MALTA FINANCIAL SERVICES AUTHORITY

Domestic Insurance Stress Test

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Abbreviations

ARCH	Autoregressive Conditional Heteroscedasticity
AoL	Assets over Liabilities
Bps	Basis points
CIU	Collective Investment Undertakings
CoVaR	Conditional Value at Risk
DoF	Degree of Freedom
eAoL	Excess of Assets over Liabilities
ECB	European Central Bank
EIOPA	European Insurance and Occupational Pensions Authority
ESRB	European Systemic Risk Board
EU	European Union
GARCH	Generalised Autoregressive Conditional Heteroscedasticity
IAIS	International Association of Insurance Supervisors
PCA	Principal Component Analysis
RFR	Risk-Free Rate
SCR	Solvency Capital Requirement
TP	Technical Provisions
UL-IL	Unit-Linked and Index-Linked
VaR	Value at Risk

Executive Summary

The Domestic Insurance Stress Test framework developed by the Financial Stability Function represents the first comprehensive attempt to assess the resilience of the domestic insurance sector. This tool is one of several risk assessment techniques that take a macroprudential view. It complements other work carried out by the Malta Financial Services Authority to analyse risks and vulnerabilities through a range of macroprudential and microprudential tools at its disposal. Eight licence-holders, having the largest links to the domestic economy, have been included within the scope of the analysis, which includes life, non-life and composite insurance undertakings. Their combined share of total assets represents around 30% (or €3.8 billion) of all insurance undertakings' assets licensed by the MFSA as at end 2019.[1]

The adverse scenario narrative shaped for the purpose of the stress test relates to a protracted period of extremely low interest rates (yield curve down – YCD – scenario). This scenario is driven by a drop in swap rates, which in turn generates a deterioration in corporate bond yields and equity prices. With respect to government bond yields, the impact intensity arising following the shocks differs across maturities and creditworthiness of sovereigns.

Following scenario design, shocks were calibrated to enable an assessment on the ultimate impact on the insurers' balance sheets. In this regard, a top-down approach has been adopted, whereby the authors directly compute the effect of the scenario. The identification of potential vulnerabilities is assessed by comparing post-stress test results to the baseline scenario (i.e. pre-stress), by observing changes in the assets over liabilities (AoL) ratio.

Under the baseline scenario, the sample of insurers considered for the purpose of the analysis reported an aggregate AoL of 116%, with the ratio ranging between 108% and 216% across individual institutions. Main results show that under a YCD adverse scenario the overall AoL ratio decreases to 108%, corresponding to a drop in excess of assets over liabilities (eAoL) of 44%. Particularly, two insurance undertakings recorded a substantial drop in AoL following the stress scenario, signalling potential vulnerabilities related to market risk. The impact derived from the YCD scenario mainly emanates from an increase in technical provisions (TP) on the liability side (+5%). As expected, this was driven by a rise in the life sector TP (+8%) due to the reduction of the discounting curve. Overall, the YCD scenario results in a decline of total assets, equivalent to -2%. This is mainly due to the resulting lower value of unit-linked and index-linked (UL-IL) assets and equity holdings (-6%), which was partly offset by the increase in value of fixed income assets (+2% government bonds and +2% corporate bonds).

This stress test marks the first step towards the evaluation of domestic insurance undertakings' balance sheets under a stress scenario. Stress test results should not be strictly interpreted in terms of institutions passing or failing a stressed scenario but rather to highlight

[1] The data used for the application of this framework is submitted annually by the license holders to the Authority. Hence, latest data available at time of publication is end 2019.

possible sectoral vulnerabilities that could emerge should such adverse movements on the financial market materialise in the future. Also, the methodology could serve as a guide to the industry to understand better the way the Authority is analysing sectoral risks from a financial stability perspective. Looking forward, possible enhancements include developing further the methodology, primarily to enhance the process utilised in generating the stressed scenarios, and secondly to capture changes arising in the solvency capital requirements.

Introduction

Stress tests are widely recognised to be effective in measuring the resilience to severe but plausible events. Within the financial sector, this technique has gained prominence as a risk management tool. Also, as a financial sector supervisory tool, it is considered to be useful to identify pockets of vulnerabilities and is increasingly being used in addition to the more conventional risk analysis techniques.

During the past years, several international entities involved in the insurance sector have been actively engaged in developing stress testing guidelines and principles. In 2003, the International Association of Insurance Supervisors (IAIS) led this transition by encouraging the use of a standardised design and implementation of supervisory stress tests as a means to facilitate comparability of insurance risk scenarios. More recent examples include the US National Association of Insurance Commissioners (NAIC), which in 2019 developed a liquidity stress test framework for large life insurers. Similarly, in the United Kingdom, the Prudential Regulation Authority (PRA) (2016, 2017) conducted stress test exercises for general insurers and a combined exercise for both general and life insurers in 2019.

Within the EU, the European Insurance and Occupational Pensions Authority (EIOPA) and the European Central Bank (ECB) have been mainly active in stress tests. EIOPA (2011, 2014, 2016 and 2018) undertakes regular bottom-up stress tests, set up in cooperation with the European Systemic Risk Board (ESRB). The aim is to obtain an EU-wide assessment of the resilience of the insurance sector to particular adverse scenarios. The latest stress test exercise published in 2018 focused on two scenarios: the impact of a prolonged low yield environment; and a sudden reversal of risk premia, with both scenarios being identified at the time as being key risk sources. The stress test scenarios were also complemented by longevity and instantaneous shocks to lapse rates and claims inflation, respectively. Subsequently, EIOPA initiated a process of enhancing its bottom-up methodology for stress testing by launching two discussion papers with stakeholders. As a result, a methodological paper (2020) was published focusing on enriching the stress testing toolbox to be used for analytical purposes by supervisors, insurers and other stakeholders.

In 2021, EIOPA and ESRB initiated the process for the 2021 EU-wide insurance sector stress test, by submitting the specifications for the adverse scenario of insurance-specific components and market stresses. The narrative elaborates on a prolonged COVID-19 scenario in a “lower for longer” interest rate environment.

In the light of the growing challenges that the financial sector faces both from domestic and international sources, the Financial Stability Function developed a stress testing framework to complement the risk oversight assessments already carried out by the Authority.[2] The

[2] In 2020, a liquidity stress test framework for the Maltese retail investment funds was published (Meglioli and Gauci, 2020).

Domestic Insurance Stress Test framework adopts a top-down approach, analysing the eight insurance undertakings which are classified as having the largest domestic footprint in Malta. It tests the resilience of these insurers to shocks based on a narrative of a protracted period of extremely low interest rates. Insurance undertakings holding the closest ties to the domestic economy are those having their main underwriting business situated in Malta.
The report is structured as follows: the first section provides an overview of the stress test framework adopted, including a methodology description and an overview on the narrative and adverse scenario considered. This is followed by an outline of the main characteristics within the baseline scenario and the stress tests results. The final section presents concluding remarks together with suggestions for further improvements to the framework.

Stress Test Framework

The objective of this stress test is to assess the capacity of domestic insurers in meeting their obligations under severe but plausible circumstances, as captured by the adverse scenario. A prescribed shock (instantaneous stress scenario), specified in line with the identified adverse scenario, is applied utilising a static balance sheet approach. Hence, the exercise assumes that no immediate adjustments through management actions are carried out. Furthermore, the stress test assesses the resilience of institutions on a stand-alone basis, that is, without allowing for any support within a group structure, including a parent company.

A top-down approach has been adopted, whereby the shocks are applied on insurers' balance sheets, generating results under the adverse scenario. The stress test scenario is based on a hybrid approach, taking into account both historical and forward-looking perspectives. Through this approach it is possible to assess the impact of various grades of hypothetical shocks and unexpected combination of stresses, while maintaining plausibility and consistency with economic theory. The main benefit of adopting such a framework is that it does not necessitate having to request additional information from licence-holders and in fact is solely based on regulatory reporting data already available at the Authority.

In order to construct a scenario in line with the narrative, two separate but interlinked methodologies were implemented within this framework. Firstly, shocks to swap rates are used to derive the stressed risk-free rate (RFR) curve, in line with the standard approach based on the Smith-Wilson model. Specifically, the principal component analysis (PCA) technique was applied to daily observations of the swap term structure, in order to reduce the dimensionality of the highly correlated data series into a small number of principal components. PCA-based shocks were developed and then converted to a stressed term structure across the maturities considered. Subsequently, to capture the tail dependency structures across a number of risk factors within different classes, a t-grouped copula approach was adopted. The Conditional Value at Risk (CoVaR) was the metric utilised to measure quantitatively the systemic risks and the spill over contagion effects among the risk factors. Finally, the calibration was based on 10,000 paths of simulated data.

The following sub-sections delve into the above-mentioned methodologies providing details to the derivation and calibration of shocks, together with the resulting shock inputs applied within the stress test exercise.

Deriving the Stressed Risk-Free Rate Curve

Insurance undertakings use the risk-free interest rate term structure to discount their future cash flows, allowing the calculation of their best estimate TPs, which represents the future obligations insurers are expected to settle. A stressed RFR is obtained through shocked swap rates using the PCA technique, which are then subject to control input parameters within the Smith-Wilson model. These parameters are aligned to the narrative and market environment devised for this analysis, and refer to the ultimate forward rate, the last liquid point, convergence period and the credit rating adjustment.

For this analysis, a dataset containing daily Euro swap rates observations between January 2005 and December 2019 is constructed. This time horizon incorporates international financial distress periods such as the 2008 financial crisis and the European sovereign debt crisis. Furthermore, tenors 1-15, 20 and 30 years are used. Upon close inspection of these observations, the spread across the different maturities has been generally moving together since 2009.

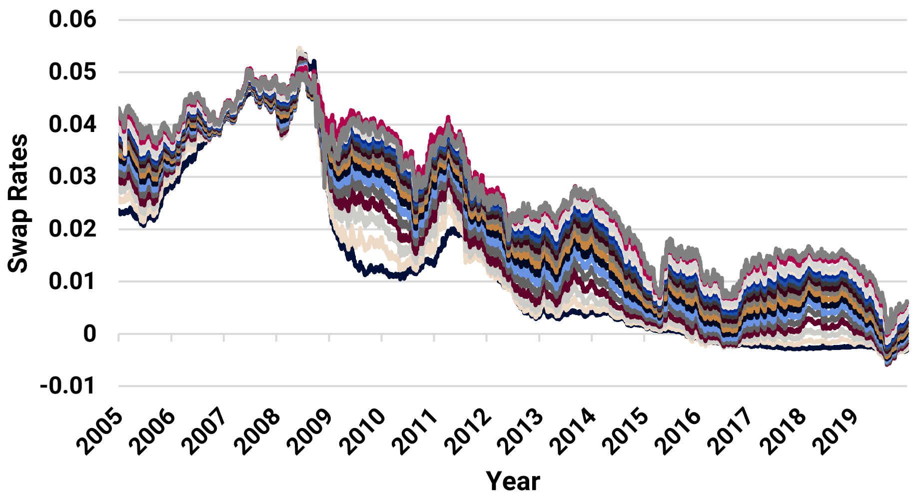

Figure 1 – Euro swap rates across 17 tenors

Statistical stationarity is achieved by utilising the daily changes through:

$$\Delta r_{t-1}^{n} = r_t^n - r_{t-1}^n$$

for each tenor n in the term structure and for each period t. The daily changes are visually observed in the figure below.

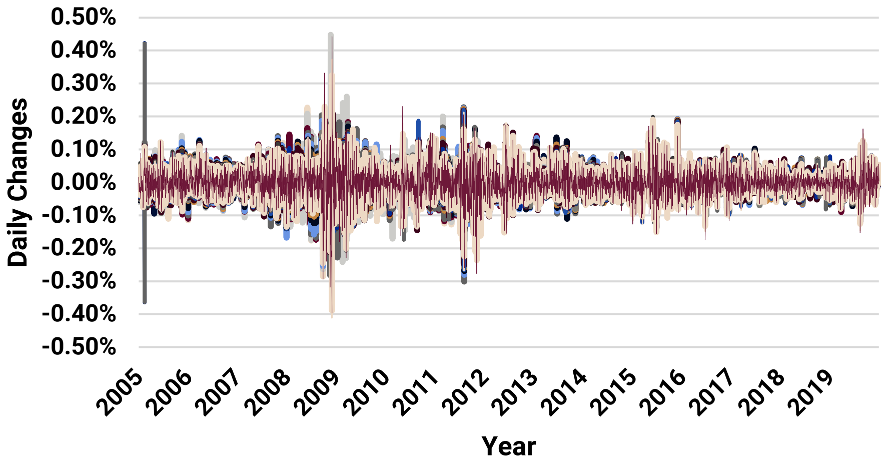

Figure 2 – Daily changes in Euro swap rates

From this series of daily changes, a variance-covariance matrix with dimensions 17 x 17 (representing the 17 tenors) is computed, from which the following correlation matrix is obtained:

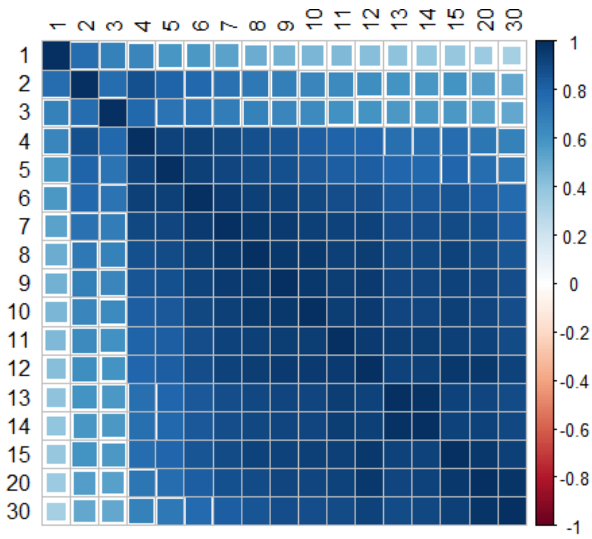

Figure 3 – Correlation matrix across the 17 Euro swap rate changes

To reduce the dimensionality of the highly correlated data series, PCA technique is applied to capture the variability in the movement of interest rates along the term structure. This technique, applied to highly correlated data series, reduces dimensionality. Within this context, it employs statistical methods to determine the components which are most important in explaining changes in the shape, slope and curvature of the yield curve. These three components capture most of the variation in swap rates. Essentially, the process entails deriving a set of values which represent the changes in the swap rate across the term structure to the variability among the rates. Denoting the daily growth rates by matrix X and the eigenvectors from the covariance matrix by $A = [a_1, \ldots, a_{17}]$, the principal components denoted by Y are derived through:

$$Y = A^T X$$

This decomposition also establishes the variances of the principal components $\lambda_1, \ldots, \lambda_{17}$, which are called eigenvalues.

The share of the variance explained by each principal component is directly measured. The first three principal components present a cumulative variance of 94%. Specifically, 82% of the total variation is explained by the first principal component (PC1), representing a parallel shift in the yield curve. The second principal component (PC2) explains 9% of the variation and can be interpreted as the change in the slope of the yield curve, while the third principal component (PC3) which accounts for 3% reflects the curvature effect. This interpretation is often given when applying PCA to yield curve data and is more of an empirical evidence rather than a mathematical truth.

Figure 4 gives further insight into the effect that these first three principal components have on the yield curve. A parallel shift in the yield curve is shown to be flat (PC1), while the factor relating to a change in slope exhibits a positive slope coefficient (PC2). The curvature is represented by a u-shape (PC3), indicating an added level of variability across the tenors.

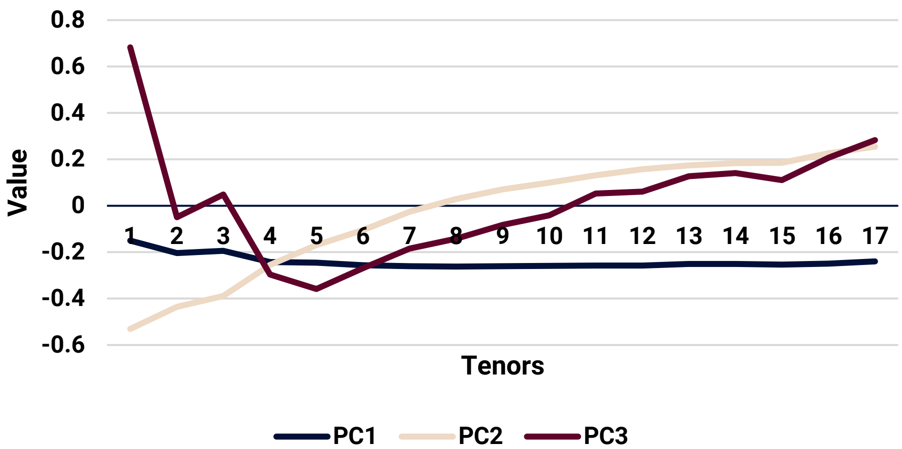

Figure 4 – Three most important principal components

PCA-based shocks are subsequently developed by considering the product of the principal component vectors and their standard deviations (i.e. square root of the eigenvalues). The degree of stress is then applied using an analytical Value at Risk (VaR) based on a normal distribution which focuses on the 99.5th percentile. This position is in line with benchmarks set by the SII standard formula:

$$Stressed\ Principal\ component_{ij} = a_{ij} \cdot \sqrt{\lambda_i} \cdot \Phi(0.995)$$

where $i = 1, \ldots, 3,\ j = 1, \ldots, 17$ and Φ denotes the inverse standard normal distribution.

These stressed principal components are subsequently converted to stressed rates of return across the 17 tenors, using an inverse transformation from principal components to the normalised daily growth rates. Finally, the daily volatility is annualised and added to the interest rate term structure at the last observed point, that is December 2019, in order to attain the shocked swap rates.

The shocked swap rates are utilised to derive the stressed RFR curve by means of the Smith-Wilson model[3] applying the following parameters:

1) Last liquid point is defined according to the results of the Deep Liquid and Transparent assessment run by EIOPA,
2) Ultimate forward rate is set at 1.8, in order to reflect properly the market situation being depicted,
3) Credit risk adjustment is kept unchanged with respect to the baseline at 10 basis points, and
4) Convergence is kept consistent at 60 years.

The scenario parameters are consistent with the Solvency II European Directive[4], although certain aspects were adjusted to reflect the different specificities of the scenario.

Calibration of market shocks

The shocks prescribed by the stress test are identified from adverse market movements, such as decline in interest rates, which are then translated into an impact on the asset and liability value of the insurer (market-based shocks). Shocks to financial assets within this framework were generated by quantitatively measuring the systemic risks observed through spill-over effects that were inferred on a number of ‘risk factors’. These ‘risk factors’ relate to government and corporate bond yields of different credit qualities, along with swap rates and equity indices from different geographical regions.[5] The ‘risk factors’ were selected in view of their significant influence on the balance sheet of domestic insurers.

The financial time series for the ‘risk factors’ includes several missing data points. This is predominantly explained by the differences across countries in relation to financial market holidays and varied liquidity levels across bond maturities. For the purpose of this exercise,

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[3] For a further understanding of the Smith-Wilson model used in the derivation of EIOPA's RFR term structures, refer to the technical document available at: https://www.eiopa.europa.eu/sites/default/files/risk_free_interest_rate/12092019-technical_documentation.pdf

[4] Directive 2009/138/EC of the European Parliament and of the Council of 25 November 2009 on the taking-up and pursuit of the business of Insurance and Reinsurance (Solvency II). Available at: https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32009L0138

[5] Refer to Appendix A for a comprehensive list of financial assets used.

these data points are linearly interpolated. Standard approaches, such as first difference for bond returns and log-returns for equity quotes, are applied to obtain stationarity.

The Ljung-Box test is used to examine data from a time series model in order to infer whether the autocorrelations between different lags are zero. The null hypothesis that the data is independently distributed is rejected for most lags. Thus, an autoregressive moving average (ARMA) model is fitted to the data in order to filter out the conditional mean. The ARMA specification was identified by using information criteria in view of identifying the best model for each time series.

Furthermore, the presence of conditional heteroscedasticity is tested, utilising the Engle's autoregressive conditional heteroscedasticity (ARCH) test on the squared residuals. Following this a generalised autoregressive conditional heteroscedasticity (GARCH) specification is fitted. As per empirical applications of Bollerslev et al. (1992), a GARCH (1,1) model is fitted, given that this is sufficient for representing a vast range of financial series. As suggested in the literature, the conditional mean and GARCH components are determined simultaneously, to avoid inconsistent parameter estimates of the ARMA process. With the help of information criteria, the t-distribution is chosen as the preferred distribution.

In order to link the 'marginal innovations' (i.e. error terms) across the financial assets, a grouped t-copula is fitted.[6] Grouped t-copulas, as demonstrated by Daul et al. (2003), are superior to both the Gaussian- and t-copulas when it comes to modelling the tail dependence in the data. Additionally, such copula distribution functions enable more robust modelling of 'risk factors' when components within a group are of similar type, such as a group of fixed-income assets, and conversely when components within groups have different characteristics. Indeed, this copula allows the risk factors within each group to have a t-copula with different degrees of freedom (DoF) parameters. This provides a more flexible overall dependence structure.

An estimate of the density for a grouped t-distribution is in general not available in closed-form, hence one should rely on its estimation. As suggested by Hintz et al. (2020), the copula is estimated efficiently using randomised quasi-Monte Carlo algorithms, whereby the DoF are estimated jointly to eliminate the possibility of over- or under-estimation of the joint tails. The figure below displays the estimated DoF obtained for various specifications of the maximum number of iterations (maxit) for the underlying optimiser. With 1,000 iterations, constant DoF are obtained.

[6] Refer to Appendix B for definitions of t-copula and Grouped t-copula.

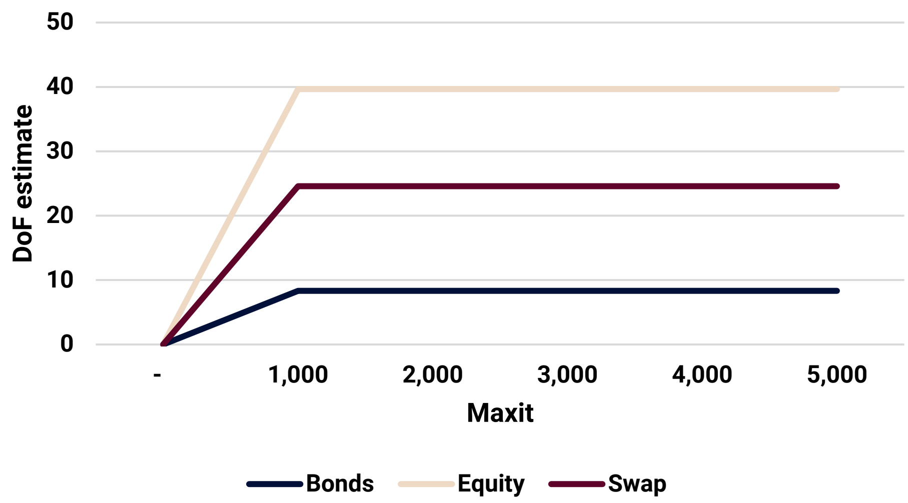

Figure 5 – Estimated degrees of freedom for different number of iterations

As presented in the table below, the difference between the estimated DoF across the three groups confirms that a grouped t-copula is more appropriate for describing the dependence structure.

Group	**Number of Risk Factors**	**Estimated DoF**
Bond	14	8.3
Equity	4	39.7
Swap	5	24.6

Table 1 – Estimated degrees of freedom parameters for the risk factor groups

Finally, 10,000 simulations were carried out from the fitted grouped t-copula GARCH time series model. Each simulation was performed over a length of 260 days, which roughly corresponds with the number of trading days in one year. These paths are used to calibrate the market shocks.

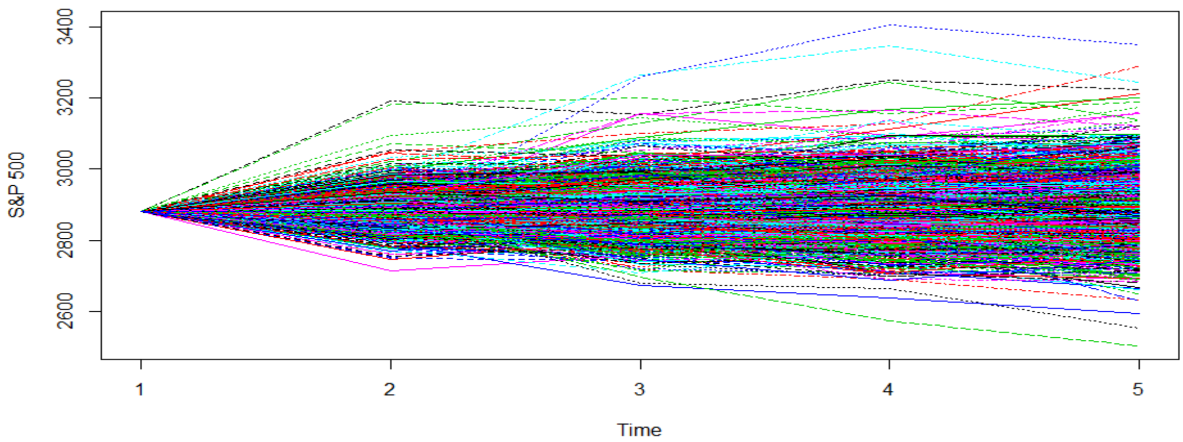

Figure 6 – 10,000 path simulations

Systemic risk across financial assets is also analysed through the model, by evaluating the spillovers that amplify the initial adverse shocks. The calibration of such shocks is carried out in relation to the plausibility criterion. This is estimated through the computation of CoVaR, developed by Adrien and Brunnermeir (2011). This risk metric determines the VaR of a variable under the condition that another variable is under a distress scenario, the latter defined as a specific percentile at the tail of its distribution. The simulation process is run through a grouped t-copula GARCH approach.

To this end, the financial assets are labelled as response variables. The CoVaR ($CoVaR^{Resp}$) allows to define the change in the VaR of a financial asset, conditional on some trigger variable being in distress ($VaR^{Trigger}$). The trigger variable is constructed as a weighted average of the daily swap rate returns of advanced economies. The narrative of the scenario defines these rates as an exogenous shock that trigger the entire scenario. The distress scenario relates to the values which fall in a certain tail of the distribution, such that observations falling below the 5th percentile of the triggering variable are selected.

Quantile regression is used to estimate the CoVaR. In particular, in order to capture time-variation in the tail of the joint distribution of the trigger and response variables, VaRs and CoVaRs are estimated as a function of lagged state variables (M_{t-1}). Hence, the evolution of the joint distributions over time is modelled. The state variables selected refer to short-term swap rates. Consequently, the quantile regression equations take the form:

$$VaR_t^{Trigger}(q) = \hat{\alpha}_q^{Trigger} + \hat{\gamma}_q^{Trigger} M_{t-1}$$

$$CoVaR_t^{Resp}(q) = \hat{\alpha}_q^{Resp|Trigger} + \hat{\beta}_q^{Resp|Trigger} VaR_t^{Trigger}(q) + \hat{\gamma}_q^{Resp|Trigger} M_{t-1}$$

The subscript t represents time variation, q refers to the quantile chosen, and $\hat{\alpha}_q^{Trigger}$, $\hat{\gamma}_q^{Trigger}$, $\hat{\alpha}_q^{Resp|Trigger}$, $\hat{\beta}_q^{Resp|Trigger}$, $\hat{\gamma}_q^{Resp|Trigger}$ are parameters to be estimated.

Scenario

Narrative:
The scenario designed assumes a protracted period of low interest rates which is triggered by a decline in swap rates (YCD scenario).

The methodologies described in the previous sub-sections provide a stressed risk-free rate along with a set of market shocks. These are used to determine the shock inputs that are applied within the stress test exercise. The shocks of the different financial assets used to stress the balance sheet of insurance undertakings are outlined below, with the formulas used to implement such scenarios found in Appendix C.

Government bonds

One-year government bond yields for countries with AAA-A rating decline by 17 bps under the stressed scenario, while for countries with a rating of BBB or lower increase by 13 bps. This reflects the inferior creditworthiness of lower-rated sovereign debt. The observation of more severe shocks for higher-rated government bonds is sustained across maturities.

	Shocks				
Rating	**1Y**	**2Y**	**5Y**	**10Y**	**20Y**
High Rated	-17	-19	-34	-25	-29
Low Rated	13	-5	-17	-21	-6

Table 2 – Shocks to government bond yields (bps)

Corporate bonds

Corporate bond yields decline by 29 basis points under the stressed scenario, which is observable across both credit rating groupings.

Rating	**Shock**
AAA-A	-29
≤BBB	-29

Table 3 – Shocks to corporate bond yields (bps)

Equity

Stock prices decline in both advanced and emerging economies under the stressed scenario. The decline for emerging markets is more prominent in view of the level of volatility that is attributed to such economies.

Region	**Shock**
EU	-5
Asia	-4
US	-7
Emerging Markets	-10

Table 4 – Shocks to stock prices (%)

Other financial assets

With respect to asset holding by insurers in real estate, the decline in the RFR curve shaped by the scenario and the presumable lower economic growth would give rise to a conflicting effect on real estate prices. In view of this, residential and commercial real estate are assumed to have a neutral effect in this scenario, thus remaining unchanged. Regarding collective investment undertakings (CIU), these are shocked according to the equity shocks prescribed by the scenario, since it is the asset class most closely resembling the CIU. On the other hand, assets held for UL-IL contracts are treated with the look-through approach. Finally, due to data restrictions, no impact on the creditworthiness of reinsurance recoverables (namely credit risk) is considered.

Technical provisions

The analysis of the best estimate of the technical provisions (TP) under the YCD scenario is based on the cashflow projections observed in the baseline. Such cash flows are discounted with the stressed Euro RFR, whereby, an assumption on the currency of the cash flows is set[7]. In the event that an insurance undertaking projects cashflows for more than 30 years (that is, beyond the mark of yearly cashflow submissions), an averaging approach is considered. None of the undertakings in the sample make use of volatility adjustments. Hence, this is excluded from the scope of the scenario.

The spread of the Euro risk free rate is represented by the difference between the two RFR lines as outlined in the figure below. In the Euro Area, under this stressed scenario, the 10-year swap rate declines by 98 basis points while one-year swap rate declines by 23 basis points.

[7] Ideally cashflows should be discounted with a corresponding RFR based on their currency denomination. However, in this exercise this is not possible as cashflows submitted by the undertakings are not split between currencies.

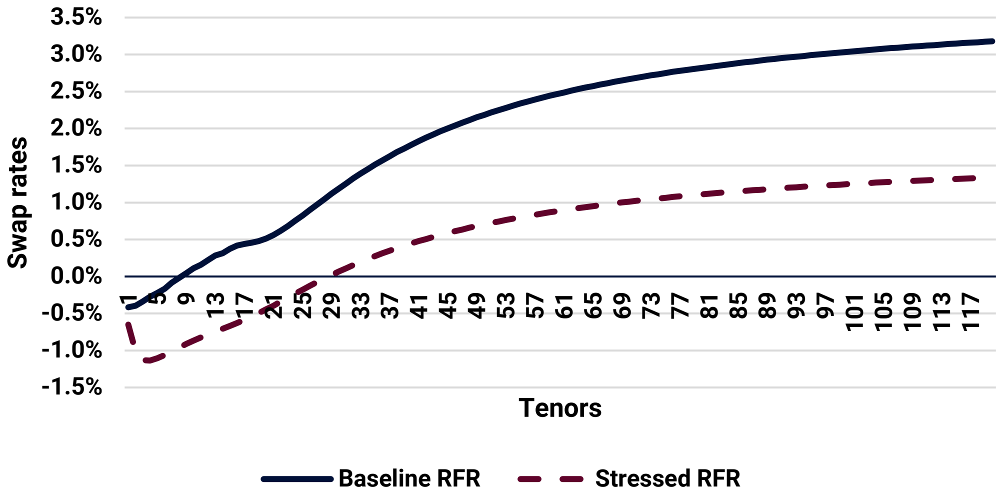

Figure 7 – Baseline and Stressed risk-free rate

The risk margin is recalculated to ensure that the value of the TP is equivalent to the amount that insurance undertakings would require to take over and meet their obligations. In line with the hierarchy of methods for the calculation of the risk margin[8], the simplest method is adopted, whereby the approximation of the risk margin is calculated as a percentage of the best estimate.

With respect to UL-IL contracts, any market shock is expected to have an equivalent offsetting adjustment on insurers' liabilities. This is because through such products, policyholders have some discretion over the asset allocation, thereby the risk is transferred from the insurance undertaking onto policyholders.

Stress Test Results

The stress test exercise is conducted on the eight insurance undertakings which hold a material footprint on the domestic market. Their combined asset value stood at €3.8 billion as at end 2019, of which three life undertakings dominate the domestic insurance sector with their assets accounting for €3.3 billion (or 87% of the total). The remaining undertakings refer to three non-life companies and two composites, that are engaged in both life and non-life insurance business.

[8] Reference is made to the *Guidelines on the valuation of technical provisions* (EIOPA-BoS-14/166 EN).

Baseline Scenario Characteristics

Domestic life insurers mainly hold assets in the form of bonds, although their asset composition can be considered as relatively diversified, as seen in the figure below:

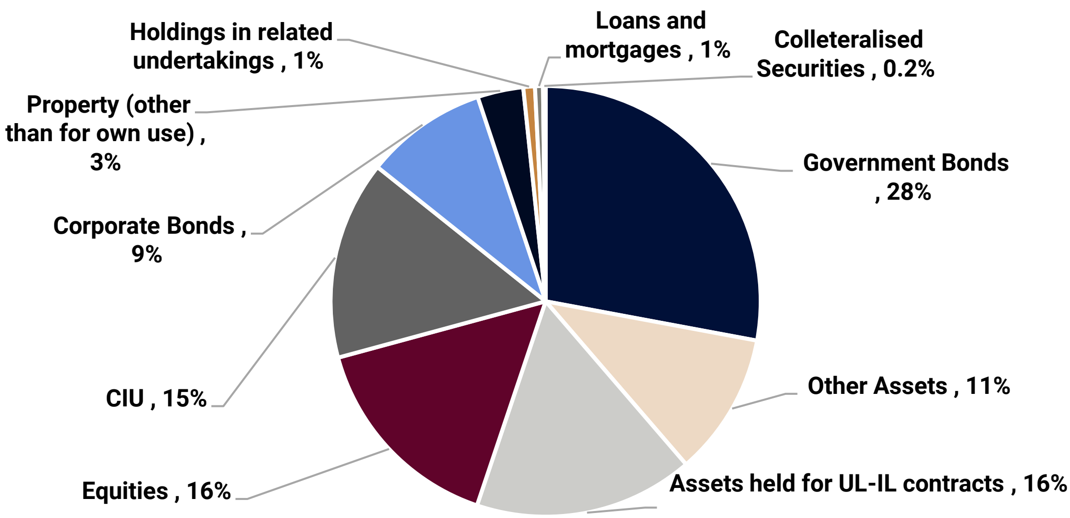

Figure 8 – Domestic life assets composition in the baseline scenario

In fact, government bonds make up 28% of life insurers' asset composition. Of note is that their weighted average modified duration stands at 7.7, albeit heterogeneity across institutions is present with the modified duration ranging between 7.6 to 8.5. For the corporate bond portfolio, this makes up 9% of life insurers' asset composition, with the weighted modified duration standing slightly lower from government bonds, at 6.1. Assets held for UL-IL contracts account for 16% of total asset.

The asset composition of the domestic non-life and composite undertakings is depicted hereunder:

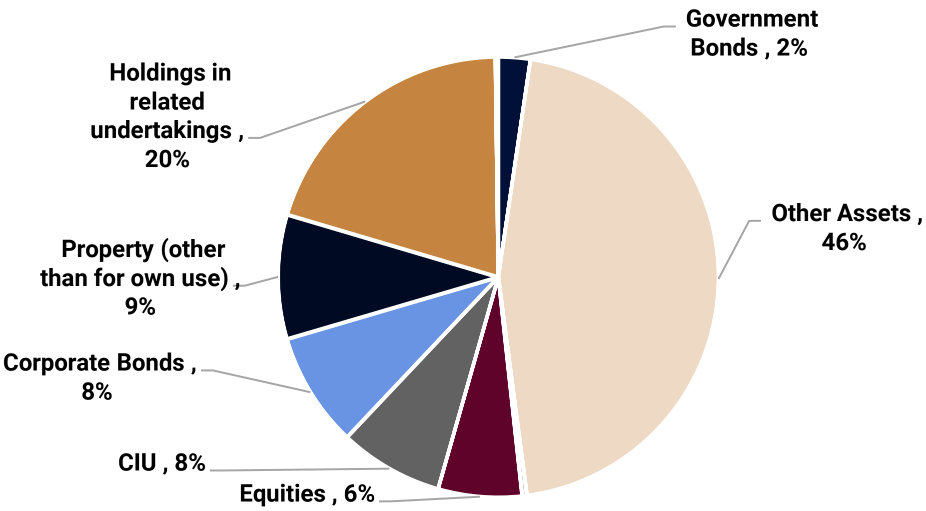

Figure 9 – Domestic non-life and composite assets composition in the baseline scenario

Almost half of the non-life and composite undertakings' assets are classified as 'other assets'. Predominantly this category is made up of cash and cash equivalents (14%), reinsurance recoverables (11%), insurance and intermediaries' receivables (8%), and property, plant and equipment held for own use (8%). None of these assets are stressed in this exercise given the limited or conflicting impacts from market risk.

With respect to the liability structure, the life undertakings show a concentration in life TP (excluding UL-IL) which represents 80% of total liabilities. Subsequently, UL-IL TP account for a further 17% of total liabilities. Also, as shown in the figure below, domestic insurers do not rely extensively on external market financing.

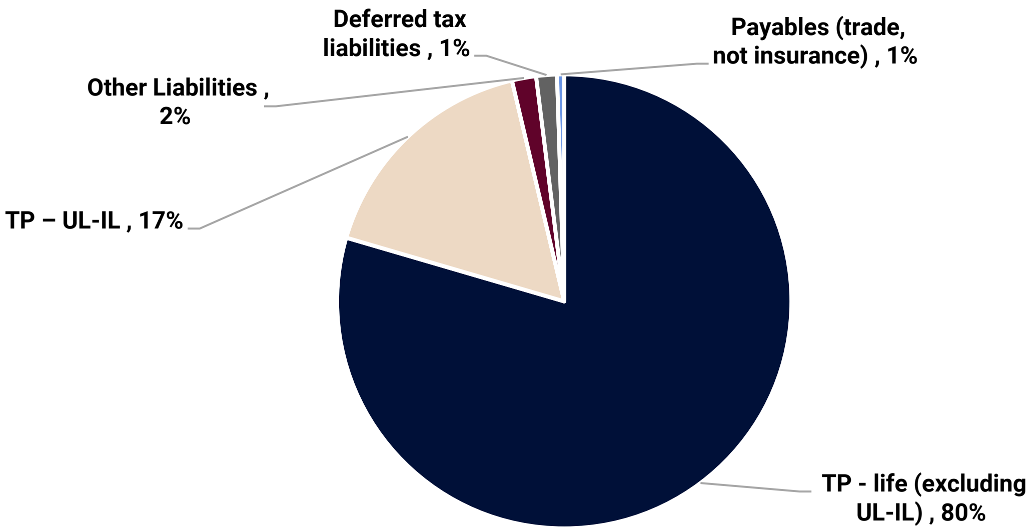

Figure 10 – Domestic life liabilities composition in the baseline scenario

Non-life and composite undertakings' liability structure is largely concentrated in non-life TP (incl. health), equivalent to 77%, while life TP for the composite undertakings account for a mere 1% of the total. Although the share of external market financing is higher than that of their life counterparts, it is still minimal. The other liabilities (12%) mainly refer to insurance and intermediaries' payables (3.1%) and reinsurance payables (5.5%).

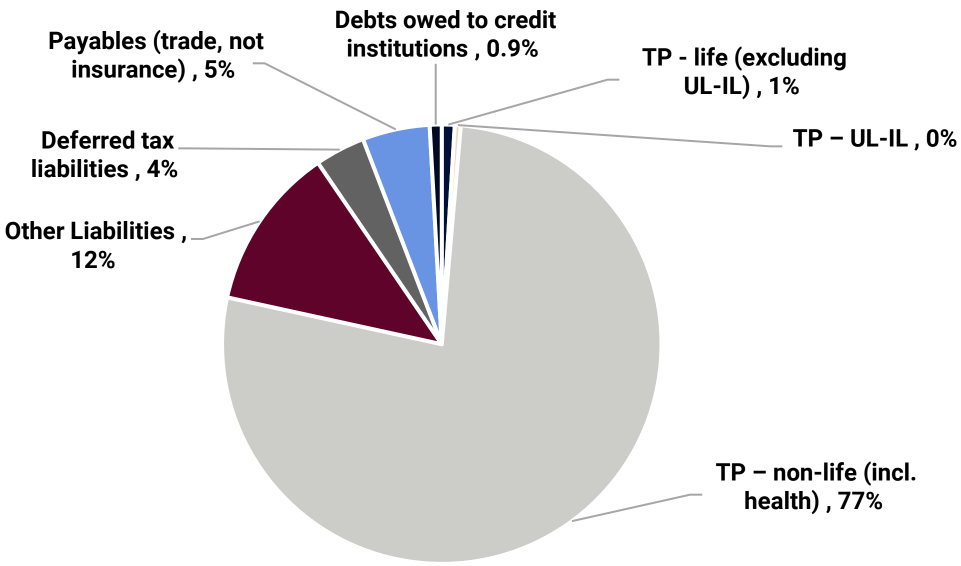

Figure 11 – Domestic non-life and composite liabilities composition in the baseline scenario

The assets over liabilities (AoL) ratios[9] for insurance undertakings – on an individual level – range between 108% and 216%, with life undertakings on average recording the lowest ratio standing at 110%.

Market Stress Scenarios Impact

Applying the prescribed scenario shocks result in an excess of assets over liabilities (eAoL) of €287 million, which corresponds to a 44% drop from that recorded in the baseline scenario which stood at €512 million. The figure below portrays the decomposition of the change in the eAoL following the stressed scenario. Both the overall decrease in assets and the overall increase in TP contribute negatively on the final eAoL.

[9] Equations for AoL and eAoL are available in Appendix C.

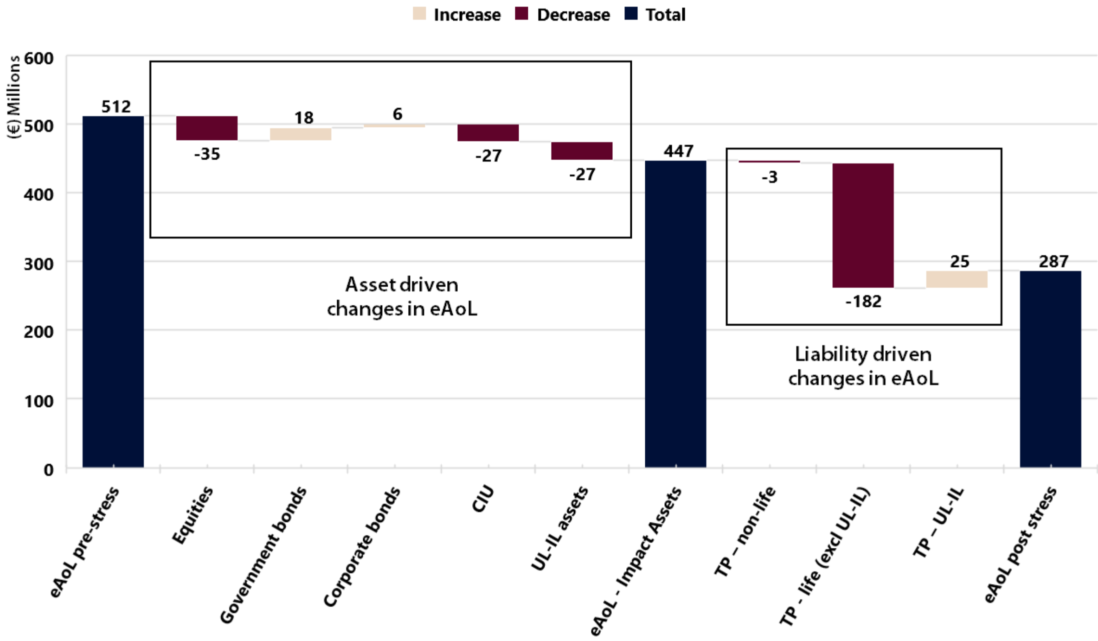

Figure 12 – Decomposition of the change in eAoL

The most significant drop recorded on the asset side emanates from equities, recording a drop of 6%. UL-IL assets decrease by 5%, the impact of which is offset by a corresponding change in UL-IL TP on the liabilities side. The value of government and corporate bonds increases by 2% respectively, as the persistence of low interest rates force bond prices to increase. On the liabilities side, TP rises by 5% with TP increasing for life business by 8% and 2% for non-life, in line with the lower interest rates (including a lower ultimate forward rate than in the baseline). The higher TP accounts for the largest part of the decrease in eAoL.

From the calculated results, it transpires that three insurance undertakings are the most affected, in view of recording the most significant drops in eAoL. Two of these insurance undertakings are mainly influenced by changes in their liabilities. This is mainly driven by the relatively high duration of their liabilities, ultimately rendering these insurance undertakings highly susceptible to interest rate changes. As expected, life undertakings are more prone to this risk given the long-term characteristics of their business.

The overall impact arising on the AoL ratio under the adverse scenario is that of a 7 percentage point drop, with the overall ratio shifting from 116% pre-stress to 108% post-stress. Vulnerability is present within two insurers given the substantial drop in AoL following the stress scenario.

It should be noted that the calculations in this stress test are applied across the board, without allowing for adjustments through supervisory or management actions. Thus, these results should not be considered as a pass or fail test but rather as an identification of vulnerabilities within institutions. Furthermore, these results are based on internal calculations adopted on the cashflow projections and balance sheet submissions by the insurance undertakings.

Concluding Remarks

This stress test framework developed by the Financial Stability Function is used internally within the function to assess the vulnerabilities of the domestic insurance sector to market shocks, triggered by a protracted period of extremely low interest rates. This stress test evaluates the resilience of individual insurance undertakings rather than outright failures. The results complement other tools used by the Authority in assessing the vulnerability of specific insurance undertakings, allowing the Authority to focus its attention by adopting supervisory policy actions as necessary. Furthermore, the stress test assesses the resilience of insurance undertakings on a stand-alone basis, that is, without allowing for any support within a group structure, including parent company. Also, the methodology could be used by licence holders as a guide to better understand the way the Authority is analysing sectoral risks from a financial stability perspective.

Results indicate that the eight domestic insurance undertakings considered within this exercise, under the post-stress scenario, will incur an overall 7 percentage point drop in their AoL ratio in comparison with the baseline scenario. The post-stress AoL ratio of 108% is derived by a -1.7% drop in assets and a 4.9% increase in liabilities. The latter is mainly attributed to the high duration of liabilities, which reflects the sensitivity to changes in interest rates. As a result, under the prescribed scenario, insurance undertakings are expected to lose 44% of their combined eAoL position, that is €225 million below that recorded from the baseline scenario.

This analysis confirms that under the adverse scenario of a protracted period of extremely low interest rates (YCD scenario), apart from a surge in liabilities, the positive impact arising on bond prices does not offset the decline experienced by the other asset classes, such as equities and CIUs. Of note are three undertakings which experience significant declines in eAoL, following the stress on both their assets and liabilities. In particular, two insurance undertakings end up with a limited AoL signalling potential vulnerabilities related to market risk.

This exercise, along with the framework adopted to generate and shape the YCD scenario, represents the initial step in setting up a macroprudential insurance stress test tool. Going forward, possible enhancements to the tool include switching to a non-parametric framework which will allow for greater flexibility. Furthermore, analysis could be carried out in recalculating the solvency capital requirement following the stress.

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Appendix A – List of financial assets

Name	ID Code
1 Year German Sovereign Bond	ISIN/DE0001030336
2 Year German Sovereign Bond	ISIN/DE0001104834
5 Year German Sovereign Bond	ISIN/DE0001141836
10 Year German Sovereign Bond	ISIN/DE0001102531
20 Year German Sovereign Bond	ISIN/DE0001135366
30 Year German Sovereign Bond	ISIN/DE0001102481
2 Year Italian Sovereign Bond	ISIN/IT0005366007
3 Year Italian Sovereign Bond	ISIN/IT0005405318
5 Year Italian Sovereign Bond	ISIN/IT0005419848
10 Year Italian Sovereign Bond	ISIN/IT0005422891
15 Year Italian Sovereign Bond	ISIN/IT0005433195
30 Year Italian Sovereign Bond	ISIN/IT0005425233
STOXX Europe 600	ISIN/EU0009658202
MSCI International Asia Pacific	RIC/MIAP00000PUS
MSCI International Emerging Markets	ISIN/US55353S1050
S&P 500	ISIN/US78378X1072
Moody's Seasoned Aaa Corporate Bond Yield	RIC/aUSCRBYLD
Moody's Seasoned Baa Corporate Bond Yield	RIC/aUSCRBBAA
EURO 2 Year Interest Rate Swap	RIC/EURAB6E2Y
EURO 5 Year Interest Rate Swap	RIC/EURAB6E5Y
EURO 10 Year Interest Rate Swap	RIC/EURAB6E10Y
EURO 20 Year Interest Rate Swap	RIC/EURAB6E20Y
US Dollar 2 Year Interest Rate Swap	RIC/USDSB3L2Y

Table 5 – Comprehensive list of data

Appendix B – Background information on copulas

The following is background information on t-copulas and grouped t-copulas as found in Daul et al. (2003).

t-copula

Let $\boldsymbol{Z} \sim \mathcal{N}_d(\boldsymbol{0}, \boldsymbol{\Sigma})$ and $R = \sqrt{\nu}/\sqrt{S}$, with $S \sim \chi^2_\nu$ (a Chi Square distribution with ν DoF), be independent, where $\boldsymbol{\Sigma}$ is a linear correlation matrix. Then, the $\mathbb{R}^d$-valued random vector $\boldsymbol{Y}$ given by:

$$\boldsymbol{Y} = R\boldsymbol{Z}$$

has a centred t-distribution with ν DoF.

Using Sklar's Theorem, the copula of $\boldsymbol{Y}$ can be written as:

$$C^t_{\nu,\boldsymbol{\rho}}(\boldsymbol{u}) = t^d_{\nu,\boldsymbol{\rho}}(t_\nu^{-1}(u_1), \dots, t_\nu^{-1}(u_d))$$

where, $t^d_{\nu,\boldsymbol{\rho}}$ denotes the distribution function of $\sqrt{\nu}\boldsymbol{Z}/\sqrt{S}$, and $S \sim \chi^2_\nu$ and $\boldsymbol{Z} \sim \mathcal{N}_d(\boldsymbol{0}, \boldsymbol{\rho})$ are independent.

Let $H_1, \dots, H_J$ be some arbitrary continuous strictly increasing distribution functions. Then

$$\boldsymbol{X} = \left(H_1^{-1}\left(t_\nu(Y_1)\right), \dots, H_d^{-1}\left(t_\nu(Y_d)\right)\right)'$$

has a t_ν-copula and marginal distributions $H_1, \dots, H_J$.

Grouped t-copula

Let $\boldsymbol{Z} \sim \mathcal{N}_J(\boldsymbol{0}, \boldsymbol{\rho})$, where $\boldsymbol{\rho}$ is defined as an arbitrary linear correlation matrix independent of U. Furthermore, let G_ν denote the distribution function of $\sqrt{\nu/\chi^2_\nu}$. The set $\{1, \dots, J\}$ is partitioned into m subsets of sizes $s_1, \dots, s_m$. Let $R_k = G_{\nu_k}^{-1}(U)$ for $k = 1, \dots, m$. If

$$\boldsymbol{Y} = \left(R_1 Z_1, \dots, R_1 Z_{s_1}, R_2 Z_{s_1+1}, \dots, R_2 Z_{s_1+s_2}, \dots, R_m Z_J\right)'$$

then the random vector $\left(Y_1, \dots, Y_{s_1}\right)'$ has an s_1-dimensional t-distribution with ν_1 DoF and, for $k = 1, \dots, m-1$, $\left(Y_{s_1+\dots+s_k+1}, \dots, Y_{Y_{s_1+\dots+s_{k+1}}}\right)'$ has an s_{k+1}-dimensional t-distribution with ν_{k+1} DoF. Finally, let F_k denote the distribution function of Y_k, and let $H_1, \dots, H_J$ be some arbitrary continuous strictly increasing distribution functions. Then

$$\boldsymbol{X} = \left(H_1^{-1}\left(F_1(Y_1)\right), \dots, H_J^{-1}\left(F_J(Y_J)\right)\right)'$$

is a generalisation which allows different subsets of the components to have different DoF parameters.

Appendix C – Formulas

Formulas used to shock the financial assets

- Change in government bond value:

$$\Delta V = -V_{t_0} * ModD * \Delta yield$$

Where V_{t_0} is the value of the government bond issued by a sovereign with a specific rating, $ModD$ is the modified duration of the particular bond and $\Delta yield$ is the shock applied to government bond yields as presented in Table 2.

- Change in corporate bond value:

$$\Delta V = -V_{t_0} * ModD * \Delta yield$$

Where V_{t_0} is the value of the corporate bond issued by a corporate with a specific rating, $ModD$ is the modified duration of the particular bond and $\Delta yield$ is the shock applied to corporate bond yields as presented in Table 3.

- Change in equity value:

$$\Delta V = V_{t_0} * \Delta r$$

Where V_{t_0} is the value of the equity listed within EU, America, Asia and Emerging markets. Δr is the shock applied to equity price as presented in Table 4.

Other formulas

- AoL ratio formula:

$$\frac{Total\ Assets}{Total\ Liabilities} * 100$$

- eAoL formula:

$$Total\ Assets - Total\ Liabilities$$

Appendix D – Data sources

The data used in this report is based on the following data sources:

- Solvency II Quantitative Reporting Template S.02.01 – Balance Sheet
- Solvency II Quantitative Reporting Template S.06.02 – List of Assets
- Solvency II Quantitative Reporting Template S.13.01 – Projection of future gross cash flows (Life obligations)
- Solvency II Quantitative Reporting Template S.18.01 – Projection of future cash flows (Best Estimate – Non-Life)
- Thomson Reuters Eikon

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