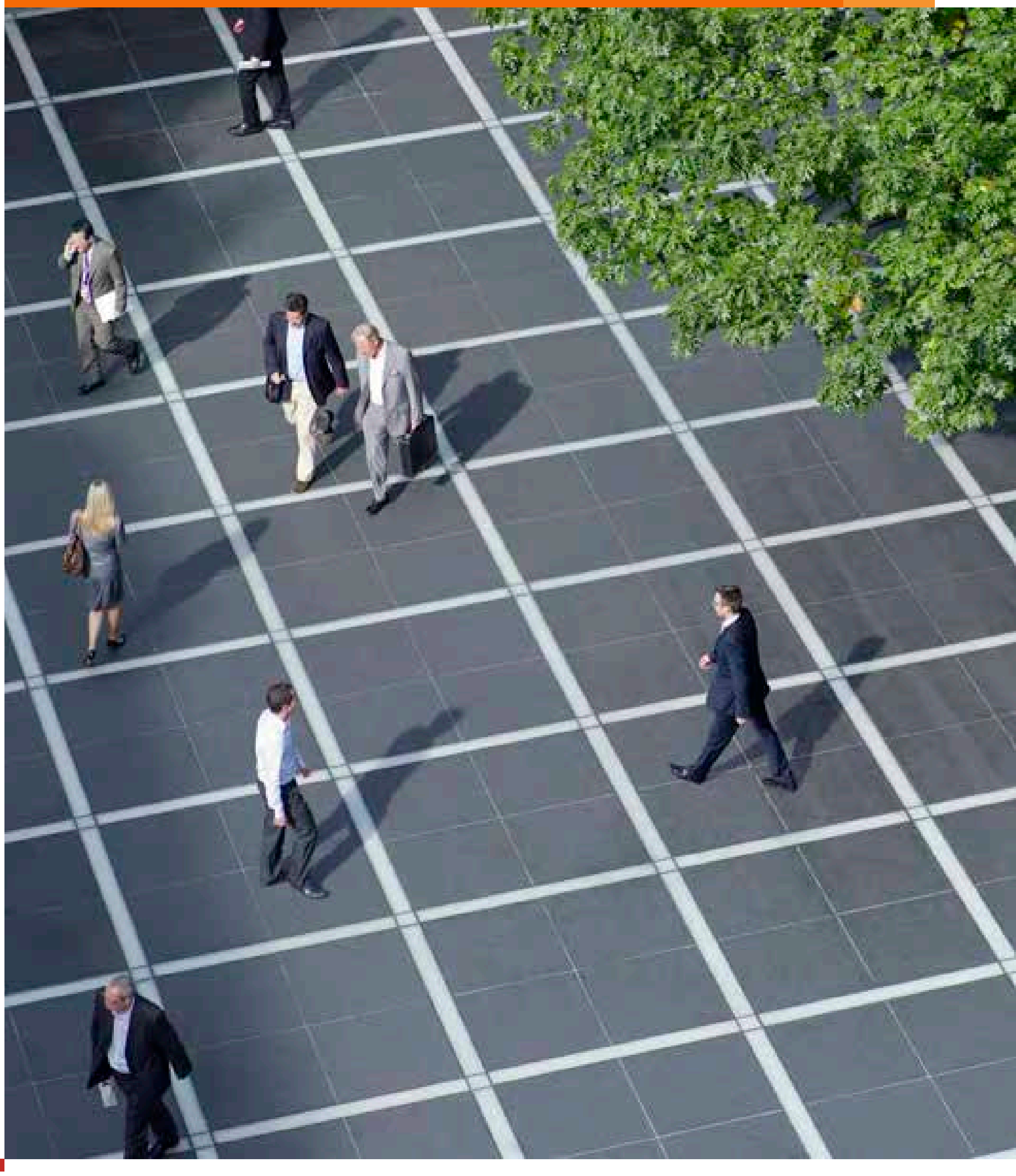
www.pwc.co.uk/fsrr

PwC Solvency II Life Insurers' Capital Model Survey 2016

Summary Report

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 considers Internal Model and Standard Formula life insurance companies in the UK.

November 2016



pwc

Participants

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

Admin Re UK

AEGON UK

AVIVA UK Life

Legal & General Group Plc

Lloyds Banking Group Plc

LV=

Phoenix Group

Prudential UK

Royal London Mutual Insurance Society Limited

Standard Life Assurance Limited

Contents

1. Introduction

Dom Veney

Partner, Life Insurance Lead
dominic.veney@uk.pwc.com
0772 520 1950

Rebecca Macdonald

Senior Consultant
rebecca.macdonald@uk.pwc.com
0787 200 5513

Welcome to the 2016 life insurers' Solvency II capital models survey. This is the first survey we have published since the announcement of Internal Model Application Process (IMAP) approvals in December 2015 and go-live for Solvency II reporting on 1 January 2016. The report aims to capture the final post-IMAP approval stresses for key risks and help your business compare its operation and assumptions with peers in the market. This can provide valuable insights at a time when many insurers are coping with the day to day operation of approved Internal Models, or are in discussion with their regulators over planned model changes.

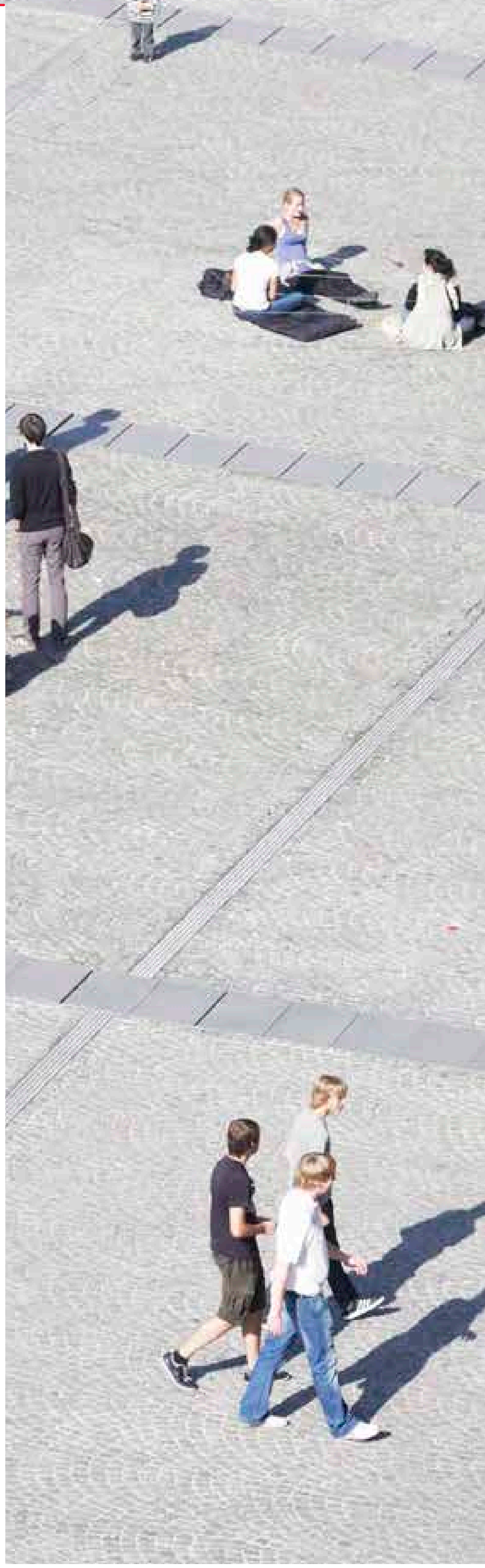
The survey covers the capital evaluation of material risks, drawing on information from ten of the UK's largest life insurers. This year we have focused more on the detailed implementation of models, and known judgmental areas, and less on the methodologies for risk calibrations.

The survey covers a diverse range of UK participants, seven of which are using an Internal Model or Partial Internal Model with the remaining three using the Standard Formula. Where a risk sits under the Standard Formula, or outside a Partial Internal Model, we asked for the calibration methodology and results to be from the Pillar 2 Economic Capital Model used by the participant. We use the term "Internal Model" interchangeably for these results, and those from a Partial or Full Internal Model.

Our thanks go to the firms who took part for kindly sharing their time and their insights (please see the participants page for the full list).

Dom Veney and Rebecca Macdonald
PwC

PricewaterhouseCoopers LLP
7 More London Riverside
London SE1 2RT
Telephone +44 (0) 20 7583 5000
Facsimile +44 (0) 20 7804 1002



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 all of those sources of 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 Standard Formula 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 ten participants responded to the questions asked. This may be for various reasons, for example where participants employ the Standard Formula calibrations to calculate a risk under their Economic Capital Model; where the question is not relevant to the participant's business, etc. In these instances, the total number of responses will be less than ten; 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.

2. Key messages

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

Material risk exposures

Generally, credit, equity, longevity and persistency risks remain the highest individual contributors to participants' undiversified and diversified Solvency Capital Requirement ("SCR"). This survey therefore concentrates on these risks, alongside key issues in the ongoing operation of the internal model.

Result highlights

Market risk module

- The majority of participants model credit spread risk separately from transition and default risk.
- The average 1-in-200 increase in spread for a 10 year A rated non-financial bond (281bps) shows an increase of 20bps over the year.
- There is considerable variation in the level of credit spread stress being applied to UK gilts, particularly at the 5 year term.
- A small majority of participants make an allowance for interest rates to fall below 0% in their internal model.

Operating the internal model

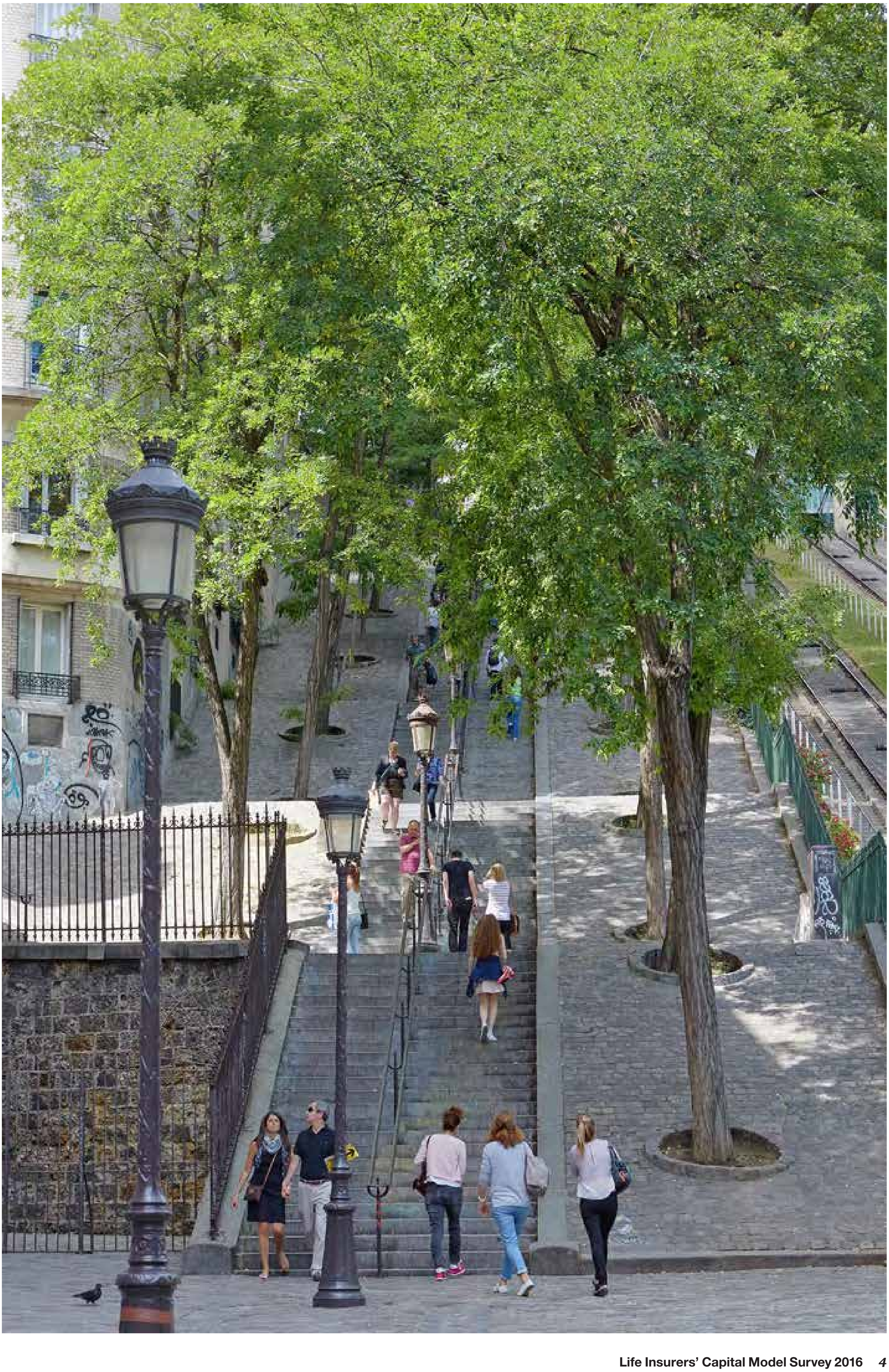
- All participants who use a matching adjustment make an allowance for the portion of the increase in credit spread that feeds through to an increase in the assumed matching adjustment, however there is no consensus as to the size of this allowance and there is also disparity around the capital offset from the matching adjustment under stress.
- The majority of participants do not intend to carry out a full recalculation of the transitional measure on technical provisions (using Solvency I processes) every two years, opting instead to use simplifications.

Life insurance risk module

- A range of approaches is used across the industry to model longevity trend risk. Only half of participants use causal analysis (typically a Cause of Death model) to support the statistical modelling used to determine their trend stress.
- Average changes in expectation of life from longevity base and trend stresses are broadly consistent with those observed in 2015.
- The average persistency level stress chosen by participants is 54.28% for term assurances, 54.77% for unit-linked pensions and 50.93% for with-profits pensions, all slight increases from the stresses observed in 2015. However, we note that the stresses on term assurance business vary widely, with the average driven by two particularly low stress calibrations.

Aggregation

- The most common method for overall capital aggregation remains a variance-covariance matrix, with the relative simplicity of this approach favoured for aggregation of diverse risks across entities.
- Most participants allow for diversificaiton within components of individual risks within both the market and life insurance risk modules.

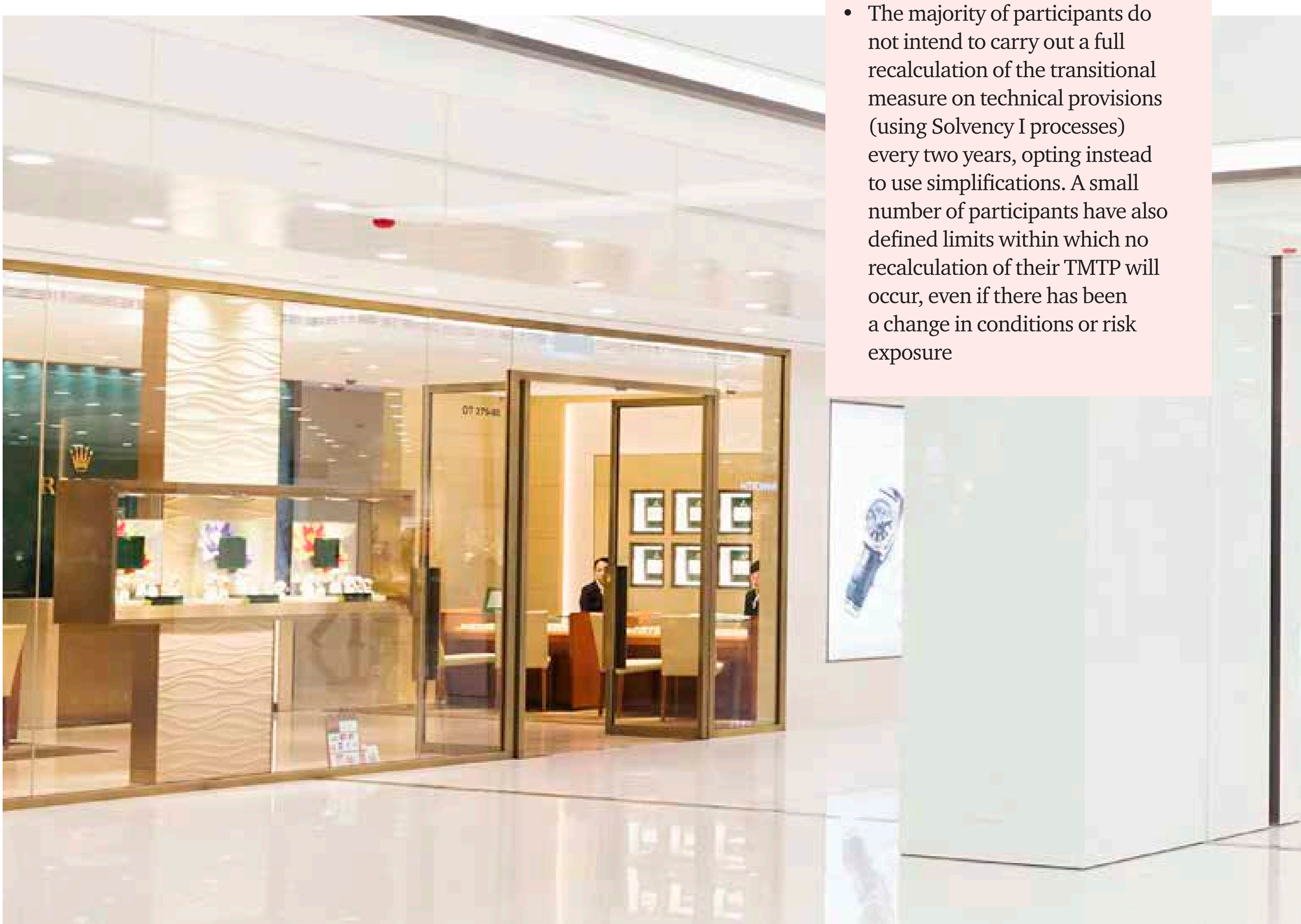


3. Operating the internal model

Following IMAP approvals at the end of 2015 and go-live for Solvency II reporting on 1 January 2016, for most participants attention has shifted from the specifics of calibration methodology to the task of embedding the internal model and operating it in a BAU environment.

In this section we summarise the key themes emerging from the replies provided by our participants in respect of management of the matching adjustment (MA), transitional measure on technical provisions (TMTP), proxy modelling and planned changes to their internal models.

- All participants who use a matching adjustment make an allowance for the portion of the increase in credit spread that feeds through to an increase in the assumed matching adjustment, however there is no consensus as to the size of this allowance. There is also disparity around the capital offset from the matching adjustment under stress.
- The majority of participants do not intend to carry out a full recalculation of the transitional measure on technical provisions (using Solvency I processes) every two years, opting instead to use simplifications. A small number of participants have also defined limits within which no recalculation of their TMTP will occur, even if there has been a change in conditions or risk exposure

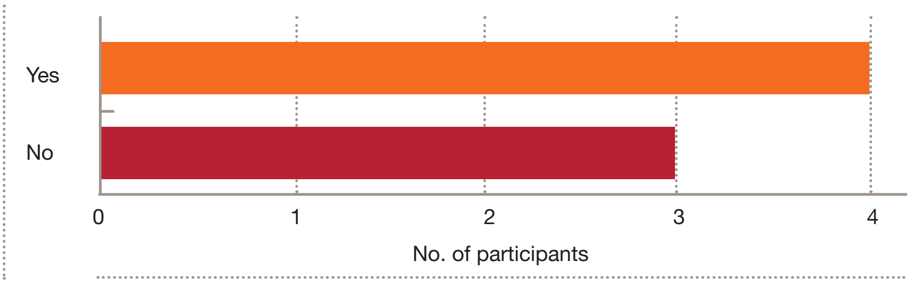


Matching adjustment

The 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 an 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, which we explore in this section.

Participants are divided as to whether their internal model captures expected changes in the composition of the opening MA portfolio over time (i.e. between calibration dates). Of those who do make an allowance, some noted that this varies depending on whether the calibration is off cycle or on cycle, when a pragmatic approach may be required.

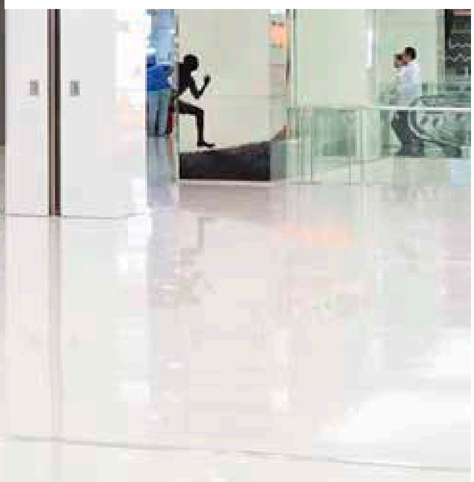
Figure 3.1: Reflection of the 3 PRA matching tests in the internal model



Practice varies as to whether participants' internal models reflect the three PRA matching tests, summarised in Figure 3.1.

The complexity of rebalancing assumptions applied under stress to the MA portfolio also varies between participants and can be summarised as follows:

- Sales and acquisitions to maintain the quality of the portfolio under stress
- Excess assets assumed to be invested in MA compliant assets and injected to cover any loss under stress
- Shortfalls filled by credit assets within the group, with any further shortfall sourced from external debt markets
- Bps impact on the MA of rebalancing under stress calculated off cycle for key stresses and the impacts applied on cycle as required



In a shift from 2015, when some participants noted that their internal models applied limits on how much of the increase in total spread translated into increases in the matching adjustment, none of our 2016 participants indicated the use of limits in this way.

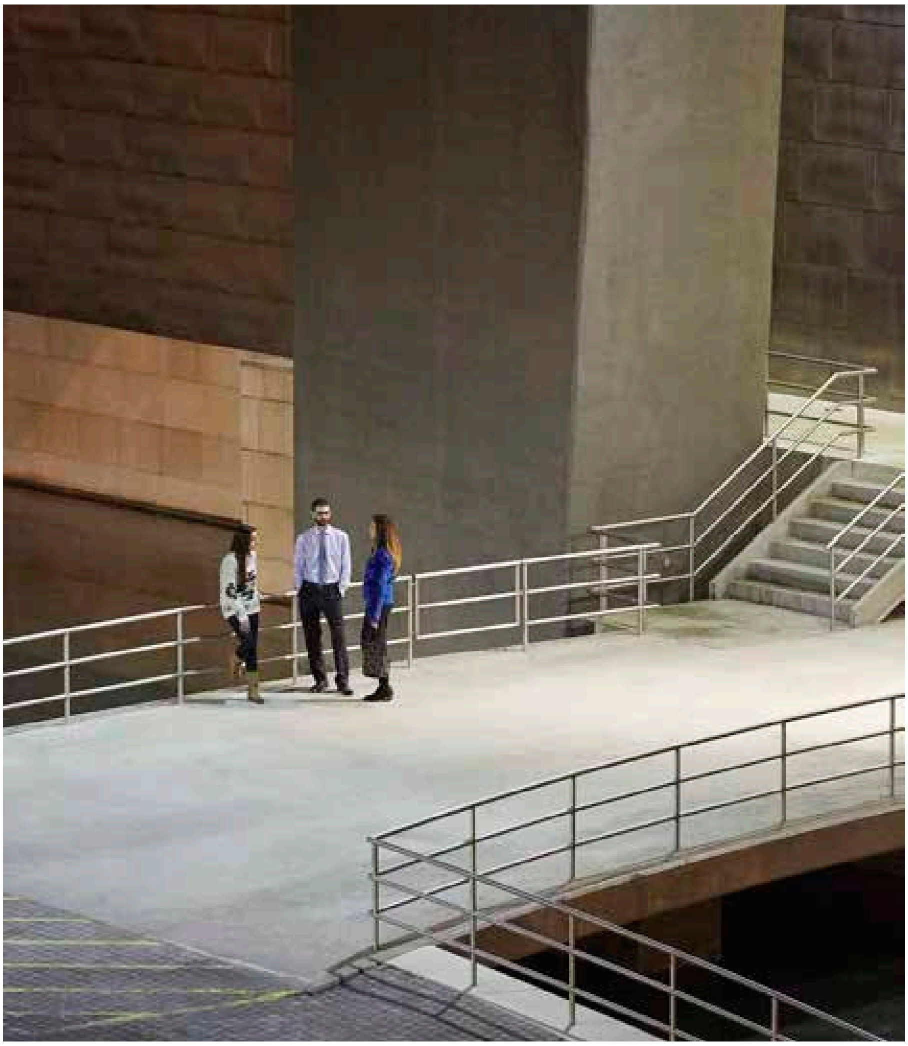
The majority of participants indicated that the cost of downgrade within the MA calculation is increased dynamically from the widening in spreads between ratings which are assumed under stress assumptions, rather than modelling this in a static manner.

We asked participants to describe the end result of a widening in total credit spread (including transition and default) for matching adjustment business
All participants who use a matching adjustment make an allowance for the portion of the increase in credit spread that feeds through to an increase in the assumed matching adjustment, however we note there is no consensus as to the size of this allowance, observing a range of responses between 50% and 60%. There is also disparity around the capital offset from the MA under stress, with some firms having a proportionally higher MA offset to their univariate credit risk capital requirement than the offset to fundamental spread.

Transitional Measure on Technical Provisions

Use of a TMTP gives insurers the opportunity to defer some of the impact of moving from Solvency I to Solvency II. The TMTP allows firms to deduct the difference between the Solvency II TPs and the Solvency I Pillar 2 (ICA) TPs from the risk margin (and then from the BEL if risk margin is eliminated), subject to ensuring that the financial resource requirement under the transitioned Solvency II position is at least as large as that under Solvency I. All ten participants indicated that they include a TMTP on their Solvency II balance sheet.

With the publication of SS6/16 “Recalculation of the ‘transitional measure on technical provisions’ under Solvency II”, the PRA confirmed their expectation for a recalculation of the TMTP at least every 24 months, or more frequently following a material change in risk profile. There is a variety of approaches to recalculation between firms, noting that at the time the survey was completed most firms had not agreed a recalculation with the PRA.



Most participants assume that the TMTP can increase beyond the initial 1 January 2016 amount on recalculation. If the TMTP cannot increase then it will respond to interest rate rises (which may lead to a reduction in TMTP) but not to falls in rates (which would lead to an increase). As such, most participants who do not allow for an increase beyond the 1 January 2016 amount on recalculation classify changes in interest rates as a “change in risk profile” that requires a review of the TMTP, i.e. they will consider if the TMTP should increase at recalculations where there is deemed to be a change in risk profile due to falling interest rates.

The majority of participants do not intend to carry out a full recalculation (using Solvency I processes) every two years, preferring to use a simplified approach, e.g. adjusting Solvency II technical provisions to get back to ICA technical provisions, or adjusting for changes in the risk margin and key risk drivers without a full bottom-up calculation. None of the participants proposing simplifications stated that this had been agreed with the PRA. The level of granularity for recalculation is likely to remain an area of focus as firms look to avoid maintaining full Solvency I reporting capability.

A few participants have already defined limits within which no recalculation of their TMTP will occur, even if there has been a change in conditions or risk exposure. The limits are typically outcome based (e.g. a minimum change in solvency coverage ratio required to trigger recalculation). Other firms indicated that they are currently considering what would constitute a change in conditions or risk exposure requiring recalculation.

Most participants plan to recalculate the TMTP as at the relevant reporting date, rather than referring back to 1 January 2016. Firms which take this approach will need to be mindful of avoiding “double run-off” when determining the TMTP run-off pattern, as in addition to the x/16th run off at the reporting date the run-off must be retrospectively applied to the back book from 1 January 2016.

Proxy modelling

For many insurers it is not practical to carry out the required number of simulations for an SCR calculation in the full "heavy" liability models, and so a proxy model is used. A proxy model comprises a number of loss functions, fitted algebraic functions that can be used to reproduce the crystallisation of multiple risks under a particular combined scenario of risk. All but two participants noted that they use proxy modelling within their internal model.

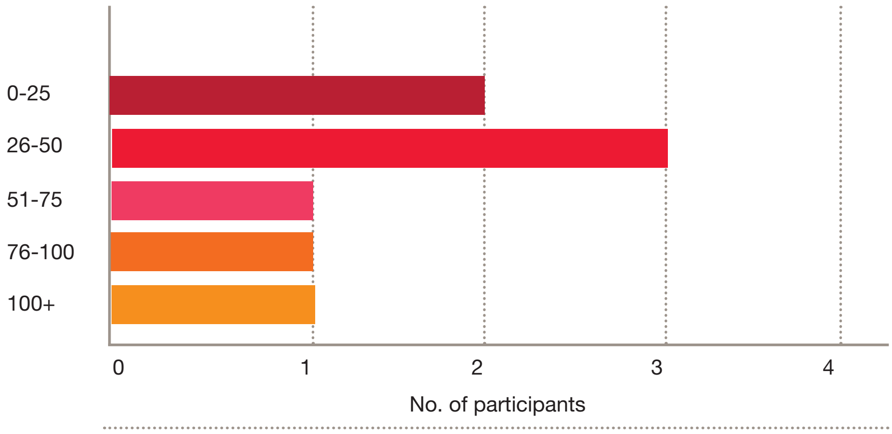
A key expert judgement in the use of proxy modelling is the number of risk factors used. We asked participants how many risk factors are included in their proxy models and the results are presented in Figure 3.2.

The variety of responses reflects both the disparity in the level of granularity between modelling approaches and the differing complexity of business between insurers.

Most participants indicated that they use 50-200 heavy model scenarios for out-of-sample testing to validate the goodness of fit of the loss functions in the internal model. In addition to out-of-sample testing, participants indicated that they use R^2, AIC, absolute differences and absolute % differences.

A small number of firms with significant with-profits books use Least Squares Monte Carlo (LSMC) simulations within their modelling process, which uses a large number of less accurate estimates to fit a loss function rather than fewer more accurate heavy models as the basis of fitting. The key associated challenge is the ability to generate the volume of ESGs required.

Figure 3.2: Number of risk factors used by participants in proxy modelling



Few participants carry out full calibrations of their proxy models on-cycle. A more common approach is to complete a full calibration off-cycle (typically at Q3) and roll forward to year end.

Most participants are planning to make changes to their proxy modelling process this year, with the changes broadly falling into two categories:

- Modelling and process simplifications, in order to reduce on-cycle production timescales
- Improvements to roll-forward methodologies.

Model changes

The publication of SS12/16 "Solvency II: Changes to internal models used by UK insurance firms" in September this year confirmed the PRA's expectation that under normal circumstances firms will submit "no more than one model change application per year". All participants with an approved internal model or partial internal model plan to make a major model change this year. While many intend to use the model change process to address feedback from the IMAP process, a number intend to extend the scope of their partial internal model to further blocks of business and/or more risks.

4. Market risk

Solvency II states that the market risk module 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.

In this section, we consider the following sub-modules of market risk:

- *Credit spread*
- *Credit transition and default*
- *Equity*
- *Interest rate*

For each risk sub-module, 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 of the module. Should firms opt to model the relevant risk using the Standard Formula under Solvency II, they were asked to provide responses as applicable to their Economic Capital Model.

Credit spread

Introduction

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 from transiton and default risk.
- The average 1-in-200 increase in spread for a 10 year A rated financial bond (359bps) is broadly consistent with 2015, with a slight decrease of 4bps over the year. However, the average 1-in-200 increase in spread for a 10 year A rated non-financial bond (281bps) has increased by 20bps since 2015.
- There is considerable variation in the level of gilt-to-swap stress being applied to UK gilts, particularly at the 5 year term.

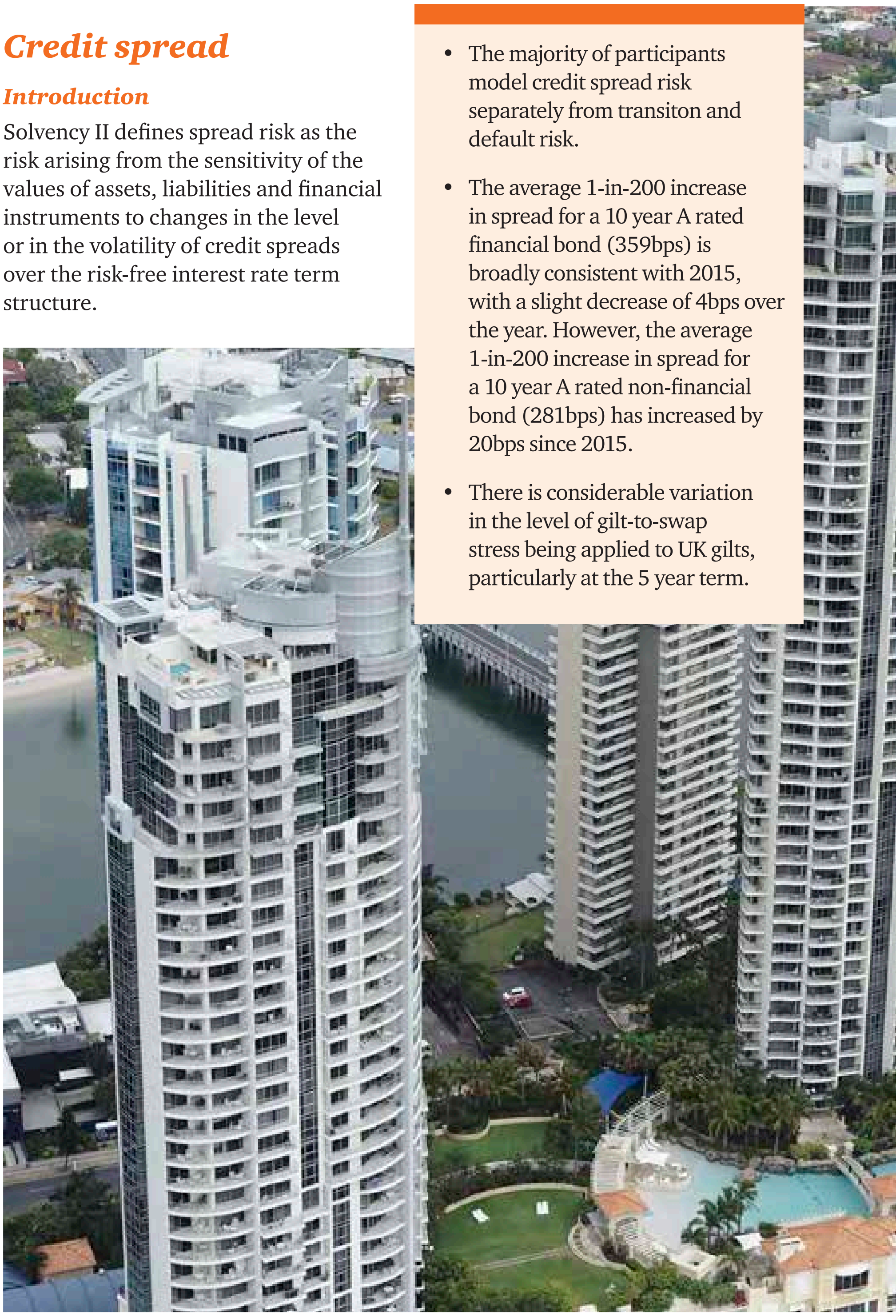
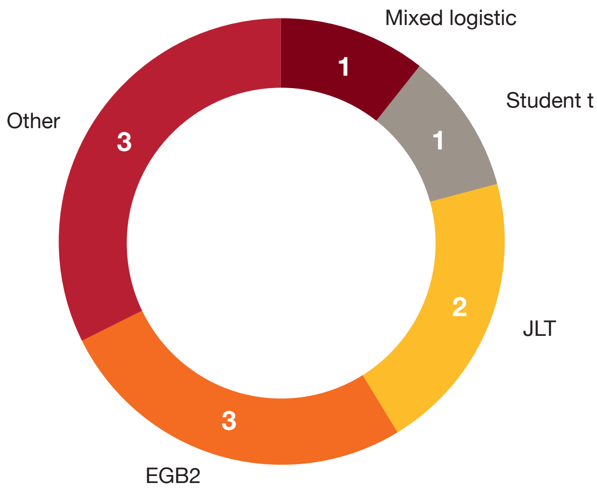


Figure 4.1: Distribution of modelling methodology used by survey participants to calibrate credit spread stresses.



Methodology

Calibration Model

A wide range of models are used to calibrate spread risk, as illustrated in Figure 4.1.

All participants indicated that their credit risk model reflects term structure and a number also split their calibrations by currency, typically GBP/USD/EUR.

Sovereign debt stresses

PRA supervisory statement SS30/15, published in July 2015, states that "the discounting of liabilities with the 'relevant risk-free rate term structure' derived from interest rate swaps may give rise to a risk that the spread between sovereign bond yields and the relevant risk-free rate changes ('gilt swap spread risk')." As part of the 2015 survey we therefore asked if participants applied spread stresses to sovereign debt within their internal model and a small majority responded affirmatively.

In 2016 we see an increased majority of participants apply spread to swap stresses to sovereign debt in their model, with the most common approach being to apply stresses as per corporate bonds of equivalent rating. Some participants make a differentiation for UK gilts and AAA rated sovereign debt from other territories, either through not applying a stress or by using a dedicated calibration.

Assets other than corporate and sovereign bonds

The majority of participants holding assets other than corporate and sovereign bonds model credit spread risk separately for these assets. However, in most cases the underlying form of the probability density function (pdf) used to fit these stresses is the same as that used in fitting the stress calibration for corporate bonds.

Results

We asked participants for details of their calibrated credit spread stresses, split by financials and non-financials. The summarised results can be seen in Figures 4.2 to 4.7. These results show that the average calibrated stress for financials remains consistently higher than that for non-financials across all terms and ratings, as observed in 2015.

Figure 4.2: Calibrated basis point yield increase for credit spread by credit rating for financial corporate bonds. (1-in-200)

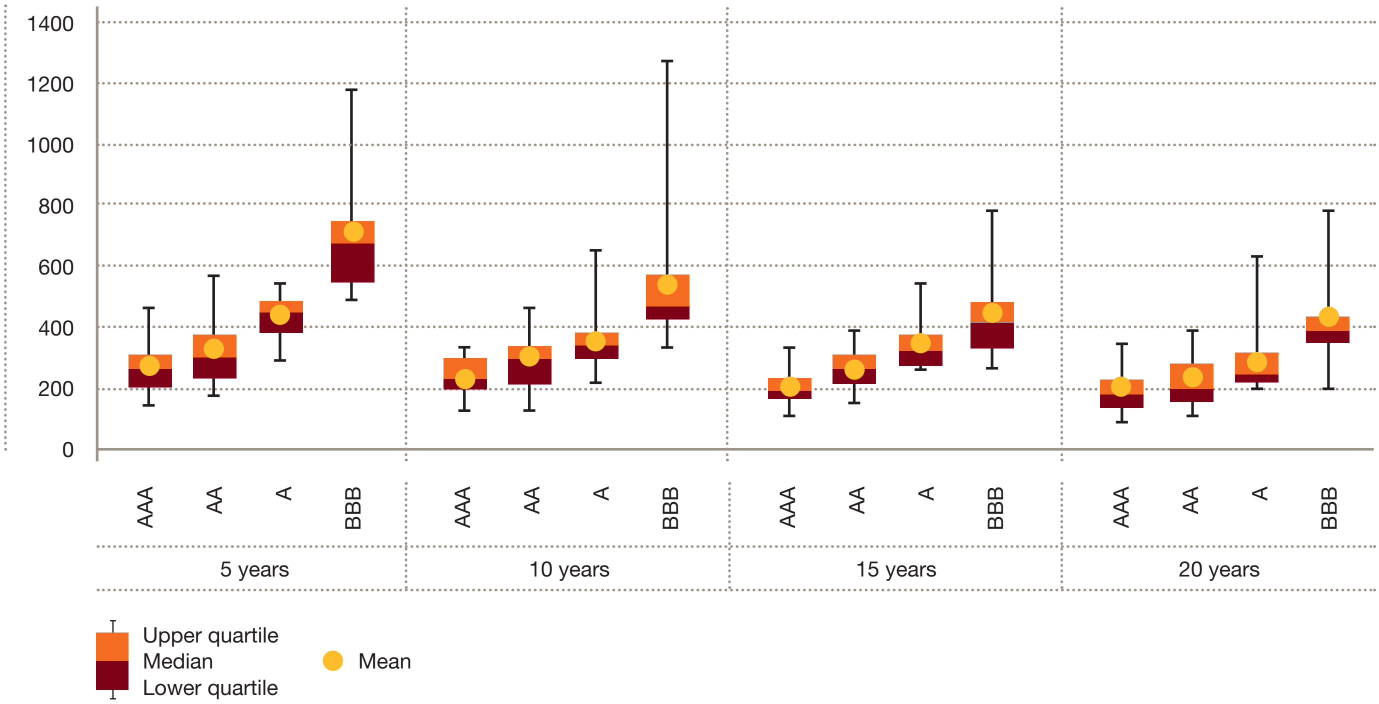
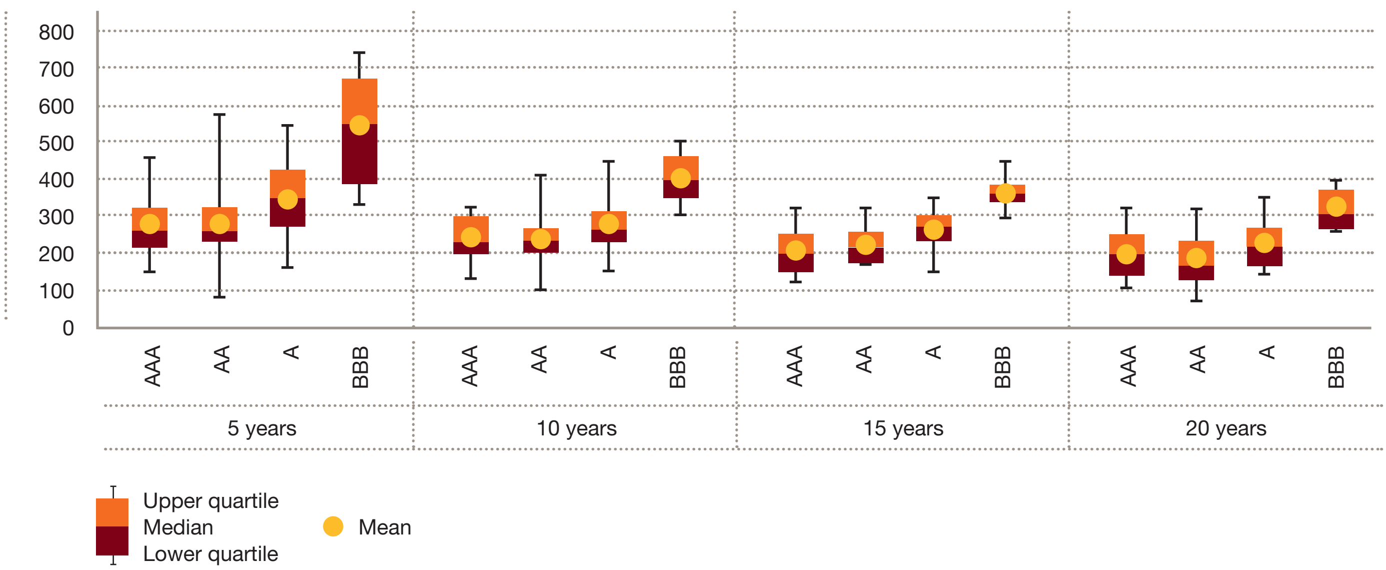


Figure 4.3: Calibrated basis point yield increase for credit spread by credit rating for non-financial corporate bonds. (1-in-200)



Comparing the average 1-in-200 increase in spread for a 10 year A rated financial bond (359bps) to the results for 2015 shows a slight decrease of 4bps over the year. However, comparing the average 1-in-200 increase in spread for a 10 year A rated non-financial bond (281bps) to the results for 2015 shows an increase of 20bps over the year.

Figure 4.4: Calibrated basis point yield increase for credit spread by credit rating for financial corporate bonds (1-in-10)

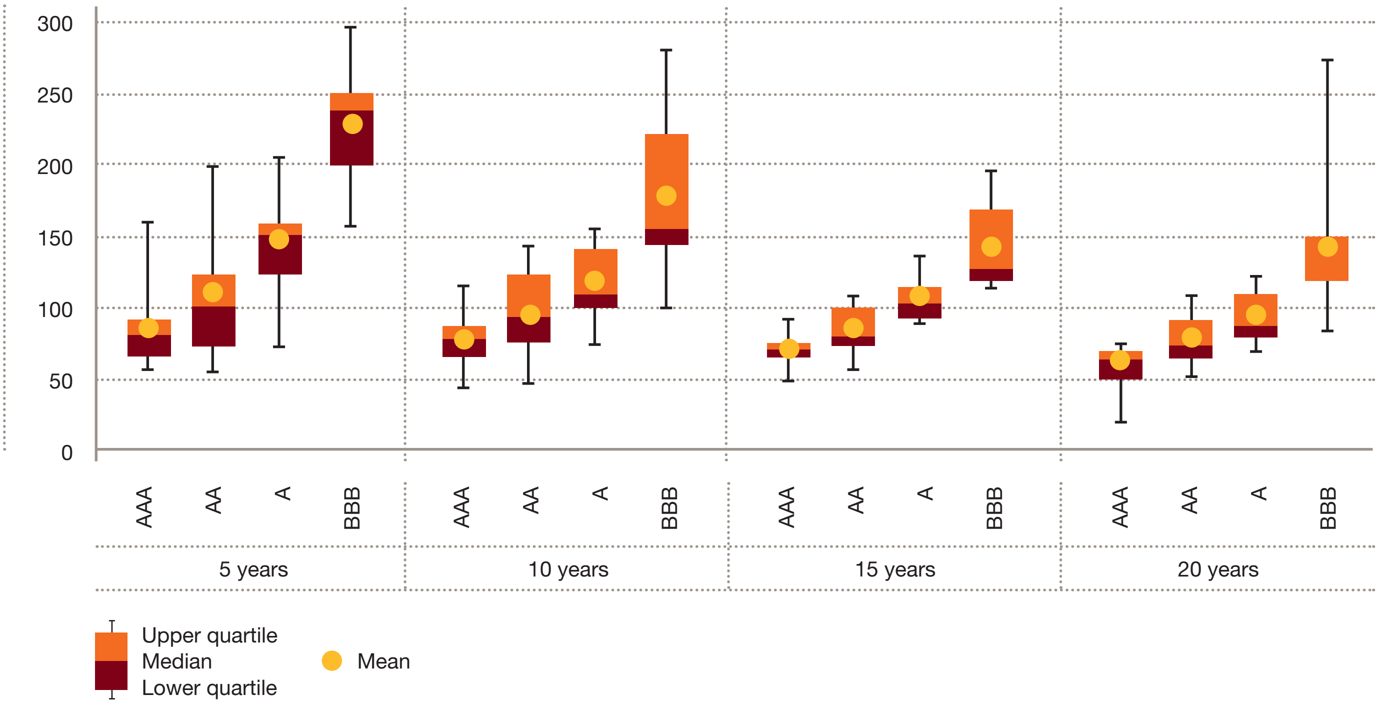


Figure 4.5: Calibrated basis point yield increase for credit spread by credit rating for non-financial corporate bonds (1-in-10)

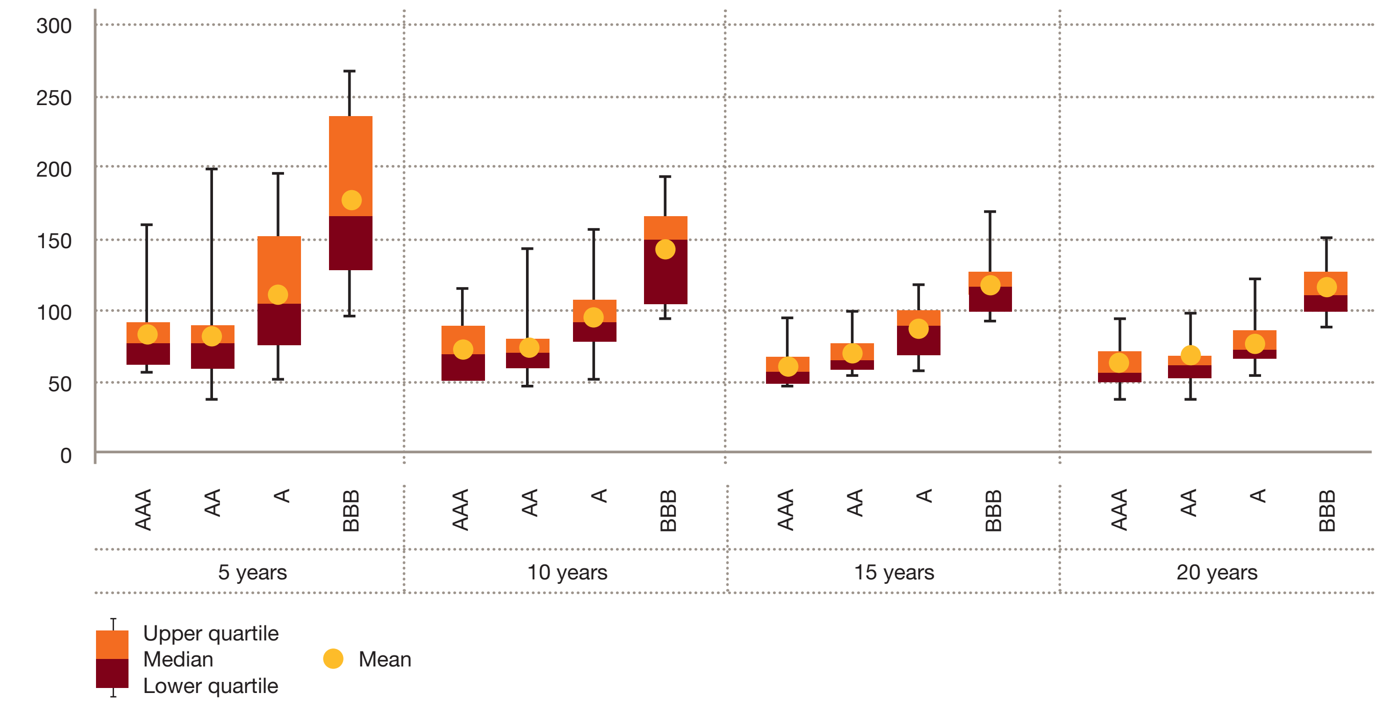


Figure 4.6: Calibrated basis point yield increase for credit spread by credit rating for financial corporate bonds (1-in-50)

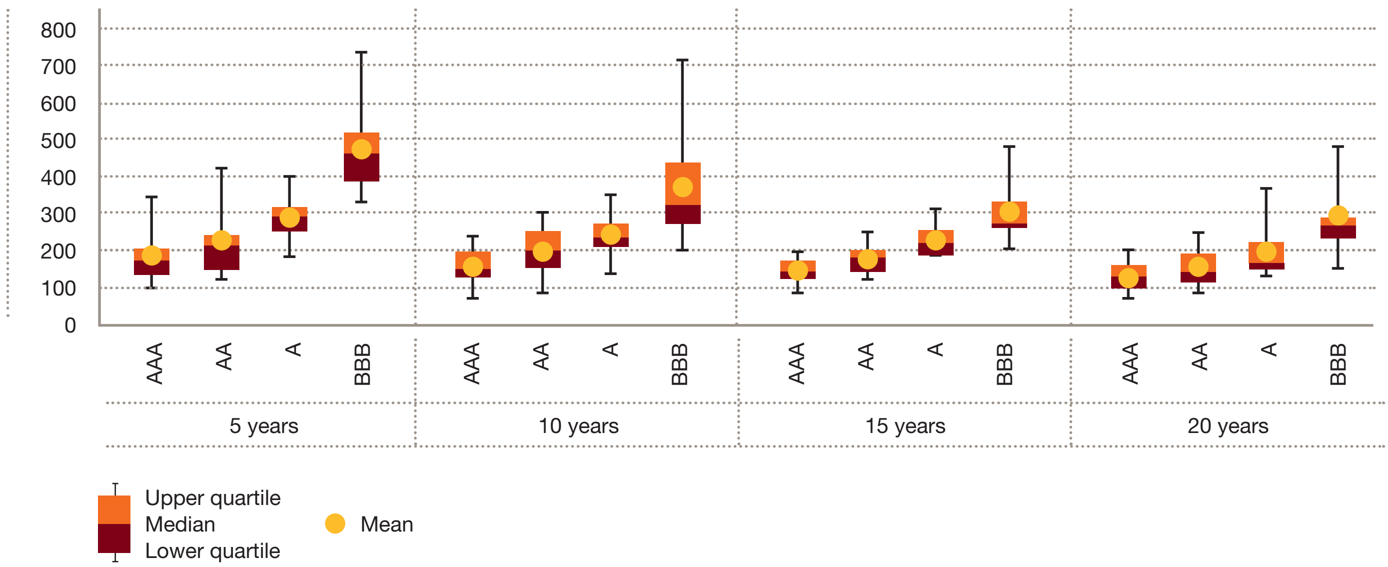
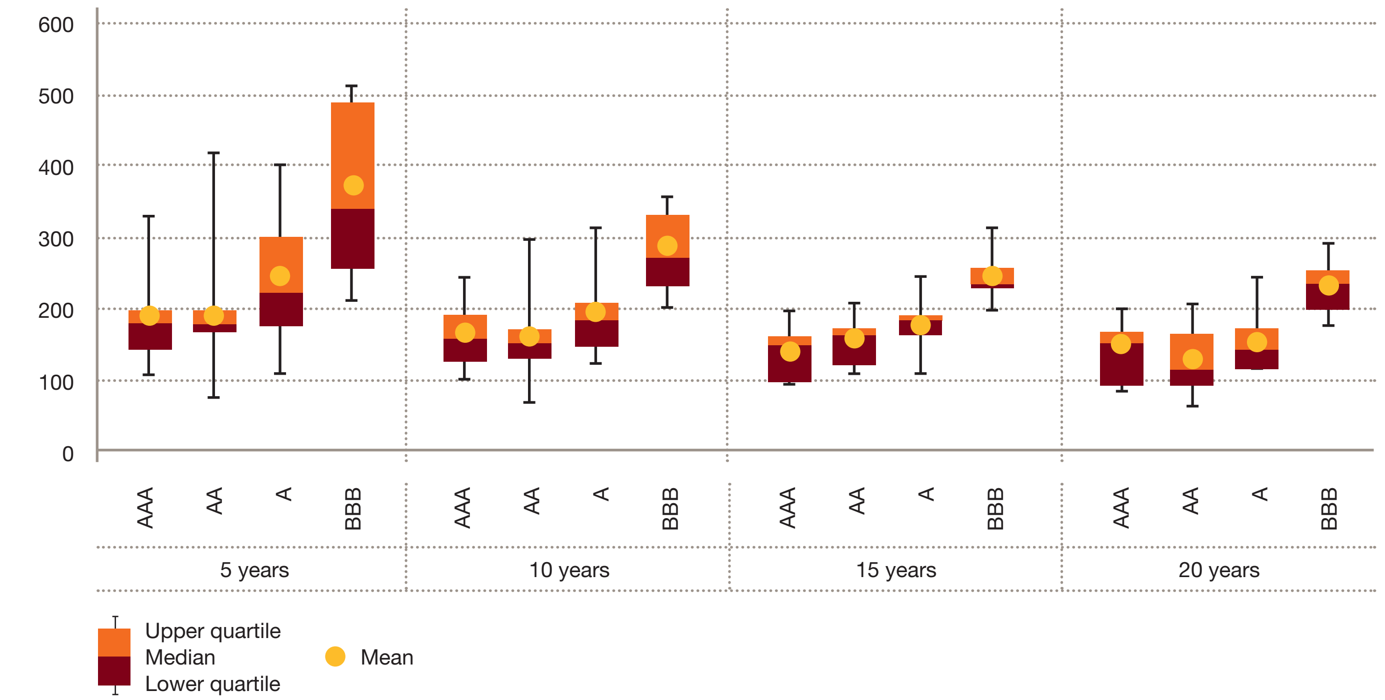


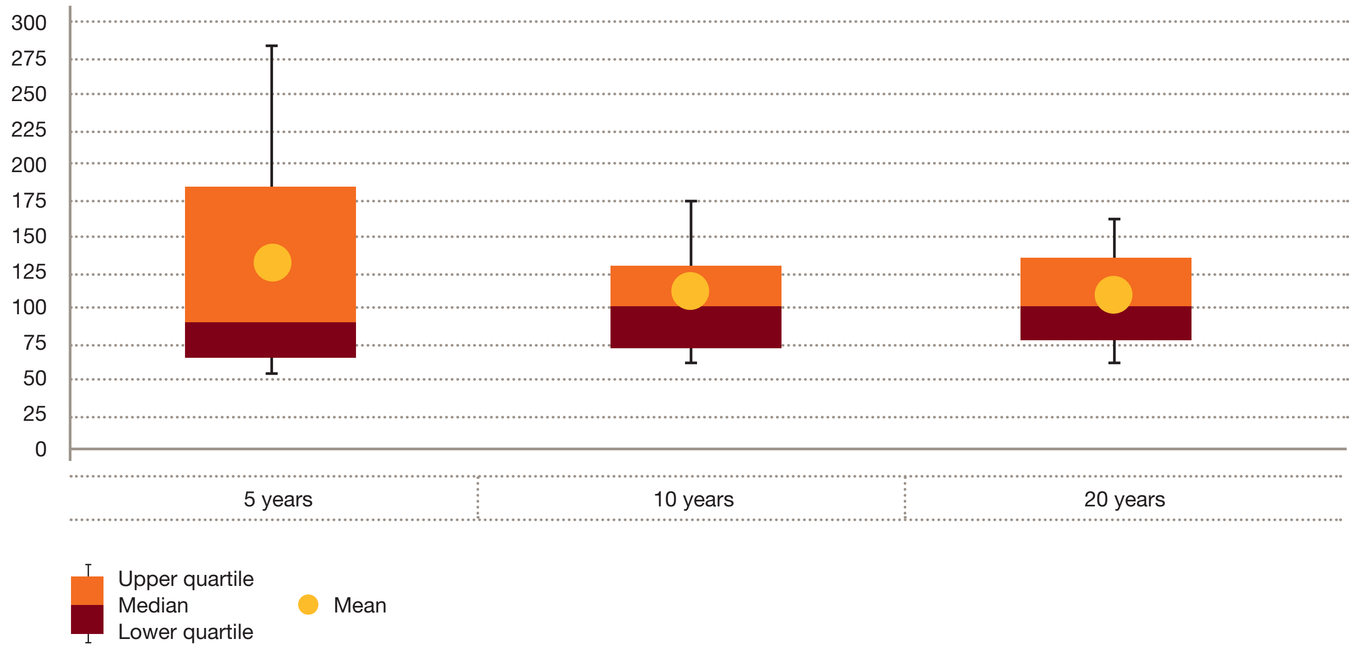
Figure 4.7: Calibrated basis point yield increase for credit spread by credit rating for non-financial corporate bonds (1-in-50)



UK gilt stresses

We also asked participants for details of their 1-in 200 gilt-to-swap stresses. The results are set out in Figure 4.8. We note that there is considerable variation in the level of stress being applied, particularly at the 5 year term.

Figure 4.8: Calibrated basis point UK gilt stress to the EIOPA risk-free curve (1-in-200)

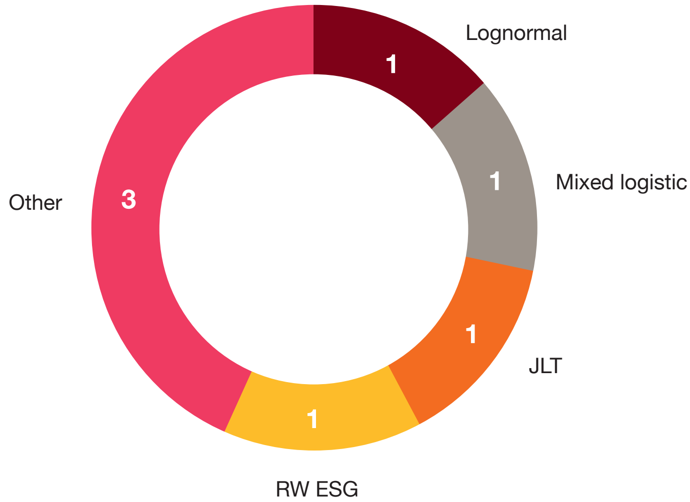


Credit transition and default

Losses can also arise from the sensitivity of the values of asset and liabilities to changes in market assessments of the risk of future migration and/or default. Historically insurers have focused on modelling credit risk holistically, focusing on spread changes to reflect movements in total return/value, what we termed combi-modelling in the section above. The matching adjustment calculation and associated split of transition and default risk from spread risk, combined with regulatory pressure, has led to a number of insurers choosing to reflect spread, transition and default elements separately within their modelling.

As in 2015, the majority of participants indicated that transition and default is modelled separately to credit spread risk in their internal model.

Figure 4.9: Distribution of modelling methodologies used by survey participants when calibrating transition and default stresses



Calibration Model

The models used by participants to calibrate credit transition and default risk are illustrated in Figure 4.9. As observed for credit spread risk, there is a range of approaches adopted.

A small majority of participants indicated that the cost of transition within their internal model represents an average over a period of time (i.e. a "through the cycle" approach) rather than being driven by modelled stressed spreads at the point of transition (i.e. a "point in time" approach). This represents a shift from 2015, when only a few participants were using a "through the cycle" approach.

Most participants use recovery rates derived as an average over a period of time rather than modelling them dynamically at the point of default.

The majority of participants apply default and downgrades to sovereign debt, however we note some variation between insurers as to whether this is applied across all ratings and territories, or only to lower ratings and non-UK debt.

Aggregation of credit risk module

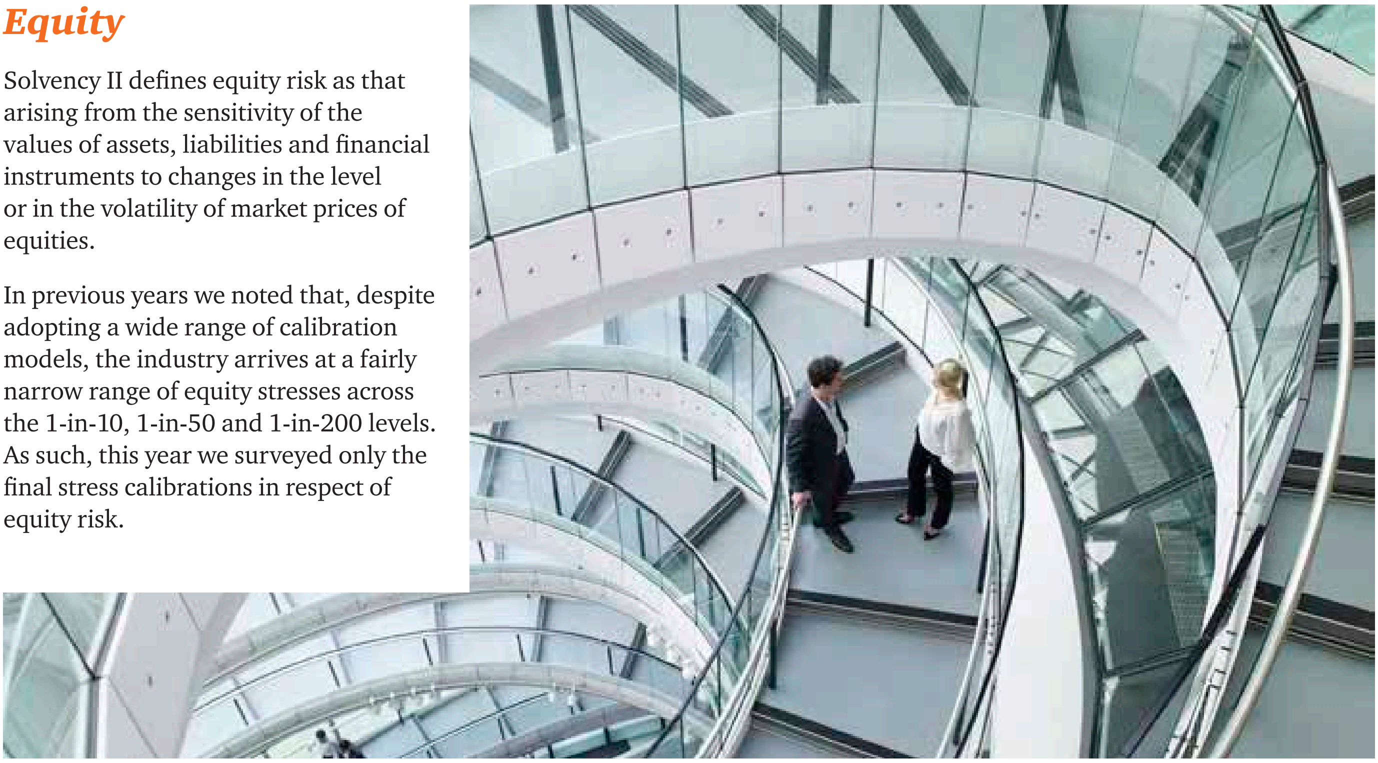
Aggregation methods used for sub-risks within the credit risk module where the spread risk element is modelled separately from transition and default include multivariate t-copulas, use of a variance-covariance matrix and use of a real world ESG.

The majority of participants who model the spread element of credit risk separately from the transition and default element allow for an element of diversification between the components of their overall credit risk module. In practice, this means that for these companies the 1-in-200 credit spread stresses captured above will be diluted by the effect of diversification.

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.

In previous years we noted that, despite adopting a wide range of calibration models, the industry arrives at a fairly narrow range of equity stresses across the 1-in-10, 1-in-50 and 1-in-200 levels. As such, this year we surveyed only the final stress calibrations in respect of equity risk.

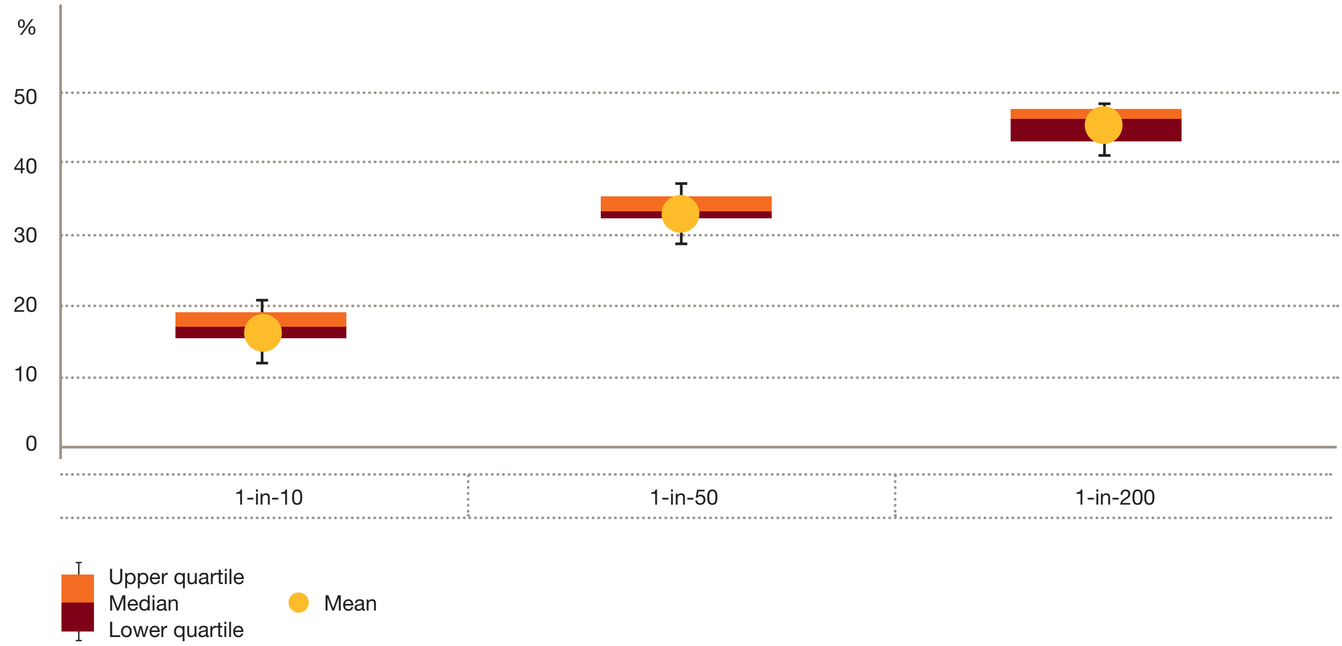


Results

We asked participants to provide their calibrated stresses for equity risk at the 1-in-10, 1-in-50 and 1-in-200 levels. Figure 4.10 shows the resulting level stresses, expressed as a drop in equity values.

A number of participants provided multiplicative rather than additive equity volatility stresses and we do not have a sufficient number of consistent responses to publish individual stresses. However, we note that additive stresses are typically in the range of 10% - 15%.

Figure 4.10: Distribution of calibrated 1-in-10, 1-in-50 and 1-in-200 UK equity level stresses, expressed as a drop in equity values

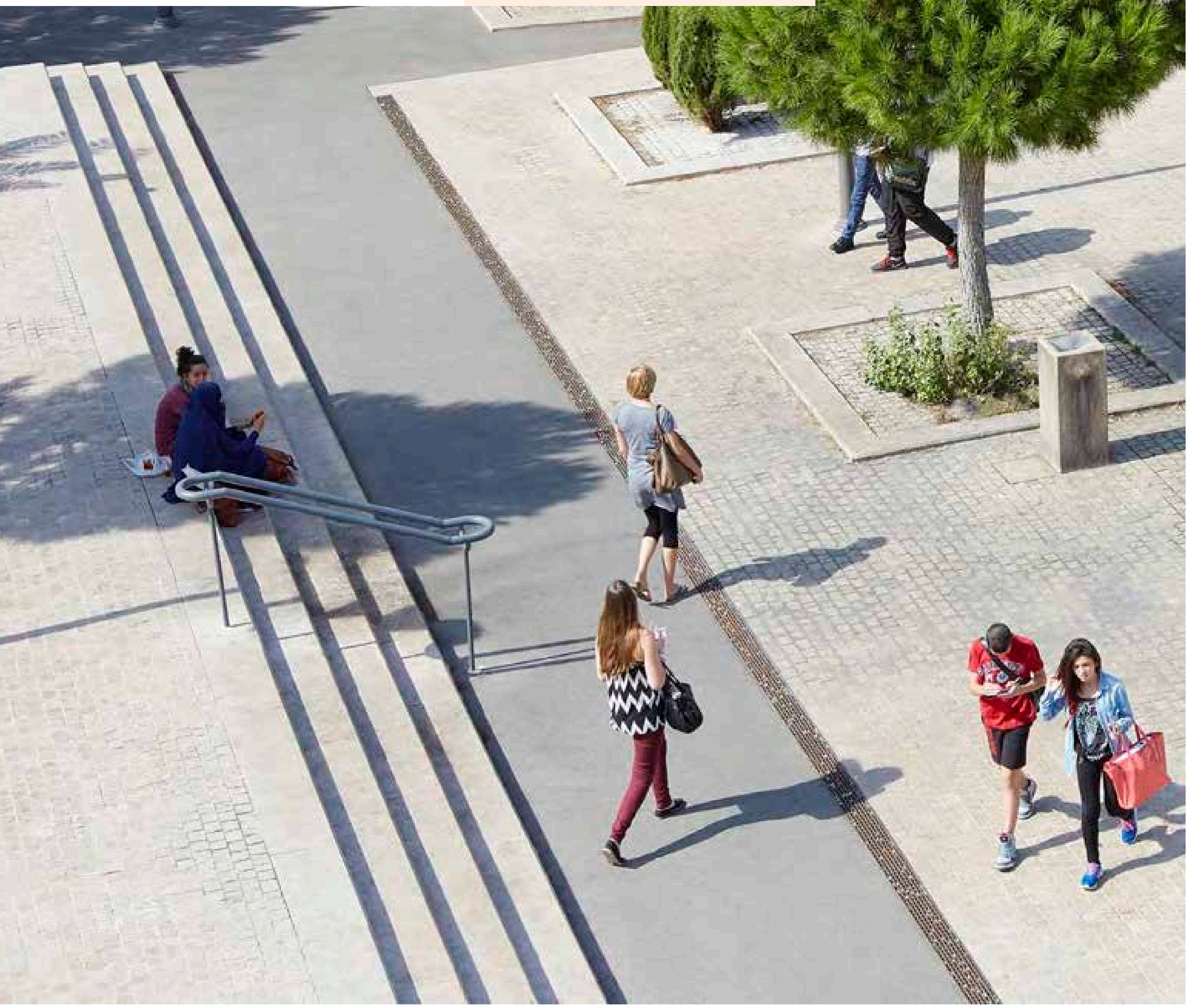


Interest rate

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 interest rate risk does not typically make a material contribution to diversified SCR, it has been an area of increasing focus given the sustained low yield environment across the UK and Europe and recent cuts to the Bank of England base rate.

- 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.
- The majority of participants make an allowance for interest rates to fall below 0% in their internal model.



Methodology

Calibration Model

We asked participants for their modelling approach for the level and volatility elements of their interest rate risk module. The results are illustrated in Figures 4.11 and 4.12.

The results show that there is a wide range of calibration methodology adopted by participants. Most participants indicated that they use principal components analysis (PCA) to determine their interest rate level stress and provided the distribution fitted to the first principal component.

Dependency between interest rate level and volatility risks

We asked participants what, if any, dependency is assumed between the level and volatility stress. The majority noted correlations in the range of -30% to -50% between level (PC1 of the level stress where PCA is used) and volatility stresses.

Allowance for negative interest rates

With continued economic uncertainty and low interest rates in both the UK and the Eurozone, we considered if participants allow for negative interest rates in their interest rate stress calibration. The majority do make an allowance for interest rates to fall below 0% or have planned model changes to make such an allowance. Where participants with large with-profits books allow for negative interest rates in their calibrations, this also impacts their choice of ESG, for example requiring the use of a displacement factor if using a 2-Factor Black-Karasinski ESG model.

Figure 4.11: Models used by participants in calibrating interest rate level stresses

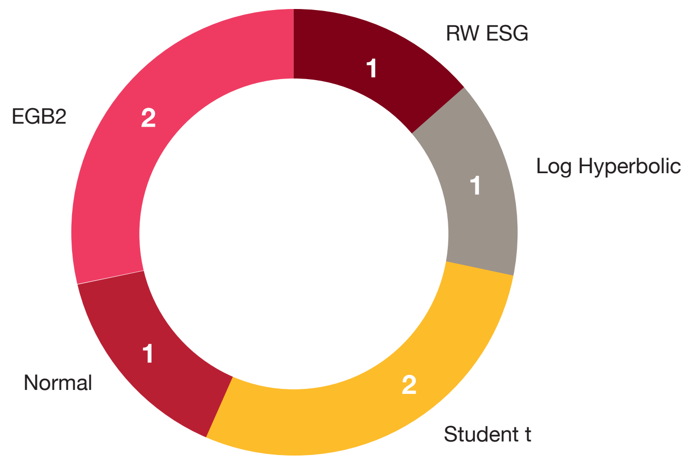
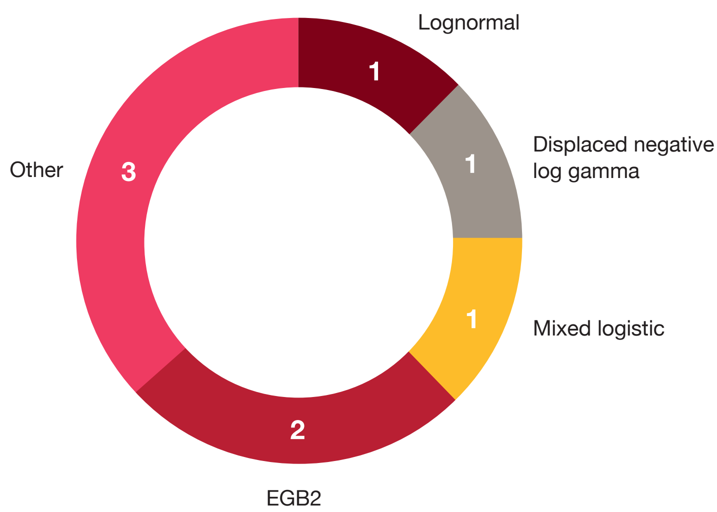


Figure 4.12: Models used by participants in calibrating interest rate volatility stresses



5. Life insurance risk

In this section, we consider what have proved to be the more material non-market risks for life insurers, namely longevity and persistency. For each of these risks we asked participants for a range of qualitative and quantitative information on their risk calibrations as applied in their Internal Model.

Longevity risk

Introduction

Solvency II defines longevity risk as 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. It affects contracts where benefits are based on the likelihood of survival, i.e. annuities, pensions with guaranteed annuity options, pure endowments and specific types of health contract.

- As in 2015, most participants use a two-risk-factor modelling approach for longevity risk, i.e. base and trend components.
- A range of approaches is used across the industry to model longevity trend risk. Only half of participants use causal analysis (typically a Cause of Death model) to support the statistical modelling used to determine their trend stress.
- Average changes in expectation of life from longevity base and trend stresses are broadly consistent with those observed in 2015.

Data

There remains general consensus within industry with regards to data sources used for modelling longevity stress. All participants indicated that they rely on own historic data when calibrating longevity base stresses and data from the Office of National Statistics (“ONS”) when calibrating trend stresses. Some participants noted that they supplement these sources with additional data from reinsurers for the base stress and the Human Mortality Database for both base and trend stress calibrations. The allowance for trend risk is inherently subjective, as improvements develop over long timescales and cannot be captured by analysis of insurers’ own experience and this is reflected in the choice of an external data source.

Figure 5.1: Data period used by survey participants in calibrating longevity risk stresses.

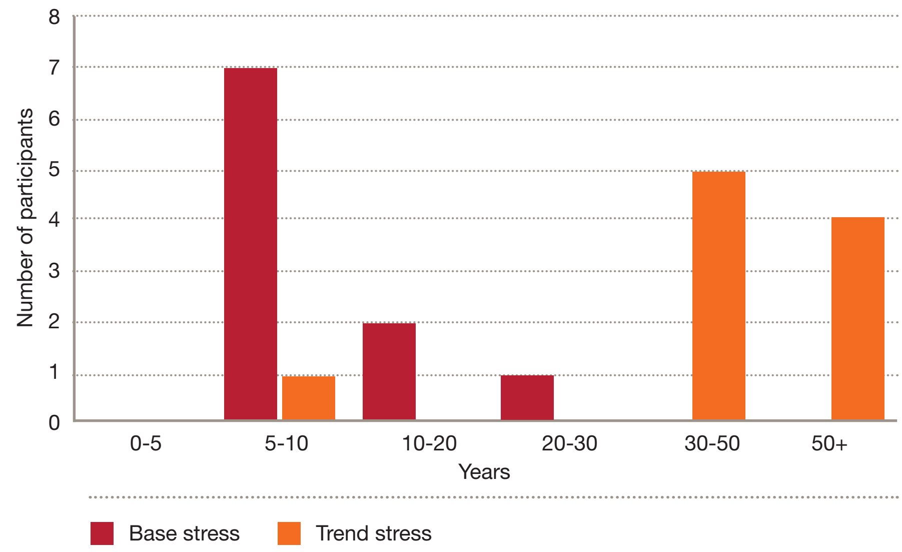


Figure 5.1 shows the data periods used for modelling longevity base and trend risks. The results are in line with the expectation that external data sources used in the calibration of trend risk are typically of a longer duration than internal experience data used for base risk, as observed in previous surveys.

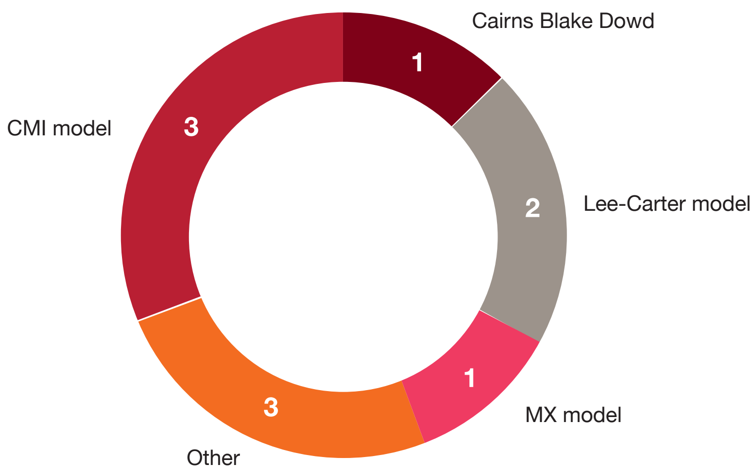
Most participants confirmed that the same data period is used to calibrate the longevity base stress as for setting the underlying best estimate assumption.

Methodology

As in previous years, most participants fit a Normal distribution for the longevity base stress calibration. However, there is variation in whether participants derive a historic one-year deviation which is then applied for the full term or if they derive a historic deviation over a longer period, and whether the same level of base stress is applied across all risk factors (age, gender, smoker status etc.).

There is much greater variation in approaches for modelling longevity trend stresses, as illustrated in Figure 5.2. Responses captured within ‘Other’ include stochastic modelling and a combination of stochastic modelling and scenario analysis. Only half of participants indicated they that use causal analysis (typically a Cause of Death model) to support the statistical modelling used to determine their longevity trend stress.

Figure 5.2: Distribution of modelling methodology used by survey participants in determining longevity trend risk stresses.



Data

We also asked participants to outline the level of correlation assumed between their base and trend risk factors, and applied the following definitions for the various levels of correlation:

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

In this case, correlation refers to the dependency between falls in the mortality base tables and increases in the long-term improvement factors. The majority indicated a low assumed level of dependency. This is a significant assumption, as the stresses tend to be similar in size and in practice insurers may find it difficult to differentiate emerging experience as being driven by either level or trend risk.

Results

Figures 5.3 and 5.4 summarise impact of participants' 1-in-200 longevity base and trend stresses, as applied to immediate non-smoker annuitants aged 65.

The average increase in expectation of life from a 1-in-200 base stress is 0.93 years for males and 0.88 years for females.

As observed in the 2015 benchmarking survey, for the majority of participants, the male stress is higher than the female. There is general consensus that male longevity would be impacted more heavily than the equivalent female assumptions by a 1-in-200 shock to longevity base risk.

Comparing the average changes in expectation of life from the 1-in-200 base longevity stress for the participants who provided details in both 2015 and 2016, we see slight increases, of 0.09 years for males and 0.10 years for females.

The average increase in expectation of life from a 1-in-200 trend stress is 2.64 years for males and 2.58 years for females.

Unlike the base stress, there is variation in whether the male or female stress is higher with regard to the total expectation of life.

Figure 5.3: Distribution of calibrated 1-in-200 longevity base stresses for male and female lives expressed as a change in future expectation of life for a non-smoker immediate annuitant aged 65, measured in years

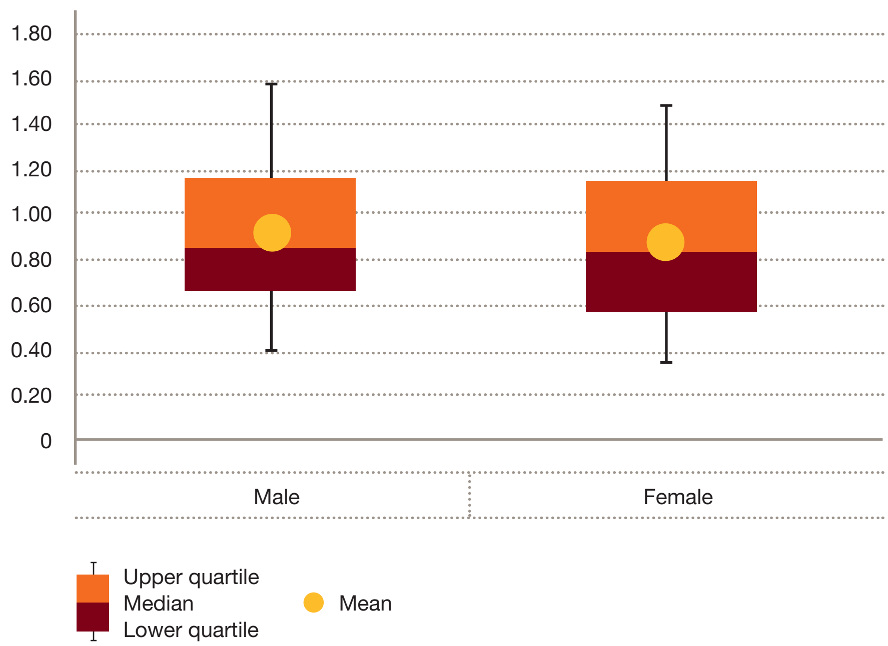
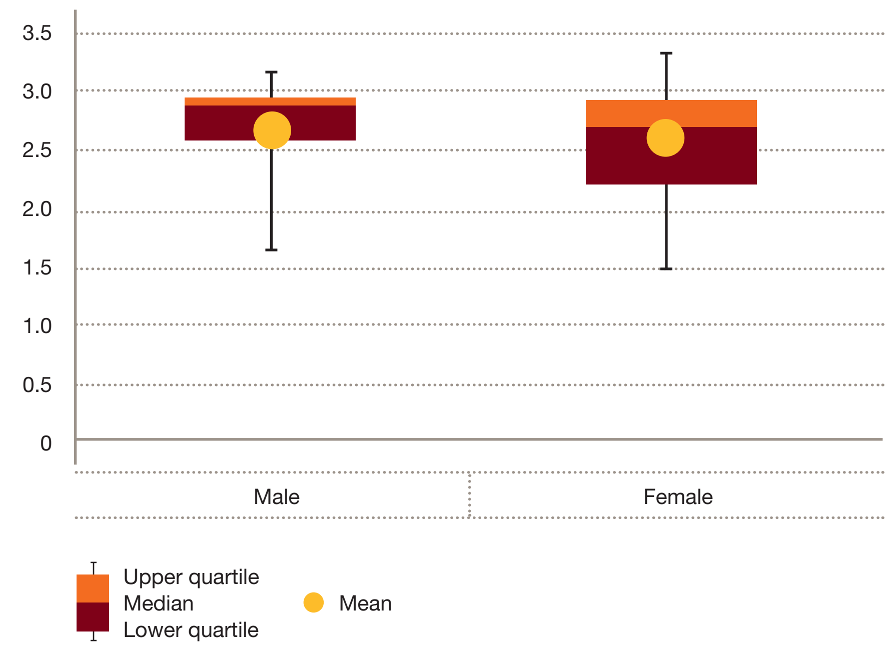


Figure 5.4: Distribution of calibrated 1-in-200 longevity trend stresses for male and female lives expressed as a change in future expectation of life for a non-smoker immediate annuitant aged 65, measured in years



The average change in trend stress across participants who provided details in both 2015 and 2016 shows a slight increase, of 0.2 years for males, but a slight decrease of -0.17 years for females.

The average increase in expectation of life from an overall 1-in-200 longevity stress is 2.83 years for males and 2.77 years for females.

Persistency risk

Introduction

Solvency II defines persistency risk as 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.

- Persistency has traditionally been a very major risk for most lines of business under ICA. However, Solvency II comes with short contract boundaries for many savings contracts which mute the impact of persistency stress for some firms and leads to variation in the relative significance of this risk.
- There is some consistency (across the industry) around average level stresses for unit-linked pensions and with-profits pensions, however the stresses on term assurance business vary widely.

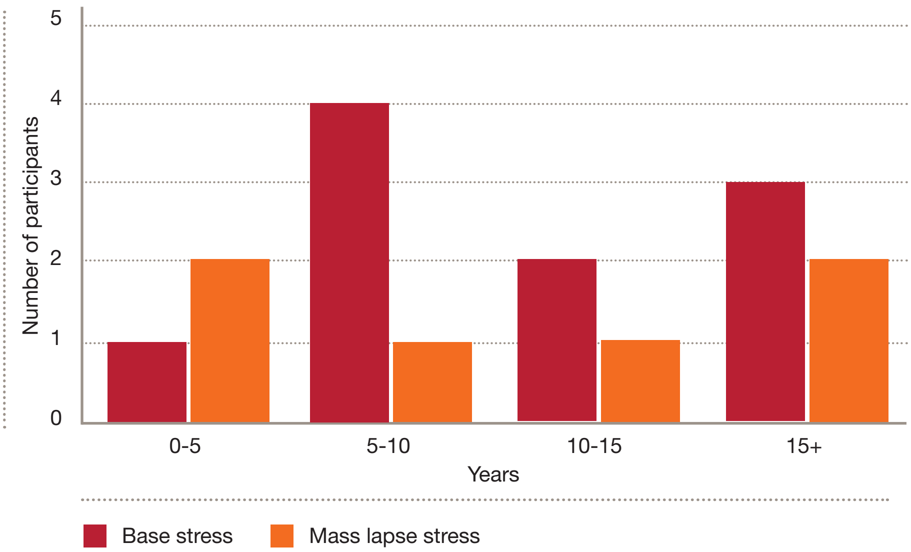
Data

All participants rely on their own historical data when calibrating their persistency level stress, with other sources such as academic research or benchmarking information being used in a limited capacity. However, by contrast, for mass lapse risk most participants struggle with sufficient own historical data and use external data to support expert judgement in setting this stress. These sources include industry benchmarking, historic UK regulatory returns and the standard formula calibration.

There is little consensus on the data period used for either the base or mass lapse persistency stress, illustrated in Figure 5.5. For the base stress, a number of participants commented that the data period can vary by product, depending on the availability. Considering longer data periods for the base stress is understandable from a credibility point of view, however, quality and relevance may be a challenge as older data may suffer from heterogeneity issues.

Although there is varying practice in the data period used to calibrate the persistency level stress, ,most participants derive a one year stress which is then applied across every future year.

Figure 5.5: Data period used by survey participants in the calibration of persistency stresses.



Methodology

Half of participants apply separate base stresses to “strain on lapse” and “profit on lapse” policies, typically at broad product group level (e.g. unit linked, protection). However, only a minority use durational persistency stresses.

As observed in 2015, most participants use a Normal or Lognormal distribution to model persistency level risk. However, we see a shift in approach to modelling persistency one-off (mass lapse) stresses compared to prior year. In the 2015 survey we observed the most common approach for mass lapse risk was to apply expert judgement to a variety of industry data sources rather than to fit a statistical model. This year we see a majority of participants using a Normal or Lognormal distribution, in line with the level stress.

There is little industry consensus on the appropriate dependency assumption between persistency base and one-off risks. All participants who provided dependency assumptions indicated that they were based on expert judgement rather than data.

Persistency sees a far greater variation in practical application than many other risks. This means the information on the stresses surveyed, shown below, should be used with care given that the eventual capital impact relies on their practical implementation.

Results

The average 1-in-200 level stress chosen by participants is 54.28% for term assurances, 54.77% for unit-linked pensions and 50.93% for with-profits pensions.

Comparing the average assumed level stresses to last year's survey we see increases across all three products, with increases of 6.6% for term assurances, 3.3% for unit-linked pensions and 3.7% for with profits pensions.

Figure 5.6: Calibrated persistency level stresses expressed as percentage stresses applied to best estimate withdrawal assumptions separately for Non-linked Term Assurance, Unit-linked Personal Pensions products and With-profits Personal Pension products.

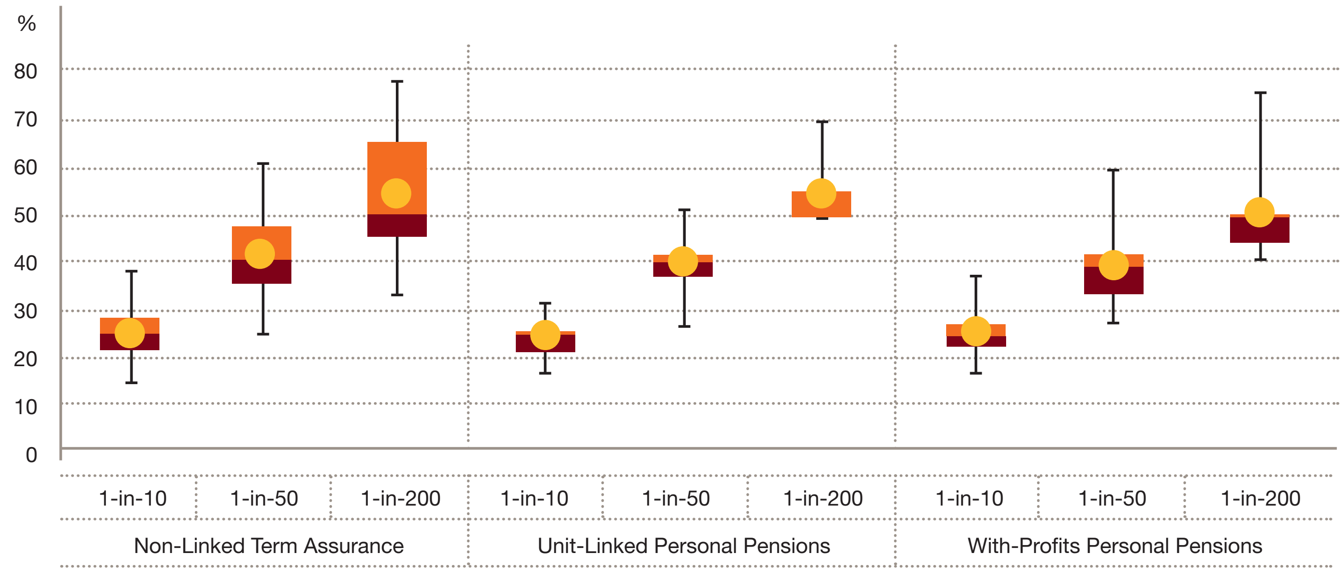
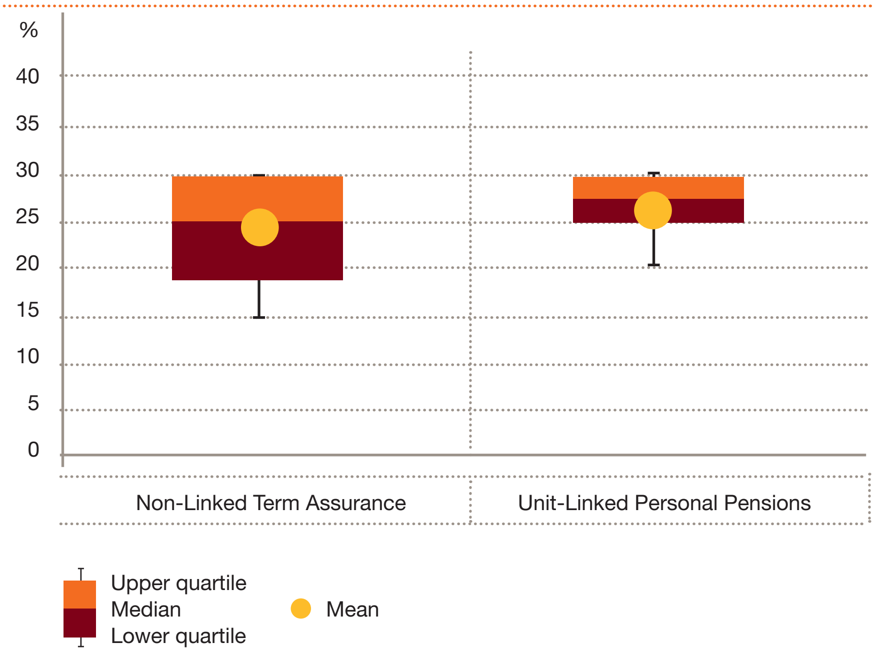


Figure 5.7: Calibrated 1-in-200 persistency mass lapse stresses expressed as percentage stresses applied to best estimate withdrawal assumptions separately for Non-linked Term Assurance and Unit-linked Personal Pensions products.



The average 1-in-200 mass lapse stress chosen by our participants is 23.75% for non-linked term assurance business and 26.69% for unit-linked personal pensions business. We did not receive sufficient responses to disclose results for with-profits personal pensions.

6. Risk aggregation

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

We considered aggregation approaches for the following risk modules within the Solvency Capital Requirement calculation:

- *Market risk*
- *Life insurance risk*

We also considered the methodology for aggregating the sub modules together.

- The most common method for overall capital aggregation remains a variance-covariance matrix, with the relative simplicity of this approach favoured for aggregation of diverse risks across entities.
- Most participants allow for diversification between componenets of individual risks within both the market risk module and the life insurance risk module.
- Dependency assumptions are in line with those observed in last year's survey.

Market risk

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 this risk module. Those using a univariate method of aggregation either make adjustments to their central correlations or calibrate conditional correlations.

Data

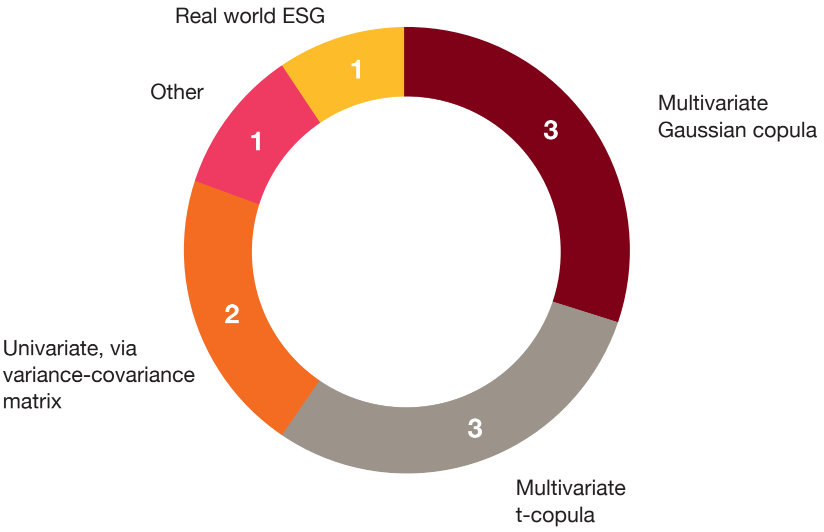
All participants use asset market data to determine dependencies within the market risk module. A few noted that this is supplemented with benchmarking information and expert judgement.

In line with the 2015 survey, the majority of participants stated that the data period used varies for each risk, based on the maximum amount of data available for each pair of dependencies.

A variety of approaches is taken for aggregation of the market risk module, illustrated in Figure 6.1.

The majority of participants allow for diversification between components of individual risks within the market risk module, e.g. between fixed interest principal components or equities in different regions.

Figure 6.1: Distribution of methodology used by survey participants in the aggregation of risks within the market risk module.



Market risk dependencies

As mentioned earlier, the availability of data means the setting of dependency assumptions is less subjective for correlations in normal times but becomes far more subjective in stress, and is a key area requiring the application of expert judgement.

We asked participants for their assumed dependencies between key risks in the market risk module. While we did not receive a sufficient number of consistent responses to publish individual assumed dependencies within the market risk module, we have summarised the trends observed in this section.

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.

All participants assume a medium/high positive correlation between credit spread and equity risks. This is consistent with previous surveys and indeed with the Standard Formula's proposed high positive correlation (+75%), although many participants assume a lower dependency than the Standard Formula.

A range of dependency assumptions is observed between credit spreads and interest rate level risks, with most participants using a low positive correlation, as in 2015. There is also variation in the assumed equity-interest rate dependency, with most using a low positive assumption, again as in 2015.

Most participants assume a medium positive dependency between property and each of credit, equity and interest rate risk.

Life insurance risk

Unlike market risk correlations, which are set by taking into account observable market information, the dependencies between demographic risks rely far more on causal links and expert judgement, and less on data analysis.

We asked participants about the data used for establishing dependencies within the life insurance risk module, with the results set out in Figure 6.8. The wide use of expert judgement is in line with expectation.

Note that a number of participants use a combination of benchmarking, expert judgement and their own historical data, and as such the total number of responses is greater than ten.

Methodology

Aggregation approaches taken for the life risk module are presented in Figure 6.9.

As observed in 2015, a Gaussian copula remains the most popular aggregation method for the life insurance risk module, however there is still a range of approaches being adopted.

As for the market risk module, the majority of participants allow for diversification between components of individual risks within the life insurance risk module.

Figure 6.2: Data sources used by survey participants in determining correlations within the life risk module

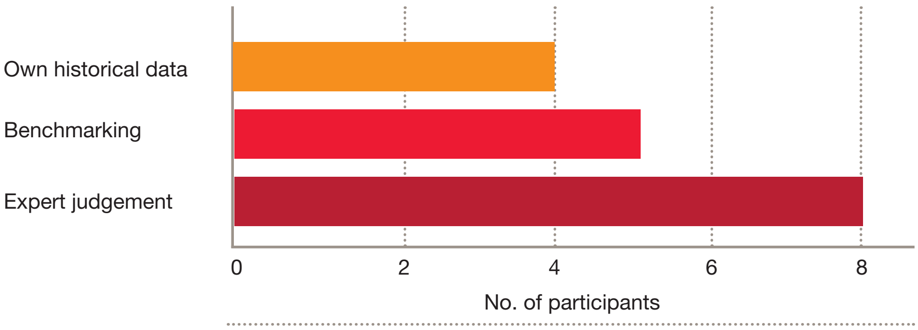
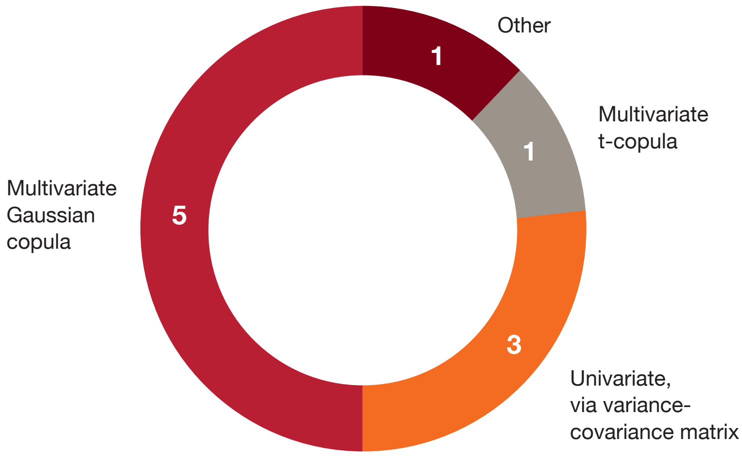


Figure 6.3: Distribution of methodology used by survey participants in the aggregation of risks within the life risks module



Life insurance risk dependencies

This section sets out a summary of assumed dependencies between key risks in the life insurance risk module. We have applied the following definitions for the various levels of dependency:

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

Figure 6.4: Assumed dependencies – longevity to persistency

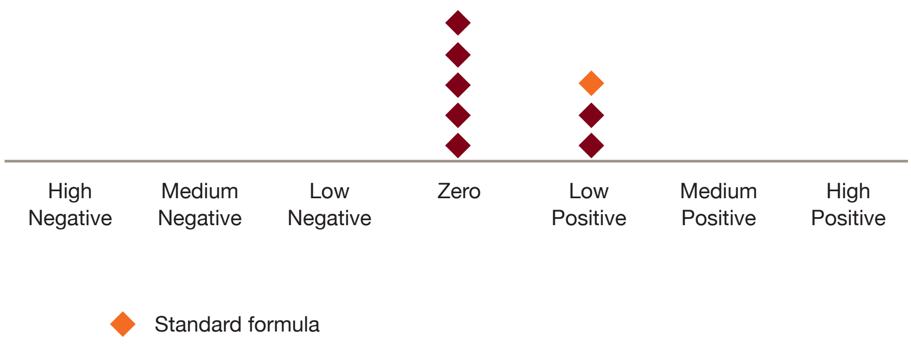


Figure 6.5: Assumed dependencies – longevity to mortality

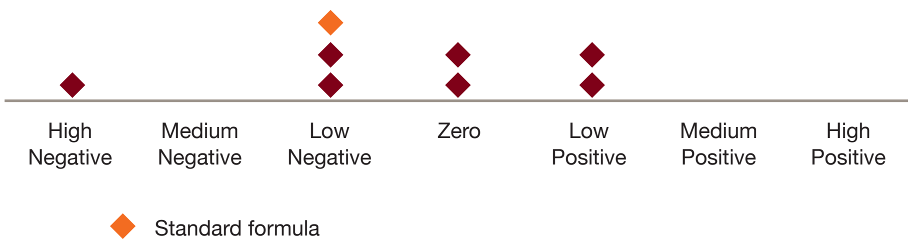
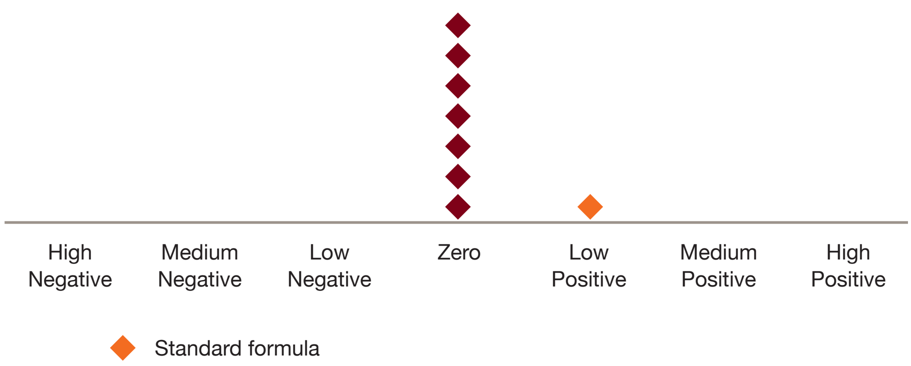


Figure 6.6: Assumed dependencies – longevity to expenses



Participants assume a range of correlations, both positive and negative, between mortality and longevity risks. Nevertheless, a significant proportion of responses point to a weaker (i.e. low positive) dependency.

All participants assume independence of longevity and expense risks.

The majority of participants assume low/zero dependency between longevity and persistency risks. Less than a third of participants assume the Standard Formula's proposed low positive dependency (25%).

Likewise, the majority assume low/zero dependency between mortality and expense risks and most participants assume independence of mortality and persistency risks.

For expenses and persistency, there is a spread from zero to the Standard Formula's proposed medium positive.

Figure 6.7: Assumed dependencies – mortality to expenses

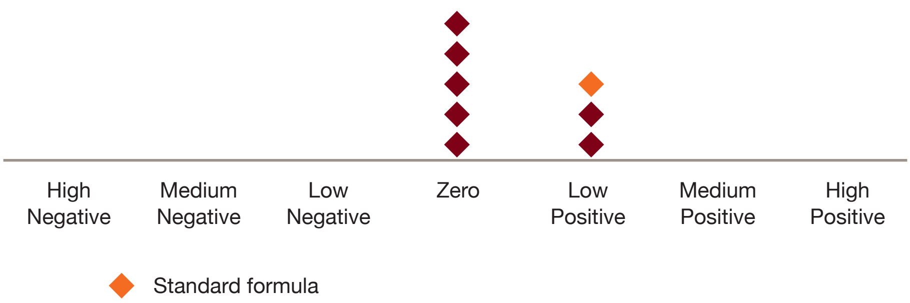


Figure 6.8: Assumed dependencies – mortality to persistency

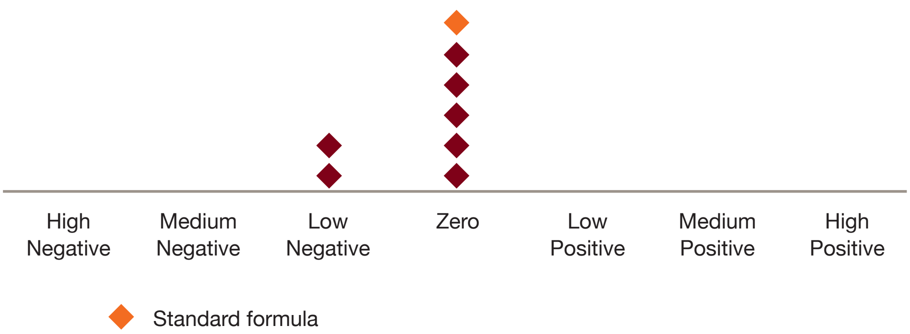
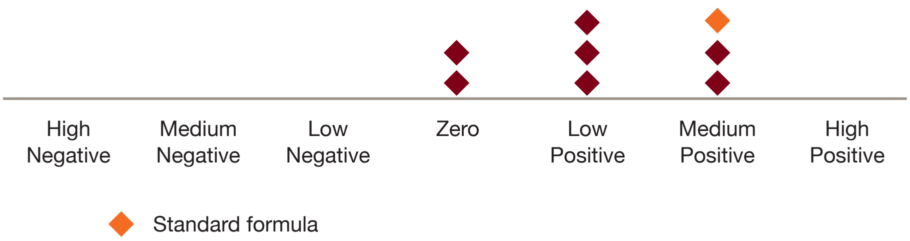


Figure 6.9: Assumed dependencies – expenses to persistency



Aggregation across risk modules

We asked participants to detail the approach taken in aggregating all risks together. Combining risk factors together using a variance-covariance matrix remains the most common approach for overall aggregation, adopted by half of participants, with the remaining participants using either a Gaussian or t-copula. All participants have the practical challenge of aggregating diverse risks within entities and within groups and this may be the driver for the popularity of simpler methods at the highest level of aggregation.

Key dependencies across risk modules

The majority of insurers assume low/zero dependency between both longevity and credit and persistency and credit risks.

Figure 6.10: Key dependencies – Longevity to credit

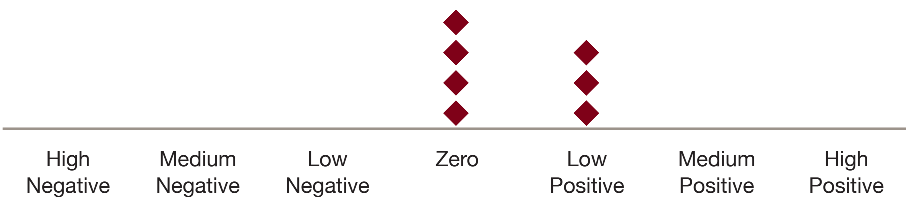


Figure 6.11: Key dependencies – Persistency to credit