First Comparative Study

on

Market and Credit Risk Modelling

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1.   Executive summary

Market and credit risk contribute significantly to the solvency capital requirement (SCR) of insurance undertakings[1] and is also of material importance for the majority of internal model undertakings. Consequently, with the first official Solvency II reporting a project group of several National Competent Authorities (NCAs) and EIOPA started a European-wide comparative study of market and credit risk in internal models based on year-end 2015 data (Solvency II "day-one"[2]), aiming for a systematic stock take, the development of tools and to foster common supervisory practices.

This report summarises the key findings from this study undertaken in 2016/2017 and provides an insight into the supervisory initiatives being taken following the conclusions of this study.

The year-end 2015 study focused on EUR denominated instruments and consisted of 14 participants from 7 different Member States covering 95% of the Euro investments (excluding unit-linked assets) held by all undertakings with an approved internal model covering market and credit risk in the EEA.

It is important to note that the study focusses on drivers for the value of investments, but does not aim to cover the overall SCR. Hence, no direct conclusion could be drawn with regards to a specific undertaking solvency with this comparative study. In particular, specific undertaking risk profile, dynamics of liabilities under changing financial market conditions, tax impacts or volatility and matching adjustment are intentionally not considered – with the purpose of directly assessing the study's key subject, taking into account the other aspects in the judgement of relevance of the findings.

The overall results show significant variations in asset model outputs, which could be partly attributable to model specificities already known by the relevant NCAs, but also indicate a certain need for further supervisory scrutiny. However, this report should be considered as a first step in an ongoing process of monitoring and comparing internal market and credit risk models. This will be complemented by further refinements and developments in the future, and, the results, tools and experience will be feeding in the SRP on internal models and vice versa.

As a final introductory remark, internal models under Solvency II are governed by strong regulatory requirements, as on statistical quality, validation, documentation, justification of expert judgements, internal controls and model change governance. On-going compliance to these standards is safeguarded under the Supervisory Review Process (SRP).

Main results from the stock take and consequences for the analysis

The stock take from the study confirmed that there are two main approaches used by undertakings to model market and credit risk: integrated ones and modular ones (cf. section 4). Additionally, certain aspects of credit risk modelling are visible on portfolio level only. The study therefore took an extensive approach to enable a like for like comparison and ensure reliable conclusions can be drawn. In that spirit this report mainly presents results under the combined market and credit risk at the level of benchmark portfolios and supplementary from the drill down to facets of market and credit risk.

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[1] Cf. e.g. page 23 of the report on the EIOPA Insurance Stress Test 2016: Market risk accounts for 64% of the net solvency capital requirement before diversification benefits for standard formula users.

[2] Please note that already during the preparatory phase of Solvency II two pilot studies were performed to support the internal model pre-application in advance of "day-one".

Sample size, data quality and implications

From a statistical point of view, although having a broad coverage, the sample size is not large. Consequently, to keep as many data points as possible, the main priority of this first study consisted of an extensive data and model exploration including feedback loops with participants on the final results. Another finding was that some benchmark assets were not relevant or not material for certain participants, which led to model results of lower quality, causing distortions in the results.

Importantly, given the small number of models in the market and in the comparative study, all results and statistical key figures in this report (e.g. median) shall not be regarded as calibration target.

Main quantitative results

For the risk charge, i.e. relative loss in value, the results show a sizeable variation between undertakings, which in some cases might require further review. Ordering the benchmark portfolios according to the risk charge ("risk ranking") shows common trend but also variations. Overall, parts of the observed variations can be attributed to issues of data relevance and to risk management preferences. Drilling down into facets of risk and asset types requires further development of tools and clustering of models in order to better explore the underlying causes.

Thematic focus: Interest rate risk modelling

Given the specific relevance of interest rate risk (e.g. 65% of investments in the EEA insurance balance sheet are directly held in fixed income instruments), the current low yield environment and the credit spread volatility in the recent years, a certain focus was set on fixed income instruments in case of an interest rates rise. Most importantly, while five participants did not model negative rates at the date of the study, all of the respective models have been adapted to incorporate this feature as at year-end 2017.

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 has decided to perform regular annual studies to further develop supervisory tools and foster consistency of supervisory approaches. The next study will enrich the spectrum of analysis, as further described in section 6.

2. Motivation and objectives of the study

In general, market and credit risk contributes significantly to the overall SCR of internal model undertakings. In addition, the definition of market and credit risk as regards 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). Therefore, there is generally a higher expectation for similarity in the modelling of market and credit risk on that level than for other types of risk, although there are a certain variety of appropriate modelling approaches, ways to consider historic data and finally the influence of the actual risk profile (on e.g. focus topics and expert judgements in the model development process). This variety also to a certain degree is considered to mitigate herding behaviour.

The principal objective of the market and credit risk modelling comparative study was to take a first step towards developing a European supervisory tool in the area of market and credit risk modelling, in order to support the supervision of models and foster convergence of supervisory approaches given the potential choices of mathematical, statistical and IT solutions to tailor models to the concrete risk profile. In the longer

term, such tool should also allow for the analysis of changes, models, approaches and calibrations over time and spot potential trends. In practice, the tool has already been used by NCAs, or colleges when relevant, and the conclusions of the study provide input to the Supervisory Review Process, e.g. with regards to internal model changes. NCAs have engaged with undertakings for further analysis and follow-up actions were agreed, where necessary.

Given the complexities of the overall market risk modelling process and the different risk profiles, the data should allow reviewing the overall variability of model outcomes but also analysing single components of a model (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. yield up and down shocks).

    The metric of this comparison is the ratio of the asset Value at Risk (99.5%, 1 year) and the provided market value of the asset portfolio (this metric is called risk charge).

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

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

3.   Process and scope

Process

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

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

The overall results based on anonymised data were discussed in the supervisory community, and dedicated feedback packages were prepared to be discussed by the participating NCAs with undertakings, and initiating follow-ups if deemed necessary. Where relevant, the results of these discussions were collated by the project group and fed into this report. The collected lessons learnt will feed the setup of the future regular study (see section 6).

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

Scope of the study: Risks

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

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"[3], where the first might be defined as the risk from the default of the issuer of securities, the second as the risk from spread movements related to rating migrations, and the third as the risk from spread movements within the same credit rating class in the one year horizon. It is important to note that market risk usually includes other sub-risks such as inflation, implied volatilities for equity risk and implied volatilities for interest rate risk. One should have in mind that these risks are modelled by most of the participating undertakings, but not in the standard formula.

The data collected is composed of market values for a number of real and synthetic market instruments, as well as a few benchmark portfolios composed of a selection of real 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 own "Value-at-Risk" estimate. This was supplemented by data on the own asset portfolio and qualitative information about the model and the approach to the study to support the quantitative analysis.

Scope of the study: Undertakings

As market and credit risk models within groups typically are uniform, the 14 participants from 7 Member States mainly are international insurance groups with an approved internal model at group level[4], covering market and credit risk, and with material EUR exposure. The Euro investments (excluding unit-linked assets) of participants amount to 95% of the total Euro investments[5] of EEA internal model undertakings fulfilling these criteria. The total assets of participants amount to 37% of total EEA assets.

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 setup and second the modelling of the one-year time horizon in the risk measure of Solvency II.

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[3] The notion of "credit spread risk" deserves further explanation, given that this sub-risk is often treated as one aspect of market risk; with reference to the 14 participating undertakings the spread risk is included for all of them in the market risk module of the model, except for two undertakings, for which certain parts of spread risk are covered in the credit module of the model.

[4] Two participants are individual undertakings for which there is no ultimate parent group within the EEA that could participate in the study.

[5] Based on data submitted by EEA undertakings as of end-2016.

Regarding the structural model setup it is necessary to differentiate between integrated approaches covering both, market and credit risk, in one sole simulation from modular approaches covering most facets of market risk in one module while the remaining parts of market and credit risks are covered in another module. Also, the granularity of model outputs, which could be provided for this study, varies along this dimension (e.g. scenario by scenario data vs. aggregated data).

Nine participants use integrated approaches while five participants use modular approaches.

From the latter, two participants include some parts of credit spread risk in the credit module. Credit modules furthermore tend to use credit portfolio model approaches, which tend to reveal the real risk charge only at the overall portfolio level and not at instrument level.

Consequently results are best compared and analysed at the level of combined market and credit risk for portfolios.

With regards to the one-year time horizon required for Solvency II there broadly exist two different approaches: the majority of participants apply so-called 'instantaneous shock models' on the Solvency II balance-sheet. Only two participants modelled the evolution of the balance-sheet over the following year explicitly by taking into account ageing effects (e.g. remaining maturity of a bond is reduced by one year). This needs to be considered appropriately in the definition of the respective risk measure Value-at-Risk (VaR) underlying the Solvency Capital Requirement (SCR) and might deviate from a simple quantile estimator.

Furthermore, feedback from undertakings showed that certain chosen test assets were not relevant, neither for the current exposure, nor for expected future investments. Consequently only rough proxies were available for these assets and in some cases even no test asset results at all could be provided by the participants.

Overall, for certain detailed analysis, clusters of similar model approaches have to be build, further reducing the sample size. Section 6 explains how this observation is taken into account for future studies.

Limitations

Although the coverage of the study is broad, from a statistical point of view the sample is not large, as it includes 14 participants only.

Furthermore, the study compares models and their calibrations at year-end 2015, but models have continued to evolve since that point. Some of the model changes might make part of the results obsolete. In particular, the conclusions for interest rate risk show that several internal models did not allow for negative interest rates at year-end 2015; however all of these models have adopted a new approach for the modelling of interest rates and now allow for negative rates and higher charges (Interest Rates down) in a low yield environment.

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

5.   Main results and supervisory action

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 and on the 'modelled Value-at-Risk' (see section 4).

The key metric chosen for comparison is the 'risk charge' in terms of the Value-at-Risk on assets, i.e. relative reduction of the initial value based on the modelled Value-at-Risk, not taking into account e.g. effects from liabilities or tax. Therefore, one can conclude that the findings of this report refer to the calibration of the models and not to the actual risk profiles of the undertakings.

Beyond the analysis of the risk charges targeting the overall calibration level, 'risk ranking' characteristics are also considered. This is achieved by arranging the respective financial instruments and benchmark portfolios in increasing order of the median risk charge. The undertaking specific risk ranking can then be compared to the median of the overall sample. This kind of consideration corresponds to the requirement that internal models should be able to rank risk, which is part of the 'use test'. Note that such risk ranking does not reflect a potential view of EIOPA on the relative 'riskiness' of BMPs.

5.1. Combined Market and Credit Risk, Benchmark portfolios

Considering the variety of real investment portfolios, one key assumption of the study was that reliable conclusions could most likely be drawn from typical portfolios, called benchmark portfolios ('BMP'), rather than from single assets. However, in subsequent steps the analysis of the presumed variability according to that approach was supported by 'drilling down' to certain aspects, including at the level of single instruments composing the BMPs.

Searching for typical portfolios with supposed relevance for the participants, the project group analysed the representative portfolios used by EIOPA to derive the year-end 2015 Volatility Adjustment (VA) for EUR and seven country VAs, namely for BE, DE, ES, FR, IE, IT and NL. To supplement these, two portfolios were constructed purely consisting of sovereign bonds resp. corporate bonds, both with equal weights for all included instruments.

It is important to note here that the BMPs react upon a combination of various risk factor movements. The following table includes a high-level overview of the main characteristics of the BMPs, i.e. main composition, average maturity and average credit quality step. From this, one can conclude that the BMPs are exposed to upward movements in interest rates and credit spreads in varying degrees (some portfolios are to a lesser extent also exposed to real estate and equity risk).

Table 1: Main composition of each benchmark portfolio

Name (starting point for setup)	Composition (%)[6]			Maturity (years)[7]	CQS[8]
	% Sovereign	% Corporate	% Other instruments		
EUR_BP1 (EUR VA currency represent. PF YE 2015)	44% *Of which 15% FR and 10% IT Sovereign Bond*	43%	14%	6.0	1.3
EUR_BP2 (BE country VA represent. PF YE 2015)	52% *Of which 33% BE Sovereign Bond*	32%	16%	7.9	1.0
EUR_BP3 (DE country VA represent. PF YE 2015)	31% *Of which 17% DE Sovereign Bond*	60%	10%	8.8	0.9
EUR_BP4 (ES country VA represent. PF YE 2015)	52% *Of which 47% ES Sovereign Bond*	36%	12%	7.2	2.4
EUR_BP5 (FR country VA represent. PF YE 2015)	43% *Of which 29% FR Sovereign Bond*	41%	16%	5.6	1.1
EUR_BP6 (IE country VA represent. PF YE 2015)	43% *Of which 11% UK, 8% DE, 6% IE and 6% FR Sovereign Bond*	50%	6%	5.5	1.1
EUR_BP7 (IT country VA represent. PF YE 2015)	63% *Of which 60% IT Sovereign Bond*	25%	12%	5.4	2.5
EUR_BP8 (NL country VA represent. PF YE 2015)	43% *Of which 16% NL and 15% DE Sovereign Bond*	47%	10%	7.6	1.0

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[6] The table shows the composition of the MCRBS benchmark portfolios. These were constructed with the aim to mimic the EIOPA VA representative portfolios. However, since MCRBS portfolios are composed of a limited number of instruments the composition does not perfectly match the EIOPA RFR representative portfolios.

[7] Averages of maturities for each portfolio weighted according to market values of the instruments included. Please note that EIOPA representative portfolios are defined based on the average duration of the main type of instruments, which is not directly comparable to these maturities.

[8] Weighted averages derived from publicly available rating information for the respective instruments per year-end 2015 and translated into credit quality steps (CQS) according to Commission Implementing Regulation (EU) 2016/1800. A CQS of 0/1/2/3 etc. corresponds to an S&P-Rating of AAA/AA/A/BBB etc.

Name (starting point for setup)	Composition (%)[6]			Maturity (years)[7]	CQS[8]
	% Sovereign	% Corporate	% Other instruments		
EUR_BP9	100%	0%	0%	10.7	0.9
EUR_BP10	0%	100%	0%	5.9	1.9

The following plot displays the risk charges for the benchmark portfolios in the form of boxes, bounded by the 75% quartile at the top and by the 25% quartile at the bottom. It means that 75% and 25% of the risk charges from the sample are lower than the upper and lower line respectively. Note that the undertakings' results which fall outside of these 'boxes' do not appear on the chart.
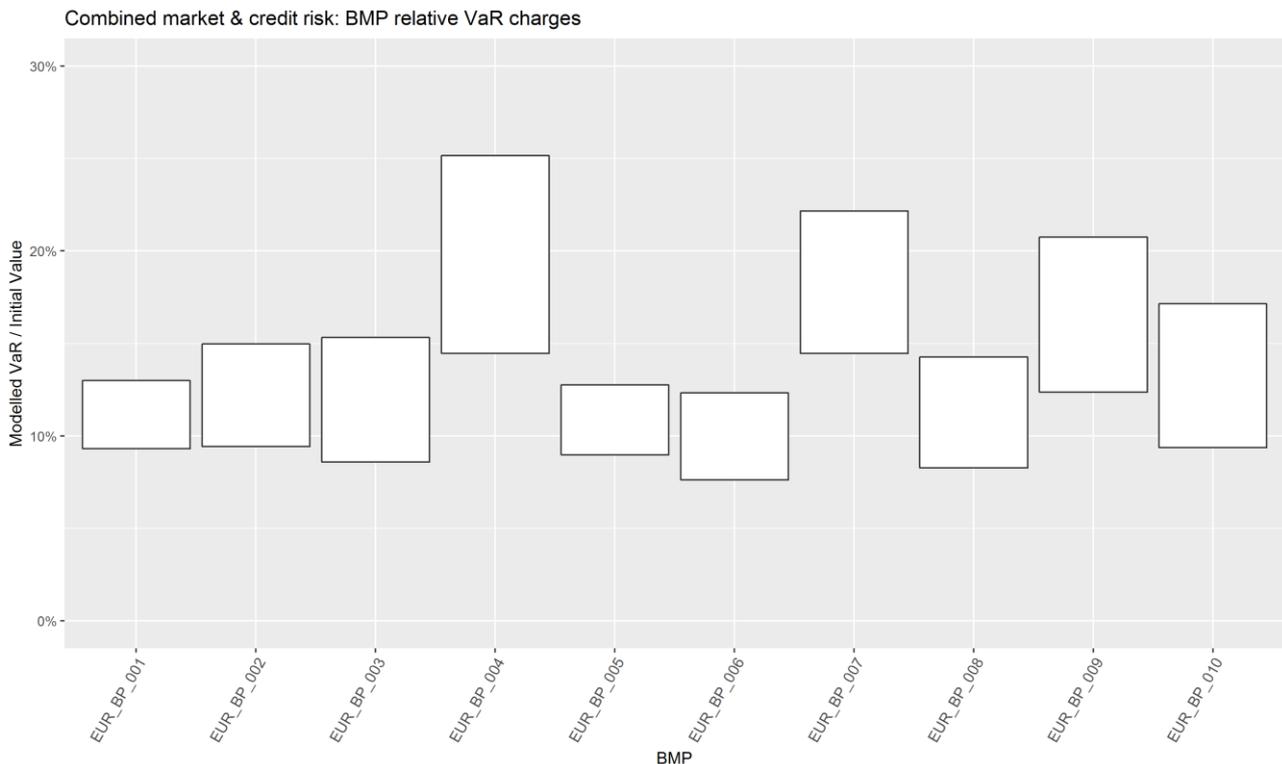

Figure 1: Risk charge for benchmark portfolios

Figure 1 shows sizeable variations, but given the uneven number of 11 participants[9], the boxes (respectively the quartiles) are defined to only exclude two values above and two values below the boxes. Thus 7 from 11 participants are within the box for each BMP. Consequently, from the graphs one can conclude, that for 7 from 11 relevant participants, the differences over all BMPs range between 3.7% and 10.7% with a mean of 6.5% and for eight of the BMPs the range is between 3.7% and 7.8%.

Given that the BMPs consist to a large extent of bonds (100% for BMP09 and BMP10 and 84% to 94% for the others in terms of market value with different maturity profiles), the primary drivers for the observed risk charges are credit quality and interest

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[9] Please note, that due to technical restrictions (see section 4) this sample includes data from 11 participants. Given this sample size, the boxes from their definition cover 7 participants and their size is in the ranges described.

rates. Regarding the latter, because the study focusses on the asset side, upwards movements of interest rates are the risk relevant scenarios. From an undertaking's global perspective, liabilities are also sensitive to interest rates and therefore the net asset value will often be exposed to interest rate down movements (depending on the duration profile of assets and liabilities).

Risk ranking

The following figure illustrates how NCAs could use the study to assess the risk ranking behaviour of individual models:
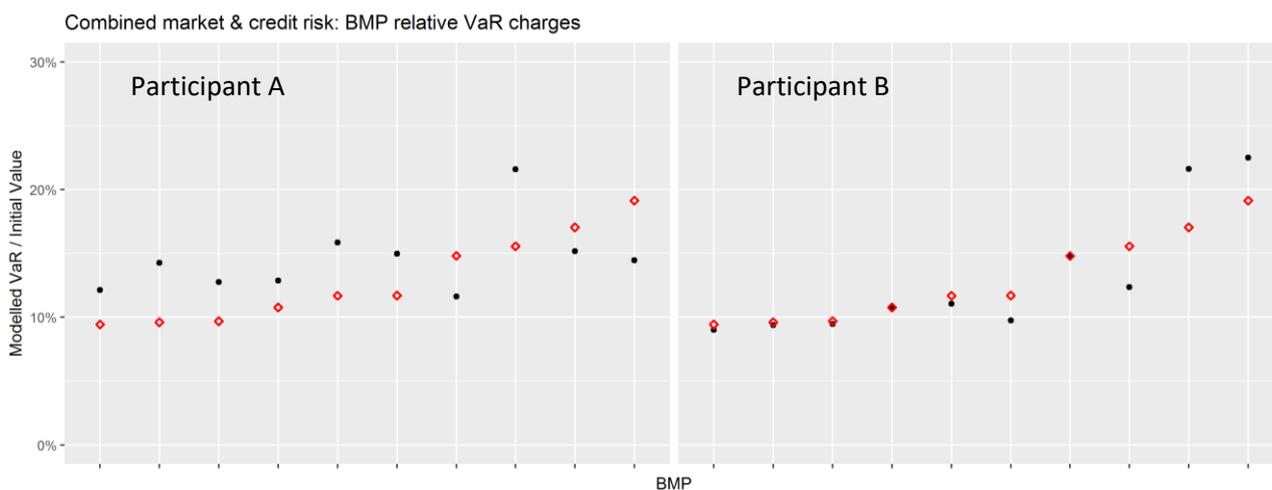

Figure 2: Example of risk ranking for two anonymous participants A (left plot) and B (right plot)

Note that the order of BMPs on the x-axis of these charts differs from the one in the chart in Figure 1. Additionally to avoid misinterpretations, the names of the BMPs are not displayed.

In this graph, the black dots indicate the risk allocated to each BMP by two random participants, while the red circles indicate the median charge in the sample. There are sometimes pronounced variations from the median charge, either higher or lower. While the 'slope' for undertaking B (right-hand plot) is still comparably similar to the median 'slope', that is less the case for undertaking A (left-hand plot). Conversely, there are cases (not shown here) of participants which risk charge is systematically higher (or lower) than the median, with an almost identical BMP ranking.

Summing up and supported by insights from the drill down illustrated in the following section, NCAs might find these types of observations useful to supervisory review process (SRP) on the on-going appropriateness of the model.

Closing remark

It is important to note that the median shall not be interpreted as a 'target calibration'.

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.

Interest rates – risk free

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

The starting risk free rate curves for these simulations in the liquid part are essentially identical across participants, but in three cases differ in the extrapolated part, for which essentially 'flat extrapolation'[10] is used. I.e. although the EIOPA risk free rate curve is used by all undertakings for the valuation of technical provisions, for these three undertakings the derivation of 'shocked curves' does not starts from the EIOPA curve. Such a modelling choice is not considered to be per se critical: for certain assets and liabilities exposures only the liquid part of the curve might be relevant to calculate the risk, and in other cases the modelled variations are independent from the base curve.

At year-end 2015 not all models allowed for negative interest rates, but all of these were changed by the publication date of this report.

When restricting the comparison to single maturities, a significant variability in risk charges can be observed, and will partly require re-assessment. The development of refined tools should help eliminating the ageing effects and the differentiating between components of interest rate movements.

Interest rates – Corporates and Sovereign bonds

Unlike the standard formula, credit risk is actually modelled for sovereign bonds in the presented internal models.

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. Consequently, an attempt was made to differentiate these aspects. But, the observed variability in calculated risk charges beyond the calibration of risk free stresses and calibration of credit risk components is also driven by the fact that the model outputs available for integrated models covers all facets of credit risk, while in modular approaches neither migration nor default risk is included. This aspect will be re-assessed in future studies with refined tools.

Equity and property

Observed variability of calculated risk charges can partly be attributed to limited relevance or irrelevance of the proposed test assets in terms of exposures. Consequently, in some submissions, participants used mapping or rough proxies to be able to provide data. For future studies qualitative information will be collected at single instrument level in order to support the evaluation and credibility of results.

5.3. Supervisory actions

The responsible NCAs discussed results with participating undertakings based on feedback packages prepared for each undertaking going beyond the level of details sketched in this report. The undertakings were additionally asked to provide written feedback on the results and their evaluation of these. Furthermore, feedback on the study itself and future improvements was collected.

Some undertakings have planned to incorporate remarkable observations from the study into their regular model validation activities. In some selected cases this could even trigger model change processes. Other aspects resulted in validation activities which will be followed up within the Supervisory Review Process and with the next edition of the study (see Outlook).

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[10] I.e. essentially constant spot or forward rate after the last liquid point.

6. Outlook

Appreciating the insight gained from this study and given the open questions identified, EIOPA decided to perform regular studies on the market and credit risk modelling in internal models starting from year-end 2017. The scope, legal references, objectives and process of these studies have been published on EIOPA's website[11].

The YE 2017 edition of the study will build on the lessons learnt from this edition and will again focus on risk charges for benchmark portfolios under the combined market and credit risk. To enhance the analysis of combined risks, the tools will be refined. Especially to enrich spectrum of analysis, the study will also explore interest rate down shocks via a simplified liabilities portfolio consisting of short positions in zero coupon bonds.

The future studies will furthermore mainly rely on synthetic assets instead of real assets, aiming to remain to a large extent stable in order to support comparison over time and limit the effort of execution for participants.

Finally, EIOPA needs to be able to better assess the quality and relevance of model results. Therefore, qualitative scores for the test assets will be collected to indicate both the modelling quality and exposure relevance of the respective asset, which will also be used to assess the appropriateness of the YE 2017 specifications[12].

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[11]
https://eiopa.europa.eu/Publications/Protocols/Decision%20on%20the%20Annual%20Market%20and%20Credit%20Risk%20Modelling%20Comparative%20Study.PDF
[12] https://eiopa.europa.eu/Pages/Supervision/Insurance/Data_request_for_MCRCS.aspx