

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

**SCR Standard Formula
Calibration of the Health Underwriting
Risk**

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1. Executive summary

- 1.1. This paper provides the proposed calibration of the health underwriting risk module (premium and reserve sub-modules) in accordance with the requirements of Article 104 of the Level 1 text¹. This is the revised version of CP72, following stakeholder feedback from consultation and further collection of data.
- 1.2. The Commission has requested CEIOPS to base its recommendations on evidence from as wide a range of Member States and types of undertakings within the EEA as possible. CEIOPS members have provided a wider range of data than was available for the QIS3, QIS4 and previous CP71 analysis exercises. However this data was mainly gross of reinsurance, with a more limited coverage of net of reinsurance data. Consequently CEIOPS decided to perform the main analysis using exclusively gross of reinsurance data, and has produced separate recommendations on how to obtain appropriate net factors to use in the SCR standard formula.

Data

- 1.3. The data used for this exercise comes from fifteen Member States. This represents a significant improvement compared to previous calibration exercises undertaken by CEIOPS. Only six Member States provided data for the previous CP72 analysis, and only three for QIS3 and QIS4.
- 1.4. The data was judgementally filtered to remove, to the best possible extent as best as possible:
 - Distortions due to mergers and acquisitions
 - Typographic mistakes
 - Apparent inconsistencies between different years and between opening reserve and closing reserve for the same company
 - Catastrophe losses
 - As well as other features which were considered to be incorrect based on expert judgement.
- 1.5. Data available for some lines of business was still limited despite collecting further data. The analysis produced for these lines of business is thus naturally not as robust as that for lines of business with more data.

Assumptions

¹ Article 104 of the Level 1 text states that each of the risk modules referred to in paragraph 1 shall be calibrated using a Value at Risk measure with a 99.5% confidence level, over a one year period

- 1.6. CEIOPS has performed the analysis in line with the requirements underlying the design of the standard formula, such as:
- Provide an estimate for a set of factors which are pan-European
 - Allowance has been made for an average level of geographical diversification, as implied by the data.
 - No allowance for underwriting cycle
 - No allowance for expected profits and losses
 - No allowance for a size factor ie diversification by volume. This has the implication that the proposed calibration may overestimate for large portfolios and underestimate for small portfolios.
- 1.7. In addition:
- No explicit allowance has been made for inflation in the calibration process. Implicitly therefore it assumed that the inflationary experience in the period 1999 to 2008 was representative of the inflation that might occur in the future. The period analysed was a relatively benign period with low inflation in the countries supplying data and without unexpected inflation shocks which might be expected to increase the factors.
 - When assessing the capital requirements under the standard formula approach, the impact on the net asset value (difference between asset market value and insurance liabilities) is assessed under the assumption that the risk margin does not change after the stress.
- 1.8. CEIOPS would like to highlight that any changes made to the assumptions underlying the design of the standard formula would require a recalibration of the proposed factors.

Methodologies

- 1.9. A range of methodologies was used to test different sets of assumptions and goodness of fit. The methods used were based on sound statistical analysis and (some) were based on published actuarial papers. Some of the methods are directly comparable to the methods used under QIS 4.
- 1.10. A variety of methods was used to estimate the factors across all undertakings and Member States for each line of business. However results vary across methods because each method uses different underlying assumptions. For example:
- Some methods will place more weight on volatilities estimated for larger companies which tend to have lower standard deviations thus producing a lower overall result.
 - Other methods will give an equal weight to each undertaking and as a result will tend to produce a higher overall result.

Results

- 1.11. The final gross technical fitted result across all methods was derived by taking an average of the methods that best fit the data. CEIOPS would like to highlight that the selection was not conservatively selected, but rather based on the goodness of fit results and the adequacy of the method. Furthermore by taking an average, CEIOPS is ensuring that the factors are not biased towards factors most appropriate for larger portfolios (and hence lower). The analysis shows that for most lines of business the factors should be higher for smaller and medium portfolios.
- 1.12. In line with industry comments, CEIOPS has recommended an adjustment factor for Premium Risk that is undertaking specific, and so it is not possible to provide a net premium factor. For reserve risk, CEIOPS used the net data available from Member States to estimate an adjustment to the gross estimate.
- 1.13. To get a further insight and consider other information available, CEIOPS supplemented the above analysis with additional exercises provided by CEIOPS or the industry. These additional exercises also suggest that factors proposed for QIS4 may not be appropriate at least for some lines of business.
- 1.14. Having considered the results from the technical analysis along with these other analyses and wider considerations, CEIOPS recommends that the factors for the premium and reserve risk sub modules should be as follows:

LOB	Net premium factor ²	Net reserve factor
Accident	12.5%*(NCR _i /GCR _i)	17.5%
Sickness	9.5%*(NCR _i /GCR _i)	12.5%
Workers compensation	5.5%*(NCR _i /GCR _i)	12%

Observations

- 1.15. Throughout this document, CEIOPS has endeavoured to show transparency in the process it has followed as far as possible.
- 1.16. The increase is significant for sickness and accident. However based on the data provided, the analysis does not support a lower calibration.
- 1.17. Finally CEIOPS recognises that as the Standard Formula is intended to be pan-European, it is not possible to select a factor that fits all portfolio specificities and works perfectly for all undertakings operating in the EEA. The Solvency 2 framework provides a wide range of approaches for an undertaking to determine its SCR. Undertakings that consider that some or all of the standard parameters within the Standard Formula do not appropriately reflect their risk profile, may wish to consider using undertaking specific parameters or applying for the approval of a (partial) internal model.

² CEIOPS has recommended an adjustment factor for Premium Risk that is undertaking specific, and so it is not possible to provide a net premium factor. NCR and GCR stand for net combined ratio and gross combined ratio respectively

2. Introduction

- 2.1. 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.
- 2.2. This paper aims at providing advice with regard to the calibration of the health underwriting risk module. In particular, it includes a description of the data, analysis, assumptions and methodology used to calibrate the standard deviations required for the calculation of the health risk sub-module.
- 2.3. This advice does not include details of the calibration of the catastrophe risk. Advice on the standardised scenarios required under the SLT Health catastrophe risk sub-module and the non-SLT Health catastrophe risk sub-module shall be provided for June 2010.
- 2.4. This advice should be read in conjunction with CEIOPS advice on the design of the SCR Standard Formula Health Underwriting Risk (CEIOPS DOC-43-09)³.

³ <http://www.ceiops.eu/media/files/consultations/consultationpapers/CP50/CEIOPS-L2-Final-Advice-on-Standard-Formula-Health-underwriting-risk.pdf>

3. Extract from the Level 1 Text

Legal basis for implementing measure

- 3.1. According to the guiding principles referred to in the Commission's letter, the legal basis for the advice presented in this paper is primarily found in Article 109 (1)(f) of the Level 1 text, which states:⁴

Article 111 – Implementing measures

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:

- (a) a standard formula in accordance with the provisions of Articles 101 and 103 to 109;
- (b) any sub-modules necessary or covering more precisely the risks which fall under the respective risk modules referred to in Article 104 as well as any subsequent updates;
- (c) the methods, assumptions and standard parameters to be used, when calculating each of the risk modules or sub-modules of the Basic Solvency Capital Requirement laid down in Articles 104, 105 and 304[...];

Other relevant Articles for providing background to the advice

Article 101 - Calculation of the Solvency Capital Requirement

1. The Solvency Capital Requirement shall be calculated in accordance with paragraphs 2 to 5:
2. The Solvency Capital Requirement shall be calculated on the presumption that the undertaking will carry on its business as a going concern.
3. The Solvency Capital Requirement shall be calibrated so as to ensure that all quantifiable risks to which an insurance or reinsurance undertaking is exposed are taken into account. It shall cover existing business, as well as the new business expected to be written over the next twelve months. With respect to existing business, it shall cover unexpected losses only.

It shall correspond to the Value-at-Risk of the basic own funds of an insurance or reinsurance undertaking subject to a confidence level of 99.5% over a one-year period.

4. The Solvency Capital Requirement shall cover at least the following risks:
 - (c) health underwriting risk;[...]

⁴ 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>

- 5 When calculating the Solvency Capital Requirement, insurance and reinsurance undertakings shall take account of the effect of risk mitigation techniques, provided that credit risk and other risks arising from the use of such techniques are properly reflected in the Solvency Capital Requirement.

Article 104 - Design of the Basic Solvency Capital Requirement

1. The Basic Solvency Capital Requirement shall comprise individual risk modules, which are aggregated in accordance with point 1 of Annex IV.

It shall consist of at least the following risk modules:

- (a) non-life underwriting risk;
- (b) life underwriting risk;
- (c) health underwriting risk;
- (d) market risk,
- (e) counterparty default risk.

[...]

6. With regard to risks arising from catastrophes, geographical specifications may, where appropriate, be used for the calculation of the life, non-life and health underwriting risk modules.

Article 105 - Calculation of the Solvency Capital Requirement

[...] The health underwriting risk module shall reflect the risk arising from the underwriting of health insurance obligations, whether it is pursued on a similar technical basis to that of life insurance or not, following from both the perils covered and the processes used in the conduct of business.

It shall cover at least the following risks:

- (a) the risk of loss, or of adverse change in the value of insurance liabilities, resulting from changes in the level, trend, or volatility of the expenses incurred in servicing insurance or reinsurance contracts;
- (b) the risk of loss, or of adverse change in the value of insurance liabilities, resulting from fluctuations in the timing, frequency and severity of insured events, and in the timing and amount of claim settlements at the time of provisioning;
- (c) the risk of loss, or of adverse change in the value of insurance liabilities, resulting from the significant uncertainty of pricing and provisioning assumptions related to outbreaks of major epidemics, as well as the unusual accumulation of risks under such extreme circumstances.

4. Advice

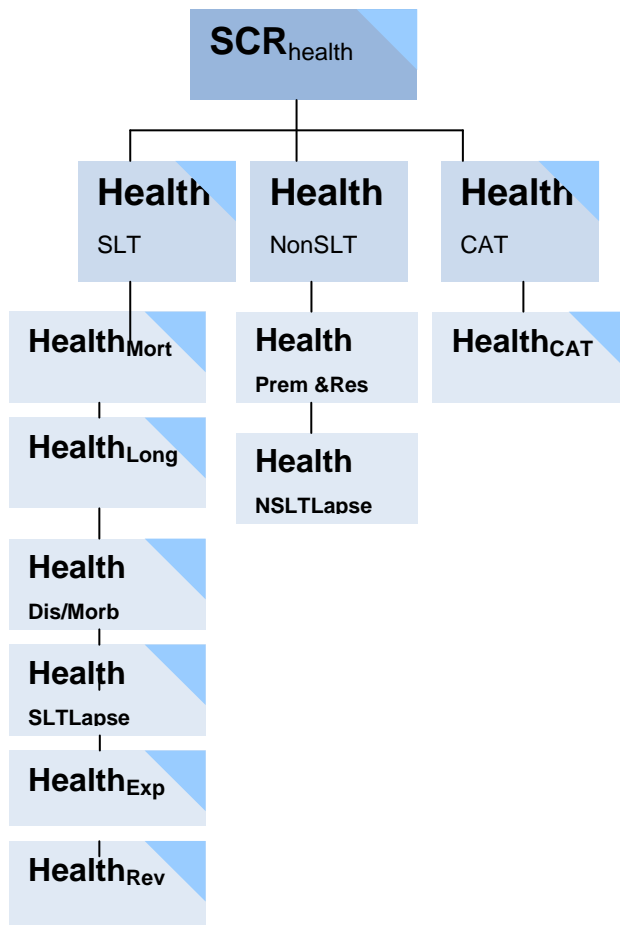
4.1 Explanatory text

4.1. CP50 provided a draft advice in respect of the design of the health underwriting risk module, on the scope of the module and the calculation of the capital requirement for risk arising from the underwriting of health insurance obligations, where it is pursued on a similar technical basis to that of life insurance or not, following from both the perils covered and the processes used in the conduct of business.

4.2. Health underwriting risks are split into 3 categories:

- Health insurance obligations pursued on a similar technical basis to that of life insurance (SLT Health)
- Health insurance obligations not pursued on a similar technical basis to that of life insurance (Non-SLT Health).
- Health insurance obligations Catastrophe risk (Health CAT)

Overall description:



4.2 SLT Health underwriting risk

SLT Health mortality risk

4.3. No health-specific analysis for the calibration of mortality risk was made. As there are no indications that the mortality risk of health obligations differs substantially from the mortality risk of life obligations, the same shock is assumed as for the life underwriting risk module specified in CEIOPS' Advice on Life Underwriting Risk (former CP49, now CEIOPS-DOC-42-09, see <http://www.ceiops.eu//content/view/17/21/>).

SLT Health longevity risk

4.4. No health-specific analysis for the calibration of longevity risk was made. As there are no indications that the longevity risk of health obligations differs substantially from the longevity risk of life obligations, the same shock is assumed as for the life underwriting risk module specified in Draft CEIOPS' Advice on Life Underwriting Risk (former CP49, now CEIOPS-DOC-42-09).

SLT Health disability risk for medical insurance

4.5. For medical insurance, disability/morbidity risk can be split into three components:

- The assumption on the trend of health claims needs to be revised (inflation risk).
- The assumptions on the level of claims need to be revised because the level estimated from past observations deviates from the underlying claims level of the observations (estimation risk).
- The assumptions on the level of claims need to be revised for any other reason than estimation risk (e.g. model risk, risk of change, random error)

4.6. There is no reliable database to estimate the volatility of medical inflation on a 99.5% VaR level. For the calculation of the expense risk sub-module an increase of inflation by 1% (in absolute terms) is proposed. Although the level of medical inflation may deviate from the level of general expense inflation, there are no indications that the variability of the level is significantly different. Therefore, the same inflation shock as for expense risk is proposed.

4.7. For estimation risk, a shock can be derived as follows: It is assumed that undertakings estimate the level of claims from the last five observations, i.e. the annual inflation-adjusted claims for the last five years. If the distribution of annual claims is assumed to be approximately normal, the estimation error on a 99.5%-VaR level can be calculated as follows:

$$\text{estimation error} = \frac{N^{-1}(0.995)}{\sqrt{5}} \cdot \sigma \approx 1.15 \cdot \sigma$$

where N is the cumulative distribution function of the standard normal distribution and σ the standard deviation of annual claims.⁵

- 4.8. From data of the German health insurance market the standard deviation of annual claims was estimated for 37 health insurance undertakings. In order to allow for inflation and portfolio changes the annual claims were standardised with the expected annual claims as taken into account in the premium calculation. The standard deviations varied from 2% to 10% of the expected annual claims; the average value was 4.4%. According to the formula of the above paragraph, the estimation error is 5% of the expected annual claims. The resulting scenario for a permanent increase of the claims level is a relative increase of 5%.

SLT Health disability risk for income insurance

- 4.9. No specific analysis was made. As there are no indications that the disability risk of health obligations differs substantially from the disability risk of life obligations, the same shock is assumed as for the disability-morbidity risk in the life underwriting risk module specified in Draft CEIOPS' Advice on Life Underwriting Risk (former CP49, now CEIOPS-DOC-42-09).

SLT Health expense risk

- 4.10. No health-specific analysis for the calibration of expense risk was made. As there are no indications that the expense risk of health obligations differs substantially from the expense risk of life obligations, the same shock is assumed as for the life underwriting risk module specified in Draft CEIOPS' Advice on Life Underwriting Risk (former CP49, now CEIOPS-DOC-42-09).

SLT Health revision risk

- 4.11. No specific analysis was made. As there are no indications that the revision risk of health obligations differs substantially from the revision risk of life obligations, the same shock is assumed as for the life underwriting risk module specified in Draft CEIOPS' Advice on Life Underwriting Risk (former CP49, now CEIOPS-DOC-42-09).
- 4.12. However, considering that SLT Health Revision risk covers too the risk of loss, or of adverse change in the value of insurance liabilities resulting from fluctuations in the level, trend, or volatility of the revision rates applied to benefits due to changes in inflation (not currently in the scope of Life Revision risk sub-module), a specific shock of 1% is assumed to be added as for the life underwriting risk module.

⁵ A corresponding derivation for lognormal distributed annual claims produces to similar results. For example, a lognormal distribution as applied in the non-life premium and reserve risk sub-module with a standard deviation of 20% leads to an estimation error of approximately $1.25 \cdot \sigma$.

SLT Health lapse risk

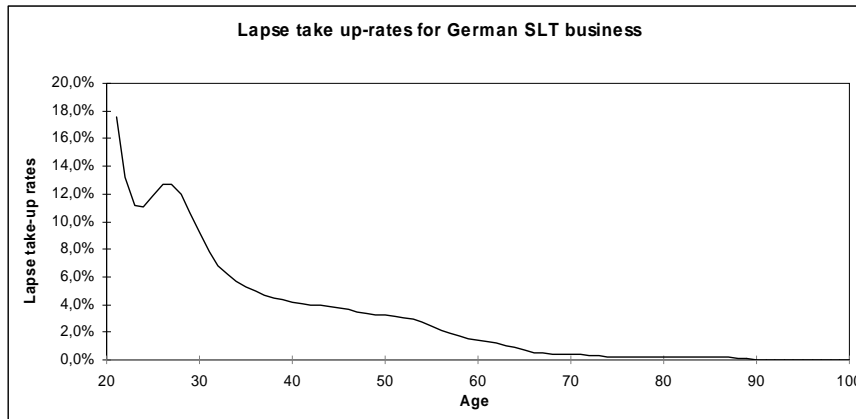
- 4.13. A statistical study was carried out on basis of comprehensive data in the German Health insurance market.
- 4.14. The raw data comprised lapse take-up rates from each insurance undertaking in the German market writing Health SLT business in the time period 2001 to 2008, differentiated per individual ages of the insured. This raw data is available to BaFin due to supervisory reporting requirements set out in the insurance law, and is used by BaFin to develop and publish tables for lapse take-up rates in the German Health insurance market on a yearly basis.
- 4.15. In the statistical analysis, the data on the lapse take-up rates for individual ages was grouped into over-lapping age bands comprising each 10 years of age, beginning with the age band of 21 to 30.6 For each age band, the mean value and standard deviation of the observed lapse-up rates for the time period 2001 to 2008 was determined. Assuming a normal risk distribution this then allowed computation of a lapse shock for each age band corresponding to the VaR 99.5% confidence level.

Overall, this resulted in the following lapse shocks:

Age bands	Lapse shock 99.5% VaR
25	21%
30	13%
35	15%
40	17%
45	21%
50	19%
55	17%
60	13%
65	13%
70	11%
75	23%
80	47%
85	63%
90	84%
95	104%

- 4.16. To determine which age-independent lapse risk shock would be appropriate based on basis of these results, it was considered that the absolute take up-rates for lapse risks from age 70 on-wards are very small, as is illustrated in the following diagram which shows lapse take-up rates in the German Health SLT business market:

⁶ The next age band then comprised the ages between 26 and 35 years, i.e. the mid-points of age bands were set at every five years.



- 4.17. Hence for the calibration of lapse risk the ages 60 to 100 have an only immaterial effect and can be disregarded for the purpose of determining an age-independent shock scenario.
- 4.18. Hence a medium required lapse shock scenario can appropriately be determined as an average across the age bands with mid-points between 25 and 55.
- 4.19. The shock scenario of **20%** (for both the up-ward and the down-ward shock) is calibrated on the basis of these results for the lapse risk sub-module of Health SLT business.

4.3 Non-SLT Health underwriting risk - Premium and Reserve risk calibration

- 4.20. CEIOPS points out that the calibration in this advice is being considered to be in line with 99.5% VaR and a one year time horizon. QIS5 will give an indication of the overall impact of the proposed calibrations, not limited to the SCR but including technical provisions and own funds.
- 4.21. CEIOPS' advice on health underwriting risk (CEIOPS-DOC-43-09), provides advice in respect of the design of the health underwriting risk module, in particular the methods, assumptions and standard parameters to be used when calculating this risk module.
- 4.22. The capital charge for the combined premium risk and reserve risk is determined as follows:

$$Health_{Premium\&\ Reserve}^{NonSLT} = \rho(\sigma_{NonSLT\ Health}) \cdot V_{NonSLT\ Health}$$

Where

$V_{NonSLT\ Health}$	=	Volume measure (for NSLT Health insurance obligations)
$\sigma_{NonSLT\ Health}$	=	Standard deviation (for NSLT Health insurance obligations) resulting from the combination of the reserve and premium risk standard deviation

$\rho(\sigma_{\text{NonSLT Health}})$	=	A function of the standard deviation
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4.23. The overall volume measure $V_{\text{NonSLT Health}}$ is determined as follows:

$$V = \sum_{\text{Lob}} V_{\text{lob}}$$

where, for each individual line of business LoB, V_{lob} is the volume measure for premium and reserve risk:

$$V_{\text{lob}} = V_{(\text{prem,lob})} + V_{(\text{res,lob})}$$

4.24. The function $\rho(\sigma)$ is specified as follows:

$$\rho(\sigma) = \frac{\exp(N_{0.995} \cdot \sqrt{\log(\sigma^2 + 1)})}{\sqrt{\sigma^2 + 1}} - 1$$

where

$N_{0.995}$	=	99.5% quantile of the standard normal distribution
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4.25. The function $\rho(\sigma_{\text{NonSLT Health}})$ is set such that, assuming a lognormal distribution of the underlying risk, a risk capital charge consistent with the VaR 99.5% standard is produced. Roughly $\rho(\sigma_{\text{NonSLT Health}}) \approx 3 \cdot \sigma_{\text{NonSLT Health}}$.

4.26. The overall net standard deviation σ is determined as follows:

$$\sigma = \sqrt{\frac{1}{V^2} \cdot \sum_{r,c} \text{CorrLob}_{r,c} \cdot \sigma_r \cdot \sigma_c \cdot V_r \cdot V_c}$$

where

r,c = All indices of the form (lob)

$\text{CorrLob}^{r,c}$ = the cells of the correlation matrix CorrLob

V_r, V_c = Volume measures for the individual lines of business, as defined above

4.27. In order to estimate the capital charge for the Health non SLT premium and reserve risk submodule, CEIOPS needs to provide calibrated factors for the following inputs:

- Net standard deviation for premium risk $\sigma(\text{prem}, \text{LoB})$
- Net standard deviation for reserve risk $\sigma(\text{res}, \text{LoB})$
- correlation factors between LoB (CorrLob)

4.28. The corresponding LoBs shall be:

LoB number	
1	Accident
2	Sickness
3	Workers Compensation

4.4 General Observations

QIS 3 and QIS 4 calibration

- 4.29. During the CP72 consultation, stakeholders emphasized that the parameters provided by CEIOPS deviated significantly from previous exercises and that QIS 4 was a better benchmark.
- 4.30. CEIOPS would like take this opportunity to provide some background in respect of QIS 4 and QIS 3 as well as to highlight the main differences between the current and previous analyses.
- 4.31. CEIOPS provided the first Health NonSLT calibration paper as part of QIS 3 (CEIOPS- FS-14/07). The calibration was carried out with German data for premium risk, some UK and German data for reserve risk and French data for the health segments. The exercise was carried out on a best efforts basis with the very limited data set available at the time and working under the assumption that the application of the above approach would be suitable for premium and reserve risk. The document presented a simple approach regarding fitting underwriting risk.
- 4.32. CEIOPS also provided a calibration for the QIS 4 exercise which was presented in the QIS 4 Technical Specifications which made some adjustments to the results of the QIS 3 calibration.
- 4.33. CEIOPS has worked on the basis that it is able to refine calibrations as and when data becomes available. For example the following note was attached to TS.XIII.B.25 in the QIS4 Technical Specifications (MARKT/2505/08):
- "Please note that the proposed calibration for the "reserve risk" standard deviations is tentative and has been developed for QIS4 purposes only. It is recommended that further work should be carried out in order to refine this calibration by dedicating a specific workstream to this issue."*
- 4.34. During June to September 2009 CEIOPS decided to carry out a full calibration exercise using data which was representative of EEA, fully laying out assumptions, applying a range of methods and carrying out goodness of fit tests. CP 72 was the result of this work.
- 4.35. During CP72 and the current revised version, it was acknowledged that there were various issues in respect of previous calibrations:

Data Applicability for the whole of the EEA

- 4.36. The previous calibrations were performed using data from an unrepresentatively small set of member states within the EEA.
- 4.37. Whilst the introduction of more data leads to heterogeneity calibration problems, the resultant parameters should be more appropriate for more undertakings within the EEA.

- 4.1. CEIOPS have included Method 1 in CP 72 (for both premium risk and reserve risk) as this is the closest of all the methods presented to the approach used in the earlier calibrations. This has been adjusted to allow for some of the issues identified, but clearly still has some of the same limitations. As can also be seen in CP 72, this method also tends to give the lowest calibrations, as expected from the issues identified.

Relationship between volatility and volume measure

- 4.38. CP 72 identifies a clear relationship between the level of volatility of the undertaking and its associated volume measure. Namely that, in general, the larger the undertaking's volume the smaller the associated undertaking standard deviation.
- 4.39. The approach used in historic calibrations to derive a single factor from the company specific estimates of volatility placed a significant weight (the volume measure squared) upon the volatilities from the larger firms, with the smallest volatilities. This has the effect of materially understating the resultant fitted volatility in relation to the underlying firms.

Fitting Algorithm

- 4.40. The previous calibrations used a single fitting approach. Different fitting approaches for the same model and data can give materially different answers, especially in the circumstances where there is a finite amount of data.
- 4.41. This issue was not explored in the previous calibrations and could have resulted in a misinterpretation of the certainty of the resultant calibration.
- 4.42. The fitting algorithm used was the least squares approach which is most usually regarded as appropriate when the underlying distribution is a Normal distribution – when the least squares estimator is the same as the maximum likelihood estimator. The distributional assumptions in the standard formula are LogNormal, as would be considered more appropriate for the right skewed nature of claims development.

Model Assumptions

- 4.43. The approach used a single set of model assumptions. Different, but similar, model assumptions fitted to the same data can give materially different answers.
- 4.44. This issue was not explored in the previous calibrations and could have resulted in a misinterpretation of the certainty of the resultant calibration.

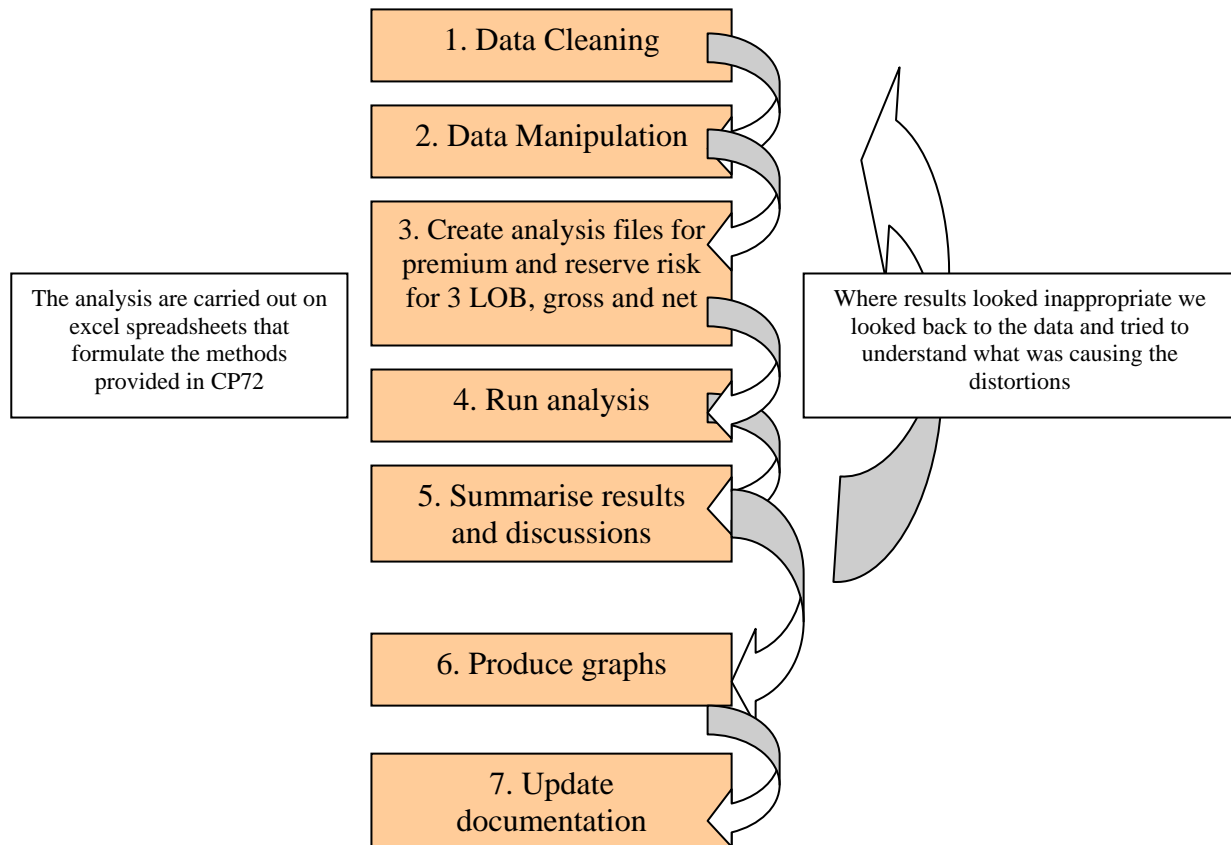
Over-fitting

- 4.45. The previous calibrations estimated standard deviations by undertaking. With regards to premium risk this also involved an estimation of the mean loss ratio by company.

4.46. This involves estimating a wide variety of parameters in order to derive, in the end, the single parameter. The effect of this is to over-fit the model and understate the resultant market volatility.

Process followed for Health NSLT calibration

4.47. This section provides some general information regarding the process followed:



- Data:
 - The data used for the analysis relates to the period from 1999 to 2008.
 - Only a limited amount of data was available net of reinsurance. As a result CEIOPS based the analysis on gross of reinsurance data, and this is also consistent with the industry feedback. If CEIOPS had done the analysis based on the net data, the results would have only been representative of 5 member states. A list of the countries that provided data by LoB gross and net of reinsurance compared to the first version on CP72 has been provided in this paper.
 - There were issues around confidentiality which required standardisation of the data. In order to use the standardised data CEIOPS had to unstandardise it making some broad assumptions regarding the size of the firms. In general this should have had little impact upon the

calibration. However, there were some occurrences where companies were growing very quickly where the resultant gearing of the broad assumptions led to infeasible data and such companies had to be excluded from the analysis to avoid any material distortions in the overall calibration.

- Diversity of data from different member states as a result of different regulatory systems or accounting regimes.
- The historic posted reserves are on an undiscounted best estimate basis rather than discounted best estimate basis.
- The level of prudence embedded in the historic posted reserves is different among different undertakings (even undertakings from the same member state).
- Catastrophe double counting. The industry was concerned about the impact of including catastrophe data within the analysis. CEIOPS has attempted to remove catastrophe claims where possible. Furthermore CEIOPS has requested from member states that data should be clean of catastrophes. CEIOPS has further carried out a filtering process to remove observations that could suggest being related to a catastrophe event.
- Historic premium provisions as defined under Solvency 2 are not necessarily readily available. Only data on an accident year basis was available. Therefore given that there is a potential for deterioration in the premium provision (although this would be much smaller than the associated earned exposure) over the one year time horizon, but premium provision is not included in the volume measure, the premium risk calibration will be slightly understated.
- There are no risk margins in the data. The calibration should cover the change in risk margin over the year. However for the purpose of this calibration CEIOPS has assumed the risk margin does not change. This will lead to understanding the factors.
- Adjustment to net:
 - Gross volatilities will need to be adjusted to allow for reinsurance before they can be used in the Standard Formula. For premium risk CEIOPS has proposed to use an approach based on the experience of individual undertakings, as this will allow for the particular features of their reinsurance protections. This is covered in below. For reserve risk, CEIOPS has proposed to use a more general industry wide adjustment factor, which is explained in below.

4.5 Premium risk

4.48. This section describes the premium risk calibration and results.

4.5.1. Data

4.49. By line of business, undertaking and accident year:

- Earned premium net of reinsurance costs, but gross of acquisition costs
- Posted ultimate claims after one year gross of reinsurance recoveries, comprising the claims paid over the year and the posted outstanding claims provision posted after the one year gross of expected reinsurance recoveries.
- Paid claims triangle gross of reinsurance recoveries

4.50. These data are judgementally filtered to remove problem data points:

- Distortions due to mergers and acquisitions
- Typographic mistakes
- Apparent inconsistencies between different years and between opening reserve and closing reserve for the same company
- Catastrophe losses
- As well as other features which were considered to be incorrect based on expert judgement..

4.5.2. Assumptions

4.51. For practical reasons net earned premium is used as the volume measure in the calibration (as opposed the maximum of net earned premium, net written premium, etc as in the standard formula).

4.52. The calibration is based on the assumption that the expenses (excluding allocated claims handling expenses) are a deterministic percentage of premium and hence do not affect the volatility of the result. The largest component of these expenses is likely to be the acquisition expenses and this assumption would appear to be relatively reasonable in these circumstances.

4.53. No explicit allowance was made for inflation in the calibration process. Implicitly therefore it assumed that the inflationary experience in the period 1999 to 2008 was representative of the inflation that might occur. The period analysed was a relatively benign period with low inflation in the countries supplying data and without unexpected inflation shocks which would be expected to increase the factors significantly. Thus as the data excludes significant inflationary shocks, it may underestimate the uncertainty in the provisions.

4.2. An average level of geographical diversification is implicitly allowed for in the calibration because the volatility of the undertaking's time series reflects the geographical diversification of their business.

4.54. The risk margin does not change after stressed conditions.

The SCR is the difference between the economic balance sheets over the one year time horizon in the distressed scenario. This implicitly suggests the

difference between all component parts should be analysed which includes the risk margin. CEIOPS has assumed for the purpose of the standard formula that there is no change in the risk margin.

4.5.3. Analysis

- 4.55. The analysis is performed using the net earned premiums as the volume measure and the net posted ultimate claims after one year to derive a standard deviation.
- 4.56. This figure is then adjusted to allow for the effect of discounting. These adjustments are applied on a bulk basis, ie not on a company by company basis, to ensure that the resultant calculations are manageable.
- 4.57. The adjustment for discounting involves projecting the aggregate triangle of paid claims (summed across undertakings) to derive a payment profile for the claims. It is assumed that the claims are paid in the middle of the corresponding year and use a discount rate of 4% to derive a resultant overall discount factor that we could apply to the posted ultimate in one year's time to discount to today's money. This adjustment is applied on a bulk basis, ie not on an undertaking by undertaking basis, for reasons of practicability.
- 4.58. The constant discount rate is used to avoid double counting the risk of the effect of changing yield curves which is covered within market risk in the standard formula.
- 4.59. The level of the discount rate is chosen judgementally. The rate of 4% is not intended to reflect current risk-free rates but rather a long-time average of risk-free rates.

4.5.4. Methodology

- 4.60. A variety of methods was used to estimate the factors a set of pan European factor for each line of business.
- 4.61. CEIOPS carried out the following methods for the estimation of the premium risk standard deviations:

Method 1

- 4.62. This approach is intended to follow as closely as possible the approach detailed in "CEIOPS- FS-14/07 QIS3, Calibration of the underwriting risk, market risk and MCR".
- 4.3. This involves the firm calculating the average net earned premium and the standard deviation of the loss ratios posted after the first development year.
- 4.63. The process involves two stages. The first stage fits a separate model of each undertaking's mean and standard deviations of loss ratio and allows for more diversification credit within larger volumes of earned premium per line of business in the same way across all years within a single undertaking.

- 4.64. This stage uses a least squares fit of the loss ratio and an associated variance estimator. This estimator is optimal when the underlying distribution is Normal, as opposed to the assumptions within the standard formula of Log Normality.
- 4.65. The second stage fits the premium risk factor to these resultant undertaking specific models.
- 4.66. The use of a two stage process, clearly introduces a large number of parameters that need to be calibrated which translates to a significant risk of over-fitting. The effect of this would be to understate the resultant premium risk factor, but it is not entirely clear by how much.
- 4.67. Furthermore, the second stage puts significantly more weight to those undertakings which write larger volumes of a specific line of business, therefore any result will be biased towards factors most appropriate for larger portfolios.
- 4.68. Specifically if the following terms are defined:

$U_{C,Y,lob}$	=	The posted ultimate after one year by undertaking, accident year and LoB
$V_{C,Y,lob}$	=	Earned premium by undertaking, accident year and LoB
$\sigma_{C,lob}$	=	Standard deviation of loss ratio by undertaking and LoB
$N_{C,lob}$	=	The number of years of data available by undertaking and LoB
$V_{C,lob}$	=	Average earned premium by undertaking and LoB

- 4.69. The following relationships are obtained:

$$\sigma_{C,lob} = \sqrt{\frac{1}{V_{C,lob}}} \sqrt{\frac{1}{N_{C,lob} - 1} \left(\sum_Y \frac{1}{V_{C,Y,lob}} \left(U_{C,Y,lob} - V_{C,Y,lob} \sum_Y \frac{U_{C,Y,lob}}{V_{C,Y,lob}} \right)^2 \right)}$$
 and

$$V_{C,lob} = \frac{1}{N_{C,lob}} \sum_Y V_{C,Y,lob}$$

- 4.70. The factors are then determined using least squares optimisation across the undertakings within the LoB.
- 4.71. If following term is defined:

$\sigma_{(prem,lob)}$	=	Standard deviation for premium risk by LoB
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- 4.72. Then a value for $\sigma_{(prem,lob)}$ can be derived by taking a volume weighted average of the fitted undertaking specific standard deviations as below:

$$\hat{\sigma}_{(prem,lob)} = \frac{\sum_C V_{C,lob} \sigma_{C,lob}}{\sum_C V_{C,lob}}$$

Method 2

- 4.73. This approach is consistent with the undertaking specific estimate assumptions from the Technical Specifications for QIS4.
- 4.74. The assumptions are that for any undertaking, any year and any LoB:
- The expected loss is proportional to the premium
 - Each undertaking has a different, but constant expected loss ratio
 - 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
- 4.75. The process involves two stages. The first stage fits a separate model of each undertaking's mean but fits a single model for the standard deviations across all undertakings simultaneously. Thus the standard deviations by undertaking take into account the experience of all the other undertakings when assessing this particular undertaking.
- 4.76. This stage also allows for more diversification credit within larger volumes of earned premium per line of business in the same way across all years and all undertakings.
- 4.4. This stage uses a maximum likelihood for a lognormal to fit the expected loss ratio and an associated variance estimator. As opposed to method 1 this fitting approach is optimal is aligned to the assumptions within the standard formula of LogNormality.
- 4.77. As an attempt to derive a single factor per line of business, across all firms a linearly weighted average of the standard deviations by undertaking has been taken.
- 4.78. Effectively this assumes that the sample of undertakings used in the fitting process is representative of all of Europe in terms of associated premium volumes as well as putting significantly more weight to those undertakings which write larger volumes of a specific line of business, therefore any result will be biased towards factors most appropriate for larger portfolios.

$U_{C,Y,lob}$	=	The posted ultimate after one year by undertaking, accident year and LoB
$\mu_{C,lob}$	=	Expected loss ratio by undertaking and by LoB
β_{lob}^2	=	Constant of proportionality for the variance of loss by LoB
$\varepsilon_{C,Y,lob}$	=	An unspecified random distribution with mean zero

		and unit variance
$V_{C,Y,lob}$	=	Earned premium by undertaking, accident year and LoB
$M_{C,Y,lob}$	=	The mean of the logarithm of the posted ultimate after one year by undertaking, accident year and LoB
$S_{C,Y,lob}$	=	The standard deviation of the logarithm of the posted ultimate after one year by undertaking, accident year and LoB
$V_{C,lob}$	=	Average earned premium by undertaking and LoB

Then the distribution of losses can be formulated as:

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

4.79. This allows to formulate the parameters of the lognormal distributions as follows:

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

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

4.80. The resultant simplified log Likelihood becomes

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

4.81. The parameter values β_{lob} and $\mu_{C,lob}$ are chosen to maximise this likelihood.

4.82. The following term is defined:

$\sigma_{(C,prem,lob)}$	=	Standard deviation for premium risk by Undertaking by LoB
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4.83. The $\sigma_{(C,prem,lob)}$ then becomes :

$$\sigma_{C,prem,lob} = \frac{\hat{\beta}_{lob}}{\sqrt{V_{C,lob}}} \text{ where}$$

$$V_{C,lob} = \frac{1}{N_{C,lob}} \sum_Y V_{C,Y,lob}$$

4.84. If the following term is defined:

$\sigma_{(prem,lob)}$	=	Standard deviation for premium risk by LoB
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4.85. Then a value for $\sigma_{(prem,lob)}$ can be derived by taking a volume weighted average of the fitted undertaking specific standard deviations as below:

$$\hat{\sigma}_{(prem,lob)} = \frac{\sum_C V_{C,lob} \sigma_{C,prem,lob}}{\sum_C V_{C,lob}}$$

Method 3

4.86. This approach is consistent with the undertaking specific estimate assumptions from the Technical Specifications for QIS4, but assumes that the expected loss ratio is industry wide rather than undertaking specific.

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

- The expected loss is proportional to the premium
- Each undertaking within a single LoB has the same constant expected loss ratio
- 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

4.88. The process involves two stages. The first stage fits a single model for the mean and standard deviations across all undertakings simultaneously. Thus the means and standard deviations by undertaking take into account the experience of all the other undertakings when assessing this particular undertaking.

4.89. Compared to methods 1 and 2, only two parameters are fitting per line of business. The consequences of this will result in a less over-fitting and as a result is likely to lead to an overall higher volatility. However, this will also result in a worse fit to the data.

4.90. This stage also allows for more diversification credit within larger volumes of earned premium per line of business in the same way across all years and all undertakings.

4.91. This stage uses a maximum likelihood for a lognormal to fit the expected loss ratio and an associated variance estimator. As opposed to method 1 this fitting approach is optimal is aligned to the lognormal distribution within the standard formula.

4.92. As an attempt to derive a single factor per line of business, across all firms a linearly weighted average of the standard deviations by undertaking has been taken.

4.93. If the following terms are defined:

$U_{C,Y,lob}$	=	The posted ultimate after one year by undertaking, accident year and LoB
μ_{lob}	=	Expected loss ratio by LoB
β_{lob}^2	=	Constant of proportionality for the variance of loss by LoB
$\varepsilon_{C,Y,lob}$	=	An unspecified random distribution with mean zero and unit variance
$V_{C,Y,lob}$	=	Earned premium by undertaking, accident year and LoB
$M_{C,Y,lob}$	=	The mean of the logarithm of the posted ultimate after one year by undertaking, accident year and LoB
$S_{C,Y,lob}$	=	The standard deviation of the logarithm of the posted ultimate after one year by undertaking, accident year and LoB

Then distribution of losses can be formulated as follows:

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

4.94. The parameters of the lognormal distributions are formulated as follows:

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

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

4.95. The resultant simplified log Likelihood becomes

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

4.96. The parameter values β_{lob} and μ_{lob} are chosen to maximise this likelihood.

4.97. If the following term is defined as:

$\sigma_{(C,prem,lob)}$	=	Standard deviation for premium risk by Undertaking by LoB
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4.98. The $\sigma_{(C,prem,lob)}$ then becomes :

$$\sigma_{C,prem,lob} = \frac{\hat{\beta}_{lob}}{\sqrt{V_{C,lob}}} \text{ where}$$

$$V_{C,lob} = \frac{1}{N_{C,lob}} \sum_Y V_{C,Y,lob}$$

4.99. If the following term is defined as:

$\sigma_{(prem,lob)}$	=	Standard deviation for premium risk by LoB
-----------------------	---	--

4.100. Then a value for $\sigma_{(prem,lob)}$ can be derived by taking a volume weighted average of the fitted undertaking specific standard deviations as below:

$$\hat{\sigma}_{(prem,lob)} = \frac{\sum_C V_{C,lob} \sigma_{C,prem,lob}}{\sum_C V_{C,lob}}$$

Method 4

4.101. This approach is essentially consistent with the standard formula representation of the relationship between volatility of future losses and volume.

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

- The expected loss is proportional to the premium
- Each undertaking has a different, but constant expected loss ratio
- The variance of the loss is proportional to the square of the earned premium
- The distribution of the loss is lognormal and
- The maximum likelihood fitting approach is appropriate

4.103. The process involves fitting a single model for the standard deviations across all undertakings simultaneously. Thus the standard deviations by undertaking take into account the experience of all the other undertakings when assessing this particular undertaking.

4.104. This method allows for no diversification credit unlike methods 1, 2 and 3.

4.105. This method uses a maximum likelihood for a lognormal to fit the expected loss ratios and an associated variance estimator. As opposed to method 1 this fitting approach is optimal is aligned to the lognormal distribution assumptions within the standard formula.

4.106. If the following terms are defined as:

$U_{C,Y,lob}$	=	The posted ultimate after one year by undertaking, accident year and LoB
$\mu_{C,lob}$	=	Expected loss ratio by undertaking and by LoB
β_{lob}^2	=	Constant of proportionality for the variance of loss by LoB

$\varepsilon_{C,Y,lob}$	=	An unspecified random distribution with mean zero and unit variance
$V_{C,Y,lob}$	=	Earned premium by undertaking, accident year and LoB
$M_{C,Y,lob}$	=	The mean of the logarithm of the posted ultimate after one year by undertaking, accident year and LoB
$S_{C,Y,lob}$	=	The standard deviation of the logarithm of the posted ultimate after one year by undertaking, accident year and LoB

Then the distribution of losses can be formulated as:

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

4.107. The parameters of the lognormal distributions can be formulated as follows:

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

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

4.108. The resultant simplified log Likelihood becomes

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

4.109. The parameter values β_{lob} and $\mu_{C,lob}$ are chosen to maximise this likelihood.

4.110. If the following term is defined as:

$\sigma_{(prem,lob)}$	=	Standard deviation for premium risk by LoB
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4.111. The $\sigma_{(prem,lob)}$ then becomes :

$$\sigma_{(prem,lob)} = \hat{\beta}_{lob}$$

4.5.5. Premium Risk Results

4.112. CEIOPS has presented the results of the analysis through a combination of tables and graphs.

4.113. The table presents the results of methods 1 to 4 above:

- The analysis includes a column of fitted factors by method based on an estimated volume weighted average of the standard deviation estimates by undertaking. Effectively this assumes that the sample of undertakings used in the fitting process is representative of all of Europe in terms of associated premium volumes as well as putting significantly more weight to those undertakings which write larger volumes of a specific line of business, therefore any result will be biased towards factors most appropriate for larger portfolios.
- The table includes the percentage of undertakings which would have a gross standard deviation, as assessed under Method 1, greater than the selected technical result.

4.114. The individual estimates of the standard deviations by undertaking that result from the application of Method 1 are plotted against the prediction model for comparison. The individual estimates can be used as evidence of the existence of diversification credit for volume. Where such an effect does exist the graph would be expected in general to be decreasing.

4.115. Where there are signs of diversification, this implies that capital requirements are significantly higher for smaller than larger portfolios. This arises for two reasons:

- Larger accounts are usually less volatile than smaller accounts. Thus expressed as a percentage of premiums a larger account often has smaller theoretical capital requirements than a smaller account.
- Larger insurers often have a greater degree of diversification of risks than smaller insurers.

4.116. For methods 2 and 3, where diversification credit is assumed to exist, an illustration of what the factor could be for 3 sizes is presented: small, which equates to a 25th percentile of the sample observations, medium a 50th percentile, large 75th percentile.

4.117. The appropriateness of methods 2, 3 and 4 are tested and presented by showing the results of a goodness of fit test through a PP plot.

4.118. Results varied across methods because each method uses different underlying assumptions. For example:

- Some methods will place more weight on volatilities estimated for larger companies which tend to have lower standard deviations thus producing a lower overall result.
- Other methods will give an equal weight to each undertaking and as a result will tend to produce a higher overall result.
- Others will test different fitting techniques (least squares vs maximum likelihood).

4.119. The selection of the final fitted factors was based on the following:

- The evidence of diversification by size has not been given full allowance. i.e. no consideration has been given to the fact that volatilities by size of

portfolio may be significantly different. Therefore more focus has been placed on the fitted factors.

- Factors have been selected as the average of those methods which were considered to produce an acceptable fit according to the goodness of fit plots shown

4.120. CEIOPS would like to highlight that the selection was not conservatively selected, but rather based on the goodness of fit results. Furthermore by taking an average across methods, CEIOPS is ensuring that the factors are not biased towards factors most appropriate for larger portfolios (and hence lower).

Accident

4.121. CEIOPS recommendation is that for the accident lob the gross factor for premium risk should be 12.5%.

4.122. The data sample included data from 28 undertakings, was gross of reinsurance and included data from the following member states: PO, LU, SI, SK, IS and DK.

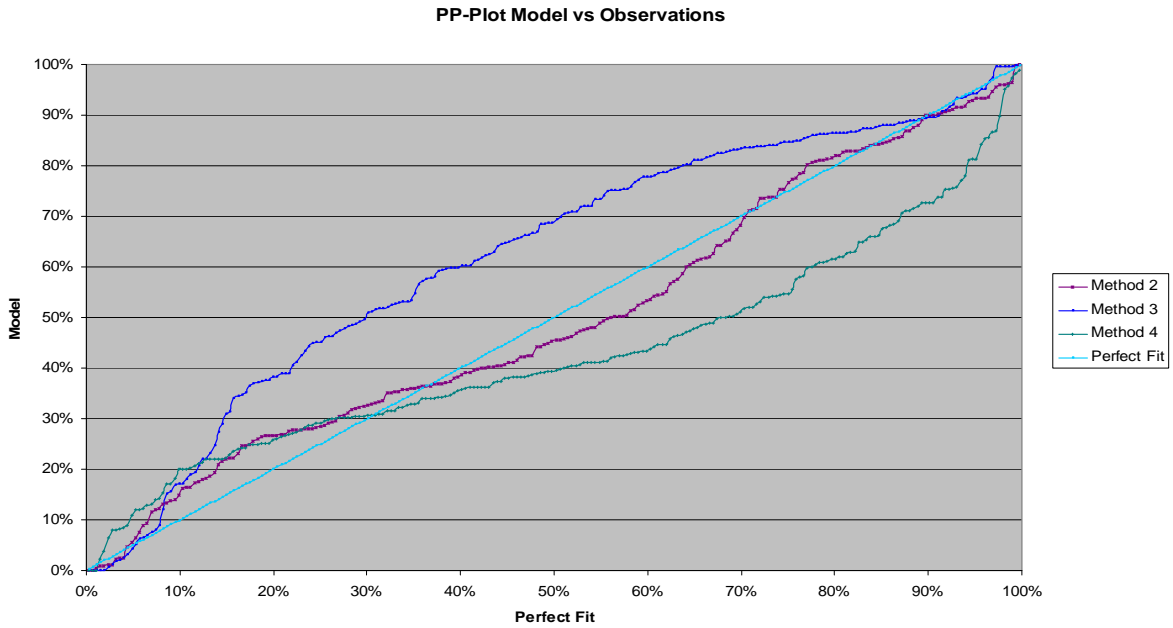
Reference co	Small	Medium	Large
Accident - Euros	6,142	31,281	43,531

GROSS Standard Deviations

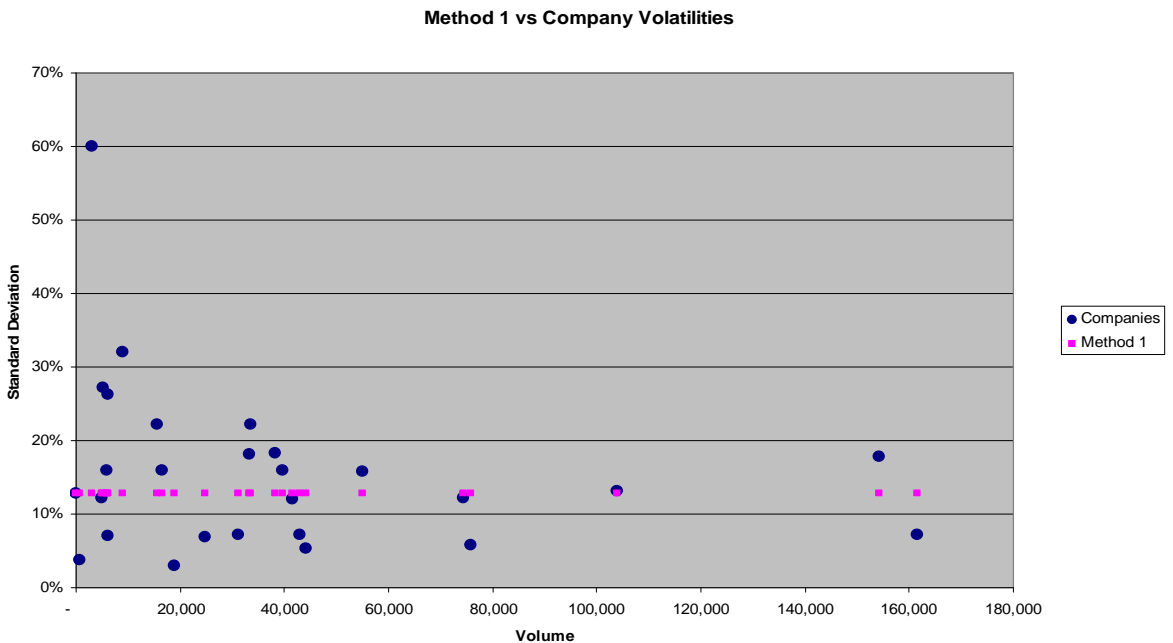
Discounted

Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result based on VWA	% firms with higher sd
Method 1				12%	12.5%	55.6%
Method 2	37%	17%	14%	13%		
Method 3	73%	32%	27%	25%		
Method 4				31%		

4.123. The graph below shows a pp plot of the fit of the models. Method 2 shows the best fit.



4.124. The result on the graph below shows no real signs of diversification credit. It also shows the volatility of the individual observation compared to the fitted selection for method 1.



Overall conclusions:

4.125. The selected technical factor was chosen as the average of the results from methods 1 and 2 – result 12.5%

Sickness

4.126. CEIOPS recommendation is that for the sickness lob the factor for premium risk should be 9.5%.

4.127. The data sample included data from 175 undertakings, was gross of reinsurance and included data from the following member states: UK, PT, PO, DE, DK and SE.

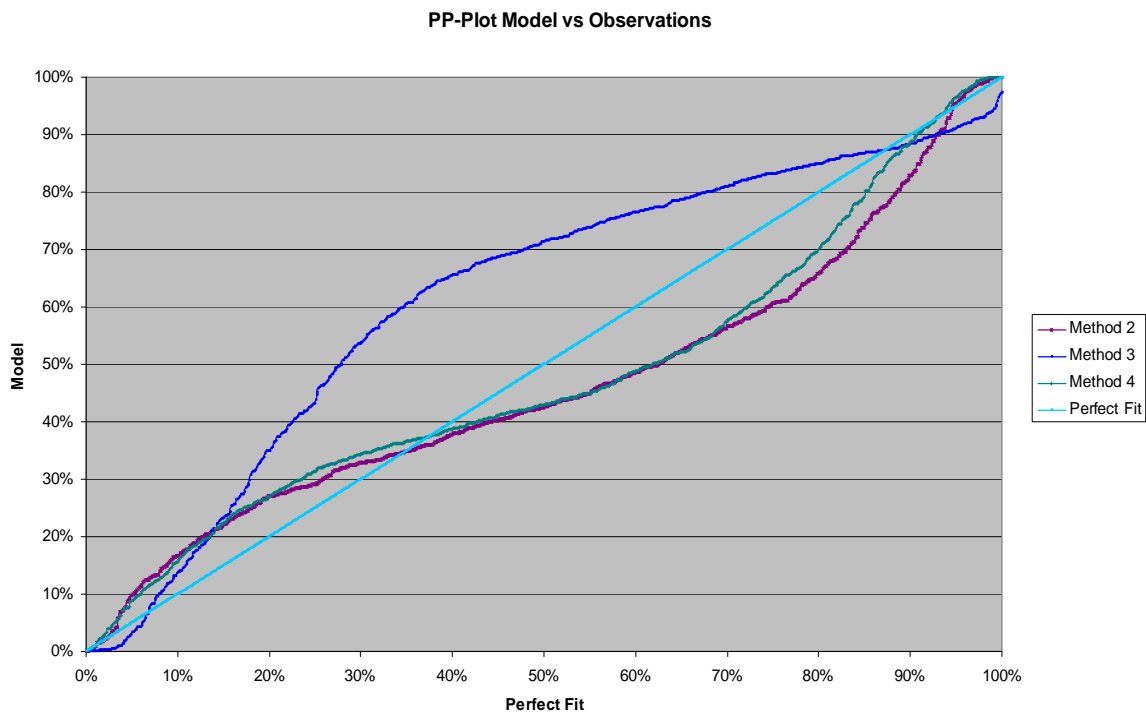
Reference co	Small	Medium	Large
Sickness - Euros	1,051	7,326	31,035

GROSS Standard Deviations

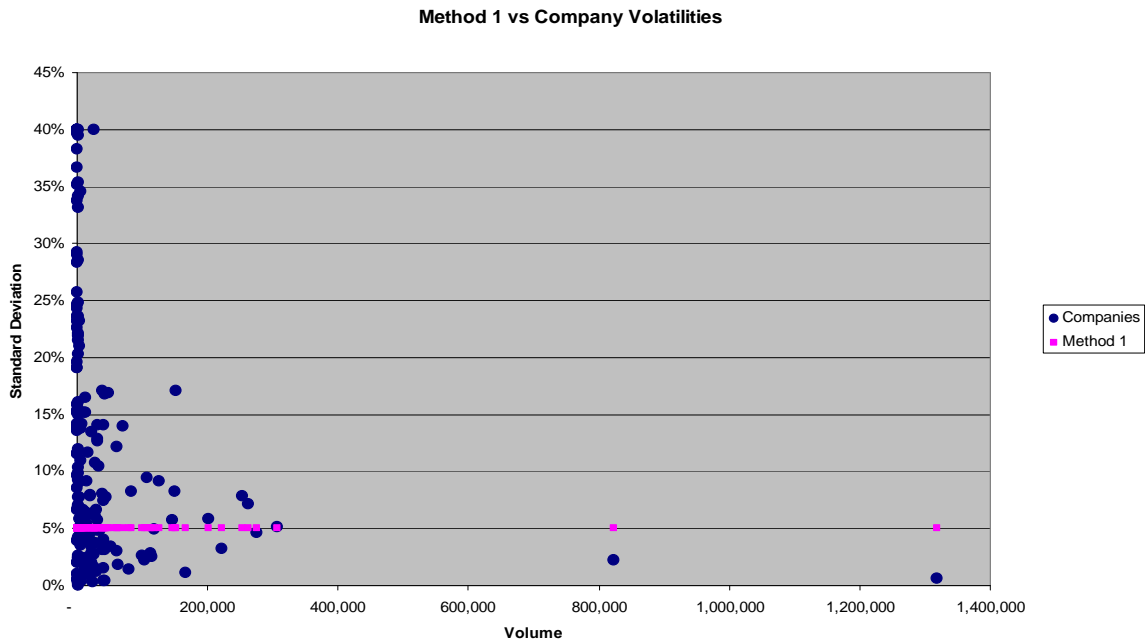
Discounted

Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result based on VWA	% firms with higher sd
Method 1				5%	9.3%	43.4%
Method 2	51%	19%	9%	5%		
Method 3	271%	103%	50%	28%		
Method 4				18%		

4.128. The result on the graph below shows that method 2 and 4 provide the best fits to the model, although neither is that good.



4.129. The result on the graph below shows signs of diversification credit. The graph also shows for method 1, the observations that lie above and below the fitted factor.



Overall conclusions:

4.130. The selected technical factor was chosen as the average of the results from methods 1, 2 and 4 – result 9.3%

Workers' compensation

4.131. CEIOPS recommendation is that for the workers' compensation lob the gross factor for premium risk should be 5.5%.

4.132. The data sample included data from 31 undertakings, was gross of reinsurance and included data from the following member states: PT, FI and DK.

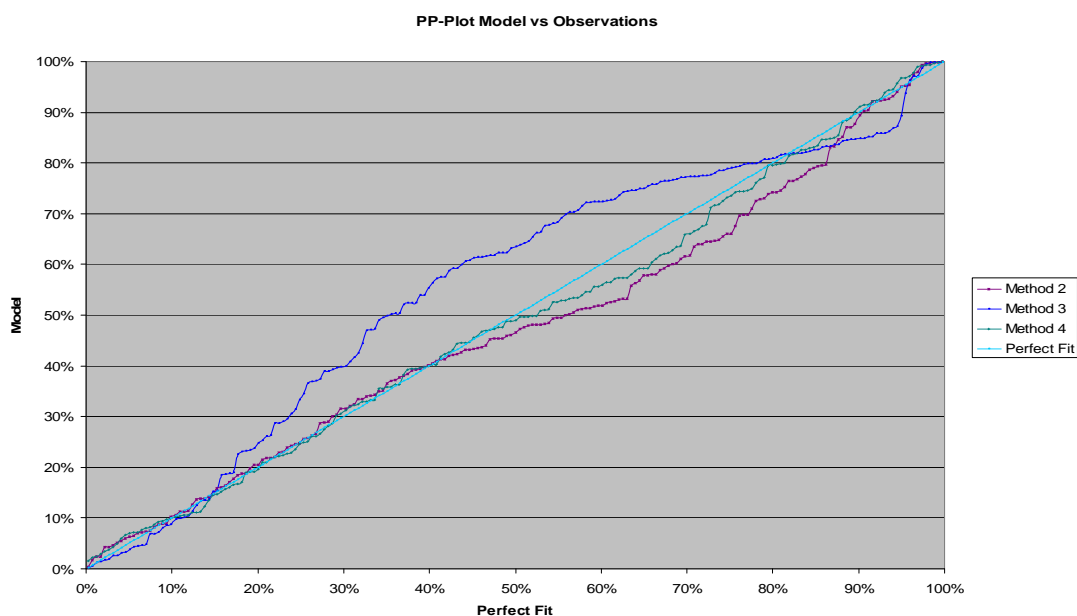
Reference co	Small	Medium	Large
Workers compensation - Euros	12,230	25,000	110,477

GROSS Standard Deviations

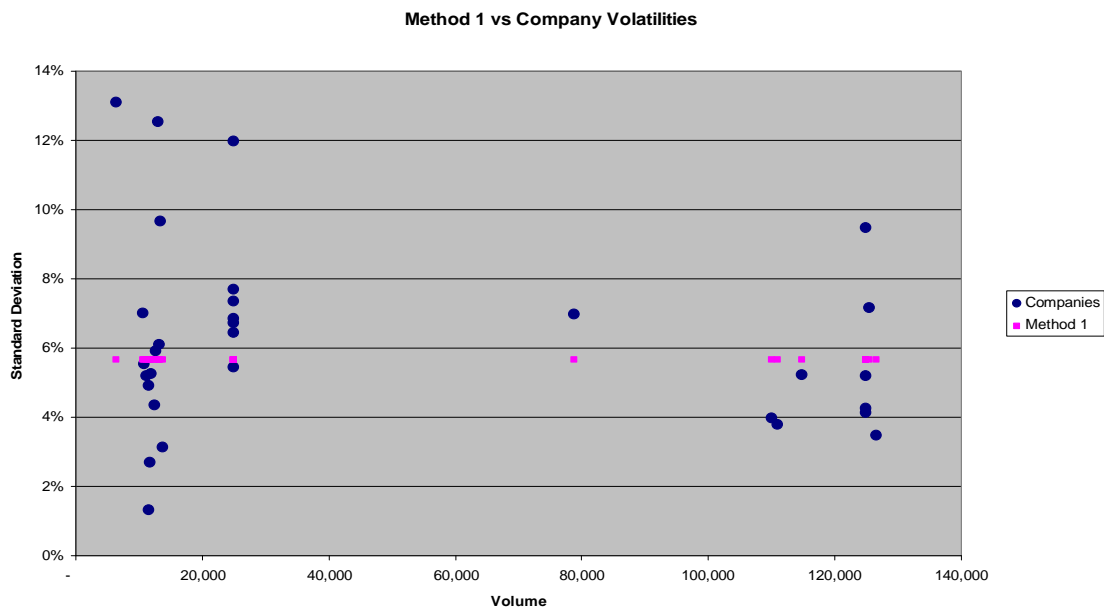
Discounted

Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result based on VWA	% firms with higher sd
Method 1				5%	5.3%	65.0%
Method 2	11%	7%	4%	5%		
Method 3	36%	25%	12%	16%		
Method 4				5%		

4.133. The graph below shows a pp plot of the fit of the models. Methods 2 and 4 are reasonable fits, with method 4 being the best.



4.134. The result on the graph below shows no real signs of diversification credit. The graph also shows for method 1, the observations that lie above and below the fitted factor.



Overall conclusions:

4.135. The selected technical factor was chosen as the average of the results from methods 1, 2 and 4 – result 5.3%

4.5.6. Adjusting gross to net for premium risk

4.136. CEIOPS considers that it is important that the standard capital charge for premium and reserve risk adequately takes into account the risk mitigation effect of reinsurance covers. To improve the risk-sensitivity of the standard formula in this respect, CEIOPS suggests introducing a company-specific adjustment factor which translates the gross standard deviation observed in a line of business into a net standard deviation which is aligned to the risk profile of the insurer's portfolio. CEIOPS notes that in the context of the standard formula this is a technically challenging task, considering on the one hand the diversity and complexity of reinsurance covers (especially in the case of non-proportional reinsurance) and on the other hand the necessity to provide a standardised calculation which is technically feasible for all undertakings.

4.137. CEIOPS has discussed with the industry the design of such a gross-to-net adjustment factor, and has welcomed and fully considered the industry proposal for a gross-to-net adjustment⁷, which focuses on a specific type of non-proportional reinsurance cover. CEIOPS has developed an approach which aims to provide a more simple and generally applicable solution to this issue. However, CEIOPS is aware of the limitations of the proposals that are on the table today, and further work may be needed to achieve a design and calibration of a gross-to-net factor which is both sufficiently risk-sensitive and also appropriate for the purposes of a standard formula calculation.

⁷ See annex .

- 4.76. The calibration (gross) has been performed using data gross of reinsurance. However, the standard formula uses premiums net of reinsurance as a volume measure. The volatility of net claims will be lower than the volatility of gross claims, however, the net premiums will also be lower than the gross premiums.
- 4.77. Our provisional analysis has shown that the reduction in claims volatility due to the presence of reinsurance may be less than the reduction in premium for many undertakings due to the cost of the reinsurance, ie the appropriate net factor may often be larger than the gross factor.
- 4.78. Initially this may appear counter-intuitive, since it is common understanding that there are capital benefits through the purchase of reinsurance. However, we need to consider the following:
- An increase in factor (net vs gross) is not inconsistent with a lower capital requirement, since this is being driven by a lower volume measure (net premium vs gross premium). Indeed, we would clearly expect a lower net capital requirement than the comparable gross capital requirement.
 - The reinsurance protection is on a "to ultimate" basis, whilst the calibration is performed on a "1 year" basis. As a result, over the one year, not all the benefit of the reinsurance is realised. However, the reinsurance cost is all charged up front (other than reinstatements). As a result there is a mismatch between the benefit of the reinsurance that emerges over the one year and the change in the premium.
 - The difference between the gross and net premiums is not purely due to the claims benefits of the protection, but also used to fund the reinsurance expenses such as broker commissions, underwriting costs, etc and also to give the reinsurer an appropriate level of recompense for the level of risk they are accepting, ie risk loading, profit loading, etc.
- 4.79. Undertakings will be required to adjust the gross volatilities for reinsurance as follows:
- The ratio of the net combined ratio at financial year end and the gross combined ratio at financial year end can be viewed as a transformation factor for performing gross-net transitions by accident year.
 - This ratio is exact in the case of quota-share reinsurance and should be viewed as a convenient approximation for surplus and non-proportional reinsurance.
 - Basing the ratio on the most recent 3 financial years, will create some stability of the ratio.
 - At the same time the ratio will be responsive to changes in reinsurance programs in a 3-year moving average way.
 - The inputs for determining the net-gross ratio should be purified of any catastrophe effect on premiums, losses and costs. ie both gross and net claims should exclude any catastrophe claims, and catastrophe reinsurance premiums should not be deducted from gross premiums when determining net premiums. When deciding which claims should be considered as catastrophe claims, undertakings should refer to the report of the Catastrophe Task Force.

4.138. The net-gross ratio, by line of business, is determined in three steps:

$$\text{gross combined ratio} = \frac{\text{gross loss}}{\text{gross earned premium}} + \frac{\text{gross costs}}{\text{gross written premium}}$$

$$\text{net combined ratio} = \frac{\text{net loss}}{\text{net earned premium}} + \frac{\text{net costs}}{\text{net written premium}}$$

$$\text{net-gross ratio} = \frac{\text{net combined ratio}}{\text{gross combined ratio}}$$

with the following definitions of the terms:

gross losses total best estimate ultimate claims for the last three accident years gross of reinsurance, net of salvage and subrogation, but gross of ALAE. The ultimate claims amounts are as booked as at the end of each accident year, without allowing for any subsequent development. These figures should not include any catastrophe claims.

gross earned premium total ultimate premium earned over the last three accident years gross of reinsurance

gross costs total expenses (ULAE and other company expenses appropriately allocated to the LoB) excluding ALAE paid over the last three financial years.

gross written premium total ultimate premium written over the last three financial years

net losses total best estimate ultimate claims for the last three accident years net of reinsurance of reinsurance, net of salvage and subrogation, but gross of ALAE. The ultimate claims amounts are as booked as at the end of each accident year, without allowing for any subsequent development (to be consistent with the definition of gross losses). These figures should not include any catastrophe claims and similarly there should be no allowance for the reinsurance recoveries associated with those claims.

net earned premium total ultimate premium earned over the last three accident years net of reinsurance. The net earned premium should include the cost of the catastrophe reinsurance protections, ie these should not be deducted from the associated gross figures.

net costs total expenses (ULAE and other company expenses appropriately allocated to the LoB) excluding ALAE paid over the last three financial years, but including outwards

reinsurance commissions. The outwards reinsurance commissions should not include any of the costs of the catastrophe protections.

net written premium total ultimate premium written over the last three financial years net of reinsurance. The net written premium should include the cost of the catastrophe reinsurance protections, i.e. these should not be deducted from the associated gross figures.

4.139. The CEIOPS proposal has the advantages of:

- It is undertaking specific
- It is a simple and objective approach, which is produced using information that will already be supplied to the supervisor – so is less open to manipulation by undertakings.
- If a company has significant reinsurance recoveries it should produce commensurate adjustments
- The factor does not lead to over reduction in capital requirements.

4.140. Potential drawbacks are:

- Let us consider the situation where the reinsured company has just had a bad year. In this instance we would expect the effect of reinsurance to have been relatively large. As a consequence when the calculation is performed, as per the proposal from the Netherlands, the reinsurer loss ratio will be very large and thus the capital benefit the reinsured company will gain from its reinsurance will be very large. This would have the effect of reducing capital requirements after a company has a bad year, which although beneficial to companies (whose available capital is likely to have been reduced) does not appear to be sensible dynamics from a regulator's perspective. However the proposal to average experience over the last 3 years goes some way to address this issue.
- There is no evidence that this will represent the reduction equivalent to the mitigation effect over a one year time horizon.

4.6 Reserve Risk

4.141. The reserve risk calibration and results are presented below:

4.6.1. Data

4.142. The data was provided by line of business, undertaking and accident year:

- Paid claims triangle net of reinsurance recoveries
- Incurred claims triangle net of reinsurance recoveries
- Posted reserves claims triangle net of reinsurance recoveries (including case estimates, IBNR and IBNER)
- The data was judgementally filtered to remove problem data points. Examples of such adjustments include:
 - Negative values in any of the data.
 - Zero values for the data – since all the models used assume that this is impossible.
 - Massive implied development ratios where these appear to be “errors” in the data – since these completely distort some of the methods used.
- Typographic mistakes
- Apparent inconsistencies between different years and between opening reserve and closing reserve for the same company
- Catastrophe losses
- As well as other features which were considered to be incorrect based on expert judgement.

4.143. Data available for some lines of business was still limited despite collecting further data. The analysis produced for these lines of business is thus naturally not as robust as that for lines of business with more data.

4.144. The analysis was performed directly using the data available. Thus dependent upon the data in question, implicit assumptions were made.

4.6.2. Assumptions

4.145. The expenses (excluding allocated claims handling expenses) will be a fixed proportion of the future claims reserve, i.e. these expenses will be 100% correlated to the claims reserve. Our analysis ignores the impact of expenses to derive the reserve risk standard deviation, but in the standard formula this will be applied to the reserves including these expenses. We would expect these expenses to be less volatile than the claims and for these expenses to be less than 100% correlated to the claims. As a result, in theory, we would expect the estimate we derive to be conservative in this respect. CEIOPS was limited to what it could do due to lack of expense data. CEIOPS does not

consider that this would be material enough to justify an adjustment to the resultant volatilities produced from the analysis.

4.146. 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.

4.147. No explicit allowance was made for inflation in the calibration process. Implicitly therefore it assumed that the inflationary experience in the period 1999 to 2008 was representative of the inflation that might occur. The period analysed was a relatively benign period with low inflation in the countries supplying data and without unexpected inflation shocks which would be expected to increase the factors significantly. Thus as the data excludes significant inflationary shocks, it may underestimate the uncertainty in the provisions.

4.148. An average level of geographical diversification is implicitly allowed for in the calibration because the volatility of the undertaking's time series reflects the geographical diversification of their business.

4.149. The risk margin does not change after stressed conditions. The SCR is the difference between the economic balance sheet over the one year time horizon in the distressed scenario. This implicitly suggests that the difference between all component parts should be analysed, including the risk margin. CEIOPS has assumed that the risk margin does not change and therefore no adjustment to the factors has been made for this feature.

4.6.3. Analysis

4.150. The analysis is performed using either:

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

4.6.4. Methodology

4.151. CEIOPS chose the following methods for the estimation of the Non life underwriting parameters for reserve risk:

Method 1

4.152. This approach is intended to follow as closely as possible the approach detailed in "CEIOPS- FS-14/07 QIS3, Calibration of the underwriting risk, market risk and MCR".

4.153. This method assumes that the expected reserves in one year plus the expected incremental paid claims in one year is the current best estimate for claims outstanding.

- 4.80. This method involves by firm calculating the average claims reserve at each historic calendar year and the standard deviation of the following ratio: reserves in the next calendar year (excluding the new accident year) and the incremental paid claims emerging over the next calendar year (excluding the new accident year) to the reserves in this calendar year.
- 4.154. Essentially the standard deviation will represent the uncertainty in the expected ultimate claims over the one year time horizon for the same accident years.
- 4.155. The fitting process involves two stages. The first stage fits a separate model of each undertaking's standard deviation of the ratio and allows for more diversification credit within larger volumes of opening claims provision per line of business in the same way across all years within a single undertaking.
- 4.156. This stage uses a least squares fit of the ratio and an associated variance estimator. This estimator is optimal when the underlying distribution is Normal, as opposed to the lognormal distribution assumptions within the standard formula.
- 4.157. The second stage fits the reserve risk factor to these resultant undertaking specific models.
- 4.158. The use of a two stage process, clearly introduces a large number of parameters that need to be calibrated which translates to a significant risk of over-fitting. The effect of this would be to understate the resultant premium risk factor, but it is not entirely clear by how much.
- 4.159. Furthermore, the second stage puts significantly more weight to those undertakings holding larger claims provision volumes of a specific line of business, therefore any result will be biased towards factors most appropriate for larger portfolios.
- 4.160. Specifically if the following terms are defined as:

$PCO_{C,lob,i,j}$	=	The best estimate for claims outstanding by undertaking and LoB for accident year i and development year j
$I_{C,lob,i,j}$	=	The incremental paid claims by undertaking and LoB for accident year i and development year j
$V_{C,Y,lob}$	=	Volume measure by undertaking, calendar year and LoB
$R_{C,Y,lob}$	=	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 undertaking, calendar year and LoB
$\sigma_{C,lob}$	=	Standard deviation of reserve development ratio by undertaking and LoB
$N_{C,lob}$	=	The number of calendar years of data available by undertaking and LoB where there is both a value of $V_{C,Y,lob}$ and $R_{C,Y,lob}$.

$V_{C,lob}$	=	Average volume measure by undertaking and LoB
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4.161. Then the following relationships can be defined as:

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

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

4.162. Then, remembering that the reserve should be the expected value of future claims development,

$$\text{i.e. } E\left(\frac{R_{C,Y,lob}}{V_{C,Y,lob}}\right) = 1$$

the following relationships are obtained:

$$\sigma_{C,lob} = \sqrt{\frac{1}{V_{C,lob}}} \sqrt{\frac{1}{N_{C,lob}-1} \left(\sum_Y \frac{1}{V_{C,Y,lob}} (R_{C,Y,lob} - V_{C,Y,lob})^2 \right)} \text{ and}$$

$$V_{C,lob} = V_{C,\max(Y),lob}$$

4.163. The factors are then determined using least squares optimisation across the undertakings within the LoB.

4.164. If the following term is defined as:

$\sigma_{(res,lob)}$	=	Standard deviation for reserve risk by LoB
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4.165. Then $\sigma_{(res,lob)}$ can be derived by taking a volume weighted average of the fitted undertaking specific standard deviations as below:

$$\hat{\sigma}_{(res,lob)} = \frac{\sum_C V_{C,lob} \sigma_{C,lob}}{\sum_C V_{C,lob}}$$

Method 2

4.166. This approach is consistent with the undertaking specific estimate assumptions from the Technical Specifications for QIS4 for reserve risk.

4.167. 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 maximum likelihood fitting approach is appropriate.

4.168. The process involves two stages. The first stage fits a single model for the standard deviations across all undertakings simultaneously. Thus standard deviations by undertaking takes into account the experience of all the other undertakings when assessing this particular undertaking.

4.169. Compared to method 1, only one parameter is fitted per line of business. The consequences of this will be less over-fitting and as a result is likely to lead to an overall higher volatility.

4.170. This stage also allows for more diversification credit within larger volumes of opening claims provision per line of business in the same way across all years and all undertakings.

4.171. This stage uses a maximum likelihood for a lognormal to fit the variance estimator. As opposed to method 1 this fitting approach is aligned to the lognormal distribution assumptions within the standard formula.

4.172. As an attempt to derive a single factor per line of business, across all firms we have taken a linearly weighted average of the standard deviations by undertaking.

4.173. Effectively this assumes that the sample of undertakings used in the fitting process is representative of all of Europe in terms of associated claims provision volumes as well as putting significantly more weight to those undertakings which write larger volumes of a specific line of business, therefore any result will be biased towards factors most appropriate for larger portfolios.

4.174. If the following terms are defined as:

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
$\mathcal{E}_{C,Y,lob}$	=	An unspecified random distribution with mean zero and unit variance
$M_{C,Y,lob}$	=	The mean of the logarithm of the best estimate for claims outstanding in one year plus the incremental claims paid over the one year by undertaking, accident year and LoB
$S_{C,Y,lob}$	=	The standard deviation of the logarithm of the best estimate for claims outstanding in one year plus the incremental claims paid over the one year by undertaking, accident year and LoB
$PCO_{C,lob,i,j}$	=	The best estimate for claims outstanding by undertaking and LoB for accident year i and development year j

$I_{C,lob,i,j}$	=	The incremental paid claims by undertaking and LoB for accident year i and development year j
$V_{C,Y,lob}$	=	Volume measure by undertaking, calendar year and LoB
$R_{C,Y,lob}$	=	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 undertaking, 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 $R_{C,Y,lob}$.
$V_{C,lob}$	=	Average volume measure by undertaking and LoB

4.175. Then the following relationships can be determined as:

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

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

4.176. Then the distribution of losses can be formulated as:

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

4.177. The parameters of the lognormal distributions can be formulated as follows:

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

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

4.178. The resultant simplified log Likelihood becomes

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

4.179. The parameter β_{lob} is chosen to maximise this likelihood.

4.180. If the following term is defined as:

$\sigma_{(C,res,lob)}$	=	Standard deviation for reserve risk by Undertaking by LoB
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4.181. The $\sigma_{(C,res,lob)}$ then becomes :

$$\sigma_{C,res,lob} = \frac{\hat{\beta}_{lob}}{\sqrt{V_{C,lob}}} \text{ where}$$

$$V_{C,lob} = V_{C,max(Y),lob}$$

4.182.If the following term is defined as:

$\sigma_{(res,lob)}$	=	Standard deviation for reserve risk by LoB
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4.183.Then a value for $\sigma_{(res,lob)}$ is determined by taking a volume weighted average of the fitted undertaking specific standard deviations as below:

$$\hat{\sigma}_{(res,lob)} = \frac{\sum_C V_{C,lob} \sigma_{C,res,lob}}{\sum_C V_{C,lob}}$$

Method 3

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

4.185. 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 square of the current best estimate for claims outstanding and
- The maximum likelihood fitting approach is appropriate.

4.186. If the following terms are defined:

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
$\mathcal{E}_{C,Y,lob}$	=	An unspecified random distribution with mean zero and unit variance
$M_{C,Y,lob}$	=	The mean of the logarithm of the best estimate for claims outstanding in one year plus the incremental claims paid over the one year by undertaking, accident year and LoB
$S_{C,Y,lob}$	=	The standard deviation of the logarithm of the best estimate for claims outstanding in one year plus the incremental claims paid over the one year by undertaking, accident year and LoB

$PCO_{C,lob,i,j}$	=	The best estimate for claims outstanding by undertaking and LoB for accident year i and development year j
$I_{C,lob,i,j}$	=	The incremental paid claims by undertaking and LoB for accident year i and development year j
$V_{C,Y,lob}$	=	Volume measure by undertaking, calendar year and LoB
$R_{C,Y,lob}$	=	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 undertaking, 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 $R_{C,Y,lob}$.

4.187. Then the following relationships are defined:

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

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

4.188. Then the distribution of losses can be formulated as:

$$R_{C,Y,lob} \sim V_{C,Y,lob} + V_{C,Y,lob} \beta_{lob} \varepsilon_{C,Y,lob}$$

4.189. This allows the parameters of the lognormal distributions to be formulated as follows:

$$S_{C,Y,lob} = \sqrt{\log(1 + \beta_{lob}^2)}$$

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

4.190. The resultant simplified log Likelihood becomes

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

4.191. The parameter β_{lob} is chosen to maximise this likelihood.

$\sigma_{(res,lob)}$	=	Standard deviation for reserve risk by LoB
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4.192. Then we can derive a value for $\sigma_{(res,lob)}$ as below:

$$\hat{\sigma}_{(res,lob)} = \hat{\beta}_{lob}$$

Method 4

4.193. This approach is consistent with the undertaking specific estimate assumptions from the Technical Specifications for QIS4 for reserve risk.

4.194. This method involves a three stage process:

a. Involves by undertaking calculating the mean squared error of prediction of the claims development result over the one year.

- 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 Wuthrich, Casualty Actuarial Society E-Forum, Fall 2008.
- Furthermore, in the claims triangles:
- cumulative payments $C_{i,j}$ in different accident years i are independent
- for each accident year, the cumulative payments $(C_{i,j})_j$ are a Markov process and there are constants f_j and s_j such that $E(C_{i,j}|C_{i,j-1})=f_j C_{i,j-1}$ and $Var(C_{i,j}|C_{i,j-1})=s_j^2 C_{i,j-1}$.

b. Involves fitting a model by undertaking to the results of the Merz method:

- The assumptions are that for any LoB:
- The appropriate volume measure is the best estimate for claims outstanding as derived by the chain ladder for the undertaking.
- The variance of the claims development result is proportional to the current best estimate for claims outstanding and
- The least squares fitting approach, of the undertaking specific standard deviations, is appropriate.

4.195. Specifically if the following terms are defined:

$PCO_{C,lob}$	=	The current best estimate for claims outstanding as derived by the chain ladder by undertaking and LoB
$V_{C,lob}$	=	Volume measure by undertaking and LoB
$MSEP_{C,lob}$	=	The mean squared error of prediction of the claims development result in one year's time, as prescribed by the paper referenced above, by undertaking and LoB

4.196. Then the following relationship can be defined:

$$V_{C,lob} = PCO_{C,lob}$$

4.197. If the following term is defined:

β_{lob}^2	=	Constant of proportionality for the variance of the claims development result by LoB
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Then the least squares estimator of the coefficients of variation is the value of β_{lob} which minimises the following function:

$$\sum_C \left(\frac{\beta_{lob}}{\sqrt{V_{C,lob}}} - \frac{\sqrt{MSEP_{C,lob}}}{V_{C,lob}} \right)^2$$

4.198. By differentiating this function with respect to β_{lob} and setting this to zero the following least squares estimator is obtained:

$$\hat{\beta}_{lob} = \frac{\sum_C \frac{\sqrt{MSEP_{C,lob}}}{V_{C,lob}^{3/2}}}{\sum_C \frac{1}{V_{C,lob}}}$$

And

$$\sigma_{C,res,lob} = \frac{\hat{\beta}_{lob}}{\sqrt{V_{C,lob}}} \text{ where}$$

c. Estimating the volume weighted average across all undertakings

4.199. If the following terms are defined:

$V'_{C,lob}$		The best estimate for claims outstanding by undertaking and LoB
$\sigma_{(res,lob)}$	=	Standard deviation for reserve risk by LoB

4.200. Then a value for $\sigma_{(res,lob)}$ can be determined by taking a volume weighted average of the fitted undertaking specific standard deviations as below:

$$\hat{\sigma}_{(res,lob)} = \frac{\sum_C V'_{C,lob} \sigma_{C,res,lob}}{\sum_C V'_{C,lob}}$$

Method 5

4.201. This approach is consistent with the undertaking specific estimate assumptions from the Technical Specifications for QIS4 for premium risk.

4.202. This method involves a two stage process:

a. Involves by undertaking calculating the mean squared error of prediction of the claims development result over the one year.

- 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 Wuthrich, Casualty Actuarial Society E-Forum, Fall 2008.
- Furthermore, in the claims triangles:
- cumulative payments $C_{i,j}$ in different accident years i are independent
- for each accident year, the cumulative payments $(C_{i,j})_j$ are a Markov process and there are constants f_j and s_j such that $E(C_{i,j}|C_{i,j-1})=f_j C_{i,j-1}$ and $Var(C_{i,j}|C_{i,j-1})=s_j^2 C_{i,j-1}$.

b. Involves fitting a model by undertaking to the results of the Merz method:

- The appropriate volume measure is the best estimate for claims outstanding as derived by the chain ladder for the undertaking.
- The variance of the claims development result is proportional to the square of the current best estimate for claims outstanding and
- The least squares fitting approach, of the undertaking specific standard deviations, is appropriate.

4.203. Specifically if the following terms are defined:

$PCO_{C,lob}$	=	The current best estimate for claims outstanding as derived by the chain ladder by undertaking and LoB
$V_{C,lob}$	=	Volume measure by undertaking and LoB
$MSEP_{C,lob}$	=	The mean squared error of prediction of the claims development result in one year’s time, as prescribed by the paper referenced above, by undertaking and LoB

4.204. Then the following relationship can be defined:

$$V_{C,lob} = PCO_{C,lob}$$

4.205. If the following term is defined:

$\sigma_{(res,lob)}$	=	Standard deviation for reserve risk by LoB
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Then the least squares estimator of standard deviation is the value of $\sigma_{(res,lob)}$ which minimises the following function:

$$\sum_C \left(V_{C,lob} \sigma_{(res,lob)} - \sqrt{MSEP_{C,lob}} \right)^2$$

4.206. By differentiating this function with respect to $\sigma_{(res,lob)}$ and setting this to zero the following least squares estimator is obtained by :

$$\hat{\sigma}_{(res,lob)} = \frac{\sum_C V_{C,lob} \sqrt{MSEP_{C,lob}}}{\sum_C V_{C,lob}^2}$$

Method 6

4.207. This method involves a two stage process:

a. Involves by undertaking calculating the mean squared error of prediction of the claims development result over the one year.

- 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 Wuthrich, Casualty Actuarial Society E-Forum, Fall 2008.
- Furthermore, in the claims triangles:
- cumulative payments $C_{i,j}$ in different accident years i are independent
- for each accident year, the cumulative payments $(C_{i,j})_j$ are a Markov process and there are constants f_j and s_j such that $E(C_{i,j}|C_{i,j-1})=f_j C_{i,j-1}$ and $Var(C_{i,j}|C_{i,j-1})=s_j^2 C_{i,j-1}$.

b. Involves fitting a model by undertaking to the results of the Merz method:

- The appropriate volume measure is the best estimate for claims outstanding as derived by the chain ladder for the undertaking.
- The variance of the claims development result is proportional to the square of the current best estimate for claims outstanding and
- The least squares fitting approach, of the undertaking specific coefficients of variation, is appropriate.

4.208. Specifically the following terms are defined:

$PCO_{C,lob}$	=	The current best estimate for claims outstanding as derived by the chain ladder by undertaking and LoB
$V_{C,lob}$	=	Volume measure by undertaking and LoB
$MSEP_{C,lob}$	=	The mean squared error of prediction of the claims development result in one year’s time, as prescribed by the paper referenced above, by undertaking and LoB
N_{lob}	=	The number of undertakings by LoB where there is both a value of $PCO_{C,lob}$ and $MSEP_{C,lob}$.

4.209. Then we can define the following relationship:

$$V_{C,lob} = PCO_{C,lob}$$

4.210. The following term is defined as follows:

$\sigma_{(res,lob)}$	=	Standard deviation for reserve risk by LoB
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Then the least squares estimator of the coefficients of variation is the value of $\sigma_{(res,lob)}$ which minimises the following function:

$$\sum_C \left(\sigma_{(res,lob)} - \frac{\sqrt{MSEP_{C,lob}}}{V_{C,lob}} \right)^2$$

4.211. By differentiating this function with respect to $\sigma_{(res,lob)}$ and setting this to zero we obtain the following least squares estimator:

$$\hat{\sigma}_{(res,lob)} = \frac{\sum_C \frac{\sqrt{MSEP_{C,lob}}}{V_{C,lob}}}{N_{lob}}$$

4.6.5. Reserve Risk Results

4.212. CEIOPS has presented the results of the gross analysis through a combination of tables and graphs.

4.213. The tables present the results for all 6 methods described above:

- The analysis includes a column of fitted factors by method based on an estimated volume weighted average of the standard deviation estimates by undertaking. Effectively this assumes that the sample of undertakings used in the fitting process is representative of all of Europe in terms of associated premium volumes as well as putting significantly more weight to those undertakings which write larger volumes of a specific line of business, therefore any result will be biased towards factors most appropriate for larger portfolios.
- The table includes the percentage of undertakings which would have a gross standard deviation, as assessed under Method 1, greater than the selected technical result.

4.214. Results vary across methods because each method uses different underlying assumptions. For example:

- The individual estimates of the standard deviations by undertaking that result from the application of Method 1 are plotted against the prediction model for comparison. The individual estimates can be used as evidence of the existence of diversification credit for volume. Where such an effect does exist the graph would be expected in general to be decreasing.

- This also implies that capital requirements are significantly higher for smaller than larger portfolios. This arises for two reasons:
- Larger accounts are usually less volatile than smaller accounts. Thus expressed as a percentage of premiums a larger account often has smaller theoretical capital requirements than a smaller account.
- Larger insurers often have a greater degree of diversification of risks than smaller insurers.

4.215. For those methods where diversification credit is assumed to exist, an illustration of what the factor could be for 3 sizes is presented: small, which equates to a 25th percentile of the sample observations, medium a 50th percentile, large 90th percentile.

4.216. The appropriateness of each method and the underlying assumptions are tested and presented by showing the results of a goodness of test fit through a PP plot.

4.217. The Merz methods (4, 5 and 6) are plotted in a third graph. Here we are able to observe whether there is diversification credit as well as a comparison of the individual observations versus the fitted models. Observations used for methods 1 to 3 are not necessarily included in methods 4 to 6.

4.218. The selection of the final fitted factors was based on the following:

- The evidence of diversification by size has not been given full allowance. i.e. no consideration has been given to the fact that volatilities by size of portfolio may be significantly different. Therefore more focus has been placed on the fitted factors.
- Factors have been selected as the average of those methods which were considered to produce an acceptable fit according to the goodness of fit plots shown

4.219. CEIOPS would like to highlight that the selection was not conservatively selected, but rather based on the goodness of fit results and the adequacy of the method. Furthermore by taking an average across methods, CEIOPS is ensuring that the factors are not biased towards factors most appropriate for larger portfolios (and hence lower).

Accident

4.220. CEIOPS recommendation is that for the accident lob the gross factor for reserve risk should be 18%.

4.221. The data sample included data from 32 undertakings, was gross of reinsurance and included data from the following member states: LU, SI, SK, PO, IS and DK.

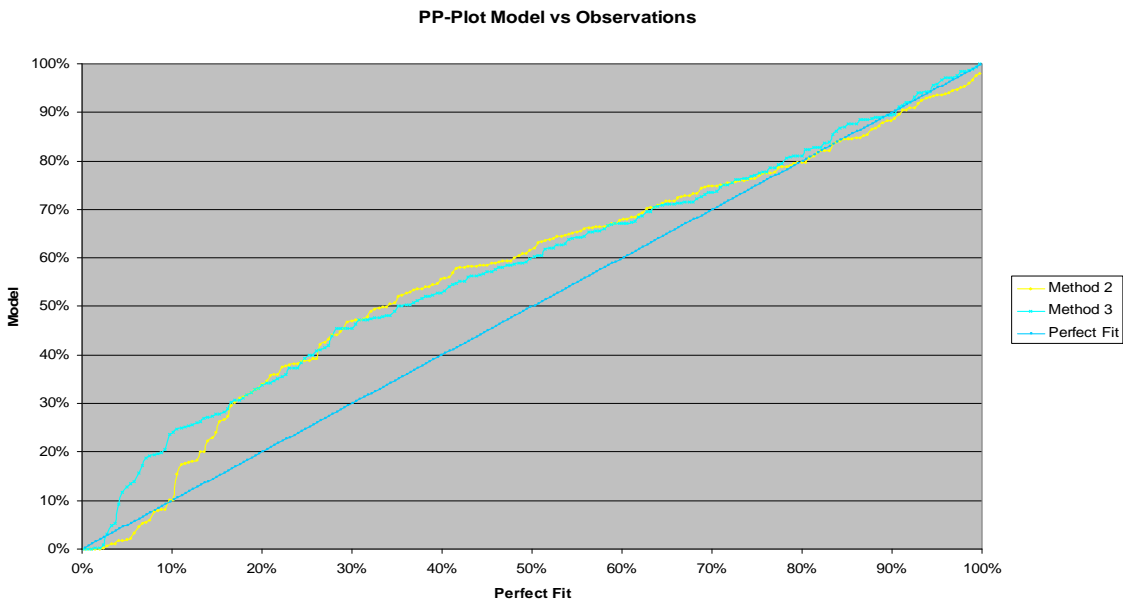
Reference co	Small	Medium	Large
Accident - Euros	5,578	12,625	35,390

GROSS SD

Discounted

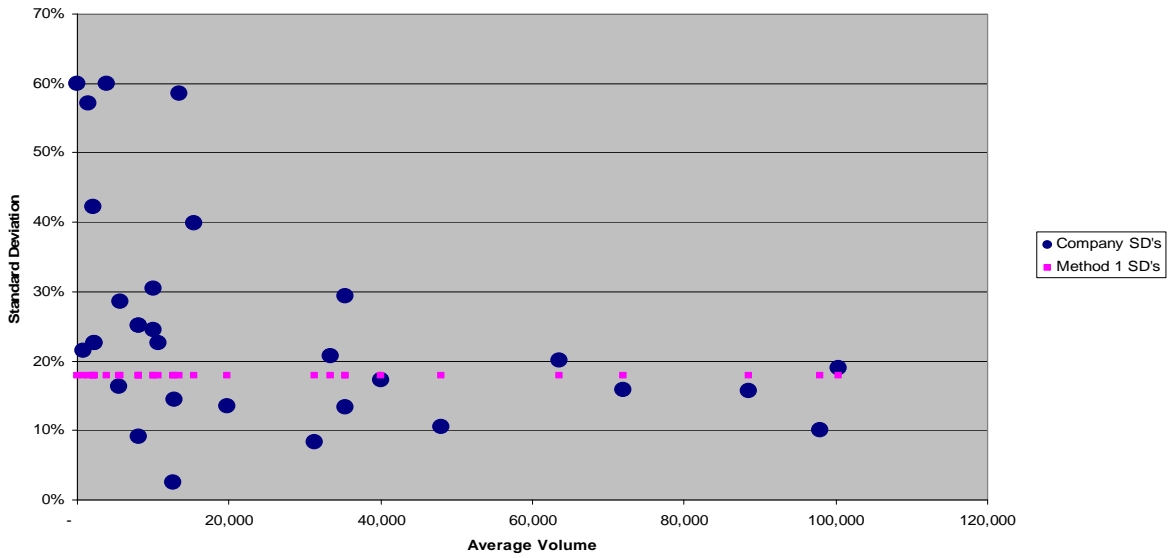
Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result	% firms with higher sd
Method 1	29%	21%	15%	18%	17.9%	61.3%
Method 2	47%	31%	19%	18%		
Method 3				32%		
Method 4	16%	11%	7%	6%		
Method 5				17%		
Method 6				19%		

4.222. The graph below shows a pp plot of the fit of the models. Both methods provide a relatively poor fit, although there is some credibility in the tail.



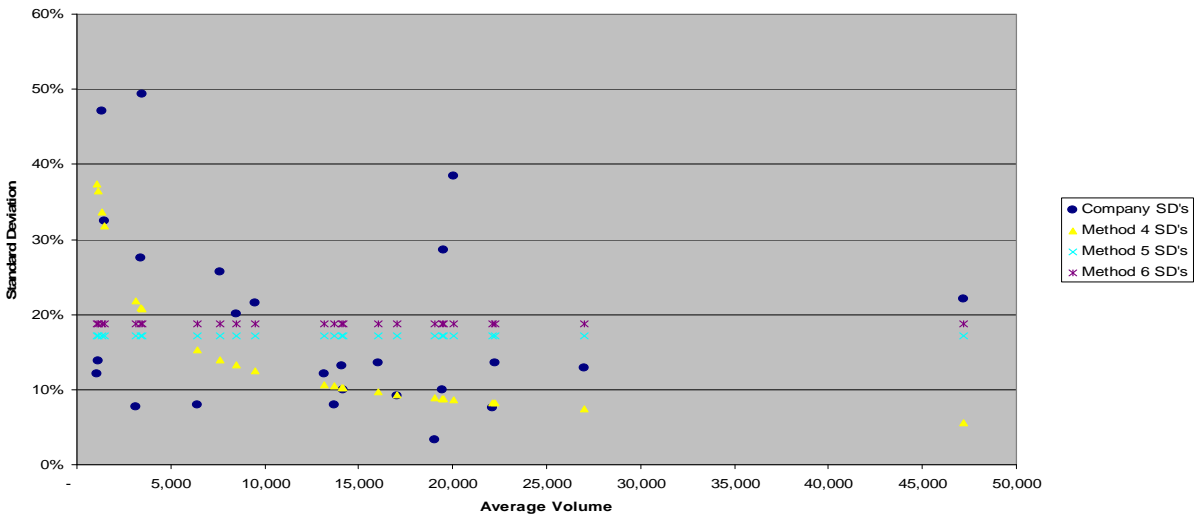
4.223. The result of the graph below shows some evidence for diversification credit. It also shows the volatility of the individual observations compared to the fitted selection for method 1.

Standard Deviations for Method 1 vs Companies



4.224. The graph below shows the results for the Merz methods.

Standard Deviations for Methods 4, 5 and 6 vs Companies



Overall conclusions:

4.225. The selected technical factor was chosen as the average of methods 1, 5 and 6 – result 17.9%.

Sickness

4.226. CEIOPS recommendation is that for the sickness lob the factor for reserve risk should be 25%.

4.227. The data sample included data from 126 undertakings, was gross of reinsurance and included data from the following member states: UK, PT, PO and SE.

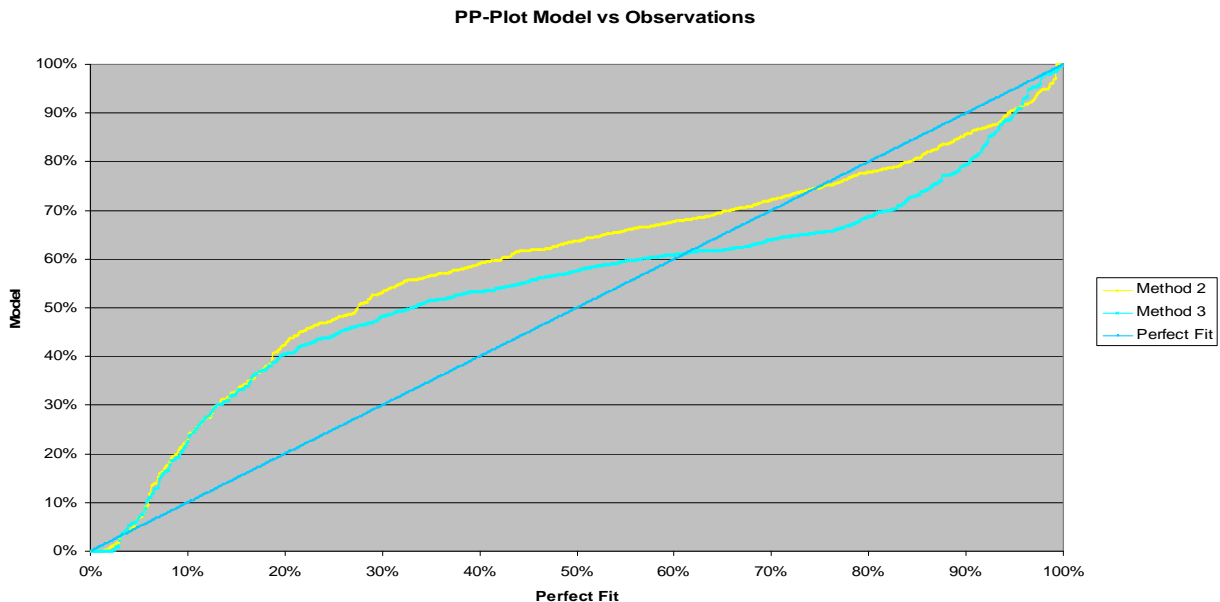
Reference co	Small	Medium	Large
Sickness – Euros	534	3,740	10,151

GROSS SD

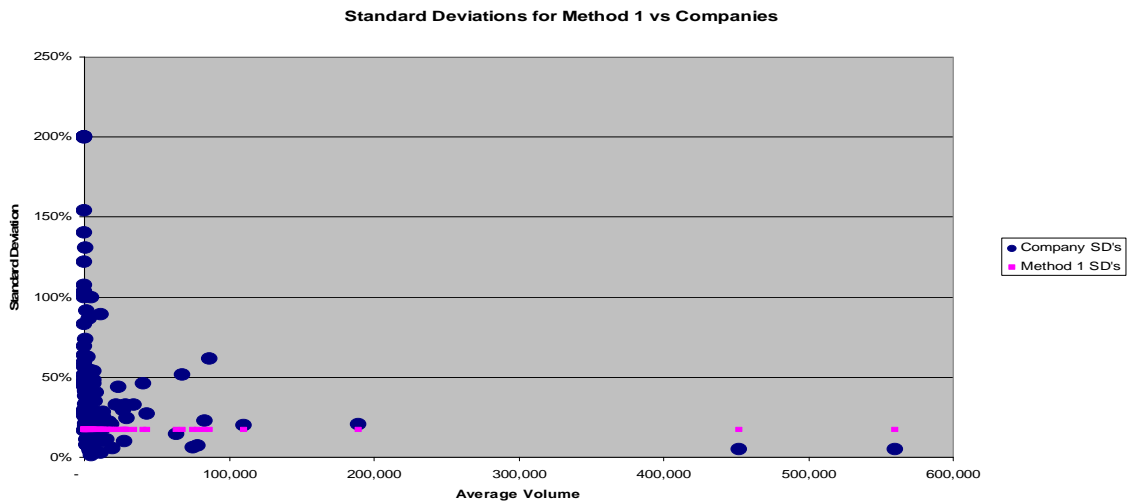
Discounted

Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result	% firms with higher sd
Method 1	51%	28%	14%	17%	25.2%	54.0%
Method 2	211%	80%	48%	21%		
Method 3				65%		
Method 4	31%	12%	7%	3%		
Method 5				17%		
Method 6				41%		

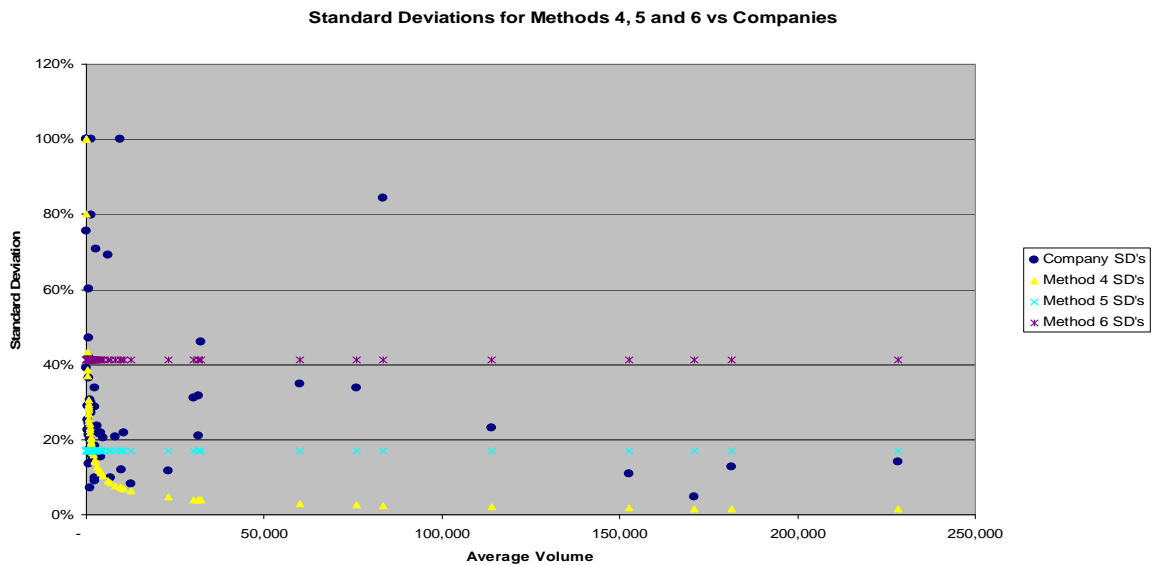
4.228. The graph below shows a pp plot of the fit of the models. Both methods provide a relatively poor fit.



4.229. The result of the graph below shows some evidence for diversification credit. It also shows the volatility of the individual observations compared to the fitted selection for method 1.



4.230. The graph below shows the results for the Merz methods.



Overall conclusions:

4.231. The selected technical factor was chosen considering the average of methods 1, 5 and 6 – result 25.2%.

Workers' compensation

4.232. CEIOPS recommendation is that for the workers' compensation job the factor for reserve risk is 25%.

4.233. The data sample included data from 27 undertakings, was gross of reinsurance and included data from the following member states: PO, BE, DK and LU, FI.

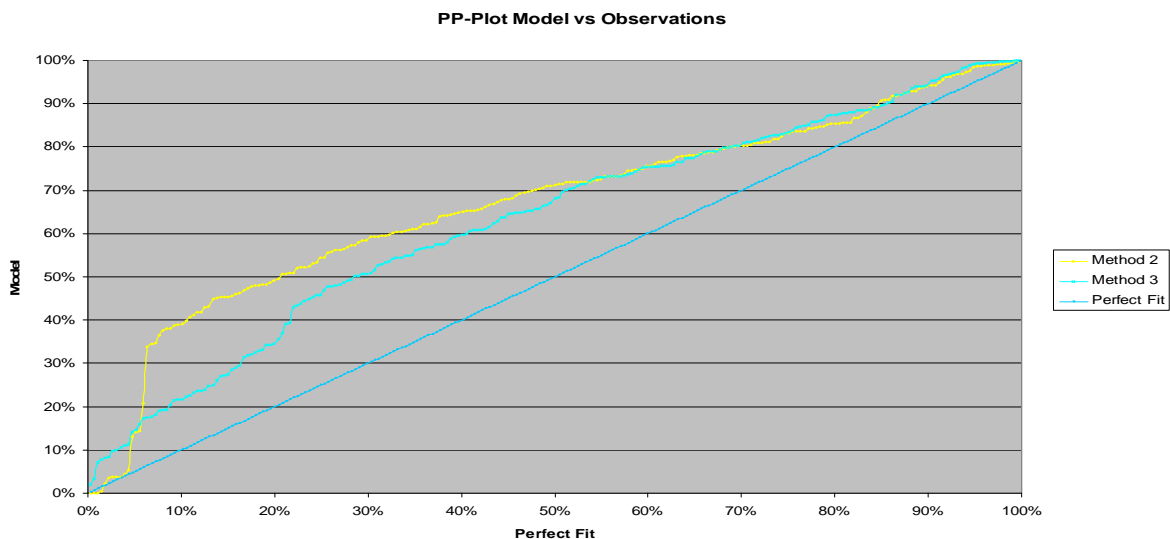
Reference co	Small	Medium	Large
Workers compensation – Euros	4,533	18,440	49,310

GROSS SD

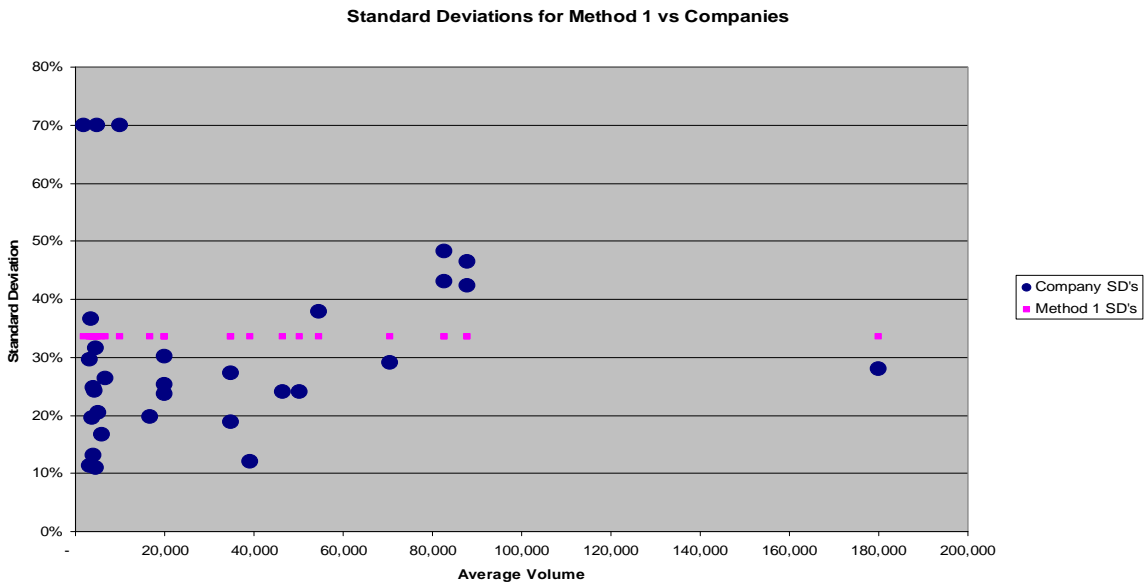
Discounted

Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result	% firms with higher sd
Method 1	37%	26%	20%	34%	24.4%	65.0%
Method 2	77%	38%	23%	24%		
Method 3				38%		
Method 4	15%	8%	5%	5%		
Method 5				3%		
Method 6				11%		

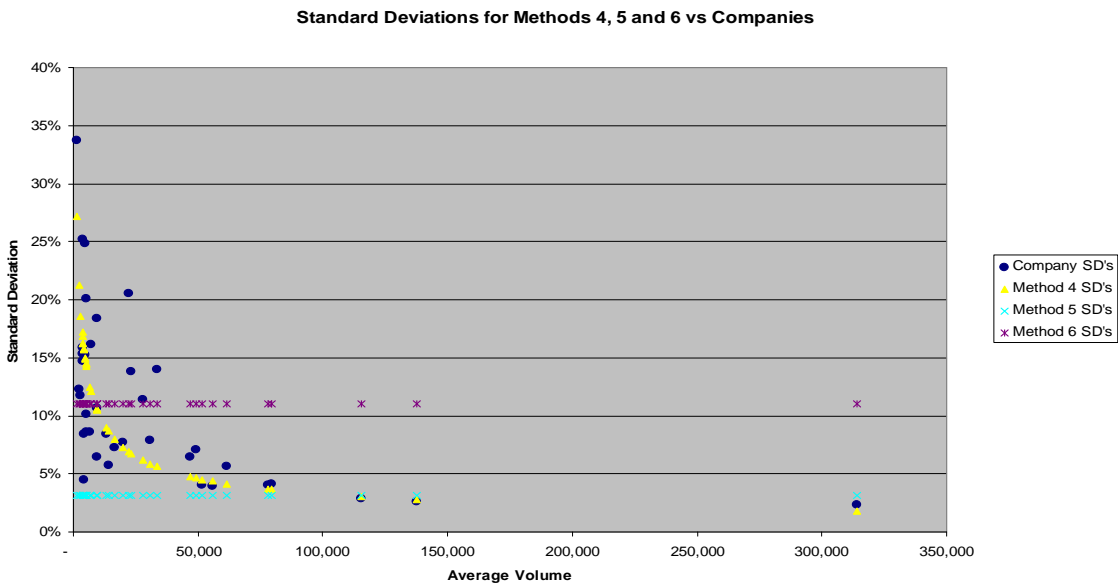
4.234. The graph below shows a pp plot of the fit of the models. Method 3 provides the best fit.



4.235. The result of the graph below shows some evidence for diversification credit. It also shows the volatility of the individual observations compared to the fitted selection for method 1.



4.236. The graph below shows the results for the Merz methods.



Overall conclusions:

4.237. The selected technical factor was chosen considering the average of methods 3 and 6 – result 24.4%.

4.3.6. Adjusting gross to net for reserve risk

4.238. CEIOPS initially considered whether it was possible to derive an approach similar to the method being used in the premium risk to convert the gross reserving risk factors to an appropriate net reserving risk factor.

4.239. However, an initial impact study made it immediately clear that this resulted in a relatively small reduction in the factors for individual undertakings. This was due to undertakings having an insufficient number of years of observations of the benefit of reinsurance over one year to realistically derive a reduction that was appropriate for the 1 in 200 year scenario implicit within the gross calibration.

4.240. As a result CEIOPS felt obliged to help undertakings by using data across multiple companies and subsequently many more one year observations than available to any one undertaking to help estimate appropriate reductions in the gross calibration.

4.241. CEIOPS has selected the following net factors as the calibration for the non-life underwriting module for the purpose of the standard formula:

Line of Business	Net Factor	QIS 4	CP 71
Accident	17.5%	15.0%	17.5%
Sickness	12.4%	7.5%	12.5%
Workers Compensation	11.9%	10.0%	12.5%

4.242. The approach used to derive the net reserving risk factor from the gross reserving risk factor involved three steps.

- The first step was to derive an uplift to the gross factor. This is needed as the original gross volatility factor was designed to be applied to gross reserves to get the gross capital amount. It is now to be applied to the net reserves, and so an uplift is needed to arrive at the same gross capital amount.
- The second step was to derive the benefit of the mitigating effect of the reinsurance programme on the large gross deteriorations. This was done by looking at the net to gross experience of claims development over the year, but limited to situations where claims deterioration was relatively extreme, so that the factor would reflect the experience at these levels rather than at expected levels.
- The third step was to blend these analyses together with the results from the gross calibration. This effectively meant taking the gross volatility, applying the uplift factor obtained in step 1 and then applying the reinsurance mitigation obtained from the second step.

4.243. Essentially this approach looks at the reduction in the net to gross ratio over the one year time horizon conditioned upon the gross deterioration being relatively extreme – ie consistent with the scenario effectively identified by the gross calibration.

Data

4.244. The data used was four time series per line of business by individual companies and years.

- First time series: The opening gross reserve by company by year. (This time series was used as part of the calibration of the gross factors.)
- Second time series: The closing gross reserve after one year plus the incremental gross claims paid during the year, for the same accident years as the first time series by company by accident year. (This time series was used as part of the calibration of the gross factors.)
- Third time series: The opening net reserve by company by year.
- Fourth time series: The closing net reserve after one year plus the incremental net claims paid during the year, for the same accident years as the third time series by company by accident year.

Formulaic Filter

4.245. Due to the nature of the data collected for the calibration exercise it was necessary to apply a restrictive filter to remove apparent mismatches between the gross and net figures. This comprised the following components:

- First Filter: Only observations where a value existed for each of the time series were included in the calibration.
- Second Filter: Only observations where the net amounts were smaller than the associated gross amounts for both the opening and closing time series were included in the calibration.
- Third Filter: Only observations where the change in the net position was smaller than the associated change in the gross position were included in the calibration.

Manual Filter

4.246. Even with the formulaic filters described above there were a few observations that had to be removed from the calibration due to apparent inconsistencies between the gross and net amounts.

Calibration Step 1

4.247. The volume weighted average gross to net ratio was selected. This was the volume weighted average of the first time series divided by the third time series.

Calibration Step 2

4.248. This analysis comprised taking the observations with the largest gross deteriorations and summarising the closing net to gross ratios (ie the fourth time series divided by the second time series).

Calibration Step 3

4.249. The final step multiplied the gross calibration factor by the gross to net ratio derived in step 1 and then multiplied by the associated net to gross ratio derived in step 2.

4.7 Summary results

4.250. CEIOPS has selected the following gross factors as the calibration for the Non-SLT Health underwriting risk module for the purpose of the standard formula:

LOB	Gross Premium factor	Gross Reserve Factor
Accident	12.5%	18%
Sickness	9.5%	25%
Workers compensation	5.5%	25%

1.18. After adjusting for reinsurance as recommended above, the net technical factors for the calibration for the Non-SLT health underwriting module for the purpose of the standard formula would be as follows:

LOB	Net premium factor ⁸	Net reserve factor
Accident	12.5%*(NCR _i /GCR _i)	17.5%
Sickness	9.5%*(NCR _i /GCR _i)	12.5%
Workers compensation	5.5%*(NCR _i /GCR _i)	12%

4.8 Data availability

4.251. Below we present a table that shows the availability of data for premium and reserve risk respectively for CP72 and the revised set of data set used for the current analysis.

CP72 Version1			CP72 Version2		
Premium risk	Gross	Net	Premium risk	Gross	Net
WC	Portugal		WC	Portugal, Denmark, Finland	
Sickness	UK, Germany, Poland, Portugal	UK, Poland	Sickness	UK, Germany, Poland, Portugal, Denmark, Sweden	UK, Poland
Accident	Lux, Slovenia, poland	Lux, Germany, poland	Accident	Lux, Slovenia, Poland, Iceland, Denmark, Slovakia	Lux, Germany, Poland, Iceland, Denmark

CP72 Version1			CP72 Version2		
RESERVE RISK	Gross	Net	RESERVE RISK	Gross	Net
Workers compensation	Portugal		WC	Portugal, Belgium, Denmark, Lux, Finland	
Sickness	UK, Portugal, poland	UK, poland	Sickness	UK, Portugal, Poland, Sweden	UK, poland
Accident	Lux, Slovenia, poland	Lux, poland	Accident	Lux, Slovenia, Poland, Iceland, Denmark, Slovakia	Lux, poland, Iceland, Denmark

4.9 Health Catastrophe standardised scenarios

4.252. The Health Catastrophe standardised scenarios considered in this document are:

- Arena disaster

⁸ CEIOPS has recommended an adjustment factor for Premium Risk that is undertaking specific, and so it is not possible to provide a net premium factor. NCR and GCR stand for net combined ratio and gross combined ratio respectively

- Concentration scenario
- Pandemic scenario

4.253.Scenarios should be EEA based.

4.254.Geographical boundaries should be recognised where necessary.

4.255.Scenarios should be provided gross of reinsurance and gross of all other mitigation instruments (for example national pool arrangements). Undertakings shall take into account reinsurance and other mitigation instruments to estimate their net loss as specified by the CEIOPS advice in CP50.

4.256.Scenarios have not been provided by line of business nor segmented between NSLT and SLT. Scenarios are provided for the health catastrophe risk module allowing for the respective risks affecting SLT and NSLT.

4.257.The scenarios have been built by CEIOPS in cooperation with industry representatives in the Catastrophe Task Force and will be tested for a first time in QIS5.

4.9.1 Application of Health Catastrophe standardised scenarios

ARENA DISASTER

4.258.The total capital charge is estimated as follows:

$$CAT_{ARENA_STATE} = S * \sum^{products} I_P * X_P * E_P * MS_P$$

$$CAT_{ARENA} = \sum^{allSTATES} CAT_{ARENA_STATE}$$

Where

S = the number of people affected by the event

I_p = insurance penetration for product type and by member state

x_p= proportion of accidental deaths/disabilities (short and long term) and injuries (p = product type).

MS_p = market share by product type

E_p = exposure measure i.e. average sum insured by product type

4.259.The value for S is 50% of the arena full capacities provided in Annex.

4.260.The value of I_p are provided in Annex.

- 4.261. Where the health product types considered are features of a larger product package (such as workers' compensation) then a calculation of required capital should be made for each of the relevant product types. Disabilities are split into short-term and long-term in assessing likely claim amounts under disability income policies taking into account the monthly benefit amount and the expected duration of the claim. Where a lump sum is payable under a permanent and total disability policy or rider benefit then this would be considered as a long term disability claim.
- 4.262. The market share by product type MS_p shall be provided by the undertaking. The factors shall be estimated according to their share of the market for each of the respective member states where they have exposure. Undertakings will provide a short but detailed explanation of how they have arrived at their estimation.
- 4.263. Each undertaking will be required to provide its average sum insured by product type, E_p . For the estimation of E_p , undertakings need to consider:
- In the case of disability where payments are not lump sums, the exposure measure should be the present value of expected future payments for disability claims.
 - In calculating the present value of future payments, firms should assume that a short term disability would last for 12 months and a long term disability would last for 10 years (or such shorter period for which the average policy would make payments) from the date of the catastrophe event; firms should also make allowance for any deferred period before claim payments commence.
 - For medical expense insurance, the sum insured may be taken as zero. See further below.
 - Firms shall also add extra exposure for any Personal Accident riders.

CONCENTRATION SCENARIO

4.264. The total capital charge is estimated as follows:

$$CAT_{CONC_STATE} = S * \sum^{products} X_p * E_p$$

$$CAT_{CONC} = \sum^{STATES} CAT_{CONC_STATE}$$

Where

CAT_{CONC} = is the capital charge for the concentration scenario.

S = largest known concentration of lives in a group scheme portfolio.

X_p = proportion of accidental deaths/disabilities (short and long term) and injuries (p = product type)

E_p = exposure measure i.e. average sum insured by product type and by undertaking.

4.265. The product type factors x_p for all member states:

Proposed Injury Distributions

	%
Deaths	12.00
Permanent Total Disability	2.00
Long Term Disability	5.00
Short Term Disability	15.00
Medical/Injuries	30.00
Total percentage*	65.00

4.266. Each undertaking will be required to provide:

4.267. Where the health product types considered are features of a larger product package (such as workers' compensation) then a calculation of required capital should be made for each of the relevant product types. Disabilities are split in to short-term and long-term in assessing likely claim amounts under disability income policies taking into account the monthly benefit amount and the expected duration of claim. Where a lump sum is payable under a permanent and total disability policy or rider benefit then this would be considered as a long term disability claim.

4.268. For the estimation of E_p , undertakings need to consider:

- In the case of disability where payments are not lump sums, the exposure measure should be the present value of expected future payments for disability claims.
- In calculating the present value of future payments, firms should assume that a short term disability would last for 12 months and a long term disability would last for 10 years (or such shorter period the average policy would make payments) from the date of the catastrophe event; firms should also make allowance for any deferred period before claim payments commence.
- For medical expense insurance, the sum insured should be taken as the average claim paid in the last two underwriting years in respect of hospital treatments for accidental causes.
- Firms shall also add extra exposure for any Accident riders.

4.269. For the estimation of S undertakings need to select the scheme with the largest known concentration of lives within a group scheme portfolio.

PANDEMIC SCENARIO

4.270. The total capital charge is estimated as follows:

$$CAT_{PAN_STATE} = R \sum_{products} E_P$$

$$CAT_{PAN} = \sum_{STATES} CAT_{PAN_STATE}$$

Where

CAT_{PAN} is the capital charge for the pandemic scenario

R = is the proportion of lives affected by the Pandemic = 0.075%

E_P = exposure measure i.e. average sum insured by product type and by undertaking.

4.271. The scenario will impact the following products:

- disability income (both long and short term)
- products covering permanent and total disability either as a stand alone benefit or as part of another product, such as a stand alone critical illness product.

4.272. The product type factors x_P for all member states:

Proposed Injury Distributions

	%
Deaths	12.00
Permanent Total Disability	2.00
Long Term Disability	5.00
Short Term Disability	15.00
Medical/Injuries	30.00
Total percentage*	65.00

4.273. Each undertaking will be expected to provide:

E_P Average sum insured by product type

4.274. For the estimation of E_P , undertakings need to consider:

- In the case of disability where payments are not lump sums, the exposure measure should be the present value of future payments for disability claims.
- In calculating the present value of future payments, firms should assume that claimants would not recover and that payments would cease only on death or at the end of the claim payment period specified in the policy conditions; firms should also make allowance for any deferred period before claim payments commence.

4.9.2 Calibration of Health Catastrophe standardised scenarios

4.275. The following 3 scenarios have been considered to be an adequate selection of extreme and exceptional events that can impact the Health SLT and NSLT portfolios:

- Arena disaster
- Concentration scenario
- Pandemic scenario

4.276. While many different catastrophic scenarios may be considered, CEIOPS believes these scenarios capture the main exposure and catastrophe risks that affect health products and lines of business.

4.277. Each one of these scenarios has been calibrated at a 99.5% level and has taken into account diversification where appropriate.

4.278. For the Arena disaster the scenario aims to capture the risk of having lots of people in one place at one time and a catastrophic event affecting such location and people. It is recognised that while many people will be affected by a major event such as this, not all them will be insured and the insured lives will be covered by all (or almost all) of the insurance firms operating in the member state. The formula attempts to reflect this dilutive effect on the exposure of any one firm.

4.279. For the Concentration scenario, the scenario aims to capture the risk of having concentrated exposures the largest of which being affected by a disaster. For example: a disaster within densely populated office blocks in a financial hub.

4.280. For the Pandemic scenario, the scenario aims to capture the risk that there could be a pandemic that results in non lethal claims, e.g. where victims infected are unlikely to recover and could lead to a large disability claim

Arena and Concentration

4.281. The construction and calibration of the Arena and Concentration scenarios consisted of

- a. Definition of number of people affected by the event (S)
- b. Footprint for a scenario
- c. Definition of products affected by the scenario (P)

- d. Definition of Insurance penetration (I_p)
- e. Calibration of proportion of lives affected (X_p)
- f. Duration of benefits

A. Definition of the number of people affected by the event (S)

4.282. A table is included in **Annex 5** and has been constructed by collecting information regarding the capacity of the largest arena in each member state. It is then assumed that the arena is full at the time of the disaster and that 50% of those people in the arena are affected by the scenario.

B. Footprint for a concentration scenario

4.283. The task force modelled footprints for a concentration scenario.

4.284. For a 10-ton truck bomb, the largest bomb modelled, fatalities and serious injuries extend in measurable quantities up to 300m in low-rise buildings and 200m in high-rise engineered buildings commonly found in central business districts.

C. Definition of products affected by the scenario

4.285. The fundamental product types considered to be affected by such Arena and Concentration scenarios are:

- accidental deaths
- disabilities (short and long term)
- medical expenses
- Total and permanent disability (TPD)
- Personal Accident covers.

4.286. In particular for medical expense insurance:

- When trying to assess the impact of a catastrophic event on medical expense insurance, it is important to consider the ability of medical services providers to deal with the consequences of the catastrophic event (regardless of whether it is a mass accident or some form of pandemic). The supply of medical services is normally fixed and is generally much less than the demand for those services. As a result, there is little or no surplus capacity within the medical services systems. In addition, the nature of the local medical expense insurance market must be considered.
- Medical expense insurance, be it on a SLT or non-SLT basis, may cover all of an insured's medical treatment (such as in the Netherlands or Germany)

or may function to top up or provide an alternative to the state health system. In the latter type of market, medical treatment of the consequences of a catastrophe would fall to the state health system rather than to health insurers. As healthcare resources are transferred to deal with the catastrophe within the state health system, it is possible that the claims on the medical expenses insurers would reduce rather than increase. For example, UK products provide access to care from private care providers. These providers attend to acute conditions such as cancer, cardiovascular disease, etc and not emergencies. In emergencies arising from an accident or a pandemic, policyholders would rely on the National Health Service for treatment/care rather than private providers. For markets such as these, no capital requirements are considered necessary for the catastrophe scenarios specified. For the former type of market, insurers would have to pay the medical expenses of those affected by the catastrophe. For a market event (such as an arena event or some form of pandemic) the constrained capacity within the medical services systems means that it is anticipated that the treatment would be in place of other healthcare treatments that the insurer would be paying for anyway. The types of treatment and their costs would differ. However, it is expected that the overall increase in claim cost would be modest and would be reflected in the ordinary volatility risk.

- The one scenario in which catastrophe capital may be required is under the concentration scenario and the insurer would cover the cost of all medical treatment arising out of the scenario. If medical expense insurance is offered to a group of employees (or similar) then an event effecting those employees would generate an unanticipated increase in claim cost for the insurer and any offset from the substitution effect considered above would be very small. Capital would be required here and should be calculated in a similar manner to that for other types of benefit. As a result this has been allowed for under the Concentration scenario.

4.287. For personal accident riders, because the underlying benefits are the same as for accidental death or disability, any exposure will be treated the same as for accidental death or disability.

D. Definition of Insurance penetration (I_p)

4.288. The expression "insurance penetration" is used to measure the degree that a certain insurance product (covering individual and group risk) is acquired in the population. It can be viewed as a probability: What is the chance that a randomly drawn member of the population will have acquired the specific product? In case of a catastrophe, penetration serves as a share of the total loss to ascertain the loss that will be claimed from the insurance industry.

4.289. This factor is only relevant under the Arena scenario. CEIOPS is still estimating what these factors should be for some countries. This section is still work in progress. The I_p parameters are stated in Annex 6 and have been estimated as described below:

UK

- IP, standalone CI, and LTC: relates to number of in force policies in 2008, published by the ABI.
- Medical expenses: number of people covered by PMI in 2008 written by insurance companies and healthcare trust schemes, published by the ABI.
- Personal accident: relates to total payment protection policies (not only personal accident) written by the 12 largest providers in 2006 (source: OFT).
- Note: Penetration rates have been calculated using the number of in force policies and differs significantly from the consumer survey data published in Swiss Re's Insurance Report (see below).

Swiss Re Insurance report, 2009

- Critical illness, incl. accelerated
- Income protection
- Mortgage payment protection

France

- LTC: number of in force policies in 2008 (source: FFSA). Includes business written by insurance companies (2 million) and Mutuelles 45 and Institutions de Prevoyance (1 million)
- Income protection & medical expenses insurance: Data is from a consumer survey published in the AXA protection report, October 2007. This appears to include business written by Mutuelles 45 and Institutions de Prevoyance. The data on medical expenses penetration is quite similar to that published by the OECD (88% in 2006). The FFSA does not appear to publish data on the number of policies for medical expenses and disability.
- Personal accident: Data is for long term unemployment insurance from the AXA survey. Personal accident insurance is significant in France, but the FFSA does not appear to publish number of policies.

Germany

- Based on data on number of in force policies from GDV and BAFIN. Includes standalone and rider business, compulsory and supplementary policies, and business written by health insurers (PVK).
- OECD medical expenses penetration data is quite similar (28% in 2007).

Italy

- Income protection, medical expenses & personal accident: Data is from a consumer survey published in the AXA protection report, October 2007. There is no way of verifying this data, but apparently a lot of disability and medical expenses is sold as riders to life policies.
- Long term care: estimate based on small in force premium volume (EUR 25m in 2008)

Netherlands

- The Netherlands has a large disability insurance market, but data on number of policies does not seem to be available.
- Medical expenses: OECD data for 2007.

Spain

- Income protection: market research data on ownership compiled by AXA, October 2007. According to ICEA, the "majority" of life policies in Spain have a disability rider (no data available).
- Medical expenses: based on number in force policies as at Sept. 2009, compiled by ICEA. Includes non-life disability (14% by premium in 2008)
- Long term care: data is for the number of in force standalone policies as at end-Sept. 2009. Most Long term care policies are written as riders of life and non-life policies (data not available).

Other:

International sources

Health insurance ownership: Axa protection report, October 2007

	UK	FR	DE	IT	ES	BE
Health, medical, hospitalisation insurance	40%	91%	85%	34%	51%	88%
Disability	40%	64%	71%	39%	48%	39%
Long term unemployment insurance	20%	18%	n.a.	5%	3%	6%
Critical illness, incl. accelerated*	38%					

* Unclear whether CI is included in product categories above.

Source: Market research published in the Axa protection report, October 2007, page 40.

People covered by private health insurance, 2006: CEA data*															
Millions	UK	FR	DE	IT	ES	NL	BE	AT	PT	DE**	NO	CZ.	CH	SI	CY
Number of insured, 2006	6	14	22	n.a.	11	16	5	3	2	1	0		2	2	0
Population, 2008	61	64	82	60	46	16	11						8		
Penetration	11%	22%	27%		25%	99%	47%	34%	17%	28%	1%		22%	71%	18%
* Medical expenses insurance.															
** Denmark is for 1996.															

Notes

- Figures for France are rough estimates.
- For the Netherlands, the 2006 figure corresponds to the number of people covered by the mandatory system only. The supplementary system is excluded.
- For Switzerland, the data relates to number of contracts.
- Source: Health insurance in Europe 2006. CEA, p. 34 & 56.

Individuals covered by private health insurance: OECD data

Millions	UK	FR	DE	IT	ES	NL	BE	AT	PT	DE**	NO	CZ.	HU	IS	CH
	2006	2006	2007		2006	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007
Number of insured	7	54	23		6	15	8	3	2	1	-	-	-		
Penetration	11%	88%	28%		14%	92%	77%	34%	18%	16%	0%	0%	0%	0%	30%
* Medical expenses insurance.															

E. Calibration of proportion of lives affected (Xp)

4.290. For each product defined in b) CEIOPS had to calibrate the proportion of people affected under each scenario.

4.291. This was a difficult task. For such an exercise there is a need for data and statistics collated from similar disasters and these are not necessarily available at the detail required. The lack of disasters at a 1 in 200 year frequency was a slight barrier here. However two analysis were considered:

Analysis 1

4.292. One of the documents available is "*World Trade Center Cases in the New York Workers' Compensation System*", New York State Workers' Compensation Board, September 2009.

4.293. An extract from the document suggests as follows:

[National Institute of Standards and Technology (NIST) estimated that approximately 17,400 civilians were in the World Trade Center complex at the time of the September 11, 2001 attacks.]

Extract from Table 2: Frequency Distribution of WTC Workers' Compensation Claims by Claim Type

Table 1. Proposed Injury Distributions

	% claims	% workforce
Deaths	32.0	11.82
Permanent Total Disability	0.5	0.18
Permanent Partial Disability (scheduled loss)	2.5	0.92
Permanent Partial Disability (non scheduled loss)	5.5	2.03
Temporary Disability	16.3	6.02
Medical only	9.5	3.51
Denied	4.2	1.55
Non-Compensatory	29.5	10.90
Total number of claims/workforce	6427	36.93

NB: These figures exclude claims from rescue workers.

Indemnity benefits are provided to claimants with temporary or permanent disabilities (defined as loss of wage-earning capacity) or to the survivors (spouse, and dependent children) of workers fatally injured at work. A condition that, according to medical opinion, will not improve during the claimant's lifetime is deemed a permanent one.

Permanent disability awards are made after a medical determination that the work related injury has stabilized and the permanent effects of the injury can thus be assessed. Permanent disability benefits too can be either total or partial.

Two principal categories of permanent partial disability awards for workers' compensation are scheduled and non-scheduled. Permanent partial disability scheduled loss benefits are available for permanent disability to a statutorily specified list of selected members of the body and are calculated according to a statutorily prescribed fixed number of weeks of indemnity benefits for loss or loss of use. The specified (or fixed) amount of indemnity benefits compensation for a schedule loss is paid even if the workers' compensation claimant has not experienced actual wage loss. Permanent partial disability non-scheduled benefits pertain to injuries to the internal organs, trunk, nervous system, and other body systems not typically included on the statutory schedule.

Temporary benefits are payable at either a total or partial disability level during one's recovery from the work-related injury.

Medical benefits pay for medical treatment of work-related injuries or disabilities. Medical-only claims pay for medical care but do not pay an indemnity benefit because the claimant was out of work less than the statutorily-specified waiting period of seven days and has not received permanent disability or death benefits.

Denied claims are workers' compensation claims that do not satisfy the statutory criteria for eligibility for benefits, per a ruling of a Board administrative law judge and, if appealed, by a Board panel of commissioners or, potentially, the judiciary.

Non-compensatory claims are claims that have not been established but also have not been denied. They consist in large part of claims filed by the worker but for which the claimant did not produce prima facie medical evidence, and/or did not actively pursue the claim.

4.294. Based on the interpretation of these categories, the proposal for the percentages of lives affected by the arena or concentration catastrophe would be as below.

Table 2. Proposed Injury Distributions

	%
Deaths	12.00
Permanent Total Disability	1.00
Long Term Disability	3.00
Short Term Disability	6.00
Medical/Injuries	25.00*
Total percentage*	35.00*

4.295. Medical/injuries were increased from 3.60 to 25%. The analysis above shows "Medical only" at 3.51% but also showed "Non-compensatory" at 10.90%. The view was that these were potential medical claims that were filed but were either not pursued or had insufficient evidence to support them, but were potentially claims that should be included. The increase to 14.41% (3.51+10.90) - i.e. 15% - would make the number of medical expense/injury claims more in line with experience from other disasters which had far more medical claims than deaths. Furthermore a further 10% was added to allow for the fact that those disabled (the 1%+3%+6%) would also need treatment.

Analysis 2

4.296. Furthermore it was concluded that the WTC bombings were unusual in that there was a lack of damage upon impact to the lower 2/3 of the buildings and a relatively low occupancy at the time of the attack. This resulted in an injury to fatality ratio that was lower than is typically observed when the death rate is ~12%. Egress rates and subsequently, fatality and injury rates in triggered building collapse are highly dependent on occupancy rates and most likely buildings will be targeted during the highest occupancy periods.

4.297. The type of injuries sustained in a bomb blast is going to increase the number of permanent injuries when compared to building collapse. In addition to head and spinal cord injuries, bombs have been shown to cause disabling soft tissue injuries, hearing and sight loss due to the blast wave, and burns.

4.298. As a result the final factors proposed are:

Table 3. Proposed Injury Distributions

	%
Deaths	12.00
Permanent Total Disability	2.00
Long Term Disability	5.00
Short Term Disability	15.00
Medical/Injuries	30.00
Total percentage*	65.00

Pandemic

4.299. For the Pandemic Scenario, compared to Life where we are concerned about Pandemics that lead to a large number of deaths, such as a lethal influenza pandemic, in health we are concerned with pandemics that could potentially lead to a large or severe number of health claims.

4.300. A number of Chief Medical Officers were consulted on this matter and came to the conclusion that such a pandemic could be Encephalitis Lethargica (EL) which occurred at or around the same time as the Spanish Flu outbreak of 1918 -19 and similar pandemics are believed to have occurred in earlier

centuries. Sufferers from this illness would not be able to work and would be eligible for disability income benefits and, with a very poor prognosis for recovery, would not be expected to recover and return to work. For more information: http://en.wikipedia.org/wiki/Encephalitis_lethargica.

4.301. A pandemic where victims are very unlikely to recover once they enter a coma, but where the condition is not fatal was chosen. The illness would also lead to a valid claim under policies that cover permanent and total disability.

4.302. In order to calibrate R the reference is made to:

- The Vilensky reports: *Sleeping Princes and Princesses: The Encephalitis Lethargica Epidemic of the 1920s and a Contemporary Evaluation of the Disease*, Joel A. Vilensky Ph.D. Indiana University School of Medicine Fort Wayne:
 - Page 6 states that there were in excess of some 1 million cases reported over the long period that the last known pandemic of Encephalitis Lethargica (EL) took place. The precise period is not quoted but could be up to 25 years (1916 to 1940).
 - It is unclear how a total in excess of 1 million can be reconciled to the "official" case count being a maximum of 10,000 in 1924 (page 6).
 - There is no information to determine what a 1 in 200 year event is. In the absence of other information, it was assumed that the 1 million cases occurred as the result of one event and all occurred in one year.
 - Vilensky estimated (page 30) that 15% of all cases die (without discussing how quickly). Of the 85% that survive some 34% become chronic invalids – long term disabled for our purposes.
- The UN Population Study (page 5) suggests that at the height of the EL pandemic the world's population was roughly 2 billion.
- Benjamin Malzberg: Age of first admissions with encephalitis lethargica. *Psychiatric Quarterly*, Volume 3, Number 2 / June, 1929 which suggest that slightly under half of those affected by EL were aged under 20. This group is very unlikely to have disability insurance cover.

4.303. This suggests a population incidence rate of EL of 0.5‰ but that this can be reduced to a rate of 0.3‰ for an insurance population. It would be reasonable to expect modern medicine to have a greater impact on the diagnosis and treatment of EL, even if its true cause is still unknown.

4.304. Taking this incidence rate and applying it to the proportion who would be expected to be long term disabled, we get a factor of:

$$R = 0.3‰ * 0.85 * 0.34 = 0.087 ‰ \text{ of the capital value of the sums at risk.}$$

4.305. This is approximately one-tenth of the lethal pandemic factor. This would be round down to at most 0.075‰ of the capital value of the sums at risk to reflect the impact of modern medicine.

4.306. So the final R factor is 0.075‰

4.307. It was considered whether it would be appropriate to divide the injuries from encephalitis lethargica into short-term and long-term or whether to keep all injuries as long-term. Medical reports outlined in the references below indicate that residual neurologic symptoms persisted beyond the acute phase in virtually all patients. Since the overwhelming majority of patients were young and likely to live more than 10 years after their illness it seems to make sense to uniformly assume long-term disability.

- Kroker, Kenton. Epidemic Encephalitis and American Neurology, 1919-1940 Bulletin of the History of Medicine - Volume 78, Number 1, Spring 2004, pp. 108-147
- Association for Research in Nervous and Mental Disease, P. B. Hoerber, 1921, Acute epidemic encephalitis (lethargic encephalitis): an investigation by the Association for research in nervous and mental diseases; report of the papers and discussions at the meeting of the association, New York city, December 28th and 29th, 1920, Volume 1 of Series of investigations and reports, Association for Research in Nervous and Mental Disease
- http://books.google.com/books?id=3pMPAAAAYAAJ&dq=age+distribution+of+encephalitis+lethargia+cases&source=gbs_navlinks_s

4.10 Comprehensive pools in health insurance

4.308. CEIOPS is aware of the diversity that characterises health systems across Europe, and is willing to take into account the specificities of the different regimes, as long as such differentiated treatments are adequately justified and kept in line with the level 1 text requirements.

4.309. Datapools and mutual claim pools, which find their historical inspiration as a form of social insurance, are forms in which activities and organizations have grown in the health insurance industry. Often this concerns compulsory health insurance.

4.310. Heterogeneity in the mean for health insurance risks is often modelled through the use of (generalized) linear regression models. This generates actuarial fair expected values for such health insurance risks. Variances of these health insurance risks will be reduced due to the modelling of the heterogeneity in the means. This has a mitigating effect on the risk level and should be addressed in the calculation of the SCR.

4.311. A mutual claim pool is a natural extension of the datapool. For all members of the claim pool it implies a further mitigation of the SCR-level.

Calibration of standard deviation based on pools:

4.312. A comprehensive pool in health insurance is defined as an arrangement respecting the following conditions:

- It collects data on individual insureds from portfolios of health insurance undertakings;

- The information collected by the pool relates to health insurance covers which are sufficiently homogeneous and comparable;
- The pool facilitates the use of statistical methods, such as (generalized) regression models, to correct for heterogeneity in health risks;
- The datapool may be combined with a mutual claims pool;
- Where the pool is not effectively used as a mechanism for sharing risks between different undertakings, the standard deviation derived from the information of the datapool should where materially relevant be adjusted upwards to appropriately capture the increased volatility due to the non-systematic component of the risk inherent in the undertaking's portfolio.
- The pool focuses on a large subset of the market-wide population of health insurance risks;
- The size of the pool should be sufficiently large to enable the extraction of representative and statistically credible results;
- The comprehensive pool should be transparent and auditable, and capable of being reviewed and regulated by the supervisor.

4.313. If all the above mentioned conditions are met, the comprehensive datapool is in the position to evaluate the mean and standard deviation of the loss ratio by accident year. A time series of these standard deviations will exhibit the (non)stationarity of the underwriting risk process through time.

4.314. Its own quantification σ_{pool} will have maximum relevance for the SCR calculation of the undertakings integrating the pool arrangement. Where applicable, both premium and reserve risk can be modified in this manner.

4.315. The standard deviation σ_{pool} will also be applied, where appropriate, to the determination of the capital charges for health SLT business (on the basis of fixed assumptions on the underlying risk distributions).

4.316. The most recent value of the standard deviation may be used as an input for the current SCR calculation. However, when granting supervisory approval, supervisory authorities shall verify the adequacy of the value retained for the SCR calculation if the most recent value calculated by the pool does not take into account the claims occurred on the exercise for which the SCR is calculated. In the case of only one year of data, supervisory authorities shall verify the completeness, accuracy and appropriateness of the result for the SCR calculation. In cases where the undertaking fails to demonstrate that the completeness, accuracy and appropriateness of the result for the SCR calculation complies with the expectation of the supervisory authorities, those results shall not be accepted, and the general approach must be followed by the undertaking.

Simplifications:

4.317. Considering that the comprehensive pool is not a sub-part of the undertaking specific parameters, consequently and following Level 1 text, the application of

comprehensive pools in health insurance does not exclude the possibility of applying simplifications.

Possibility of using undertaking specific parameters:

4.318. On the other hand, if viewed appropriate by an insurance undertaking integrating the pool, there is no objection for this undertaking to use the pool-wide standard deviation in the credibility weighted procedure of undertaking specific parameters, replacing $\sigma_{(M, \text{prem}, \text{lob})}$ and/or $\sigma_{(M, \text{res}, \text{lob})}$.

5. CEIOPS' Advice

SLT Health underwriting risk sub-module

- 5.1. For SLT Health mortality risk, CEIOPS suggests to use the same shock assumed as for the life underwriting risk module and specified in CEIOPS' Advice on Life Underwriting Risk (former CP49, now CEIOPS-DOC-42-09, [see http://www.ceiops.eu//content/view/full/17/21/](http://www.ceiops.eu//content/view/full/17/21/)).
- 5.2. For SLT Health longevity risk, CEIOPS suggests to use the same shock assumed as for the life underwriting risk module and specified in CEIOPS' Advice on Life Underwriting Risk (CEIOPS-DOC-42-09).
- 5.3. For SLT Health disability risk for medical insurance, CEIOPS suggests to use a shock based on a permanent increase/decrease of claims level of 5% combined with a permanent increase/decrease of inflation by one percentage point.
- 5.4. For SLT Health disability risk for income insurance, CEIOPS suggests to use the same shock assumed as for disability/morbidity risk in the life underwriting risk module and specified in CEIOPS' Advice on Life Underwriting Risk (CEIOPS-DOC-42-09).
- 5.5. For SLT Health expense risk, CEIOPS suggests to use the same shock assumed as for the life underwriting risk module and specified in CEIOPS' Advice on Life Underwriting Risk (CEIOPS-DOC-42-09).
- 5.6. For SLT Health revision risk, CEIOPS suggests to use as a basis the same shock assumed as for the life underwriting risk module and specified in CEIOPS' Advice on Life Underwriting Risk (CEIOPS-DOC-42-09). In addition, to this basis, a 1% shock increase should be added in order to fully take into account the impact on benefits of changes in inflation.
- 5.7. For SLT Health lapse risk, CEIOPS suggests to use the same shock assumed as for the life underwriting risk module and specified in CEIOPS' Advice on Life Underwriting Risk (CEIOPS-DOC-42-09), but for $Lapse_{up}$, and for $Lapse_{down}$, the increase and the decrease is 20% instead of 50%.

Non-SLT Health underwriting risk sub-module

- 5.8. CEIOPS has selected the following factors as the calibration for the premium and reserve risk sub-module for the purpose of the standard formula:

LOB	Net premium factor ⁹	Net reserve factor
Accident	$12.5\% * (NCR_i / GCR_i)$	17.5%
Sickness	$9.5\% * (NCR_i / GCR_i)$	12.5%
Workers compensation	$5.5\% * (NCR_i / GCR_i)$	12%

5.9. CEIOPS has recommended an adjustment factor for Premium Risk that is undertaking specific, and so it is not possible to provide a net premium factor. NCR and GCR stand for net combined ratio and gross combined ratio respectively

Health CAT risk sub-module

5.10. The following Health Catastrophe standardised scenarios should be considered:

- Arena disaster
- Concentration scenario
- Pandemic scenario

ARENA DISASTER

5.11. The total capital charge is estimated as follows:

$$CAT_{ARENA_STATE} = S * \sum^{products} I_P * x_P * E_P * MS_P$$

$$CAT_{ARENA} = \sum^{allSTATES} CAT_{ARENA_STATE}$$

Where

S = the number of people affected by the event

IP = insurance penetration for product type and by member state

xP= proportion of accidental deaths/disabilities (short and long term) and injuries (p = product type).

MSP = market share by product type

EP = exposure measure i.e. average sum insured by product type

5.12. The value for S is 50% of the arena full capacities provided in Annex.

5.13. The value of I_p are provided in Annex .

5.14. The market share by product type MS_p shall be provided by the undertaking.

5.15. Each undertaking will be required to provide its average sum insured by product type, E_p. For the estimation of E_p, undertakings need to consider:

- In the case of disability where payments are not lump sums, the exposure measure should be the present value of expected future payments for disability claims.
- In calculating the present value of future payments, firms should assume that a short term disability would last for 12 months and a long term disability would last for 10 years (or such shorter period for which the average policy would make payments) from the date of the catastrophe event; firms should also make allowance for any deferred period before claim payments commence.
- For medical expense insurance, the sum insured may be taken as zero.

- Firms shall also add extra exposure for any Personal Accident riders.

5.16. The product type factors x_P for all member states are specified as follows:
Proposed Injury Distributions

	%
Deaths	12.00
Permanent Total Disability	2.00
Long Term Disability	5.00
Short Term Disability	15.00
Medical/Injuries	30.00
Total percentage*	65.00

CONCENTRATION SCENARIO

5.17. The total capital charge is estimated as follows:

$$CAT_{CONC_STATE} = S * \sum^{products} x_P * E_P$$

$$CAT_{CONC} = \sum^{STATES} CAT_{CONC_STATE}$$

Where

CATCONC = is the capital charge for the concentration scenario.

S = largest known concentration of lives in a group scheme portfolio.

XP= proportion of accidental deaths/disabilities (short and long term) and injuries (p = product type)

EP = exposure measure i.e. average sum insured by product type and by undertaking.

5.18. The product type factors x_P for all member states are specified as follows:
Proposed Injury Distributions

	%
Deaths	12.00
Permanent Total Disability	2.00
Long Term Disability	5.00
Short Term Disability	15.00
Medical/Injuries	30.00
Total percentage*	65.00

5.19. For the estimation of E_p , undertakings need to consider:

- In the case of disability where payments are not lump sums, the exposure measure should be the present value of expected future payments for disability claims.
- In calculating the present value of future payments, firms should assume

that a short term disability would last for 12 months and a long term disability would last for 10 years (or such shorter period the average policy would make payments) from the date of the catastrophe event; firms should also make allowance for any deferred period before claim payments commence.

- For medical expense insurance, the sum insured should be taken as the average claim paid in the last two underwriting years in respect of hospital treatments for accidental causes.
- Firms shall also add extra exposure for any Accident riders.

5.20. For the estimation of S undertakings need to select the scheme with the largest known concentration of lives within a group scheme portfolio.

PANDEMIC SCENARIO

5.21. The total capital charge is estimated as follows:

$$CAT_{PAN_STATE} = R \sum^{products} E_P$$

$$CAT_{PAN} = \sum^{STATES} CAT_{PAN_STATE}$$

Where

CATPAN is the capital charge for the pandemic scenario

R = is the proportion of lives affected by the Pandemic = 0.075‰

EP = exposure measure i.e. average sum insured by product type and by undertaking.

5.22. The scenario will impact the following products:

- disability income (both long and short term)
- products covering permanent and total disability either as a stand alone benefit or as part of another product, such as a stand alone critical illness product.

5.23. Each undertaking will be expected to provide:

EP Average sum insured by product type

5.24. For the estimation of E_P , undertakings need to consider:

- In the case of disability where payments are not lump sums, the exposure measure should be the present value of future payments for disability claims.
- In calculating the present value of future payments, firms should assume that claimants would not recover and that payments would cease only on death or at the end of the claim payment period specified in the policy conditions; firms should also make allowance for any deferred period before claim payments commence.

Health Pools

5.25. A comprehensive pool in health insurance is defined as an arrangement respecting the following conditions:

- It collects data on individual insureds from portfolios of health insurance undertakings;
- The information collected by the pool relates to health insurance covers which are sufficiently homogeneous and comparable;
- The pool facilitates the use of statistical methods, such as (generalized) regression models, to correct for heterogeneity in health risks;
- The datapool may be combined with a mutual claims pool;
- Where the pool is not effectively used as a mechanism for sharing risks between different undertakings, the standard deviation derived from the information of the datapool should where materially relevant be adjusted upwards to appropriately capture the increased volatility due to the non-systematic component of the risk inherent in the undertakings' portfolio.
- The pool focuses on a large subset of the market-wide population of health insurance risks;
- The size of the pool should be sufficiently large to enable the extraction of representative and statistically credible results;
- The comprehensive pool should be transparent and auditable, and capable of being reviewed and regulated by the supervisor.

5.26. If all the above mentioned conditions are met, the comprehensive datapool is in the position to evaluate the mean and standard deviation of the loss ratio by accident year. A time series of these standard deviations will exhibit the (non)stationarity of the underwriting risk process through time.

5.27. Its own quantification σ_{pool} will have maximum relevance for the SCR calculation of the undertakings integrating the pool arrangement. Where applicable, both premium and reserve risk can be modified in this manner.

5.28. The standard deviation σ_{pool} will also be applied, where appropriate, to the determination of the capital charges for health SLT business (on the basis of fixed assumptions on the underlying risk distributions).

5.29. The most recent value of the standard deviation may be used as an input for the current SCR calculation. However, when granting supervisory approval, supervisory authorities shall verify the adequacy of the value retained for the SCR calculation if the most recent value calculated by the pool does not take into account the claims occurred on the exercise for which the SCR is calculated. In the case of only one year of data, supervisory authorities shall verify the completeness, accuracy and appropriateness of the result for the SCR calculation. In cases where the undertaking fails to demonstrate that the completeness, accuracy and appropriateness of the result for the SCR calculation complies with the expectation of the supervisory authorities, those results shall not be accepted, and the general approach must be followed by the undertaking.

5. Annexes

Annex 1: Full arena capacity by member state

Stadium/Arena information			
Country	Name	Location	Capacity
AT	Ernst Happel Stadion	Vienna	50,000
BE	Koning Boudewijn Stadion	Brussels	50,000
CZ	Synot Tip Arena (Eden)	Prague	21,000
DK	Parken	Copenhagen East	50,000
EE	A. le Coq Arena	Tallinn	9,700
FI	Helsinki Olympic Stadium	Helsinki	50,000
FR	Stade de France	Saint Denis	80,000
DE	Signal Iduna Park	Dortmund	80,552
HU	Puskás Ferenc Stadion	Budapest	56,000
IS	Laugardalsvöllur	Reykjavík	20,000
IE	Croke Park	Dublin	82,300
IT	Giuseppe Meazza	Milan	83,679
LV	Mezaparks	Riga	45,000
LT	Siemens Arena	Vilnius	12,500
LU	Rockhal	Esch-sur-Alzette	5,400
MT	Ta' Qali National Stadium	Ta' Qali	35,000
NL	Amsterdam Arena	Amsterdam South East	51,628
NO	Ullevaal Stadion	Oslo (North)	25,600
PL	National Stadium	Warsaw	55,000
PT	Estádio da Luz	Lisbon	65,400
RO	Arena Romana	Bucharest	50,000
SK	Tehelne pole	Bratislava	30,000
SI	Ljudski vrt	Maribor	12,435
ES	Camp Nou	Barcelona	98,787
SE	Nya Ullevi	Gothenburgh	43,000
UK	Wembley Stadium	London	90,000

Source: This information was provided by CEIOPS member states.

Annex 2: Health catastrophe: Insurance penetration statistics (Ip)

Health insurance coverage																						
	UK	FR	DE	IT	ES	NL	BE	AT	PT	DK	NO	CZ	FI	EL	HU	IE	PL	CH	SK	SE	SI	LU
% population																						
Income protection	5%	64%	21%	39%	48%	92%	39%	0.1%													78%	
Medical expenses insurance: including hospital cash, etc.	10%	91%	25%	34%	24%	92%	77%	34%	18%	16%	1%	0%	0%		0%	51%	0%				82%	71.4%
Medical expenses insurance: reimbursement only			11%																			
Long term care	0%	5%	13%	1%	0.03%			0.1%														
Standalone critical illness	1%							0.6%							1%							
Personal accident	20%	18%	15%	5%	3%		6%					13%			9%						52%	
Number of persons covered (millions)																						
Income protection	3.7	40.9	17.0	23.3	21.9			0.01														
Medical expenses insurance	7.3	58.2	20.4	20.3	10.7	15.1																1.9
Medical expenses insurance: reimbursement only			8.7																			
Long term care	0.02	3.0	10.8		0.015			0.01														
Standalone critical illness	0.7							0.1							0.1							
Personal accident	14.6		12.0	3.0								1.3			0.9							
Population	73.9	63.9	82.2	59.8	45.6	16.4	10.7	8.3	10.6	5.5	4.8	10.2	5.3	11.2	10.0	4.4	38.0	9.2	5.4	7.7	2.0	0.5
Adult population	53.8	52.1	71.0	51.4	38.9	13.5	8.9	7.1	9.0	4.5	3.9	8.7	4.4	9.6	8.5	3.5	32.1	7.7	4.6	6.5		0.4

Sources below:

UK

- IP, standalone CI, and LTC: relates to number of in force policies in 2008, published by the ABI.
- Medical expenses: number of people covered by PMI in 2008 written by insurance companies and healthcare trust schemes, published by the ABI.
- Personal accident: relates to total payment protection policies (not only personal accident) written by the 12 largest providers in 2006 (source: OFT).
- Note: Penetration rates have been calculated using the number of in force policies and differs significantly from the consumer survey data published in Swiss Re's Insurance Report (see below).

Swiss Re Insurance report, 2009

- Critical illness, incl. accelerated
- Income protection
- Mortgage payment protection

France

- LTC: number of in force policies in 2008 (source: FFSA). Includes business written by insurance companies (2 million) and Mutuelles 45 and Institutions de Prevoyance (1 million)
- Income protection & medical expenses insurance: Data is from a consumer survey published in the AXA protection report, October 2007. This appears to include business written by Mutuelles 45 and Institutions de Prevoyance. The data on medical expenses penetration is quite similar to that published by the OECD (88% in 2006). The FFSA does not appear to publish data on the number of policies for medical expenses and disability.
- Personal accident: Data is for long term unemployment insurance from the AXA survey. Personal accident insurance is significant in France, but the FFSA does not appear to publish number of policies.

Germany

- Based on data on number of in force policies from GDV and BAFIN. Includes standalone and rider business, compulsory and supplementary policies, and business written by health insurers (PVK).
- OECD medical expenses penetration data is quite similar (28% in 2007).

Italy

- Income protection, medical expenses & personal accident: Data is from a consumer survey published in the AXA protection report, October 2007. There is no way of verifying this data, but apparently a lot of disability and medical expenses is sold as riders to life policies.
- Long term care: estimate based on small in force premium volume (EUR 25m in 2008)

Netherlands

- The Netherlands has a large disability insurance market, but data on number of policies does not seem to be available.
- Medical expenses: OECD data for 2007.

Spain

- Income protection: market research data on ownership compiled by AXA, October 2007. According to ICEA, the "majority" of life policies in Spain have a disability rider (no data available).
- Medical expenses: based on number in force policies as at Sept. 2009, compiled by ICEA. Includes non-life disability (14% by premium in 2008)
- Long term care: data is for the number of in force standalone policies as at end-Sept. 2009. Most Long term care policies are written as riders of life and non-life policies (data not available).

Other:

International sources

Health insurance ownership: Axa protection report, October 2007

	UK	FR	DE	IT	ES	BE
Health, medical, hospitalisation insurance	40%	91%	85%	34%	51%	88%
Disability	40%	64%	71%	39%	48%	39%
Long term unemployment insurance	20%	18%	n.a.	5%	3%	6%

Critical illness, incl. accelerated*	38%					
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* Unclear whether CI is included in product categories above.

Source: Market research published in the Axa protection report, October 2007, page 40.

People covered by private health insurance, 2006: CEA data*															
Millions	UK	FR	DE	IT	ES	NL	BE	AT	PT	DE**	NO	CZ.	CH	SI	CY
Number of insured, 2006	6	14	22	n.a.	11	16	5	3	2	1	0		2	2	0
Population, 2008	61	64	82	60	46	16	11						8		
Penetration	11%	22%	27%		25%	99%	47%	34%	17%	28%	1%		22%	71%	18%
* Medical expenses insurance.															
** Denmark is for 1996.															

Notes

- Figures for France are rough estimates.
- For the Netherlands, the 2006 figure corresponds to the number of people covered by the mandatory system only. The supplementary system is excluded.
- For Switzerland, the data relates to number of contracts.
- Source: Health insurance in Europe 2006. CEA, p. 34 & 56.

Individuals covered by private health insurance: OECD data

Millions	UK	FR	DE	IT	ES	NL	BE	AT	PT	DE**	NO	CZ.	HU	IS	CH
	2006	2006	2007		2006	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007
Number of insured	7	54	23		6	15	8	3	2	1	-	-	-		
Penetration	11%	88%	28%		14%	92%	77%	34%	18%	16%	0%	0%	0%	0%	30%
* Medical expenses insurance.															

Annex 3: Return Period of Encephalitis Lethargia Scenario

The age distribution is a key factor in determining the return period of the event. The following calculation can provide some colour around a ballpark return period using fatalities as a proxy.

The initial assumptions are as spelled out in the scenario and referenced in The Vilensky reports *Sleeping Princes and Princesses: The Encephalitis Lethargica Epidemic of the 1920s and a Contemporary Evaluation of the Disease*, Joel A. Vilensky Ph.D. Indiana University School of Medicine Fort Wayne)

- 1 million cases reported over the last known pandemic of Encephalitis Lethargica (EL) as stated on page 6.
- 15% of all cases result in fatality as stated on page 30
- World population of 2 billion as the denominator as stated by the The UN Population Study (page 5)
- This suggests an incidence rate of EL of 0.5‰.
- Taking this incidence rate and applying it to the proportion expected to die results in:
- .05% incidence * .15 fatal = 7.5 fatalities /100,000 population

The assumptions for the age and gender distribution in the tables that follows were found in

Benjamin Malzberg. Age of first admissions with encephalitis lethargica. *Psychiatric Quarterly*, Volume 3, Number 2 / June, 1929

	Male		Female		Total	
	Number	Percent	Number	Percent	Number	Percent
5 - 9	29	11.5	9	5.1	38	8.9
10 - 14	42	16.7	29	16.5	71	16.6
15-19	51	20.3	40	22.7	91	21.3
20-24	32	12.7	28	15.9	60	14.1
25-29	27	10.8	21	11.9	48	11.3
30-34	18	7.2	12	6.8	30	7
35-39	17	6.8	13	7.4	30	7
40-44	19	7.6	11	6.3	30	7
45-49	5	2	6	3.4	11	2.6
50-54	6	2.4	3	1.7	9	2.1
55-59	4	1.6	3	1.7	7	1.6
60-64	1	0.4	1	0.6	2	0.5

The UK (England and Wales) was used as the representative baseline all cause mortality. Estimates were obtained from the UK office on National

Statistics for 2008.

(http://www.statistics.gov.uk/downloads/theme_health/DR2008/DR_08.pdf)

The fatality rates per 100,000 population are as follows:

Age	Males	Females
All ages	907	962
0-4	130	107
5 - 9	12	9
10 - 14	11	9
15-19	43	20
20-24	65	25
25-29	76	33
30-34	99	51
35-39	135	71
40-44	182	114
45-49	274	175
55-59	669	433
60-64	1044	673
65-69	1720	1075
70-74	2776	1808
75-79	4752	3211
80-84	8213	5940
85-89	13369	10463
90 and over	24113	22532

With a weighting of 55% male and 45% female consistent with the Malzberg study the annual baseline mortality is 85/100,000.

An increase on 7.5/100,000 from encephalitis Lethargia fatalities would be an excess mortality of 8.8% from the pandemic.

Using the RMS infectious disease model as a benchmark, an infectious disease event in the UK with an excess mortality in the age groups specified above of 8.8% has a return period of 75 years. The short return period is due primarily to the large number of children who are infected. Children are assumed to have a larger infection and mortality rate in most pandemics.

If we exclude children, who are unlikely to be insured, and renormalize the event with the following age distribution the scenario becomes ~1/200 fatality event.

	Male Percent	Female Percent
5 - 9	0	0
10 - 14	0	0

15-19	0	0
20-24	24.66%	28.55%
25-29	20.97%	21.36%
30-34	13.98%	12.21%
35-39	13.20%	13.29%
40-44	14.76%	11.31%
45-49	3.88%	6.10%
50-54	4.66%	3.05%
55-59	3.11%	3.05%
60-64	0.78%	1.08%

Annex 4. AMICE proposal for non proportional reinsurance

This paper summarises the improvements to the QIS5 standard formula suggested by AMICE and supported by the CRO Forum concerning the non proportional reinsurance for the premium risk. It is not dealing with Cat risk which is addressed in the CEIOPS Taskforce on Cat Risk.

In order to better capture the effects of risk mitigation strategies, especially in the case of non-proportional reinsurance, the following methodology can be easily tested in the QIS5 standard formula.

Due to complexity of some non proportional reinsurance contracts, no standard formula would be able to catch all reinsurance features. We are aware that the topic is not simple if we want to keep a standard formula as operational as we can.

Nevertheless, in the standard formula framework, it is easy to improve some aspects which do not add any complexity and do not ask so much additional information.

Our proposal: a pragmatic approach

The proposal does not change the actual standard formula framework. We think the standard formula is complex enough and it does not make sense to completely change the design of the non life underwriting module.

The underlying idea is to adjust the premium factor for each line of business according to the mitigation effect due to the non proportional contract. The approach adjusts the original volatility factors for premium risk which are supposed to be calibrated gross on reinsurance. There is no change for the rest of the standard formula.

The limited scope of this approach in the standard formula is linked to its simplicity and it should be a good incentive for non life insurers to further improve risk management with partial internal models on reinsurance or undertaking specific parameters in order to capture the full reduction of volatility from the reinsurance strategy.

The adjustment ratio is based on frequency-severity approach which is intensively used in reinsurance impact studies. It is a global frequency-severity model, not only for large claims, but also for all claims for a given line of business. We suppose the independence between the frequency and the severity of the claims which is generally accepted.

The assumptions are:

- Frequency N of all claims: $N \longrightarrow \text{Poisson}(\lambda)$
- Severity X for a single claim gross of reinsurance : $X \longrightarrow \text{Lognormal}(m; \sigma)$

The choice of a Lognormal distribution for a single claim severity is rather conservative.

It is also possible to show that the frequency has no impact on volatility reduction. So there is no need to calibrate the factor λ . No assumption on the frequency is requested in the approach.

From the distribution of a claim gross of reinsurance, it is easy to estimate the average cost net of reinsurance and the volatility reduction with an Excess of Loss layer.

For a given b XoL a, the net loss is: $Y = \begin{cases} X & \text{if } X \leq a \\ a & \text{if } a < X \leq a+b \\ X-b & \text{if } X \geq a+b \end{cases}$ and the variance of the random

variable S aggregate losses after reinsurance is: $\text{Var}(S^{\text{Net}}) = \lambda \cdot (\text{Var}(Y) + E^2(Y))$

We immediately have: $\frac{\text{Var}(S^{\text{Net}})}{\text{Var}(S^{\text{Gross}})} = \frac{\text{Var}(Y) + E^2(Y)}{\text{Var}(X) + E^2(X)}$ (independent from the number of claims N)

The assumptions on which this calculation is based are quite common in non life insurance. The layer can be limited or unlimited.

All the details are given in appendix 2.

Thus the adjustment ratio is based on a comparison between the volatility of a claim net of reinsurance and the volatility gross of reinsurance.

The adjusted premium factor (net of reinsurance) is: $\varphi \cdot \sqrt{\frac{\text{vol}^2(Y)+1}{\text{vol}^2(X)+1}}$

Where $\text{vol}(X) = \frac{\sqrt{\text{Var}(X)}}{E(X)}$ and $\text{vol}(Y) = \frac{\sqrt{\text{Var}(Y)}}{E(Y)}$

φ : Volatility factor for premium risk gross of reinsurance

Extra - Input data needed are also limited

In this approach, the only additional requested information is the average cost per claim for each line of business and its standard deviation. We believe that entity specific parameters are relevant.

But in a first approach for the coming quantitative impact study, country parameters could also be tested.

When the average cost of a claim and its standard deviation are given, we automatically know the value σ with the formula $\sigma = \sqrt{\ln\left(1 + \frac{Var(X)}{E^2(X)}\right)}$ for a Lognormal distribution. The other parameter m is given by the formula: $m = \ln E(X) - \frac{\sigma^2}{2}$

Limitations of the proposal

All reinsurance features are not caught in this approach. The impact of an annual aggregate deductible or annual limit is not quantified. We assume in a standard framework there is only one Excess of Loss layer with unlimited reinstatements.

In some cases, the reinsurance contracts are too complicated to be considered adequately in the standard formula and would thus require partial modelling.

The capital requirement calculation is based on the usual linear assumption for lognormal random variables, closed to three times the standard deviation net of reinsurance, commonly used in the Solvency II framework.

Numerical examples

1st example:

Gross Premium Factor: 15%

The average cost is constant and equal to 3000. The coefficient of variation (standard deviation / average cost) is variable.

Coefficient of variation Gross claim	Unlimited layer XoL p				
	p = 500 000	p = 1 000 000	p = 5 000 000	p = 10 000 000	p = 15 000 000
500%	12,2%	13,3%	14,6%	14,8%	14,9%
1000%	8,3%	9,6%	12,4%	13,2%	13,7%
1500%	6,3%	7,4%	10,3%	11,5%	12,1%

2nd example:

Gross Premium Factor: 15%

In this example the coefficient of variation of a claim gross is constant and equal to 500%. The average cost is variable.

Average cost Gross claim	Unlimited layer XoL p				
	p = 500 000	p = 1 000 000	p = 5 000 000	p = 10 000 000	p = 15 000 000
1 000	13,7%	14,3%	14,9%	15,0%	15,0%
3 000	12,2%	13,3%	14,6%	14,8%	14,9%
5 000	11,3%	12,5%	14,3%	14,7%	14,8%

Appendix 1: The adjusted premium factor

The expected aggregate loss $S = \sum_{i=1}^N X_i$ for this lob is given by: $E(S) = E(N) \cdot E(X) = \lambda \cdot E(X)$

The variance is: $Var(S) = Var(X) \cdot E(N) + E^2(X) \cdot Var(N) = \lambda \cdot (Var(X) + E^2(X))$

For a given b XoL a, the net loss is: $Y = \begin{cases} X & \text{if } X \leq a \\ a & \text{if } a < X \leq a+b \\ X-b & \text{if } X \geq a+b \end{cases}$ and the variance of the random

variable S after reinsurance is: $Var(S^{Net}) = \lambda \cdot (Var(Y) + E^2(Y))$

We immediately have: $\frac{Var(S^{Net})}{Var(S^{Gross})} = \frac{Var(Y) + E^2(Y)}{Var(X) + E^2(X)}$ (independent from the number of claims N)

The closed formulas to estimate $E(Y)$ and $Var(Y)$ are given in the next appendix. It only depends on (m, σ) and the layer b XoL a.

The formula used in the non life underwriting module for calculating SCR is:

$$SCR = V \cdot \left(\frac{\exp\left(2.5758 \cdot \sqrt{\ln(1 + \varphi^2)}\right)}{\sqrt{1 + \varphi^2}} - 1 \right) = V \cdot VaR_{99.5\%}^{Mean}(\Psi)$$

Where:

ψ : Lognormal distributed random variable with $E(\psi) = 1$ and $Var(\psi) = \varphi^2$

$VaR_{99.5\%}^{Mean}(\Psi)$: 99.5% Value at Risk of $\psi - E(\psi)$

V : Volume measure (premium)

In the standard formula, on a gross basis, it is assumed that $S^{Gross} - E(S^{Gross})$ has the same distribution as $V^{Gross} \cdot (\psi^{Gross} - 1)$

In case of non proportional reinsurance, we would like to find a random variable ψ^{Net} where $S^{Net} - E(S^{Net})$ would have the same distribution as $V^{Net} \cdot (\psi^{Net} - 1)$ (Lognormal distributed).

We have: $Var(S^{Net}) = Var(S^{Gross}) \cdot \frac{Var(Y) + E^2(Y)}{Var(X) + E^2(X)} = (V^{Gross})^2 \cdot \varphi^2 \cdot \frac{Var(Y) + E^2(Y)}{Var(X) + E^2(X)}$

With the assumption $V^{Net} = V^{Gross} \cdot \frac{E(Y)}{E(X)}$, the variance of S^{Net} becomes:

$$Var(S^{Net}) = \left(V^{Net} \cdot \frac{E(X)}{E(Y)} \right)^2 \cdot \varphi^2 \cdot \frac{Var(Y) + E^2(Y)}{Var(X) + E^2(X)} = (V^{Net})^2 \cdot \varphi^2 \cdot \frac{vol^2(Y) + 1}{vol^2(X) + 1}$$

where $vol(X) = \frac{\sqrt{Var(X)}}{E(X)}$ and $vol(Y) = \frac{\sqrt{Var(Y)}}{E(Y)}$

To be consistent with the standard formula, $S^{Net} - E(S^{Net})$ has the same distribution as $V^{Net} \cdot (\psi^{Net} - 1)$

where ψ^{Net} is a Lognormal distributed random variable with $E(\psi^{Net}) = 1$ and

$$Var(\psi^{Net}) = \varphi^2 \cdot \frac{vol^2(Y) + 1}{vol^2(X) + 1}$$

The adjusted premium factor (net of reinsurance) is: $\varphi \cdot \sqrt{\frac{vol^2(Y)+1}{vol^2(X)+1}}$

Appendix 2: Average cost and standard deviation of a claim net of reinsurance

A claim net of reinsurance for a layer b XoL a is given by:
$$Y = \begin{cases} X & \text{if } X \leq a \\ a & \text{if } a < X \leq a+b \\ X-b & \text{if } X \geq a+b \end{cases}$$

For a Lognormal distribution, we have the following results:

$$E(X) = e^{\frac{m+\sigma^2}{2}} \quad \text{Var}(X) = E^2(X) \cdot (e^{\sigma^2} - 1) \quad E(X^2) = e^{2m+2\sigma^2}$$

Lemma:

$$\int_p^{+\infty} x \cdot f(x) \cdot dx = \frac{1}{\sigma\sqrt{2\pi}} \cdot \int_{\ln p}^{+\infty} e^x \cdot e^{-\frac{1}{2}\left(\frac{x-m}{\sigma}\right)^2} \cdot dx = e^{\frac{m+\sigma^2}{2}} \cdot \frac{1}{\sigma\sqrt{2\pi}} \cdot \int_{\ln p}^{+\infty} e^{-\frac{1}{2}\left(\frac{x-m-\sigma^2}{\sigma}\right)^2} \cdot dx$$

$$\int_p^{+\infty} x \cdot f(x) \cdot dx = E(X) \cdot [1 - F_{m+\sigma^2, \sigma}(p)]$$

where $F_{m+\sigma^2, \sigma}$ is the distribution function of a Lognormal random variable with parameters $(m + \sigma^2, \sigma)$

$$\int_p^{+\infty} x^2 \cdot f(x) \cdot dx = \frac{1}{\sigma\sqrt{2\pi}} \cdot \int_{\ln p}^{+\infty} e^{2x} \cdot e^{-\frac{1}{2}\left(\frac{x-m}{\sigma}\right)^2} \cdot dx = e^{2m+2\sigma^2} \cdot \frac{1}{\sigma\sqrt{2\pi}} \cdot \int_{\ln p}^{+\infty} e^{-\frac{1}{2}\left(\frac{x-m-2\sigma^2}{\sigma}\right)^2} \cdot dx$$

$$\int_p^{+\infty} x^2 \cdot f(x) \cdot dx = E(X^2) \cdot [1 - F_{m+2\sigma^2, \sigma}(p)]$$

where $F_{m+2\sigma^2, \sigma}$ is the distribution function of a Lognormal random variable with parameters $(m + 2\sigma^2, \sigma)$

Average cost

$$E(Y) = \int_0^a x \cdot f(x) \cdot dx + a \cdot \int_a^{a+b} f(x) \cdot dx + \int_{a+b}^{+\infty} (x-b) \cdot f(x) \cdot dx$$

$$E(Y) = E(X) - \int_a^{+\infty} x \cdot f(x) \cdot dx + a \cdot [F_{m, \sigma}(a+b) - F_{m, \sigma}(a)] + \int_{a+b}^{+\infty} x \cdot f(x) \cdot dx - b \cdot [1 - F_{m, \sigma}(a+b)]$$

$$E(Y) = E(X) - E(X) \cdot [1 - F_{m+\sigma^2, \sigma}(a)] + a \cdot [F_{m, \sigma}(a+b) - F_{m, \sigma}(a)] + E(X) \cdot [1 - F_{m+\sigma^2, \sigma}(a+b)] - b \cdot [1 - F_{m, \sigma}(a+b)]$$

$$E(Y) = E(X) \cdot [1 - F_{m+\sigma^2, \sigma}(a+b) + F_{m+\sigma^2, \sigma}(a)] + a \cdot [F_{m, \sigma}(a+b) - F_{m, \sigma}(a)] - b \cdot [1 - F_{m, \sigma}(a+b)]$$

For an unlimited cover $b = +\infty$, the average cost net of reinsurance becomes:

$$E(Y) = E(X) \cdot F_{m+\sigma^2, \sigma}(a) + a \cdot [1 - F_{m, \sigma}(a)]$$

Standard deviation

$$E(Y^2) = \int_0^a x^2 \cdot f(x) \cdot dx + a^2 \cdot \int_a^{a+b} f(x) \cdot dx + \int_{a+b}^{+\infty} (x-b)^2 \cdot f(x) \cdot dx$$

$$E(Y^2) = E(X^2) - \int_a^{+\infty} x^2 \cdot f(x) \cdot dx + a^2 \cdot [F_{m,\sigma}(a+b) - F_{m,\sigma}(a)]$$

$$+ \int_{a+b}^{+\infty} x^2 \cdot f(x) \cdot dx - 2b \cdot \int_{a+b}^{+\infty} x \cdot f(x) \cdot dx + b^2 \cdot [1 - F_{m,\sigma}(a+b)]$$

$$E(Y^2) = E(X^2) - E(X^2) \cdot [1 - F_{m+2\sigma^2,\sigma}(a)] + a^2 \cdot [F_{m,\sigma}(a+b) - F_{m,\sigma}(a)]$$

$$+ E(X^2) \cdot [1 - F_{m+2\sigma^2,\sigma}(a+b)] - 2b \cdot E(X) \cdot [1 - F_{m+\sigma^2,\sigma}(a+b)] + b^2 \cdot [1 - F_{m,\sigma}(a+b)]$$

$E(Y^2) = E(X^2) \cdot [1 - F_{m+2\sigma^2,\sigma}(a+b) + F_{m+2\sigma^2,\sigma}(a)] + a^2 \cdot [F_{m,\sigma}(a+b) - F_{m,\sigma}(a)]$ $- 2b \cdot E(X) \cdot [1 - F_{m+\sigma^2,\sigma}(a+b)] + b^2 \cdot [1 - F_{m,\sigma}(a+b)]$
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For an unlimited cover $b = +\infty$, the variance net of reinsurance becomes:

$$E(Y^2) = E(X^2) \cdot F_{m+2\sigma^2,\sigma}(a) + a^2 \cdot [1 - F_{m,\sigma}(a)]$$