency II framework already imposes extensive disclosures and reporting requirements, any further such burden is carefully considered by undertakings before being taken on.

4.5 Limitations and further research recommendations

The thesis provides valuable insights into the mechanisms behind the non-transitional LTG measures, their regulatory objectives and limitations, with a particular focus on the VA in the Slovenian insurance market. However, the empirical analysis of the thesis is subject to limitations that need to be acknowledged. Their addressing creates opportunities for further research, particularly in areas where data was lacking, or assumptions were made.

The first key limitation were the assumptions made in the process of applying the VA on the Slovenian insurance undertaking's liabilities. The assumption that the projected annual liability cash flows, the profit participation and the portfolio of assets remain constant over the calculation period was applied with the aim of simplifying the calculation and data needed, as well as isolating the effect of the VA. However, this does not reflect actual conditions, as these variables change constantly and influence the undertaking's solvency position. If sufficient data is available, further research could omit this assumption and provide a more accurate picture of the VA's impact over time. While the revised VA is smoother over time, it is not possible to conclude whether it leads to systematically higher or lower values than the current VA. Further research is needed, particularly

without the assumptions applied in the empirical analysis, to determine the long-term behavior of the revised adjustment. Moreover, the empirical analysis focused solely on the currency VA, as the country-specific VA for Slovenia has not been activated since the implementation of the Solvency II framework. Nevertheless, a comparative analysis with the new macro VA could provide further insight into Slovenia's country-specific or macro VA values and show whether activation criteria for the macro VA would be met.

The application of the currency VA, current or revised, would lead to an overshooting effect for the Slovenian insurance company. To offset such overshooting effects, further research should include the newly introduced undertaking-specific adjustment to the currency risk-corrected spread, presented in Chapter 2.2.3.2. Lastly, extending the analysis to include multiple Slovenian insurance and reinsurance undertakings could assess the market-wide applicability of the VA.

With regard to the other LTG measures, the extrapolation of the RFR and the MA, the implications of their revision were theoretically acknowledged but should be further empirically analyzed. Along with the empirical analysis of the revised VA, it would provide a more complete understanding of the impact of the 2020 Solvency II Review on the LTG measures.

5 CONCLUSION

The thesis examines the non-transitional LTG measures under the Solvency II framework in light of their revision introduced by the 2020 Solvency II Review. It provides an overview of the extrapolation of the RFR, the MA, and the VA, with the aim of evaluating their effectiveness in fulfilling their regulatory objectives. The particular focus of the thesis is the VA and its application on a Slovenian insurance undertaking's liabilities.

The empirical analysis evaluates the impact of the current and revised VA on the solvency position of the undertaking. The results show that applying the VA leads to a decrease in the undertaking's BEL and an increase in the SCR ratio. However, the calculation of the undertaking-specific VA highlighted the differences between the undertaking's asset portfolio and EIOPA's euro reference portfolio. The Slovenian insurance undertaking does not meet the criteria commonly associated with the application of the VA:

- A similar duration of assets and liabilities.
- Sufficient similarity of the asset portfolio or own specific VA to the representative portfolio or the standard VA.
- High share of credit spread sensitive assets.

As a result, the application of the VA, current or revised, for the Slovenian insurance undertaking leads to a disproportionate capital relief, i.e. overshooting. The revised VA methodology certainly

lowers the probability of under- or overshooting effects, as the newly introduced CSSR tailors the adjustment to the undertaking's risk profile, but it does not eliminate them. The analysis further provides evidence that the revised VA methodology is smoother and more undertaking-specific, supporting the regulatory objective of providing balance sheet stability and mitigating procyclical risks. At the same time, it confirms that the effectiveness of the revised VA depends on the alignment between the undertaking's asset and liability characteristics and the assumptions behind the reference portfolio.

The results provide an explanation for the underutilization of the VA in the Slovenian insurance market, despite the historical presence of material volume of LTG products. Slovenian undertakings tend to be highly capitalized, and the additional operational and reporting burden outweighs the relatively small capital relief provided by the measure. Moreover, taking into account that almost half of the Slovenian insurance undertakings are composite, the operational burden of applying the VA can be even larger, since they manage both life and non-life portfolios with different characteristics. This supports the conclusion that the revised VA, while an improvement, may still not be utilized by smaller or composite undertakings in highly capitalized markets. Moreover, given the characteristics of the Slovenian life insurance market, the absence of pension insurance products and the declining share of annuity insurance products further lower the need for the application of the VA.

In addition to the VA, the thesis also discussed the extrapolation of the RFR and the MA. The revised extrapolation methodology introduces a more market consistent approach beyond the FSP, which increases the sensitivity of liabilities to real market movements but increases incentives for proper risk management and duration matching. While the MA methodology remains unchanged, the allowance for diversification benefits between MA portfolios and other business activities may incentivize wider use among undertakings already applying it. However, due to the complexity of the eligibility requirements, this change alone is not likely to incentivize its use outside of the UK and Spain. Overall, the LTG measures are a relevant mechanism, that stabilizes undertaking's balance sheets and mitigates procyclicality. Designing measures that are both harmonized and proportionate, without further increasing the operational burden for undertakings is challenging, since they apply to 28 member states with different national- and undertaking-specific characteristics. Nevertheless, the revision of the LTG represents an important step forward towards a more harmonized, proportionate and risk-sensitive framework.

Limitations of the analysis include the assumption of constant asset and liability cash flows, which simplifies the calculation but does not reflect actual conditions. Further research omitting this assumption could provide a more accurate picture of the VA's impact over time. The empirical analysis focused solely on one Slovenian insurance undertaking and its currency VA. A broader analysis including more undertakings and the revised macro VA could provide valuable insights on the market-wide applicability of the VA. Lastly, the extrapolation and the MA mechanisms were

addressed theoretically but should be further empirically analyzed. Along with the empirical analysis of the revised VA, it would provide a more complete understanding of the impact of the 2020 Solvency II Review on the LTG measures.

The insights of the thesis have practical implications for undertakings aiming to better understand the mechanisms behind the revised LTG measures and evaluate the cost-benefit of applying the revised VA. The analysis highlights how undertaking-specific asset and liability characteristics influence the VA and its impact on solvency positions. This understanding can help undertakings in assessing whether the application of the VA will mitigate their short-term balance sheet volatility or lead to overshooting and increased procyclicality.

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APPENDICES

Appendix 1: Requirements for the application of the matching adjustment

Article 77b (1) of the Solvency II Directive states that the application of the MA is subject to prior approval, where specific requirements must be met:

- A specific portfolio of assets, mainly bonds and assets with similar cash-flow characteristics, must be assigned to cover the BE of the undertakings' liabilities. The undertaking shall maintain such allocation throughout the lifetime of its liabilities, unless adjustments are necessary to maintain the alignment of cash flows.
- The matched portfolio of liabilities and assigned assets must be managed separately from other activities of the undertaking and cannot be used to cover losses from other activities.
- Cash flows from the assigned assets must closely match the expected cash flows of the liabilities in the same currency, with no significant mismatches giving rise to material risks.
- The only underwriting risks should be mortality, longevity, expense and revision. If mortality risk is included, the BEL should not increase by more than 5% under a mortality stress test.
- The contracts in the matched portfolio should not contain future premium payments and policyholder options, except for a surrender option if the surrender value does not exceed the value of assigned assets covering the liabilities.
- The cash flows of the assigned assets must be fixed and cannot be changed by the issuer or any third party. If there is such a right, the asset may still be included in the portfolio, only if the undertaking receives sufficient compensation and is able to reinvest in assets of equivalent or better credit quality.
- Cash flows of the assigned assets can be inflation-dependent, if they replicate the cash flows of inflation-dependent liabilities.
- The liabilities are not split into different parts when forming the matched portfolio.

Appendix 2: Input for the calculation of the volatility adjustment

Table A1 summarizes the inputs needed for the calculation of the VA. In the calculation of the currency VA, the market yield for government bonds of non-euro area issuers is derived from government bond yield curves. Column **Government Bond Ticker Id** in Table A2 provides the Bloomberg tickers used to obtain the market yield data. The Bloomberg identifier is Prices PX_LAST.

Table A1: Specification of inputs 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

Source: EIOPA (2024b).

Table A2: Government bonds used in the government bond reference portfolio

Country	ISO 3166	ISO 4217	Swap Ticker	Swap freq	Swap Float Ticker	Government Bond Ticker Id	Govts/ Swaps
Euro	-	EUR	EUSA CMPL Curncy	1	EUR006M Index	ECB curve all governments-spot	SWP
Austria	AT	EUR	EUSA CMPL Curncy	1	EUR006M Index	G0063Z BLC2 Curncy	SWP
Belgium	BE	EUR	EUSA CMPL Curncy	1	EUR006M Index	G0006Z BLC2 Curncy	SWP
Bulgaria (*)	BG	BGN	EUSA CMPL Curncy	1	EUR006M Index	BI0662Z BVLI Curncy	SWP
Croatia	HR	HRK				G0369Z BLC2 Curncy	GVT
Cyprus	CY	EUR	EUSA CMPL Curncy	1	EUR006M Index		SWP
Czech Rep.	CZ	CZK	CKSW CMPL Curncy	1	PRIB06M Index	G0112Z BLC2 Curncy	SWP
Denmark (*)	DK	DKK	EUSA CMPL Curncy	1	EUR006M Index	G0011Z BLC2 Curncy	SWP
Estonia	EE	EUR	EUSA CMPL Curncy	1	EUR006M Index		SWP
Finland	FI	EUR	EUSA CMPL Curncy	1	EUR006M Index	G0081Z BLC2 Curncy	SWP
France	FR	EUR	EUSA CMPL Curncy	1	EUR006M Index	G0014Z BLC2 Curncy	SWP
Germany	DE	EUR	EUSA CMPL Curncy	1	EUR006M Index	G0016Z BLC2 Curncy	SWP
Greece	GR	EUR	EUSA CMPL Curncy	1	EUR006M Index	G0156Z BLC2 Curncy	SWP
Hungary	HU	HUF	HFSW CMPL Curncy	1	BUBOR06M Index	G0165Z BLC2 Curncy	GVT
Iceland	IS	ISK				I328 CMPL Index	GVT
Ireland	IE	EUR	EUSA CMPL Curncy	1	EUR006M Index	G0062Z BLC2 Curncy	SWP
Italy	IT	EUR	EUSA CMPL Curncy	1	EUR006M Index	G0040Z BLC2 Curncy	SWP
Latvia	LV	EUR	EUSA CMPL Curncy	1	EUR006M Index		SWP
Liechtenstein	LI	CHF	SFSW CMPL Curncy	1	SF0006M Index		SWP
Lithuania	LT	EUR	EUSA CMPL Curncy	1	EUR006M Index		SWP
Luxembourg	LU	EUR	EUSA CMPL Curncy	1	EUR006M Index		SWP
Malta	MT	EUR	EUSA CMPL Curncy	1	EUR006M Index		SWP
Netherlands	NL	EUR	EUSA CMPL Curncy	1	EUR006M Index	G0020Z BLC2 Curncy	SWP
Norway (*)	NO	NOK	NKSW CMPL Curncy	1	NIBOR6M Index	G0078Z BLC2 Curncy	SWP
Poland	PL	PLN				G0177Z BLC2 Curncy	GVT
Portugal	PT	EUR	EUSA CMPL Curncy	1	EUR006M Index	G0084Z BLC2 Curncy	SWP
Romania	RO	RON	RNSW CMPL Curncy	1	BUBR3M Index	BI0631Z BVLI Curncy	GVT
Russia	RU	RUB	RRSWM CMPL Curncy	1	MOSKP3 Index	G0326Z BLC2 Curncy	SWP
Slovakia	SK	EUR	EUSA CMPL Curncy	1	EUR006M Index	G0256Z BLC2 Curncy	SWP
Slovenia	SI	EUR	EUSA CMPL Curncy	1	EUR006M Index	G0259Z BLC2 Curncy	SWP
Spain	ES	EUR	EUSA CMPL Curncy	1	EUR006M Index	G0061Z BLC2 Curncy	SWP
Sweden	SE	SEK	SKSW CMPL Curncy	1	STIB3M Index	G0021Z BLC2 Curncy	SWP
Switzerland	CH	CHF	SFSW CMPL Curncy	1	SF0006M Index	G0082Z BLC2 Curncy	SWP
United Kingdom	GB	GBP	BPSW CMPL Curncy	2	BP0006M Index	G0022Z BLC2 Curncy	SWP
Australia	AU	AUD	ADSW CMPT Curncy	2	BBSW6M Index	G0001Z BLC2 Curncy	SWP
Brazil	BR	BRL				G0393Z BLC2 Curncy	GVT
Canada	CA	CAD	CDSW CMPN Curncy	2	CDOR03 Index	G0007Z BLC2 Curncy	SWP
Chile	CL	CLP	CHSWP CMPN Curncy	2	CLICP Index	G0351Z BLC2 Curncy	SWP
China	CN	CNY	CCSWO CMPT Curncy	4	CNRR007 Index	G0299Z BLC2 Curncy	SWP
Colombia	CO	COP	CLSWD CMPN Curncy	4	DTF RATE Index	G0217Z BLC2 Curncy	GVT
Hong Kong	HK	HKD	HDSW CMPT Curncy	4	HIHDC3M Index	G0095Z BLC2 Curncy	SWP
India	IN	INR				BI0571Z BVLI Curncy	GVT
Japan	JP	JPY	JYSW CMPT Curncy	2	JY0006M Index	G0018Z BLC2 Curncy	SWP

(table continues)

(continued)

Country	ISO 3166	ISO 4217	Swap Ticker	Swap freq	Swap Float Ticker	Government Bond Ticker Id	Govts/ Swaps
Malaysia	MY	MYR	MRSWQO CMPT Curncy	4	KLIB3M Index	G0196Z BLC2 Curncy	SWP
Mexico (*)	MX	MXN	MPSW CMPN Curncy	13	MXIBTIIE Index	G0251Z BLC2 Curncy	SWP
New Zealand	NZ	NZD	NDSW CMPT Curncy	2	NFIX3FRA Index	G0049Z BLC2 Curncy	SWP
Singapore	SG	SGD	SDSW CMPT Curncy	2	SORF6M Index	G0107Z BLC2 Curncy	SWP
South Africa	ZA	ZAR	SASW CMPL Curncy	4	JIBA3M Index	G0090Z BLC2 Curncy	SWP
South Korea	KR	KRW	KWSWO CMPT Curncy	4	KWCDC Index	G0173Z BLC2 Curncy	SWP
Taiwan	TW	TWD				BI0594Z BVLI Curncy	GVT
Thailand	TH	THB	TBSWO CMPT Curncy	2	THFX6M Index	BI0570Z BVLI Curncy	SWP
Turkey	TR	TRY	TYSW CMPL Curncy	1	TRLIB3M Index		SWP
United States	US	USD	USSW CMPN Curncy	2	US0003M Index	G0111Z BLC2 Curncy	SWP

Source: EIOPA (2018b).

Table A3: Euro iBoxx indices used in the euro corporate reference portfolio

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)				

Source: EIOPA (2024b).

The market yield for corporate bonds is provided by the Markit iBoxx indices listed in Table A3. The yield is the 'Annual Yield' and the duration is the 'Duration' in the Markit FTP server (EIOPA, 2024b). Due to unavailability of direct access to the Markit FTS server, the data used in the empirical analysis was sourced Bloomberg. The fields used were 'Yield to Maturity' and 'Macaulay Duration'.

Appendix 3: Allocation of assets in the fixed income portfolio for the calculation of the CSSR

The CIC codes of asset classes presented in Table A4 should be used to allocate assets to the fixed income portfolio in the calculation of the *CSSR* (EIOPA, 2020b).

Table A4: CIC codes used to allocate assets in the fixed income portfolio

	CIC codes
Government portfolio	11, 13*, 14*, 15, 16, 17, 19
Corporate portfolio	12, 13*, 14*, 21, 22, 23, 24, 25, 26, 27, 28, 29, 42, 52, 54, 62, 64, 81, 82, 84, 85, 86, 89
Other	All other CIC codes

* The CIC codes 13 and 14 were used to identify bonds issued by Regional government and local authorities and otherwise to non-financial corporate portfolio according to their credit quality step

Source: EIOPA (2020b).