YE2019 COMPARATIVE STUDY ON MARKET AND CREDIT RISK MODELLING

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European Insurance and Occupational Pensions Authority

Print	ISBN 978-92-9473-291-0		doi:10.2854/36194	EI-AQ-21-001-EN-C
PDF	ISBN 978-92-9473-290-3	ISSN 2600-2884	doi:10.2854/38049	EI-AQ-21-001-EN-N

Luxembourg: Publications Office of the European Union, 2021

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CONTENTS

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 at the 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 foster common supervisory practices.

This report summarises the key findings from the market and credit risk comparative study (MCRCS) undertaken in 2020 based on year-end 2019 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 the corresponding foreign exchange rate indices. The 21 participants from 8 different Member States cover close to 100% of the EUR investments held by all undertakings with an approved internal model covering market and credit risk in the EEA (excluding UK).

It is important to note that the study focuses on drivers of the value of investments, but does not aim to cover the overall SCR. In particular, specific undertakings' risk profiles, the dependency effects between market & credit risk and other risks, 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 regard 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.

As in past editions, the overall results continue to show significant variations in asset model outputs, which could be partly attributable to model and business specificities already

[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)

known by the relevant NCAs, but also indicate a certain need for further supervisory scrutiny.

In March 2020, the COVID-19 crisis became a global pandemic and turned from a health event into a crisis which quickly spread to other sectors, including the financial sector. The MCRCS started to evaluate effects on the modelling of market and credit risk, but analysis will be on-going. A first attempt is documented as a comparison of model outcomes against historical experience. Summarising this analysis, it can be said that the COVID-19 related market impacts are significant, but no immediate conclusions can be drawn regarding a potentially inappropriate model behaviour under such circumstances.

This report is part of an ongoing process of monitoring and comparing internal market and credit risk models. Refinements and enhancements are a regular and important part of the studies and are expected to continue. The results, tools and experience will be feeding into 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.

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 with 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 mitigating 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

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 to ensure that reliable conclusions can be drawn. In that spirit, this report mainly presents results under 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 sample achieves nearly full coverage from a statistical point of view, the sample size (with 21 participants) is not large – and will remain so in the short term at least. Furthermore, some benchmark assets are not relevant or not material for certain participants. This in part led to the consideration of model outcomes of lower quality, causing distortions in some of the results, which is mitigated by an enhanced use of the 'relevance scores' provided by the participants.

A small number of participants had issues with providing the requested data in time and with sufficient quality. The situation has improved compared to the last edition and the participating NCAs will engage with these participants to further remedy this issue in the next one.

For this edition, participants were also asked about the consideration of sustainability in their modelling approach. Of 21 participants in the study, only one explicitly uses a taxonomy in its model.

MAIN QUANTITATIVE RESULTS

For the combined market and credit risk charge, i.e. relative loss in value at the level of benchmark portfolios, some results show a sizeable variation between undertakings. In that respect, as a regular practice, supervisors engage 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. These results are influenced by firms which show zero or low credit risk shocks across the instruments.

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.

An analysis of dependency structures was performed for the first time and leads to observations which will be taken up in further work and need further scrutiny; see section 5.2.6.

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 the consistency of supervisory approaches. The next study will enrich the spectrum of analysis, as described in section 6.

2. OBJECTIVES OF THE STUDY

Market and credit risk contribute significantly to the solvency capital requirement (SCR) of insurance undertakings and are also of material importance for the majority of internal model undertakings. Consequently, the EIOPA Board of Supervisors at the beginning of 2018 decided 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. 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 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 foster common supervisory practices.

The principal objective of the year-end 2019 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 internal models and foster the 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 instruments provides a stable comparison point over time which is combined with an 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 regard 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 Value at Risk (99.5%, one year horizon) and the provided market value of the portfolio (this metric is called ‘risk charge’).

ii. Highlighting the causes of 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.).

Following the conclusions of the previous study and the low yield environment, special attention has been given to models used for interest rates and their outcomes on the valuation of the portfolios. The objective was to get an overview of modelling choices related to interest rates.

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, as the latter especially considers 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 NCAs responsible ('participating NCAs') including first checks.

The project group processed the answers from the undertakings and performed thorough data quality and sense checks, with the aim of ensuring 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 process the data submitted by undertakings and to carry out the analysis of the benchmark portfolios and individual instruments. These tools mainly consist of a programme written with the open source language R. This programme allows the data from different participants to be aggregated 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 analysis and visual exploration.

In comparison to the previous studies, an additional qualitative questionnaire was prepared to understand the specifics of the participants' interest rate models, which was filled in by the participating NCAs. In a one-time activity, the evaluation of the answers from this questionnaire led to a deeper understanding of the respective model approaches in the project group, also taking into account potential connections between the approaches and the delivered data. As a result, the project group set up a document to use in the future, should questions on approaches to interest rate modelling arise.

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 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 models 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 enable 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 is defined in this study 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.

The data collected are 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 may differ from the 99.5% sample quantile on the simulated asset values, due to the statistical estimator and, for instance, to the inclusion of interpolation or smoothing schemes. Participants were expected to provide an assessment of the relevance of each instrument for their own exposure, as well as in terms of modelling quality. This was supplemented by data on their own asset portfolio, 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 participants address concentration implicitly through the correlation matrix used in Monte-Carlo simulations or, less commonly, through concentration thresholds defined by the company in a specific policy. Some undertakings add an 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 are typically uniform, the 21 participants from 8 Member States are mainly international insurance groups with an approved internal model at group level, covering market and credit risk, and with significant EUR exposure. The EUR investments (excluding unit-linked assets) of participants amount to 100% of the total EUR investments[3] of EEA internal model undertakings (without UK) fulfilling these criteria. The total assets of participants amount to 35.9% of total EEA assets (without UK).

3 Based on data submitted by EEA undertakings (excluding UK) as of year-end 2019.

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 and '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).

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

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

Furthermore, credit modules 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 combined market and credit risk level for portfolios.

With regard to the one-year time horizon required for Solvency II, two different approaches broadly exist: fifteen participants apply 'instantaneous shock models' on their Solvency II balance sheet. Five[4] participants model the evolution of the balance sheet over the following year explicitly by taking into account 'ageing effects' (for example, the remaining maturity of a bond is reduced by one year) for market and credit risk. One participant models 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 it could deviate from a simple quantile estimator[5].

Regarding the use of the volatility adjustment (VA), nine participants do not use the VA, three participants keep the VA constant in the simulations and nine participants anticipate changes in the VA in line with the modelled credit spreads ('Dynamic VA', see also section 5.1.3).

Furthermore, the qualitative scores collected from undertakings to indicate exposure relevance showed that certain selected 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.

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[4] These five participants apply adjustments to their models for the purpose of the study 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.

[5] 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.

SUSTAINABILITY CRITERIA

For this edition, participants were also asked about the consideration of sustainability[6] in their modelling approach. Only one participant (over 21) indicated to be using a taxonomy[7] of sustainable economic activities (for assets) in its internal model. Although the remaining participants do not use a taxonomy for sustainable activities in their internal model, 6 of them indicated to have developed (or to be in the process of developing) such taxonomies.

LIMITATIONS

Although the coverage of the study is very high in terms of exposure to EUR-denominated investments, from a statistical point of view the sample is not large, as it includes 21 participants only.

Regarding credit risk, the number of instruments and issuers could still be considered low for exploring portfolio models, but it 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 also includes an analysis that is extended to more realistic asset-liability exposures. Since the liability side is represented by a very simplified set of negative zero-coupon bonds, 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 in 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 between the business and investment profiles of the participants, the results of the study should not be considered as a calibration target.

6 The concept of sustainability encompasses environmental issues that relate to the quality and functioning of the natural **E**nvironment and natural systems, **S**ocial issues that relate to the rights, well-being and interests of people and communities and **G**overnance issues that relate to the governance of companies. This is also known as 'ESG' risks and factors.

7 To define whether an economic activity substantially contributes to environmental or social objectives, and hence whether investing in the activity is sustainable, the European Commission is developing a taxonomy, i.e. a classification system for sustainable activities. Technical screening criteria will allow, for example, the definition of economic activities that can make a substantial contribution to climate change mitigation or adaptation, while avoiding significant harm to four other environmental objectives: sustainable use and protection of water and marine resources, transition to a circular economy, pollution prevention control, and protection and restoration of biodiversity and ecosystems. Other screening criteria will apply to define activities that contribute to social objectives. See: https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en#delegated

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 on a one-year horizon ("mVaR[8]) not taking into account effects from liabilities or tax, for instance. Therefore, it can be concluded that the findings of this report refer to the calibration of the models and not to the actual risk profiles of the undertakings.

Section 5.2 below 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 the '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 see footnotes 19 and 20.
>
> 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 0.5% and 99.5% quantiles for two-sided risk factors and the 99.5% quantile for one-sided risk factors, respectively.

[8] The mVaR may 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.

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 synthetic fixed income, equity and real estate instruments ('asset-BMPs').

In order to extend the analysis to a more realistic asset-liability perspective, some of these asset-BMPs were combined with two very simplified portfolios of liabilities in form of risk-free zero coupon bond short positions ('BMPLs') with different durations. 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'). The different liability portfolio durations result in different hypothetical asset-liability duration gaps. Additionally the simplified liabilities were valued with and without Volatility Adjustment (VA) so as to give a first impression of the effect of using this measure on the risk charges. More concretely, the following steps were taken to construct the three BMP-types:

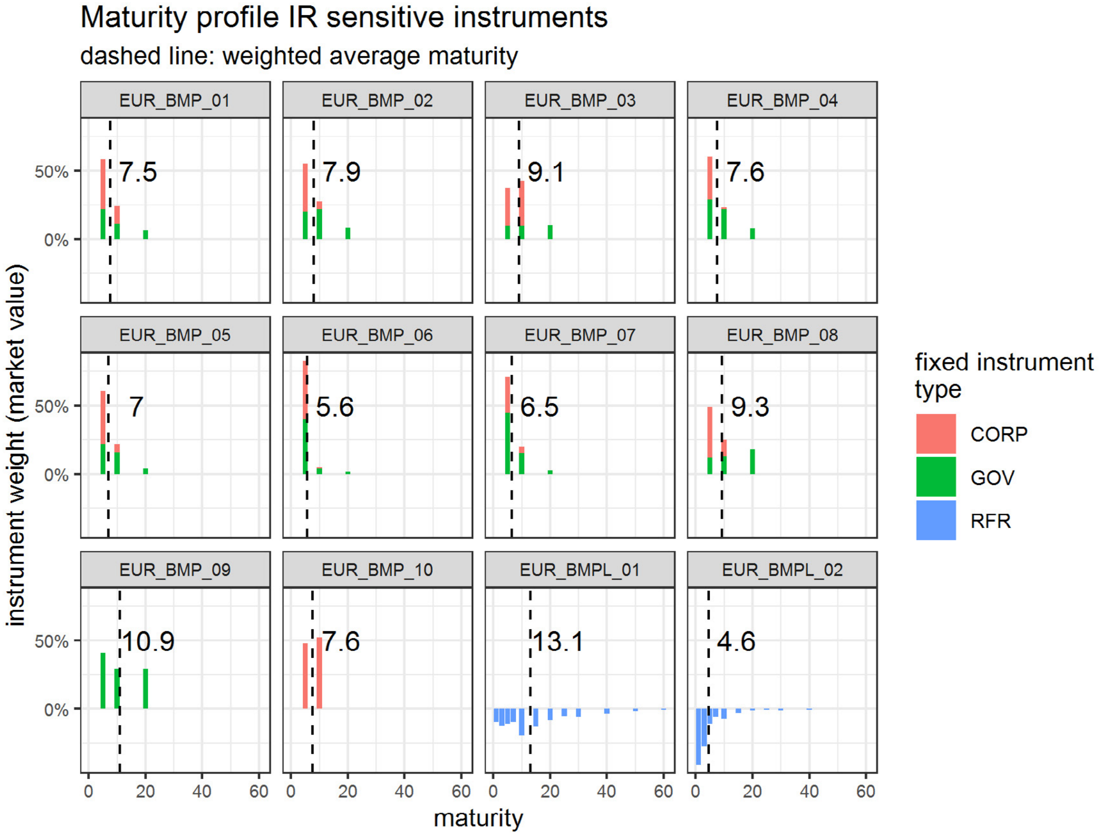
- **Asset-BMPs:** The BMPs were chosen in relation to real asset allocations of the insurance sector in the respective market. Therefore, the representative portfolios used by EIOPA to derive the volatility adjustment (VA), for year-end 2019 for EUR and seven country VAs, namely for BE, DE, ES, FR, IE, IT and NL, served as a basis for the target allocations[9]. The 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 in the first case and purely of corporate bonds in the second case, 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 do not include either derivatives, or inflation-linked bonds or instruments that are sensitive to implied volatility.
- **BMPL**: an extremely simplified representation of liabilities in terms of risk-free zero coupon bond short-positions. Two BMPLs were set up in order to reflect different cash flow profiles. The maturity profile of these zero coupon bonds for BMPL-01 was chosen in such 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'). For BMPL-02, shorter dated zero coupon bonds were selected representing the average cash flow profile of the non-life liabilities of all European insurance undertakings, leading to a lower weighted duration on the liability side compared to the fixed income assets (i.e. a 'positive duration mismatch'). It is important to note that the simplified liability portfolios do 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 two BMPLs and the liabilities were scaled in such a way that the net asset value of the A-L-BMPs reflected the average 'NAV to total assets' ratio across all European insurance undertakings (approx. 13%). This resulted in 10 A-L-BMP combinations which are shown in the following table:

Table 1: A-L BMP combinations

		Asset-BMP				
		EUR EUR_BMP_1	DE EUR_BMP_3	IT EUR_BMP_7	Sov. only EUR_BMP_9	Corp. only EUR_BMP_10
Liability BMP	long dur. BMPL_01	AL_01_01	AL_02_01	AL_03_01	AL_04_01	AL_05_01
	short dur. BMPL_02	AL_01_02	AL_02_02	AL_03_02	AL_04_02	AL_05_02

[9] The benchmark portfolios were constructed with the aim of mimicking 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 portfolios



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

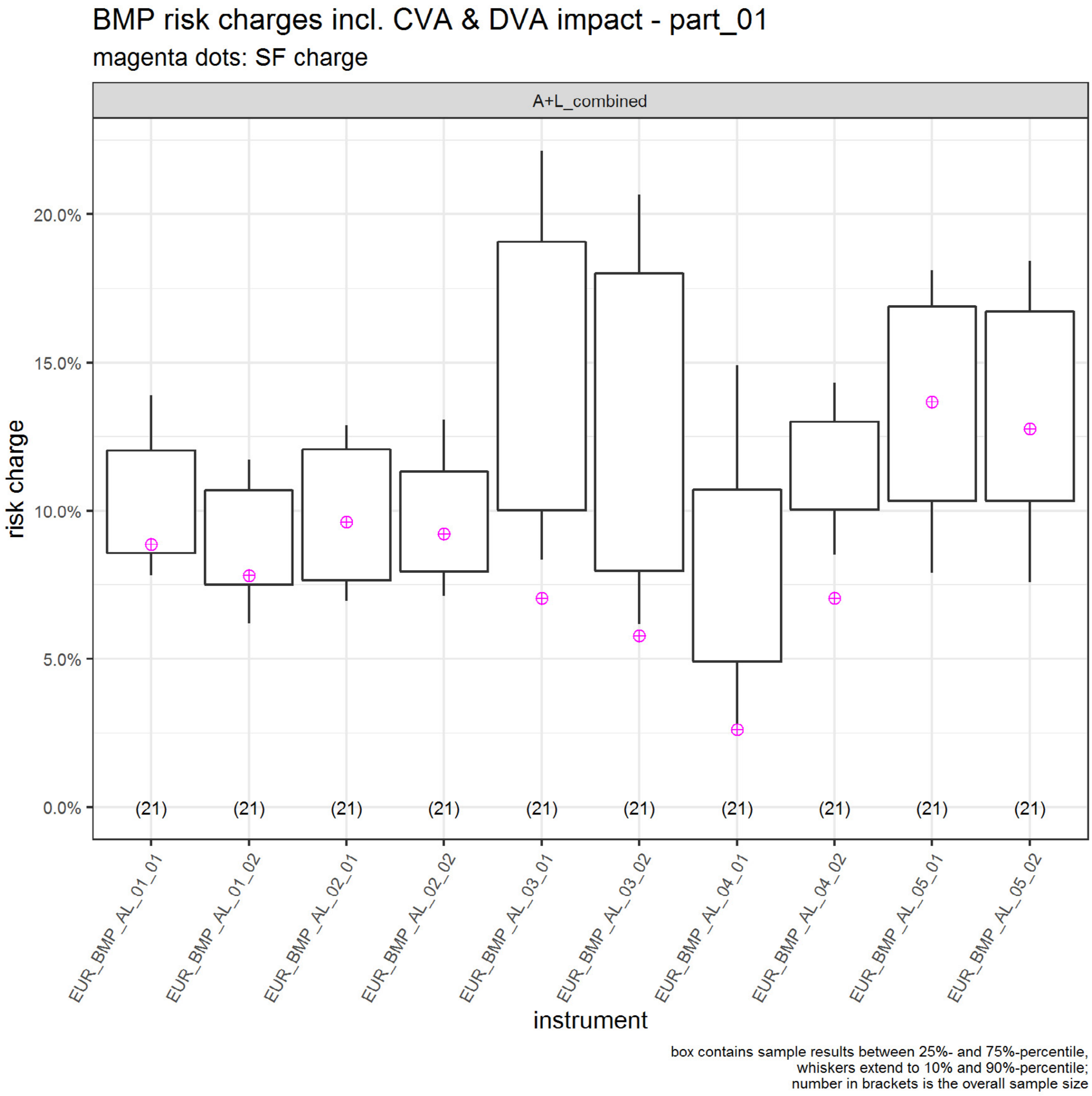
From Figure 1 (above) it can be seen that the fixed income instruments of the BMPs have different maturity profiles and therefore lead to different portfolio durations:

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, bound by the 75% quartile at the top and by the 25% quartile at the bottom. This means that 75% and 25% of the risk charges in the sample are lower than the upper and lower line respectively. Additionally, the lines ('whiskers') at the bottom and the top indicate the 10% quantile and the 90% quantile, i.e. the plot covers 80% of the sample. Note that 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 the valuation of Technical Provisions but not modelling the VA explicitly in the internal model a CVA-effect is considered;
- 'dynamic VA', i.e. for the 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 the asset-liability benchmark portfolios



Each of the boxes in Figure 2 covers a set of 10 out of 21 relevant participants[10]. The interquartile range (IQR), i.e. size of the boxes, for all A-L-BMPs ranges from 3.0% to 10.0%. 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_01 and EUR_BMP_AL_03_02 containing a large amount of sovereign exposure. EUR_BMP_AL_05_01 and EUR_BMP_AL_05_02 constructed with the corporates-only asset allocation also show an increased level of variability compared to EUR_BMP_AL_01_01 / _02 and EUR_BMP_AL_02_01 / _02. The spread aspect will be explored further in section 5.2.2. The variations of EUR_BMP_AL_01_01 / _02 and EUR_BMP_AL_02_01 / _02 are in a comparable range.

Due to the negative duration-mismatch, the A-L-BMPs ending with the suffix '_01' are in general exposed to interest rate 'down' movements while those with the suffix '_02' are exposed to interest rate 'up' movements, respectively. Given the current low-interest rate environment, the interest rate 'down' risk is not fully captured in the standard formula while all internal models take this into account. By and large the variations are in a similar range irrespective of the duration gap, with exception of EUR_AL_BMP_04_01/ _02 (sovereigns only) where the IQR for

[10] This subset of participants could differ from BMP to BMP

the long liability duration is about twice as high as the short liability duration (5.8% and 3.0%, respectively).

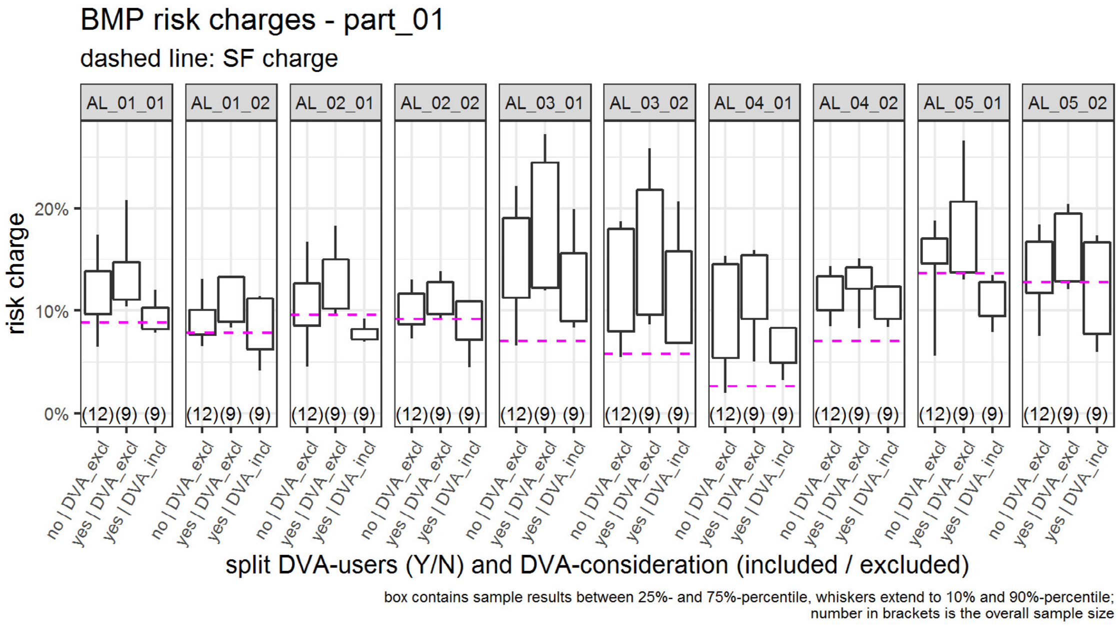
5.1.3. IMPACT OF THE DYNAMIC VOLATILITY ADJUSTMENT

The VA is applied to the risk-free interest rate curve under Solvency II. Application by undertakings is optional, and in some Member States its application to approval. The value of the VA depends on the currency (and possibly the country) of the liabilities; and is set by EIOPA based on a formula using the average credit spread on reference portfolios of fixed-income instruments[11]. 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 VA' (DVA) approach[12]. When an undertaking keeps the VA constant in its model, it is called a 'static' or 'constant' VA approach[13] (CVA).

In order to disentangle this DVA effect in 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.

The box on the left-hand side of each plot shows the risk charge for models not using a DVA in their model setup, but for three of those including a CVA effect. The boxes on the right-hand side convey the impact of activating the dynamic VA mechanism (for those models including a DVA). While for the A-L-BMPs with long-duration liabilities the variation seems to decrease, the opposite seems to be the case for the A-L-BMPs with short-duration liabilities, with the exception of EUR_BMP_AL_03.

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



11 Please refer to section 8.A of the RFR Technical Documentation https://www.eiopa.europa.eu/sites/default/files/risk_free_interest_rate/21.08.2020_-_technical_documentation.pdf

12 Please refer to EIOPA Opinion on the supervisory assessment of internal models including a dynamic volatility adjustment https://www.eiopa.europa.eu/sites/default/files/publications/opinions/2017-12-20_eiopa-bos-17-366_internal_model_dva_opinion.pdf

13 Among the undertakings covered by this study, nine do not use any VA in their internal model calculations, nine use a dynamic VA, and 3 use a constant VA.

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 significantly increase the risk charges.

5.1.4. ASSET-BMPS

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

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 3.1% to 6.7% (with a mean of 4.4%). The highest IQR (6.7%) is observed for BMP_07, the lowest IQR (3.1%) for BMP_06. Almost all asset-BMP risk charges are higher compared to the standard formula. This holds especially for BMPs with a dominant weight of sovereign bonds (e.g. BMP 04, 07 and 09) and is explained by the fact that for sovereign bonds credit risks are generally reflected in internal models, in contrast to the standard formula[14].

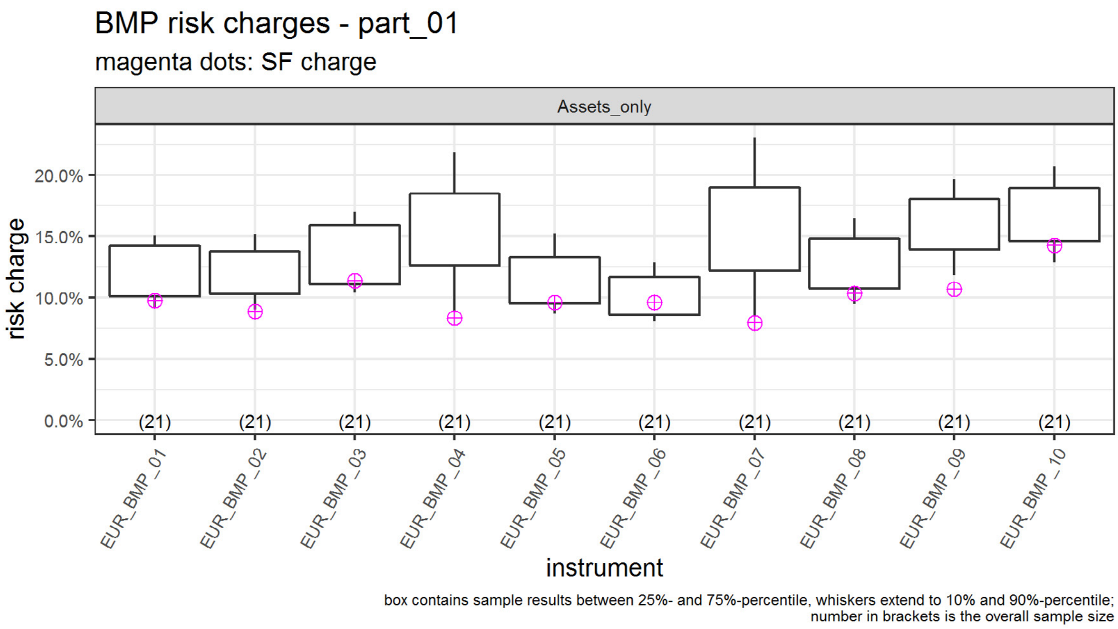
5.1.5. LIABILITY-BMP (BMPL)

Two BMPLs were introduced particularly to analyse interest rate 'down' movements, also in the combination of different maturities and different portfolio durations (e.g. in combination with the asset BMPs resulting in positive and negative asset-liability 'duration gaps'). Stand-alone results for the BMPLs and plots are presented in section 5.2.1.

5.1.6. EXCURSUS: COVID-19 RELATED MARKET IMPACTS

In March 2020, the COVID-19 crisis became a global pandemic and turned from a health event into a crisis which quickly spread to other sectors, including the financial sector. In an attempt to contrast this reality with internal models' forecasting capabilities, a hypothetical revaluation of MCRCS synthetic instruments and BMPs was performed and compared against the undertakings' 1-year forecasts as of 31/12/2019. The details of this analysis are presented in the Focus Box.

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



[14] 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 'dynamic volatility adjustment' which is applied by some undertakings. For details see previous sub-section.

FOCUS BOX: COMPARISON OF MODEL OUTCOMES AGAINST HISTORICAL EXPERIENCE

In contrast to typical market risk models in the banking sector with short forecasting horizons of one or ten days, which can be backtested against daily P&L realisations, the situation for internal models under Solvency II is different: on the one hand the forecasting horizon of one year is much longer and, on the other hand, there is no comparable concept of a realised own funds P&L that could be used for backtesting purposes[15].

This general setup imposes significant limitations for evaluating the model forecasts within a sound statistical framework. However, it is still possible to compare the internal model outcomes against experience in the sense of Article 242 (2) DR ('Validation tools') and this sets the stage for the analysis presented below. The following results should therefore not be interpreted as a strict test or 'backtesting' in a statistical sense but as a means for providing insights into whether model results look plausible or not.

From a high-level perspective, we try to answer the following questions:

- Which events in recent history had a major impact on market prices and when did they occur?
- Given the undertakings' internal model results as of YE 2019: are these events covered by the undertaking specific probability distribution forecasts? If so, what probability was assigned to these events? ('How far in the tail of the distribution are these events located?')

Keeping in mind that the ultimate goal of an internal model is to predict the changes of *basic own funds* within one year, we intend to capture the respective portfolio and diversification effects in our analysis. While this makes the analysis more complex at first sight and requires some additional assumptions, the results have greater relevance for an overall assessment of the internal market risk models compared to restricting the analysis to isolated risk factors (e.g. 'stand-alone' one year changes of the EuroStoxx 50 index or EUR RFR 5 year spot rate).

More concretely, we proceed as follows:

1. The composition of the Benchmark Portfolios (BMPs) as of 31/12/2019 serves as a starting-point (i.e. constant notional portfolio weights over time for Asset, Liability and Asset-Liability BMPs).
2. All BMPs are revalued based on observable market data for the time period 01/01/2016 to 30/09/2020[16].
3. For each BMP, discrete rolling 1-year returns are calculated at each month end.
4. The minimum return for each BMP is calculated and interpreted as a *deterministic worst-case shock scenario.*
5. The percentiles of the respective market risk probability distribution forecasts for the (negative) returns calculated in the previous step are determined and compared to the modelled *Value-at-Risk (mVaR)* figures provided by the undertakings. For consistency reasons, this step is based on part-02b data because the revaluation in step 2 does not include default and/or migration events.

Please note that by combining step 3 and 4 we increase the number of observations but at the same time circumvent the need to address the autocorrelation contained in the time series explicitly in our analysis. It should also be noted that when comparing historic returns with YE 2019 forecasts we do not capture any *conditionality* features that some models might have. Given the short time-window of less than 5 years and the prevailing low-interest rate environment we deem this simplification in general as acceptable. However, a careful interpre-

[15] Please note that the P&L-attribution prescribed in Article 123 Solvency II Directive serves a different purpose.

[16] Exceptions are the real estate exposures which are kept constant over time; the RFR information is provided by EIOPA.

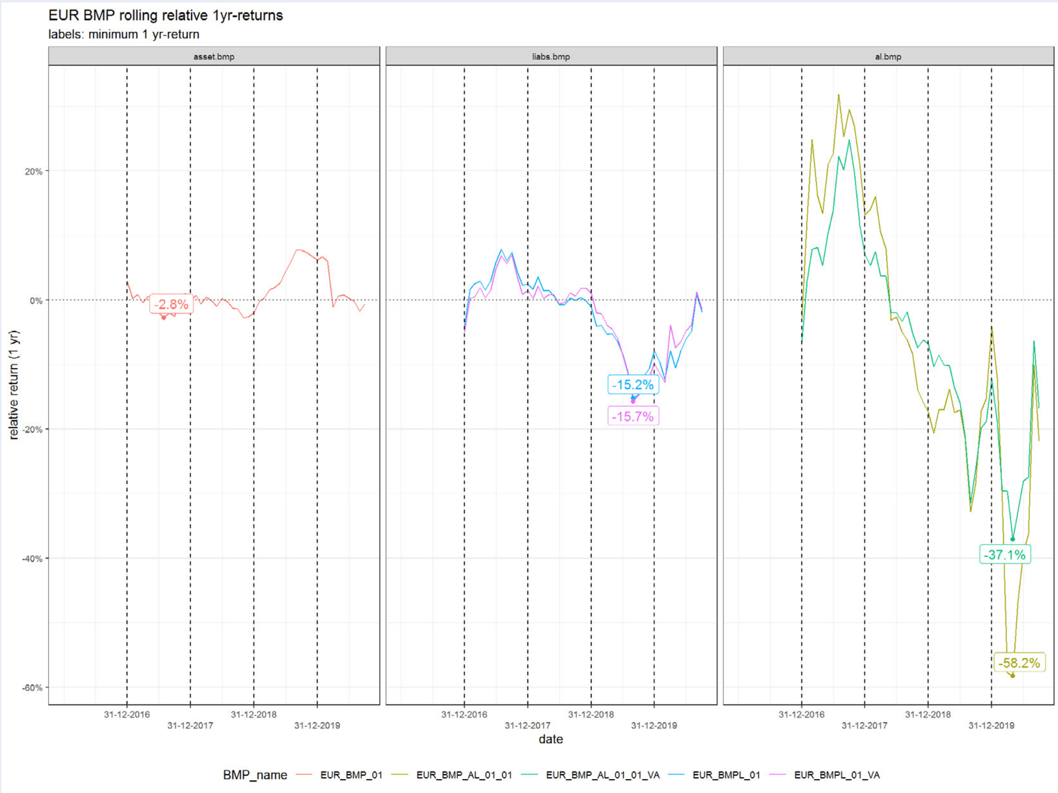
tation of results is necessary in cases where market conditions have changed more fundamentally (e.g. significant changes in interest rate levels).

The process outlined above is illustrated in the following.

Based on the EUR-related BMPs, the following BMPs are considered:

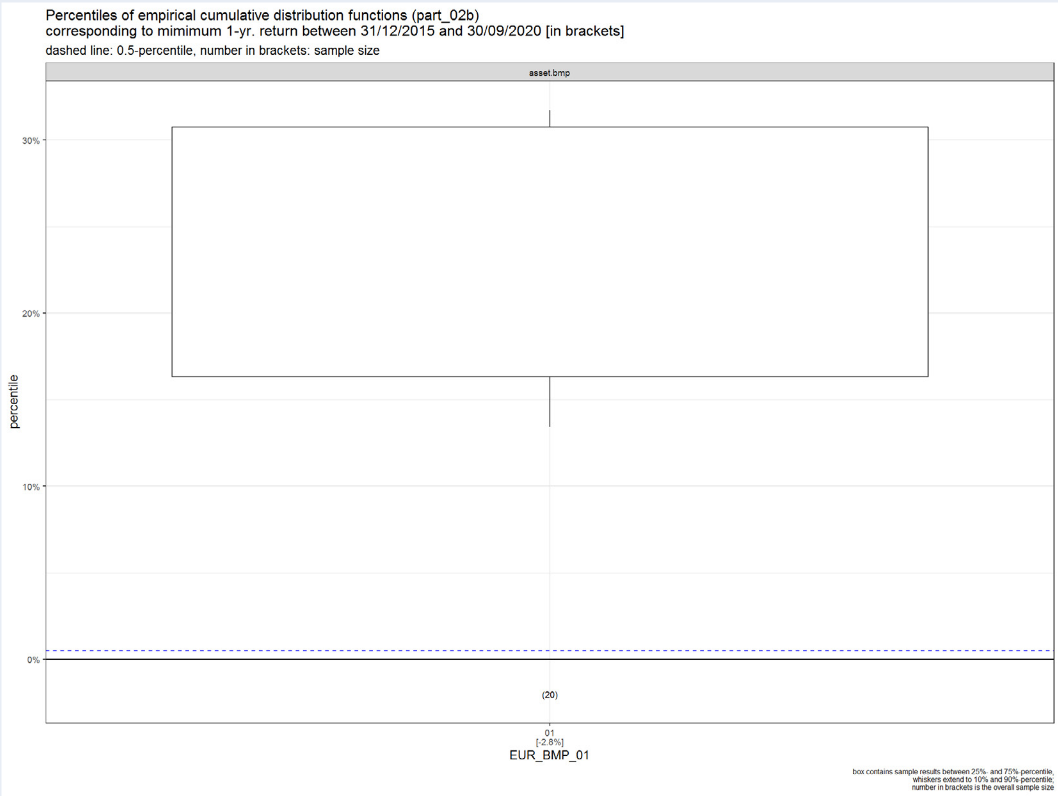
- Asset BMP: *EUR_BMP_01*
- Long-dated liability BMP without and with volatility adjustment: *BMPL_01* and *BMPL_01_VA*
- Asset-Liability BMP with and without volatility adjustment: *AL_BMP_01_01* and *AL_BMP_01_01_VA*

The following graph displays the time series of rolling 1-year relative returns for the respective BMPs including their minima:



While the return distribution of the Asset-BMP depends on a variety of risk factors (interest rates, corporate and government credit spreads, equity returns), the Liability BMPs depend exclusively on the RFR (without VA and with VA; the latter therefore also indirectly depends on credit spreads). Finally, the Asset-Liability BMP is the combination of the asset and liability side, integrating all market movements. It can be clearly observed that the different worst case scenarios occur at different points in time in the past. This emphasises the importance of extending the analysis of isolated risk factors to portfolios capturing diversification effects.

In the next step, the percentiles for these deterministic scenarios are derived from the undertakings' market risk probability distribution forecasts. The results are displayed as boxplots, starting with the asset side (the layout of the boxplot is identical to the explanation contained in section 5.1.2 (Asset-Liability BMPs)):



The worst-case shock for the assets-only BMP is rather moderate (-2.8%) and this is reflected by the fact that for most undertakings the location of this event is not very far in the tail. I.e. for half of the sample this event corresponds to a percentile of 16% to 27% of the probability distribution forecast. The blue dashed line corresponds to the 0.5%-percentile and serves a reference for judging the distance to the tail of the distribution.

The same approach can be applied for all other BMPs. Of particular interest in view of the COVID-19-related market turmoil in the first half of 2020 is the combination of assets and liabilities. As noted above, the long-dated AL-BMP values saw a severe decline in March/April 2020. Although occurring at the same date (30 April 2020), the decline of the A-L-BMP value excluding VA is stronger (-58%) than the decline of the A-L-BMP including VA (-37%). This difference is due to the fact that the VA compensates for credit spread related losses on the asset side by a higher discounting rate for the liabilities. The following table displays the 1 year-changes of a subset of major risk factors driving these value changes.

- EUR risk free rate and EUR volatility adjustment:

Term	30/04/2019	30/04/2020	1-yr. diff. (bps)
5	-0.07%	-0.42%	-34.9
10	0.42%	-0.25%	-66.6
20	0.96%	-0.07%	-102.7
30	1.58%	0.70%	-88.1
50	2.43%	1.82%	-60.9
EUR VA (bps)	9	33	24

- Credit spreads:

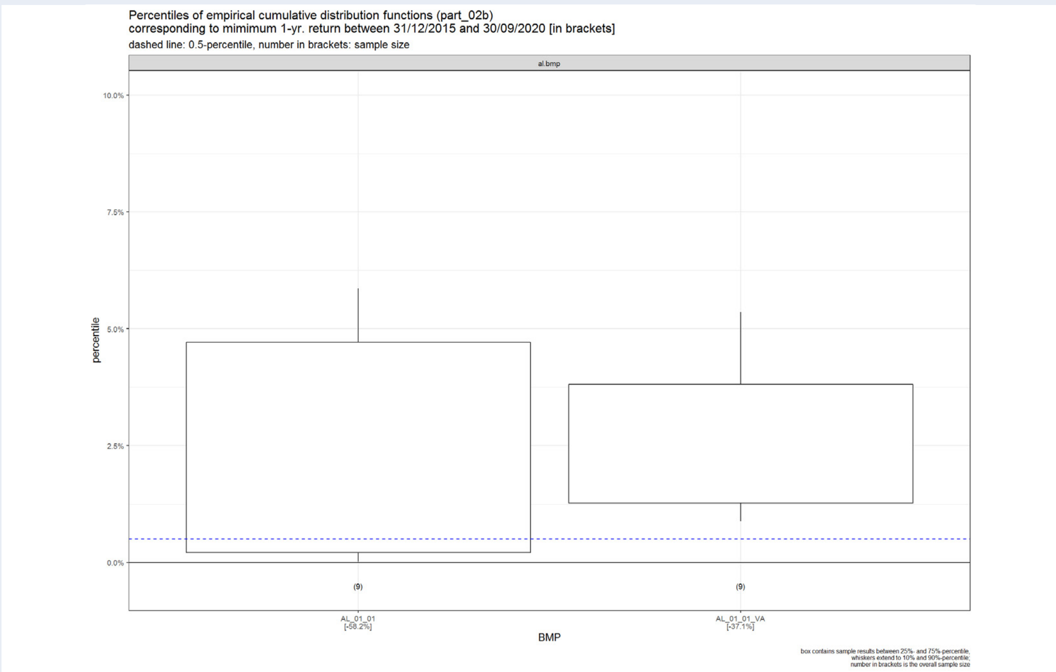
Sector	Issuer / Rating	Maturity	30/04/2019	30/04/2020	1-yr. diff. (bps)
Corporates	Non-Financials AA	5	12	69	56.9
Corporates	Non-Financials A	5	22	86	63.6
Corporates	Non-Financials BBB	5	42	144	101.8
Governments	DE	10	-50	-42	8
Governments	FR	10	-19	5	24.1
Governments	IT	10	199	198	-1.2

- Equity:

Index	30/04/2019	30/04/2020	1-yr. rel. diff.
EuroStoxx 50	7326.3	6251.2	-14.7%
FTSE 100	6666.8	5524.1	-17.1%
S&P 500	5242.4	5256.0	0.3%

The worst-case minimum return for AL_BMP-01_01 is therefore driven by a combined interest rate down, credit spread 'up' (corporates) and equity 'down' scenario.

The respective percentiles for these deterministic worst-case scenarios of the probability distribution forecasts are displayed in the graph below[17]. The presentation of results corresponds to the approved internal model scopes regarding the treatment of the volatility adjustment (VA), i.e. undertakings without VA appear in the left boxplot and CVA/DVA undertakings in the right boxplot, respectively.



[17] Please note that the total number of observations here is slightly different compared to the previous graph as not all DVA undertakings were able to provide A-L-BMP results incl. VA for part-02b-data.

While both boxes move strongly downwards towards zero, the effect is more pronounced for the A-L-BMP excluding VA, i.e. the deterministic worst case scenario is located further in the tail and in some cases even exceeds the predicted *mVaR*. The majority of observations, however, are located above the 0.5%-percentile.

Summarising the analysis, it could be said that the COVID-19 related market impacts in the first half of 2020 can certainly be seen as significant. From a general perspective of internal market risk models, there is no evidence that this could be interpreted as an event beyond the scope of application of these models. On a case-by-case basis some follow-up actions might however still be advisable, e.g. to check whether all relevant risk factors are appropriately reflected in the internal model. This also depends on the BMP under consideration and the individual undertaking's risk profile.

Limitations: This analysis is based on simplifying assumptions, especially on a simplified and standardised representation of assets and liabilities in the BMPs. These BMPs might differ from the actual risk profile of the undertakings, therefore, the results might not be directly representative of an undertaking's individual risk profile. This holds especially for the complex valuation impact on the liability side in the case of asset-liability interactions. Consequently, as stated for the MCRCS in the introduction, these other aspects should be taken into account when judging the relevance of findings. On the other hand, this standardisation and simplification is a prerequisite for comparing results across different undertakings. To some extent, the disadvantages are compensated by considering a multitude of different, yet still standardised, analysis objects.

It should also be taken into account that this analysis focuses exclusively on market risk (i.e. part-02b data). All models contain an additional component for credit risk which is not covered in the results above and which can be interpreted as some kind of additional buffer.

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 portfolios (BMP) and their individual calibration. Additionally, analyses performed on currencies other than the EUR as well as on derivatives and intra-market risk dependency 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).

For Euro risk free rates, the starting curves for these simulations in the liquid part are essentially identical across participants, but in one case differ in the extrapolated part, for which there is no convergence to the EIOPA UFR and the extrapolation appears to be essentially flat[18]. 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 critical per se: for certain assets and liabilities exposures to only the liquid part of the curve might be relevant for calculating 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 the liability portfolios in Figure 6).

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:

[18] 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

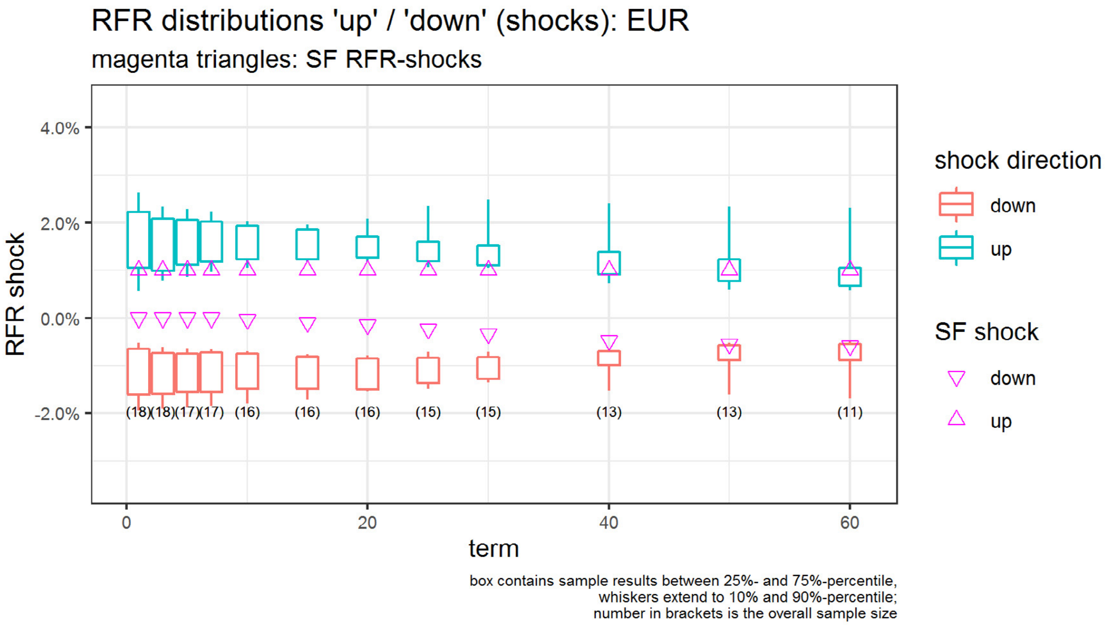


Figure 5 displays shocks on the initial spot rate[19] for selected maturities from the sample of participants. But note that these shocks are marginal, i.e. in only one dimension. This differs from the shocks underlying the risk charges for BMPLs presented below.

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 (11 – 18) for the different maturities, also leading to a varying number of participants included in the boxes and whiskers. It can be observed that the longer the underlying maturities the fewer the participants reporting exposure.

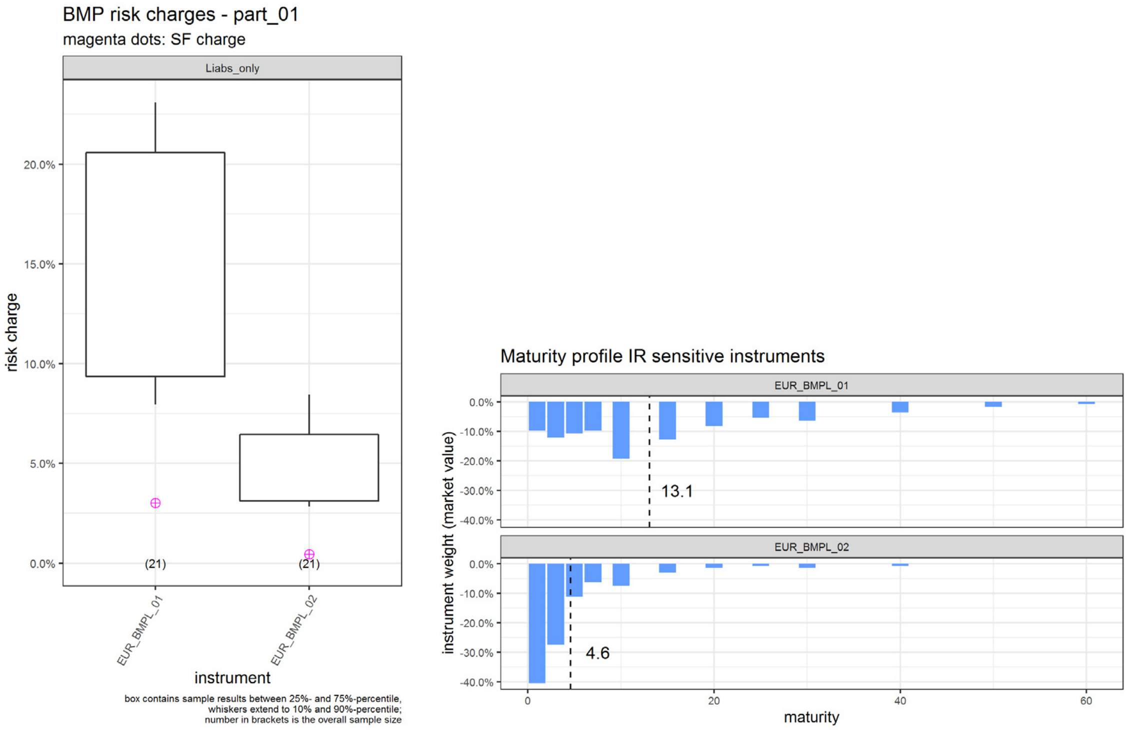
A similar analysis has been carried out for GBP and USD, which is presented in section 5.2.4.

As stated above, movements of yield curves are more complex than variations in single maturities. To further explore these aspects, the study also comprises two simplified portfolios of short positions in risk free instruments. One portfolio was derived from the cash flow profile and duration of the combined liabilities of all European insurers ("BMPL_01"). The second one is new in the MCRCS YE 2019, has a shorter duration (4.6 years compared to 13.1) and was derived from combined non-life and health-NSLT liabilities only ("BMPL_02"). They can be thought of as simplified and deterministic liability portfolios (cf. also section 5.1.2, Asset-Liability BMP). Evaluating these portfolios 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.

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

[19] Spot rates are derived from risk free zero coupon bonds by discrete compounding, e.g. for maturity T and currency ccy:.For the 'shock'-definition see the beginning of section 5.

Figure 6: Risk charges and maturity profiles for the simplified liability portfolios (short position in risk free rates, no options and guarantees)



The boxes show that for 50% of this sample (comprised by the box, excluding the whiskers) the risk charges for BMPL_01 lie between 9.3% and 20.6% and for BMPL_02 between 3.1% and 6.4%, i.e. a variation of 11.3% for BMPL_01 and a variation of 3.3% for BMPL_02. 80% of the sample (represented by the box and the whiskers) show variations of 15.1% for BMPL_01 and 5.6% for BMPL_02. The portfolio with the longer duration exhibits higher risk charges as well as a larger variation, which is primarily driven by the fact that from a fixed income valuation perspective a higher duration implies higher absolute value changes and therefore variations at longer maturities are amplified. The risk charges for both BMPLs 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 looking solely at an asset or liability portfolio does not capture the impact of rate curve movements on the combination of assets and liabilities, as encountered in an undertaking's balance sheet.

For this edition of the MCRCS, supplementary information on modelling approaches for interest rates were collected from the participating NCAs. As expected, a certain variety of approaches were observed. Comparing different facets of the resulting data however, there is no obvious indication of a one-on-one implication of the modelling choices with the resulting outcomes, meaning one specific choice does not necessarily lead to one specific outcome but the entirety of the modelling choices leads to the respective results.

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 the 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[20]. 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, covering, in general, only credit spread risk.

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

In the following analysis we have, as previously mentioned, excluded the subset of participants in the plots who reported no exposure to the underlying bonds. Therefore, the number of participants captured in the figures will once 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 variations 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 was 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 analysed at an instrument level). Credit risk charges were also generally higher for bonds with lower credit ratings.

Figure 7 demonstrates the variability 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.

Other notable features observed:

- Comparing 5Y and 10Y bonds, the differences in modelled credit spread shocks generally depended on the modelling approach and the bond's credit rating:
  - For firms using a modular modelling approach, for which, in general, only 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 seen 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 quarter of firms, models 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 all the 23 specified corporate bonds. The portfolio had a weighted average duration of 7.6 years.

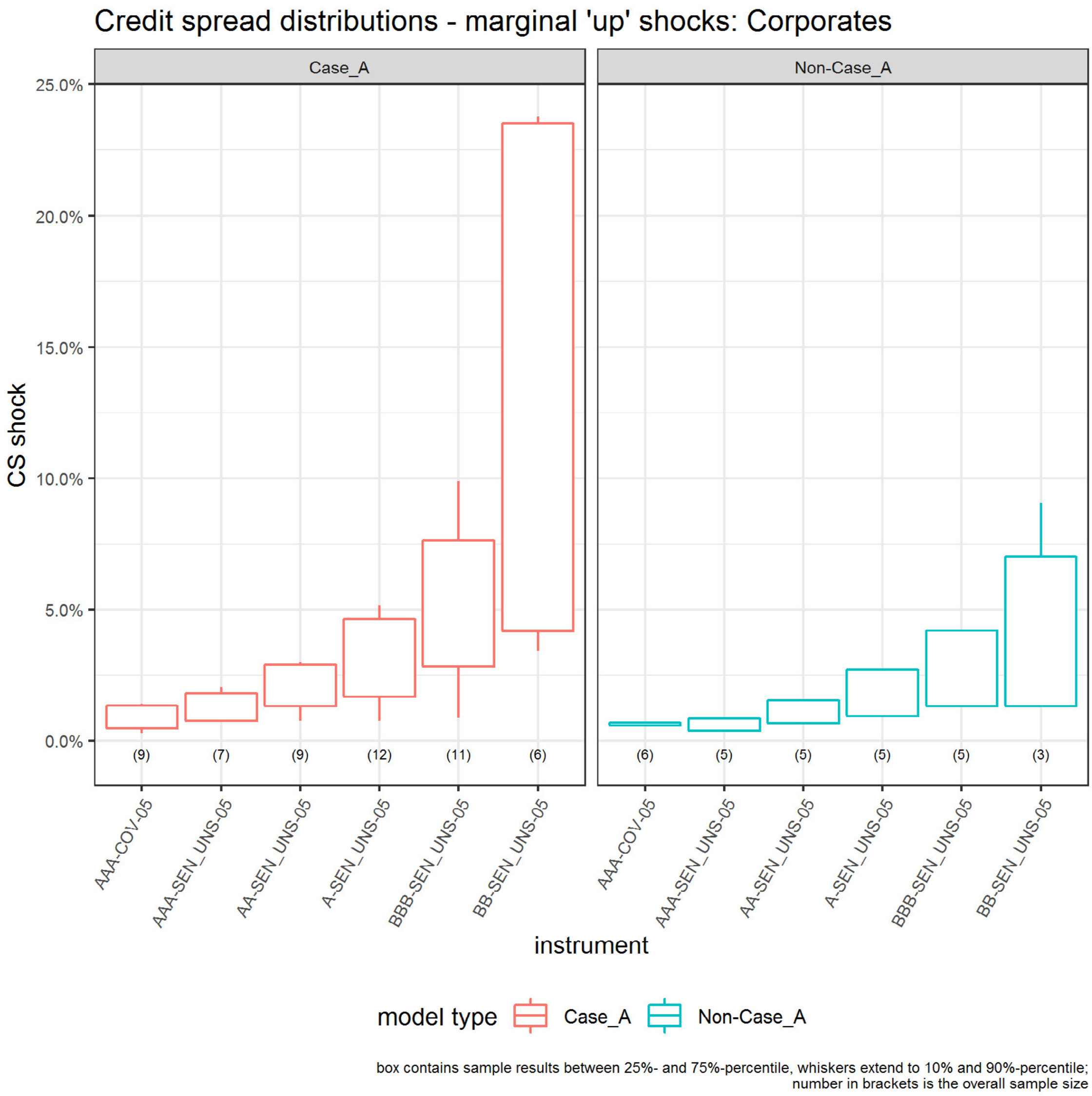
[20] Credit spreads are calculated from the credit risky zero coupon bond values analogously to spot rates but subtracting the risk free portion from the yield.

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 definition of 'shock' see the beginning of section 5.

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



SOVEREIGN BONDS

Sovereign bond data showed relatively less variation in credit risk charges among 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.

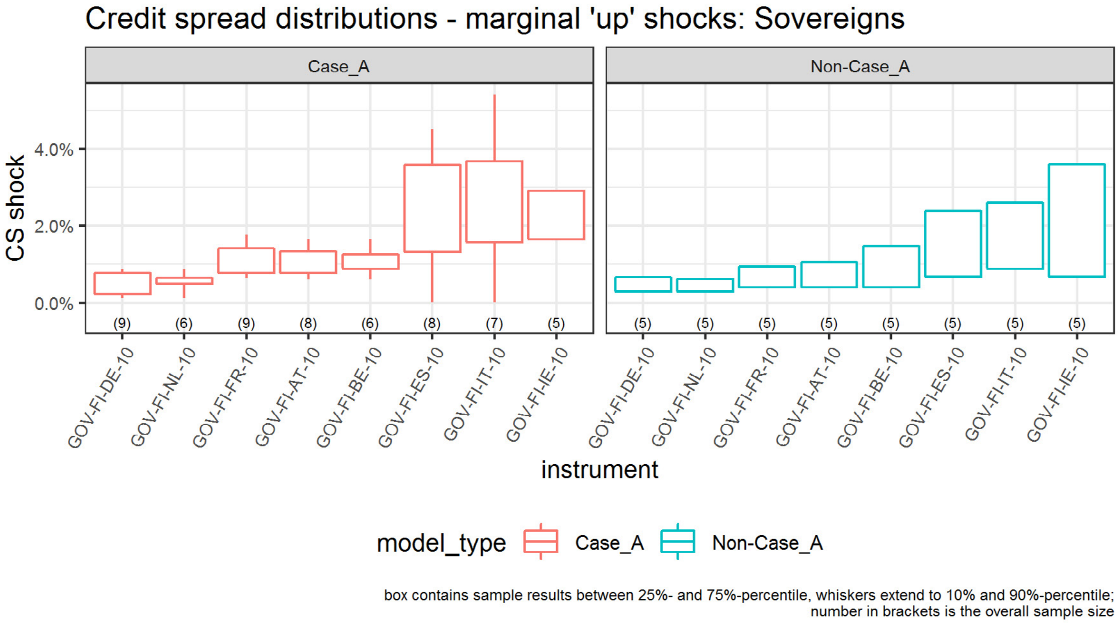
Credit risk charges showed relatively low variation for the bonds issued by Germany, Netherlands, Austria, France, and Belgium. Greater variation was observed for the bonds issued by Ireland, Portugal, Spain, and Italy. The following graph demonstrates this finding for 10 year bonds[21].

In contrast, the standard formula does not include a credit risk charge for sovereigns[22] which are examined in this study. We therefore omit any comparison with the standard formula in the analysis.

21 For Portugal, only a 5 year bond was specified as part of the exercise and so the variation of the 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.

22 Note also that the standard formula keeps the volatility adjustment constant.

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



The analysis of individual cases also reveals the following information:

- Two integrated models show a near-zero risk charge for all sovereign instruments. A third participant shows a near-zero risk charge for the Italian sovereign instrument. A fourth participant shows a near-zero risk charge for the German sovereign instrument.
- Three groups apply a different calibration for some domestic sovereign bonds held by local entities.

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.

5.2.3. EQUITY AND PROPERTY

The study indicates that internal model firms apply a wider variation of risk charges for property risks when compared to listed equity risks. In contrast, risk charges for undertakings' insurance participations exhibit significant variations. The study has also indicated that the undertakings' equity risk exposure tends to be higher than the standard formula shock, which is not the case for property risk. Further, for most undertakings, equity risk modelling is more sophisticated when compared to the property risk modelling.

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

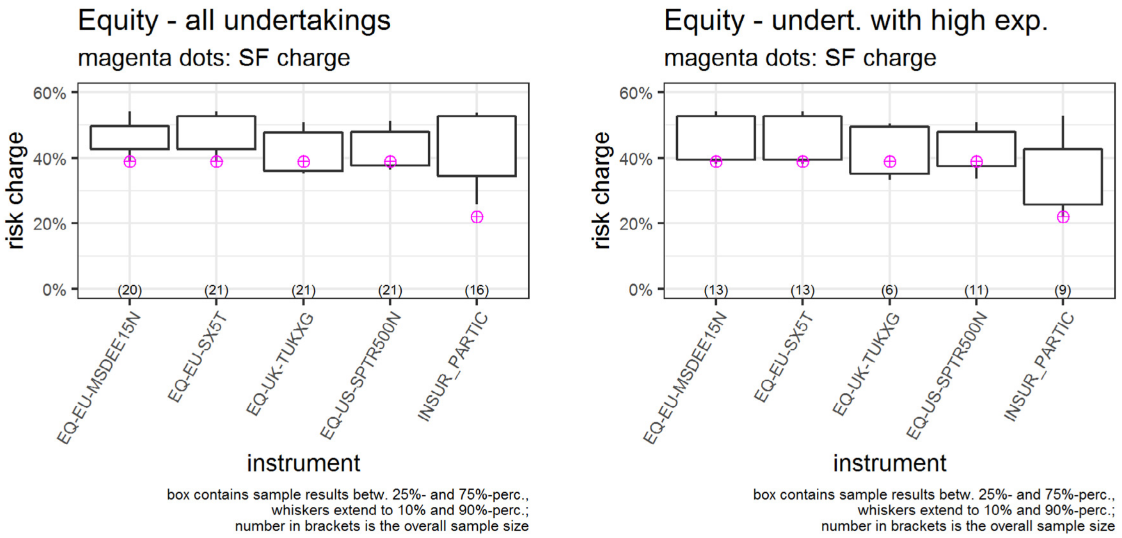
The study indicates that undertakings show less variation in risk charges for the major equity indices such as EuroStoxx 50, MSCI Europe, FTSE100 and S&P500, when compared to the risk charge applied to the instrument 'strategic insurance equity participation' (INSUR_PARTIC)[23].

There is also a relatively small difference between the variation in risk charges that is applied by an undertaking with either higher or lower[24] equity exposure.

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

[24] Higher exposure is defined as the undertakings that have reported an exposure relevance score of 3 (medium exposure) or 4 (high exposure). Lower exposure is defined as the undertakings that have reported an 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.

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)



The boxplots above compare quartiles for each equity index for all the undertakings (on the left) and only for the undertakings that have higher exposure to a given synthetic equity risk (on the right).

As for equity participation, the risk charges applied by the undertakings with higher exposure tend to be lower and closer to the standard formula than those applied by the full sample of participants.

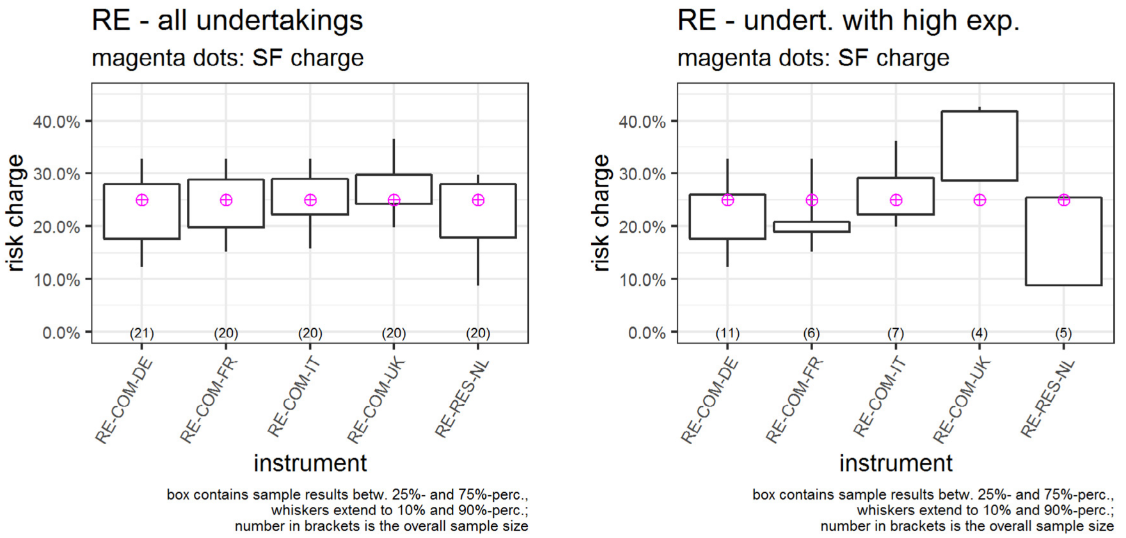
PROPERTY RISK

For the four commercial property risk metrics, highest risk charges within the sample are applied to UK instruments, the 25% standard formula shock constituting the lower quartile for this market. Residential property instruments, represented in the study by the NL market, tend to be calibrated with lower risk charges in the overall sample.

The study indicates some differences in the variation in the risk charges that are applied by the participants with higher exposure, when compared to the risk charges applied by all participants (i.e. including the undertakings with low exposures), in particular for FR, 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 this effect is reversed. Both effects could be the result of a more granular modelling and calibration approach for undertakings with significant exposures to the respective markets. Another source could be the comparable low sample size of just five undertakings with higher exposure. Also, within the sample of six undertakings with higher exposure to the FR commercial instrument a significant narrowing of the lower and upper quartile is observed.

The boxplots 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 valuation methods and the risk profile of the undertakings' actual investment portfolio than referring to 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, an inspection of the respective modelling still is of general interest. As the most material foreign currencies, the GBP and USD are included in the scope of this study. The following plots only include data from those firms that claim to have exposure to these risk free rates or the respective exchange rates.

Regarding the risk free rate, the dispersion of the marginal shocks term-wise is in general more pronounced than for EUR especially for long term maturities:

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

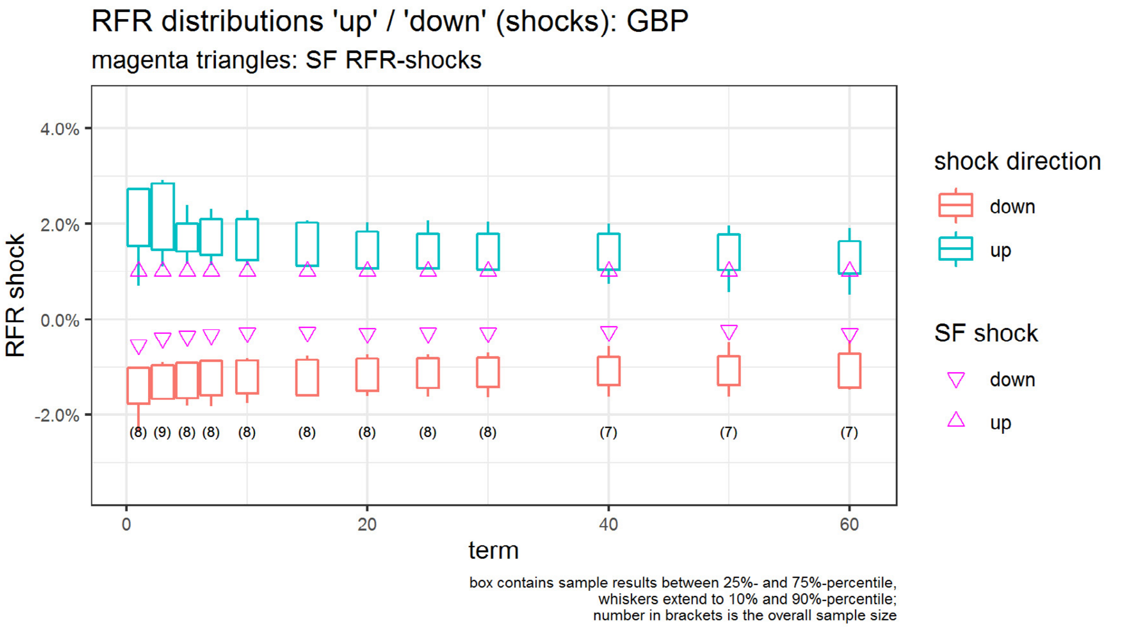


Figure 12: Downward and upward shocks on the spot rates for USD risk free rates for single maturities (i.e. 'marginal' shocks on single nodes, not shocked curves) restricted to firms that reported exposure

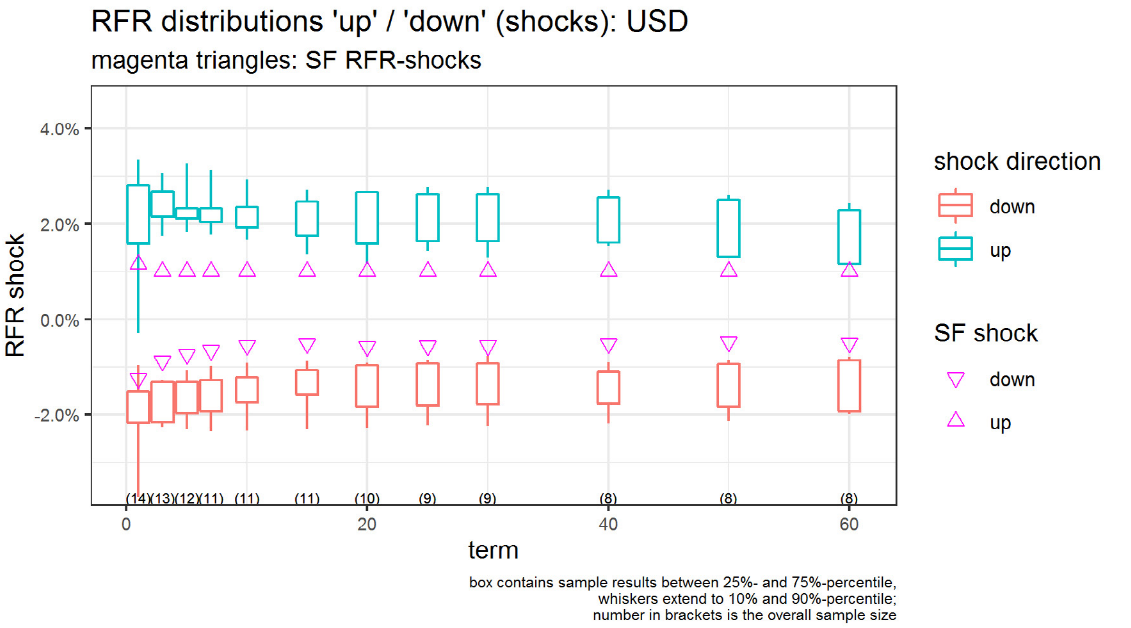
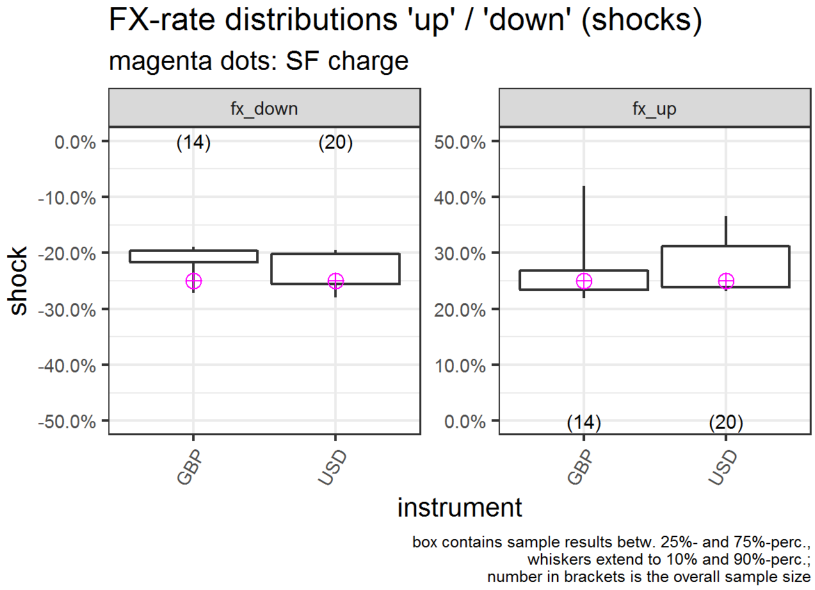


Figure 13: Risk charge for exchange rates for firms that reported exposure



FX RATES

Another aspect when looking at the risk stemming from investment in different currencies, is the modelled exchange rate. Figure 13 shows upwards and downwards shocks on the exchange rate instruments collected in the study on the EUR/GBP and EUR/USD exchange rates.

Similarly to interest rate risk, currency risk is a two-sided risk. Therefore, exposure to the shocks is not clear per se, but depends on the exposure in the balance sheet. For example, a firm reporting in Euro that has a large exposure of assets denoted in USD (or GBP respectively) on the asset side without any exposure on the liability side is exposed to an increase in the EUR/USD exchange rate (or the EUR/GBP rate respectively).

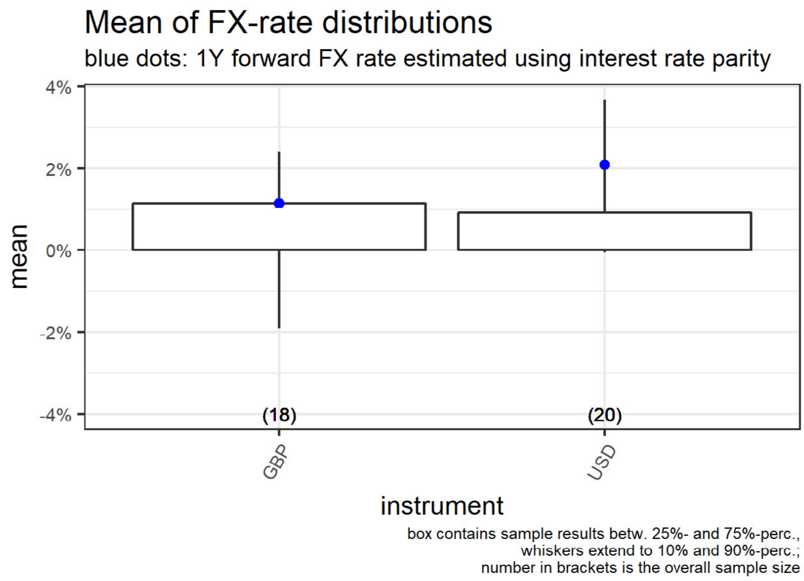
It can be observed in Figure 13 that the variability of the shocks on modelled foreign exchange rates across undertakings is limited and in a similar range to that of the standard formula (+/-25%). However, it is worth noting that upward shocks on FX rates (shocks corresponding to an appreciation of the EUR against the GBP and USD) have a greater amplitude than downward shocks (shocks corresponding to a depreciation of the EUR against the GBP and USD) for all the undertakings in the sample.

This difference in amplitude between upward and downward shocks could also be interpreted as the fact that the modelled probability of a +25% upward shock is higher than the probability of a -25% downward shock for most of the undertakings.

This asymmetry between upward and downward shocks suggests that for some undertakings the spot FX rates modelled distributions might not be centred on the initial spot FX rate value.

A way to look at a potential bias or 'drift' of the FX distributions is to look at the mean of the simulated spot FX distributions at t=1Y across undertakings. Additionally, the mean of the simulated spot FX distributions at t=1Y can be compared to the corresponding 1Y forward FX rates at YE19. Indeed, these forward rates could be seen as the market anticipations of FX rates over 2020 at YE19 (see also Figure 14 below).

Figure 14: FX rate average 1Y expectation (boxplots) compared to the 1Y forward FX rates estimates derived from interest rate parity (blue dots).



Note that the 1Y forward FX rates at year-end 2019 were both higher for EUR/GBP and EUR/USD than the corresponding spot FX rates. This means that the exchange rates of OTC 1 year forward contracts were higher than the spot FX rate. In other words, participants of the forward FX market anticipated at year-end 2019 an appreciation of the EUR against both the GBP and USD over 2020.

The 1Y forward FX rates can be estimated using the interest rate parity condition:

$$\widehat{FX}_{DOM,FOR}^{forward\ 1Y}(t=0) = \frac{ZC_{FOR}^{1Y\ RFR}(t=0)}{ZC_{DOM}^{1Y\ RFR}(t=0)} * FX_{DOM,FOR}^{spot}(t=0)$$

Where DOM stands for domestic currency (here EUR), FOR stands for foreign currency (here, either GBP or USD) and $ZC_{CCY}^{1Y\ RFR}$ represents the price of a risk-free zero-coupon bond of the currency CCY.

Using the EIOPA curves for EUR, GBP and USD without VA and the spot FX rates at YE19, the 1Y forward FX rates estimates $\widehat{FX}_{DOM,FOR}^{forward\ 1Y}(t=0)$ at YE19 are both higher for EUR/GBP and EUR/USD than the corresponding spot FX rates, representing an appreciation of 1.1% by the EUR against the GBP and 2.1% by the EUR against the USD over 2020 (blue dots on Figure 14).

In other words, the 1Y expectations that can be derived from the nominal interest rate differential between the two pairs of currencies (EUR/GBP and EUR/USD) are consistent with the 1Y FX forward rate on 31/12/2019. Both approaches suggest an appreciation of the EUR against both the GBP and USD over 2020.

Several conclusions can be drawn from this analysis:

- Most of the undertakings forecast an average appreciation of the EUR against the GBP and USD in their internal model over 2020 (11 out of 18 for EUR/GBP and 11 out of 20 for EUR/USD). This is consistent with the forecast derived from the interest rate parity (blue dots) and the 1Y forward FX rate at YE19.
- Some undertakings seem to model FX distributions centred on the initial spot FX rate at YE19 (5 out of 18 for EUR/GBP and 7 out of 20 for EUR/USD).
- Only a few undertakings appear to model FX expectations that are opposite to those suggested by the interest rate parity and the 1Y FX forward rate.

Please note that many phenomena can determine spot FX rates in the real world. Spot FX rates are not only driven by forward FX rates and we can cite other drivers such as purchasing power parity, country risk premiums, market events and official interventions by central banks.

It should also be kept in mind that the interest rate parity condition is used here to obtain an estimate of the 1Y forward FX rates that can be observed on OTC markets. This interest rate parity condition relies on several assumptions such as market efficiency, capital mobility and perfect substitutability of domestic and foreign assets which are not fully verified in real world.

Hence, for all these reasons, the 1Y forward FX rates estimated using the interest rate parity condition should not be seen as a calibration target for FX rate models in internal models nor to be the most relevant driver of FX rate models.

5.2.5. DERIVATIVES

OVERVIEW

The data request also comprised four standardised 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.[25]

The chosen derivative instruments can be considered as fairly standard products and almost all participants apply common market-standard valuation models in 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.

12 participants assigned an exposure relevance score of at least 2 to these instruments, i.e. indicating a minimum level of 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 the Technical Provisions of the traditional life business, in particular their embedded options and guarantees. Life insurance products often contain embedded options in the 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'[26]. 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. This is most likely 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 in the market-curve (swap) are more pronounced.

RESULTS OF THE 'IMPLIED VOLATILITY' RISK FACTOR

The valuation of derivatives depends on several variables entering simultaneously in 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 'implied volatility' risk factor over a one-year horizon in the internal models.

Depending on the direction of the derivative's exposure - i.e. 'long' vs. 'short' - an undertaking can be exposed to either an increase or decrease of the implied volatility risk factor. Therefore, the following graphs display the 0.5%-down and 99.5%-up percentiles of absolute changes in implied volatility. Considering the overall sample size for the 10/10-swaption, only the results from the subset of participants using a 'normal implied volatility' convention are displayed. It is worth noting that implied volatility is not part of the Standard Formula risk framework and therefore no comparison with the Standard Formula is provided here. By and large, the extreme percentiles for this risk factor are in a comparable range for both instruments (the observed implied volatilities at year-end 2019 were approx. 16% for the EQ-Put and 58 bps for the 10/10-swaption).

[25] 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.

[26] 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' (0.5%-percentile) and 'up' (99.5%-percentile)

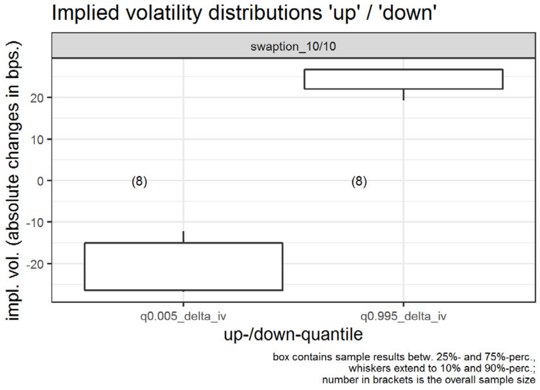
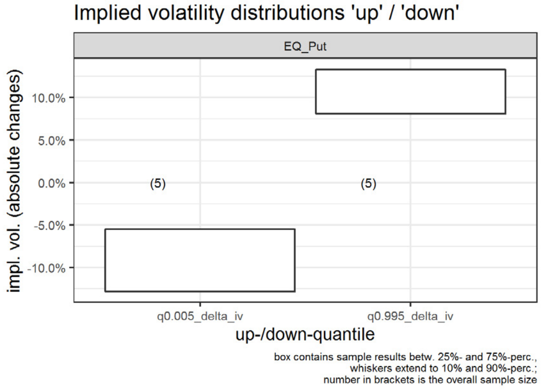


Figure 16: Risk factor equity implied volatility absolute changes 'down' (0.5%-percentile) and 'up' (99.5%-percentile)



5.2.6. INTRA-MARKET RISK DEPENDENCY

While the focus of the study is the combined market and credit risk, the other part of the analysis involved drilling down to the level of single instruments. To close the 'gap' between these levels, the MCRCS has performed a first analysis on dependency structures within market risk, i.e. excluding migration and default of credit risk (technically speaking this refers to the *part-o2b data* of the MCRCS-questionnaire) and the dynamic volatility adjustment.

To allow for a direct comparison of dependency structures across model types, participants with integrated models were asked to deliver data from which the migration and default risk component was removed[27]. This allowed for a similar scope of risks. Another key requirement was the full consistency of simulation data for benchmark portfolios and single instruments.

MULTIVARIATE DEPENDENCIES: EMPIRICAL COPULA

Under these conditions, it was possible to derive the implied dependency structure in form of the empirical copula of the undertaking from the simulation data across all synthetic instruments, representing the underlying risk factors for the purpose of the MCRCS. Such an exercise could be performed for almost all undertakings[28]. The marginal distributions (derived from simulated data for the single instruments) of a given undertaking A could then be combined with the empirical copula of another undertaking B[29]. This would give rise to a hypothetical joint distribution which would, for instance, allow a hypothetical mVaR to be calculated for the value of benchmark portfolios for undertaking A. By repeating this exercise for the dependency structures of all other undertakings, sets of hypothetical mVaRs based on the dependency structure of other participants in the study could be generated. Comparing the mVaRs based on the undertaking's own dependency structure with these sets of hypothetical mVaRs could give an indication for possible model uncertainty (variation/shape of the resulting boxplot) related to the dependency structure for a given benchmark portfolio and allows to compare the effects of dependency structures at an aggregated level across undertakings (relative position of the undertaking compared to the boxplot). Here it should be noted that the own portfolio typically differs from the benchmark portfolios and that conclusions should be taken in this light. Also the individual choice for marginal distributions influences the consequential choice of dependency structures.

27 As a possible approach to eliminate migration and default the undertakings could perform a simulation but hold all ratings constant, i.e. not allowing for either migration or default.

28 Two undertakings were not able to deliver the necessary data and for two undertakings this calculation led to results that were unexpected and still need to be analysed.

29 It is important to keep in mind that marginal distributions, joint distributions and dependency structures for an internal market risk model are in general not chosen independently but are part of the general model specification process and therefore the respective choices and decisions are somewhat interlinked.

BIVARIATE DEPENDENCIES: JOINT QUANTILE EXCEEDANCE PROBABILITIES

In addition, an analysis of dependencies was performed on the individual instrument data. This data allowed risk factor information to be derived, e.g. for corporate bonds: to determine the spreads as described in section 5.2.2. On a risk factor level, it was then possible to construct bivariate Joint Quantile Exceedance probability (JQE) as the joint probability that both risk factors will simultaneously surpass the same quantile. For this exercise, a quantile of 80% was used on the one hand to allow for enough data to have significance and on the other hand to focus on the tail of the distribution. This estimator is a more relevant measure of tail dependencies than correlations, which take the whole distribution into account.

In the table below, the values of the JQE measure are compared with theoretical correlation coefficients in a Gaussian copula framework. Different use cases are shown based on different thresholds (i.e. 80%, 90% and 95% percentiles).

In the case of perfect negative dependence, we observe that the JQE equals zero. Indeed, a strong upward movement for one risk factor would be accompanied by an equally strong downward movement for the other risk factor.

Table 2: Comparison of Joint Quantile Exceedance probabilities and correlations for a Gaussian copula and for thresholds of 80%, 90% and 95%

Correlation Coefficient	Joint Quantile Exceedance probabilities		
	80%	**90%**	**95%**
-100%	0,00%	0,00%	0,00%
-75%	0,09%	0,001%	0,00001%
-50%	0,84%	0,07%	0,01%
-25%	2,22%	0,39%	0,07%
0%	4,00%	1,00%	0,25%
25%	6,14%	1,93%	0,61%
50%	8,72%	3,24%	1,22%
75%	12,06%	5,12%	2,20%
100%	20,00%	10,00%	5,00%

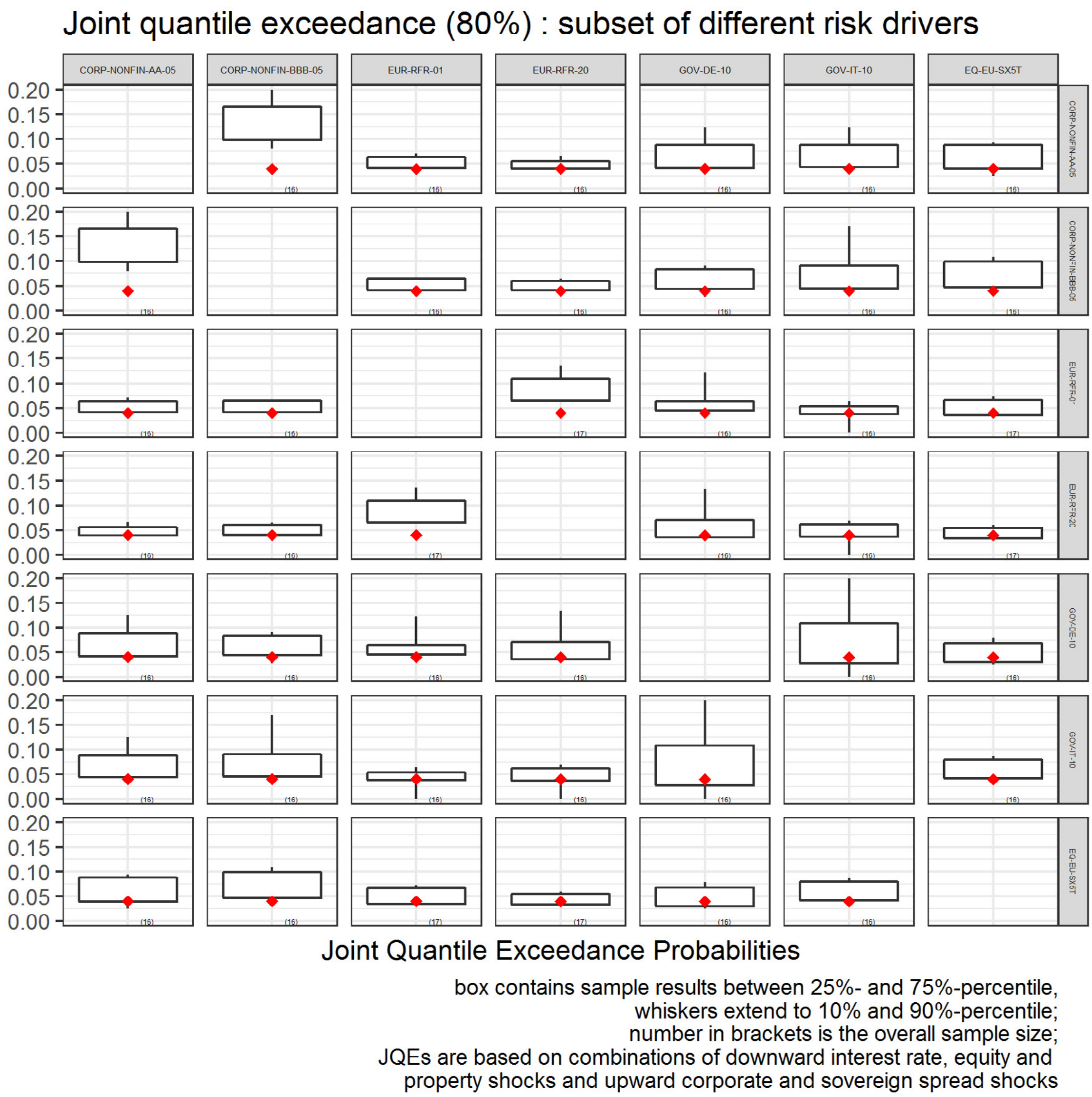
In the case of perfect positive dependence, the JQE would depend on the value of the threshold. All upward movements above a certain threshold for one risk factor would also lead to a movement above the same threshold for the other risk factor (comonotonicity). The JQE would then equal the number of observations above this threshold (e.g. 20% in the case of an 80% threshold).

In the case of independence, the probabilities of surpassing the threshold can simply be multiplied to obtain the joint probability of surpassing the threshold, e.g. 20% times 20% (= 4%) for an 80% threshold.

In the graph below we give an overview of the different JQEs across a selection of risk factors (including two risk free rate maturities, two corporate and sovereign spreads as well as an equity index). For instance, we focus on the specific example of the boxplot between AA and BBB Non-Financial corporate bonds at 5 years. Here, we can see that the box lies between 9.9% and 17.7% and the whiskers lie between 7.6% and 20.0%. The JQE assuming full independence of the risk factors is also shown as a red diamond for comparison purposes. For interpretation of the scale, the JQE values contained in Table 2: (column '80%') can also be used as a reference for the specific case of a Gaussian copula. The JQEs show that both corporate spreads are positively dependent for all participants.

The whole matrix of JQEs presents a boxplot for all pairs of selected risk factors. Since the JQE is symmetric, the boxplots shown in the upper and lower triangles are the same. If we compare the JQE across risk factors for the undertakings in the sample, we observe that the range of JQEs between different sovereign spreads is wider than for other risk factors. Also, for different corporate spreads and between corporate and sovereign spreads, the range is wider than between other risk factors, but less so than for sovereign spreads.

Figure 17: Joint Quantile Exceedances based on an 80% quantile for a range of risk factors



5.3. SUPERVISORY FOLLOW-UP

The Market and Credit Risk Comparative Study (MCRCS) is not a stand-alone exercise but one important element in the EEA-supervisory tool-kit for monitoring the on-going appropriateness of internal market and credit risk models. Parts of it have been and are being used in other supervisory processes and especially the assessment of model changes and initial applications.

After each edition of the MCRCS, the participating NCAs are provided with tailored feedback packages going beyond the global view outlined in this report and enabling them to discuss and challenge the participating undertakings. In some instances the MCRCS results also feed into the respective regular validation processes and specific validation exercises performed by undertakings, which sometimes also led to model changes. All of this could also be expected to occur in the future and EIOPA will follow up on NCAs' activities.

Specific topics discussed and challenged in this edition include the following:

(i) Three participants model only the pure credit spread risk. Remedial actions and a model change in these cases were all started before this study, and are ongoing, to extend the model scope to migration and default risks. EIOPA has requested to be kept informed of the developments in a timely manner.

(ii) Detailed results of the analysis of COVID-19 related market impacts were discussed in the feedback meetings, including the appropriateness of and potential consequences for the model calibration.

(iii) Certain data are still missing from the submission of single participants. Discussions have taken place in order to include them in the next study, when possible under the participants' model setup.

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 setup of the study itself and potential future improvements was collected. The outlook for the forthcoming edition of this study can be found in the next section.

In the case of insurance groups, group supervisors are encouraged to inform the college about the study and discuss relevant insights with the supervisory authorities concerned.

6. OUTLOOK

Following EIOPA's decision to perform the MCRCS annually there will be a study on year-end 2020 data. The data requested will follow, as closely as possible, the scope and extent of the last data request. The only additions concern the modelling of inflation and are restricted to five additional instruments and qualitative questions. Moreover, the project group plans to further develop the analysis on dependency and sovereign risk modelling.

7. ANNEXES

7.1. ANNEX 1: COMPOSITION OF THE ASSET BENCHMARK PORTFOLIOS

Benchmark portfolios /	EUR	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
Fixed Income Instruments	89.3%	91.7%	90.1%	92.6%	86.5%	89.5%	94.0%	92.1%	100.0%	100.0%
CORPORATES	49.6%	40.8%	60.3%	33.1%	44.8%	43.5%	31.3%	48.7%	0.0%	100.0%
ESM	2.4%	0.5%	3.7%	1.0%	2.4%	0.4%	0.6%	2.6%	0.0%	4.3%
Other CORP	47.2%	40.3%	56.6%	32.2%	42.5%	43.1%	30.7%	46.0%	0.0%	95.7%
AAA	7.6%	6.9%	19.5%	1.9%	4.2%	6.2%	0.5%	5.8%	0.0%	26.1%
AA	9.4%	7.6%	11.7%	4.1%	8.7%	8.9%	2.4%	7.7%	0.0%	17.4%
A	15.3%	12.2%	13.4%	9.3%	16.2%	14.2%	6.0%	15.6%	0.0%	17.4%
BBB	13.3%	12.9%	9.3%	15.1%	12.2%	11.6%	19.2%	16.1%	0.0%	17.4%
BB	1.6%	0.7%	2.7%	1.6%	1.1%	2.2%	2.6%	0.9%	0.0%	17.4%
GOVERNMENTS	39.7%	50.9%	29.8%	59.5%	41.7%	46.0%	62.7%	43.5%	100.0%	0.0%
AT	1.6%	2.1%	2.6%	0.3%	1.6%	1.5%	0.2%	3.2%	11.1%	0.0%
BE	3.2%	33.2%	2.2%	0.6%	2.4%	2.0%	0.4%	3.0%	11.1%	0.0%
DE	5.5%	2.1%	14.0%	0.5%	0.9%	4.7%	0.9%	11.9%	11.1%	0.0%
ES	4.0%	1.9%	1.8%	52.1%	2.4%	2.9%	3.0%	1.4%	11.1%	0.0%
FR	12.0%	6.2%	4.0%	0.6%	29.2%	5.1%	0.9%	6.2%	11.1%	0.0%
IE	0.4%	1.1%	0.5%	0.3%	0.6%	4.5%	0.4%	0.9%	11.1%	0.0%
IT	9.6%	3.2%	1.8%	4.1%	4.0%	11.6%	56.0%	1.3%	11.1%	0.0%
NL	2.0%	0.5%	1.1%	0.2%	0.4%	1.5%	0.3%	15.0%	11.1%	0.0%
PT	0.4%	0.2%	0.1%	0.6%	0.2%	0.5%	0.1%	0.0%	3.7%	0.0%
UK	0.3%	0.0%	0.5%	0.0%	0.1%	6.0%	0.1%	0.3%	3.7%	0.0%
US	0.6%	0.4%	1.3%	0.2%	0.1%	5.8%	0.4%	0.3%	3.7%	0.0%
Equity	6.7%	4.3%	6.4%	3.4%	9.0%	6.5%	3.5%	4.3%	0.0%	0.0%
Real Estate	4.0%	4.0%	3.5%	4.0%	4.5%	4.0%	2.5%	3.6%	0.0%	0.0%
Commercial	3.2%	3.2%	2.8%	3.2%	3.6%	3.2%	2.2%	2.0%	0.0%	0.0%
Residential	0.8%	0.8%	0.7%	0.8%	0.9%	0.8%	0.3%	1.6%	0.0%	0.0%
Total Assets	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

7.2. ANNEX 2: COMPOSITION OF THE LIABILITY BENCHMARK PORTFOLIOS

Benchmark portfolios	LIAB_Long	LIAB_Short
Risk free rates (maturity)	**EUR_BMPL_01**	**EUR_BMPL_02**
1	9.7%	40.6%
3	12.1%	27.4%
5	10.8%	11.1%
7	9.7%	6.2%
10	19.2%	7.5%
15	12.7%	3.0%
20	8.2%	1.3%
25	5.3%	0.7%
30	6.3%	1.4%
40	3.6%	0.8%
50	1.7%	0.0%
60	0.7%	0.0%
Total Liabilities	100.0%	100.0%

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EI-AQ-21-001-EN-C

EUROPEAN INSURANCE AND OCCUPATIONAL PENSIONS AUTHORITY

Westhafenplatz 1,
60327 Frankfurt am Main, Germany

Publications Office of the European Union

ISBN 978-92-9473-291-0