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YE2018 Comparative Study on Market and Credit Risk Modelling

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1. Executive summary

Market and credit risk contribute significantly to the solvency capital requirement (SCR) of insurance undertakings[1] and are also of material importance for the majority of internal model undertakings. Consequently, the EIOPA Board of Supervisors beginning of 2018 decided[2] to perform annual European-wide comparative studies on the modelling of market and credit risks, to be run by a joint project group of National Competent Authorities (NCAs) and EIOPA. Undertakings with a significant exposure to assets denominated in Euro and an approved internal model covering market and credit risk shall take part in this annual study.

The ambition is to ensure a consistent and regular collection of information in order to carry out such comparative studies on internal model outputs efficiently, and have an up to date overview of the modelling approaches, as well as to further develop supervisory tools and to foster common supervisory practices.

This report summarises the key findings from the market and credit risk comparative study (MCRCS) undertaken in 2019 based on year-end 2018 data and provides an insight into the supervisory initiatives being taken following the conclusions of this study.

The study focuses on EUR denominated instruments, but also looks into selected GBP and USD denominated instruments as well as foreign exchange rate indices. The 22 participants from 8 different Member States cover 98.3% of the Euro investments held by all undertakings with an approved internal model covering market and credit risk in the EEA.

It is important to note that the study focuses on drivers for the value of investments, but does not aim to cover the overall SCR. In particular, specific undertakings' risk profiles, the dependency effects between the market module and the other risk modules, tax impacts or matching adjustment are intentionally not considered – with the purpose of directly assessing the study's key subject. These other aspects should however be taken into account when judging the relevance of findings. Hence, no direct conclusion could be drawn with regards to a specific undertaking's solvency position or the overall appropriateness of the model with this comparative study.

Nevertheless, as in the previous edition, this study based on simplified asset-liability-portfolios also puts focus on the analysis of interest rate down movements, more relevant for liabilities. Furthermore, to achieve a more holistic picture, effects from the undertakings approach to the volatility adjustment (VA) are taken into account in the analysis of those portfolios.

The overall results show significant variations in asset model outputs, which could be partly attributable to model and business specificities already known by the relevant NCAs, but also indicate a certain need for further supervisory scrutiny. Especially in this context, this report is part of an ongoing process of monitoring and comparing internal market and credit risk models. Refinements and enhancements since the last study will be further developed already with the next study. The results, tools and experience will be feeding in the Supervisory Review Process (SRP) on internal models and vice versa. For example, data in the MCRCS format is not only used for the MCRCS itself but also to assess model changes or models in pre-applications.

[1] Cf. e.g. page 27 of the report on the EIOPA Insurance Stress Test 2018: market risk accounts for 60% of the net solvency capital requirement before diversification benefits.
[2] Decision of the Board of Supervisors on the annual market and credit risk modelling comparative study' (EIOPA-BoS 18/062)

As a final introductory remark, internal models under Solvency II are governed by strong regulatory requirements on statistical quality, validation, documentation, justification of expert judgements, internal controls and model change governance as well as reporting to supervisors and the public. On-going compliance to these standards is safeguarded under the SRP. As a consequence of the variety of business models and risk profiles and the freedom of modelling, a variety of models are being used which contributes to mitigate a potential herding behaviour. Another consequence is that national supervisors, participants and further stakeholders need tools, such as European comparative studies, to be provided with a necessary overview of model calibrations although the results and statistical key figures in this report shall not be regarded as calibration targets.

Main qualitative results

The update of the stock-take from the previous study confirmed that there are two main approaches used by undertakings to model market and credit risk: integrated approaches and modular approaches (cf. section 4). Additionally, certain aspects of credit risk modelling are visible on portfolio level only. The approach taken in the study therefore puts some effort into enabling a like for like comparison and ensures reliable conclusions can be drawn. In that spirit, this report mainly presents results under the combined market and credit risk at the level of benchmark portfolios, supplemented with a drill down analysis of facets of market and credit risk. Although the number of participants compared to the previous edition increased from 19 to 22 participants and achieves a nearly full coverage from a statistical point of view the sample size is not large – and will remain so in the short term at least. Furthermore, the analysis revealed that some benchmark assets were not relevant or not material for certain participants. This in parts led to model results of lower quality, causing distortions in the results, which was mitigated by an enhanced use of the 'relevance scores' provided by the participants.

A small number of participants had issues to provide the requested data in time and with sufficient quality. National supervisors concerned will engage with these participants to remedy this issue in the next edition.

Main quantitative results

For the combined market and credit risk charge, i.e. relative loss in value at the level of benchmark portfolios, the results show a sizeable variation between undertakings. In that respect supervisors have especially engaged with the undertakings in feedback meetings and will continue evaluating results at European level (see also 5.3 and 6). Parts of the observed variations can be attributed to risk management preferences. Drilling down from the level of benchmark portfolios into facets of risk and asset types confirms this.

For the drill down analyses in section 5.2, undertakings reporting no exposure on a particular financial instrument were excluded to a large extent. This makes the results more meaningful. A side-effect is that by and large the overall modelling quality underlying the results presented also becomes higher.

Credit risk charges for sovereign bonds across groups of modelling approaches show relatively low variation for bonds issued by Germany, Netherlands, Austria, Belgium, and France. The variation is greater for the bonds issued by Ireland, Portugal, Spain, and Italy. The results are influenced by a small number of firms showing unusually low credit risk shocks across the instruments which requires further investigation.

Credit risk charges for corporate bonds are generally higher for bonds with lower credit ratings and the variation increases materially with worsening credit quality. The

variation becomes substantial for BB-rated bonds. This demonstrates the variety of modelling assumptions being taken by firms, particularly for low rated bonds.

With respect to equity risk, undertakings in general show less variation in the risk charges for major equity indices compared to risk charges applied to the strategic equity participation. Risk charges applied to the five real estate investments vary to a larger extent compared to equity. However, for asset categories like real estate, model calibrations might place more emphasis on the risk profile of the undertakings' actual investment portfolio and less on publicly available indices.

Way forward: Regular Studies and fostering the Supervisory Review Process ('SRP')

Finally, the findings highlighted by the study indicate the need for further supervisory scrutiny, including at the European level. Consequently, EIOPA will further develop supervisory tools and foster consistency of supervisory approaches. The next study will enrich the spectrum of analysis, as described in section 6.

2. Objectives of the study

In general, market and credit risk contributes significantly to the overall SCR of internal model undertakings. In addition, the definition of market and credit risk in terms of the fluctuations in the level and in the volatility of market prices of financial instruments is to a large extent common to most undertakings (e.g. identification of similar risk factors, use of the same or similar historic data).

The principal objective of the year-end 2018 market and credit risk modelling comparative study was to further develop and refine European comparative studies as a supervisory tool in the area of market and credit risk modelling. This should support the supervision of models and foster convergence of supervisory approaches given the potential choices of mathematical, statistical and IT solutions to tailor models to the actual risk profiles. The use of synthetic assets allows to have a stable comparison point over time which is combined to the assessment of the relevance of these assets in terms of exposure and modelling for the participants. The study should also allow supervisors to analyse models, model changes, approaches and calibrations over time and spot potential trends. In practice, the tool has already been used by NCAs, or supervisory colleges when relevant, and the conclusions of the study have provided input to the Supervisory Review Process (SRP), for example with regards to internal model changes.

Given the complexities of the overall market risk modelling process and the different risk profiles of firms, the data should facilitate reviews of the overall variability of model outcomes as well as analyses of single model components (e.g. risk factor model) more deeply in order to explain the overall behaviour. More concretely, the objectives were:

i. Comparing model outputs for a set of realistic asset portfolios that should reflect typical asset risk profiles of European insurance undertakings, e.g. by country.

   Although the focus is on the asset side, the setup of the study should be flexible enough to analyse different exposures against different interest rate movements (e.g. interest rate up and down shocks).

   The metric of this comparison is the ratio of the modelled asset Value at Risk (99.5%, one year horizon) and the provided market value of the asset portfolio (this metric is called 'risk charge').

ii. Highlighting the causes for the presumed variability in the risk charges by analysing additional information such as individual risk charges (e.g. individual asset classes such as Fixed Income, Equity, etc.).

In order to take an informed decision about the relevance of variations, beyond choosing realistic asset portfolios, it is important to distinguish the metric chosen (the 'risk charge') from the SCR, the latter especially considering both assets and liabilities, their interrelations, dynamics and potential mismatches. Furthermore, actual business and risk profiles as well as risk and investment strategies have to be taken into account in the judgment.

3. Process and scope

Process

A project group operationalised the objectives, deriving concrete goals and updating the data request and questionnaire to undertakings, which was collected by the responsible NCAs ('participating NCAs') including first checks.

The project group processed the answers and performed thorough data quality and sense checks, with the aim to ensure the reliability of results. This step included feedback loops with undertakings and resubmissions when necessary. This also holds true for the analysis and its successive refinements.

The project group developed dedicated tools to carry out the analysis of the benchmark portfolios and individual instruments. These tools mainly consist in a programme written with the open source language R. This programme allows aggregating the data from different participants into a single database. This database can then be filtered to extract specific information in the form of tables, or to plot it for further visual exploration. All information used for this report is directly based on the data provided by the participating undertakings, which makes it easier for them to understand how comparisons are made. Only spot rates and spreads have to be calculated as the collected data with exception of derivatives is based on values. The corresponding formulae are explained in the relevant sections.

The overall results were discussed in the supervisory community and dedicated feedback packages were prepared to be discussed by the participating NCAs with undertakings, initiating follow-ups if deemed necessary. Where relevant, the results of these discussions were collated by the project group and fed into this report. The collected lessons learnt will feed the setup of the next study editions.

Last but not least, insights, methods and tools developed for analysis, comparison, data processing and data quality checks as well as collaborative experience will feed into supervision of the on-going appropriateness of internal model under the SRP and enhance the consistency of supervisory approaches.

Scope of the study: Risks

The subject of this study is the modelling of the market and credit risks related to investment instruments. As a consequence, the conclusions of the study allow a comparison between participating undertakings of model outputs for some of these risks only, and not in terms of overall capital requirements. In particular, several effects which drive the overall SCR are not considered in the study, such as the dynamics of liabilities under changing financial market conditions or tax impacts.

While the main components of **market** risk are interest rate risk, equity risk, property risk and currency risk, **credit** risk could be split into three components, namely "default risk", "migration risk" and "spread risk", where the first might be defined as the risk from the default of the issuer of securities, the second as the risk from spread movements related to rating migrations, and the third as the risk from spread movements within the same credit rating class in the one year horizon. Market risk models usually include other sub-risks such as inflation, implied volatilities for equity risk and implied volatilities for interest rate risk, which are not included in the standard formula. For the first time, the report presents some analysis performed on implied volatilities for equity risk and for interest rate risk.

The data collected is composed of market values for a number of synthetic market instruments, as well as a few benchmark portfolios composed of a selection of these synthetic instruments. For each instrument and portfolio the participating undertakings were expected to send the complete set of values generated by their model (scenario-

by-scenario data or selected percentiles depending on risk type and modelling approach), in addition to the initial market value of the instrument and the "modelled Value-at-Risk" (mVaR) estimate. For some participants the mVaR might differ from the 99.5% sample quantile on the simulated asset values, due to the statistical estimator and e.g. including interpolation or smoothing schemes. For each instrument, the undertakings were expected to provide an assessment of the relevance of such instrument for the undertaking's own exposure, as well as in terms of modelling quality. This was supplemented by data on the own asset portfolio, on implied volatility for derivatives and qualitative information about the model and the approach to the study to support the quantitative analysis.

Concerning the concentration/accumulation of exposures, most undertakings take care of concentration implicitly through correlation matrix used in Monte-Carlo simulations or, less commonly, through concentration thresholds defined by the company in a specific policy. Some undertakings add explicit mark-up/penalisation for concentration calculated with standard formula or with a specific model.

Scope of the study: Undertakings

As market and credit risk models within groups typically are uniform, the 22 participants from 8 Member States are mainly international insurance groups with an approved internal model at group level[3], covering market and credit risk, and with significant Euro exposure. The Euro investments (excluding unit-linked assets) of participants amount to 98.3% of the total Euro investments[4] of EEA internal model undertakings fulfilling these criteria. The total assets of participants amount to 36.6% of total EEA assets.

[3] Four participants are individual undertakings for which the group head is not participating in the study, but the model is the one used by the group.
[4] Based on data submitted by EEA undertakings as of year-end 2018.

4. Modelling approaches and limitations

Qualitative analysis of modelling approaches

Two aspects are crucial for the interpretation of the results: first, the characterisation of various structural model setups and second the modelling of the one-year time horizon in the risk measure of Solvency II.

Regarding the structural model setup it is necessary to differentiate between 'integrated approaches' covering both market and credit risk in one sole simulation from 'modular approaches' covering most facets of market risk in one module while the remaining parts of market and credit risks are covered in another module. To simplify, we use the terms 'market module' and 'credit module' from this point forward. Also, the granularity of model outputs provided for this study varies along this dimension (for example scenario by scenario data vs. aggregated data).

Fifteen participants use integrated approaches while seven participants use modular approaches. Regarding the different sub-risks of credit risk, all undertakings with an integrated approach model pure credit spread risk, migration risk and default risk, except for three undertakings that model only pure credit spread risk. All undertakings with a modular approach include credit spread modelling in the market risk module. From the latter, two participants include also some parts of pure credit spread risk in the credit risk module.

Therefore, in order to have meaningful comparisons, clusters of similar model approaches (integrated vs. modular) have been built for certain detailed analyses, reducing the sample size.

Credit modules furthermore tend to use credit portfolio model approaches which tend to reveal the real risk charge only at the overall portfolio level and not at instrument level. For this reason, results are best compared and analysed at the level of combined market and credit risk for portfolios.

With regards to the one-year time horizon required for Solvency II, two different approaches broadly exist: seventeen participants apply so-called 'instantaneous shock models' on the Solvency II balance-sheet. Five[5] participants model the evolution of the balance-sheet over the following year explicitly by taking into account 'ageing effects' (for example remaining maturity of a bond is reduced by one year) for market and credit risk. Three participants model a one year-evolution for credit risk but not for market risk. This needs to be appropriately considered in the definition of the respective risk measure Value-at-Risk (VaR) underlying the Solvency Capital Requirement (SCR) and might deviate from a simple quantile estimator[6].

Furthermore, the qualitative scores collected from undertakings to indicate the exposure relevance showed that certain chosen test assets were not relevant, neither for the current exposure nor for expected future investments. Consequently, in certain detailed analyses, some undertakings which are not exposed to some instruments or only provided rough proxies were excluded from the sample. This also explains why the usually explicitly reported numbers of observations in the analysis vary and often do not cover the full set of participating undertakings.

[5] Of which three participants for the purpose of the study apply adjustments to their models to enable meaningful comparison with 'instantaneous shock models'. This has to be taken into account in the use of these results with respect to the Solvency Capital Requirement.

[6] If modelling a one year evolution of the portfolio the firms must take the expectation contained in their model approach into account. This can for example lead to the SCR being defined as the quantile of the distribution corrected by the mean.

Limitations

Although the coverage of the study is very high with reference to exposure to EUR-denominated investments, from a statistical point of view the sample is not large, as it includes 22 participants only.

Regarding credit risk, the number of instruments and issuers might still be considered low in order to explore portfolio models, but had to be limited for the sake of practicality for participants and analysis.

Additionally, because most of the analyses were performed considering only the asset side of the balance sheet, the risk charges presented in this report represent only capital charges for investments.

The study includes also an analysis extended to more realistic asset-liability exposures. However since the liability side is represented by a very simplified portfolio, the risk charges should not be interpreted or compared to Solvency II regulatory capital requirements which depend on the risk profile of each undertaking and take into account all the balance sheet features.

Furthermore, the risk charges presented in this report take into account the diversification effects within the market and credit risk modules, but not the diversification effects with and among other risk modules.

Taking into account the limitations described and given the differences among the business and investment profiles of the participants, the results from the study should not be considered as calibration target.

5. Results and supervisory actions

General remarks

Aiming to cover integrated approaches as well as modular approaches, the key idea is to focus the analysis on the combined market and credit risk. The key metric chosen for comparison is the 'risk charge':

> The **risk charge** corresponds to the relative reduction of the initial value based on the modelled Value-at-Risk at one year horizon ("mVaR"[7]) not taking into account e.g. effects from liabilities or tax. Therefore, one can conclude that the findings of this report refer to the calibration of the models and not to the actual risk profiles of the undertakings.

The subsequent section 5.2 contains information which is in some instances based on supplementary variables (e.g. interest rates and credit spreads). Here, the metric chosen for comparison is called 'shock':

> The **shock** corresponds to a tail event of the underlying (marginal) risk factor distributions. For details on the derivation of the risk factor distributions from the value distributions please cf. footnotes 15 and 16.
>
> More concretely, the absolute changes of a risk factor over a one year time horizon are considered and depending on the type of risk factor the displayed shocks can either be two-sided (e.g. interest rates 'up/down') or one-sided (e.g. credit spreads 'up').
>
> This metric takes into account the undertakings' individual risk measure definitions (in particular whether the mean of the distribution is taken into account or not) and is based on the 0.50%- and 99.50%-quantiles for two-sided and the 99.50%-quantile for one-sided risk factors, respectively.

5.1. Combined Market and Credit Risk, Benchmark portfolios

5.1.1. Benchmark portfolio setup

For the purpose of the study a set of benchmark portfolios ('BMPs') was specified consisting of linear combinations of various fixed income, equity and real estate instruments ('asset-BMPs'). In order to extend the analysis towards a more realistic asset-liability perspective, some of these asset-BMPs were combined with a very simplified portfolio of liabilities in form of risk-free zero coupon bond short positions ('BMPL'). These asset-liability BMPs therefore contain both long and short positions and can be interpreted as a simplified representation of an insurer's balance sheet ('A-L-BMPs'). More concretely, the following steps were taken to construct the three BMP-types:

[7] See above: The mVaR might differ from the 99.5% sample quantile on the simulated asset values, owing to the statistical estimator which can include for example interpolation or smoothing schemes.

- **Asset-BMPs:** The BMPs were chosen in relation to real asset allocations of the insurance sector in the respective market. Therefore the representative portfolios used by EIOPA to derive the volatility adjustment (VA), for year-end 2018 for EUR and seven country VAs, namely for BE, DE, ES, FR, IE, IT and NL, served as a basis for the target allocations[8]. Main criteria for the decomposition of fixed income instruments were sector (government, corporate), duration, maturity and credit quality step, using the usual mapping of ECAIs' credit assessments ('ratings') to credit quality steps ('CQS'). To supplement these, two portfolios were constructed consisting purely of sovereign bonds resp. corporate bonds, both with equal weights for all included instruments and leading in total to 10 asset-BMPs. Besides, only the most material and common financial instruments are used to construct these BMPs which include neither derivatives, nor inflation-linked bonds nor instruments sensitive to implied volatilities.
  In contrast to the previous study two major changes were introduced: i) exclusion of unit-linked assets and ii) exclusion of equity positions which have been classified as 'participation' in the QRT-reporting, in order to reduce the equity exposure in the asset-BMPs to a more realistic share compared to the previous edition.
- **BMPL**: a simplified representation of liabilities in terms of risk-free zero coupon bond short-positions. The maturity profiles of these zero coupon bonds were chosen in a way to approximate the average cash flow profile of all European insurance undertakings (irrespective of segment Life / Health and Property / Casualty) leading to a higher weighted average duration on the liability side compared to the fixed income assets (i.e. a 'negative duration mismatch'). It is important to note that the simplified liability portfolio does not capture potential asset-liability interactions, different kinds of products sold in the European market, loss-absorbing capacities of technical provisions or any other optionality.
- **A-L BMPs**: a subset of five asset-BMPs was combined with the BMPL and the liabilities were scaled in such a way that the net asset value of the A-L-BMPs reflects the average 'NAV to total assets' ratio across all European insurance undertakings (approx. 13%). The subset of asset-BMPs are EUR_BMP 1 ('EUR'), EUR_BMP 3 ('Germany'), EUR_BMP 7 ('Italy'), EUR_BMP 9 ('sovereigns only') and EUR_BMP 10 ('corporates only').

Annexes 1 and 2 provide a detailed overview of the portfolio compositions.

Three participants were not able to provide results for the benchmark portfolios, therefore, the sample on asset and liability BMPs includes 19 undertakings. While for asset-liability BMPs the sample consists of 18 participants, as one participant was excluded due to data quality issues.

From the following graph it can be seen that the fixed income instruments of the BMPs have different maturity profiles and therefore lead to different portfolio durations:

[8] The benchmark portfolios were constructed with the aim to mimic the EIOPA VA representative portfolios. However, since the MCRCS portfolios are composed of a limited number of instruments the composition does not perfectly match the EIOPA VA representative portfolios.

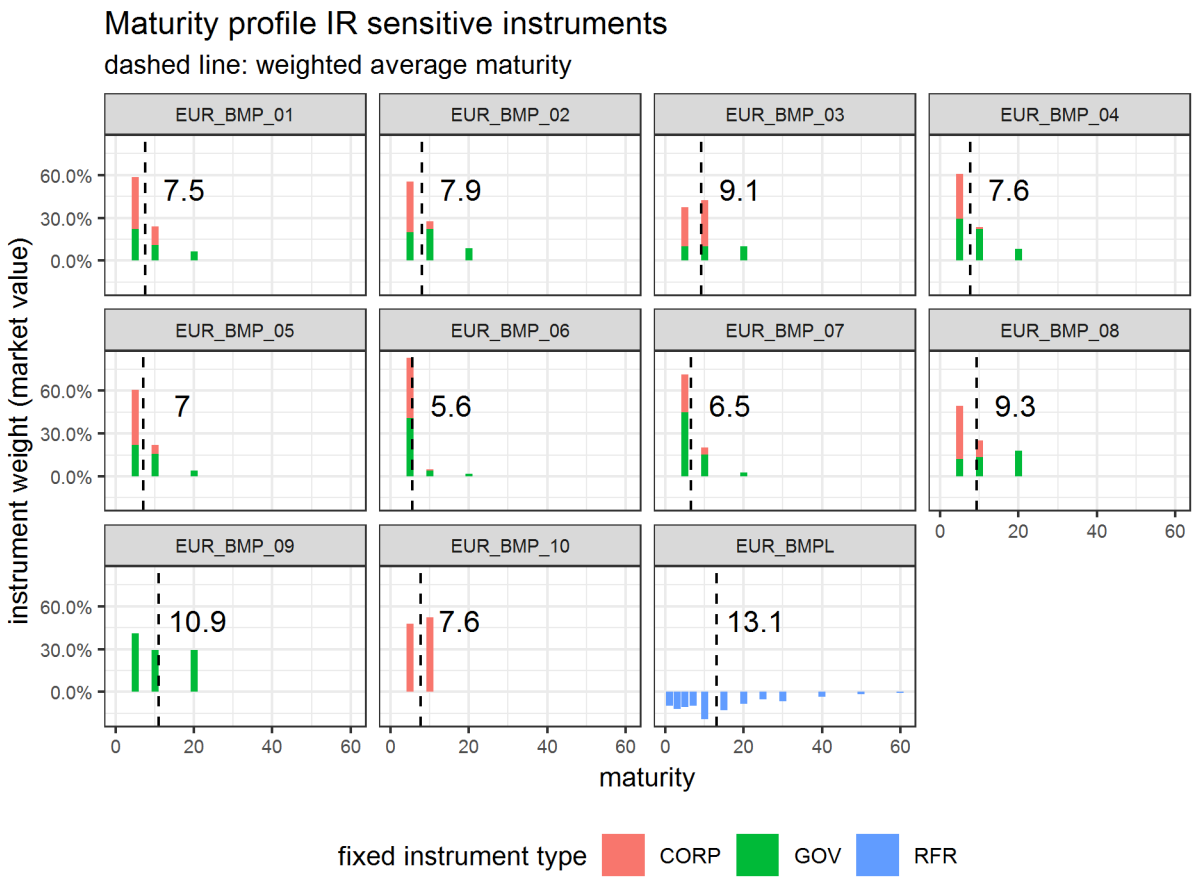

Figure 1: Maturity profiles of the asset benchmark portfolios and of the liability portfolio

5.1.2. Asset-Liability BMPs

The following plot displays the risk charges for the A-L BMPs in terms of loss in the net value compared to the total initial asset value. It shows the combined market and credit risk charges for the A-L BMPs in the form of boxes, bounded by the 75% quartile at the top and by the 25% quartile at the bottom. It means that 75% and 25% of the risk charges from the sample are lower than the upper and lower line respectively. Additionally, the lines ('whiskers') at the bottom and at the top indicate the 10% quantile and the 90% quantile, i.e. the plot covers 80% of the sample. Note that the undertakings' results which fall outside of these 'boxes and whiskers' are not included in the chart. The magenta coloured dot represents the BMP specific risk charge based on the currently applicable standard formula. The size of the sample is indicated in brackets underneath or above each box. The results presented in Figure 2 correspond to the approved internal model scopes regarding the treatment of the volatility adjustment (VA) and therefore offer the highest degree of comparability among the participants. More concretely, for undertakings using

- 'no VA' there is no VA-effect considered at all,
- 'constant VA', i.e. for valuation of Technical Provisions but not modelling the VA explicitly in the internal model a CVA-effect is considered,
- 'dynamic VA', i.e. for valuation of Technical Provisions and also modelling the VA explicitly in the internal model a DVA-effect is considered.

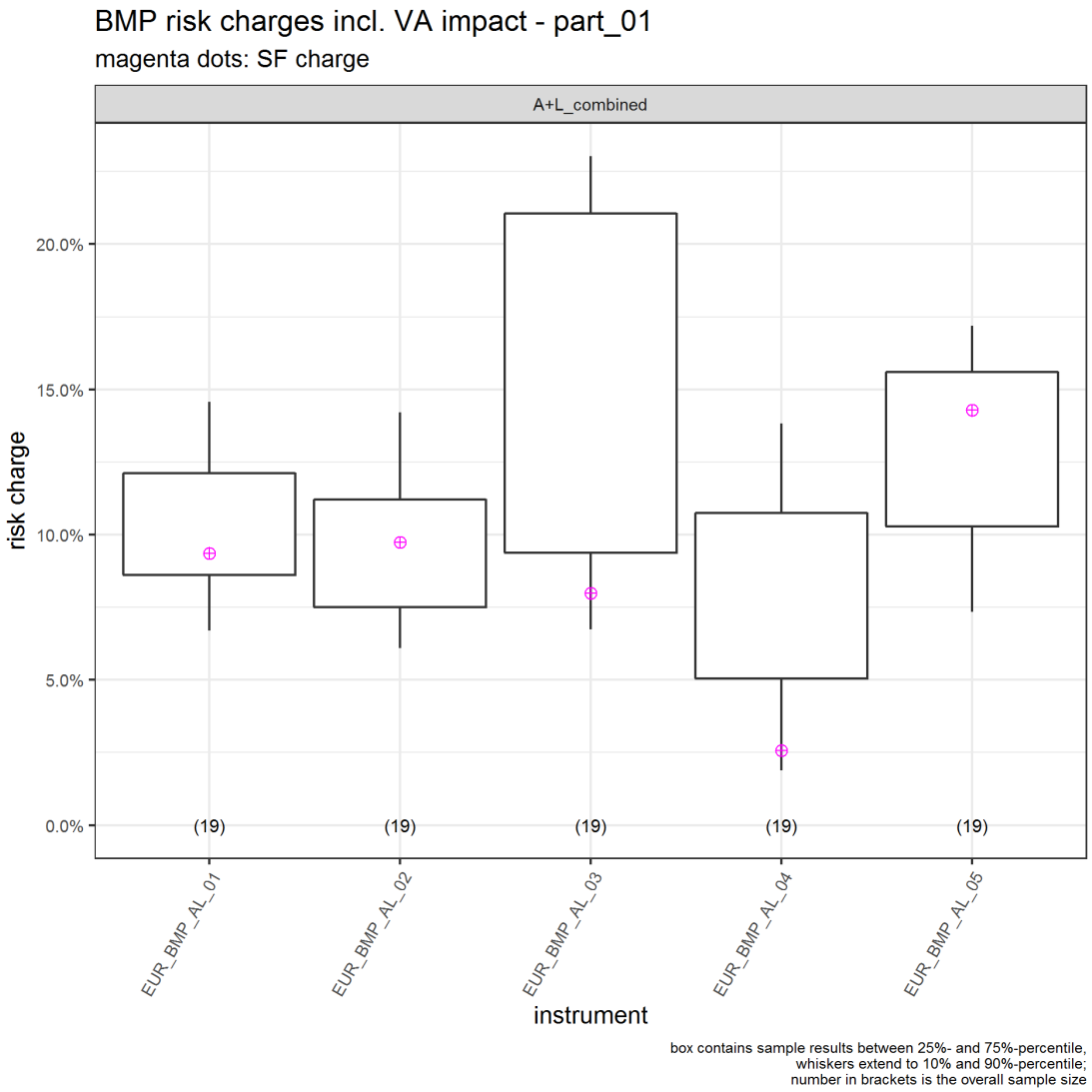

Figure 2: combined market & credit risk charges for asset-liability benchmark portfolios

Each of the boxes in Figure 2 covers a set of 10 out of 19 relevant participants[9]. The interquartile range (IQR), i.e. size of the boxes, overall A-L-BMPs ranges from 4% to 13%. This indicates sizeable variations but at the same time there is no indication of risk charges under internal models being – globally speaking – systematically lower compared to risk charges under the standard formula. The variations are especially pronounced for EUR_BMP_AL_03 and EUR_BMP_AL_04 containing a large amount of sovereign exposure. Excluding these two A-L-BMPs the IQR-dispersion reduces to between 4% and 6%. The corporates-only asset allocation in EUR_BMP_AL_05 also shows an increased level of variability compared to EUR_BMP_AL_01 and EUR_BMP_AL_02. This aspect will be explored further in section 5.2.2. The variations of EUR_BMP_AL_01 and EUR_BMP_AL_02 are in a comparable range but on different levels. To some extent this can be explained by the smaller duration-mismatch of EUR_BMP_AL_02 and the overall credit quality of the respective asset-BMP.

[9] This subset of 10 participants might be different from BMP to BMP

Due to the negative duration-mismatch the A-L BMPs are in general exposed to interest rate down movements. Given the current low-interest rate environment this risk is not fully captured in the standard formula while all internal models take this into account.

Regarding the length of the whiskers in this section it should be noted that one participant provided results based on incorrect input data used for the model calibration of interest rate risk, resulting in too low risk charges. As the official year-end 2018 SCR-reporting of this undertaking was based on these incorrect results it was decided to keep the observation in the sample with the effect of adding variability especially to the lower part of the results. The undertaking and its respective NCA have identified this mistake and expect this to change with next year's MCRCS-edition.

5.1.3. Impact of the dynamic Volatility Adjustment

The VA is applied to the risk-free interest rate curve under Solvency II. Its application by undertakings is optional, and in some Member States is subject to approval. The value of the VA depends on the currency (and possibly the country) of the liabilities; and it is set by EIOPA based on a formula using the average credit spread on reference portfolios of fixed-income instruments[10]. Given that the VA depends on credit spreads, some internal model undertakings dynamically model the VA using their market & credit risk model, i.e. letting the VA move in line with the modelled credit spreads – this is called the 'dynamic Volatility Adjustment' (DVA) approach[11]. When an undertaking keeps the VA constant in its model, it is called 'static' or 'constant' VA approach[12] (CVA).

In order to disentangle this DVA-effect the results from Figure 2 the following graph splits the results into the subsets of 'DVA-users' and 'Non-DVA-users', the latter including CVA-users. The vertical axis displays again the 'risk charge'. For comparison, the risk charge given by the standard formula is shown as a purple dashed line.

[10] Please refer to section 8.A of the RFR Technical Documentation https://eiopa.europa.eu/Publications/Standards/20180813_Technical%20Documentation%20%28RP%20methodology%20update%29.pdf

[11] Please refer to EIOPA Opinion on the supervisory assessment of internal models including a dynamic volatility adjustment https://eiopa.europa.eu/Publications/Opinions/2017-12-20%20EIOPA-BoS-17-366_Internal_model_DVA_Opinion.pdf

[12] Among the undertakings covered by this study, 11 don't use VA at all in their internal model calculations, 7 use the dynamic VA, and 4 use a constant VA.

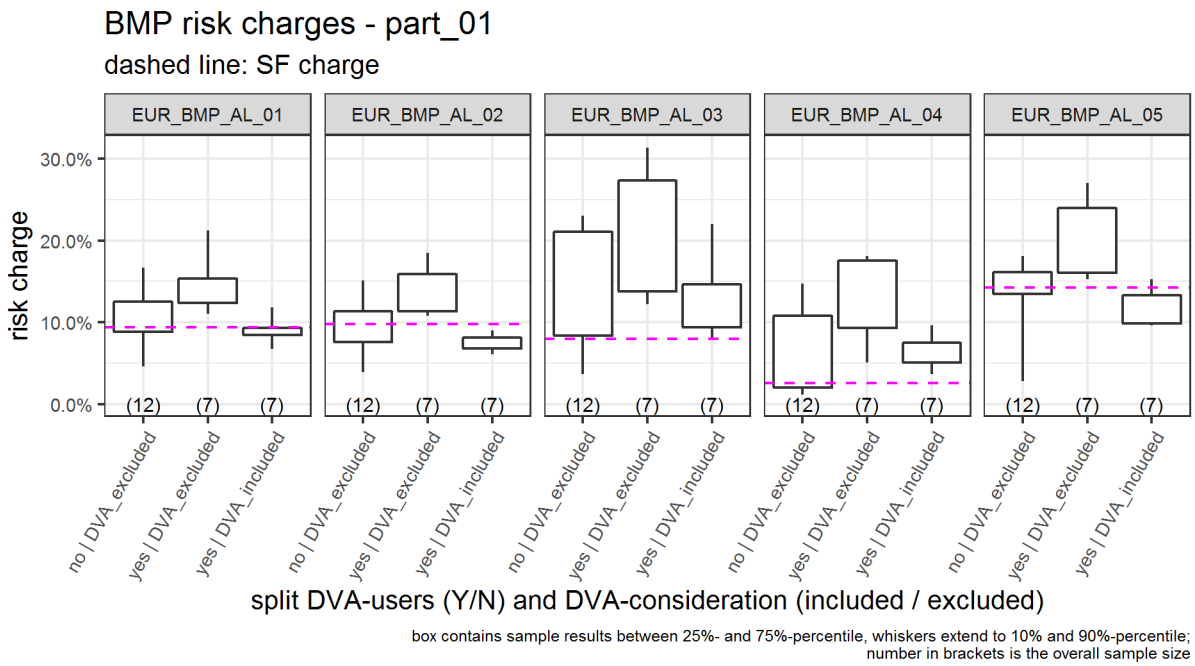

Figure 3: Risk charge for simplified asset-liability portfolios separately for non-dynamic VA users and for dynamic VA users (for these without and with dynamic VA impact)

The left-side box of each plot shows the risk charge for models not using the DVA, but for two of those a CVA effect. The right-side boxes convey the impact of activating the dynamic VA mechanism (for the models including DVA). Before activation, this group exhibits in general higher risk charges (see central boxes) than the group without DVA. Activation of the DVA reduces these to a level within the lower part of the leftmost group of undertakings. When looking at either the activated or 'non-activated' DVA, we generally see a lower variation of risk charges than in the group of undertakings not using the DVA.

As mentioned above the various A-L BMPs show different levels of variation. Excluding the DVA-effect for the DVA-users would increase this variability and move the whole boxes significantly upwards.

5.1.4. Asset-BMPs

The following graph displays the risk charges for the different asset-BMPs.

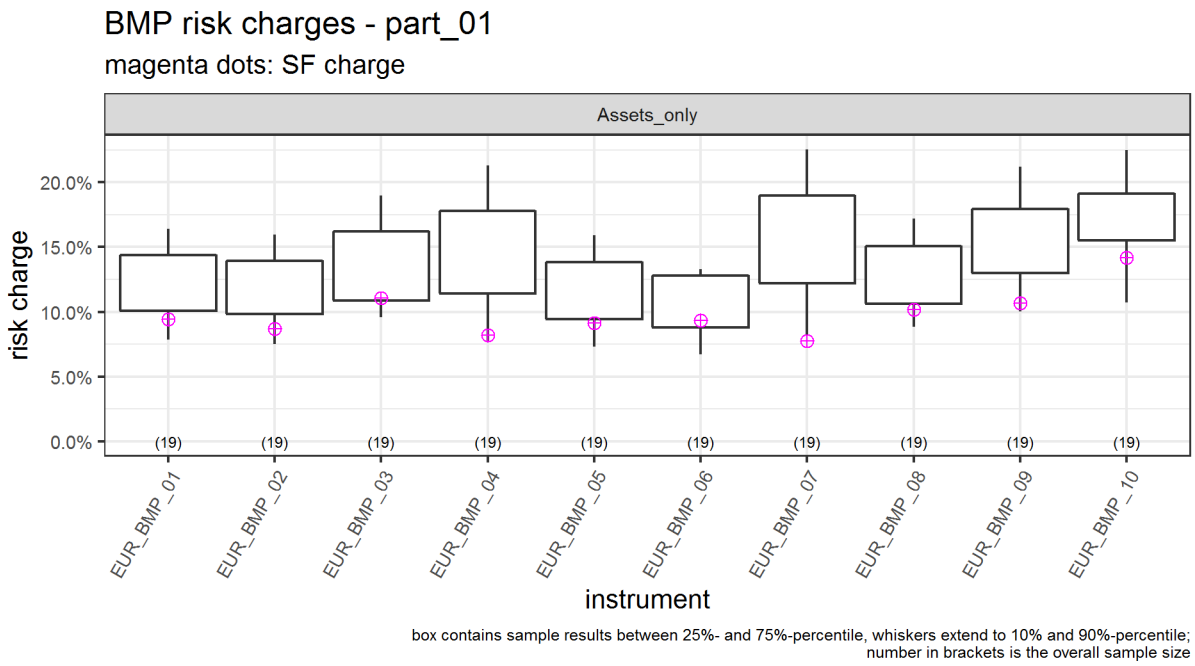

Figure 4: combined market & credit risk charges for asset benchmark portfolios

Figure 4 shows sizeable variations: but at the same time the risk charges give no indication of internal models producing – globally speaking – systematically lower risk charges compared to the standard formula. The IQR ranges from 4% to 7% (with a mean of 4.8%) and when excluding BMP 4 and BMP 7 from 4% to 5% (with a mean of 4.4%). The highest IQR (7%) is observed for BMP 7, the lowest IQR (4%) for BMP 10. In contrast to MCRCS 2017 the internal model risk charges for almost all asset-BMPs are significantly higher compared to the standard formula. This effect is to a large extent due to the reduced equity allocation in MCRCS 2018 compared to MCRCS 2017 and a consequently dominant weight of bonds. Especially, for sovereign bonds credit risks are generally reflected in internal models, in contrast to the standard formula[13].This is relevant for BMP 9 consisting purely of sovereign bonds, but also for BMPs 4 and 7 (albeit with higher variation for BMPs 4 and 7 than for BMP 9).

5.1.5. Liability-BMP (BMPL)

The BMPL was introduced in particular to analyse interest rate down movements, also in the combination of different maturities. Therefore, results and plots are consequently presented in section 5.2.1.

5.2. Drilling down

Despite the limitations in model comparison due to differences in model types (see section 4), certain facets of market & credit risk were analysed, especially interest rate risk, spread risk, equity and property risk, to support the analysis of benchmark

[13] All internal model results in this sub-section are purely related to the asset side, i.e. they do not include the risk-mitigating effect of the so-called 'dynamic volatility adjustment' which is applied by some undertakings. For details cf. previous sub-section.

portfolios (BMP) and their individual calibration. Additionally analyses on currencies different from the EUR as well as on derivatives are presented in this section.

5.2.1. Interest rates – risk free

Unlike the standard formula, interest rate risk in internal models does not only comprise two scenarios, up and down, but a large set of simulated variations (including a change in slope and curvature of the interest rate curve).

The starting risk free rate curves for these simulations in the liquid part are essentially identical across participants, but in one case differs in the extrapolated part, for which essentially 'flat extrapolation'[14] is used. Although the EIOPA risk free rate curve is used by all undertakings for the valuation of technical provisions, for this undertaking, the derivation of 'shocked curves' does not start from the EIOPA curve. Such a modelling choice is not considered to be per se critical: for certain assets and liabilities exposures only to the liquid part of the curve might be relevant to calculate the risk, in other cases the modelled variations are independent from the base curve or the same base curve is used for assets and liabilities, based on market information, consistent with the classification of risk in the risk management system.

Unlike the standard formula, all models allow for negative interest rates and also allow for shocks to negative rates.

When restricting the comparison to single maturities, a significant variability in shocks can be observed. But as interest curve movements in general are more complex, this observation will partly require re-assessment (see analysis on liability portfolio below).

The following graph illustrates the observed spectrum of marginal downward and upward shocks per term node in the sample for a EUR risk free rate:

[14] i.e. essentially constant spot or forward rate after the last liquid point.

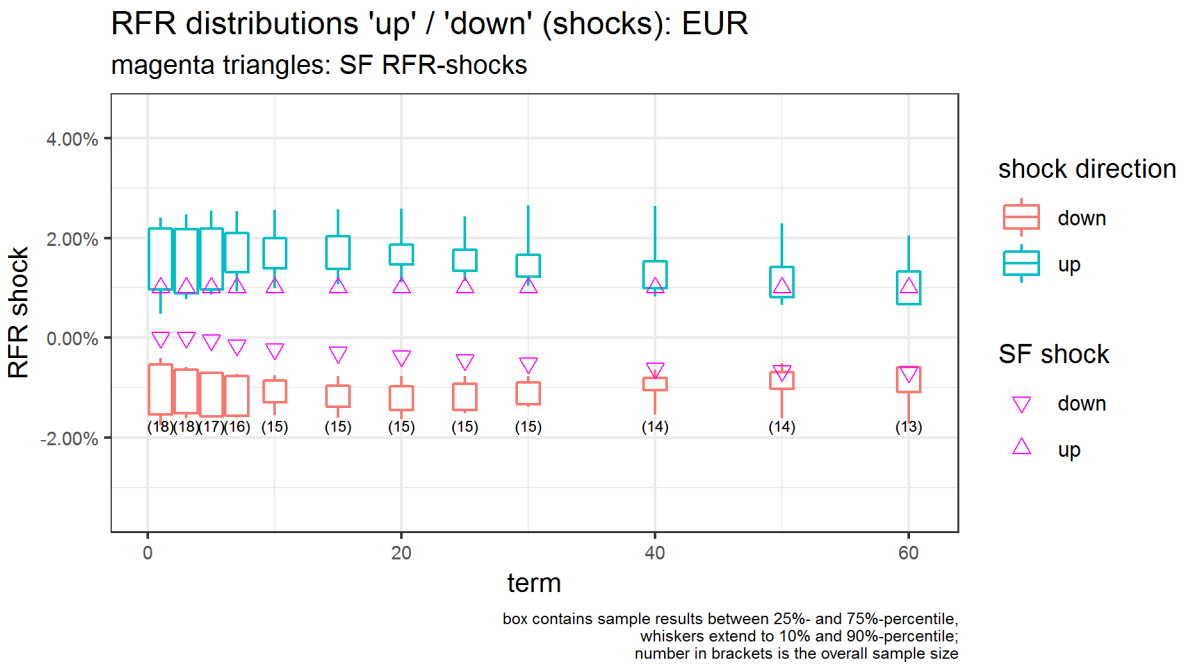

Figure 5: Downward and upward shocks on the spot rates for EUR risk free rates for single maturities (i.e. 'marginal' shocks on single nodes, not shocked curves) restricted to firms reporting an exposure

Figure 5 displays shocks on the initial spot rate[15] for selected maturities from the sample of participants. But please note that these shocks are marginal, i.e. in only one dimension. This differs from the shocks underlying the risk charges for BMPL presented below.

Figure 5 only depicts the results of those participants that stated at least some exposure, for the underlying zero coupon bond for the respective maturity. This means that the graph is based on the input for a varying numbers of participants (13 – 18) for the different maturities, also leading to varying number of participants included in the boxes and whiskers. It can be observed that the longer the underlying maturities the lesser participants report exposure.

Similar analysis has been carried out for GBP and USD, which is presented in section 5.2.4.

As stated, movements of yield curves are more complex than variations in single maturities. To further explore these aspects, the study comprises also a simplified portfolio of short positions in risk free instruments. This portfolio was derived from the cash flow profile and duration of the combined liabilities of all European insurers and can be thought of as a simplified and deterministic liability portfolio (cf. also section 0 Asset-Liability BMP). Evaluating this portfolio is a first step in analysing the characteristics of interest rate modelling beyond parallel shifts, although it only provides a global picture of the aggregated impact of the modelled rate curve shapes.

[15] Spot rates are derived from risk free zero coupon bonds by discrete compounding, e.g. for maturity T and currency ccy: $spot\ rate(ZCB^{rf}(T,ccy)) = \sqrt[T]{\frac{notional(ZCB^{rf}(T,ccy))}{value(ZCB^{rf}(T,ccy))}} - 1$. For the 'shock'-definition please cf. beginning of section 5.

The following graph shows, similarly to the BMPs, the relative risk charge:

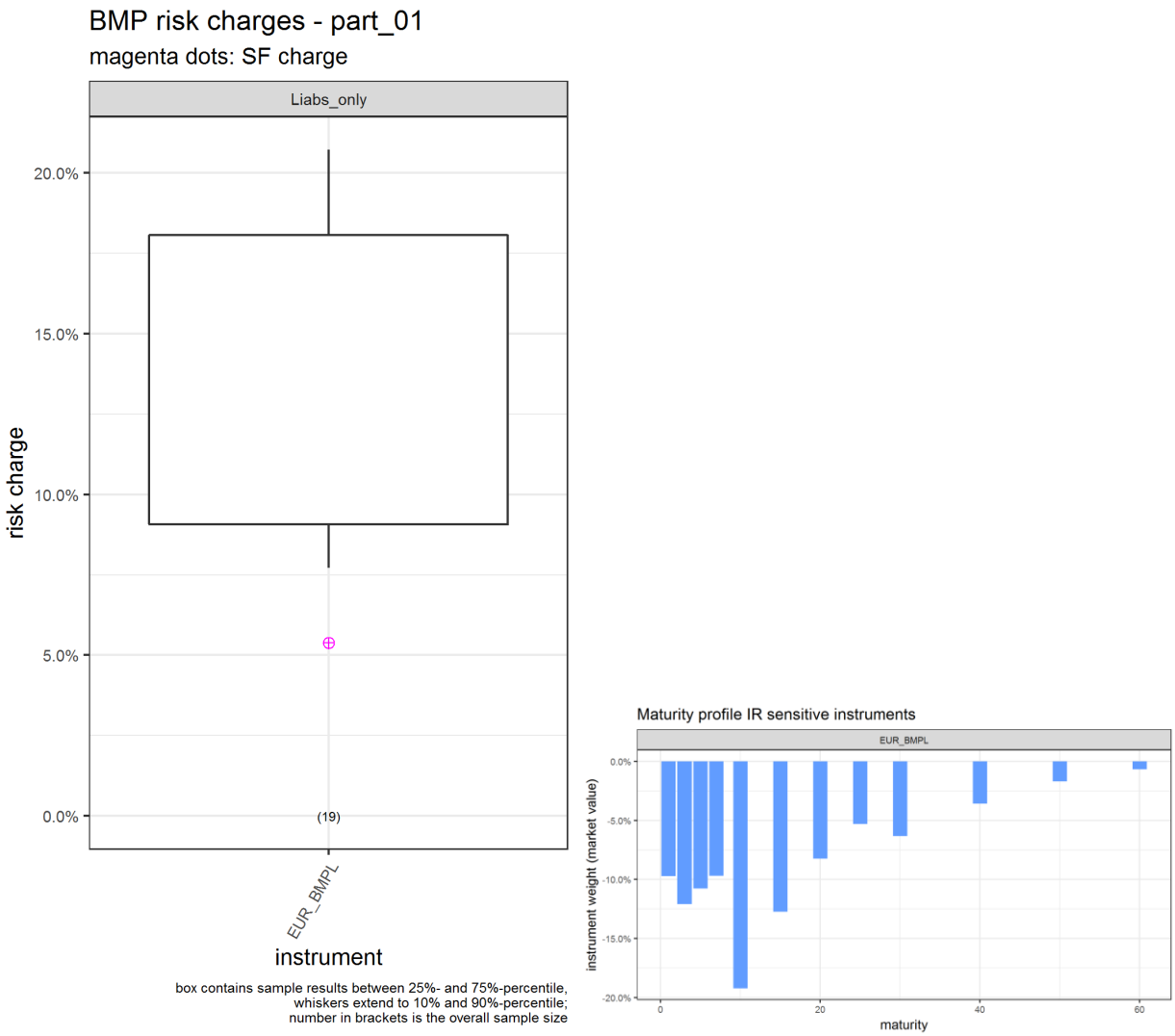

Figure 6: Risk charge and maturity profile for the simplified liability portfolio (short position in risk free rates, no options and guarantees)

The box shows that for 50% of this sample (comprised by the box, excluding the whiskers) the variation is 9% and for 80% of the sample it is 13%. The risk charges are significantly higher compared to the standard formula. As noted above, this is due to the fact that internal models reflect the current low interest rate environment more appropriately. It should also be noted that solely looking at an asset or liability portfolio does not allow capturing the impact of rate curve movements on the combination of assets and liabilities, as encountered in an undertaking's balance sheet.

5.2.2. Credit spreads on Corporates and Sovereign bonds

The study required participating undertakings to submit values on the modelled credit risk associated with a selection of synthetic corporate and sovereign bonds. Unlike the standard formula, credit risk for sovereign bonds is, in general, modelled by the participants.

The values of corporate bonds and sovereign bonds are driven by the overall risk-free interest rate level and by the instrument-specific credit risk. The study has been structured to enable these aspects to be differentiated.

However, analysis of the observed credit risk charges is complicated by the different model types encountered. In particular, model outputs for integrated models have generally covered all facets of credit risk while model outputs for modular approaches do not provide data on migration risk or default risk at the single instrument level.

The analysis of credit risk modelling focused on credit spread information which was derived from the data submissions[16]. Analyses have been grouped as follows:

Participating undertakings were combined into two groups: undertakings using an integrated modelling approach, for which instrument level data on credit spread risk, migration risk, and default risk is covered in one simulation; and, undertakings using a modular approach, for which the market module was used to provide instrument level data in general for credit spread risk only.

Corporate bonds were combined into three groups: financial; non-financial; and, supranational.

In the following analysis we have as mentioned before again excluded the subset of participants in the plots who reported no exposure towards the underlying bonds. Therefore the number of participants captured in the figures will again vary and be smaller than the whole sample.

Corporate Bonds

Data submitted by firms reveal certain risk factors which are important drivers of modelled credit risk charges and others which are not. Significant variation in firms' sensitivity to certain risk factors, such as bond credit ratings, were observed. Mixed treatments of bond issuers, bond durations, and bond security (covered or unsecured) were evident.

At the highest level, a variety of expected features were observed in the submitted data. Comparing across the groups of modelling approaches, credit risk charges at an instrument level were generally higher for those firms using an integrated approach ('case A', covering all facets of credit risk in an integrated simulation) versus those using a modular approach ('non-case A', for which only credit spread risk can be

[16] Credit spreads are calculated from the credit risky zero coupon bond values analogously to spot rates but subtracting the risk free portion from the yield.

For example, for maturity T and currency ccy:

$$credit\ spread(ZCB^{risky}(T,ccy)) = \sqrt[T]{\frac{notional(ZCB^{risky}(T,ccy))}{value(ZCB^{risky}(T,ccy))}} - spot\ rate(ZCB^{rf}(T,ccy)) - 1.$$

As, in general, quantiles from risk-free and risky instruments do not coincide, spreads are calculated on scenario-by-scenario data. This data includes market and credit risk for integrated modelling approaches and market risk for modular approaches. For the 'shock'-definition please cf. beginning of section 5.

analysed at an instrument level). Credit risk charges were also generally higher for bonds with lower credit ratings.

The following graph demonstrates the variation of modelled credit risk charges depending on the type and credit quality of 5-year financial corporate bonds. The variation increases materially as the credit rating underlying the bond decreases. The deviation becomes substantial for BB rated bonds. This demonstrates the variety of modelling assumptions being taken by firms, particularly for low rated bonds.

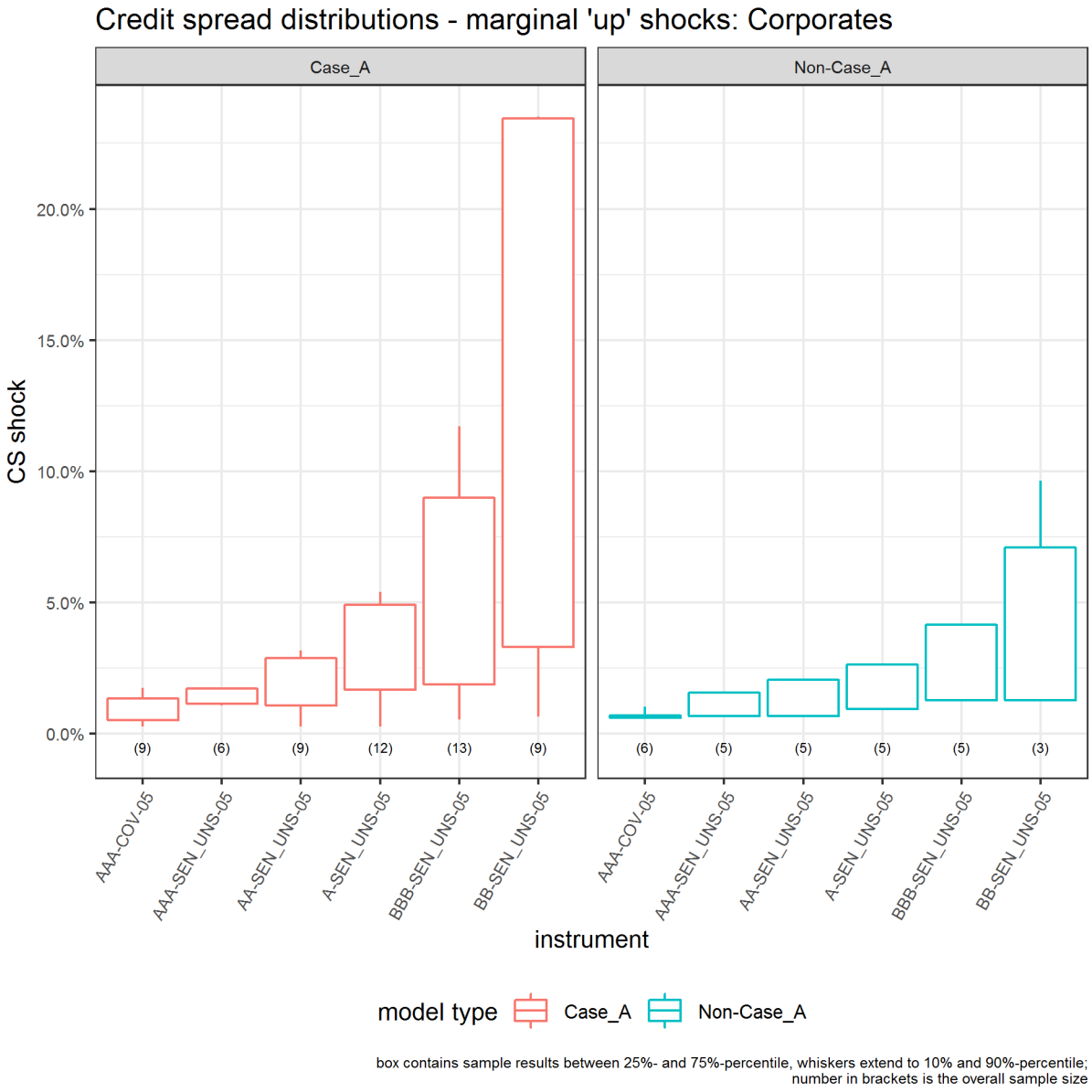

Figure 7: Credit spread marginal up shocks for financial corporates on instrument level: integrated approaches ('case A') with all facets of credit risk, modular approaches ('non-case A') without migration & default restricted to firms that reported exposure

Other notable features which were observed were as follows.

- Comparing 5Y and 10Y bonds, the differences in modelled credit spread shocks generally depended upon the modelling approach and the bond's credit rating:

    - For firms using a modular modelling approach, for which in general solely credit spread risk was analysed, modelled credit spread shocks were similar for 5Y and 10Y bonds across all credit ratings.
    - For firms with an integrated modelling approach, for which all facets of credit risk were analysed, modelled credit spread shocks were, on average, lower for 10Y bonds than for 5Y bonds. The difference was observed to become larger as the credit rating declined.
- For approximately one third of firms, models consistently produced higher credit risk charges for financial bonds than for the equivalent non-financial bonds. For the other firms, no appreciable difference was observed.
- For approximately one third of firms, models consistently produced a higher credit risk charge for senior unsecured bonds than for the equivalent covered bond. For a small number of firms, the models produced higher credit risk charges for the covered bonds, while no appreciable difference was observed for the remaining firms.

Finally, the study specified a benchmark portfolio, BMP 10, which comprised entirely the 23 specified corporate bonds. The portfolio had a weighted average duration of 7.6 years.

BMP 10 is further analysed in section 0. The results show a higher variation in model output for BMP 10 than for the single closest equivalent instrument. This is reasonable as section 0 analyses all sources of market and credit risk, whereas this here section has isolated only credit risk (specifically all facets of credit risk for integrated approaches and only credit spread risk for modular approaches).

Sovereign Bonds

Sovereign bond data showed relatively less variation in credit risk charges between firms with integrated approaches, covering all facets of credit risk, and those with modular approaches, covering only credit spread risk. This appears to demonstrate that credit risk for sovereign bonds is largely driven by pure spread risk, while default and migration risks are generally considered less relevant.

Credit risk charges showed relatively low variation for the bonds issued by Germany, Netherlands, Austria, France, and Belgium. Greater variation was observed for the bonds issued by Ireland, Portugal, Spain, and Italy. The following graph demonstrates this for 10 year bonds[17]. The graph is influenced by a small number of firms which showed unusually low credit risk shocks across the instruments which requires further investigation.

[17] For Portugal, only a 5 year bond was specified as part of the exercise and so the variation of modelling output for that issuer is not shown in the graph. A similar pattern was observed for 5 year bonds, with Portuguese bonds showing a similar variation to Irish, Spanish and Italian bonds.

By contrast, the standard formula does not introduce a credit risk charge for the sovereigns[18] which are examined in this study. We therefore omit any comparison to the standard formula in the analysis.

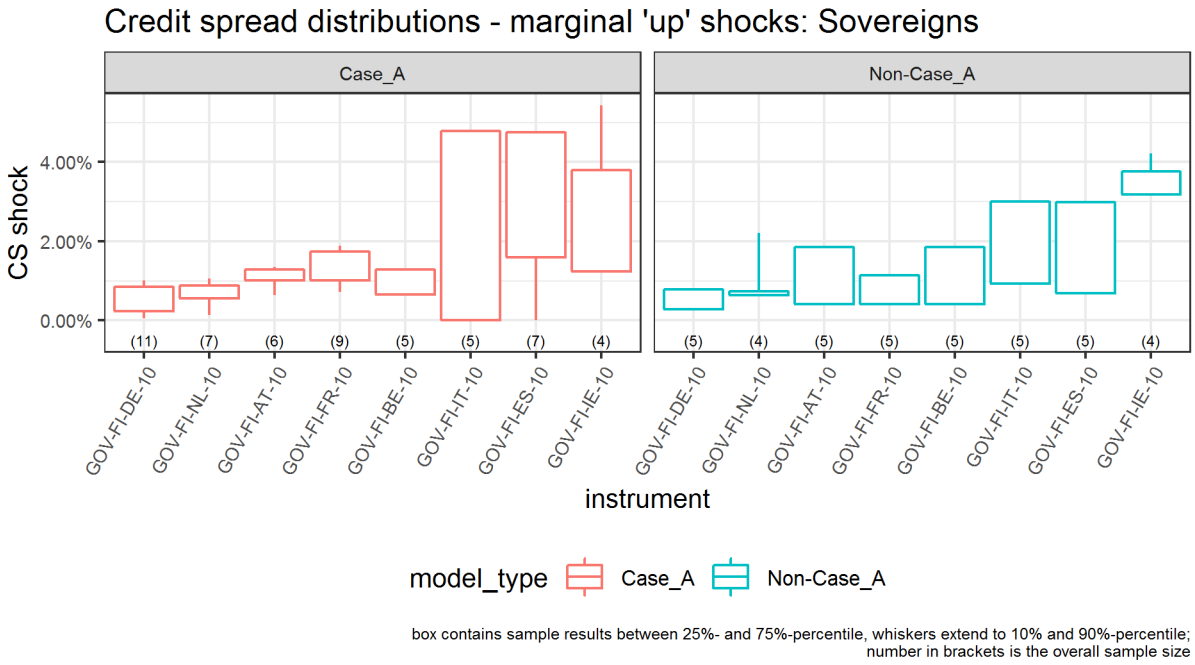

Figure 8 Credit spread marginal up shocks on instrument level for 10 year sovereign bonds across modelling approaches restricted to firms that reported exposure

Finally, the study specified a benchmark portfolio, BMP 09, which was comprised entirely of the 27 specified sovereign bonds with uniform weights. The portfolio had a weighted average duration of 10.9 years.

BMP 09 is further analysed in section 0. This shows a higher variation in model output for BMP 09 than for the single closest equivalent instrument. This is reasonable as section 0 analyses all sources of market and credit risk, whereas this section has isolated only credit risk (specifically all facets of credit risk for integrated approaches and only credit spread risk for modular approaches).

5.2.3. Equity and property

The study indicates that internal model firms apply a wider variation in risk charges for property risks when compared to equity risks. The study has also indicated that the undertakings' equity risk exposure is higher when compared to the property risk; and also the equity risk modelling is more sophisticated when compared to the property risk modelling.

Significant variation is also observed in the firms' assumed expected growth for the synthetic equity and property risks. This means that a degree of caution needs to be

[18] Note also that the standard formula keeps the volatility adjustment constant.

taken when interpreting the risk charge that is applied by an undertaking in its capital calculation (for example at the 99.5th percentile) and whether it appropriately reflects any adjustments firms might make for expected growth. The following analysis for equity risk and property risk is based on the "Modelled Value-at-Risk (mVaR)" information provided by the undertakings.

Equity risk

The study indicates that undertakings show less variation in the risk charges for the major equity indices such as EuroStoxx50, MSCI Europe, FTSE100 and S&P500, when compared to the risk charge applied to the instrument 'strategic insurance equity participation' (INSUR_PARTIC)[19].

There is also a relatively small difference between the variation in risk charges that is applied by an undertaking with either a higher or a lower[20] equity exposure.

The box plots below compare quartiles for each equity index for all the undertakings (on the left) and only for the undertakings that have higher exposure in a given synthetic equity risk (on the right).

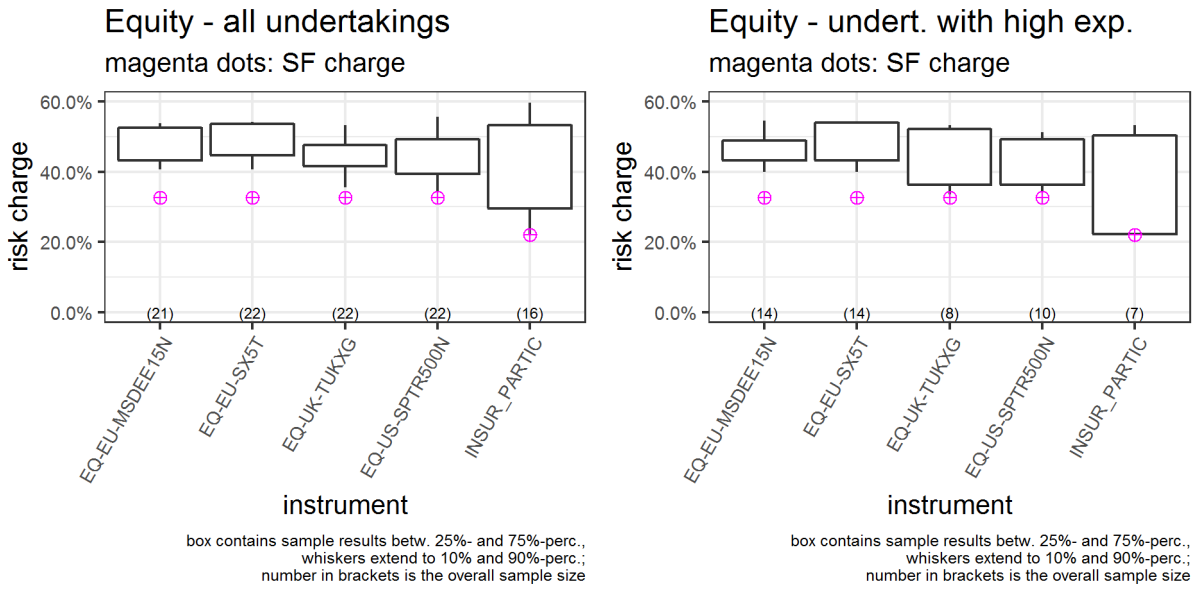

Figure 9: Risk charges for equity indices and participations for the overall sample (on the left) and for undertakings with higher exposure (on the right)

Property risk

[19] Strategic equity participation in a non-listed insurance entity.

[20] Higher exposure is defined as the undertakings that have reported exposure relevance score of 3 (medium exposure) or 4 (high exposure). Lower exposure is defined as the undertakings that have reported exposure relevance score of 1 (not relevant) or 2 (immaterial). Please note that these categories were intentionally not defined by concrete thresholds and thus will also reflect the participants' materiality concepts.

For the four commercial property risk metrics, the study indicates some differences in the variation in the risk charges that are applied by the participants with a higher exposure, when compared to the risk charges applied by all participants (i.e. including the undertakings with low exposures), in particular for UK and NL.

For the NL residential property risk metric, the risk charge applied by participants with higher exposure tends to be lower than that applied by all the participants. For the UK commercial property instrument the risk charge applied by participants with higher exposure tends to be higher than that applied by all the participants.

The box plots below compare quartiles for each property risk metric for all the undertakings (on the left) and only for the undertakings that have higher exposure (on the right) in a given synthetic property risk.

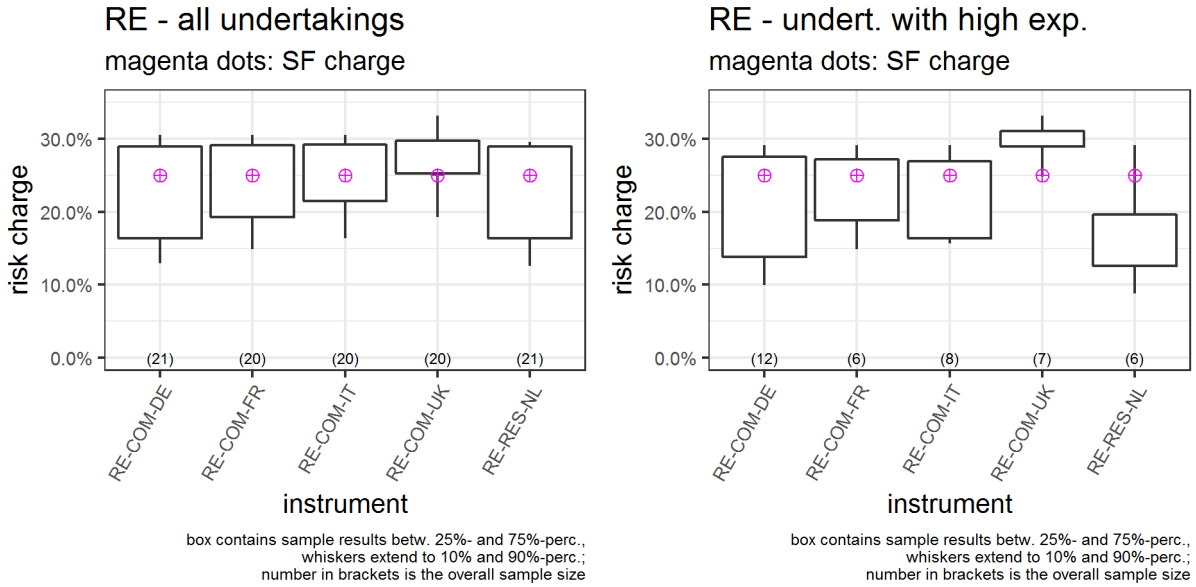

Figure 10: Risk charges for real estate for the overall sample (on the left) and for undertakings with higher exposure (on the right)

For certain asset categories, such as real estate, model calibrations might place more emphasis on the risk profile of the undertakings' actual investment portfolio and less on publicly available indices. Lower stresses compared to other participants or standard formula results can therefore also be an indication for a more defensive investment strategy of an undertaking in a particular asset class.

5.2.4. Other currencies

Although the BMPs do not include material parts of non-EUR currencies, the inspection of the respective modelling still is of general interest. As being the most material foreign currencies GBP and USD are in scope of this study. The following plots only include data from those firms that claim to have exposure towards these risk free rates or the respective exchange rates.

Regarding risk free rate, the dispersion of the term wise shocks is more pronounced than for EUR:

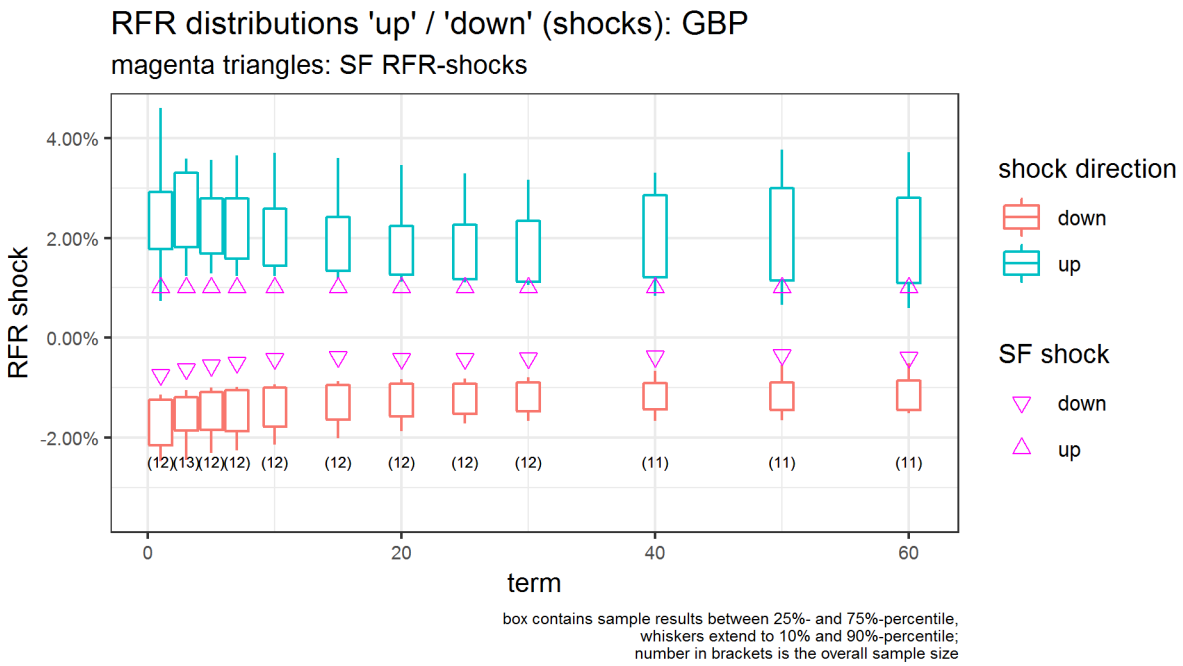

Figure 11 Downward and upward shocks on the spot rates for GBP risk free rates for single maturities (i.e. 'marginal' shocks on single nodes, not shocked curves) restricted to firms that reported exposure

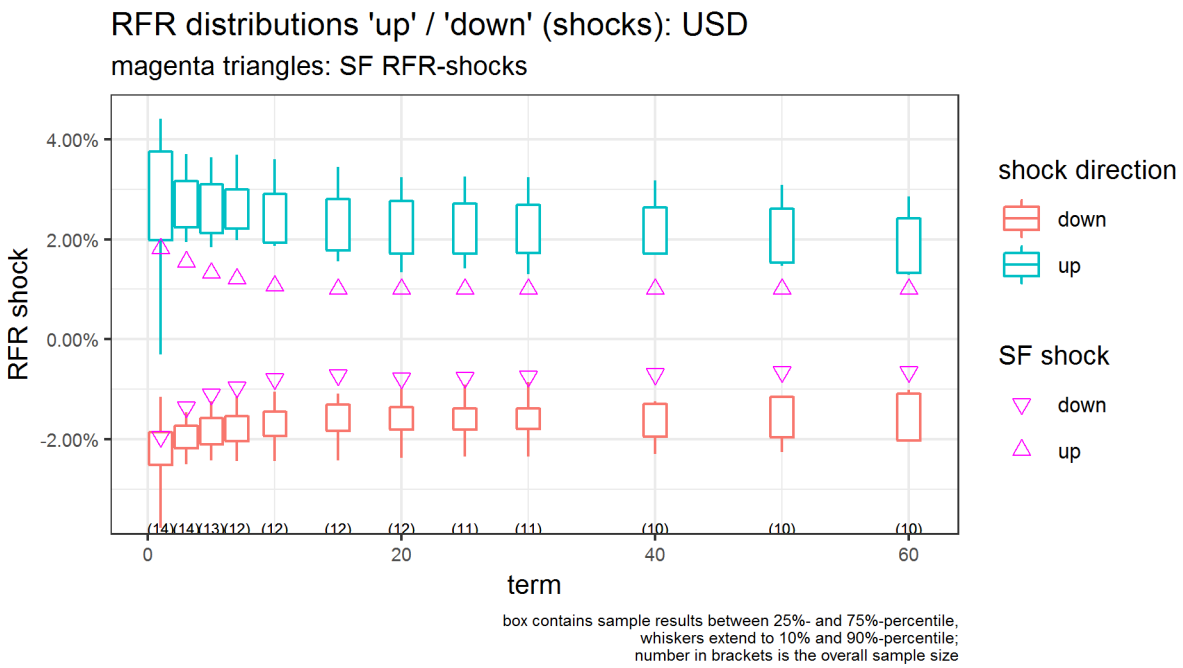

Figure 12: Downward and upward shocks on the spot rates for USD risk free rates for single maturities (i.e. 'marginal' shocks on single nodes, not shocked curves) restricted to firms that reported exposure

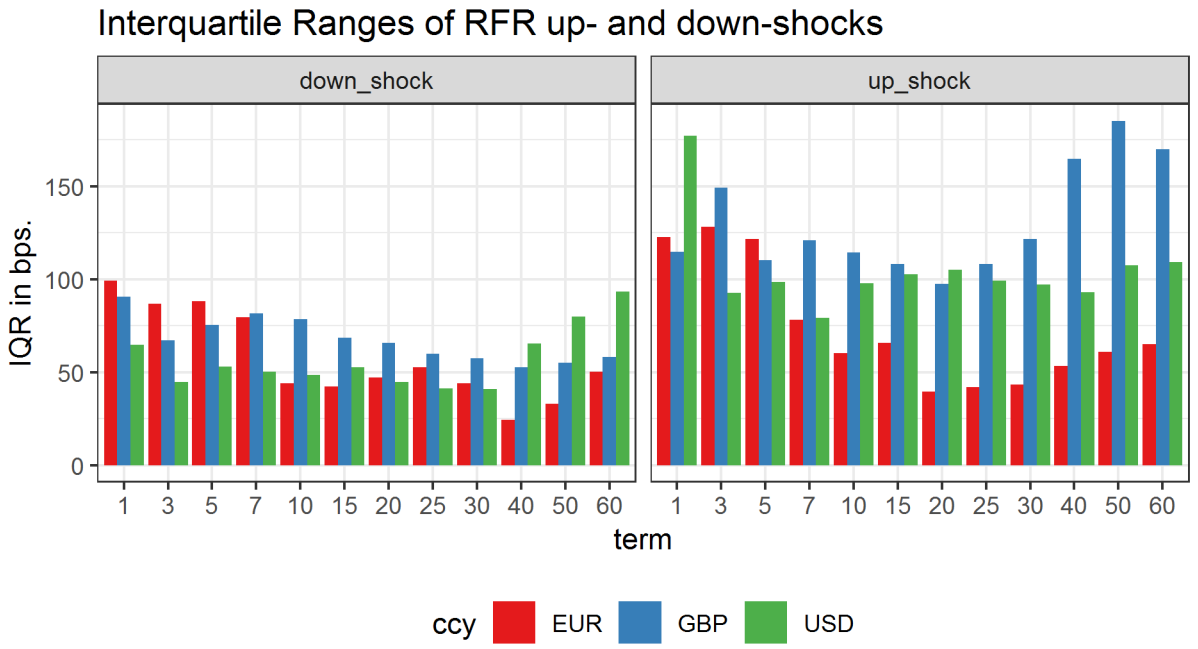

Figure 13: Length of the IQR in bps for the modelled RFR in EUR, GBP and USD for those firms that reported exposure.

The above figure shows the IQR of the modelled RFR for the three currencies included in the study. This range gives an indication of the variety of assumptions and beliefs towards the market used for modelling.

Overall it can be said, that for the down shocks there is a smaller variability per currency than for up shocks. In general the variability of GBP and USD is higher compared to EUR. Slight differences can be seen by maturity and currency. For the down shocks on the Euro RFR with short maturity there is a slightly larger IQR in bps than for GBP which is in turn again larger than for USD. It is worth noting that the EUR RFR level at year-end 2018 is significantly lower than for GBP and USD.

One potential reason for the lower EUR IQR for both up- and down-shocks is that many undertakings take into account the UFR-extrapolation mechanism in some way or another. In contrast to GBP and USD extrapolation, for EUR it already starts from year 20.

Another aspect when looking at the risk stemming from investment in different currencies, is looking at the modelled exchange rate. Figure 14 shows upwards and downwards shocks of the exchange rate instruments collected in the study on the EUR/GBP and EUR/USD exchange rates. It can be observed that the variability of the shocks across undertakings is limited and in a similar range than the standard formula.

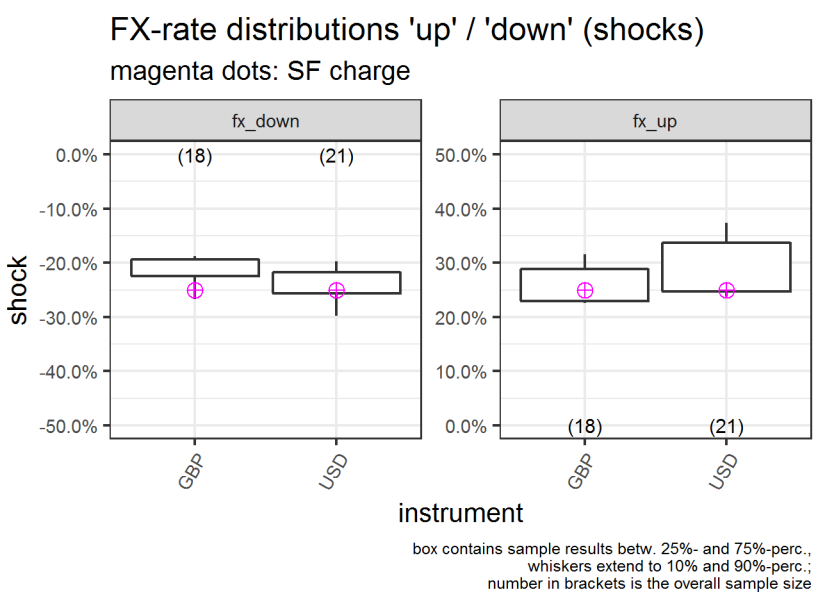

Figure 14: Risk charge for Exchange rates for firms that reported exposure

5.2.5. Derivatives

Overview

The study request also comprised four standardized derivative instruments: one 5 year at-the-money European equity put (EuroStoxx 50) and three European at-the-money EUR-receiver swaptions with term-/tenor-combinations of 1/10, 10/10 and 20/20 years.[21]

The chosen derivative instruments can be considered as rather standard products and almost all participants apply common market-standard valuation models within their internal models (e.g. Black-Scholes for the equity put). Regarding the implied volatility convention / pricing model for the swaptions a large majority of undertakings adopt a 'Normal / Bachelier'-approach. Three undertakings use a 'Lognormal / Black76'-valuation approach which had been common market-practice before interest rates moved permanently into low and negative territory.

10 participants assigned an exposure relevance score of at least 2 to these instruments, i.e. indicating at least an immaterial exposure. From the point of view of 'invested assets' these exposures are of limited materiality compared to the other asset classes and they are therefore not included in the benchmark portfolios (although it should be noted that equity put options are a common instrument for hedging the downside-risk of equity exposures on an undertaking's balance-sheet).

However, the relevance of these instruments also needs to be assessed in the context of valuing Technical Provisions of traditional life-business, in particular their embedded options and guarantees. Life insurance products often contain embedded options in the

[21] A receiver swaption gives the holder of the swaption the right but not the obligation to enter into an interest rate swap where he/she receives the fixed leg and pays the floating leg.

form of profit sharing and guaranteed returns on premiums deposited by the customer. From a market-consistent valuation perspective the costs of these options and guarantees depend, among other things on the level of 'implied volatility'.[22] A significant part of the undertakings' exposure to the risk category 'implied volatility' relates to these embedded options and guarantees. Internal models aim to capture the dynamics of this valuation-parameter over a one-year horizon and this section provides some insights about these dynamics.

Regarding the initial valuation of the instruments (t=0) most of the values provided by undertakings are in a comparable range and close to mark-to-model prices observed at a third party market data provider. This does not completely hold for the 20/20-swaption where undertakings have applied different valuation approaches. Most likely this is due to the fact that the relevant part of the yield curve for this swaption is in the extrapolated part of the EIOPA risk free rate where deviations to the market-curve (swap) are more pronounced.

Results risk factor 'implied volatility'

The valuation of derivatives depends on several variables entering simultaneously into the pricing functions. Some of them have already been covered in other sections of this report (cf. sections 5.2.1 and 5.2.3) and therefore the following results are not based on 'risk charges'. Instead, the focus is on the dynamics of the risk factor 'implied volatility' over a one-year horizon in the internal models.

Depending on the direction of the derivatives exposure - i.e. 'long' vs. 'short' - an undertaking can be exposed to both an increase and decrease of the risk factor implied volatility. Therefore the following graph displays the 0.50%-down and 99.50%-up percentiles of absolute changes in implied volatility. Considering the overall sample size for the 10/10-swaption only the summary results from the subset of participants using a 'normal implied volatility' convention is displayed. It is worth noting that implied volatility is not part of the Standard Formula risk framework and therefore no comparisons to the Standard Formula are provided here. By and large these extreme percentiles for this risk factor are in a comparable range for both instruments (the observed implied volatilities at year-end 2018 were approx. 16% for the EQ-Put and 64 Bps. for the 10/10-swaption).

[22] In contrast to other pricing-relevant parameters this is not directly observable but implicit in the observed market price of the option and usually derived via market-standard pricing models.

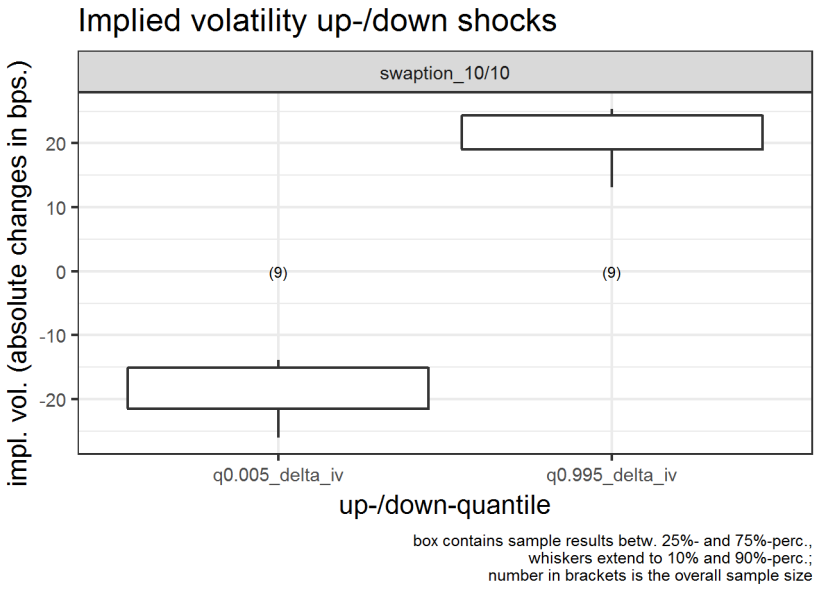

Figure 15: Risk factor 10/10-swaption implied volatility absolute changes down (0.50%-percentile) and up (99.50%-percentile)

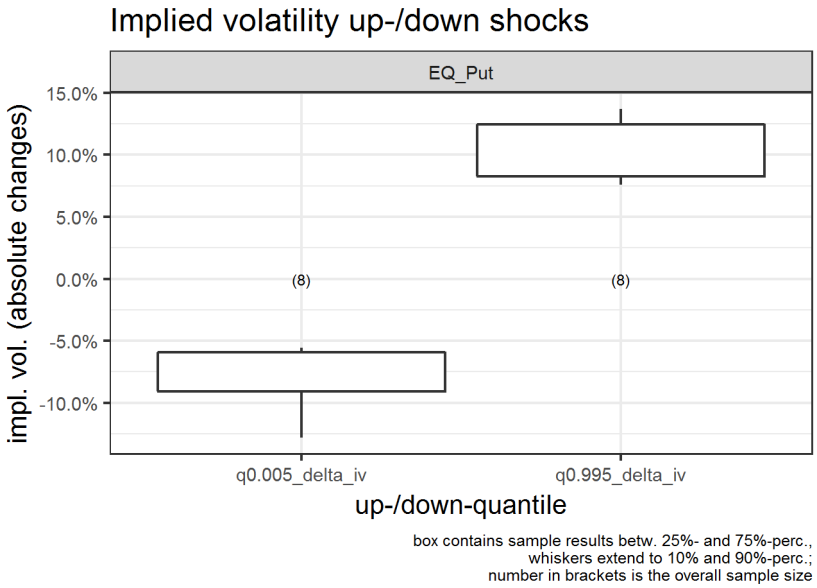

Figure 16: Risk factor equity implied volatility absolute changes down (0.50%-percentile) and up (99.50%-percentile)

5.3. Supervisory follow-up

As with last studies, the responsible NCAs have been provided with tailored feedback packages which go beyond the global image outlined in this report and enable them to discuss and challenge the participating undertakings.

Three examples of topics being discussed and challenged: (i) Even though there has been an improvement in the data and modelling quality for interest rates, there remain some open aspects. Some extreme shocks, as well as some irregularities in the model output, have been identified especially for long maturities and will be followed up on.

(ii) Certain data is still missing from the submission of single participants. Discussions will take place in order to be able to include them in the next study, if possible under the model setup. (iii) For credit spread risk some undertakings showed very low risk charges. Further supervisory inspections will be performed.

Also, the interactions with the undertakings comprise aspects of data quality and improvements of the coverage of single submissions. The undertakings were additionally asked to provide written feedback on the results and their evaluation of these. Furthermore, the NCAs' feedback on the set-up of the study itself and potential future improvements was collected. The outlook for the next edition of this study can be found in the next section.

In this year's study, one undertaking was identified with exceptionally low risk charges for the risk free interest rates. This aspect was confirmed by the respective NCA as a result of an input error made in the official calibration. The process bug has been fixed in the meantime, therefore we expect to see an improvement on this in next year's study.
The continuous engagement between NCAs and undertakings will allow the project group to enhance the annual MCRCS analyses throughout the next editions, thereby fostering a positive dynamic to further support on-going internal model supervision. At the level of each individual undertaking, this will concretely be achieved in conjunction with its NCA's Supervisory Review Process. Therefore responsible group supervisors are encouraged to inform about the study and discuss relevant insights with the supervisory authorities concerned.

6. Outlook

Following EIOPA's decision[2] to perform the MCRCS annually there will again be a study on year-end 2019 data.

The year-end 2018 edition of the study was built on the lessons learnt from the previous editions and again focused on risk charges for benchmark portfolios under the combined market and credit risk. To enhance the analysis of combined risks, the tools were again refined. Specifically, to enrich the spectrum of analyses, the study also explored a larger number of simplified asset-liability-portfolios, i.e. further asset portfolios combined with a simplified liabilities portfolio consisting of short positions in zero coupon bonds. This was used to further explore interest rate down shocks and impacts from the dynamic volatility adjustment. The study, as the previous one, relied on synthetic assets instead of real assets, aiming to remain, to a large extent, stable in order to support comparison over time and limit the effort of execution for participants. The use of qualitative scores for the test assets, indicating both the modelling quality and exposure relevance of the respective asset, was extended. As indicated in the MCRCS year-end 2017 report, this year the study included a deeper look into foreign currencies and a new analysis on extended derivatives data collected the first time this year.

The data requested for future studies, and in particular the next "year-end 2019" edition will follow, as closely as possible, the scope and extent of the current data request. However, EIOPA plans to put a focus on the modelling of interest rates, broaden the analysis of derivatives and include an analysis of dependency modelling within market and credit risk.

7. Annexes

7.1. Annex 1: Composition of the asset benchmark portfolios

Benchmark portfolios /	Euro currency	BE	DE	ES	FR	IE	IT	NL	SOV	CORP
\ Type of instrument	EUR_BMP_01	EUR_BMP_02	EUR_BMP_03	EUR_BMP_04	EUR_BMP_05	EUR_BMP_06	EUR_BMP_07	EUR_BMP_08	EUR_BMP_09	EUR_BMP_10
Financial instruments	89.28%	91.72%	90.08%	92.59%	86.54%	89.51%	93.99%	92.13%	100.00%	100.00%
CORPORATES	49.61%	40.77%	60.28%	33.13%	44.82%	43.56%	31.25%	48.65%	0.00%	100.00%
ESM	2.38%	0.51%	3.71%	0.97%	2.35%	0.40%	0.57%	2.64%	0.00%	4.35%
Other CORP	47.23%	40.26%	56.58%	32.16%	42.46%	43.16%	30.68%	46.02%	0.00%	95.65%
A	15.33%	12.17%	13.43%	9.34%	16.22%	14.19%	6.04%	15.61%	0.00%	17.39%
AA	9.37%	7.60%	11.67%	4.13%	8.70%	8.91%	2.37%	7.66%	0.00%	17.39%
AAA	7.63%	6.86%	19.47%	1.94%	4.23%	6.25%	0.49%	5.77%	0.00%	26.09%
BB	1.57%	0.74%	2.75%	1.61%	1.11%	2.17%	2.61%	0.91%	0.00%	17.39%
BBB	13.33%	12.89%	9.26%	15.14%	12.20%	11.65%	19.18%	16.07%	0.00%	17.39%
GOVERNMENTS	39.67%	50.95%	29.80%	59.46%	41.72%	45.95%	62.73%	43.48%	100.00%	0.00%
AT	1.62%	2.06%	2.64%	0.26%	1.61%	1.45%	0.24%	3.22%	11.11%	0.00%
BE	3.24%	33.21%	2.21%	0.59%	2.36%	1.97%	0.45%	3.00%	11.11%	0.00%
DE	5.55%	2.09%	14.02%	0.55%	0.87%	4.69%	0.85%	11.91%	11.11%	0.00%
ES	3.99%	1.95%	1.78%	52.14%	2.43%	2.89%	3.05%	1.39%	11.11%	0.00%
FR	11.99%	6.19%	3.96%	0.58%	29.18%	5.15%	0.93%	6.17%	11.11%	0.00%
IE	0.41%	1.09%	0.53%	0.33%	0.55%	4.51%	0.39%	0.87%	11.11%	0.00%
IT	9.59%	3.16%	1.77%	4.06%	3.96%	11.60%	55.95%	1.28%	11.11%	0.00%
NL	2.04%	0.55%	1.06%	0.16%	0.42%	1.42%	0.26%	15.01%	11.11%	0.00%
PT	0.40%	0.22%	0.08%	0.59%	0.23%	0.45%	0.14%	0.01%	3.70%	0.00%
UK	0.28%	0.04%	0.45%	0.00%	0.07%	6.02%	0.05%	0.28%	3.70%	0.00%
US	0.57%	0.38%	1.30%	0.20%	0.05%	5.79%	0.42%	0.33%	3.70%	0.00%
Risk Free Rates	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Equity	6.72%	4.28%	6.42%	3.41%	8.96%	6.49%	3.51%	4.27%	0.00%	0.00%
Real Estate	4.00%	4.00%	3.50%	4.00%	4.50%	4.00%	2.50%	3.60%	0.00%	0.00%
Commercial	3.20%	3.20%	2.80%	3.20%	3.60%	3.20%	2.20%	2.00%	0.00%	0.00%
Residential	0.80%	0.80%	0.70%	0.80%	0.90%	0.80%	0.30%	1.60%	0.00%	0.00%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

7.2. Annex 2: Composition of the liability and asset-liability benchmark portfolios

Benchmark portfolios / \ Type of instrument	Liabilities EUR_BMPL	Asset & Liab (1) EUR_BMP_AL_01	Asset & Liab (2) EUR_BMP_AL_02	Asset & Liab (3) EUR_BMP_AL_03	Asset & Liab (4) EUR_BMP_AL_04	Asset & Liab (5) EUR_BMP_AL_05
Financial instruments	0.00%	47.74%	48.17%	50.26%	53.47%	53.47%
CORPORATES	0.00%	26.52%	32.23%	16.71%	0.00%	53.47%
ESM	0.00%	1.27%	1.98%	0.31%	0.00%	2.32%
Other CORP	0.00%	25.25%	30.25%	16.41%	0.00%	51.15%
A	0.00%	8.20%	7.18%	3.23%	0.00%	9.30%
AA	0.00%	5.01%	6.24%	1.27%	0.00%	9.30%
AAA	0.00%	4.08%	10.41%	0.26%	0.00%	13.95%
BB	0.00%	0.84%	1.47%	1.39%	0.00%	9.30%
BBB	0.00%	7.13%	4.95%	10.26%	0.00%	9.30%
GOVERNMENTS	0.00%	21.21%	15.93%	33.54%	53.47%	0.00%
AT	0.00%	0.87%	1.41%	0.13%	5.94%	0.00%
BE	0.00%	1.73%	1.18%	0.24%	5.94%	0.00%
DE	0.00%	2.97%	7.50%	0.46%	5.94%	0.00%
ES	0.00%	2.13%	0.95%	1.63%	5.94%	0.00%
FR	0.00%	6.41%	2.12%	0.50%	5.94%	0.00%
IE	0.00%	0.22%	0.28%	0.21%	5.94%	0.00%
IT	0.00%	5.13%	0.95%	29.92%	5.94%	0.00%
NL	0.00%	1.09%	0.57%	0.14%	5.94%	0.00%
PT	0.00%	0.21%	0.04%	0.07%	1.98%	0.00%
UK	0.00%	0.15%	0.24%	0.03%	1.98%	0.00%
US	0.00%	0.31%	0.70%	0.23%	1.98%	0.00%
Risk Free Rates	100.00%	46.53%	46.53%	46.53%	46.53%	46.53%
Equity	0.00%	3.60%	3.43%	1.88%	0.00%	0.00%
Real Estate	0.00%	2.14%	1.87%	1.34%	0.00%	0.00%
Commercial	0.00%	1.71%	1.50%	1.18%	0.00%	0.00%
Residential	0.00%	0.43%	0.37%	0.16%	0.00%	0.00%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%