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PwC Solvency II Life Insurers' Capital Model Survey

Summary Report

November 2018

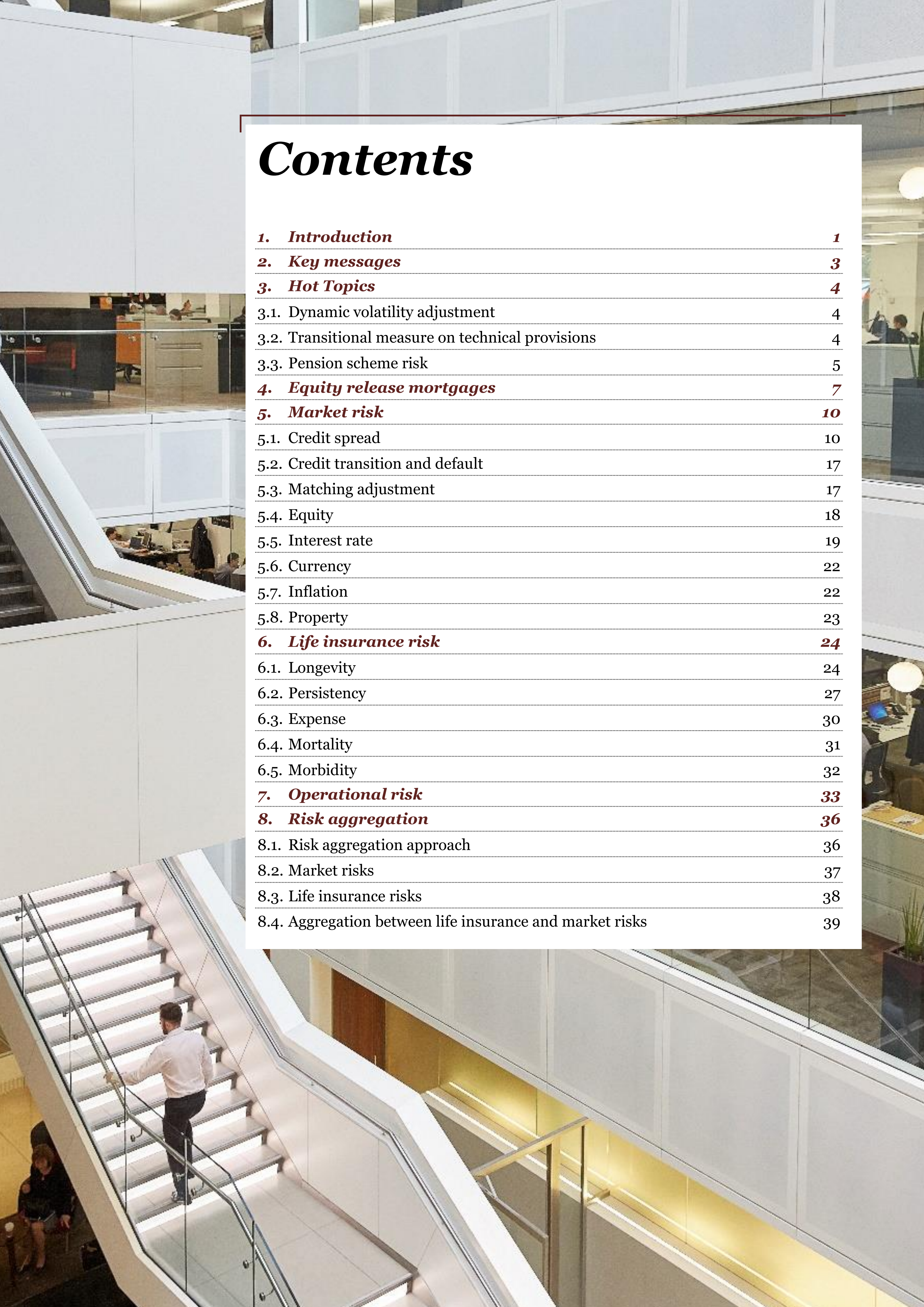
pwc

PwC's capital models survey covers the key data and methodology decisions taken by firms in determining risk capital under Solvency II, as well as the resulting risk calibrations. This survey covers Internal Model and Partial Internal Model life insurance companies in the UK.

Participants

We would like to express our thanks to the following firms which took part in our survey:

- AEGON UK
- AVIVA UK Life
- Just Retirement Limited
- Legal & General Group Plc
- Lloyds Banking Group Plc
- Phoenix Group
- PIC
- Prudential UK
- ReAssure
- Royal London Mutual Insurance Society Limited
- Standard Life Assurance Limited



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1. Introduction

Welcome to the 2018 life insurers' Solvency II capital models survey. This report aims to capture the methodology and the stresses applied in the year-end 2017 capital models across a wide range of risks and any changes in the calibrations over 2017, in order to help your business compare its operation and assumptions with peers in the market. This can provide valuable insights at a time when many insurers continue to be in discussion with their regulators over planned model changes, while others are in the process of seeking internal model approval for the first time.

The survey covers the evaluation of capital for the majority of risks, drawing on information from eleven of the UK's largest life insurers. This year we added questions on selected "hot topics" – the PRA's proposals to allow a dynamic volatility adjustment, recalculation of the transitional measure on technical provisions and the treatment of pension scheme risks – and updated the section on equity release mortgages to reflect the PRA's latest consultation paper. We capture information on a wide range of risk calibrations, with the depth of each section tailored to the materiality of the risk.

The survey covers a diverse range of UK participants, nine of which are currently using an approved internal model or partial internal model. Where there is not an approved internal model, or where the standard formula is used for certain risks within a partial internal model, we asked for information on an economic capital calibration as it stood at 31 December 2017.

Our thanks go to the firms which took part for kindly sharing their time and their insights.

Regards,

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Purpose and use of this report

This report has been prepared to be shared with the public. We accept no liability (including for negligence) to you or anyone else in connection with this report. The report should be read in its entirety; reading individual sections in isolation may result in misinterpretation. The report contains information obtained from survey participants. We have not sought to establish the reliability of the information or otherwise verify the information so provided. Accordingly no representation or warranty of any kind (whether express or implied) is given by PwC to any person as to the accuracy or completeness of the report.

This report is a summary of the detailed PwC survey which covers the data and methodologies adopted by firms in determining risk capital under Solvency II, as well as the resulting risk calibrations. The survey considers Internal Model and Partial Internal Model life insurance companies in the UK. Participants have received a more detailed version of this report, however the key messages summarised here are consistent with the detailed report.

In some areas, not all 11 participants responded to the questions asked. This will have been for various reasons, e.g. where participants employ the standard formula calibrations to calculate a risk capital requirement or where the question is not relevant to the participant's business. In these instances, the total number of responses is less than 11; however we have ensured that results disclosed in this report are always from a sufficiently credible set of responses. Where we have received an insufficient number of responses to meet this objective, we have refrained from disclosing quantitative results.

Compliance with TAS requirements

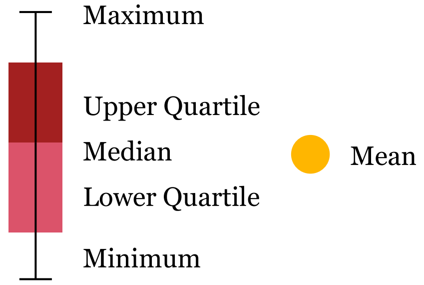
The Financial Reporting Council ('FRC') requires actuaries to comply with Technical Actuarial Standards ('TASs') for various types of actuarial work. We also believe that it is normally appropriate to apply the requirements of the TASs to other work conducted by actuaries. Given the nature of the work, however, we have not attempted to follow the requirements of the TASs on this assignment. You will need to consider the impact of this limitation on your interpretation of our work and results.

Materiality

We have defined materiality as a capital component that is above 5% of the total diversified SCR. This definition is applied consistently throughout the report.

Key to graphs

For all of the results graphs throughout this survey, the dates represent the year-end to which the calibration corresponds (rather than the year in which the survey was published) and the following key applies:



In certain areas where we received limited data, we show only the maxium, minimum and mean.

2. Key messages

In this section we summarise the key themes emerging from the results provided by our participants.

Material risk exposures

Credit, longevity, persistency and equity risks remain the highest individual contributors to participants' undiversified and diversified Solvency Capital Requirement ('SCR'). As in previous years, this survey concentrates in the most detail on these risks and the aggregation of all risks. We consider the calibration of less material life insurance and market risks and of operational risk in less detail.

Result highlights

It is now nearly three years since the first round of internal model approvals and we are starting to see some stabilisation in the calibrations of the major risks. However, this does not imply that all insurers are using the same approach to calibrating a given risk or converging on a particular level of stress – models and their output remain tailored to the individual businesses and their risk management policies.

The modelling of credit risk continues to vary markedly between survey participants, with new statistical distributions added to the wide array of models in use this year, and is one of the more common areas where refinements to the methodology continue to be made. There is little consensus in how the calibrated spread stresses have changed over the year, either in direction or in magnitude, but the average stress for a 10-year A-rated bond has increased for both financial and non-financial bonds. Some participants made changes to the modelling of interest rate risk over 2017, with a general strengthening of the resulting calibrations. Updates to the calibrations for other market risks are largely due to refreshing the data on which they are based.

A range of approaches is used to model longevity trend risk across the industry, with the majority of participants using either a cause of death model or other medical forecasting to support expert judgement. The average change in expectation of life from the longevity base stress decreased slightly over the year, as in the prior year, but there remains no obvious long-term trend. For the first time in our capital surveys, we have seen the average change in expectation of life from the longevity trend stress decrease over the year.

It is encouraging to see that the PRA is now proposing certain relaxations to their supervisory approach, for example by permitting the use of a volatility adjustment which varies under stress. These proposals were open to consultation at the time that the survey was carried out and, at that stage, only three participants indicated plans to introduce a dynamic volatility adjustment once the proposals are finalised. However, we may see other insurers alter their approach in future.

While making concessions in some areas, the PRA continues to tighten up the approach when supervising firms with illiquid assets, with a particular focus on equity release mortgages and the extent to which benefit can be taken for them within the matching adjustment. The most recent proposals, which set out a more prescriptive Effective Value Test for these assets, were also open to consultation at the time that the survey was carried out so we do not capture their potential impact on calibrations.

3. Hot Topics

Within this section we present our findings on three new topics included in our survey this year: the PRA's proposal to allow a dynamic volatility adjustment within internal models, the approach taken to transitional measures on technical provisions and the allowance for pension scheme risk within the capital model. The treatment of equity release mortgages, which remains an area of focus for the PRA, is covered in the next section.

- Fewer than half of participants currently intend to update their internal model to allow for the dynamic volatility adjustment.
- The transitional measure on technical provisions expressed as a proportion of the Solvency Capital Requirement varies markedly between survey participants, and has been recalculated up to four times since Solvency II implementation in 2016.
- Typically the biting scenario for the credit spread stress differs between the pension scheme and the long-term business funds. Participants reported using a range of approaches during aggregation, including offsetting the impacts and zeroising any benefit arising from the pension scheme.

3.1. Dynamic volatility adjustment

On 11 April 2018, the PRA published Consultation Paper (CP) 9/18 on the modelling of the volatility adjustment (VA) for internal model firms. The PRA is proposing to introduce a new supervisory statement (SS) allowing a dynamic volatility adjustment (DVA) when modelling Solvency II market risk stresses within the SCR calculation.

Previously, the PRA stated its view that internal models should not allow the VA to change under stress. The new proposals allow the VA to move with modelled credit spreads in the own funds projection. The CP and draft SS outline the points that firms need to consider within the model change application when seeking approval to use the DVA, including: consistency of parameters with the best-estimate liability calculation; constraints on adjustments which may result in capital benefits; constraints on excessive capital relief on options and guarantees; and the dependency between risks when changing the discount rate methodology.

Fewer than half of participants indicated that they intended to update their internal model to allow for the dynamic volatility adjustment. However, please note that responses were largely received in early July 2018 prior to the deadline for feedback on CP 9/18 (11 July 2018) and thus indicate a preliminary view of intentions.

3.2. Transitional measure on technical provisions

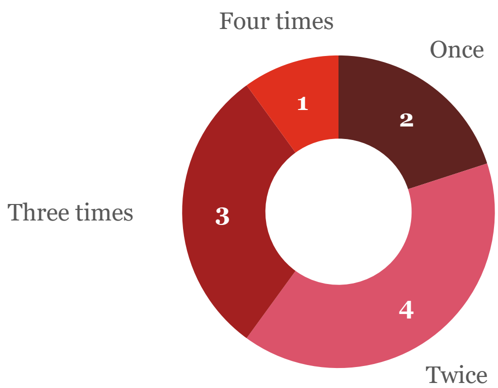
Since the implementation of Solvency II on 1 January 2016, firms have been allowed (subject to PRA approval) to apply a transitional measure on technical provisions (TMTP) to dampen the initial impact of any increase in net technical provisions. This impact is measured relative to the more onerous of the Solvency I Pillar 1 or Pillar 2 bases and is spread over a period of 16 years. The TMTP can be applied to business which also uses either the matching or volatility adjustment.

The PRA expects, as per SS 6/16, that recalculation of the TMTP will be performed biennially, or more frequently (with supervisory approval) should there be a material change in the risk profile of the insurer. Whether or not a change in risk profile is deemed material is assessed relative to the impact on the insurer's solvency ratio, i.e. the extent to which the TMTP offsets the SCR. Firms are expected to maintain their own policies defining what would constitute a change in risk profile sufficient to trigger an application to recalculate the TMTP. While the recalculation methodology is not prescribed, it is expected that firms will need to retain some Solvency I calculation functionality for this purpose.

The TMTP expressed as a proportion of the SCR varies markedly between survey participants (between about 10% and about 80%), and so for many is a material contributor to the overall solvency ratio.

Figure 3.1 shows how often participants have reset the TMTP since Solvency II implementation. We would expect all participants to have performed at least one recalculation since 2016 given the biennial Solvency II requirement, however the majority of participants have reset the TMTP more than once.

***Figure 3.1:** Number of TMTP recalculations since Solvency II implementation.*



All participants confirmed that they have a TMTP recalculation policy, as would be expected in line with SS 6/16. When asked how a material risk profile change is defined, the majority of participants specified criteria in line with SS 6/16, e.g. with reference to a 5% change in the solvency ratio or a change of more than 50bps in the risk-free rate.

As expected, all participants confirmed that a change in the risk margin would trigger a recalculation of the TMTP. Changes in risk-free rates and company structures are also common triggers, whereas changes in with-profits transfers and enhancements are unlikely to trigger a recalculation across those surveyed. Other than the mandatory biennial reset, participants cited changes to reinsurance, economic events and significant mergers or acquisitions as other potential drivers.

The majority of participants confirmed that some form of simplification is made when segregating business written prior to 1 January 2016, which is necessary for the recalculation, with many firms using current systems with manual adjustments rather than maintaining systems as at 1 January 2016 for earlier business.

When asked about the length of time required to obtain both internal and supervisory approval for a TMTP reset, participants provided a range of responses between two and six months in total.

3.3. Pension scheme risk

For internal model firms, the Solvency II regulations require that the SCR calculation considers all material risks to which the insurer is exposed. The PRA emphasised this in the context of pension scheme risk in SS 5/15.

Where pension schemes are valued on the Solvency II balance sheet under IAS19, insurers use the yield on high-quality corporate bonds for the valuation of the liabilities. This may differ from the yield on assets actually held by the scheme. Insurers are required to consider the impact of a credit shock on the scheme. Due to the different valuation approach and the differing nature of the liabilities, the pension scheme may behave differently under stress from the long-term insurance business.

For most participants, the pension scheme is exposed to a narrowing of credit spreads, while all participants indicated that their long-term business is exposed to a widening of credit spreads.

Where the direction of the onerous credit stress differs between the pension scheme and long-term business, participants allow for this in a variety of ways when calculating the overall SCR. Approaches include the following:

- Any beneficial impact from the pension scheme from spread widening is offset against the onerous stress for the long-term business in the overall SCR.
- The benefit from the pension scheme is zeroised under the spread widening stress so as not to offset the stress on the long-term business, e.g. via a fungibility restriction on the pension scheme surplus.
- Full diversification between risks (with approximations) is allowed for.

4. Equity release mortgages

Illiquid unrated assets such as equity release mortgages (ERM) have been increasingly used by life insurers with large annuity books in recent years to optimise their capital position under Solvency II. David Rule, Executive Director of Insurance Supervison at the PRA, noted in his speech of July 2017 that, at the time, based on supervisory information, 25% of annuity liabilities were backed by illiquid direct investment assets with the PRA expecting this to increase to 40% by 2020. In a more recent speech, focused on the bulk annuity market, David Rule highlighted that ERM is the illiquid asset category in which exposures have been growing most quickly.

Given the subjectivity involved in valuing and managing ERM and the materiality of this asset class, such assets are receiving increasing regulatory scrutiny. In July 2017, the PRA issued a supervisory statement (SS 3/17) which set out its expectations for insurers investing in illiquid, unrated assets (including ERM) within their Solvency II matching adjustment (MA) portfolios. The supervisory statement focused on the PRA's expectations for internal credit rating assessments, the assessment of and allowance for guarantees embedded within ERM (specifically the 'no negative equity' guarantees (NNEGs)) and the extent to which the fundamental spread properly reflects the insurer's exposure to NNEG risks. This supervisory statement built on earlier papers released by the PRA regarding the treatment of illiquid unrated assets and, in particular, provided insight into the level of evidence and justification the PRA expects for the treatment and valuation of ERM.

In July 2018, the PRA released Consultation Paper 13/18, which builds on the previous papers by proposing a more prescriptive calculation of the value of the NNEG within the Effective Value Test (EVT) introduced in SS 3/17. This aims to address concerns that the MA benefit of ERM is overstated due to the assumption that future residential property growth is in excess of the risk-free rate.

The proposals set out a minimum calibration to meet the PRA's expectations, including use of a Black-Scholes model with defined deferment rate and volatility parameters. If the proposals are adopted without change, this could significantly impact the capital position of insurers with ERM portfolios and leave some unable to meet the EVT. For such firms, the PRA proposed to allow a phasing-in period of no more than three years for firms to revisit their risk modelling approaches for both the base balance sheet and capital requirements. In October 2018, the PRA announced that it would take more time to consider the responses to the consultation and that the final changes will take effect from 31 December 2019, not 2018 as originally proposed.

The increased regulatory scrutiny of ERM highlights the importance of ensuring that the relevant risks are properly modelled in the base and stressed valuations. A number of insurers have also restructured their ERMs, splitting the cashflows into loan notes with different levels of security. Valuation of these loan notes can be particularly challenging.

We asked participants for a range of quantitative and qualitative information on their current calibrations, data and the methodology for their base and stressed assumptions. We note that, due to the requirements of CP 13/18, there may be significant changes to these calibrations in the future, e.g. the property assumptions used in valuing the NNEG risk.

- In line with prior year, the 1-in-200 property level stress sits within a range from about 20% to 30%. The stress applied to the ERM property volatility stress, as an addition to the base stress, is also similar to prior year, typically in the range 5% to 10%.
- A Black-Scholes formula is the most common method for valuation of the NNEG risk.
- When revaluing the restructured ERM assets under stress, the most common approach is in line with last year's survey results, i.e. the underlying ERM assets are stressed and the senior notes and junior notes are revalued in line with the base valuation methodology (which typically values the junior note first).

Property growth

Similar to the results of last year's survey, the majority of participants indicated that they used Nationwide, Halifax or Bank of England data to set their property growth assumption. The data periods used by participants ranged from 20 to 50+ years.

The majority of participants use a statistical distribution to model changes in property prices, and a number of distributions were given.

Participants model the best estimate property growth assumption in one of two ways – either using a risk-free rate or as a margin over RPI or the RPI swap curve, with the margin ranging from 0.5% to 2%. Those using a risk-free rate apply a stress in line with the interest rate calibration. The other participants apply a reduction to the assumed best estimate growth rate, ranging between about 1.25% p.a. and 2.60% p.a., similar to the stresses reported in last year's survey.

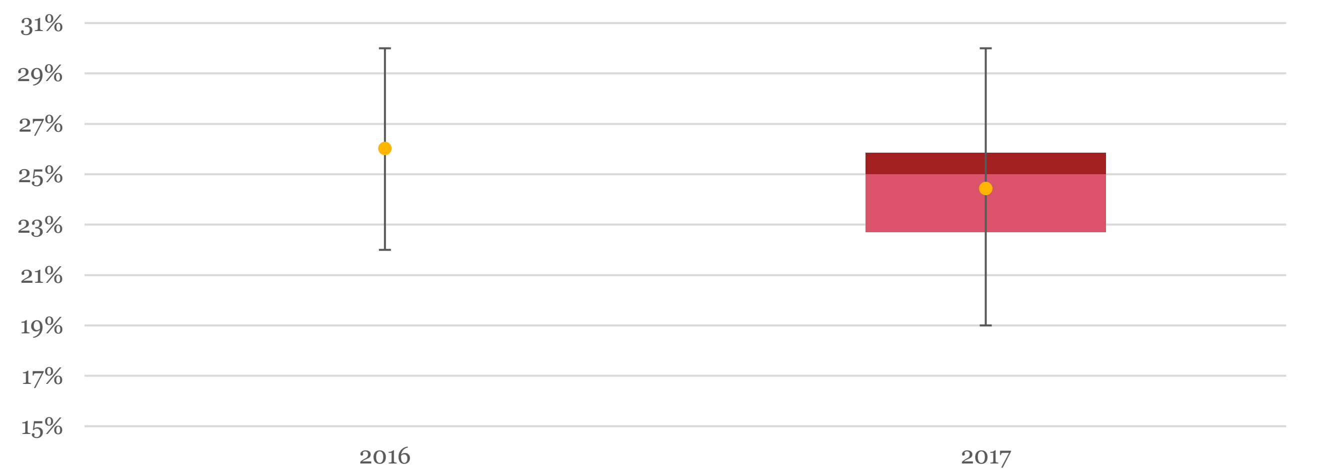
Property level

A small majority of participants use only Nationwide data to calibrate the property level stress. Other data sources, such as Halifax, Office for National Statistics (ONS) and Organisation for Economic Co-operation and Development (OECD) are also used, with some participants using a combination of data sources. The period of data used in the calibrations varies widely, from 10–20 years to over 50 years.

Both the data source and period of analysis are broadly in line with those used within the property risk component of market risk, and with last year's survey.

The 1-in-200 calibrated property level stresses for ERM are shown in Figure 4.1. We received insufficient responses last year to be able to present quartile information for 2016, but have included the mean and range of responses for comparison.

Figure 4.1: *Property level stress calibrated at the 1-in-200 level for ERM.*

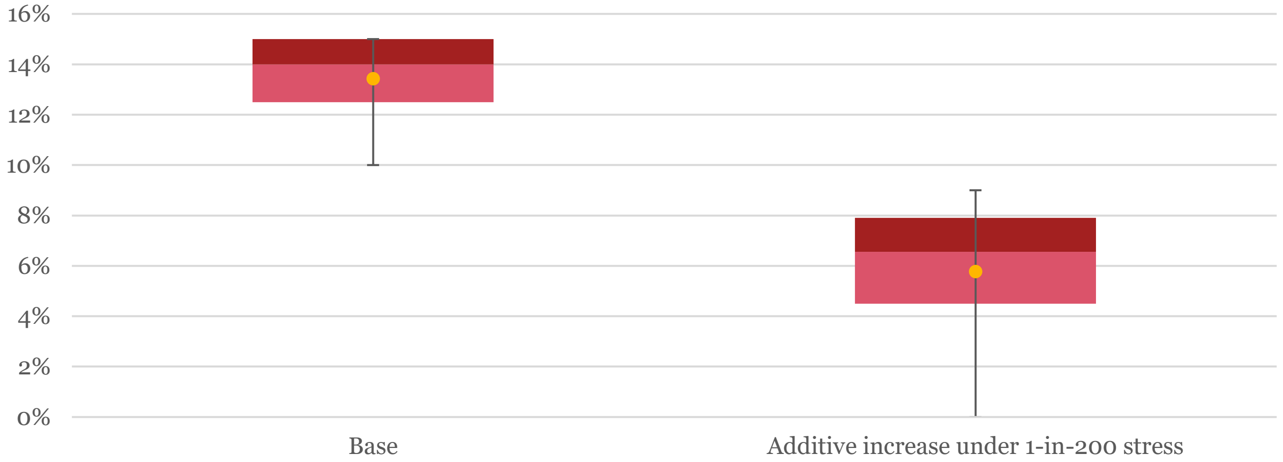


Property volatility

Participants use a variety of data sources to calibrate the base and stressed property volatility assumptions, including Halifax, Nationwide and Land Registry. Significant expert judgement is applied in respect of the required allowance for de-smoothing volatilities derived from indices, uncertainty around dilapidation, autocorrelation and idiosyncratic risk.

We asked participants to provide the assumed ERM property volatility in base and stressed conditions. Figure 4.2 summarises the range of base assumptions adopted by participants as well as the additive increase to the assumption under stress.

Figure 4.2: *Base property volatility assumptions for ERM and additive increase under 1-in-200 stress.*



Other assumptions and model choice

Many participants use internal data for setting prepayment assumptions, alongside additonal sources such as Aviva Equity Release Funding data. We note that CP 13/18 is specific in its requirement to include all risks within the EVT, including prepayment.

All participants make an allowance for property dilapidation costs when modelling the projected property price, using a variety of approaches including an explicit reduction in value or an implicit allowance via the property growth assumption or the volatility assumption.

Restructuring ERM cash flows

It is possible to restructure ERM cash flows into securitisations (senior and junior notes), with the senior note cash flows structured in such a way that they can be demonstrated to be eligible for the MA and therefore for inclusion in the MA portfolio. We note the following observations from the responses we received:

- All participants assume that an equation of value holds between the unstructured ERM assets and the aggregation of the structured senior and junior notes. Some participants value one note (more commonly the junior note) first and determine the value of the other note using the equation of value, while others value both notes simultaneously within the constraints of the equation of value and assumptions about the spread differential.

- In line with our prior year survey, all participants confirmed that an internal credit rating is used to map loans directly to an EIOPA corporate bond fundamental spread (FS). For complex assets such as restructured ERMs, the range of risk exposures can be considerably greater than for conventional bonds and PRA SS 3/17 mandates that firms investing in illiquid, unrated assets within the MA portfolio require a strong internal credit rating process to ensure that all risks to which a firm is exposed are reflected in the FS.

- When revaluing ERM assets under stress, all participants described an approach whereby stresses are applied to the ERMs and then the base valuation methodology is applied, e.g. revaluing the junior note under stress and defining the senior note to be a balancing item. Participants adopt a variety of approaches for modelling the FS on the securitised assets under stress, e.g. stressing the FS consistently with other similarly credit-rated assets.

- Some participants indicated that they apply stress tests to the value of ERMs in order to inform the internal credit assessment, with use of Moody's published tests common across approaches.

5. Market risk

Solvency II states that the market risk module of the standard formula shall reflect the risk of loss or adverse change in the financial situation resulting, directly or indirectly, from fluctuations in the level and in the volatility of market prices of assets, liabilities and financial instruments. It shall properly reflect the structural mismatch between assets and liabilities, in particular with respect to duration. Similar considerations would be expected to inform market risk calibrations of an internal model.

In this section, we consider the components of market risk. For each risk, we asked participants for a range of quantitative and qualitative information on their risk calibrations as applied in their Solvency II internal model, with a focus on the credit risk elements.

5.1. Credit spread

Solvency II defines spread risk as the risk arising from the sensitivity of the values of assets, liabilities and financial instruments to changes in the level or in the volatility of credit spreads over the risk-free interest rate term structure.

- The majority of participants model credit spread risk separately to transition and default risk.
- The average 1-in-200 increase in spread for a 10-year A-rated financial bond (403bps) has increased by 25bps (2017: 378bps). The average 1-in-200 increase in spread for a 10-year A-rated non-financial bond (264bps) has increased by 17bps (2017: 247bps). The increase for non-financial bonds is around three times larger when only firms which participated in both years are considered; the change in participants has a much smaller effect on the average for financial bonds.
- There is considerable variation in the level of credit spread stress being applied to UK gilts, particularly at the 5-year term, but little change in the average stress since last year.

Changes in approach over the year

The majority of participants noted that they made changes to the credit risk calibration (encompassing both spread risk and transition and default risk) over 2017. Of these, almost all made changes to the methodology used within the calibration and around half refreshed the data used in the calibration, with some overlap between these actions. While the average stresses quoted above increased, there were differences between participants as to whether changes made over the year either weakened or strengthened the calibration, or in some cases had a broadly neutral impact.

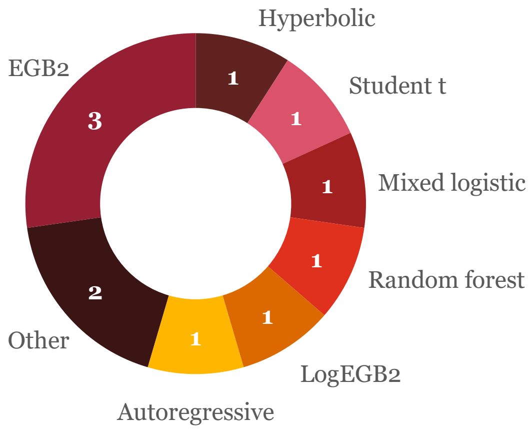
Around half of participants stated that the changes were driven by external factors, primarily interactions with the PRA, while the others cited internal factors.

Methodology

Calibration Model

The majority of participants model spread risk separately from transition and default risk. The range of models used to calibrate spread risk is wider than in previous years, as illustrated in Figure 5.1

Figure 5.1: *Distribution of modelling methodology used by survey participants to calibrate credit spread stresses.*



All participants indicated that their credit spread risk model reflects term structure, with the majority of participants grouping holdings into buckets by term or tenor. All participants indicated that they use credit rating as a risk factor and the majority calibrate stresses separately by market sector. Calibrations are also split by currency where relevant and a small number of participants use other factors such as seniority.

Sovereign debt stresses

The majority of participants model some sovereign debt using the same underlying model as for corporate bonds, with lower credit-rated sovereign debt in particular treated as though it was corporate debt. A number of these participants model higher-rated sovereign and supranational debt (where the minimum rating for different treatment varies by participant between A and AAA) using the same model as corporate bonds but different data, resulting in separate calibrations. A small number of participants treat UK gilts as risk-free.

Assets other than corporate and sovereign bonds

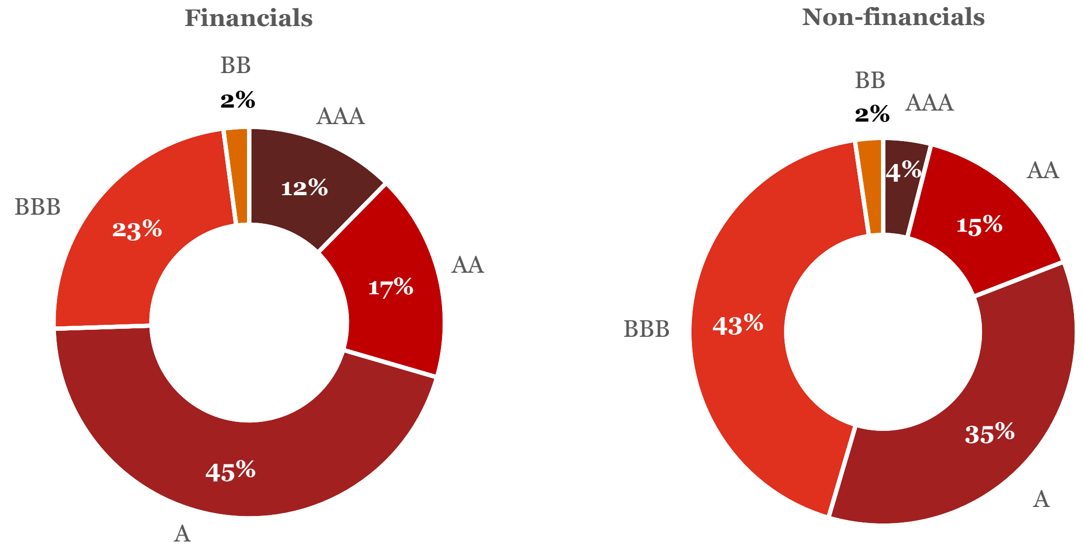
The majority of participants indicated that they hold some amount of assets other than corporate and sovereign bonds, for example infrastructure loans, equity release mortgages or social housing loans. Approximately half of these participants stated that they calculate credit spread stresses for these assets separately from those for corporate and sovereign debt, although it is common to use the same underlying model as for corporate bonds with different data relevant to the risk driver for the stress on the asset being modelled.

Results

We asked participants for details of their calibrated credit spread stresses by sector (financial / non-financial) and credit rating. The summarised results can be seen in Figures 5.3 to 5.10, in each case combined with equivalent data from the last four years of this survey to show the movement over time.

To set the results in context, we also present information on the average split of the bond portfolio by credit rating, separately for financial and non-financial corporate bonds. Figure 5.2 shows that the stresses for A-rated financial bonds are of most relevance, while for non-financials there are material holdings of both A- and BBB-rated bonds.

***Figure 5.2:** Average exposure to financial and non-financial corporate bonds*



Financial corporate bonds

The following graphs show the stresses for **financial corporate bonds** only. As expected, there is a general increase in calibrated stress as bond rating decreases. Note the change in scale of the y-axis between different terms.

There is no consistent trend in the calibrated stresses over time, although perhaps some evidence of a general drift upwards for A-rated bonds at terms of 10 years and above, nor evidence of convergence to a narrower range of stresses as modelling evolves. This is perhaps to be expected given the range of modelling approaches and differences in the composition of asset portfolios, resulting in different combinations of term and rating being more important to different participants.

***Figure 5.3:** Calibrated basis point yield increase for credit spread by credit rating for financial corporate bonds (5 year term, 1-in-200).*

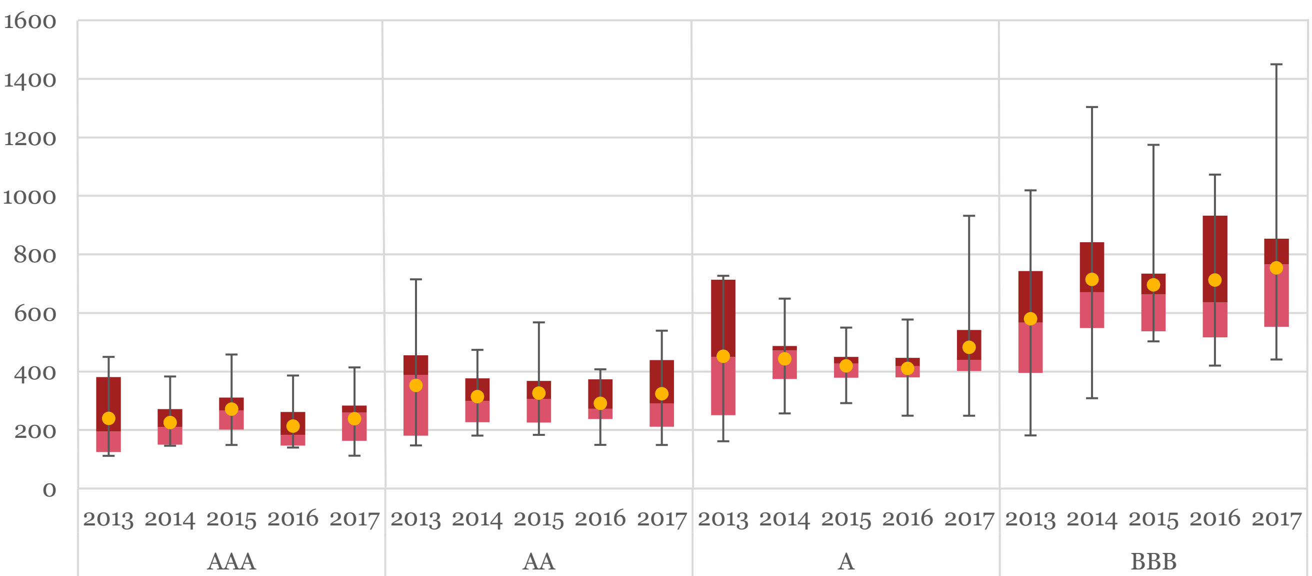


Figure 5.4: *Calibrated basis point yield increase for credit spread by credit rating for financial corporate bonds (10 year term, 1-in-200).*

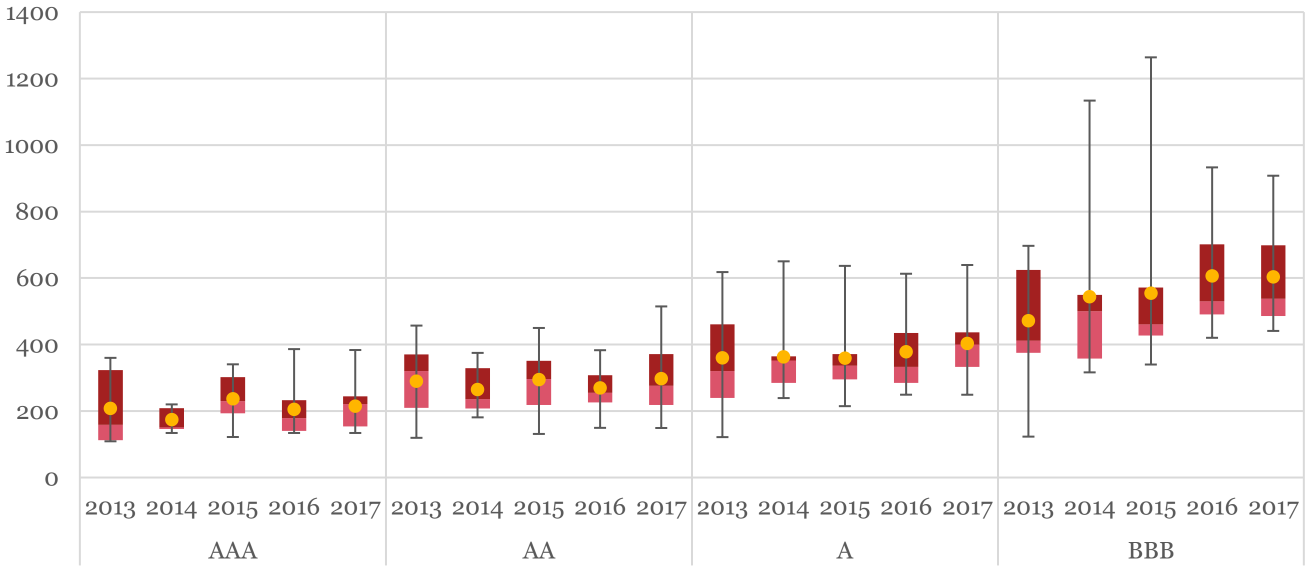


Figure 5.5: *Calibrated basis point yield increase for credit spread by credit rating for financial corporate bonds (15 year term, 1-in-200).*

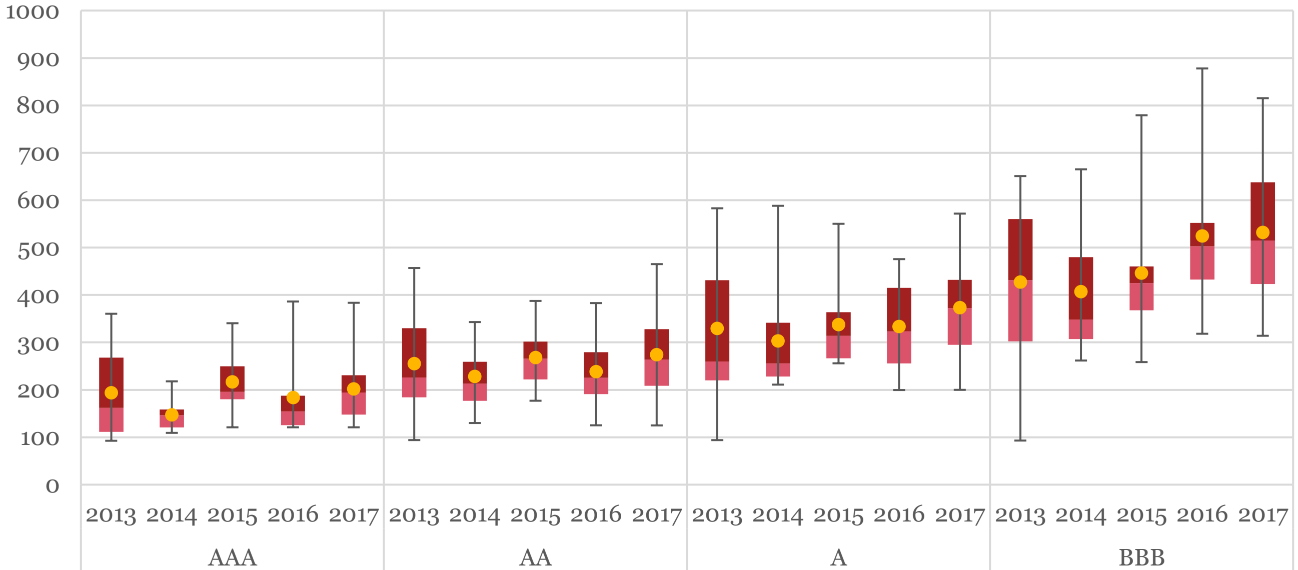
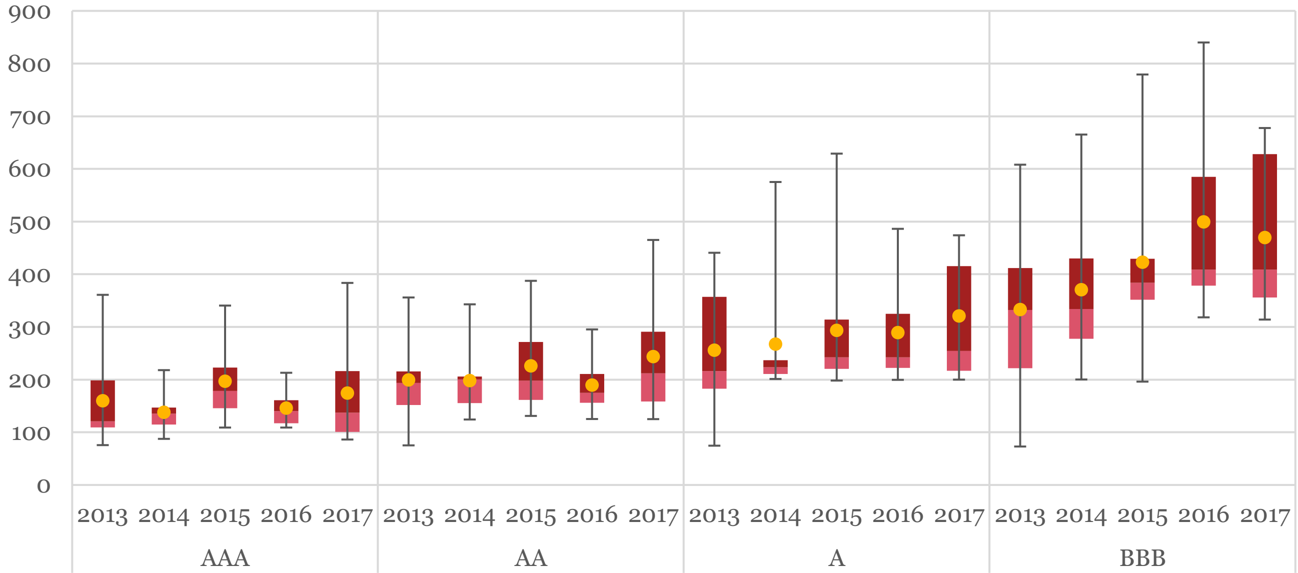


***Figure 5.6:** Calibrated basis point yield increase for credit spread by credit rating for financial corporate bonds (20 year term, 1-in-200).*



Non-financial corporate bonds

The following graphs illustrate the calibrated stresses for **non-financial corporate bonds** only. Again, note the change in scale of the y-axis between different terms.

There continues to be some evidence of more consistency of the mean stress over time than for financials, although the evidence is not strong, particularly at the longest terms.

***Figure 5.7:** Calibrated basis point yield increase for credit spread by credit rating for non-financial corporate bonds (5 year term, 1-in-200).*

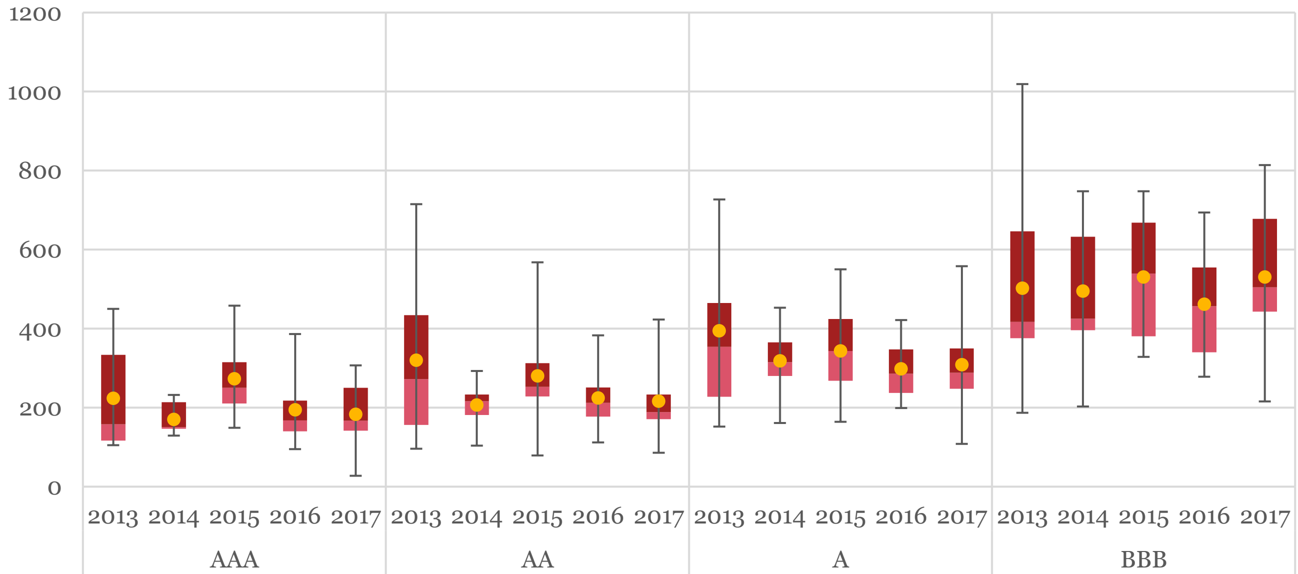


Figure 5.8: *Calibrated basis point yield increase for credit spread by credit rating for non-financial corporate bonds (10 year term, 1-in-200).*

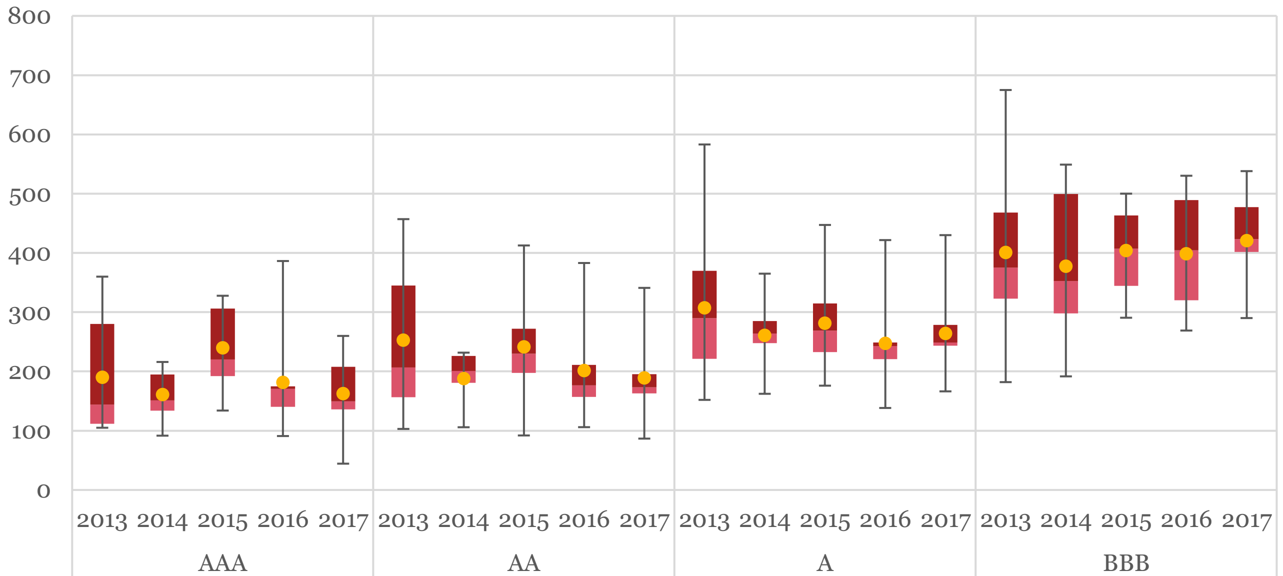


Figure 5.9: *Calibrated basis point yield increase for credit spread by credit rating for non-financial corporate bonds (15 year term, 1-in-200).*

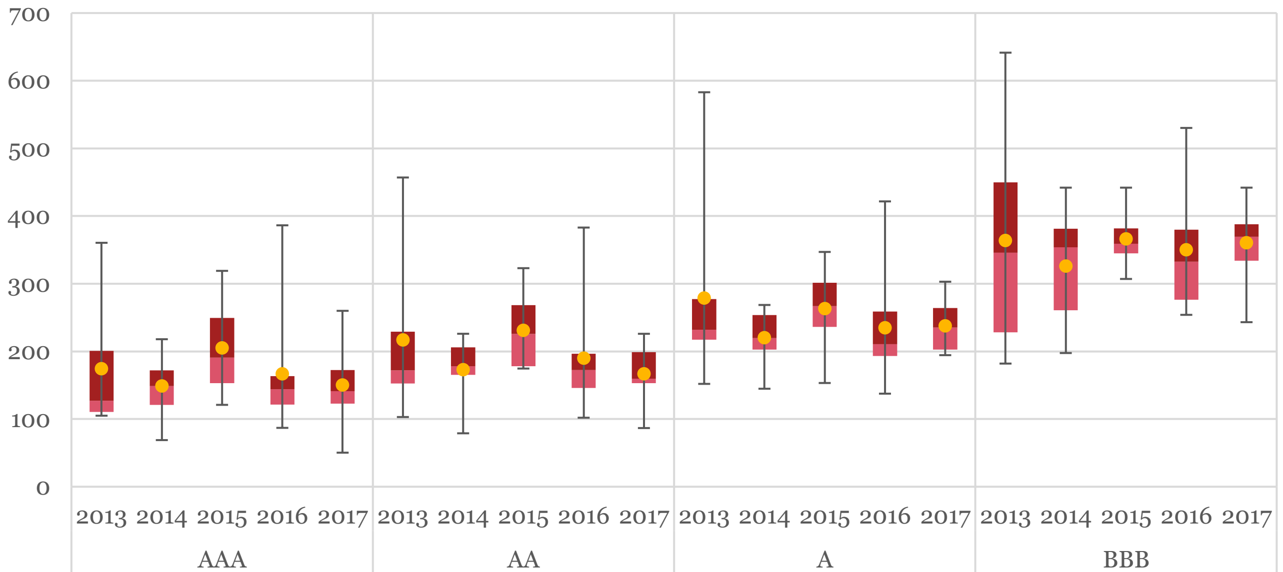
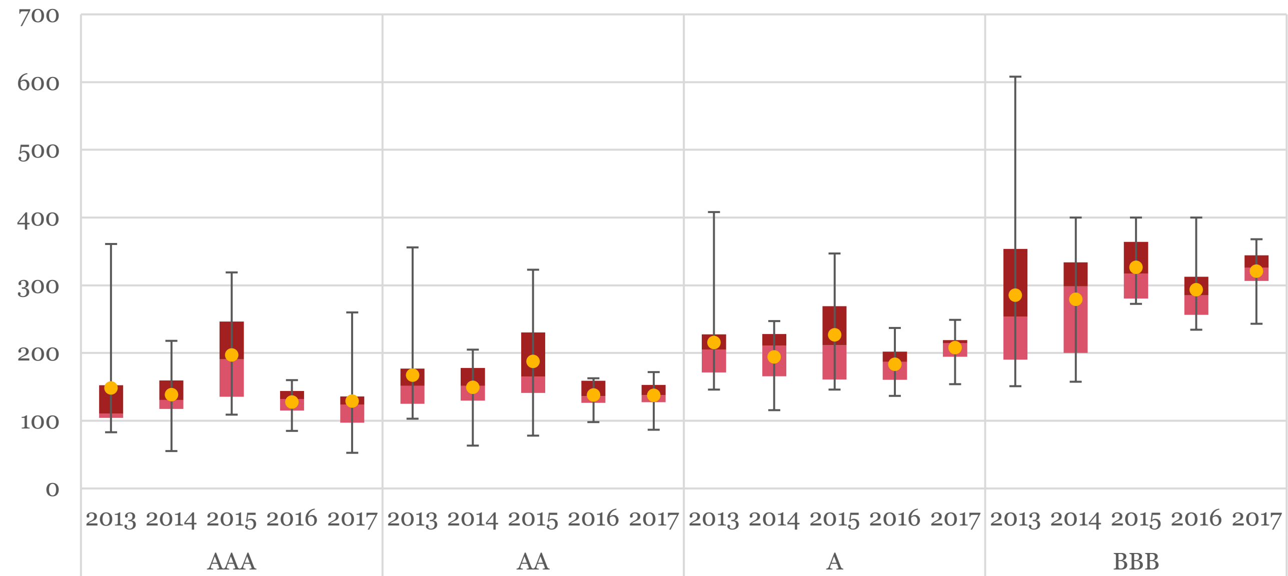


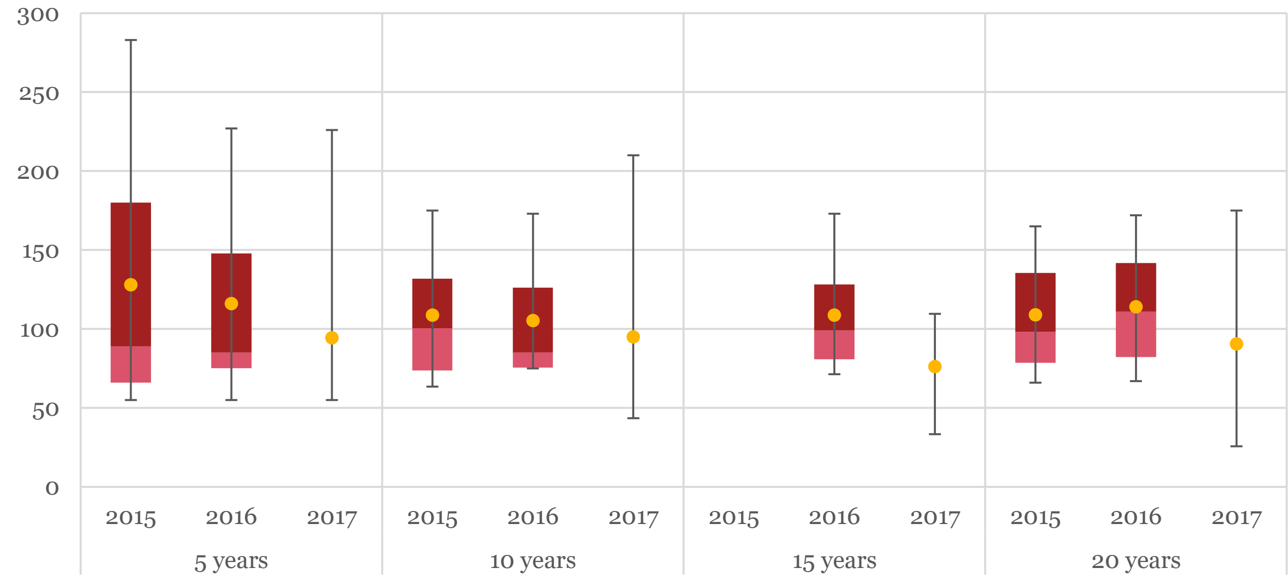
Figure 5.10: *Calibrated basis point yield increase for credit spread by credit rating for non-financiacorporate bonds (20 year term, 1-in-200).*



UK gilt stresses

We also asked participants for details of the 1-in 200 stresses applied to UK gilts where modelled separately. We received insufficient responses to be able to present quartile information this year, but the means and ranges for the 1-in-200 stresses are set out in Figure 5.11, along with those from the last two years' surveys where available. There is some evidence of a decrease in the mean stresses this year, although this may simply be due to the more limited data received.

Figure 5.11: *Calibrated 1-in-200 basis point UK gilt stress (to the EIOPA risk-free curve).*



5.2. Credit transition and default

Losses can also arise from the sensitivity of the values of assets and liabilities to changes in market assessments of the risk of future migration and/or default. Before the advent of Solvency II, insurers generally modelled credit risk holistically, focusing on spread changes to reflect movements in total return/value. The matching adjustment calculation and associated split of transition and default risk from spread risk, combined with regulatory pressure, has led to the majority of insurers choosing to reflect spread, transition and default elements separately within their modelling.

Methodology

Calibration model

As observed for credit spread risk, there is a wide range of approaches adopted to model credit transition and default risk, including Lognormal, mixed logistic, JLT, Markov chain, transition matrix, Vasicek and asymptotic single risk factor models.

Consistent with last year's survey, a small majority of participants stated that the cost of transition within their internal model is driven by modelled stressed spreads at the point of transition (i.e. a 'point in time' approach) rather than by spreads calculated as an average over a period of time (i.e. a 'through the cycle' approach).

The majority of participants model recovery rates as an average over a period of time rather than dynamically at the point of default. The majority also allow for the costs of rebalancing the portfolio after a downgrade within the model. There were no changes in approach since the prior year.

As in prior years, the majority of participants apply default and downgrade stresses to sovereign debt, although there continues to be some variation between insurers as to whether this is applied across all ratings and territories or only to lower ratings and non-UK debt.

5.3. Matching adjustment

The matching adjustment (MA) calculation reflects the yield over and above the risk-free rate earned on an asset portfolio ring-fenced to back designated liabilities, less the fundamental spread in respect of transition and default risk. In order to use a MA in the valuation of the Solvency II balance sheet, PRA approval is required. However, considerable variation remains over the modelling of the MA under a credit spread stress and ongoing management of MA portfolios.

The majority of participants apply a MA within their business, typically applying it to immediate annuities. Some also apply the MA to bulk purchase annuities and / or to deferred annuities.

- The proportion of the increase in credit spread that is offset by an increase in the assumed MA varies between approximately 40% and 75%, similar to that observed last year. The resulting offset in credit risk univariate capital requirement varies between approximately 35% and 65%; it is more common for this to be lower than the proportion of spread offset, but this is not the case for all participants.
- Participants are broadly equally split as to whether or not to reduce the MA under a longevity stress.

Practice varies as to whether or not participants reflect the three PRA matching tests in their model, with a small majority doing so. There is also variation in the complexity of rebalancing assumptions applied to the MA portfolio under stress. Participants typically rebalance to ensure cash flow matching or to maintain the credit quality of the portfolio.

When credit spreads widen in a stressed scenario, some of the impact on the MA portfolio assets is offset through an increase in the MA and hence in the discount rate used to value the MA liabilities. All participants which use a MA make an allowance for the portion of the increase in credit spread that feeds through to an increase in the assumed MA, typically in the range 50–60% although with some outliers. A small number allow this to vary by term. The resulting offset in credit risk univariate capital requirement broadly correlates in percentage terms to the offset in the increase in total credit spread, although there is no strong consensus as to the size of either allowance or to which is higher.

The equivalent offset for the swap spread stress applied to UK gilts is typically in the range 90–100%, which is consistent with last year's survey.

The majority of participants confirmed that no cap is applied on the increase in total spread which translates into an increase in the MA. However, some participants do apply limits, for example as a percentage of total stressed spreads at an aggregate level or as a cap to sub-investment grade debt. This is unchanged from the prior year survey.

Approximately half of participants confirmed that the MA can be reduced under a longevity stress, whereas the others assume the MA is maintained. Typically, where the MA is reduced under a longevity stress, responses show that the MA portfolio is rebalanced to meet the additional cash flows arising, resulting in rebalancing costs and a recalculation of the MA.

5.4. Equity

Solvency II defines equity risk as that arising from the sensitivity of the values of assets, liabilities and financial instruments to changes in the level or in the volatility of market prices of equities. As in prior years, we surveyed only the final stress calibrations in respect of equity risk.

Changes in approach over the year

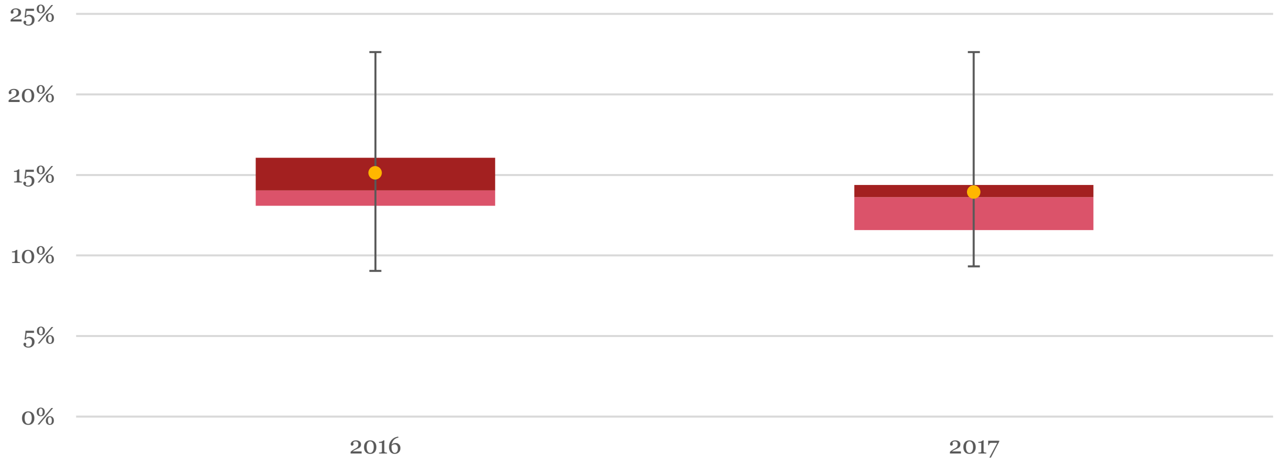
Roughly half of the participants made changes to the equity risk calibration over 2017, which in most cases was simply the refreshing of data used within the calibration. This had a broadly neutral effect for some but gave a generally weaker calibration for others.

Results

We asked participants for the calibrated stresses for equity level and volatility risk. Figures 5.12 and 5.13 show summarised information on the level and volatility stress respectively. The level stress is shown as the drop in the value of equities at the 1-in-200 level and is combined with data from the last four years of the survey to show the movement over time. While the range of the level stresses has increased when compared to the prior year, the mean is little changed.

Figure 5.12: *Calibrated 1-in-200 UK equity level stresses.*

Figure 5.13: *Calibrated 1-in-200 equity volatility stress.*



The volatility stress is shown as an absolute increase to the volatiliy at the 1-in-200 level; only one previous year of data is included because we received insufficient information in earlier years. A small number of participants do not model equity volatility explicitly. The volatility stress range remains the same as the prior year, between 9% and 23%.

Approximately half of the participants confirmed that they apply the same 1-in-200 equity stress calibration across all equity types, while the others set separate stresses for different equity holdings, typically differentiating by currency.

5.5. *Interest rate*

Solvency II defines interest rate risk as the risk of loss or adverse change in the value of assets and liabilities due to unanticipated changes in interest rates and volatility.

- While most insurers use principal components analysis to model interest rate risk, there is a wide range of distributions adopted by participants within their modelling.
- All participants now make an allowance for interest rates to fall below 0% in their internal model.
- The magnitude of stresses is generally higher for upward than for downward stresses and tends to decrease for longer terms, but there is little consensus on the variability by term.

Changes in approach over the year

The majority of participants noted that they made changes to the interest rate risk calibration over 2017. There was a broadly even split of those that refreshed the data used within the calibration and those that made methodology changes, with little overlap between the two actions. The methodology changes either resulted in a general strengthening of the calibration or had a broadly neutral effect, while refreshing data tended to the weaker side of neutral. A small majority of participants stated that the changes were driven by external, rather than internal, factors.

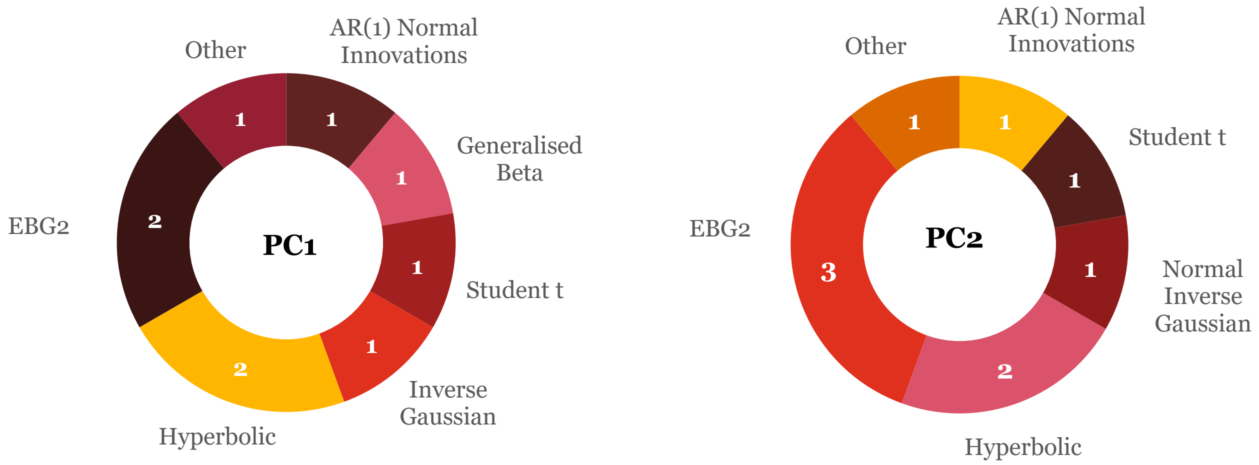
We note that of the participants that also participated in the survey last year, there has been no change in the models used to calibrate interest rate volatility stresses.

Methodology

Calibration model

In line with prior year, the majority of participants use Principal Components Analysis (PCA). Their modelling approaches for principal components 1 and 2 for the level stress within the interest rate risk component are illustrated in Figure 5.14; principal component 3 has not been reported due to the limited number of responses. Participants which do not use PCA are not included in these graphs.

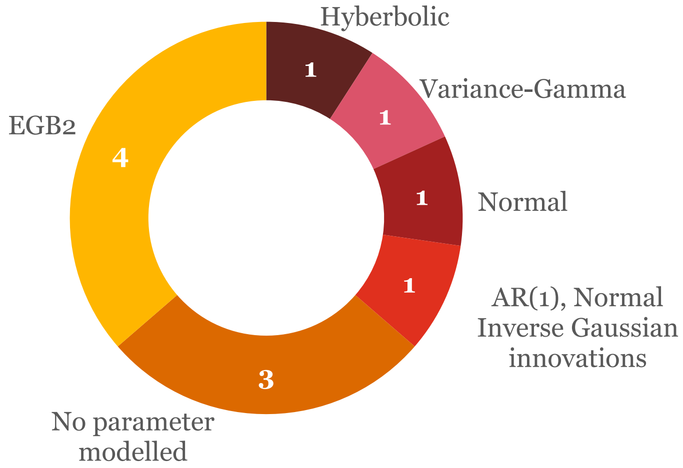
Figure 5.14: *Models used by participants for PC1 and PC2 in calibrating interest rate level stresses.*



The results show that there is a wide range of calibration methodologies adopted by participants, although the majority of participants use the same statistical model for both PC1 and PC2. Other approaches are adopted by those not using PCA.

We also asked participants for their modelling approach for interest rate volatility. The results are illustrated in Figure 5.15.

Figure 5.15: *Models used by participants in calibrating interest rate volatility stresses.*



Allowance for negative interest rates

For the first time, all participants indicated that they make an allowance for interest rates to fall below 0% in their interest rate stress calibration. Nearly half of participants apply a floor, with a variety of approaches to implementing this in practice, including a fixed floor, a shifted log-normal model or a floor based on the largest historical negative rates observed. Where a floor is not applied, most participants observe negative interest rate scenarios at the medium and long term within their models.

Results

We asked participants for the upward and downward changes in the risk-free zero coupon bond spot yield for varying terms calibrated at the 1-in-200 level and the results are shown in Figure 5.16 and Figure 5.17. We do not have comparable data from prior years.

Figure 5.16: *Upward change in the risk-free zero coupon bond spot yield for 5, 10, 15 and 25 year terms at the 1-in-200 level.*

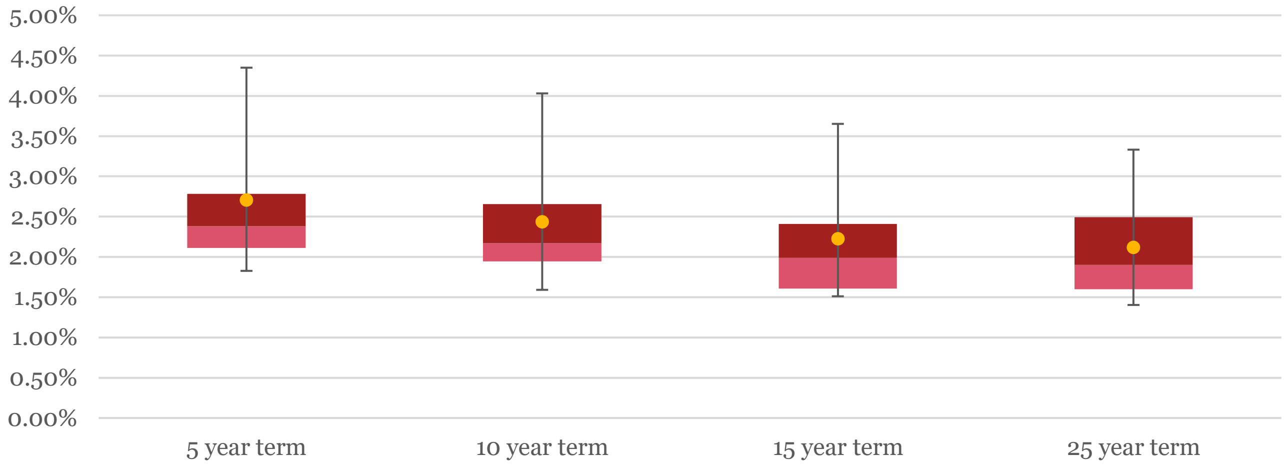
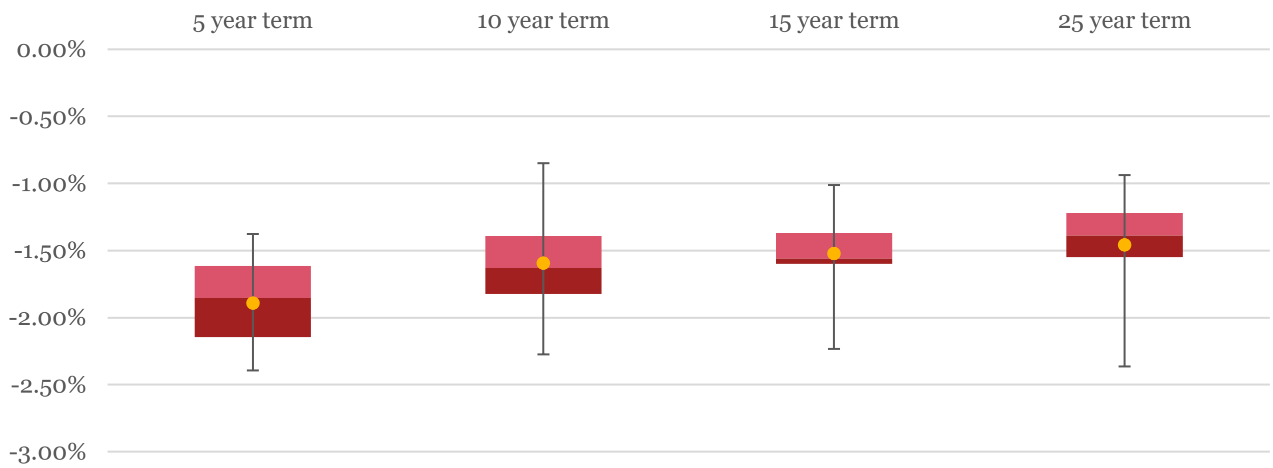


Figure 5.17: *Downward change in the risk-free zero coupon bond spot yield for 5, 10, 15 and 25 year terms at the 1-in-200 level.*



We note that the downward stresses are smaller in magnitude than the upward stresses for all participants, although the relative sizes differ widely. There is also a wide range of views about the degree of variation of the stresses by term.

The majority of participants apply a single set of stresses across all fixed interest types, rather than differentiating by currency.

The volatility stress ranged between about 15% and about 50% for participants which provided comparable information. Some participants use models for the interest rate volatility which are not directly comparable.

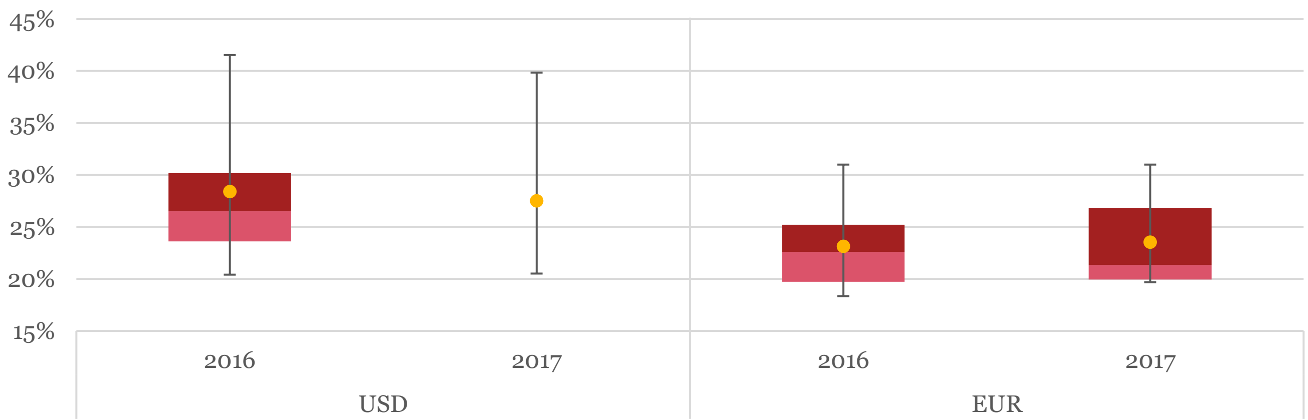
5.6. Currency

Solvency II defines currency risk as that arising from the sensitivity of the values of assets, liabilities and financial instruments to changes in the level or in the volatility of currency exchange rates.

Results

We asked participants for the calibrated stresses for each currency relative to GBP and Figure 5.18 shows the results for USD and EUR, along with equivalent data from last year. This year we received insufficient responses to be able to present quartile information for USD, but the means and ranges for the 1-in-200 stresses are included for comparison.

Figure 5.18: *Calibrated 1-in-200 currency stresses.*



The ranges of stresses observed for both EUR and USD are slightly narrower than in last year's survey.

5.7. Inflation

Changes in approach over the year

A small majority of participants noted that they made changes to the inflation risk calibration over 2017, in most cases simply to refresh the data used within the calibration. The changes generally resulted in a weaker or broadly neutral impact on the calibration.

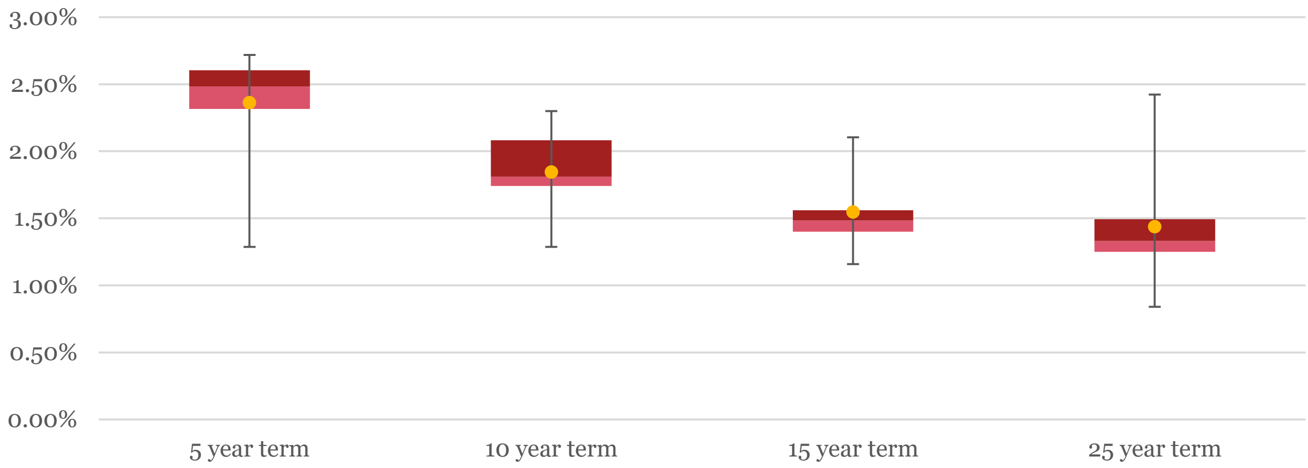
Methodology

A small number of participants apply separate inflation stresses to linked assets of different currencies. However, the majority of participants also make use of the market risk inflation calibration for inflation in the liability valuation, e.g. of expenses or index-linked benefits.

Results

Figure 5.19 shows the change in the implied inflation spot yield, calibrated at the 1-in-200 level. We do not have comparable data from prior years.

***Figure 5.19:** Change in the implied inflation spot yield calibrated at the 1-in-200 level.*



5.8. Property

Solvency II defines property risk as the risk of loss or adverse change in the value of assets and liabilities due to unanticipated changes in the level or in the volatility of market prices of real estate.

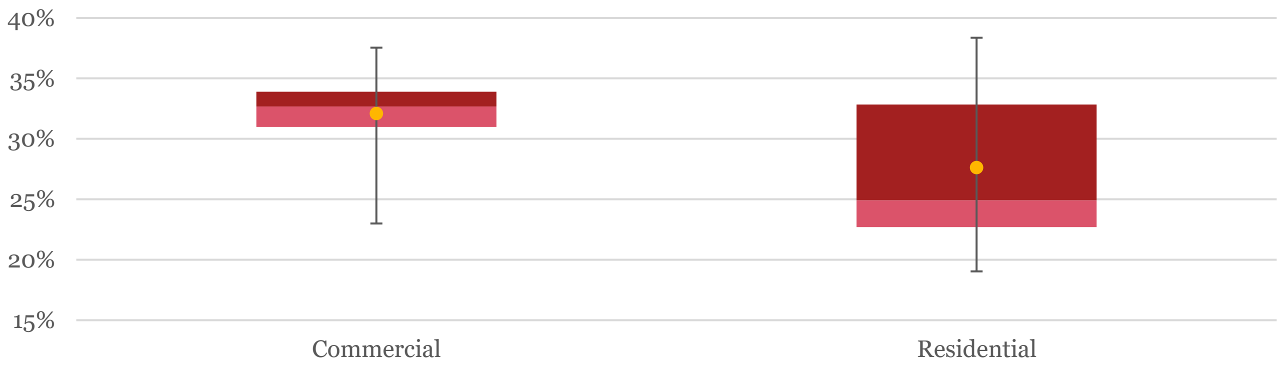
Changes in approach over the year

The majority of participants noted that they made changes to the property risk calibration over 2017, mostly to refresh the data used within the calibration. It was most common to observe that the impact of refreshed data on the calibration was broadly neutral. A small number of participants made methodology changes, either on their own or in addition to refreshing data, which generally resulted in weaker calibrations. Of the responses, most participants stated that the changes were driven by internal factors.

Results

Almost all of the participants which hold both types of property apply stresses which differ between commercial and residential property. Figure 5.20 shows the calibrated 1-in-200 property level stress over one year, separately for commercial and residential properties.

***Figure 5.20:** Calibrated 1-in-200 property level stress for residential and commercial properties.*



We note that the property level stresses lie within a wider range than observed last year, when only one participant lay outside the range of 30–35%.

We received insufficient data to provide the volatility stress calibrations, however the responses we received ranged from just under 5% to just over 10% additive stresses at the 1-in-200 level, with little difference between commercial and residential property.

6. Life insurance risk

Solvency II states that the life underwriting risk module of the standard formula shall reflect the risk arising from life insurance obligations. Similar considerations would be expected to inform life insurance risk calibrations of an internal model.

In this section, we consider the components of life insurance risk. For each risk, we asked participants for a range of quantitative and qualitative information on their risk calibrations as applied in their Solvency II internal model.

6.1. Longevity

Longevity risk, as defined by Solvency II, is the risk of loss, or of adverse change in the value of insurance liabilities, resulting from changes in the level, trend or volatility of mortality rates, where a decrease in the mortality rates leads to an increase in the value of the insurance liabilities. Longevity risk affects contracts where benefits depend on the likelihood of survival, for example annuities, pure endowments and specific types of health contract.

- A range of approaches is used to model longevity trend risk across the industry, with the majority of participants using either a cause of death model or other medical forecasting to support expert judgement.
- The average changes in expectation of life from the longevity base, trend and overall stresses have all decreased slightly from those observed last year. In the case of the trend stress, this is the first year in which we have observed a reduction in the average stress.

Changes in approach over the year

The majority of participants made changes to the longevity risk calibration over 2017. Of these, most refreshed the data used within the calibration and a small number of participants made methodology changes, with little overlap between the two actions. Where participants refreshed data alone, the impact on the calibration was broadly neutral. The effect for participants that made methodology changes varied, with a general weakening for some but strengthening for others.

Data

The data sources used within the industry remain largely the same as in prior years, although this year not all participants indicated that they use their own historical data when calibrating longevity base stresses. As in prior years, all participants use external data from the Office for National Statistics (ONS) when calibrating longevity trend stresses. This is as expected, since identifying trends over long time scales requires significantly more data than is needed when assessing base assumptions and so generally cannot be based completely on analysis of an insurer's own available data. Academic research (including the Human Mortality Database) is also a common choice of data source for calibrating the longevity trend stress.

Similarly to last year, the majority of participants use data from the past 5–10 years when calibrating base risk, whereas the setting of trend risk most commonly utilises a data period of 30+ years. This is consistent with the results from the prior year survey and is as expected given the comments above about the challenges of identifying trends in the data.

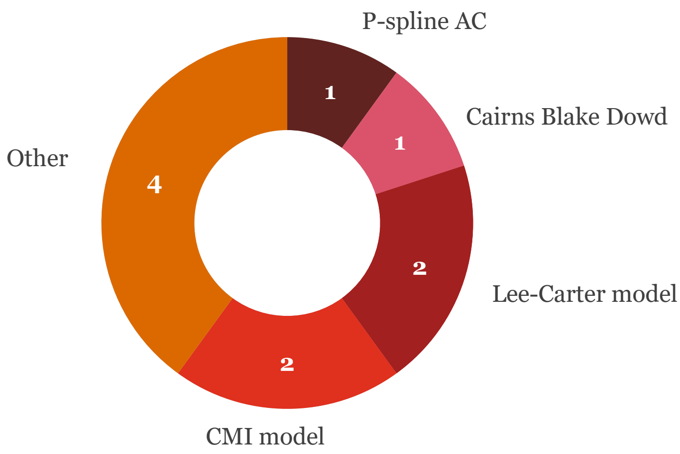
The majority of participants analyse data separately for selected risk factors when modelling the longevity base stress and all participants do this in the calibration of the longevity trend stress. However, the stresses are not always applied at the same level of granularity as their derivation. The most common risk factor used by participants is gender; age, product or socio-economic group are also used by some participants.

Methodology

Similar to prior years, the majority of participants fit a Normal distribution for longevity base stress calculation. We also asked participants if they derive a historical one-year deviation which is then applied for the full term or if they derive a historical deviation over a longer period. The majority of participants derive a one-year deviation; of this majority, about half make adjustments before applying the stress across the whole term.

As in previous years, there is much greater variation in the approaches used to model trend risk, as illustrated in Figure 6.1. Those participants included in the 'other models' category tend to use in-house models.

Figure 6.1: *Distribution of modelling methodology used by survey participants in determining longevity trend risk stresses.*



The majority of participants continue to use causal models or other medical forecasting to support the expert judgement applied to the longevity trend calibration, typically using cause of death models.

We asked participants to outline the level of correlation assumed between their base and trend risk factors, defining this as the dependency between falls in the mortality base tables and increases in the long-term improvement factors. As in prior years, the majority of participants assume a low positive correlation (as defined in section 8 of this report), with the remainder assuming no dependency.

Results

We asked participants for a range of quantitative information on their longevity risk calibrations for base and trend stresses, as applied to immediate annuities, at a 1-in-200 level and combined it with equivalent data from the last three years of this survey to show the movement over time. For all graphs throughout this section, the dates represent the year-end to which the calibration corresponds (rather than the year in which the survey was published) and the same key as in section 1 applies.

Base stress

Figure 6.2 shows the impacts in years of the 1-in-200 longevity base stresses for 65-year-old male and female annuitants.

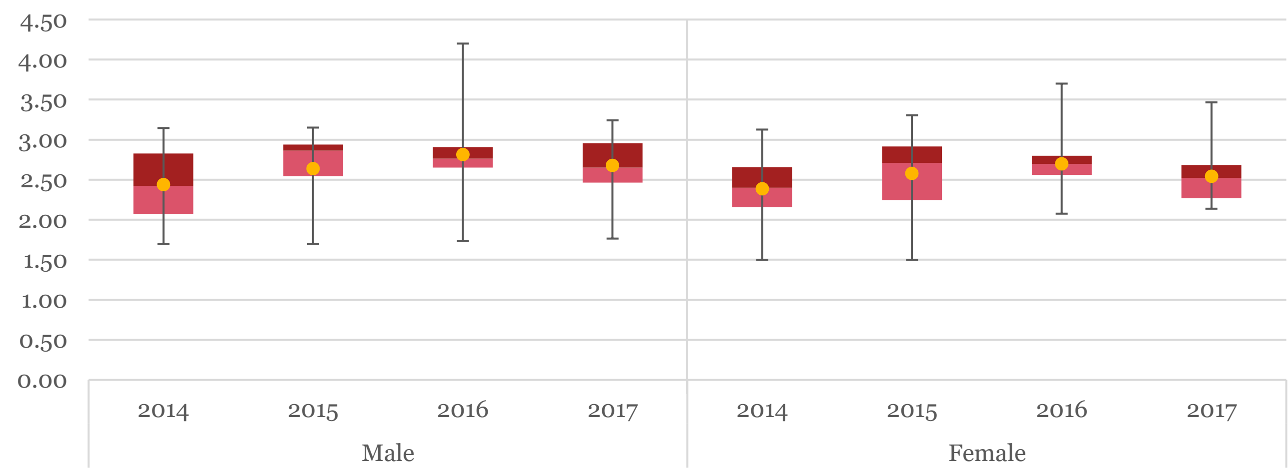
Figure 6.2: *1-in-200 base stress (in years) for 65-year-old non-smoker.*

The average increase in expectation of life from a 1-in-200 base stress is 0.78 years for males and 0.79 years for females. As can be seen, this is a small decrease compared to the stresses disclosed in last year's survey, where the equivalent figures were 0.85 and 0.81 years respectively, but there is no strong evidence of a trend over time. The average increase for females is higher than that for males for the first time in recent years, although the percentage change is still greater for males.

Trend stress

Figure 6.3 shows the impacts in years of the 1-in-200 longevity trend stresses for 65-year-old male and female annuitants.

Figure 6.3: *1-in-200 trend stress (in years) for 65 year old non-smoker.*



The average increase in expectation of life from a 1-in-200 trend stress is 2.68 years for males and 2.55 years for females. These are reductions from 2.81 and 2.70 years respectively in last year's survey and broadly reverse the increases reported last year. The average increase in expectation of life from the trend stress is (as in prior years) much higher than that from the base stress, for both males and females. Unlike for the base stress, and consistent with our findings in previous years, there is greater variation between participants in whether the impact of the trend stress on expectation of life is higher for males or for females.

The average increase in expectation of life at age 65 from an overall 1-in-200 longevity stress is 2.99 years for males and 2.87 years for females, compared to 3.10 and 2.96 years respectively last year.

6.2. Persistency

Persistency risk, as defined by Solvency II, is the risk of loss, or of adverse change in the value of insurance liabilities, resulting from changes in the level or volatility of the rates of policy lapses, terminations, renewals and surrenders.

- The average persistency level stress selected by participants is 41.3% for non-linked term assurances, 49.7% for unit-linked pensions and 49.9% for with-profits pensions. These averages are all a few percentage points different from those observed last year, but with no consistent direction of change.
- The average mass lapse stress selected by participants is 24.7% for non-linked term assurances, 27.8% for individual unit-linked pensions and 30.0% for group unit-linked pensions. This shows a general slight decrease from prior year.

Changes in approach since prior year

Most participants that responded to this section stated that they made changes to the persistency risk calibration over 2017. A small number stated that the change was due to the refreshing of data used within the calibration, with a broadly neutral impact, but a larger number made some type of methodology change over the year. There was no consensus as to whether the methodology changes acted to strengthen or weaken the calibrations, with each participant observing different impacts.

Data

In line with last year's results, all participants use their own historical data to calibrate the level stress, with other sources such as benchmarking being used in a supporting capacity. By contrast, the most common data source used for mass lapse risk is industry specific data.

Also as in previous years, there is little consensus on the data period used for the base persistency stress. However, there has been a significant movement towards longer periods of data for this stress – 15+ years of data is used by the majority of participants this year, while 5-10 years was most common last year. The limited number of responses for the mass lapse stress also showed a wide spread of data period being adopted. A number of participants commented that the data period can vary by product, depending on the availability.

Methodology

In line with the responses received last year, the majority of participants apply separate stresses depending on whether the stress is expected to create profit or strain, with groupings typically at broad product group level (e.g. unit-linked, non-profit and with-profits). While many companies set best estimate persistency assumptions which are dependent on duration, very few participants make any differentiation by duration when setting persistency base stresses and, for those that do, the differentiation is fairly high level.

In previous surveys we have found that the calibration of persistency risk exhibits far greater variation in practical application than many other risks, largely owing to the impact of bi-directional stresses. Given that the resulting capital impact depends on the practical implementation, the information presented within this section should be used with care.

Base risk

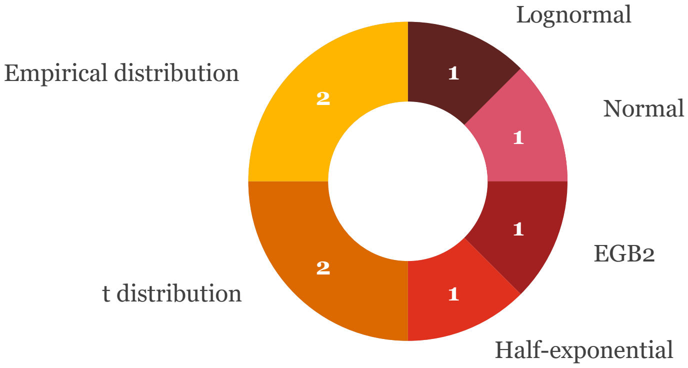
Similar to prior years, the majority of participants use some form of Normal or Lognormal distibution to model base persistency risk. The majority of participants also derive a one-year stress from the data which is then applied across every future year. This emphasises the importance of selecting appropriate data since any impact of inappropriate data may be exacerbated when applied across all future years.

We asked participants whether they make any allowance for the impact of pensions freedom in their base persistency calibration. The majority of participants which responded to this question confirmed that an adjustment is made within the base calibration, with these adjustments largely driven by expert judgement such as calibrating specific risk factors to reflect pension scheme decrements.

Mass lapse risk

Figure 6.4 shows the different distributions used by the participants to model one-off persistency (mass lapse) risk. Last year, we saw an industry shift towards utilising more sophisticated modelling techniques. There is little change in the position this year, with a similar range of statistical models being used. All participants that responded to this question still cited expert judgement as the main driver of the one-off calibration as opposed to it being largely data-driven, with lack of relevant data commonly specified as a reason for the application of judgement.

Figure 6.4: *Distributions fitted for one-off persistency stress calibration.*



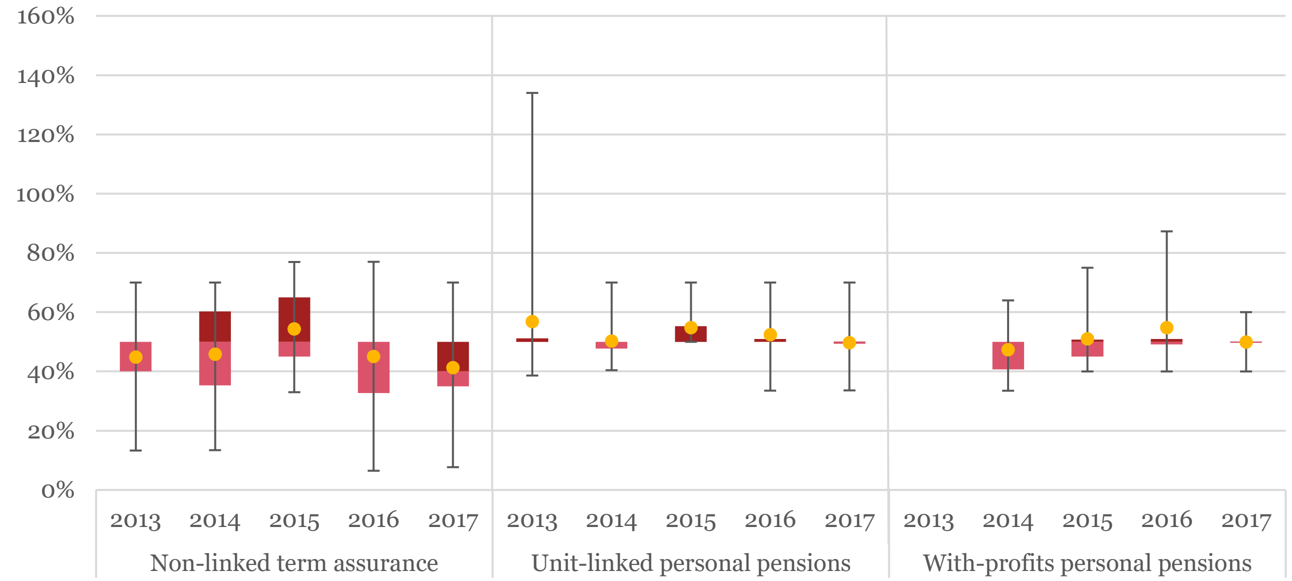
Dependency between persistency base and one-off risks

There is little industry consensus on the appropriate dependency assumptions between persistency base and one-off risks. The majority of participants confirmed that expert judgement is the main driver in setting the dependency between base and one-off persistency. A small number of participants make adjustments to allow for tail dependency effects in the calibration, again using expert judgement.

Results

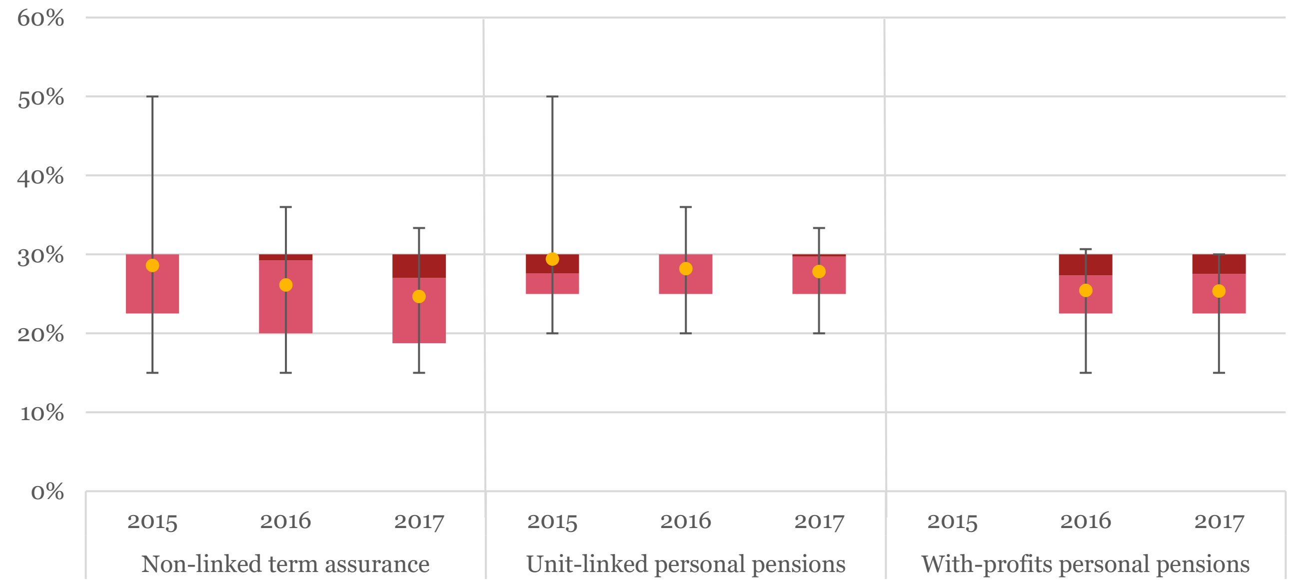
Figures 6.5 and 6.6 respectively show the magnitude of our participants' persistency level and one-off stresses for each product type, combined with data from the last four years (for persistency level) or last two years (for mass lapse) to show the change over time. We received insufficient information for with-profits personal pensions in some years to be able to show results.

***Figure 6.5:** 1-in-200 level persistency stresses expressed as percentages applied to best estimate discontinuance assumptions separately for each product type.*



For the level stress, the results show that the average stresses selected by participants are 41.3% (prior year: 45.0%) for term assurances, 49.7% (prior year: 52.4%) for unit-linked personal pensions and 49.9% (prior year: 54.7%) for with-profits pensions.

***Figure 6.6:** 1-in-200 mass lapse stress expressed as percentage of current in-force business for each product type.*



For mass lapse, the results show that the average stresses selected by our participants are 24.7% (prior year: 26.1%) for non-linked term assurance, 27.8% (prior year: 28.2%) for unit-linked personal pensions and 25.4% for with-profits pensions (unchanged from prior year).

6.3. Expense

Expense risk, as defined by Solvency II, is the risk of loss, or of adverse change in the value of insurance liabilities, resulting from changes in the level, trend or volatility of the expenses incurred in servicing insurance or reinsurance contracts.

Changes in approach since prior year

Approximately half of participants noted that they made changes to the expense risk calibration over 2017, with a greater range of reasons provided than for other risks. Some participants stated that they either refreshed the data or made methodology changes, with others reflecting changes within the business or refinement of expert judgement. In most cases, the effect on the calibration was broadly neutral.

Data

The most common data source used in the calibration of the expense level stress is internal data, with expert judgement also commonly applied. A number of participants stated that they do not model expense trend risk as a separate risk factor but, for those that do, market data is the most commonly used, followed by expert judgement.

Participants use a minimum of four years' data in the expense level calibration, with the majority of participants for which this is applicable using five years of data or more. This is consistent with the results of the prior year survey.

Methodology

We asked participants for the risk factors by which their expense stress calibration is divided. The majority of participants use both expense level and expense trend risk, with a few using these in conjunction with other risk factors, such as volatility, project costs and investment expenses.

For both of the expense level and expense trend stresses, a Normal distribution is the most common choice of modelling approach, with other statistical distributions, scenario analysis and expert judgement also used.

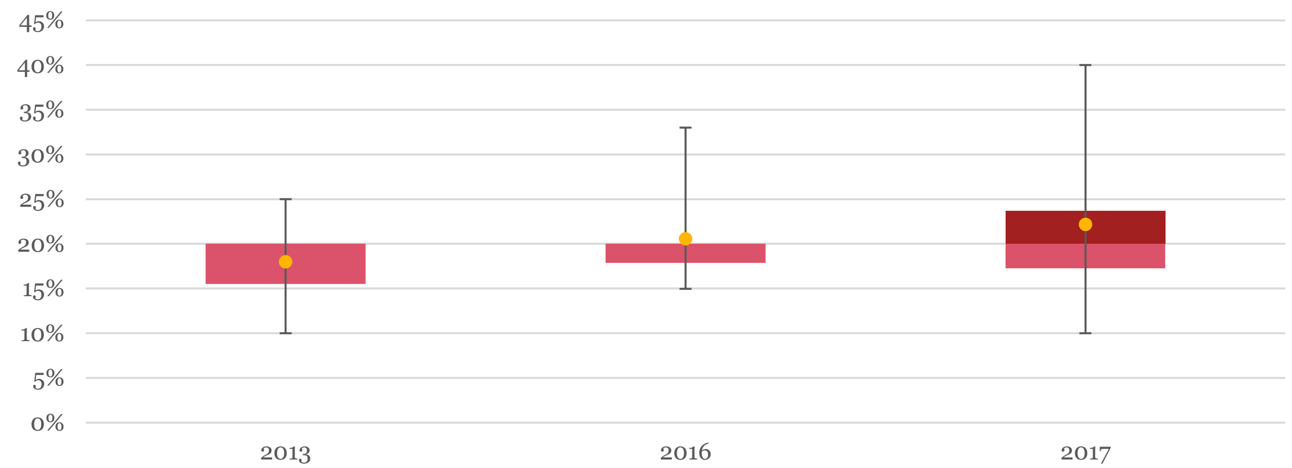
All participants which use both factors assume either zero or low positive dependency between the expense level and expense trend risks. Additionally, a small majority of participants allow for (typically positive) correlation between expense risk and one-off persistency risk.

Approximately half of participants confirmed that they have outsourcing arrangements in place for expenses. Where the exposure to expense risk is limited due to the arrangement in place, all participants confirmed that the associated risk of failure of the outsourcer has been allowed for elsewhere in the internal model.

Results

Last year's survey included expense risk for the first time since the year-end 2013 calibration. Figure 6.7 therefore shows the effect of the 1-in-200 expense level stress on the best estimate assumption at year-end 2017 compared to the 2013 and 2016 year-ends. There is a wider range of responses in this year's survey, which is driven more by participants changing their calibrations than by changes in the firms participating in the survey.

Figure 6.7: *Impact of 1-in-200 expense level stress expressed as a percentage of best estimate maintenance expense assumptions.*



6.4. Mortality

Mortality risk, as defined by Solvency II, is the risk of loss, or of adverse change in the value of insurance liabilities, resulting from changes in the level, trend or volatility of mortality rates, where an increase in the mortality rate leads to an increase in the value of insurance liabilities. It affects predominantly protection contracts, such as term assurance.

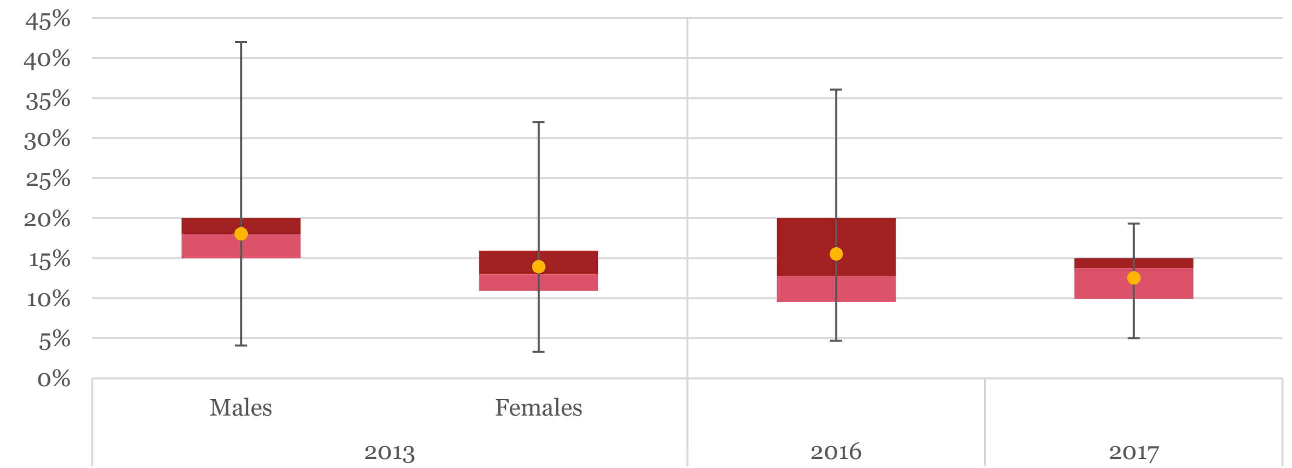
Changes in approach since prior year

Very few participants stated that they made changes to their mortality risk calibration over 2017.

Results

Last year's survey included mortality risk for the first time since the year-end 2013 calibration and showed that all participants had removed any differentiation between males and females in the calibrated stresses. The base mortality stresses are presented in Figure 6.8, separately for males and females as at year-end 2013 but as a single stress applied to both genders in later years. The range of responses for the mortality base stress has narrowed significantly from the prior year, which is largely caused by one outlier in the prior year survey changing its stress.

Figure 6.8: *1-in-200 mortality base stresses expressed as a percentage stress to base mortality assumptions for term assurance.*



6.5. Morbidity

Morbidity risk, as defined by Solvency II, is the risk of loss, or of adverse change in the value of insurance liabilities, resulting from changes in the level, trend or volatility of disability, sickness and morbidity rates. It affects predominantly health contracts such as critical illness insurance and income protection.

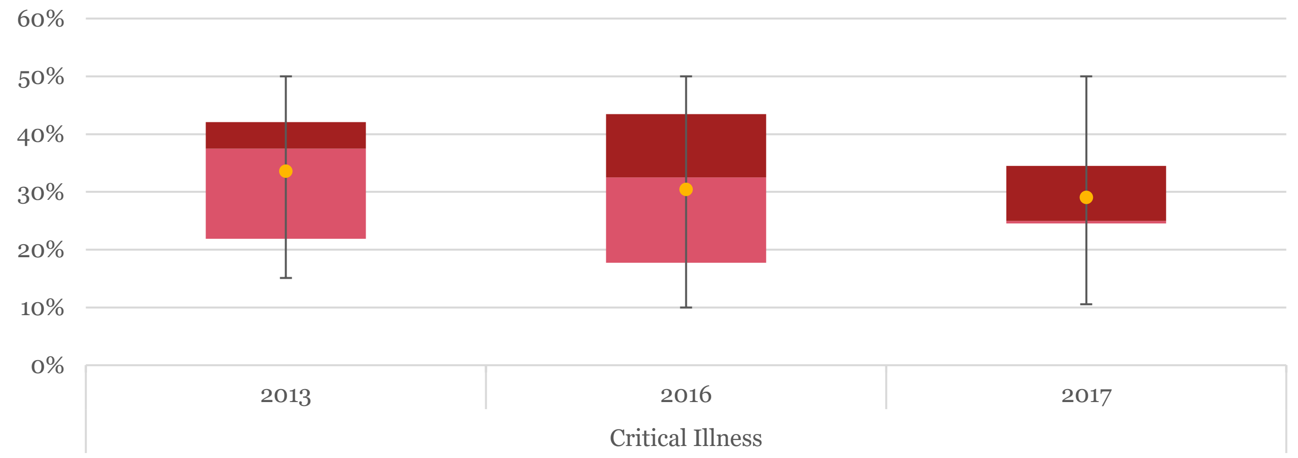
Changes in approach since prior year

As with mortality, very few participants stated that they made changes to their mortality risk calibration over 2017.

Results

Last year's survey included morbidity risk for the first time since the year-end 2013 calibration. The results for base morbidity stresses for critical illness policies are presented in Figure 6.9. While the upper and lower ends of the range of responses have remained broadly unchanged over the last few years, we have seen some convergence around the mean this year, resulting in a narrower interquartile range.

Figure 6.9: *1-in-200 morbidity base stresses for critical illness.*



7. Operational risk

Solvency II defines operational risk as the risk of loss arising from inadequate or failed internal processes, people and systems, or from external events (including legal risk).

- Operational risk, while material for many participants, is a smaller component of the SCR than life insurance or market risk for all participants. However, underlying data continues to be less robust than for other risks.
- Across the survey participants, there is a preference for modelling frequency of losses using Poisson distributions and severity of losses using Lognormal distributions.
- Most participants agree that causal rationalisation is the main driver of dependencies between scenarios/operational risk events and the majority of participants aggregate their operational risk stresses using a Gaussian copula.

Changes in approach over the year

Almost all participants made changes to the operational risk calibration over 2017. Of these, approximately half stated that the change was due to the refreshing of data used within the calibration, generally producing a broadly neutral impact on the calibration.

The reasons behind other changes to the calibration were varied. Some changed their methodology and others made refinements to their existing process. There was no consensus as to whether the changes resulted in stronger or weaker calibration.

Calibration models

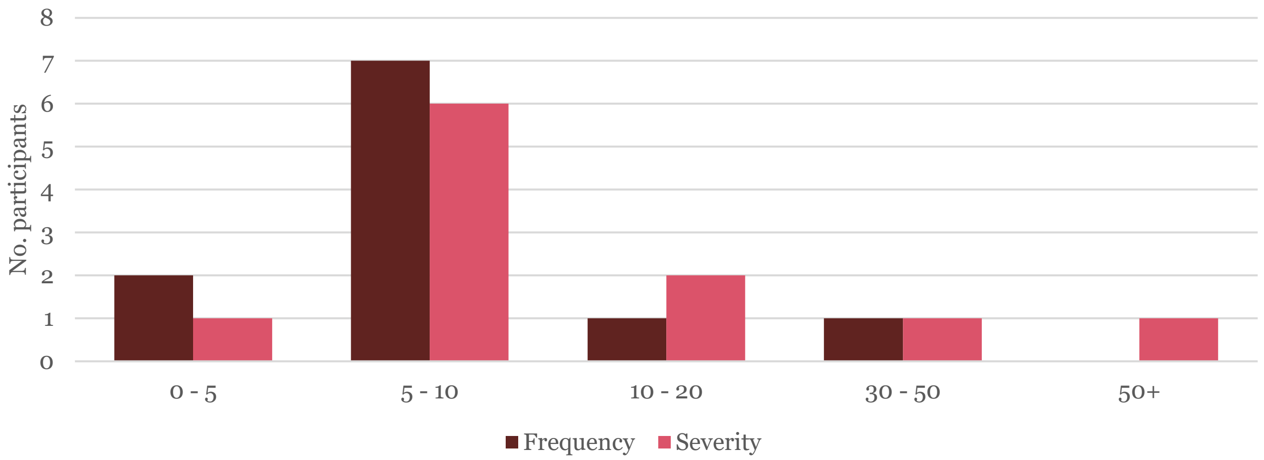
All participants indicated that they model frequency and severity of operational losses separately within their internal model.

Data

One of the key challenges still faced in modelling operational risk is the use of external data. As a result of this, many participants continue to use a mixture of internal and external data, although several told us that they are placing more reliance on their own data this year. One common source of external data is ORIC International (ORIC), which is an operational risk consortium for the global (re)insurance and asset management sector.

The periods of historical data used by respondents to calibrate frequency and severity of loss events (shown in Figure 7.1) tend to be slightly shorter than would typically be used to model other risks, consistent with the challenges of limited data described above.

***Figure 7.1** Length of time period (in years) from which frequency and severity data is drawn.*



Where participants indicated that they use a mixture of internal and ORIC data, none stated that they use different data periods for the different data sources.

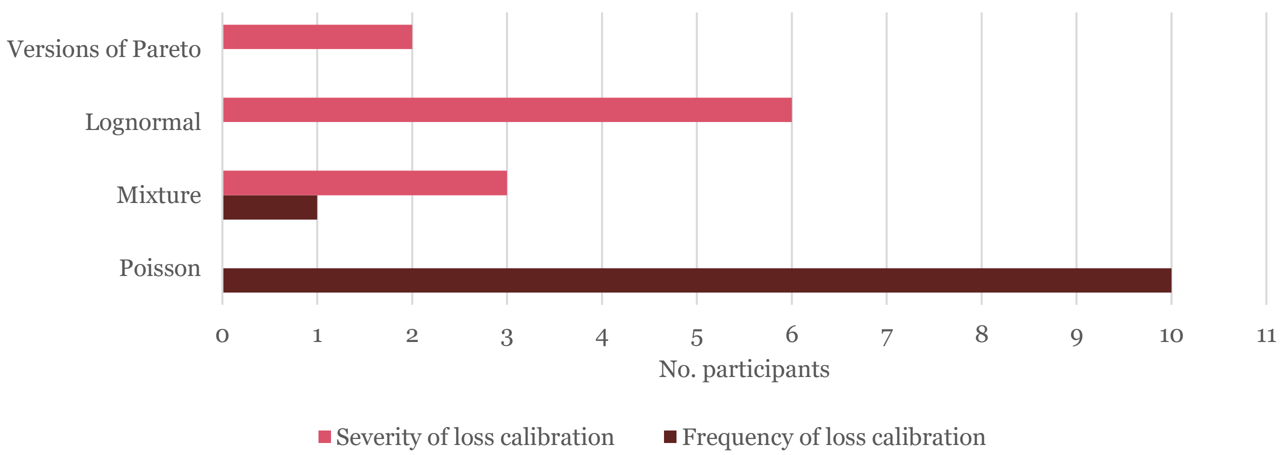
Methodology

We asked participants to describe the methodology used to model operational risk. The various approaches fall broadly into three categories, with a small majority favouring the second category:

- Hybrid models which model frequency of loss as a data-driven probability distribution function (PDF) but use scenarios to estimate severity, usually re-expressed in the form of a PDF.
- Scenario analysis for both frequency and severity, usually re-expressed in the form of a PDF.
- Data-driven PDF for each of frequency and severity, which is tested using scenario analysis.

We asked participants which statistical distributions are fitted for the frequency and severity of loss calibrations. The results are shown in Figure 7.2.

***Figure 7.2:** Models fitted for frequency and severity of loss calibrations.*



Across the survey participants, it is most common to model frequency of losses using a Poisson distribution and severity of losses using a Lognormal distribution. This is unchaged from prior year.

Due to the limited amount of data available, judgement-based scenarios are key inputs in operational risk modelling. Most participants use an internal risk framework in order to define their operational risk scenarios, while others set their scenarios with reference to internal and external events or by giving consideration to individual risks. The majority of participants use fewer than 40 scenarios, with a broadly equal split between those that model between 0-20 and 20-40. Please note that this is not how many simulations are run for each specific scenario.

The majority of participants use a copula to aggregate operational risk stresses, with most of these opting for the Gaussian copula. The dependencies between operational risks are most commonly based on either causal rationalisation or expert judgement.

8. Risk aggregation

This section considers the approaches participants use in aggregating their individual risks to determine the total SCR, including the resulting diversification benefit.

- The majority of participants combine individual risk drivers in a single step, without first calculating a capital requirement for specific risk modules, such as market or life insurance risk.
- The most common method for overall capital aggregation is the use of a copula, with both multivariate t and Gaussian copulas being common amongst participants. Very few participants use a univariate variance approach, via a variance-covariance matrix.
- Dependency assumptions are broadly in line with those observed in last year's survey.

Changes in approach over the year

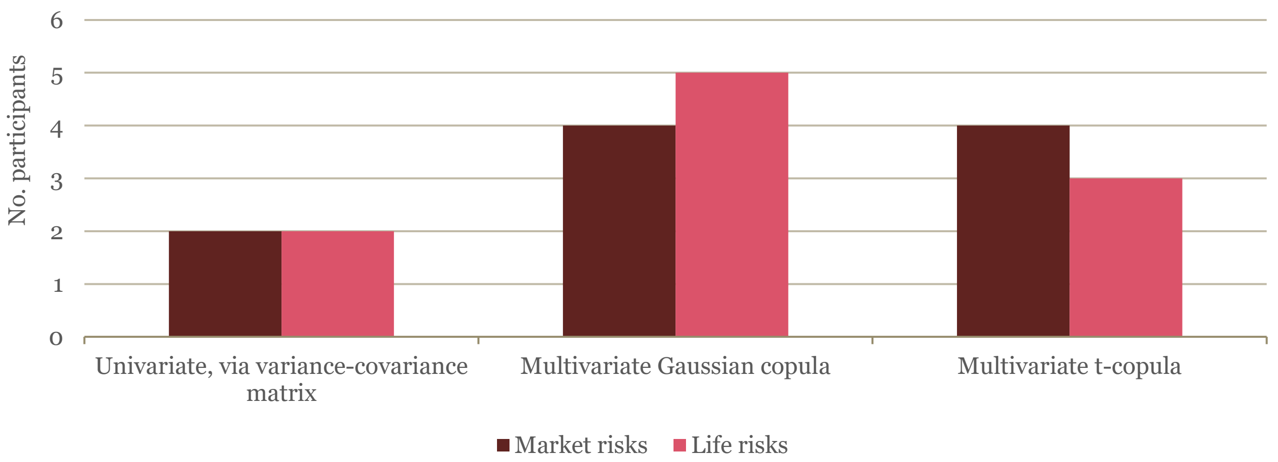
Most participants which provided information noted that they made changes to the aggregation over 2017. Of these, a small number stated that the change was due to the refreshing of data that is used to determine dependencies between risks. The majority made some level of methodology change over the period, with changes in expert judgement used to determine dependencies being the most common.

There was no consensus as to whether the changes resulted in more or less diversification between capital requirements.

8.1. Risk aggregation approach

The majority of participants aggregate all risks within a single step and do not calculate capital requirements for specific risk modules. Figure 8.1 shows the aggregation approaches which are adopted by participants. We did not receive sufficient information on the number of degrees of freedom used in the t-copulas to be able to provide further insight this year.

Figure 8.1 *Distribution of methodology used by survey participants in the aggregation of risks.*



We also asked participants about the parameter estimation used in aggregating the market and life insurance risks. The majority of participants use a Spearman methodolody for both market and life risk correlations.

Dependency between risks

We asked participants to provide their correlation matrices, together with a brief explanation of their sign convention. We have applied the following definitions for the various levels of dependency:

- High: 100%–67%
- Medium: 66%–34%
- Low: 33%–1%
- Nil: 0%

Note that where participants assume their dependency structure to be based on the movement of the risk factor rather than the occurrence of losses, we have inverted the signage of the assumptions. For instance, a number of responses indicated a negative dependency between credit spread risk and equity level risk, i.e. an increase in spreads is correlated with a drop in equity values. While this is a negative relationship, it translates to a positive dependency in terms of the losses arising from the changes in the risk factors.

While most participants do not calculate risk modules separately, we have separated the rest of this chapter into sections covering:

- Dependencies between market risks;
- Dependencies between life insurance risks;
- Cross-dependencies between market and life insurance risks.

Within each section, we focus on the source and period of data used for establishing dependencies and the resulting dependency assumptions.

8.2. Market risks

Market risk dependencies are typically set by taking into account observable market information. Judgement is applied in the derivation of these assumptions in two parts, first the rationalisation of general correlation between particular risks and then how much this dependency might worsen in extreme stress.

Determination of any worsening of correlation in stress can be captured by the use of a copula, with the majority of participants using a copula to aggregate all risks. Those using a univariate method of aggregation either make adjustments to their central correlations or calibrate conditional correlations.

Data

The majority of participants use asset market data to determine dependencies between the market risks, with the remainder noting that they rely on expert judgement. As observed in previous surveys, the majority of participants stated that the data period varies by risk, based on the maximum amount of data available for each pair of dependencies.

Results

As observed in previous surveys, all participants for which it is relevant assume a medium or high positive correlation between credit spread and equity risks. The assumptions are broadly consistent with the Standard Formula's prescribed high positive correlation (+75%).

Dependency assumptions between other pairs of market risks are similar to those observed last year. For example:

- Between **credit spreads** and **interest rate level,** dependencies range from zero to medium positive, with most participants using a low positive correlation.

- Between **equity** and **interest rate level,** dependencies range from low negative to medium positive, with the highest proportion of participants using a low positive assumption.

- Dependencies between **property** and other market risks are typically medium positive (with **credit spreads** and with **equity**) or low positive (with **interest rate level**).

We note that there is more variation in assumed dependencies between market risks than in those between life insurance risks, which is a pattern we have seen in previous years' surveys.

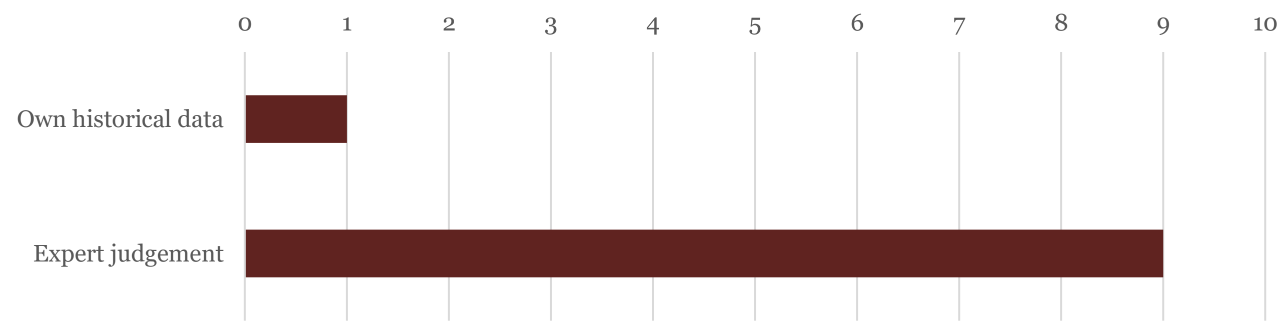
8.3. Life insurance risks

The setting of dependency assumptions between life insurance risks is highly subjective and is a key area requiring the application of expert judgement. Unlike market risk correlations, which are largely set by taking into account observable market information, correlations between life insurance risks rely far more on causal links and expert judgement, and less on data analysis. The judgment is also in two parts, first the rationalisation of general correlation between particular risks and then how much this dependency might worsen in extreme stress.

Data

We asked participants about the data used for establishing dependencies between the life insurance risks. The wide use of expert judgement is in line with expectations, as discussed above. However, the almost total reliance on expert judgement, at the expense of other sources cited in previous surveys such as industry-specific data or benchmarking, is a marked change from previous years.

Figure 8.2: *Data sources used by survey participants in determining correlations between life risk module.*



Results

There have been a few, relatively minor, changes in life risk dependencies since last year. For example:

- The majority of participants continue to assume zero dependency between **longevity trend** and **persistency level** risks, with the remainder assuming a low positive dependency.
- Participants are broadly split in assuming zero or low positive correlation between **mortality** and persistency, while a clear majority assumed independence last year .
- Almost all participants assume independence of **expenses** and **longevity** risk, while all of those providing this information last year did so.
- For **expenses** and **persistency**, there is again a spread from zero to medium positive.
- Participants assume a wider range of correlations, both positive and negative, between **mortality** and **longevity** risks, although the highest proportion continues to opt for a zero correlation.
- All participants continue to assume no correlation between expenses and mortality.

8.4. Aggregation between life insurance and market risks

As observed in previous years, all participants assume either low positive or zero dependency between **longevity** and **credit** risks, and the majority of participants assume low positive correlation between **persistency** and **credit** risks.