

**CEIOPS' Advice for
Level 2 Implementing Measures on
Solvency II:**

**SCR standard formula - Article 111 j, k
Undertaking-specific parameters**

(former Consultation Paper 75)

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1. Introduction

- 1.1. In its letter of 19 July 2007, the European Commission requested CEIOPS to provide final, fully consulted advice on Level 2 implementing measures by October 2009 and recommended CEIOPS to develop Level 3 guidance on certain areas to foster supervisory convergence. On 12 June 2009 the European Commission sent a letter with further guidance regarding the Solvency II project, including the list of implementing measures and timetable until implementation.¹
- 1.2. Pursuant to Article 104(7) and subject to approval by the supervisory authorities, insurance and reinsurance undertakings may, within the design of the standard formula, replace a subset of the standard formula parameters by parameters specific to the undertaking concerned when calculating the life, non-life and health underwriting risk modules.
- 1.3. Pursuant to Article 110, where it is inappropriate to calculate the Solvency Capital Requirement in accordance with the standard formula, because the risk profile of the insurance and reinsurance undertakings concerned deviates significantly from the assumptions underlying the standard formula calculation, the supervisory authorities may, by a decision stating the reasons, require the undertakings concerned to replace a subset of the parameters used in the standard formula calculation by parameters specific to those undertakings when calculating the life, non-life and health underwriting risk modules.
- 1.4. This Paper provides advice with regard to:
 - the subset of standard parameters in the life, non-life and health underwriting risk modules that may be replaced by undertaking-specific parameters,
 - the standardised methods to be used by an insurance or reinsurance undertaking to calculate those undertaking-specific parameters, and
 - the criteria to be met by undertakings in order for supervisory approval to be given, including the criteria with respect to the completeness, accuracy and appropriateness of the data.
- 1.5. The above stated aims of this paper are consistent with Articles 111(1) (j) and (k) of the Level 1 text.²
- 1.6. The advice should be read in conjunction with:
 - CEIOPS-DOC-37/09 Technical Provisions – Article 86 f Standards for Data Quality (former CP 43).

¹ See <http://www.ceiops.eu/content/view/5/5/>

² Directive 2009/138/EC of the European Parliament and of the Council of 25 November 2009 on the taking-up and pursuit of the business of Insurance and Reinsurance (Solvency II), Official Journal, L 335, 17 December 2009, <http://eur-lex.europa.eu/JOHtml.do?uri=OJ%3AL%3A2009%3A335%3ASOM%3AEN%3AHTML>

- CEIOPS-DOC-41/09 Standard Formula SCR Non-Life underwriting risk (former CP 48)
 - CEIOPS-DOC-42/09 Standard Formula SCR Life underwriting risk (former CP 49)
 - CEIOPS-DOC-43/09 Standard Formula SCR Health underwriting risk (former CP 50)
- 1.7. The term “undertaking” relates to both insurance and reinsurance undertaking, “LoB” refers to line of business and USP stands for undertaking-specific parameter(s).

2. Extract from Level 1 text

2.1 Legal basis for implementing measure

Article 111 – Implementing measures

1. In order to ensure that the same treatment is applied to all insurance and reinsurance undertakings calculating the Solvency Capital Requirement on the basis of the standard formula, or to take account of market developments, the Commission shall adopt implementing measures laying down the following: [...]
 - j) the subset of standard parameters in the life, non-life and health underwriting risk modules that may be replaced by undertaking-specific parameters as set out in Article 104(7);
 - k) the standardised methods to be used by the insurance or reinsurance undertaking to calculate the undertaking-specific parameters referred to in point (j), and any criteria with respect to the completeness, accuracy, and appropriateness of the data used that must be met before supervisory approval is given;

2.2 Other relevant articles for providing background to the advice

Recital 20

In particular, this Directive should not be too burdensome for insurance undertakings that specialise in providing specific types of insurance or providing services to specific customer segments, and it should recognise that specialising in this way can be a valuable tool for efficiently and effectively managing risk. In order to achieve this objective, as well as the proper application of the proportionality principle, provision should also be made to specifically allow undertakings to use their own data to calibrate the parameters in the underwriting risk modules of the standard formula of the Solvency Capital Requirement.

Article 104 – Design of the Basic Solvency Capital Requirement

7. Subject to approval by the supervisory authorities, insurance and reinsurance undertakings may, within the design of the standard formula, replace a subset of its parameters by parameters specific to the undertaking concerned when calculating the life, non-life and health underwriting risk modules.

Such parameters shall be calibrated on the basis of the internal data of the undertaking concerned, or of data which is directly relevant for the operations of that undertaking using standardised methods.

When granting supervisory approval, supervisory authorities shall verify the completeness, accuracy and appropriateness of the data used.

Article 110 – Significant deviations from the assumptions underlying the standard formula calculation

Where it is inappropriate to calculate the Solvency Capital Requirement in accordance with the standard formula, as set out in Subsection 2, because the risk profile of the insurance and reinsurance undertakings concerned deviates significantly from the assumptions underlying the standard formula calculation, the supervisory authorities may, by a decision stating the reasons, require the undertakings concerned to replace a subset of the parameters used in the standard formula calculation by parameters specific to those undertakings when calculating the life, non-life and health underwriting risk modules, as set out in Article 104(7). Those specific parameters shall be calculated in such a way to ensure that the undertaking complies with Article 101(3).

3. Advice

3.1 Explanatory text

3.1.1. QIS4 response from the industry

3.1. In QIS4 participants were allowed to replace standard deviations in premium and reserve risk by undertaking-specific standard deviations³. Undertakings commented on issues relating to the choice, reliability and availability of suitable data to back entity-specific parameterisation in point 9.7.3.2 of "CEIOPS' Report on its fourth Quantitative Impact Study (QIS4) for Solvency II". The main industry comments were:

- Many undertakings commented on issues relating to the choice, reliability and availability of suitable data to back undertaking-specific parameterisation.
- Several comments were made on the length of time series available and appropriateness for use in entity-specific parameterisation. Relevance of data has to be balanced against the need to capture long-term trends – however, some respondents queried whether sufficient entity-specific data would be available to parameterise at a 99.5% confidence level.
- Some respondents argued for a minimum length of time series, although one comment was received to the effect that the requirement for a minimum of 7 years' data, to be taken for at least 3 years since the business was first written, results effectively in a minimum of 10 years before undertakings can apply entity-specific data – this was thought to be overly restrictive. A limit on the number of years' data that can be used in the standard formula context was, however, considered an incentive for use of entity-specific data. Among those arguing for a minimum length of time series, some argued that this minimum should be the same for all undertakings, to ensure consistency. One concern raised in this context was the influence of the underwriting cycle on entity-specific data. In the entity-specific parameterisations calculated for QIS4, there was some variation in the length of time series used, with the range stretching from 1 year to over 40 years of past data. Many respondents mentioned time series of around 5-10 years.
- The need for greater specification of criteria for assessment of data quality was raised. Again, it was argued that criteria should be consistent across all undertakings. It was thought that criteria should cover completeness, accuracy and appropriateness of data.
- Some respondents noted difficulties in obtaining data in a suitable format: there were several problems such as extraction of data on

³ See paragraphs TS.VI.F. in Technical Specifications QIS4, <http://www.ceiops.eu/content/view/118/124/>.

an accident year basis and obtaining data with the classification splits needed for QIS4. The treatment of outliers and catastrophes within data sets was also mentioned: this can have a material impact, and inclusion of a catastrophe within a data set could be considered to lead to double-counting of catastrophe risk. It was noted that any delay in reporting of claims can impact data for very long tailed business.

- It was suggested that there was a need for guidance on use of approximations; for example, reported or ultimate loss ratios as at 12 months development were used as a proxy for historical best estimate, but may lead to over- or under-estimation of loss ratio variability.
- There were several comments on validation and justification of data. Several respondents suggested that data could be taken from statutory accounting systems, and would therefore have been subject to audit and independent cross-check. However, there will be a need to clarify further the requirements for own data verification.

3.1.2. Previous advice

- 3.2. CEIOPS in "Answers to the European Commission on the Second Wave of Calls for Advice in the Framework of the Solvency II project"⁴ (October 2005) advised as follows:

10.149 To the extent practicable, the coefficients in a factor-based approach should permit a limited degree of using undertaking-specific information to take account of the divergence of the risk profiles of individual insurers. To ensure comparability of results, this procedure would have to be performed in a mechanical and non-discretionary way. Further actuarial analysis is required to determine possible approaches.

10.150 The level of premium risk might be reflected in the insurers' combined ratio (excluding the claims provisions run-off result). The choice of factors for premium risk should reflect both the absolute level of the combined ratio (i.e., the adequacy of premiums), as well as its volatility. The absolute level of the combined ratio would generally need to be estimated by using undertaking-specific data, in order to take account of the profitability of the individual insurers' business. To determine the volatility of the combined ratio, a mixture of undertaking-specific data and data which is set by supervisors might be used.

10.151 The level of reserve risk might be reflected in the claims provisions run-off results, assuming that the claims provisions are consistently valued in line with the general rules on the valuation of technical provisions within the solvency framework. Whereas it does not seem appropriate, within the context of the standard formula, to completely determine the mean value and the volatility of the run-off results using undertaking-specific data, the

⁴ See <http://www.ceiops.eu/content/view/493/18/#CP7>.

determination of the coefficients might use a mixture of undertaking-specific data and data which is set by supervisors to derive these parameters.

3.3. CEIOPS in "Advice to the European Commission in the Framework of the Solvency II project on Pillar I issues – further advice"⁵ advised:

5.280 In some markets, undertakings supported the more sophisticated version of the premium risk charge insofar as this allows for a more company-specific assessment of premium risk. They pointed out that the market-wide assumptions set in the 'placeholder approach' for premium risk would have several deficiencies:

- They could only imperfectly take into account the risk-reducing effect of the company-specific reinsurance program, especially in the case of non-proportional reinsurance; and*
- They would not adequately reflect the company-specific business mix. For example, an insurer writing private liability can be expected to have a significantly lower degree of volatility of its business than an insurer writing industrial liability insurance, although the same factor would be applied to these businesses under the 'placeholder approach.*

5.281 However, participants also pointed out that the technique used in this approach was purely retrospective, and questioned the credibility of the resulting estimates.

5.301 Disregarding the specific methodology tested in QIS2, CEIOPS recognises the merits of an approach to premium risk which permits undertaking-specific information to take account of the divergence of the risk profiles of individual insurers. Therefore, such a 'personalised' approach to premium risk should be developed for QIS3. To ensure comparability of results, this should be implemented in a 'mechanical' and non-discretionary formula.

5.302 Further work and careful analysis is needed to develop such a 'personalised' approach incorporating a suitable blend of undertaking specific and market data to ensure that the resulting capital charge is soundly based. There also need to be suitable safeguards to ensure that the undertaking specific historical data remains relevant to the business currently being written and the associated reinsurance programme.

5.303 Clearly, a simple, objective and reliable standardised formula (even when it takes company-specific data into account) will not always be able to fully capture the risk profile of each individual insurer. However, where an insurer can demonstrate that the uncertainty is significantly lower than that indicated by the standard formula, then it should be able to produce a partial internal model of appropriate sophistication for its premium risk.

⁵ See <http://www.ceiops.eu/content/view/493/18/#CP20>.

3.1.3. Undertaking-specific parameters

- 3.4. Article 104 of the Level 1 text specifies that undertakings may subject to approval by the supervisory authorities, within the design of the standard formula, replace a subset of its parameters by parameters specific to the undertaking concerned when calculating the life, non-life and health underwriting risk modules.
- 3.5. According to Article 110 of the Level 1 text, where it is inappropriate to calculate the Solvency Capital Requirement in accordance with the standard formula because the risk profile of the insurance and reinsurance undertakings concerned deviates significantly from the assumptions underlying the standard formula calculation, the supervisory authorities may, by a decision stating the reasons, require the undertakings concerned to replace a subset of the parameters used in the standard formula calculation with USP.
- 3.6. Where the risk profile of the undertaking deviates significantly from the assumptions underlying the standard formula SCR, the supervisory authority may require undertakings to comply with Article 101(3) through the application of:
- Undertaking specific tools such as undertaking-specific parameters or partial⁶/internal models,
 - or where the above are not applicable, through the application of supervisory tools, such as capital add-ons.
- 3.7. The imposition of a capital add-on is understood to be a last resort measure, in the sense that a capital add-on should only be imposed when other measures proportionate to the issue at stake are considered to be ineffective or inappropriate⁷.
- 3.8. When carrying out the calibration for the standard formula SCR parameters, CEIOPS has focused on developing an accurate and transparent calibration. Wherever possible, CEIOPS set out for each parameter the risks being assessed, the sources of data and the assumptions underlying the standard calibration. CEIOPS has also highlighted the risks which are not captured due to lack of relevance to the wider population or materiality for the average undertaking.
- 3.9. Undertakings shall consider such information and the appropriateness of the standard formula parameters compared to their specific risk profile.
- 3.10. Compared to partial internal models, where undertakings are required to meet the requirements set out by Articles 112 and 113, particularly the standards introduced by articles 120-126, undertakings wishing to apply for the use of undertaking-specific parameters shall only be required to

⁶ Some further clarifications regarding the use of partial internal model can be found in CEIOPS' Advice on Partial internal models (CEIOPS-DOC-61/09).

⁷ The decisions tree leading to the imposition of "risk profile" capital add-on is discussed in CEIOPS' Advice on Capital Add-On (see CEIOPS-DOC-49/09).

comply with the criteria set out by CEIOPS in section 3.1.3.3 as required by article 111 (k).

- 3.11. CEIOPS has received stakeholder proposals for the estimation of the non-life parameters. After careful consideration CEIOPS does not consider such proposals within the scope of the standard formula but more appropriate for consideration as partial internal models as they use other assumptions than standard formula or do not fulfil the conditions of standardised methods.
- 3.12. To achieve a level playing field, CEIOPS does not want to create a possibility to by-pass the approval process of a (partial) internal model. A high degree of freedom in the standardised methods to calculate USP would lead to an unjustified privilege in comparison with undertakings which use (partial) internal models. Such a vagueness is not in line with the Directive. Therefore CEIOPS is of the opinion that a standardised methodology cannot be limited to providing only general principles with which the methodology used by undertakings shall be consistent or outlines of the methods which can be adapted by undertakings. The substantial changes in the methods shall be classified as partial internal model subject to requirements from articles 112, 113 and 120-126.
- 3.13. Taking into account the modelling limitation, CEIOPS has chosen undertaking-specific parameters, for which the standardised methodology can be provided or methods used to calibrate the standard formula parameters can be adapted.
- 3.14. CEIOPS do not propose special provisions for health activities within Social Security systems. Social Security systems are particular to each country, not harmonised and as a result their impact differs accordingly. It is difficult to include such characteristics within the scope of the standard formula or undertaking-specific parameters, as the result would be a set of national parameters.

3.1.3.1 Subset of standard parameters that may be replaced by undertaking-specific parameters

- 3.15. CEIOPS has assessed the scope of USP and the risk modules which would be most benefited from the use of undertaking-specific parameters.
- 3.16. After careful consideration, CEIOPS has decided that the following subset of standard parameters in the life, non-life and health underwriting risk modules may be replaced by undertaking-specific parameters:
 - a) Non life premium and reserve risk parameters: standard deviation for premium risk $\sigma_{(\text{prem,LoB})}$ and standard deviation for reserve risk $\sigma_{(\text{res,LoB})}$, as defined in CEIOPS' advice on the SCR non-life underwriting risk module (CEIOPS-DOC-41/09).
 - b) NSLT health premium and reserve risk parameters: standard deviation for premium risk $\sigma_{(\text{prem,LoB})}$ and standard deviation for reserve risk

$\sigma_{(\text{res,LoB})}$, as defined in CEIOPS' advice on SCR health risk module (CEIOPS-DOC-43/09).

- c) SLT Health Revision Risk: replace a standard parameter of revision shock in the SLT Health Revision risk in CEIOPS' advice on CEIOPS' advice on SCR Health risk module (CEIOPS-DOC-43/09)
 - d) Revision Risk: replace a standard parameter of revision shock in the Revision risk in CEIOPS' advice on SCR life risk module (CEIOPS-DOC-42/09).
- 3.17. Undertaking-specific parameters may be used to replace different subset of parameters within the particular risk modules stated above.
- 3.18. For all other parameters undertakings shall use the values of standard formula parameters.
- 3.19. Calibration of the USP shall be carried out at least annually. According to Article 102(1) of the Level 1 text, insurance and reinsurance undertakings shall calculate the SCR at least once a year and report the result of that calculation to the supervisory authorities. If an insurance and reinsurance undertaking is on more frequent than annual reporting/monitoring, then frequency of calibration of the USP shall be the same as the frequency of SCR calculation.
- 3.20. The parameters in simplifications are not considered to be standard parameters. Solvency II was designed to provide risk sensitive but proportionate requirements. In this regard Solvency II provides for a range of methods that increase in terms of both risk-sensitivity and complexity for the calculation of the SCR:
- simplifications,
 - standard formula,
 - use of undertaking-specific parameters within the design of the standard formula,
 - partial internal models,
 - full internal models.

According to Article 109 of the Level 1 text, insurance and reinsurance undertakings may use a simplified calculation for a specific sub-module or risk module where the nature, scale and complexity of the risks they face justifies it and where it would be disproportionate to require all insurance and reinsurance undertakings to apply the standardised calculation. It therefore would not appear to be consistent with this hierarchy to allow undertaking specific parameters to be used in conjunction with a simplified method.

Additionally, an undertaking which uses the simplified calculation due to the nature or scale of the risks may not possess data which meet the criteria with respect to the completeness, accuracy, and appropriateness of the data concerning this risk.

- 3.21. The above mentioned hierarchy should not be understood as a reason for aligning requirements for undertaking-specific parameters and partial internal models. CEIOPS sees a clear border between them. Undertaking-specific parameters form part of standard formula, which means that assumptions are basically consistent with the assumptions of the standard formula. Standardized methods are provided by CEIOPS and requirements from articles 120-126 are not applicable. Therefore the alignment of the requirements is neither possible nor necessary.
- 3.22. The following sections provide advice regarding the supervisory approval process, criteria and the description of the standardised methods that undertakings shall follow when estimating the USP.

3.1.3.2 The supervisory approval process for USP

- 3.23. Should undertakings wish to replace all or a subset of the parameters specified in 3.15 by USP, they are required to ask for supervisory approval.
- 3.24. The approval process shall consist of the following:
- a) Undertakings shall demonstrate as best as possible, that the calibration of the standard formula parameters do not appropriately reflect their risk profile and that the use of USP leads to a more appropriate result:
 - Undertakings shall consider the Own Risk and Solvency Assessment (ORSA). The identification of where the SCR does not accurately reflect an undertaking's risks is required within the ORSA (Article 45(1) letter c) of the Level 1 text).
 - Undertakings shall meet the criteria and show the completeness, accuracy and appropriateness of the data used to calibrate the USP, including the use of any qualitative adjustment made as explained in section 3.1.3.3.
 - b) Supervisors shall be satisfied that USP are not being used to "cherry-pick" the areas which give the lowest SCR. Where USPs have only been used for some lines of business, undertakings shall explain why. The choice of the alternatives of the standardised methods shall also be justified regarding its assumptions, data relevance and the risk profile. The undertaking shall provide the results for at least two of the methods included below.
 - c) Supervisors shall be satisfied that the USP have been calibrated following the standardised methods laid down in this advice (section 3.1.3.5) and meets the following criteria:
 - the risks covered by the USP are conceptually the same as those covered by the standard formula parameters,
 - the underlying assumptions behind the standard formula parameters and behind undertaking-specific parameters are the same,

- the standard methodology provided should enable a robust and reliable estimation of the undertaking-specific parameters,
 - the data used to estimate such USP complies with the criteria set out in the advice (section 3.1.3.3).
- d) Where the supervisory authority requires supplementary information to make the assessment and verify the suitability of the USP, approval shall also be subject to the availability of such additional information.
- e) The supervisory authority should assess on the basis of the information supplied by the undertaking, whether the data and revised calibration are relevant to the undertaking and whether the data is sufficient to justify the revised calibration.
- f) Should supervisors require undertakings according to Article 110 to replace the subset of parameters specified above by USP, their decision shall state the reasons. The supervisor shall be required to:
- Explain as best as possible, why they consider the standard formula parameters inadequate,
 - Where the undertaking concerned is not able to comply with such decision, supervisory authorities shall provide alternative actions, in line with the Level 1 Text and relevant Level 2 implementing measures.
- 3.25. Having received approval from the supervisory authority, undertakings are not allowed to revert to standard formula parameters unless any non-compliance with the requirements stated above is observed and subject to approval of the supervisory authority. This is also applicable if there is a necessity to change the approved standardised method. The undertakings shall immediately inform the supervisory authority when they observe they no longer satisfy the requirements. The supervisory authority decides whether the compliance can be restored and the re approval process is sufficient measure or the revert to standard parameter is necessary.
- 3.26. At this stage, CEIOPS considers that it is not appropriate to prescribe a timeframe in which all supervisory authorities must grant their approval.
- 3.27. In absence of the explicit supervisory approval, undertakings are not allowed to use USP and shall calculate SCR with the standard formula parameters. Approval would only be effective when directly and explicitly confirmed to the undertaking by the supervisory authority.

3.1.3.3 Criteria with respect to the completeness, accuracy, and appropriateness of the data

- 3.28. The Level 1 text requires implementing measures to lay down the criteria for the completeness, accuracy, and appropriateness of the data used that must be met before supervisory approval is given. These criteria shall be met as part of the supervisory approval process.

- 3.29. Definitions of completeness, accuracy, and appropriateness of the data are provided in CEIOPS' Advice on Technical Provisions –Article 86 f Standards for Data Quality (CEIOPS-DOC-37/09, former CP 43).
- 3.30. For the purpose of this advice, data is considered to represent numerical values including those that have been subject to qualitative adjustments based on expert judgement⁸ and/or prior analysis and experience.
- 3.31. Undertakings are not allowed to rely solely on expert judgment, and with no reference to specific internal or external data. However CEIOPS is aware that the process may involve some use of expert judgement, for example when deciding on the tail development factor or final claims developments pattern. Where expert judgement is used, it shall be appropriately documented and explained as part of the standardised methodology, and the requirements at this respect shall apply (e.g. see CEIOPS-DOC-33/09).
- 3.32. Data used for the purpose of estimating USP shall comply with the following criteria:
- The data shall meet the standards laid down in CEIOPS' Advice on Data Quality Standards.
 - The data can be internal or external directly relevant for the operations of that undertaking.
 - The data used for calibration of undertaking-specific parameters should be consistent with the underlying assumptions of the standardised methodology.
 - The undertaking's data set can be easily adapted and incorporated into the proposed standardised methodology. This shall apply at all stages of the calculation.
 - The estimation error as a result of using the data shall not imply that the data is inappropriate.
 - The data is considered to be representative for the expected conditions in the following year. When undertaking-specific parameters are calibrated on the basis of historic data, especially on the basis of lengthy time series, all historic data should be representative for the future conditions and environment of operations.
 - Where adjustments to the data have been introduced, such adjustments should have only been introduced to make the data more relevant and appropriate. The adjustments must be documented and shall satisfy the supervisor.
 - Any bias in the data shall be borne in mind and its impact shall be analyzed.
- 3.33. When external data is used solely or as a combination of both internal and external data, data shall be directly relevant for the operations of that

⁸ (Further information on expert judgement is described as part of CEIOPS' Advice on Technical Provisions - Article 86 Actuarial and statistical methodologies to calculate the best estimate (CEIOPS-DOC-33/09, former CP 39)).

undertaking, i.e. this data shall accurately reflect the risk profile of the undertaking and be as suitable as, or complement, internal data.

3.34. Furthermore CEIOPS allows undertakings to use external pooled data. Pooled data can be useful in cases such as the launch a new product or when undertakings do not have sufficient internal data. For example, small health mutuals may not have a sufficient internal data to calculate own parameters and might therefore wish to use pooled data.

3.35. If undertakings use pooled data to calibrate undertaking-specific parameters, undertakings shall meet the following additional criteria:

- Governance of pooling mechanism and of new database is set up as well as signed and fulfilled by members of pooling mechanism.
- The pooling mechanism is transparent and auditable.
- The rules on data management shall ensure that the data provided to the pool by different members are sufficiently comparable: in particular this shall relate to data collection, definition, assessment and cleaning/adjustment.
- The pool shall comprise similar undertakings with similar risk profile not only among them but also to the undertaking, that is:
 - The pooled data shall represent data from undertakings with a similar risk profile and the nature of the business carried out is the same,
 - Where this impact on the degree of homogeneity of the data, the pool shall not include undertakings with different legal structure,
 - The pool of data shall be based on gross data of the business considered in order to allow each undertaking to derive values net of reinsurance by applying their own reinsurance programme.
 - In respect of the volatility levels estimated by the undertaking specific parameters, the undertaking shall verify whether the pooled data provide homogeneous features compared to those of the undertaking. In particular, where the size of the pooled data is significantly different from the size of risk exposures of the undertaking, and this difference in size has impact on volatility, an appropriate adjustment shall be carried out to guarantee that the undertaking specific parameters reflect the volatility of the undertaking rather than the volatility of the wider pooled data considered.

3.36. Examples where data may be considered to be unsatisfactory are (non-exhaustive):

- Low frequency of claims due to the nature of claim process/small portfolio which limit the extraction of the proper sample length,

- Data set from a time point before a significant change (for example legislation), whose impact cannot be adequately analyzed,
 - New business without suitable external data,
 - No reliable data collection process.
- 3.37. The general data quality requirements in relation to appropriateness, completeness and accuracy which apply to all replaceable parameters can be complemented by requirements that relate to particular replaceable parameters. These additional requirements, if needed, are provided together with the standardised method to calculate the undertaking-specific parameter. For example, particular requirements on the data for the average claim size and the average claim number estimations could be:
- the data should reflect the current reinsurance programme of the undertaking (i.e. either the data were observed under a comparable reinsurance cover or they were prepared for that purpose by taking gross data and applying the current reinsurance programme in order to estimate data net of reinsurance);
 - the data should stem from a sufficiently long period such that if cycles exist, at least a full cycle is covered in the data. For example, if the average claim number for hail crop insurance needs to be estimated, it would not be appropriate to use only data from the past year where no big hail events were observed;
 - the data is sufficiently homogeneous to produce a reliable estimate (this could be specified by limits on the coefficient of variation of the data set).
- 3.38. Supervisors shall have evidence that the data is monitored on a continuous basis. Undertakings shall carry out data quality checks on a regular basis and introduce processes to provide evidence of the accuracy, completeness and appropriateness of the data used.
- 3.39. If the undertaking does not satisfy the criteria required to be met in respect of the accuracy, completeness and appropriateness of the data used for estimating USP, undertakings are not able to use USP and other alternative action is required.
- 3.40. The application and relevance of the proportionality principle is limited due to the optional character of the use of undertaking-specific parameters and because poor quality data is unlikely to give rise to a more appropriate reflection in the parameter values of the risk profile than the standard formula. The replacement of the standard parameters must be justified by demonstrating that the estimation based on the internal data or external data is more appropriate and relevant to the undertaking's risk profile than that used otherwise.
- 3.41. The onus is on:

- the undertaking to demonstrate the fulfilment of the data requirement, and to demonstrate that the resulting USPs more appropriately reflect the risk profile of the undertaking,
- the supervisory authority to consider whether the historic data and any adjustments made to it are fit for purpose and in case of application of Article 110 whether the use of own but lower quality of data can compensate the significant deviation from the assumptions underlying the standard formula.

3.1.3.4 Data limitations

3.42. CEIOPS is aware that undertakings may have data limitations, with respect to availability of best estimate data in the format required to estimate USP, for example:

- Many undertakings may have made "best estimates" in the past and then adjusted them for reporting purposes.
- Some "best estimates" may not be in line with the Solvency II requirements: for instance, intended to be the mean and fully adjusted for extreme events not sufficiently represented in the data, and they may not have been discounted using the appropriate risk free yield curve.
- The degree of rigour and consistency in the estimation may be lower than the standard undertakings need to adopt under Solvency II.
- Where undertakings have not calculated best estimates in the past (this would be the case where their estimates were deliberately prudent) it would not seem appropriate to use these estimates.

3.43. Where undertakings have not made anything that could reasonably be described as a best estimate in the past and they are not able to reproduce this historically, undertakings should justify that the use of the data, together with any adjustments, appropriately reflects the risk profile of the undertaking and satisfies as close as possible the requirements set out in 3.1.3.3. It will be for supervisors to decide whether the historic data and the adjustments made to it are fit for purpose.

3.44. Undertakings are able to do the estimation on an underwriting year basis, if they do not have historic data on an accident year basis. However, where the results could be materially different between both approaches (for example in the case of multiyear contracts) undertakings are required to show supervisory authorities how the final parameters are an adequate representation of an accident year basis parameter.

3.1.3.5 The standardised methods to calculate USP

3.45. During QIS4 the standard deviation for premium risk for each line of business was derived as a credibility mix of an undertaking-specific

estimate and a market-wide estimate. This option was deleted from the design of the standard formula parameters in line with CEIOPS' Advice on Standard Formula SCR Non-Life underwriting risk (CEIOPS-DOC-41/09). However, CEIOPS believes that this credibility mechanism is useful and necessary when applying undertaking-specific parameters and proposes to include this for USP for both premium and reserve risk, because the estimators used in the standardised methods include a significant estimation error.

3.46. The standard formula calibration is based on a large number of data sets and individual observations. However undertaking specific data will be based on one or a few sets of independent observations. As a result CEIOPS considers that undertakings specific information cannot be given 100% credibility unless the length of the time series is equal to or exceeds a specific length.

3.47. Undertakings shall derive the undertaking-specific parameters as follows:

For premium risk:

$$\sigma_{(prem,lob)} = c \cdot \sigma_{(U,prem,lob)} + (1-c) \cdot \sigma_{(M,prem,lob)}$$

where

c = credibility factor for LOB,

$\sigma_{(U,prem,lob)}$ = undertaking-specific estimate of the standard deviation for premium risk,

$\sigma_{(M,prem,lob)}$ = standard parameters of the standard deviation for premium risk which are provided in CEIOPS' advice on the Calibration of the Non Life Underwriting Risk (Pending finalization of the advice in March 2010).

For Reserve risk:

Undertakings shall derive new parameters as follows:

$$\sigma_{(res,lob)} = c \cdot \sigma_{(U,res,lob)} + (1-c) \cdot \sigma_{(M,res,lob)}$$

where

c = credibility factor,

$\sigma_{(U,res,lob)}$ = undertaking-specific estimate of the standard deviation for reserve risk,

$\sigma_{(M,res,lob)}$ = standard parameters of the standard deviation for reserve risk which are provided in CEIOPS' CP-71/09 on Calibration of Non Life Underwriting Risk (Pending finalization of the advice in March 2010).

3.48. The credibility factors to be applied shall be chosen according to the length of the time series N_{lob} used for the estimation and the LoB property. There are three cases:

a) **Use solely of internal data:** The undertaking-specific parameters are based on solely on internal data that meet the requirements set out in this advice and CEIOPS' Advice on data quality standards (CEIOPS-DOC-37/09, former CP 43):

- For Third-party liability, Motor vehicle liability and Credit and suretyship:

N_{lob}	5	6	7	8	9	10	11	12	13	14	≥ 15
C	34%	43%	51%	59%	67%	74%	81%	87%	92%	96%	100%

- for all other lines of business:

N_{lob}	5	6	7	8	9	≥ 10
C	34%	51%	67%	81%	92%	100%

b) **Use of external data:** The undertaking-specific parameters are based on solely on data which is directly relevant to the operations of the undertaking, provided they meet the requirements set out in this advice and CEIOPS' Advice on data quality standards (CEIOPS-DOC-37/09, former CP 43):

- For Third-party liability, Motor vehicle liability and Credit and suretyship:

N_{lob}	5	6	7	8	9	10	11	12	13	14	≥ 15
C	30%	34%	38%	42%	46%	50%	53%	56%	58%	61%	63%

- For all other lines of business:

N_{lob}	5	6	7	8	9	≥ 10
C	30%	38%	46%	53%	58%	63%

c) **Use of internal and external data:** the undertaking-specific parameters are based on a mixture of internal data and data directly relevant to the operations of the undertaking (that together meet the requirements set out in this advice and CEIOPS' Advice on data quality standards (CEIOPS-DOC-37/09, former CP 43): in such circumstances undertakings shall apply the credibility factors provided by the use of external data.

3.49. The rationale behind differentiating between external and internal data credibility vectors is based on the following considerations:

- The aim of '*undertaking-specific parameters*' is to achieve a better estimation of the volatility (risk) that the undertaking bears. Using external data may understate such volatility as a result of the wider population of risks considered in the external data, than those specific of the undertaking.
- Using external data implies, unavoidably, a certain divergence or error to reflect the undertaking specific risk structure (although this error should be limited, according to the requirements set out in this advice).

- External data requires a stronger harmonization process than internal data, to achieve a sufficiently degree of homogeneity. Data in different points in time may not be comparable and the lack comparability, but also data referred to the same moment obtained from different sources.

3.50. CEIOPS presents below a detailed description of the methods and assumptions that undertakings should apply to calculate undertaking-specific parameters for both premium risk and reserve risk:

Premium Risk

a. Assumptions

3.51. The methods for estimating the undertaking-specific parameters will follow as close as possibly the assumption underlying the standard formula SCR for premium risk, in particular:

- premium risk covers the risk of loss because the premium provision at the start of the year proves inadequacy and the risk of loss on new contracts written during the year,
- premium risk allows for volatility of expense payments,
- catastrophe risk is excluded from premium risk,
- the underlying risk follows a lognormal distribution,
- capital charge for premium risk is calculated as a function of the volume measure for premium risk and a standard deviation for premium risk for each LoBs.
- The volume measure for premium risk in the individual LoB is determined as follows:

$$V_{(prem,lob)} = \max(P_{lob}^{t,written}; P_{lob}^{t,earned}; P_{lob}^{t-1,written}) + C_{lob}^{PP}, \text{ where}$$

$P_{lob}^{t,written}$	=	estimate of net written premium for each LoB during the forthcoming year
$P_{lob}^{t,earned}$	=	estimate of net earned premium for each LoB during the forthcoming year
$P_{lob}^{t-1,written}$	=	net written premium for each LoB during the previous year
C_{lob}^{PP}	=	Expected present value of net claims and expense payments which relate to claims incurred after the following year and covered by existing contracts for each LoBs.

3.52. Undertaking-specific parameters shall allow for expense volatility implicitly. Undertakings shall assume claims and expense volatility are

similar, and thus no additional adjustments are needed to the volatility determined using loss ratio only.

- 3.53. Insurance and reinsurance undertakings shall adjust their data for inflation where the inflationary experience implicitly included in time series used is not representative of the inflation that might occur in the future, where this is considered to have a material impact – undertaking shall explain the approach taken.

b. Analysis

- 3.54. The analysis is performed using the net earned premiums as the volume measure and the net ultimate claims after one year to derive a standard deviation.

c. Adjustments – the risk margin

- 3.55. The SCR is the difference between the basic own funds over the one year time horizon in the distressed scenario. This implicitly suggests that undertakings should analyse the difference between all component parts of the technical provisions under the stressed scenario, including the risk margin.

This is an area that CEIOPS is still analysing and considering whether material under the scope of the standard formula for non-life underwriting. The proposed methodology is provided in CEIOPS' CP-71/09 on Calibration of Non Life Underwriting Risk (Pending finalization of the advice in March 2010).

d. Standardised methods

- 3.56. CEIOPS does not consider one method to be perfect and proposes that undertakings apply a variety of methods to estimate their appropriate volatility.
- 3.57. Undertakings will be required to explain how and why they have selected the final factor, taking into consideration their risk profile.
- 3.58. The standardised methods for estimating the undertaking-specific parameters $\sigma_{(U,prem,lob)}$ are:

Method 1

- 3.59. This approach is consistent with the undertaking-specific estimate assumptions from the Technical Specifications for QIS 4.
- 3.60. The assumptions are that for the particular undertaking, any year and any LoB:

- The expected loss is proportional to the premium
- The company has a different but constant expected loss ratio (ie does not allow for premium rate changes)
- The variance of the loss is proportional to the earned premium and
- The least squares fitting approach is appropriate.

3.61. If we defined the following terms:

$U_{Y,lob}$	=	The ultimate after one year by accident year and LoB
μ_{lob}	=	Expected loss ratio by LoB
β_{lob}^2	=	Constant of proportionality for the variance of loss by LoB
$\mathcal{E}_{Y,lob}$	=	An unspecified random variable with distribution with mean zero and unit variance
$V_{Y,lob}$	=	Earned premium by accident year and LoB
N_{lob}	=	The number of data points available by LoB
V_{lob}	=	The result from the volume calculation from the current year $V_{lob} = \max(\text{estimate of net written premium during the forthcoming year, estimate of net earned premium during the forthcoming year, net written premium during the previous year}) + \text{expected present value of net claims and expense payments which relate to claims incurred after the following year and covered by existing contracts}$

Then we can formulate the distribution of losses as:

$$U_{Y,lob} \sim V_{Y,lob}\mu_{lob} + \sqrt{V_{Y,lob}}\beta_{lob}\mathcal{E}_{Y,lob}$$

We can re-arrange this to give us a set of independent, identically distributed observations:

$$\beta_{lob}\mathcal{E}_{Y,lob} = \frac{U_{Y,lob} - V_{Y,lob}\mu_{lob}}{\sqrt{V_{Y,lob}}}$$

Our estimator for β_{lob} becomes:

$$\hat{\beta}_{lob}^2 = \frac{1}{N_{lob} - 1} \sum_Y \frac{(U_{Y,lob} - V_{Y,lob}\mu_{lob})^2}{V_{Y,lob}}$$

Minimising this estimator we obtain:

$$\hat{\mu}_{lob} = \frac{\sum_Y U_{Y,lob}}{\sum_Y V_{Y,lob}}$$

Which we can substitute back into our estimator of β_{lob} which becomes:

$$\hat{\beta}_{lob} = \sqrt{\frac{1}{N_{lob} - 1} \sum_Y \frac{\left(U_{Y,lob} - V_{Y,lob} \frac{\sum_Y U_{Y,lob}}{\sum_Y V_{Y,lob}} \right)^2}{V_{Y,lob}}}$$

3.62. The standard deviation $\sigma_{(U,prem,lob)}$ then becomes :

$$\sigma_{(U,prem,lob)} = \frac{\hat{\beta}_{lob}}{\sqrt{V_{lob}}}$$

3.63. The additional data requirements for this undertaking-specific parameter:

The data used should meet the following additional requirements:

- The data should reflect the premium risk that is covered in the line of business during the following year, in particular in relation to its nature and composition. The data should be adjusted for catastrophe claims to the extent they are addressed in the non-life or health CAT risk sub-modules.
- Claims should be net of reinsurance. The data should reflect the reinsurance cover of the undertaking for the following year.
- Claims should be adjusted for inflation. All data used should be adjusted for any trends which can be identified on a prudent, reliable and objective basis.
- Claim should not include unallocated expense payments.
- The data should stem from a sufficiently long period such that if cycles exist, at least a full cycle is covered in the data. The data should at least cover 5 years.
- The data should not lead to the increase of the estimation error to the material amount compared to the estimated value.

Method 2

3.64. This approach is consistent with the undertaking-specific estimate assumptions from the Technical Specifications for QIS 4.

3.65. The assumptions are that for the particular undertaking, any year and any LoB:

- The expected loss is proportional to the premium
- The company has a different but constant expected loss ratio (for example the undertaking does not allow for premium rate changes, or changes in the underlying risk)
- The variance of the loss is proportional to the earned premium
- The distribution of the loss is lognormal and
- The maximum likelihood fitting approach is appropriate

3.66. If we defined the following terms:

$U_{Y,lob}$	=	The ultimate after one year by accident year and LoB
μ_{lob}	=	Expected loss ratio by LoB
β_{lob}^2	=	Constant of proportionality for the variance of loss by LoB
$\epsilon_{Y,lob}$	=	An unspecified random variable with distribution with mean zero and unit variance
$V_{Y,lob}$	=	Earned premium by accident year and LoB
$M_{Y,lob}$	=	The mean of the logarithm of the ultimate after one year by accident year and LoB
$S_{Y,lob}$	=	The standard deviation of the logarithm of the ultimate after one year by accident year and LoB
V_{lob}	=	The result from the volume calculation from the current year $V_{lob} = \max(\text{estimate of net written premium during the forthcoming year, estimate of net earned premium during the forthcoming year, net written premium during the previous year}) + \text{expected present value of net claims and expense payments which relate to claims incurred after the following year and covered by existing contracts}$

3.67. Then we can formulate the distribution of losses as:

$$U_{Y,lob} \sim V_{Y,lob} \mu_{lob} + \sqrt{V_{Y,lob}} \beta_{lob} \epsilon_{Y,lob}$$

3.68. This allows us to formulate our parameters of the lognormal distributions as follows:

$$S_{Y,lob} = \sqrt{\log \left(1 + \frac{\beta_{lob}^2}{V_{Y,lob} \mu_{lob}^2} \right)}$$

$$M_{Y,lob} = \log(V_{Y,lob}\mu_{lob}) - \frac{1}{2}S_{lob}^2$$

3.69. The resultant simplified log Likelihood becomes

$$\log L = \sum_Y \left(-\log(S_{Y,lob}) - \frac{(\log(U_{Y,lob}) - M_{Y,lob})^2}{2S_{Y,lob}^2} \right)$$

3.70. We then choose the parameter values β_{lob} and μ_{lob} that maximise this likelihood.

3.71. The standard deviation $\sigma_{(U,prem,lob)}$ then becomes :

$$\sigma_{(U,prem,lob)} = \frac{\hat{\beta}_{lob}}{\sqrt{V_{lob}}}$$

3.72. The additional data requirements for this undertaking-specific parameter are stated in paragraph 3.63.

Method 3

3.73. Since the method defined above for the calculation undertaking-specific estimates for standard deviation of premium risk include a significant estimation error, CEIOPS considers an alternative methodology based on the Swiss Solvency Test⁹.

3.74. Under this approach, the calculation of undertaking-specific standard deviations in premium risk are based on the assumption that the claim number per accident year and claim size depend on a random variable $\Theta = [\Theta_1, \Theta_2]$ which represents the random fluctuation in number (Θ_1) as well as in claim size (Θ_2).

As:

$$\sigma_{(U,prem,lob)} = \frac{1}{V_{(prem,lob)}} \sqrt{\text{Var}(S_N)}, \text{ where}$$

$V_{(prem,lob)}$ - volume measure (known at the beginning of the year),

$$S_N = \sum_{i=1}^N X_i$$

- sum of a random number of claims, the claim size itself is also random,

and we assume that

$$N|\Theta_1 \sim \text{Pois}(\lambda(\Theta_1)),$$

⁹ See "Technical document on the Swiss Solvency Test", http://www.finma.ch/archiv/bpv/download/e/SST_techDok_061002_E_wo_Li_20070118.pdf

$X_i|\Theta_2 \sim F(\mu(\Theta_2),\sigma(\Theta_2))$, where N and X_i are conditionally independent, λ, μ and σ denote the parameters of the distributions

using the variance decomposition formula and the above assumptions it is easy to show that:

$$\begin{aligned} \text{Var}(S_N) &= \text{Var}(E(S_N | \Theta)) + E(\text{Var}(S_N | \Theta)) = \\ &= \text{Var}(\lambda(\Theta_1))\text{Var}(\mu(\Theta_2)) + \text{Var}(\lambda(\Theta_1))(E[\mu(\Theta_2)])^2 + \text{Var}(\mu(\Theta_2))E[\lambda(\Theta_1)]^2 + \\ &+ E(\lambda(\Theta_1))E[\mu(\Theta_2)]^2 + E\lambda(\Theta_1)E[\sigma(\Theta_2)]^2, \end{aligned}$$

which allows to use only characteristics of the underlying distributions N and X in the estimation.

3.75. For the simplifying assumptions that only N depends on Θ and $\lambda(\Theta) = \lambda\Theta$, where $E(\Theta)=1$ we get¹⁰:

$$\text{Var}(S_N) = \mu^2 \lambda^2 \text{Var}(\Theta) + \lambda \mu^2 + \lambda \sigma^2$$

Therefore the undertaking should calculate, on the basis of the internal data of the undertaking concerned, or of data which is directly relevant for the operations of that undertaking, the following input data:

μ = the average value of claim size in the individual LoB with an inflation adjustment; the estimate should be derived by

- summing up past, inflation adjusted individual ultimate claims values,
- dividing above sum by the number of claims.

σ = the standard deviation of claim size in the individual LoB with an inflation adjustment estimated by means of the standard estimator

λ = the average number of claims in the individual LoB per earned premium by:

average number of claims = total number of claims/total earned premiums with an inflation adjustment)

multiplying the average number of claims with $V_{(prem,lob)}$

If a volume measure other than earned premiums appears to be statistically more appropriate and this can be justified by the undertaking, the

¹⁰ For more details please see "The Insurance Risk in the SST and in Solvency II: Modelling and Parameter Estimation" by Alois Gisler, http://www.actuaries.org/ASTIN/Colloquia/Helsinki/Papers/S3_24_Gisler.pdf

volume measure may replace earned premiums in the above procedure.

$Var(\Theta)$ = estimate of the variance of random factor in the claim number in the individual LoB during the forthcoming year;

3.76. Insurance and reinsurance undertakings should estimate $Var(\Theta)$ based on following input data:

J = maximum numbers of years with available data based on which undertaking calculate USP

N_j = numbers of claims in year j

v_j = A priori expected number of claims in year j

Insurance and reinsurance undertakings should estimate $Var(\Theta)$ as¹¹:

$Var(\Theta) = \left(c \cdot \frac{v_{\bullet}}{J} \right)^{-1} \left(\frac{V_F}{\bar{F}} - 1 \right)$, where:

$$F_j = \frac{N_j}{v_j},$$

$$v_{\bullet} = \sum_{j=1}^J v_j,$$

$$\bar{F} = \sum_{j=1}^J \frac{v_j}{v_{\bullet}} F_j,$$

$$V_F = \frac{1}{J-1} \sum_{j=1}^J v_j (F_j - \bar{F})^2,$$

$$c = \sum_{j=1}^J \frac{v_j}{v_{\bullet}} \left(1 - \frac{v_j}{v_{\bullet}} \right).$$

3.77. The data used for this undertaking-specific parameter to estimate μ , σ , λ and $Var(\Theta)$ should meet the following additional requirements:

- The data should reflect the premium risk that is covered in the line of business during the following year, in particular in relation to its nature and composition. The data should be adjusted for catastrophe claims to

¹¹ For more details of $Var(\Theta)$ estimation please see "The Insurance Risk in the SST and in Solvency II: Modelling and Parameter Estimation" by Alois Gisler, page 24/25, http://www.actuaries.org/ASTIN/Colloquia/Helsinki/Papers/S3_24_Gisler.pdf. Alternatively CEIOPS considers providing estimates of $Var(\Theta)$ since Θ could be understood as the non-undertaking specific random variable which reflects more condition to which is subject the whole market.

the extent they are addressed in the non-life or health CAT risk sub-modules.

- Claim sizes should be net of reinsurance. The data should reflect the reinsurance cover of the undertaking for the following year. Elements of reinsurance which cannot be related to individual claims (e.g. stop loss reinsurance) should be taken into account in an appropriate manner.
- Claim sizes should be adjusted for inflation. All data used should be adjusted for any trends which can be identified on a prudent, reliable and objective basis.
- Claim sizes should not include expense payments.
- The data should stem from a sufficiently long period such that if cycles exist, at least a full cycle is covered in the data. The data used to estimate $Var\lambda(\Theta)$ should at least cover 5 years.
- The data should not lead to the increase of the estimation error to the material amount compared to the estimated value.
- The level of prudence in the earned premiums used to estimate $E\lambda(\Theta)$ should be similar. Any other volume measure used should reflect the number of claims.

Reserve Risk

a. Assumptions

3.78. The standardized methods for undertaking-specific parameters for reserve risk are based on the same assumptions underlying standard formula SCR reserve risk, especially:

- Reserve risk stems from two sources: the absolute level of the claims provisions may be misestimated and because of the stochastic nature of future claims payouts, the actual claims will fluctuate around their statistical mean value,
- the underlying risk follows a lognormal distribution,
- capital charge for reserve risk is calculated as a function of the volume measure for reserve risk (best estimate for claims outstanding) and a standard deviation for reserve risk for each LoBs.

3.79. For expenses, undertakings shall analyse claims payments excluding amounts for expenses. We assume claims and expense volatility are similar, and thus no additional adjustments are needed to the volatility determined using claims data only.

- 3.80. The effect of discounting will be the same in the stressed scenario as in the best estimate. As a result, no modification to our result is necessary.
- 3.81. Insurance and reinsurance undertakings shall adjust their data for inflation where the inflationary experience implicitly included in time series used is not representative of the inflation that might occur in the future, for example in the case of bodily injury claims.

b. Analysis

3.82. The analysis is performed using:

- the opening value of the net reserves as the volume measure and the net claims development result after one year for these exposures to derive a standard deviation.
- the net paid or net incurred triangle.

3.83. Under the Merz-Wüthrich approach used in methods 2 and 3 below, the estimator explicitly only captures the prediction error and does not capture model error (for example the chain ladder assumptions do not hold) or the error in case the past data do not reflect the future business. The impaired usability of this method for solvency purposes was also noted in the actuarial discussion.¹²

3.84. For these reasons, the estimated parameters should be complemented with a component for model error as follows:

$$\sigma_{(U, res, lob)} = \sqrt{\sigma_{(U, res, lob)}^2 + \tau^2}$$

where τ reflects the model error. Based on the assumption that this risk is independent from the prediction error, the square root formula is used for aggregation.

As the parameter τ reflects the model error which is an inherent feature of these methods it cannot be set to zero. However, the exact amount of the τ can be different among undertakings or lines of business. Therefore CEIOPS does not fix the amount, but expects that with the increasing experience regarding using the methods the parameter can be assessed properly.

c. Adjustments – the risk margin

3.85. The SCR is the difference between the basic own funds over the one year time horizon in the distressed scenario. This implicitly suggests that undertakings should analyse the difference between all component parts of

¹² See for example Alois Gisler: The Insurance Risk in the SST and in Solvency II: Modelling and Parameter Estimation (2009), page 29.
http://www.actuaries.org/ASTIN/Colloquia/Helsinki/Papers/S3_24_Gisler.pdf

the technical provisions under the stressed scenario, including the risk margin.

This is an area that CEIOPS is still analysing and considering whether material under the scope of the standard formula for non-life underwriting. The proposed methodology is provided in CEIOPS' CP-71/09 on Calibration of Non Life Underwriting Risk (Pending finalization of the advice in March 2010).

d. Standardised methods

- 3.86. CEIOPS does not consider one method to be perfect and proposes that undertakings apply a variety of methods to estimate their volatility.
- 3.87. Undertakings will be required to explain how and why they have selected the final factor, taking into consideration their risk profile.
- 3.88. The standardised methods for estimating the undertaking-specific parameters $\sigma'_{(U,res,lob)}$ are:

Method 1

- 3.89. This approach is consistent with the undertaking-specific estimate assumptions from the Technical Specifications for QIS 4 for reserve risk.
- 3.90. The assumptions are that for any undertaking, any year and any LoB:
- The expected reserves in one year plus the expected incremental paid claims in one year is the current best estimate for claims outstanding,
 - The variance of the best estimate for claims outstanding in one year plus the incremental claims paid over the one year is proportional to the current best estimate for claims outstanding, and
 - The least squares fitting approach is appropriate.
- 3.91. If we defined the following terms:

β_{lob}^2	=	Constant of proportionality for the variance of the best estimate for claims outstanding in one year plus the incremental claims paid over the one year by LoB
$\epsilon_{Y,lob}$	=	An unspecified random variable with distribution with mean zero and unit variance
$PCO_{lob,i,j}$	=	The best estimate for claims outstanding by LoB for accident year i and development year j
$I_{lob,i,j}$	=	The incremental paid claims by LoB for accident year i and development year j
$V_{Y,lob}$	=	Volume measure by calendar year and LoB
$R_{Y,lob}$	=	The best estimate for outstanding claims and

		incremental paid claims for the exposures covered by the volume measure, but in one year's time by calendar year and LoB
N_{lob}	=	The number of data points available by LoB where there is both a value of $V_{C,Y,lob}$ and $R_{C,Y,lob}$.
PCO_{lob}	=	The best estimate for claims outstanding by LoB

3.92. Then we can define the following relationships:

$$V_{Y,lob} = \sum_{i+j=Y+1} PCO_{lob,i,j}$$

$$R_{Y,lob} = \sum_{\substack{i+j=Y+2 \\ i \neq Y+1}} PCO_{lob,i,j} + \sum_{\substack{i+j=Y+2 \\ i \neq Y+1}} I_{lob,i,j}$$

3.93. Then we can formulate the distribution of losses as:

$$R_{Y,lob} \sim V_{Y,lob} + \sqrt{V_{Y,lob}} \beta_{lob} \epsilon_{Y,lob}$$

3.94. We can re-arrange this to give us a set of independent, identically distributed observations:

$$\beta_{lob} \epsilon_{Y,lob} = \frac{R_{Y,lob} - V_{Y,lob}}{\sqrt{V_{Y,lob}}}$$

3.95. Our estimator for β_{lob} becomes:

$$\hat{\beta}_{lob} = \sqrt{\frac{1}{N_{lob} - 1} \sum_Y \frac{(R_{Y,lob} - V_{Y,lob})^2}{V_{Y,lob}}}$$

3.96. The $\sigma_{(U,res,lob)}$ then becomes :

$$\sigma_{(U,res,lob)} = \frac{\hat{\beta}_{lob}}{\sqrt{PCO_{lob}}}$$

3.97. The additional data requirements for this undertaking-specific parameter:

The data used should meet the following additional requirements:

- The data should reflect the reserve risk that is covered in the line of business during the following year, in particular in relation to its nature and composition.
- Best estimates and payments should be net of reinsurance. The data should reflect the reinsurance cover of the undertaking for the following year (i.e. either the data were observed under a comparable

reinsurance cover or they were prepared for that purpose by taking gross data and applying the current reinsurance programme in order to estimate data net of reinsurance).

- Best estimates and payments should be adjusted for inflation. All data used should be adjusted for any trends which can be identified on a prudent, reliable and objective basis.
- Best estimates and payments should not include expenses.
- The data should stem from a sufficiently long period such that if cycles exist, at least a full cycle is covered in the data. The data should at least cover 5 years.
- •The data should not lead to the increase of the estimation error to the material amount compared to the estimated value.

Method 2

3.98. This approach is based on the mean squared error of prediction of the claims development result over the one year and fitting a model to these results. The mean squared errors are calculated using the approach detailed in "Modelling The Claims Development Result For Solvency Purposes" by Michael Merz and Mario V Wüthrich, Casualty Actuarial Society E-Forum, Fall 2008¹³.

3.99. The output from the Merz and Wüthrich method would be:

$$\sqrt{MSEP} = \sigma_{(U, res, lob)} * PCO_{lob}$$

3.100. Therefore $\sigma'_{(U, res, lob)} = \frac{\sqrt{MSEP}}{PCO_{lob}}$

3.101. The additional data requirements for this undertaking-specific parameter:

The data used should meet the following additional requirements:

- The estimation should be made on complete claims triangles for payments. The data should stem from a sufficiently long period such that all material payments can be estimated from the triangle. The data should at least cover 5 years.
- The data should reflect the reserve risk that is covered in the line of business during the following year, in particular in relation to its nature and composition.
- Payments should be net of reinsurance. The data should reflect the reinsurance cover of the undertaking for the following year (i.e. either the data were observed under a comparable reinsurance cover or they

¹³ See <http://www.soa.org/library/journals/north-american-actuarial-journal/2008/april/naaj-2008-vol12-no2-merz-wuthrich.pdf> and http://www.actuaries.org/ASTIN/Colloquia/Manchester/Abstracts/wuethrich_abstract_final.pdf

were prepared for that purpose by taking gross data and applying the current reinsurance programme in order to estimate data net of reinsurance).

- Best estimates and payments should be adjusted for inflation. All data used should be adjusted for any trends which can be identified on a prudent, reliable and objective basis.
- The payments should not include expenses.
- The claims triangle should be consistent with the model assumptions of the Merz and Wüthrich method.
- The data should not lead to the increase of the estimation error to the material amount compared to the estimated value.

Method 3

3.102. This approach is essentially consistent with the standard formula representation of the relationship between volatility of future reserve deterioration and volume.

3.103. This approach is based on calculating the mean squared error of prediction of the claims development result over the one year and fitting a model to these results. The mean squared errors are calculated using the approach detailed in "Modelling The Claims Development Result For Solvency Purposes" by Michael Merz and Mario V Wüthrich, Casualty Actuarial Society E-Forum, Fall 2008.

3.104.

$CLPCO_{lob}$	=	The best estimate for claims outstanding by LoB estimated via the Chain Ladder method
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$$\text{Therefore } \sigma'_{(U, res, lob)} = \frac{\sqrt{MSEP}}{CLPCO_{lob}}.$$

3.105. The additional data requirements for this undertaking-specific parameter are stated in paragraph 3.101.

Shock for revision risk

3.106. These undertaking-specific parameters should be calculated by following standardised method.

3.107. Revision risk is intended to capture the risk of adverse variation of an annuity's amount, as a result of an unanticipated revision of the claims process. This risk should be applied only to annuities and to those benefits that can be approximated by a life annuity arising from non-life claims (in particular, life assistance benefits from workers' compensation LoB). The undertaking-specific shock for revision risk is restricted only to workers' compensation or to annuities which are not significantly subject to inflation

risk. This restriction stems from the assumption in calculation procedure, that the number and severity of revisions are independent. In case of inflation the number and severity are usually dependent because the value of inflation determines which annuities will be revised and the severity of this revision.

3.108. On the computation of this risk charge, it should be considered the impact on those annuities for which a revision process is possible to occur during the next year (e.g. annuities where there are legal or other eligibility restrictions should not be included). Unless the future amounts payable are fixed and known with certainty, all those benefits that can be approximated by a life annuity (life assistance) are also subject to revision risk.

3.109. In order to derive undertaking-specific parameters for revision risk, undertaking concerned should use time series of annual amounts of individual annuities (life assistance benefits) in payment in consecutive years, during the time horizon in which they are subject to revision risk.

3.110. Input data:

μ_x = the historical average relative change of individual annuities (or life assistance benefits)

σ_x = the historical standard deviation of relative change of individual annuities (or life assistance benefits), estimated by means of the standard estimator

$E(N)$ = estimate of percentage of individual annuities (or life assistance benefits) for which a revision process is possible to occur during the forthcoming year; the estimate should be derived by

- estimating the average percentage of individual annuities (or life assistance benefits) for which a revision process occurred per best estimate of annuities provision (average percentage of revised annuities = (total number of revised annuities / total number of annuities) / total best estimate of annuities provision),

- multiplying the average percentage of individual annuities (or life assistance benefits) with best estimate of annuities provision.

If a volume measure other than best estimate of annuities provision appears to be statistically more appropriate and this can be justified by the undertaking, the volume measure may replace in the above procedure.

σ_N = the historical standard deviation of percentage of individual annuities (or life assistance benefits) for which a revision process occurred), estimated by means of the standard estimator

3.111. Calculation procedure:

- For each calendar year t , identify the set of annuities (or life assistance claims) that were exposed to revision risk during the whole year. Include also those individual annuities that were exposed only during a part of the year, but where an upward revision has effectively occurred in that period. Annuities (or life assistance claims) that entered or exited the books during the period (e.g. new claims, death of the beneficiary) should be excluded.
- Statistical fitting techniques should then be applied to these sets of observations, with the objective to fit a theoretical probability distribution to the relevant random variable Rev describing the 1-year percentage change in the annual amount of annuities (or life assistance claims) at the portfolio level.
- Insurers are expected to validate the goodness-of-fit of all the distributions and assumptions made, using the sets of observations above derived. Particular attention should be paid to the robustness of the fitting techniques to the tails of the distributions. Non satisfactory results in these tests would be sufficient conditions to reject the request to use the undertaking specific parameter under analysis.
- The next step is to calculate the mean and standard deviation of the distribution of Rev using the appropriate and unbiased estimators and the sets of observations.
- The relevant size of the shock ($Revshock$) is then given by the difference between the quantile 99.5% of the distribution $VaR_{0.995}(Rev)$ and its average \overline{Rev} divided by the average. In this step, it should be confirmed that the 'average' rate of revision assumed in the best estimate calculation is consistent with this result.

3.112. The calculation of undertaking-specific revision shock in revision risk is based on the assumption that the frequency and the severity of revision depend on a random variable Θ which represents the random in the frequency process as well as in the severity of revision.

As:

$$Revshock = \frac{VaR_{0.995}(Rev) - \overline{Rev}}{\overline{Rev}}, \text{ where}$$

$$\overline{Rev} = \sum_{i=1}^N X_i - \text{sum of a random cases of annuities revision,}$$

and we assume that

$$N|\Theta \sim \text{NB}(\alpha(\Theta), q(\Theta)),$$

$X_i|\Theta \sim \text{LN}(\mu(\Theta), \sigma(\Theta))$, where N and X_i are conditionally independent, α, q, μ and σ denote the parameters of the distributions.

Therefore

$$\overline{\text{Rev}} = \mu_x E(N) \text{ - the average of the distribution,}$$

$$\text{VaR}_{0.995}(\text{Rev}) = f(\mu_x, \sigma_x, E(N), \sigma_N).$$

3.113. $\text{VaR}_{0.995}(\text{Rev})$ shall be derived using simulation. The undertaking shall:

- I. simulate one number n_j from $\text{NB}(E(N), \sigma_N)$,
- II. simulate n_j numbers of x_i from $\text{LN}(\mu_x, \sigma_x)$, $i=1, \dots, n_j$,
- III. calculate $\text{Rev}_j = \sum_{i=1}^{n_j} x_i$,
- IV. repeat 50 000 times steps I - III, which means calculate Rev_j for $j=1, \dots, 50\,000$,
- V. calculate $\text{VaR}_{0.995}(\text{Rev})$ as $F_{\text{Rev}_j}^{-1}(0.995)$ of simulated values.

3.114. The additional data requirements for this undertaking-specific parameter:

- The goodness-of-fit of the distributions and assumptions to the sets of observations should be considered satisfactory. In particular, the estimates of the average, standard deviation and 99.5% quantile of the Rev distribution should be sufficiently robust.
- The number of available historical years, and the number of annuities (or life assistance claims) within each year should be sufficiently large to allow for statistically credible results.
- The mix of types of annuities (or life assistance claims) should be relatively comparable across different years and should be representative of the current portfolio.
- There should not be structural changes in the environment, which could lead to a significant change in the behaviour of the revision risk drivers (e.g. change in legislation), both during the historical period and when compared with the expectations for next year.

3.2 CEIOPS' Advice

3.115. This Paper provides advice with regard to:

- the subset of standard parameters in the life, non-life and health underwriting risk modules that may be replaced by undertaking-specific parameters,
- the standardised methods to be used by an insurance or reinsurance undertaking to calculate those undertaking-specific parameters, and
- the criteria to be met by undertakings in order for supervisory approval to be given, including the criteria with respect to the completeness, accuracy and appropriateness of the data.

3.116. Undertakings wishing to apply for the use of undertaking-specific parameters shall comply with the criteria set out by CEIOPS below as required by article 111 (k). Material changes in the methods shall be classified as partial internal model subject to requirements from articles 112, 113 particularly standard introduced by articles 120-126.

Subset of standard parameters that may be replaced by undertaking-specific parameters

3.117. The following subset of standard parameters in the life, non-life and health underwriting risk modules may be replaced by undertaking-specific parameters:

- a) Non life premium and reserve risk parameters: standard deviation for premium risk $\sigma_{(\text{prem,LoB})}$ and standard deviation for reserve risk $\sigma_{(\text{res,LoB})}$, as defined in CEIOPS' advice on the SCR non-life underwriting risk module (CEIOPS-DOC-41/09).
- b) NSLT health premium and reserve risk parameters: standard deviation for premium risk $\sigma_{(\text{prem,LoB})}$ and standard deviation for reserve risk $\sigma_{(\text{res,LoB})}$, as defined in CEIOPS' advice on SCR health risk module (CEIOPS-DOC-43/09).
- c) SLT Health Revision Risk: replace a standard parameter of revision shock in the SLT Health Revision risk in CEIOPS' advice on CEIOPS' advice on SCR Health risk module (CEIOPS-DOC-43/09)
- d) Revision Risk: replace a standard parameter of revision shock in the Revision risk in CEIOPS' advice on SCR life risk module (CEIOPS-DOC-42/09).

3.118. Undertaking-specific parameters may be used to replace different subset of parameters within the particular risk modules stated above.

3.119. For all other parameters undertakings shall use the values of standard formula parameters. The parameters in simplifications are not considered to be standard parameters.

3.120. Calibration of the USP shall be carried out at least annually. According to Article 102(1) of the Level 1 text, insurance and reinsurance undertakings shall calculate the SCR at least once a year and report the result of that calculation to the supervisory authorities. If an insurance and reinsurance undertaking is on more frequent than annual reporting/monitoring, then frequency of calibration of the USP shall be the same as the frequency of SCR calculation.

The supervisory approval process for USP

3.121. Should undertakings wish to replace all or a subset of the parameters specified in 3.15 by USP, they are required to ask for supervisory approval.

3.122. The approval process shall consist of the following:

- a) Undertakings shall demonstrate as best as possible, that the calibration of the standard formula parameters do not appropriately reflect their risk profile and that the use of USP leads to a more appropriate result:
 - Undertakings shall consider the Own Risk and Solvency Assessment (ORSA). The identification of where the SCR does not accurately reflect an undertaking's risks is required within the ORSA (Article 45(1) letter c) of the Level 1 text).
 - The undertaking shall meet the criteria and show the completeness, accuracy and appropriateness of the data used to calibrate the USP, including the use of any qualitative adjustment made as explained in section 3.1.3.3.
- b) Supervisors shall be satisfied that USP are not being used to "cherry-pick" the areas which give the lowest SCR. Where USPs have only been used for some lines of business, undertakings shall explain why. The choice of the alternatives of the standardised methods shall also be justified regarding their assumptions, data relevance and the risk profile. The undertaking shall provide the results for at least two of the methods included below.
- c) Supervisors shall be satisfied that the USPs have been calibrated following the standardised methods laid down in this advice (section 3.1.3.5) and meet the following criteria:
 - the risks covered by the USP are conceptually the same as those covered by the standard formula parameters,

- the underlying assumptions behind the standard formula parameters and behind undertaking-specific parameters are the same,
 - the standard methodology provided should enable a robust and reliable estimation of the undertaking-specific parameters,
 - the data used to estimate such USP complies with the criteria set out in the advice (section 3.1.3.3).
- d) Where the supervisory authority requires supplementary information to make the assessment and verify the suitability of the USP, approval shall also be subject to the availability of such additional information.
- e) The supervisory authority should assess on the basis of the information supplied by the undertaking, whether the data and revised calibration are relevant to the undertaking and whether the data is sufficient to justify the revised calibration.
- f) Should supervisors require undertakings according to Article 110 to replace the subset of parameters specified above by USP, their decision shall state the reasons. The supervisor shall be required to:
- Explain as best as possible, why it considers the standard formula parameters inadequate,
 - Where the undertaking concerned is not able to comply with such decision, supervisory authorities shall provide alternative actions, in line with the Level 1 Text and relevant Level 2 implementing measures.

3.123. Having received approval from the supervisory authority, undertakings are not allowed to revert to standard formula parameters unless any non-compliance with the requirements stated above is observed and subject to approval of the supervisory authority. This is also applicable if there is a necessity to change the approved standardised method. The undertakings shall immediately inform the supervisory authority when they observe they no longer satisfy the requirements. The supervisory authority decides whether the compliance can be restored and the re-approval process is a sufficient measure or reversion to the standard parameter is necessary.

3.124. In absence of the explicit supervisory approval, undertakings are not allowed to use USP and shall calculate SCR with the standard formula parameters. Approval would only be effective when directly and explicitly confirmed to the undertaking by the supervisory authority.

Criteria with respect to the completeness, accuracy, and appropriateness of the data

- 3.125. The Level 1 text requires implementing measures to lay down the criteria with respect to the completeness, accuracy, and appropriateness of the data used that must be met before supervisory approval is given. These criteria shall be met as part of the supervisory approval process.
- 3.126. Definitions of completeness, accuracy, and appropriateness of the data are provided in CEIOPS' Advice on Technical Provisions –Article 86 f Standards for Data Quality (CEIOPS-DOC-37/09, former CP 43).
- 3.127. For the purpose of this advice, data is considered to represent numerical values including those that have been subject to qualitative adjustments based on expert judgement¹⁴ and/or prior analysis and experience.
- 3.128. Undertakings are not allowed to rely solely on expert judgment, and without reference to specific internal or external data. Where expert judgement is used, it shall be appropriately documented and explained as part of the standardised methodology, and the requirements at this respect shall apply (e.g. see CEIOPS-DOC-33/09).
- 3.129. Data used for the purpose of estimating USP shall comply with the following criteria:
- The data shall meet the standards laid down in CEIOPS' Advice on Data Quality Standards.
 - The data can be internal or external directly relevant for the operations of that undertaking.
 - The data used for calibration of undertaking-specific parameters should be consistent with the underlying assumptions of the standardised methodology.
 - The undertaking's data set can be easily adapted and incorporated into the proposed standardised methodology. This shall apply at all stages of the calculation.
 - The estimation error as a result of using the data shall not imply that the data is inappropriate.
 - The data is considered to be representative for the expected conditions in the following year. When undertaking-specific parameters are calibrated on the basis of historic data, especially on the basis of lengthy time series, all historic data should be representative for the future conditions and environment of operations.

- Where adjustments to the data have been introduced, such adjustments should have only been introduced to make the data more relevant and appropriate. The adjustments must be documented and shall satisfy the supervisor.
- Any bias in the data shall be borne in mind and its impact shall be analyzed.

3.130. When external data is used solely or as a combination of both internal and external data, data shall be directly relevant for the operations of that undertaking, i.e. this data shall accurately reflect the risk profile of the undertaking and be as suitable as, or complement, internal data.

3.131. Furthermore CEIOPS allows undertakings to use external pooled data. Pooled data can be useful in cases such as the launch a new product or when undertakings do not have sufficient internal data. For example, small health mutuals may not have a sufficient internal data to calculate own parameters and might therefore wish to use pooled data.

3.132. If undertakings use pooled data to calibrate undertaking-specific parameters, undertakings shall meet the following additional criteria:

- Governance of pooling mechanism and of new database is set up as well as signed and fulfilled by members of pooling mechanism.
- The pooling mechanism is transparent and auditable.
- The rules on data management shall ensure that the data provided to the pool by different members are sufficiently comparable: in particular this shall relate to data collection, definition, assessment and cleaning/adjustment.
- The pool shall comprise similar undertakings with similar risk profile not only among them but also to the undertaking, that is:
 - The pooled data shall represent data from undertakings with a similar risk profile and the nature of the business carried out is the same,
 - Where this impact on the degree of homogeneity of the data, the pool shall not include undertakings with different legal structure,
 - The pool of data shall be based on gross data of the business considered in order to allow each undertaking to derive values net of reinsurance by applying their own reinsurance programme.
 - In respect of the volatility levels estimated by the undertaking specific parameters, the undertaking shall verify whether the pooled data provide homogeneous features compared to those of the undertaking. In particular, where the size of the pooled data is significantly different from the size of risk exposures of the

an appropriate adjustment shall be carried out to guarantee that the undertaking specific parameters reflect the volatility of the undertaking rather than the volatility of the wider pooled data considered.

3.133. The general data quality requirements in relation to appropriateness, completeness and accuracy which apply to all replaceable parameters can be complemented by requirements that relate to particular replaceable parameters. These additional requirements, if needed, are provided together with the standardised method to calculate the undertaking-specific parameter. For example, particular requirements on the data for the average claim size and the average claim number estimations could be:

- the data should reflect the current reinsurance programme of the undertaking (i.e. either the data were observed under a comparable reinsurance cover or they were prepared for that purpose by taking gross data and applying the current reinsurance programme in order to estimate data net of reinsurance);
- the data should stem from a sufficiently long period such that if cycles exist, at least a full cycle is covered in the data. For example, if the average claim number for hail crop insurance needs to be estimated, it would not be appropriate to use only data from the past year where no big hail events were observed;
- the data is sufficiently homogeneous to produce a reliable estimate (this could be specified by limits on the coefficient of variation of the data set).

3.134. Supervisors shall have evidence that the data is monitored on a continuous basis. Undertakings shall carry out data quality checks on a regular basis and introduce processes to provide evidence of the accuracy, completeness and appropriateness of the data used.

3.135. If the undertaking does not satisfy the criteria required to be met in respect of the accuracy, completeness and appropriateness of the data used for estimating USP, undertakings are not able to use USP and other alternative action is required.

3.136. The application and relevance of the proportionality principle is limited due to the optional character of the use of undertaking-specific parameters and because poor quality data is unlikely to give rise to a more appropriate reflection in the parameter values of the risk profile than the standard formula. The replacement of the standard parameters must be justified by demonstrating that the estimation based on the internal data or external data is more appropriate and relevant to the undertaking's risk profile than that used otherwise.

3.137. The onus is on:

- the undertaking to demonstrate the fulfilment of the data requirement, and to demonstrate that the resultant USPs more appropriately reflect the risk profile of the undertaking,
- the supervisory authority to consider whether the historic data and any adjustments made to it are fit for purpose and in case of application of Article 110 whether the use of own but lower quality of data can compensate the significant deviation from the assumptions underlying the standard formula.

The standardised methods to calculate USP

3.138. Credibility mechanism shall be used when applying undertaking-specific parameters and shall be included for USP for both premium and reserve risk, because the estimators used in the standardised methods include a significant estimation error.

3.139. Undertakings shall derive the undertaking-specific parameters as follows:

For premium risk:

$$\sigma_{(prem,lob)} = c \cdot \sigma_{(U, prem,lob)} + (1 - c) \cdot \sigma_{(M, prem,lob)}$$

where

c = credibility factor for LOB,

$\sigma_{(U, prem,lob)}$ = undertaking-specific estimate of the standard deviation for premium risk,

$\sigma_{(M, prem,lob)}$ = standard parameters of the standard deviation for premium risk which are provided in CEIOPS' advice on Calibration of Non Life Underwriting Risk (Pending finalization of the advice in March 2010).

.For Reserve risk:

Undertakings shall derive new parameters as follows:

$$\sigma_{(res,lob)} = c \cdot \sigma_{(U, res,lob)} + (1 - c) \cdot \sigma_{(M, res,lob)}$$

where

c = credibility factor,

$\sigma_{(U, res,lob)}$ = undertaking-specific estimate of the standard deviation for reserve risk,

risk which are provided in CEIOPS' CP-71/09 on Calibration of Non Life Underwriting Risk (Pending finalization of the advice in March 2010).

3.140. The credibility factors to be applied shall be chosen according to the length of the time series N_{lob} used for the estimation and the LoB property. There are three cases:

a) **Use solely of internal data:** The undertaking-specific parameters are based on solely on internal data that meet the requirements set out in this advice and CEIOPS' Advice on data quality standards (CEIOPS-DOC-37/09, former CP 43):

- For Third-party liability, Motor vehicle liability and Credit and suretyship:

N_{lob}	5	6	7	8	9	10	11	12	13	14	≥ 15
C	34%	43%	51%	59%	67%	74%	81%	87%	92%	96%	100%

- for all other lines of business:

N_{lob}	5	6	7	8	9	≥ 10
C	34%	51%	67%	81%	92%	100%

b) **Use of external data:** The undertaking-specific parameters are based on solely on data which is directly relevant to the operations of the undertaking, provided they meet the requirements set out in this advice and CEIOPS' Advice on data quality standards (CEIOPS-DOC-37/09, former CP 43):

- For Third-party liability, Motor vehicle liability and Credit and suretyship:

N_{lob}	5	6	7	8	9	10	11	12	13	14	≥ 15
C	30%	34%	38%	42%	46%	50%	53%	56%	58%	61%	63%

- For all other lines of business:

N_{lob}	5	6	7	8	9	≥ 10
C	30%	38%	46%	53%	58%	63%

c) **Use of internal and external data:** the undertaking-specific parameters are based on a mixture of internal data and data directly relevant to the operations of the undertaking (that together meet the requirements set out in this advice and CEIOPS' Advice on data quality standards (CEIOPS-DOC-37/09, former CP 43): in such circumstances undertakings shall apply the credibility factors provided by the use of external data.

Premium Risk

a. Assumptions

3.141. Undertaking-specific parameters shall allow for expense volatility implicitly. Undertakings shall assume claims and expense volatility are similar, and thus no additional adjustments are needed to the volatility determined using loss ratio only.

3.142. Insurance and reinsurance undertakings shall adjust their data for inflation where the inflationary experience implicitly included in time series used is not representative of the inflation that might occur in the future, where this is considered to have a material impact – undertaking shall explain the approach taken.

b. Analysis

3.143. The analysis is performed using the net earned premiums as the volume measure and the net ultimate claims after one year to derive a standard deviation.

c. Standardised methods

3.144. CEIOPS does not consider one method to be perfect and proposes that undertakings apply a variety of methods to estimate their appropriate volatility.

3.145. Undertakings will be required to explain how and why they have selected the final factor, taking into consideration their risk profile.

3.146. The standardised methods for estimating the undertaking-specific parameters $\sigma_{(U, prem, lob)}$ are:

Method 1

3.147. This approach is consistent with the undertaking-specific estimate assumptions from the Technical Specifications for QIS 4.

3.148. The assumptions are that for the particular undertaking, any year and any LoB:

- The expected loss is proportional to the premium
- The company has a different but constant expected loss ratio (ie does not allow for premium rate changes)
- The variance of the loss is proportional to the earned premium and
- The least squares fitting approach is appropriate.

3.149.If we defined the following terms:

$U_{Y,lob}$	=	The ultimate after one year by accident year and LoB
μ_{lob}	=	Expected loss ratio by LoB
β_{lob}^2	=	Constant of proportionality for the variance of loss by LoB
$\varepsilon_{Y,lob}$	=	An unspecified random variable with distribution with mean zero and unit variance
$V_{Y,lob}$	=	Earned premium by accident year and LoB
N_{lob}	=	The number of data points available by LoB
V_{lob}	=	The result from the volume calculation from the current year $V_{lob} = \max(\text{estimate of net written premium during the forthcoming year, estimate of net earned premium during the forthcoming year, net written premium during the previous year}) + \text{expected present value of net claims and expense payments which relate to claims incurred after the following year and covered by existing contracts}$

Then we can formulate the distribution of losses as:

$$U_{Y,lob} \sim V_{Y,lob}\mu_{lob} + \sqrt{V_{Y,lob}}\beta_{lob}\varepsilon_{Y,lob}$$

We can re-arrange this to give us a set of independent, identically distributed observations:

$$\beta_{lob}\varepsilon_{Y,lob} = \frac{U_{Y,lob} - V_{Y,lob}\mu_{lob}}{\sqrt{V_{Y,lob}}}$$

Our estimator for β_{lob} becomes:

$$\hat{\beta}_{lob}^2 = \frac{1}{N_{lob} - 1} \sum_Y \frac{(U_{Y,lob} - V_{Y,lob}\mu_{lob})^2}{V_{Y,lob}}$$

Minimising this estimator we obtain:

$$\hat{\mu}_{lob} = \frac{\sum_Y U_{Y,lob}}{\sum_Y V_{Y,lob}}$$

Which we can substitute back into our estimator of β_{lob} which becomes:

$$\hat{\beta}_{lob} = \sqrt{\frac{1}{N_{lob} - 1} \sum_Y \frac{\left(U_{Y,lob} - V_{Y,lob} \frac{\sum_Y U_{Y,lob}}{\sum_Y V_{Y,lob}} \right)^2}{V_{Y,lob}}}$$

3.150. The standard deviation $\sigma_{(U, prem, lob)}$ then becomes :

$$\sigma_{(U, prem, lob)} = \frac{\hat{\beta}_{lob}}{\sqrt{V_{lob}}}$$

3.151. The additional data requirements for this undertaking-specific parameter:

The data used should meet the following additional requirements:

- The data should reflect the premium risk that is covered in the line of business during the following year, in particular in relation to its nature and composition. The data should be adjusted for catastrophe claims to the extent they are addressed in the non-life or health CAT risk sub-modules.
- Claims should be net of reinsurance. The data should reflect the reinsurance cover of the undertaking for the following year.
- Claims should be adjusted for inflation. All data used should be adjusted for any trends which can be identified on a prudent, reliable and objective basis.
- Claim should not include unallocated expense payments.
- The data should stem from a sufficiently long period such that if cycles exist, at least a full cycle is covered in the data. The data should at least cover 5 years.
- The data should not lead to the increase of the estimation error to the material amount compared to the estimated value.

Method 2

3.152. This approach is consistent with the undertaking-specific estimate assumptions from the Technical Specifications for QIS 4.

3.153. The assumptions are that for the particular undertaking, any year and any LoB:

- The expected loss is proportional to the premium
- The company has a different but constant expected loss ratio (for example the undertaking does not allow for premium rate changes, or changes in the underlying risk)

- The variance of the loss is proportional to the earned premium
- The distribution of the loss is lognormal and
- The maximum likelihood fitting approach is appropriate

3.154. If we defined the following terms:

$U_{Y,lob}$	=	The ultimate after one year by accident year and LoB
μ_{lob}	=	Expected loss ratio by LoB
β_{lob}^2	=	Constant of proportionality for the variance of loss by LoB
$\epsilon_{Y,lob}$	=	An unspecified random variable with distribution with mean zero and unit variance
$V_{Y,lob}$	=	Earned premium by accident year and LoB
$M_{Y,lob}$	=	The mean of the logarithm of the ultimate after one year by accident year and LoB
$S_{Y,lob}$	=	The standard deviation of the logarithm of the ultimate after one year by accident year and LoB
V_{lob}	=	The result from the volume calculation from the current year $V_{lob} = \max(\text{estimate of net written premium during the forthcoming year, estimate of net earned premium during the forthcoming year, net written premium during the previous year}) + \text{expected present value of net claims and expense payments which relate to claims incurred after the following year and covered by existing contracts}$

3.155. Then we can formulate the distribution of losses as:

$$U_{Y,lob} \sim V_{Y,lob} \mu_{lob} + \sqrt{V_{Y,lob}} \beta_{lob} \epsilon_{Y,lob}$$

3.156. This allows us to formulate our parameters of the lognormal distributions as follows:

$$S_{Y,lob} = \sqrt{\log \left(1 + \frac{\beta_{lob}^2}{V_{Y,lob} \mu_{lob}^2} \right)}$$

$$M_{Y,lob} = \log(V_{Y,lob} \mu_{lob}) - \frac{1}{2} S_{lob}^2$$

3.157. The resultant simplified log Likelihood becomes

$$\log L = \sum_Y \left(-\log(S_{Y,lob}) - \frac{(\log(U_{Y,lob}) - M_{Y,lob})^2}{2S_{Y,lob}^2} \right)$$

3.158. We then choose the parameter values β_{lob} and μ_{lob} that maximise this likelihood.

3.159. The standard deviation $\sigma_{(U,prem,lob)}$ then becomes :

$$\sigma_{(U,prem,lob)} = \frac{\hat{\beta}_{lob}}{\sqrt{V_{lob}}}$$

3.160. The additional data requirements for this undertaking-specific parameter are stated in paragraph 3.63.

Method 3

3.161. Since the method defined above for the calculation undertaking-specific estimates for standard deviation of premium risk include a significant estimation error, CEIOPS considers an alternative methodology based on the Swiss Solvency Test¹⁵.

3.162. Under this approach, the calculation of undertaking-specific standard deviations in premium risk are based on the assumption that the claim number per accident year and claim size depend on a random variable $\Theta = [\Theta_1, \Theta_2]$ which represents the random fluctuation in number (Θ_1) as well as in claim size (Θ_2).

As:

$$\sigma_{(U,prem,lob)} = \frac{1}{V_{(prem,lob)}} \sqrt{\text{Var}(S_N)}, \text{ where}$$

$V_{(prem,lob)}$ - volume measure (known at the beginning of the year),

$S_N = \sum_{i=1}^N X_i$ - sum of a random number of claims, the claim size itself is also random,

and we assume that

$$N|\Theta_1 \sim \text{Pois}(\lambda(\Theta_1)),$$

$X_i|\Theta_2 \sim F(\mu(\Theta_2),\sigma(\Theta_2))$, where N and X_i are conditionally independent, λ, μ and σ denote the parameters of the distributions

using the variance decomposition formula and the above assumptions it is easy to show that:

$$\begin{aligned} \text{Var}(S_N) &= \text{Var}(E(S_N | \Theta)) + E(\text{Var}(S_N | \Theta)) = \\ &= \text{Var}(\lambda(\Theta_1))\text{Var}(\mu(\Theta_2)) + \text{Var}(\lambda(\Theta_1))(E[\mu(\Theta_2)])^2 + \text{Var}(\mu(\Theta_2))E[\lambda(\Theta_1)]^2 + \\ &+ E(\lambda(\Theta_1))E[\mu(\Theta_2)]^2 + E\lambda(\Theta_1)E[\sigma(\Theta_2)]^2, \end{aligned}$$

which allows to use only characteristics of the underlying distributions N and X in the estimation.

3.163. For the simplifying assumptions that only N depends on Θ and $\lambda(\Theta) = \lambda\Theta$, where $E(\Theta)=1$ we get¹⁶:

$$\text{Var}(S_N) = \mu^2 \lambda^2 \text{Var}(\Theta) + \lambda \mu^2 + \lambda \sigma^2$$

Therefore the undertaking should calculate, on the basis of the internal data of the undertaking concerned, or of data which is directly relevant for the operations of that undertaking, the following input data:

μ = the average value of claim size in the individual LoB with an inflation adjustment; the estimate should be derived by

- summing up past, inflation adjusted individual ultimate claims values,
- dividing above sum by the number of claims.

σ = the standard deviation of claim size in the individual LoB with an inflation adjustment estimated by means of the standard estimator

λ = the average number of claims in the individual LoB per earned premium by:

average number of claims = total number of claims/total earned premiums with an inflation adjustment)

multiplying the average number of claims with $V_{(prem,lob)}$

If a volume measure other than earned premiums appears to be statistically more appropriate and this can be justified by the

undertaking, the volume measure may replace earned premiums in the above procedure.

$Var(\Theta)$ = estimate of the variance of random factor in the claim number in the individual LoB during the forthcoming year;

3.164. Insurance and reinsurance undertakings should estimate $Var(\Theta)$ based on following input data:

J = maximum numbers of years with available data based on which undertaking calculate USP

N_j = numbers of claims in year j

v_j = A priori expected number of claims in year j

Insurance and reinsurance undertakings should estimate $Var(\Theta)$ as¹⁷:

$Var(\Theta) = \left(c \cdot \frac{v_{\bullet}}{J} \right)^{-1} \left(\frac{V_F}{\bar{F}} - 1 \right)$, where:

$$F_j = \frac{N_j}{v_j},$$

$$v_{\bullet} = \sum_{j=1}^J v_j,$$

$$\bar{F} = \sum_{j=1}^J \frac{v_j}{v_{\bullet}} F_j,$$

$$V_F = \frac{1}{J-1} \sum_{j=1}^J v_j (F_j - \bar{F})^2,$$

$$c = \sum_{j=1}^J \frac{v_j}{v_{\bullet}} \left(1 - \frac{v_j}{v_{\bullet}} \right).$$

3.165. The data used for this undertaking-specific parameter to estimate μ , σ , λ and $Var(\Theta)$ should meet the following additional requirements:

- The data should reflect the premium risk that is covered in the line of business during the following year, in particular in relation to its nature and composition. The data should be adjusted for catastrophe claims to the extent they are addressed in the non-life or health CAT risk sub-modules.

- Claim sizes should be net of reinsurance. The data should reflect the reinsurance cover of the undertaking for the following year. Elements of reinsurance which cannot be related to individual claims (e.g. stop loss reinsurance) should be taken into account in an appropriate manner.
- Claim sizes should be adjusted for inflation. All data used should be adjusted for any trends which can be identified on a prudent, reliable and objective basis.
- Claim sizes should not include expense payments.
- The data should stem from a sufficiently long period such that full cycles exist, at least a full cycle is covered in the data. The data used to estimate $Var\lambda(\Theta)$ should at least cover 5 years.
- The data should not lead to the increase of the estimation error to the material amount compared to the estimated value.
- The level of prudence in the earned premiums used to estimate $E\lambda(\Theta)$ should be similar. Any other volume measure used should reflect the number of claims.

Reserve Risk

a. Assumptions

3.166. For expenses, undertakings shall analyse claims payments excluding amounts for expenses. We assume claims and expense volatility are similar, and thus no additional adjustments are needed to the volatility determined using claims data only.

3.167. The effect of discounting will be the same in the stressed scenario as in the best estimate. As a result, no modification to our result is necessary.

3.168. Insurance and reinsurance undertakings shall adjust their data for inflation where the inflationary experience implicitly included in time series used is not representative of the inflation that might occur in the future, for example in the case of bodily injury claims.

b. Analysis

3.169. The analysis is performed using:

- the opening value of the net reserves as the volume measure and the net claims development result after one year for these exposures to derive a standard deviation.
- the net paid or net incurred triangle.

3.170. Under the Merz-Wüthrich approach used in methods 2 and 3 below, the estimator explicitly only captures the prediction error and does not capture model error (for example the chain ladder assumptions do not hold) or the error in case the past data do not reflect the future business. For these reasons, the estimated parameters should be complemented with a component for model error as follows:

$$\sigma_{(U, res, lob)} = \sqrt{\sigma_{(U, res, lob)}^2 + \tau^2}$$

where τ reflects the model error. Based on the assumption that this risk is independent from the prediction error, the square root formula is used for aggregation.

As the parameter τ reflects the model error which is an inherent feature of these methods it cannot be set to zero. However, the exact amount of the τ can be different among undertakings or lines of business. Therefore CEIOPS does not fix the amount, but expects that with the increasing experience regarding using the methods the parameter can be assessed properly.

c. Standardised methods

3.171. CEIOPS does not consider one method to be perfect and proposes that undertakings apply a variety of methods to estimate their volatility.

3.172. Undertakings will be required to explain how and why they have selected the final factor, taking into consideration their risk profile.

3.173. The standardised methods for estimating the undertaking-specific parameters $\sigma'_{(U, res, lob)}$ are:

Method 1

3.174. This approach is consistent with the undertaking-specific estimate assumptions from the Technical Specifications for QIS 4 for reserve risk.

3.175. The assumptions are that for any undertaking, any year and any LoB:

- The expected reserves in one year plus the expected incremental paid claims in one year is the current best estimate for claims outstanding,
- The variance of the best estimate for claims outstanding in one year plus the incremental claims paid over the one year is proportional to the current best estimate for claims outstanding, and
- The least squares fitting approach is appropriate.

3.176. If we defined the following terms:

β_{lob}^2	=	Constant of proportionality for the variance of the best estimate for claims outstanding in one year plus the incremental claims paid over the one year by LoB
$\epsilon_{Y,lob}$	=	An unspecified random variable with distribution with mean zero and unit variance
$PCO_{lob,i,j}$	=	The best estimate for claims outstanding by LoB for accident year i and development year j
$I_{lob,i,j}$	=	The incremental paid claims by LoB for accident year i and development year j
$V_{Y,lob}$	=	Volume measure by calendar year and LoB
$R_{Y,lob}$	=	The best estimate for outstanding claims and incremental paid claims for the exposures covered by the volume measure, but in one year's time by calendar year and LoB
N_{lob}	=	The number of data points available by LoB where there is both a value of $V_{C,Y,lob}$ and $R_{C,Y,lob}$.
PCO_{lob}	=	The best estimate for claims outstanding by LoB

3.177. Then we can define the following relationships:

$$V_{Y,lob} = \sum_{i+j=Y+1} PCO_{lob,i,j}$$

$$R_{Y,lob} = \sum_{\substack{i+j=Y+2 \\ i \neq Y+1}} PCO_{lob,i,j} + \sum_{\substack{i+j=Y+2 \\ i \neq Y+1}} I_{lob,i,j}$$

3.178. Then we can formulate the distribution of losses as:

$$R_{Y,lob} \sim V_{Y,lob} + \sqrt{V_{Y,lob}} \beta_{lob} \epsilon_{Y,lob}$$

3.179. We can re-arrange this to give us a set of independent, identically distributed observations:

$$\beta_{lob} \epsilon_{Y,lob} = \frac{R_{Y,lob} - V_{Y,lob}}{\sqrt{V_{Y,lob}}}$$

3.180. Our estimator for β_{lob} becomes:

$$\hat{\beta}_{lob} = \sqrt{\frac{1}{N_{lob} - 1} \sum_Y \frac{(R_{Y,lob} - V_{Y,lob})^2}{V_{Y,lob}}}$$

3.181. The $\sigma_{(U, res, lob)}$ then becomes :

$$\sigma_{(U, res, lob)} = \frac{\hat{\beta}_{lob}}{\sqrt{PCO_{lob}}}$$

3.182. The additional data requirements for this undertaking-specific parameter:

The data used should meet the following additional requirements:

- The data should reflect the reserve risk that is covered in the line of business during the following year, in particular in relation to its nature and composition.
- Best estimates and payments should be net of reinsurance. The data should reflect the reinsurance cover of the undertaking for the following year (i.e. either the data were observed under a comparable reinsurance cover or they were prepared for that purpose by taking gross data and applying the current reinsurance programme in order to estimate data net of reinsurance).
- Best estimates and payments should be adjusted for inflation. All data used should be adjusted for any trends which can be identified on a prudent, reliable and objective basis.
- Best estimates and payments should not include expenses.
- The data should stem from a sufficiently long period such that if cycles exist, at least a full cycle is covered in the data. The data should at least cover 5 years.
- •The data should not lead to the increase of the estimation error to the material amount compared to the estimated value.

Method 2

3.183. This approach is based on the mean squared error of prediction of the claims development result over the one year and fitting a model to these results. The mean squared errors are calculated using the approach detailed in "Modelling The Claims Development Result For Solvency Purposes" by Michael Merz and Mario V Wüthrich, Casualty Actuarial Society E-Forum, Fall 2008¹⁸.

3.184. The output from the Merz and Wüthrich method would be:

$$\sqrt{MSEP} = \sigma_{(U, res, lob)} * PCO_{lob}$$

3.185. Therefore $\sigma'_{(U, res, lob)} = \frac{\sqrt{MSEP}}{PCO_{lob}}$

3.186. The additional data requirements for this undertaking-specific parameter:

The data used should meet the following additional requirements:

- The estimation should be made on complete claims triangles for payments. The data should stem from a sufficiently long period such that all material payments can be estimated from the triangle. The data should at least cover 5 years.
- The data should reflect the reserve risk that is covered in the line of business during the following year, in particular in relation to its nature and composition.
- Payments should be net of reinsurance. The data should reflect the reinsurance cover of the undertaking for the following year (i.e. either the data were observed under a comparable reinsurance cover or they were prepared for that purpose by taking gross data and applying the current reinsurance programme in order to estimate data net of reinsurance).
- Best estimates and payments should be adjusted for inflation. All data used should be adjusted for any trends which can be identified on a prudent, reliable and objective basis.
- The payments should not include expenses.
- The claims triangle should be consistent with the model assumptions of the Merz and Wüthrich method.
- The data should not lead to the increase of the estimation error to the material amount compared to the estimated value.

Method 3

3.187. This approach is essentially consistent with the standard formula representation of the relationship between volatility of future reserve deterioration and volume.

3.188. This approach is based on calculating the mean squared error of prediction of the claims development result over the one year and fitting a model to these results. The mean squared errors are calculated using the approach detailed in "Modelling The Claims Development Result For Solvency Purposes" by Michael Merz and Mario V Wüthrich, Casualty Actuarial Society E-Forum, Fall 2008.

3.189.

$CLPCO_{lob}$	=	The best estimate for claims outstanding by LoB estimated via the Chain Ladder method
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$$\text{Therefore } \sigma'_{(U, \text{res}, \text{lob})} = \frac{\sqrt{\text{MSEP}}}{\text{CLPCO}_{\text{lob}}}.$$

3.190. The additional data requirements for this undertaking-specific parameter are stated in paragraph 3.101.

Shock for revision risk

3.191. These undertaking-specific parameters shall be calculated by following standardised method.

3.192. Revision risk is intended to capture the risk of adverse variation of an annuity's amount, as a result of an unanticipated revision of the claims process. This risk should be applied only to annuities and to those benefits that can be approximated by a life annuity arising from non-life claims (in particular, life assistance benefits from workers' compensation LoB). The undertaking-specific shock for revision risk is restricted only to workers' compensation or to annuities which are not significantly subject to inflation risk. This restriction stems from the assumption in calculation procedure, that the number and severity of revisions are independent. In case of inflation the number and severity are usually dependent because the value of inflation determines which annuities will be revised and the severity of this revision.

3.193. On the computation of this risk charge, it shall be considered the impact on those annuities for which a revision process is possible to occur during the next year (e.g. annuities where there are legal or other eligibility restrictions should not be included). Unless the future amounts payable are fixed and known with certainty, all those benefits that can be approximated by a life annuity (life assistance) are also subject to revision risk.

3.194. In order to derive undertaking-specific parameters for revision risk, undertaking concerned shall use time series of annual amounts of individual annuities (life assistance benefits) in payment in consecutive years, during the time horizon in which they are subject to revision risk.

Input data:

μ_x	=	the historical average relative change of individual annuities (or life assistance benefits)
σ_x	=	the historical standard deviation of relative change of individual annuities (or life assistance benefits), estimated by means of the standard estimator
$E(N)$	=	estimate of percentage of individual annuities (or life assistance benefits) for which a revision

process is possible to occur during the forthcoming year; the estimate shall be derived by

- estimating the average percentage of individual annuities (or life assistance benefits) for which a revision process occurred per best estimate of annuities provision (average percentage of revised annuities = (total number of revised annuities / total number of annuities) / total best estimate of annuities provision),

- multiplying the average percentage of individual annuities (or life assistance benefits) with best estimate of annuities provision.

If a volume measure other than best estimate of annuities provision appears to be statistically more appropriate and this can be justified by the undertaking, the volume measure may replace in the above procedure.

σ_N = the historical standard deviation of percentage of individual annuities (or life assistance benefits) for which a revision process occurred), estimated by means of the standard estimator

3.195. Calculation procedure:

- For each calendar year t , identify the set of annuities (or life assistance claims) that were exposed to revision risk during the whole year. Include also those individual annuities that were exposed only during a part of the year, but where an upward revision has effectively occurred in that period. Annuities (or life assistance claims) that entered or exited the books during the period (e.g. new claims, death of the beneficiary) should be excluded.
- Statistical fitting techniques should then be applied to these sets of observations, with the objective to fit a theoretical probability distribution to the relevant random variable Rev describing the 1-year percentage change in the annual amount of annuities (or life assistance claims) at the portfolio level.
- Insurers are expected to validate the goodness-of-fit of all the distributions and assumptions made, using the sets of observations above derived. Particular attention should be paid to the robustness of the fitting techniques to the tails of the distributions. Non satisfactory results in these tests would be sufficient conditions to

analysis.

- The next step is to calculate the mean and standard deviation of the distribution of Rev using the appropriate and unbiased estimators and the sets of observations.
- The relevant size of the shock (Revshock) is then given by the difference between the quantile 99.5% $VaR_{0.995}(Rev)$ and its average \overline{Rev} divided by the average. In this step, it should be confirmed that the 'average' rate of revision assumed in the best estimate calculation is consistent with this result.

3.196. The calculation of undertaking-specific revision shock in revision risk is based on the assumption that the frequency and the severity of revision depend on a random variable Θ which represents the random in the frequency process as well as in the severity of revision.

As:

$$Rev_{shock} = \frac{VaR_{0.995}(Rev) - \overline{Rev}}{\overline{Rev}}, \text{ where}$$

$$\overline{Rev} = \sum_{i=1}^N X_i \text{ - sum of a random cases of annuities revision,}$$

and we assume that

$$N|\Theta \sim NB(\alpha(\Theta), q(\Theta)),$$

$X_i|\Theta \sim LN(\mu(\Theta), \sigma(\Theta))$, where N and X_i are conditionally independent, α, q, μ and σ denote the parameters of the distributions.

Therefore

$$\overline{Rev} = \mu_x E(N) \text{ - the average of the distribution,}$$

$$VaR_{0.995}(Rev) = f(\mu_x, \sigma_x, E(N), \sigma_N).$$

3.197. $VaR_{0.995}(Rev)$ shall be derived using simulation. The undertaking shall:

- I. simulate one number n_j from $NB(E(N), \sigma_N)$,
- II. simulate n_j numbers of x_i from $LN(\mu_x, \sigma_x)$, $i=1, \dots, n_j$,
- III. calculate $Rev_j = \sum_{i=1}^{n_j} x_i$,
- IV. repeat 50 000 times steps I – III, which means calculate Rev_j for $j=1, \dots, 50\,000$,

V. calculate $VaR_{0,995}(Rev)$ as $F_{Rev_j}^{-1}(0.995)$ of simulated values.

3.198. The additional data requirements for this undertaking-specific parameter:

- The goodness-of-fit of the distributions and assumptions to the sets of observations should be considered satisfactory. In particular, the estimates of the average, standard deviation and 99.5% quantile of the *Rev* distribution should be sufficiently robust.
- The number of available historical years, and the number of annuities (or life assistance claims) within each year should be sufficiently large to allow for statistically credible results.
- The mix of types of annuities (or life assistance claims) should be relatively comparable across different years and should be representative of the current portfolio.
- There should not be structural changes in the environment, which could lead to a significant change in the behaviour of the revision risk drivers (e.g. change in legislation), both during the historical period and when compared with the expectations for next year.