BANK OF ENGLAND
PRUDENTIAL REGULATION AUTHORITY

Executive Director
Insurance Supervision
Prudential Regulation Authority

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Solvency II: internal model and matching adjustment update

On 1 April 2015 firms will be able to start making formal applications for approvals in anticipation of the implementation of Solvency II on 1 January 2016. Final information on the application process will be detailed in a Policy Statement that the PRA will be issuing towards the end of this month.

I wrote on 20 February 2015 to update you on our latest thinking with regards to the treatment of equity release mortgage assets (ERMs) in calculating the matching adjustment under Solvency II. As the matching adjustment and the internal model remain two key areas of importance to the UK industry I am writing again to clarify the PRA's expectations in respect of:

- feedback on our observations to date on how internal models are allowing for MA portfolios;
- information on the quantitative framework that the PRA will use as part of its review of internal model applications; and
- initial feedback from the matching adjustment pre-application process which will help firms submit more robust formal applications.

Given the importance of transparency, the PRA will aim to continue to provide firms with further updates on our findings from the MA pre-application process and internal model reviews.

Executive Director

Appendix 1

The PRA's proposed IMAP approach to reviewing matching adjustment

This Appendix should be read alongside Appendices 2 and 3.

On 29 August 2014 the PRA noted in Solvency II: An update on implementation that it had concerns whether a mechanistic re-application of the matching adjustment (MA) following a stress would meet the Solvency II tests and standards for internal model approval. In September 2014 the PRA then followed up with a request to firms for information on their proposed approaches to modelling the risks arising in MA portfolios. Having considered that information and undertaken further review work with firms, the PRA has come to the view that the methodologies that a number of firms are adopting are unlikely to meet the tests and standards for model approval. This update sets out some specific concerns with the approaches seen to date and describes a framework that the PRA considers useful for the purposes of its assessment of the risks inherent in MA portfolios. This appendix should be read alongside the PRA's quantitative framework for model assessments (Appendix 2).

The PRA notes that the time remaining until firms apply for internal model approval is limited and that many firms have not yet finalised the methodologies for modelling the credit risk in their MA portfolios. Although there has been uncertainty over the precise level of fundamental spread that firms will need to use in calculating their technical provisions, this should not be precluding firms from finalising their internal model capital calculation methodologies.

In the PRA's view a number of firms are making unduly optimistic assumptions about the degree to which an increase in MA will offset losses due to increases in credit spreads. That is to say, credit risk calibrations (net of MA offsets) for these firms do not appear to cover all the quantifiable risks to which firms are exposed and are therefore too weak. Moreover, the PRA has seen little evidence that firms have considered the complex interactions between risks (e.g. ALM) that arise in their MA portfolios, in the light of the eligibility criteria that must be satisfied for MA approval.

Specific concerns with the approaches that have been seen from firms to date

For the purposes of assessing credit risk, a number of firms' internal models adopt a 'mechanistic approach' of calculating fundamental spreads using the methods and assumptions prescribed by EIOPA for the purposes of calculating technical provisions (in technical information in accordance with Article 77(e) of the Solvency II Directive) following the modelled stresses to economic conditions. The PRA believes that this approach is not consistent with the tests and standards for model approval because:

- EIOPA's approach is specifically designed to be used for the purposes of calculating technical provisions. At present, conditions are relatively benign and EIOPA has undertaken its calibration work in this context. The SCR is intended to cover extreme scenarios. The techniques that are appropriate for valuing technical provisions in base conditions may not remain appropriate for re-valuing technical provisions under stress. For example, firms should consider the risk that the actual migration and default rates over the future holding period of their assets are more onerous than historic averages;

- it is implausible to assume that economic conditions will necessarily immediately revert, following the one-year modelled stress, to long-term average levels of spread, migration and default, which is the implicit assumption behind any calibration of fundamental spread to long-term average data that is unconditional on (or relatively insensitive to) the modelled credit stress;
- EIOPA's approach is new, and firms cannot know with any certainty whether and how EIOPA might revise its approach under extreme conditions such as a 1-in-200 credit stress event;
- for the reasons noted above, a mechanistic approach based on the re-application of EIOPA's calibration methodology, where the methodology has not been updated to reflect the modelled credit conditions, is unlikely to result in a stressed level of technical provisions that corresponds to a transfer value of liabilities; and
- reliance on predictions of EIOPA's technical information for the purposes of calculating technical provisions to assess the level of risk capital that a firm needs to hold is difficult to reconcile with the requirements of the use test and, in particular, the wider use of the model in a firm's risk management system.

For these reasons, a mechanistic approach to calculating the amount of MA under stress is unlikely to satisfy the Solvency II Directive requirement that the solvency capital requirement (SCR) shall take into account all quantifiable risks to which a firm is exposed. Indeed, the standard formula does not mechanistically assume the same fundamental spreads post-stress as are applied for the purposes of calculating technical provisions. The PRA therefore encourages firms to ensure that their internal models do not, through adopting a mechanistic approach to assessing the level of fundamental spreads under stress, ignore any of the quantifiable risks to which firms are exposed. Firms should particularly consider those risks the firm has retained through use of a MA and ensure that their models are parameterised such that the resulting SCR covers those risks at the 1:200 confidence level.

Firms have generally also failed to demonstrate wider consideration of the MA requirements and, in particular, whether the eligibility criteria would continue to be satisfied following extreme changes in economic and/or insurance risks. For example, there are likely to be costs associated with re-establishing a matched cash flow position on a risk-adjusted basis following the general downgrading of assets in an extreme adverse credit scenario. There are also likely to be interaction effects with insurance risks, where these lead to material changes in the liability cash-flows that then require re-matching.

The PRA's framework for considering the risks in matching adjustment portfolios

As part of its quantitative framework for assessing internal models, explained in Appendix 2, the PRA has developed the following framework for assessing how firms have reflected the risks arising from the use of a MA in their internal models.

The PRA expects firms' own methodologies to capture all the relevant issues and will consider the quality of the thinking and methodology that firms apply to each step. The steps in the framework are:

- **step 1**: re-value the MA portfolio *assets* under a one year stress;

- **step 2**: calculate *updated fundamental spread* values, reflecting the stressed modelled economic environment;
- **step 3**: verify whether the MA *qualifying conditions* are still met;
- **step 4**: if step 3 has failed, then the *cost of re-establishing* a MA compliant position should be specified, such as considering the *cost of re-balancing* the asset portfolio; and
- **step 5**: Re-calculate the MA. Note that based on the analysis in the previous steps this may need to be based on a re-balanced MA asset portfolio.

Comments on the framework steps

Step 1 produces two outputs that are used later in the framework:

- The primary output is the change in total asset portfolio value over one year, i.e. the calculation of *asset side credit risk*.

- The secondary output is the modelled credit quality (i.e. credit rating) of each asset under the modelled stresses; this is a key output requirement if firms wish to re-estimate the MA. There is limited evidence of firms giving sufficient consideration to the need to understand how the credit quality of their assets changes under stress (and hence the new fundamental spreads that would apply) and not all of the credit risk models the PRA has reviewed have been designed with this in mind.

As explained above, EIOPA's approach to calibrating the fundamental spread is designed to be used for base balance sheet technical provisions whereas an internal model should be designed to capture all quantifiable risks in stressed conditions. For example, firms might continue to value liabilities using a matching adjustment following a stress event, but would need to adjust EIOPA's fundamental spread methodology and calibration approach accordingly.

It is likely that, following an extreme economic or insurance risk stress, and after making a suitable estimate of the revised pattern of liability cash-flows, firms might conclude that the MA qualifying conditions are no longer met. For example, following an increase in life expectancy under a longevity stress the portfolio will contain insufficient assets to meet the additional long-dated liability payments that are now expected to be made. Firms should carefully consider all of the matching adjustment requirements, for example using the processes specified in their MA applications, and verify which would, or would not, continue to be met.

Assuming that the conclusion from step 3 is that the qualifying conditions would no longer be met, firms would need to determine the actions required to re-establish a qualifying portfolio and the cost of doing so. For example, additional assets might need to be inserted into the MA portfolio for a number of reasons, including in order to:

- deliver additional risk-adjusted cash-flows following the downgrade of some assets and/or a change in expectations for the probability of default, and consequent reduction in the default-adjusted cash-flows of those assets; or
- meet new expected long-term cash-flows following a longevity stress.

In either case, firms should also consider whether, under the range of scenarios in their internal models, they would be able to source additional assets of at least the same, or equivalent,

credit risk characteristics as the existing assets. Firms should consider whether, under extreme conditions and within the year of consideration in the internal model, they might be forced to buy assets that are more liquid and/or of higher credit quality than existing assets, particularly if their portfolios contain large exposure to illiquid and/or untraded assets. As a result, firms should not simply assume that they could maintain the pre-stress risk characteristics of their asset portfolios, i.e. they should not simply scale up their existing credit portfolios to deliver the additional cash-flows required without investigating and justifying the plausibility of this assumption.

Using the outputs from steps 1 to 4 above, it should then be straightforward to perform a re-valuation of the liabilities. In doing this, firms should carefully consider and justify the mapping of assets, particularly those that are non-traditional or non-rated, to fundamental spread categories. There was little evidence of such consideration in the submissions the PRA has seen to date. Firms should consider whether the approach taken for determining the mapping in order to value technical provisions remains appropriate in stressed conditions. Firms may find it useful to apply some high-level "sense checks", such as verifying that matching adjustment expressed as a percentage of spread is consistent with their own view of the inherent level of credit risk for such assets.

Appendix 2

Quantitative framework the PRA will use as part of its assessment of internal model applications

This Appendix should be read alongside Appendices 1 and 3.

The PRA's decision-making process is built around assessing the Solvency II tests and standards (T&S), building from a granular assessment of each of the criteria into broader requirement categories (e.g. documentation) through to a final approval or rejection decision. As part of this overall assessment the PRA will use its risk-based approach to supervision to focus additional scrutiny on a firm-by-firm basis in those areas where we have reason to believe that the firm may not be meeting the T&S. In this assessment process we use a series of indicators to determine the focus of review scrutiny; these are both qualitative (e.g. a view on the embedding of the model from previous supervisory engagement) and quantitative.

In this Appendix we focus on the T&S related to the calibration standard of Solvency II, and the quantitative analyses that the PRA intends to use to verify the calibration of firms' internal models. The calibration standard, which is based in Articles 101 and 122 of the Solvency II Directive, is one of the requirement categories which underpin our model approval decisions. An assessment of these requirements is geared towards ensuring that the Solvency Capital Requirement (SCR) produced by the model corresponds to the standard set out in Article 101.

Specifically, we want to highlight:

- how the PRA will use quantitative analyses as part of model approval;
- how the PRA has developed its quantitative framework for model assessment; and
- how the quantitative framework will help the PRA's decision making.

In order to give further insight into the development of this framework we also provide more specific details on the development of our quantitative indicators (QI) for longevity and credit risks and dependency.

How the PRA will use quantitative analysis as part of model approval

The PRA will use a quantitative framework as:

- a diagnostic tool to help assess model rigour and capital adequacy and hence highlight areas of potential concern;
- a prioritisation tool, to help inform where review teams should direct their attention, e.g. by identifying risks or correlations which may be under-calibrated; and
- one contributor to decision making as to whether a firm has met the T&S, and therefore whether its model should be approved.

Internal models are required to be calibrated to the standard specified in Article 101 of the Solvency II Directive. Where risks are homogeneous, a PRA quantitative assessment of the calibration of individual risks and their dependency structures can give an efficient diagnosis of whether there are areas of potential concern where the model has not been calibrated adequately

to meet the Directive requirements. Where the risks are largely (but not totally) homogeneous, the PRA will tailor its quantitative assessments to reflect a firm's specific risk profile.

Quantitative tools are important in helping review teams prioritise areas for early review where firms may have under-calibrated their risks or correlations. The PRA will want to prioritise areas for review where firms appear to have been imprudent in their assumptions. The QIs will not determine in themselves whether the T&S have been satisfied. For example, it may be that a risk that is calibrated strongly compared to our indicators should in fact be calibrated even more strongly given a firm's specific exposures.

Finally, the outputs of this quantitative analysis will constitute one of the many indicators that will be taken into account by the PRA when determining whether the PRA is satisfied that the model meets the T&S. Specifically, our quantitative analysis will help in verifying that the calibration standard in Article 101 has been met.

As is apparent from the description above, the operation of the quantitative framework proposed will not yield a mechanistic 'pass / fail' decision. Model approval will not hinge on meeting any particular quantitative criterion other than the T&S. It must also be emphasised that the use of the tools underlying our quantitative framework will always be tailored having regard to a firm's own risk profile.

The following examples may provide some clarity as to how this would work in practice:

- A positive outcome of this quantitative assessment, together with sufficient assurance around the governance used in assumption setting, strong evidence of validation and documentation of limitations could support a higher level of review of a firm's justification for its assumptions concerning a particular risk or correlation;
- A negative outcome of this quantitative assessment would engage a more in-depth review of the firm's justification for its assumptions (which could reveal that the firm's calibration is appropriate given its specific risk profile). A negative outcome of this quantitative assessment, together with a poorly explained justification and rationale for the firm's assumptions and unconvincing validation of those assumptions having regard to the firm's risk profile, would likely lead to a rejection of the model.

How the PRA has developed its quantitative framework

The PRA has tailored the quantitative framework for model reviews to best fit its intended use, as specified above. In particular, we have paid particular care to the following areas:

- **use in homogeneous risks assessments**. Many of the risks that life firms are exposed to are reasonably homogeneous (e.g. exposure to a well-diversified portfolio of equity investments). Where this is the case, it is useful to employ a homogeneous quantitative assessment as part of our evaluation of the model. This quantitative assessment will comprise both comparisons against generally accepted market practice as well as comparison against QIs which we believe are representative of models likely to meet the calibration standard. In particular, life insurance exposures are comparatively more homogeneous than general insurance exposures and hence the use of QIs in our framework is much more common when reviewing life firms' models.

Where risks are not homogenous we will not use this framework as part of our assessment;

- **alignment to firm's risk profile**. Our use of the quantitative framework will ensure that any cross-firm comparisons are made with firms that have similar risk profiles. Likewise, when compared against the QIs mentioned in the previous paragraph, we will tailor the assessment to reflect firms' respective risk profile; and
- **alignment to Solvency II requirements**. We have ensured that the development of our QIs reflects the requirements of Solvency II (e.g. such as using a consistent definition of the risk-free rate).

In order to develop the QIs mentioned above, the PRA has relied on multiple sources including reviews of academic and industry literature and input from wider industry participants (e.g. consultants),as well as the PRA's own analysis and expertise. Moreover the QIs have benefited from the PRA's oversight of industry methodologies and calibrations as part of its experience of model reviews. We have also leveraged the knowledge and expertise of the wider Bank of England.

The PRA is mindful of the dangers that a poorly applied framework could entail, such as herding of assumptions in models and concomitant financial stability implications. For these reasons we have decided not to disclose externally the precise quantum of our indicators. In order to provide more clarity on the underpinnings of our approach, this Appendix provides specific details on how we have derived the indicators for three important areas (longevity risk, diversification and credit risk).

As noted above, the PRA has also taken great care to ensure that the framework is applied in a way that is aligned with firms' risk profiles. In particular, when applying the QIs during model reviews we will take into account the fact that firms' models may use a different definition of risks, as well as reflect their specific exposures. Moreover the practical approach to implementation explicitly recognises that there is a range of reasonable judgements that can be made when modelling risks for capital purposes, which the PRA needs to consider when concluding whether it is satisfied that the T&S have been met. This underlines the importance of having a PRA view on risks, as discussed in more detail below.

How the quantitative framework will benefit the PRA's decision making

The PRA expects that its use of a quantitative framework for model reviews will result in:

- consistency and efficiency in PRA judgements;
- increased effectiveness in assessing firms' justifications and in applying an appropriate level of challenge; and
- improved assessment of compliance with the calibration standard of Solvency II.

The PRA must use its resources in the most efficient and economic way, and must make consistent judgements. We believe that the use of this quantitative framework as part of model assessments will ensure that similar risks are assessed consistently across firms, and will result in an efficient approach to model reviews.

The process of developing a series of QIs inevitably involves the identification of important judgements and assumptions which must be made as part of model development (for example, what are the best datasets to use, at least as a starting point, to derive parameters for the model). Assessing a firm as weak against those indicators can be followed through to consideration of the

judgements that a firm made when building its model. The PRA will then be able to highlight and discuss with firms the critical assumptions that they either made or have missed. In this way indicators underpin the use of the quantitative framework as a diagnostic tool and enable a deeper understanding of the model covering other relevant T&S, such as those relating to justification of assumptions.

The use of QIs will help the PRA to assess firms' calibrations against the standard set out in Article 101 of the Solvency II Directive. As set out above, this will be based on our being satisfied that the quantitative framework is sufficiently relevant to the firm in question, and complemented with other tools to form an overall supervisory view of compliance with the T&S. Whereas the use of peer comparisons results in a relative assessment of firms' models, the PRA intends to supplement such an assessment with a rigorous consideration as to whether the calibration of a model is indeed consistent with the standard of Article 101 (as opposed to, for example, consistent with peer group firms' interpretation of that standard).

In summary: model approval decisions will be entirely based upon the T&S. Our quantitative framework will be used to help inform our judgements and decisions on whether or not a firm has satisfied the T&S. The Solvency II Directive emphasises the role of supervisory judgement, and we consider that the use of the quantitative framework as described here will support efficient model assessments and decision making.

Technical overview of our longevity risk quantitative indicators

How longevity features in firms' Solvency II balance sheets

Internal models must capture longevity risk where a firm is exposed to such risk. In developing its quantitative indicator, the PRA has defined longevity risk as the risk that policyholders or pension scheme members, in aggregate, live longer than expected. The main life insurance products exposed to this risk are immediate and deferred annuities although there will be some exposure to longevity risk in an insurer's own pension scheme (if defined benefit), in respect of certain health contracts and possibly within with-profits funds. There is also growing exposure in the general insurance periodic payments space.

As there is not currently a deep and liquid market for longevity risk, firms are required to derive their longevity assumptions from first principles for two purposes:

- the valuation assumption: to value their annuity (and other longevity-dependent) liabilities; and
- the capital assumption: to quantify the level of capital that has to be held to cover longevity risk.

Decomposition of longevity risk into component parts

The PRA considers that longevity risk includes at least two sub-risks which effectively mirror the main components of the valuation assumption; namely, base mis-estimation risk and future improvement risk:

- **base mis-estimation risk** represents the risk that the actual current mortality experience differs from the assumption about current mortality rates used in the best estimate assumption; and

- **future improvement (or trend) risk** represents the risk that future improvements differ from future improvements assumed in the best estimate assumption.

In terms of risk decomposition, we note that most firms have used this broad split of longevity risk although some firms include more risks under the longevity risk banner than the PRA has done (e.g. other risks such as proportion married risk are included) or define the risks slightly differently.

Determining the sub-components of longevity risk for which a quantitative indicator is appropriate

Although the concept of setting and potentially mis-estimating the current level of mortality is well-understood, quantifications are likely to vary markedly by firm due to the heterogeneity of exposure. For this reason the PRA decided not to develop a QI for base mis-estimation risk.

The allowance for future improvements in mortality tends to be less heterogeneous across firms. We therefore consider it is appropriate to derive a QI for future improvement risk in both valuation and capital assumptions.

Modelling time-horizon

Under Solvency II, the SCR is the value-at-risk of basic own funds subject to a confidence level of 99.5% over a one-year period. However, for internal models, the risk measure or time period used may be different from this provided it can be demonstrated that the outputs of the internal model can be used to calculate the SCR in a manner that provides an equivalent level of policyholder protection.

Whilst some firms have opted to model longevity risk over a time period that is greater than one year, for the purposes of setting its QIs the PRA has modelled longevity risk directly over a one year time horizon.

For the direct one-year approach the PRA has modelled future improvement risk by considering how much the best estimate future improvement assumptions could change over one-year. This has been split into data-driven changes in the best estimate assumptions ('data risk' i.e. the impact of introducing an additional year of mortality data) and event-driven changes ('event risk' i.e. the impact of new information emerging that is not contained in the data).

Construction of the quantitative indicators for future improvements

The QIs for future improvements have been developed using the following steps:

- **step 1:** We modelled future improvement risk using ONS data. The specific choices of data period and age-range used are supported by a desire to focus on data of sufficient credibility and relevance to annuity business;
- **step 2**: We selected one model from each of four commonly used families of stochastic longevity risk models for investigation (i.e. four models in total). These models are all industry-recognised and have been subject to extensive industry challenge. None of the models are "cause of death" models due to their greater complexity, data requirements and the need for a greater level of expert judgement to be exercised. In particular we were concerned that the correlations between causes of death were not easily measured and would not be stable over time;
- **step 3**: We ran the selected models to obtain the valuation assumption (taken to be the 50th percentile output). We also made an expert judgement that the future

improvements would reduce to NIL between the highest age modelled and age 100. The range of valuation assumptions implied by the different models was wide and so we used expert judgement to derive a reasonable range for the best estimate. This was informed by the assumptions firms are currently making and judgements we had made around the expected shape of future longevity improvements;

- **step 4**: We split the modelling of future improvement risk into data risk and event risk;
- **step 5**: Data risk was modelled by simulating an additional one-year's worth of longevity data and re-fitting the models. We repeated this a number of times and then selected the empirical 99.5th percentile change in the 50th percentile simulation as a result of the additional year's data. All models gave similar calibrations for this risk;
- **step 6**: There is no statistically robust method for calibrating event risk. We have therefore done this by looking at the variation in the valuation assumptions implied by each of the models (Step 3 above). We consider a change in model to be a good proxy for this risk as we consider that a 1 in 200 longevity risk event is likely to lead firms to change their modelling approaches. Our allowance for this risk is material;
- **step 7**: The strength of the calibration obtained was validated by comparing the resulting calibration to the results in published papers on longevity risk modelling, other published projections and the impact of historic events (most notably the introduction of the cohort improvement factors); and
- **step 8**: A full pdf was derived by fitting a lognormal distribution to the 50th percentile from step 3 and the 99.5th percentile from applying steps 5 and 6.

Technical overview of our dependency quantitative indicators

How diversification effects feature in a firm's internal model SCR

Internal models must capture all of the material risks to which insurance firms are exposed. While those risks may be inter-related, it is recognised that an extreme event affecting one risk will not always simultaneously coincide with extreme events affecting other risks. This absence of automatic coincidence gives rise to diversification effects. More precisely, the Solvency II Directive defines diversification effects in Article 13(37) as:

> *"The reduction in the risk exposure of insurance and reinsurance undertakings and groups related to the diversification of their business, resulting from the fact that the adverse outcome from one risk can be offset by a more favourable outcome from another risk, where those risks are not fully correlated."*

Diversification refers to the concept that incidences of different risks are generally partly or fully unconnected with each other and the financial impact of this can be modelled using a dependency structure that captures the extent to which different risks are correlated with each other. In general we expect models to specify both the individual distributions of risks as well as their dependency relationship. The dependency relationship may be imposed (for example, set as a parameterised copula) or set structurally (for example, captured in the equations that drive the output of a scenario generator).

Developing quantitative indicators for dependency

The PRA has based its QIs for dependency on the analysis of the dependency relations between standardised risk categories. These correspond to the most common homogeneous risks that life

insurance firms are exposed to. As for all of the QIs, we will consider any specificities of a given firm's risk profile or risk definitions that might call for tailoring of the QIs.

In developing our QIs in this area, we have considered various market and other publicly available information, but have focused on our own technical analysis based on our investigation of relevant historic data (where available) as well as our application of judgement as described below. We have also considered the calibration views of firms and other parties, particularly as part of our internal validation and challenge process.

We have developed our QIs on the basis of a simple dependency structure based on the use of a Gaussian copula parameterised via the analysis of correlations between risks. This matches the approach adopted by many firms. As noted earlier in this paper, these QIs will be adjusted where firms' risk definitions or underlying dependency structure are different from the ones we have used. Our approach should not be seen as an endorsement of any particular methodology; in fact the extensive modelling freedom afforded by Solvency II allows the choice of simple models of dependency provided that appropriate adjustments are made such that the ultimate capital requirement corresponds to the standard set out in Article 101 of the Solvency II Directive.

As an example, we have made adjustments for certain risk pairs where the relationship between variables is more complex than that allowed for by a symmetric copula (for example, where this relationship may depend on whether one variable is taking on positive or negative values; or alternatively, where the relation between the variables may depend on which is the cause and which the effect). These cases can arise, for example, when considering dependencies relating to interest rates. Rather than break away from the simple correlation framework, we have allowed for these situations by developing different QIs that depend on a firm's risk profile. In other words, the QIs will be different for firms exposed to different directions of interest rate movement in order to reflect the fact that (if using a Gaussian copula) each firm would be expected to have a different appropriate dependency allowance so as to arrive at a 1:200 capital requirement.

It is worth reiterating in this example that firms may of course choose a more sophisticated way of modelling these dependencies than a relatively simple Gaussian copula. More sophisticated approaches may benefit from less need for adjustments, albeit in some cases at the expense of greater opacity. All models are ultimately simplifications of reality and, beyond making appropriate adjustments in order to ensure that the resulting capital requirement meets the 1:200 standard, we would look for assurance that a firm understands the particular limitations of its simplification, the materiality of such a simplification and that it has in place a monitoring mechanism that will identify when any adjustments that are made to take account of such simplification will cease to be effective.

Additionally, we have given consideration, when setting the QI for each risk pair, to the potential need for an adjustment to reflect the reduced diversification that may occur in times of stress. For example, where data analysis is used in the QI derivation, the QI calibration is generally stronger than would simply be obtained by calculating the mathematical rank correlation between two historical data series. Our overall data analysis has involved considering the results of a number of statistical tools such as time series plots, scatter plots, rolling correlations over the data period, historic correlation, confidence intervals, goodness of fit tests and the coefficient of finite tail dependence observed in the data.

Finally, it is important to note that we have applied judgement to derive appropriate QIs between all risk pairs, but particularly for those pairs involving non-market risks, where relevant data is scarce or absent. In applying our judgement we have sought to identify not just direct links, but also non-intuitive links and common drivers between variables. This is because it is well known that correlation is not equivalent to causation, and that in fact correlations between variables can be counterintuitive. In particular variables that might superficially appear to be independent (because neither directly causes the other) can in fact be related by common drivers that result in a non-zero correlation between them even in the absence of a direct causal link. These common drivers are often hard to identify, especially in benign conditions; the role of judgement in this area is to consider all of the routes by which changes in one variable could be reflective of conditions that might affect the other variable.

Technical overview of our credit risk quantitative indicators

Life firms' exposure to credit risk in their Solvency II balance sheets

Life insurance companies invest in a range of assets whose market value reflects the likelihood of the asset owner receiving the contractual payments in full and on time; we refer to such assets as "credit risky assets". In the context of Solvency II SCR calculations, life insurers need to consider two sources of exposure to credit risky assets:

- **Asset side credit risk**: the risk of changes in the market value of credit risky assets; and
- **Liability side credit risk**: the risk of changes in the discount rate used to value annuity liabilities by those firms that have received permission to apply a matching adjustment.

Developing QIs for asset side credit risk

Within the universe of all credit risky assets, corporate bonds constitute the largest single asset class to which life insurers are exposed and the PRA has developed QIs to assist in its reviews of firms' models of these assets. The PRA's construction and application of its corporate bond credit spread QIs reflect the following considerations:

- firms generally model the change in corporate bond prices via changes in corporate bond spreads; the PRA's QIs reflect the same structure;
- the PRA credit spread QIs are formulated as absolute changes to credit spreads, expressed in basis points that apply through-the-cycle;
- the PRA has relied mainly on GBP denominated bond data series covering approximately the last two decades in building its QI. The PRA considers this data to be most relevant to current market conditions and typical asset exposures;
- the PRA is aware that certain corporate bond option-adjusted spread index data series have been reviewed by the data provider and the individual bond spreads (although not the index spreads) restated due to the assumptions about bond call dates proving incorrect during 2008-2009. The PRA has adjusted its use of those data accordingly, primarily resulting in a reduction of the most extreme levels of spreads observed for certain short-dated bond series;
- the PRA considers that credit spread changes of corporate bonds depend on the outstanding term to maturity, i.e. that there is evidence for a term structure of spread changes;

- the PRA's approach to asset side credit risk allows for a structure whereby the spreads of shorter-dated bonds increase more under stress (in absolute terms) than for longer-dated bonds. The spreads of lower-rated bonds increase more than for higher-rated bonds;
- some market commentators consider that the spread widening seen during 2008-2009 was largely driven by liquidity factors, without an accompanying increase in realised defaults. In setting its spread QIs, the PRA has considered whether a future default-driven credit crisis might therefore result in spread levels higher than at that time, driven by a combination of increased default and liquidity risk premia; and
- in finalising its spread QIs, the PRA has applied expert judgement to the raw results of its analysis to ensure that the final QIs make economic sense and do not unduly reflect any less credible features of the calibration data. One such consideration was the implied percentage change in bond prices, comparing against the changes expected for other asset classes, both more- and less-risky.

When reviewing firms' modelling approaches for other credit risky assets, the PRA has not developed specific QIs, but does apply the general principles and logic that underpin the corporate bond QIs as a starting point.

Developing QIs for liability side credit risk

Where firms assume that the value of their liabilities in stress scenarios would benefit from use of a MA, they would need to consider both whether they would continue to qualify for MA and what might be the MA that would apply. On the former point, the PRA expects firms to verify that their portfolios still qualify for MA and to consider all risks that arise in respect of the use of the MA. On the latter point, the PRA does not consider that it would be appropriate simply to re-calculate the fundamental spreads using the methods and assumptions prescribed by EIOPA for the purposes of calculating technical provisions in the base balance sheet (see Appendix 1 and 3) and has developed QIs accordingly.

The PRA's QI can be expressed as the maximum proportion of any modelled increase in spreads that should be assumed to reflect an increase in MA. The PRA considers that "matching adjustment or fundamental spread, expressed as a percentage of spread" is a useful metric to enable comparisons between firms, noting that this presentation is the same approach followed by the standard formula. The level of the PRA's QI has been set after consideration of previous historical extreme default and extreme spread experience, published literature on the subject of credit spread decomposition and industry thinking, and has drawn upon knowledge and expertise from across the Bank of England. The PRA recognises in the application of its QI that there is scope for a justifiable dispersion of judgements in this area. As a firm's calibration of credit risk weakens against our QI the intensity of supervisory scrutiny that the T&S have been met can be expected to increase correspondingly.

Appendix 3

Solvency II: Matching adjustment

The issues discussed in this appendix relate to the implementation approach and the types of justification we expect firms to consider and put forward as part of their applications.

Although we are giving this feedback in advance of the completion of the matching adjustment (MA) pre-application exercise, the choice of the issues should not be taken as an indication that these are the most material the PRA has observed. Rather, the PRA believes that in releasing this information now, it will assist firms to improve their final MA applications.

Screening for ineligible features within asset holdings

The PRA expects firms to have a robust screening process in place to identify those asset features that could affect MA eligibility; in particular, the fixity of cash flows (considering pairs or groups of assets together where relevant) and any options for the issuer or third parties. For non-traded assets, firms should review the relevant terms and conditions or prospectuses. For traded assets, where reliance is being placed on third-party data providers, firms should perform some validation checks; for example, by comparing against another set of external data, or by examining a random sample of prospectuses. The MA eligibility requirements should be clearly reflected in the investment mandates for MA portfolios and the screening processes should be automatically applied when the firm is considering new asset purchases. We expect firms to evidence these governance processes within their final applications. We do not expect firms submit validation test results or underlying asset prospectus data as part of the application.

Assessment of the adequacy of make-whole clauses

In the Executive Director's letter on MA of 15 October 2014, it was stated that in assessing the impact of make-whole clauses on their assets firms should ensure that there is no more than negligible risk of modified Spens clauses not providing sufficient compensation if the borrower exercises the pre-payment option in the future. Firms have generally addressed PRA feedback by setting a maximum level of make-whole spread such that any assets with make-whole spreads in excess of this would be ineligible. The PRA considers this to be a sensible approach in principle.

However, in their pre-applications, firms used different approaches to calibrate the maximal spreads. In the PRA's view, scenario testing would provide a useful sense-check as well as a means of ensuring a consistent standard is applied across firms. For example, the PRA would expect firms to investigate a scenario where spreads return to historically low levels over the period for which spread data is readily available and appropriate to the exposures in question and consider whether compensation would be sufficient in that case. Few firms appear to have explicitly considered such a scenario test in arriving at their maximum make-whole clauses.

Firms should also take into account the following:

- some firms are using index data in their analysis. While there is no requirement to replace cash flows using the 'average' bond which the index represents, equally firms should not rely on being able to replace cash flows with the cheapest bond in the index;

- in assessing whether sufficient replacement bonds are available to replace cash flows, firms should confirm that the replacement bonds under consideration would be MA-eligible;
- the maximum make-whole clauses should be kept under active review to ensure that any new purchases of bonds with prepayment options would provide adequate compensation; and
- firms should consider carefully the impact of extreme spread narrowing scenarios beyond those considered in setting their maximum make-whole spreads. These scenarios should also involve consideration of wide-scale upgrading of asset ratings. The risk of mass early redemptions in such scenarios should be explicitly considered in firms' own risk and solvency assessments (ORSAs), along with their plans to manage or mitigate the risk in these extreme scenarios.

Materiality of cash flow mis-matching

The PRA needs to adopt a consistent approach to assessing whether any mismatch gives rise to risks which are material in relation to the risks inherent in the insurance business to which the matching adjustment is intended to be applied. To that end, firms have been asked to provide cash flow and statistical information for each MA portfolio in their pre-application submissions, in the form of three specified 'tests'.

The specified tests were requested for the following objectives:

- to assess the extent to which firms may be forced sellers of assets to meet liability cash flows;
- to assess the materiality of mismatch in relation to interest rate, currency or inflation risks; and
- to assess whether firms are materially under-matched.

Following analysis of the information provided by firms, the PRA has revised the 'forced seller of assets' test (the updated tests are described in the Annex to this Appendix). The PRA has also calibrated a set of indicative thresholds for each test, which are aimed at identifying material mismatches. We would like firms to submit the results of the three tests with their application and to monitor compliance against the thresholds on a regular basis. Where a firm exceeds the threshold in any one of the tests, they should notify the PRA immediately. In this case, we would expect the firm to demonstrate how it continues to satisfy the eligibility criteria, in particular Article 77b(1)(c). If the eligibility criteria are no longer satisfied, the firm will need to put in place a plan to remediate the position within 2 months, as required under Article 77b(2).

The PRA would like firms to submit details of their actual asset and liability cash flow projections (together with other relevant information) as part of their matching adjustment application to the PRA in order to validate the results of test 1 and carry out other cash flow tests that the PRA considers relevant.

The PRA also expects firms to explain how they have treated each asset (including reinsurance assets and derivatives) within the matching tests and in particular what reinvestment assumptions they have made (if any) in the cash flows presented. Where firms have assumed future management actions, they should present their cash flow tests with and without these future management actions.

Firms are required to satisfy the eligibility criteria from 1/1/2016. While firms do not have to satisfy the thresholds at the date of application, they are expected to submit the information requested above at that time, along with a credible plan as to how they will achieve compliance before 1/1/2016.

Eligibility of paired/grouped assets

The PRA's review of pre-application submissions shows that firms have not always undertaken a full assessment of the eligibility of paired derivative assets - for example, identifying whether these have break clauses. The PRA considers break clauses to be analogous to termination clauses under reinsurance contracts, and would expect firms to consider these clauses carefully. If break clauses are considered to give the counterparty an option to change the cash flows, the terms should provide sufficient compensation to replace these cash flows.

Treatment of paired/grouped assets in the assessment of matching and MA calculation

The PRA expects firms to explain carefully and justify the method by which pairing/grouping arrangements have been reflected in the assessment of matching and calculation of the MA. For example, firms should explain whether all the individual elements of the arrangement have been de-risked and mapped to fundamental spreads separately, or whether instead the combined asset has been de-risked and mapped onto a single fundamental spread.

Appropriate level of rebalancing assets in the MA portfolio

The PRA expects firms to demonstrate that the governance and controls around investment management, including the investment strategy and the discretion given to investment managers, ensures that any rebalancing of assets within MA portfolios is strictly for the purposes of good risk management.

The following highlights some good practices that were observed in the pre-application submissions.

Investment strategy

The investment strategy is drafted to reflect a buy and hold strategy with limited discretion to trade. This investment strategy is described in detail and includes:

- The target asset allocation by broad asset class;
- the extent to which each broad asset class is being held primarily on a buy-and-hold basis (e.g. long-term illiquid assets) or as a short/medium term position to maintain the matching position/level of aggregate risk (e.g. derivatives);
- appropriate limits within the investment management agreement on the turnover of the fund in the normal course of events; and
- adequate governance arrangements, appropriate to the firm's size and investment strategies that apply to any changes to the investment strategy and policy or to any trades that go beyond discretion granted to investment managers.

Discretion given to the investment managers

The investment agreement and mandates clearly set out levels of discretion available to the investment managers and include:

- the average credit quality for the various asset classes by term bucket;
- key features required or not allowed for each of the classes (e.g. no bonds allowing early repayment without adequate spens clauses);
- the target duration by term bucket and target cash-flow profiles;
- concentration limits by sector and counterparty;
- levels of turnover at sufficiently granular levels, categorised by reason for trading;
- tolerances for deviations from the above targets;
- permitted use of derivatives ;
- requirements on the receipt and provision of collateral in respect of derivatives within the MA portfolio (e.g. credit quality, strength of collateral agreements, etc.);
- restrictions on the use of gearing (e.g. investing cash collateral received into bonds);
- any other permitted activities and limits on them (e.g. stock-lending);
- frequency at which management information is provided;
- management information on a trade-by-trade basis:
    - the reason for the trading (e.g. changes to target cash flow profiles, maintaining risks within limits, consistency with investment policy etc). This could be on a set of grouped trades (e.g. bonds and derivatives) where necessary;
    - a reconciliation of assets purchased/transferred in against the eligibility criteria for assets within the matching portfolio;
- management information on a regular basis:
    - summary of the trade-by-trade information; and
    - a reconciliation with the limits within the investment mandate (covered above).

Annex to Appendix 3

Updated cash flow tests

Test 1: Discounted Accumulated Cash-flow Shortfall Test

Firms should monitor this test on a regular basis (monthly if they are writing new business in the fund and quarterly otherwise). Firms are encouraged to:

- project best estimate liability cash flows in the MA portfolio at annual intervals;
- project cash flows from assets in component A, after being adjusted for that part of the fundamental spread that corresponds to the probability of default, at annual intervals;
- any cash flow surpluses and shortfalls arising in the year should be calculated and accumulated at the risk free rate;
- firms should note the highest accumulated shortfall from all future years in the projection; and
- firms should calculate the present value of liabilities in the MA portfolio (at the valuation date) discounted at the risk free rate

Threshold rate: The maximum accumulated shortfall in any year of the projection should not exceed **3%** of the present value of liabilities.

Test 2: 99.5th Percentile Value at Risk (VaR) Test

This includes:

- firms should carry out this test on a regular basis (at least quarterly in line with SCR calculations);
- firms should calculate the 99.5th percentile 1-year value at risk (VaR) of the MA portfolio for each of interest rate, inflation and currency risks;
- the calculations should consider the change in the value of both the assets and the liabilities within the portfolio as a result of each stress;
- the PRA wishes firms to calculate undiversified capital requirements corresponding to a confidence level of 99.5% over a 1 year period for each of the risks specified in the first bullet point above. Where firms split a risk into components (such as might be the case for interest rate and currency risk), the PRA asks firms to aggregate these components into a single capital number for that risk, and to explain the approach adopted in determining this single number;
- the PRA is also asking firms to set out the best estimate liabilities of the MA portfolio, calculated by discounting at a rate equal to the relevant basic risk-free interest rate plus the MA;
- firms should then compute 6 statistics: the undiversified 99.5th percentile 1 year VaR capital requirement for the MA portfolio for each of interest rate, inflation and currency risks, and the result of dividing each of these capital requirements by the best estimate liabilities of the MA portfolio;
- for the purposes of this calculation, the assets to be included are those hypothecated to components A and B, i.e. those that are required to cover the best estimate value of the liabilities; and

- threshold Rate: the undiversified 99.5th percentile 1 year VaR capital requirement should not exceed **1%** of the firm's calculated Best estimate liabilities for any of the three risks.

Test 3: Notional Swap Test

This includes:

- firms should carry out this test on a regular basis (at least quarterly in line with SCR calculations;
- the aim of this test is to establish by how much the MA would change if the firm were able to eliminate any surplus or shortfall in its net (asset less liability) cash flows by investing in a 'notional swap' which emulates a perfectly matched position;
- firms are asked to set out:
    - the notional MA calculated by using the assets hypothecated to component A only (i.e. firms should state the amount of MA in bps);
    - the notional MA calculated by scaling the market value and cash flows (after being adjusted for that part of the fundamental spread that corresponds to the probability of default) of the assets in component A either up or down by a single factor until the present value of the future surpluses and shortfalls is zero when discounted at the basic risk-free interest rate (this is what is referred to as the 'notional swap approach' mentioned in Paul Fisher's letter to the industry of 15th October 2014); and
    - the market value of the assets in component A after they have been scaled in accordance with the above.
- the frequency of the time intervals used for the cash flows in this calculation should be consistent with how the firm conducts its matching.

Threshold Rate – There would be no specific hurdle rate set for this test but we would expect firms to explain where the scaling factor as calculated above showed a ratio above 100% or below 99%.