CEIOPS-SEC-40-10

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Solvency II
Calibration Paper

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1. Introduction

1.1 This paper provides background information to the technical analysis carried out by CEIOPS for the calibration of key parameters of the SCR standard formula and the calculation of technical provisions for the purpose of QIS5.[1]

2. Technical provisions

2.1 Extrapolation of the risk-free interest rate term structure

2.1 For liabilities expressed in any of the EEA currencies, Japanese yen, Swiss franc, Turkish lira or USA dollar, QIS5 provides to participants risk-free interest rate term structures.

2.2 This subsection serves to give a rationale for the set up of the interest rate term structures for currencies where the relevant risk-free interest rate term structures are provided in the spreadsheet included in QIS5 package.

Basic Principles

2.3 According to the recommendation of the Task Force on the Illiquidity premium, the following principles are applied in constructing the extrapolated part of the basic risk free interest rate term structure:

#1. All relevant observed market data points should be used.

#2. Extrapolated market data should be arbitrage-free.

#3. Extrapolation should be theoretically and economically sound.

#4. The extrapolated part of the basis risk free interest rate curve should be calculated and published by a central EU institution, based on transparent procedures and methodologies, with the same frequency and according to the same procedures as the non extrapolated part.

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[1] This document compiles information which has been published as part of the final advice on Level 2 Implementing Measures for Solvency II in the course of 2009 and 2010. For the overview of the Level 2 advice, please see: http://www.ceiops.eu/index.php?option=com_content&task=view&id=706&Itemid=329.

#5. Extrapolation should be based on forward rates converging from one or a set of last observed liquid market data points to an unconditional ultimate long-term forward rate to be determined for each currency by macro-economic methods.

#6. The ultimate forward rate should be compatible with the criteria of realism as stated in CEIOPS advice on the risk free interest rate term structure and the principles used to determine the macro-economic long-term forward rate should be explicitly communicated.

#7. Criteria should be developed to determine the last observed liquid market data points which serve as entry point into the extrapolated part of the interest curve and for the pace of convergence of extrapolation with the unconditional ultimate long-term forward rate.

#8. Extrapolated rates should follow a smooth path from the entry point to the unconditional ultimate long-term forward rate.

#9. Techniques should be developed regarding the consideration to be given to observed market data points situated in the extrapolated part of the interest curve.

#10. The calibration of the shock to the risk free interest rate term structure used for the calculation of the SCR should be reviewed in order to be compatible with the relative invariance of the unconditional ultimate long-term forward rate.

Extrapolation method

2.4 For QIS5, macroeconomic extrapolation techniques are used to derive the extrapolation beyond the last available data point. The overall aim is to construct a stable and robust extrapolated yield curve which reflects current market conditions and at the same time embodies economical views on how unobservable long term rates are expected to behave. Macroeconomic extrapolation techniques assume a long-term equilibrium interest rate. A transition of observed interest rates of short-term maturities to the assessed equilibrium interest rate of long-term maturities takes place within a certain maturity spectrum.

2.5 Valuation of technical provisions and the solvency position of an insurer or reinsurer shall not be heavily distorted by strong fluctuations in the short-term interest rate. This is particularly important for currencies where liquid reference rates are only available for short term maturities and simple extrapolation of these short term interest rates may cause excessive volatility. A macro-economic model meets the demands on a model that ensures relatively stable results in the long term.

2.6 There are some considerations that have to be faced when specifying the macro-economic extrapolation method for QIS5 purposes. The aim is to find a practical and pragmatic method for stipulating the interest rate, a simple approach that can be applied to all economies.

2.7 The specifications to be made are the following:

- Determination of the ultimate forward rate
- Interpolation method between the last observable liquid forward rate and the unconditional forward rate

Determination of the ultimate forward rate

2.8 A central feature is the definition of an unconditional ultimate long-term forward rate (UFR) for infinite maturity and for all practical purposes for very long maturities. The UFR has to be determined for each currency. While being subject to regular revision, the ultimate long term forward rate should be stable over time and only change due to fundamental changes in long term expectations. The unconditional ultimate long-term forward rate should be determined for each currency by macro-economic methods.

2.9 Common principles governing the methods of calculation should ensure a level playing field between the different currencies. For all currencies interest rates beyond the last observable maturity – where no market prices exist – are needed. One way to avoid creating an unlevel playing field when extrapolating the risk-free rate to time horizons of up to 100 years is to use for each currency all available market data from the liquid end of the term structure.

2.10 The most important economic factors explaining long term forward rates are long-term expected inflation and expected real interest rates. From a theoretical point of view it can be argued that there are at least two more components: the expected long-term nominal term premium and the long-term nominal convexity effect.

2.11 The term premium represents the additional return an investor may expect on risk-free long dated bonds relative to short dated bonds, as compensation for the longer term investment. This factor can have both a positive and a negative value, as it depends on liquidity considerations and on preferred investor habitats: if investors seek higher returns for accepting the interest rate risk of long bonds it is positive, if they are prepared to accept a lower return in order to enjoy the advantages of a liability-matching investment, it will be negative.

2.12 The convexity effect arises due to the non-linear (convex) relationship between interest rates and the bond prices used to estimate the interest rates. This is a purely technical effect and always results in a negative component.

2.13 As no empirical data on the term premium for ultra-long maturities exists, the practical estimation of the term premium would be a challenging task and would involve extrapolating from the term premiums for lower maturities.

2.14 In order to have a robust and credible estimate for the UFR the assessment is based on the estimates of the expected inflation and the expected short term real rate.

2.15 Making assumptions about expectations this far in the future for each economy is difficult. However, in practice a high degree of convergence in forward rates can be expected when extrapolating at these long-term horizons. From a macro economical point of view it seems consistent to expect broadly the same value for the UFR around the world in 100 years. Nevertheless, where the analysis of expected long term inflation or real rate for a currency indicates significant deviations, an adjustment to the long term expectation and thus the UFR has to be applied. Therefore, three categories are established capturing the medium UFR as well as deviations up or down.

Estimation of expected long term inflation rate

2.16 The expected inflation should not solely be based on historical averages of observed data, as the high inflation rates of the past century do not seem to be relevant for the future. The fact is that in the last 15-20 years many central banks have set an inflation target or a range of inflation target levels and have been extremely successful in controlling inflation, compared to previous periods.

2.17 Barrie Hibbert[2] propose to assess the inflation rate as 80 per cent of the globally prevailing inflation target of 2 per cent per anno and 20 per cent of an exponentially weighted average of historical CPI inflations when modelling the term structure in their Economic Scenario Generator. When they assess the historical inflation average of the main economies they still compute a high level as of December 2007 (they assess an expected global inflation rate of 2.4 per cent per anno) but with a strong downward trend over the sample of data they considered.

2.18 In order to have a robust and credible estimate for the UFR, the standard expected long term inflation rate is set to 2 per cent per anno, consistently to the explicit target for inflation most central banks operate with[3].

2.19 Nevertheless, based on historical data for the last 10-15 years and current inflation, two additional categories are introduced to capture significant deviations either up or down in the expected long term inflation rate for certain countries. Table 1 shows inflation data for the OECD-countries in the period 1994 – 2009.

Table 1: Inflation 1994 – 2009 OECD Countries

Price indices (MEI) i: Consumer prices - Annual inflation

Data extracted on 15 Mar 2010 13:35 UTC (GMT) from OECD.Stat

[2] Steffen Sørensen, Interest rate calibration – How to set long-term interest rates in the absence of market prices, Barrie+Hibbert Financial Economic Research, September 2008.

[3] Also the European Central bank aims at an annual inflation just below 2 per cent.

Measure	Percentage change on the same period of the previous year															
Frequency	Annual															
Time	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Country																
Australia	1.9	4.6	2.6	0.3	0.9	1.5	4.5	4.4	3.0	2.8	2.3	2.7	3.5	2.3	4.4	1.8
Austria	3.0	2.2	1.9	1.3	0.9	0.6	2.3	2.7	1.8	1.4	2.1	2.3	1.4	2.2	3.2	0.5
Belgium	2.4	1.5	2.1	1.6	0.9	1.1	2.5	2.5	1.6	1.6	2.1	2.8	1.8	1.8	4.5	-0.1
Canada	0.2	2.1	1.6	1.6	1.0	1.7	2.7	2.5	2.3	2.8	1.9	2.2	2.0	2.1	2.4	0.3
Czech Republic	10.0	9.1	8.8	8.5	10.7	2.1	3.9	4.7	1.8	0.1	2.8	1.9	2.6	3.0	6.3	1.0
Denmark	2.0	2.1	2.1	2.2	1.8	2.5	2.9	2.4	2.4	2.1	1.2	1.8	1.9	1.7	3.4	1.3
Finland	1.1	0.8	0.6	1.2	1.4	1.2	3.0	2.6	1.6	0.9	0.2	0.6	1.6	2.5	4.1	0.0
France	1.7	1.8	2.0	1.2	0.6	0.5	1.7	1.6	1.9	2.1	2.1	1.7	1.7	1.5	2.8	0.1
Germany	2.8	1.8	1.4	1.9	1.0	0.6	1.4	1.9	1.5	1.0	1.7	1.5	1.6	2.3	2.6	0.4
Greece	10.9	8.9	8.2	5.5	4.8	2.6	3.2	3.4	3.6	3.6	2.9	3.6	3.2	2.9	4.2	1.2
Hungary	**18.9**	**28.3**	**23.5**	**18.3**	**14.2**	**10.0**	**9.8**	**9.1**	**5.3**	**4.7**	**6.7**	**3.6**	**3.9**	**8.0**	**6.0**	**4.2**
Iceland	**1.6**	**1.7**	**2.3**	**1.8**	**1.7**	**3.2**	**5.1**	**6.4**	**5.2**	**2.1**	**3.2**	**4.0**	**6.7**	**5.1**	**12.7**	**12.0**
Ireland	2.4	2.5	1.7	1.4	2.4	1.6	5.6	4.9	4.6	3.5	2.2	2.4	3.9	4.9	4.1	-4.5
Italy	4.1	5.2	4.0	2.0	2.0	1.7	2.5	2.8	2.5	2.7	2.2	2.0	2.1	1.8	3.3	0.8
Japan	**0.7**	**-0.1**	**0.1**	**1.8**	**0.7**	**-0.3**	**-0.7**	**-0.8**	**-0.9**	**-0.2**	**0.0**	**-0.3**	**0.2**	**0.1**	**1.4**	**-1.4**
Korea	6.3	4.5	4.9	4.4	7.5	0.8	2.3	4.1	2.7	3.6	3.6	2.8	2.2	2.5	4.7	2.8
Luxembourg	2.2	1.9	1.2	1.4	1.0	1.0	3.2	2.7	2.1	2.0	2.2	2.5	2.7	2.3	3.4	0.4
Mexico	7.0	35.0	34.4	20.6	15.9	16.6	9.5	6.4	5.0	4.5	4.7	4.0	3.6	4.0	5.1	5.3
Netherlands	2.8	1.9	2.0	2.2	2.0	2.2	2.3	4.2	3.3	2.1	1.2	1.7	1.2	1.6	2.5	1.2
New Zealand	1.7	3.8	2.3	1.2	1.3	-0.1	2.6	2.6	2.7	1.8	2.3	3.0	3.4	2.4	4.0	2.1
Norway	1.4	2.4	1.2	2.6	2.3	2.3	3.1	3.0	1.3	2.5	0.5	1.5	2.3	0.7	3.8	2.2
Poland	33.0	28.0	19.8	14.9	11.6	7.2	9.9	5.4	1.9	0.7	3.4	2.2	1.3	2.5	4.2	3.8
Portugal	5.4	4.2	3.1	2.3	2.8	2.3	2.9	4.4	3.6	3.3	2.4	2.3	3.1	2.5	2.6	-0.8
Slovak Republic	13.4	9.8	5.8	6.1	6.7	10.6	12.0	7.3	3.1	8.6	7.5	2.7	4.5	2.8	4.6	1.6
Spain	4.7	4.7	3.6	2.0	1.8	2.3	3.4	3.6	3.1	3.0	3.0	3.4	3.5	2.8	4.1	-0.3
Sweden	2.2	2.5	0.5	0.7	-0.3	0.5	0.9	2.4	2.2	1.9	0.4	0.5	1.4	2.2	3.4	-0.3
Switzerland	**0.9**	**1.8**	**0.8**	**0.5**	**0.0**	**0.8**	**1.6**	**1.0**	**0.6**	**0.6**	**0.8**	**1.2**	**1.1**	**0.7**	**2.4**	**-0.5**

Turkey	**105.2**	**89.1**	**80.4**	**85.7**	**84.6**	**64.9**	**54.9**	**54.4**	**45.0**	**21.6**	**8.6**	**8.2**	**9.6**	**8.8**	**10.4**	**6.3**
United Kingdom	2.0	2.7	2.5	1.8	1.6	1.3	0.8	1.2	1.3	1.4	1.3	2.0	2.3	2.3	3.6	2.2
United States	2.6	2.8	2.9	2.3	1.6	2.2	3.4	2.8	1.6	2.3	2.7	3.4	3.2	2.9	3.8	-0.4
G7	2.2	2.3	2.3	2.0	1.3	1.4	2.2	2.0	1.3	1.8	2.0	2.4	2.4	2.2	3.2	-0.1
OECD - Europe	8.6	8.7	7.6	7.2	7.0	5.4	5.7	5.6	4.9	3.0	2.4	2.4	2.6	2.7	3.9	1.2
OECD - Europe excluding high inflation countries	2.8	2.9	2.6	2.0	1.6	1.3	2.3	2.6	2.0	1.9	2.0	2.0	2.1	2.2	3.4	0.8
OECD - Total	4.8	6.1	5.7	4.8	4.2	3.6	4.0	3.7	2.8	2.4	2.4	2.6	2.6	2.5	3.7	0.5
OECD - Total excluding high inflation countries	2.4	2.5	2.4	2.1	1.6	1.5	2.6	2.5	1.7	2.0	2.2	2.5	2.5	2.3	3.5	0.4

2.20 Table 1 shows that two OECD-countries had inflation above 5 percent in 2009: Iceland (12 percent) and Turkey (6.3 percent). During the last 15 years, Turkey has been categorised by OECD as a high inflation country[4]. Turkey's inflation target is also higher (5-7.5% for the period 2009 - 2012) than in other countries.

2.21 Based on this data basis, Hungary and Iceland are possible candidates for the high inflation group. However, deviations to the average inflation rate are far more moderate than those for Turkey. Furthermore, these countries are expected to join the Euro sooner or later (and thus have to fulfil the convergence criteria). Therefore, Hungary and Iceland are classified in the standard inflation category.

2.22 Japan, having deflation in the period since 1994, is an obvious candidate for the "low inflation"-group. Switzerland can also be seen as an outlier. This is due to the fact that historically relatively low inflation rates can be observed and that Switzerland is particular attractive in the international financial markets (exchange rate conditions, liquidity, "save haven"[5]...). For these reasons, lower inflation assumptions are applied for the Swiss francs.

2.23 The estimate covers one-year inflation rate 70 - 100 years from now. It is arbitrary to say whether the inflation differences we see today and have seen the last 15 years will persist 100 years into the future. However, historical evidence and current long term interest rates indicate that it is reasonable to have three groups of currencies with different inflation assumptions. The standard inflation rate is set to 2 per cent per anno. To allow for deviations up and down to the standard inflation rate, an adjustment to the estimate of +/- 1 percentage point is applied for the high inflation group and the low inflation group respectively. This adjustment of 1 percentage point will be applied to the estimated inflation rate for outliers based on differences in current long term interest rates (30Y), observed historical differences between the average interest rate and differences in short term inflation expectations.

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[4] http://stats.oecd.org/index.aspx

[5] http://www.cepr.org/pubs/dps/DP5181.asp "Why are Returns on Swiss Francs so low? Rare events may solve the puzzle." Peter Kugler, Weder di Mauro

2.24 The following grouping is used for the estimated expected long term inflation rate:

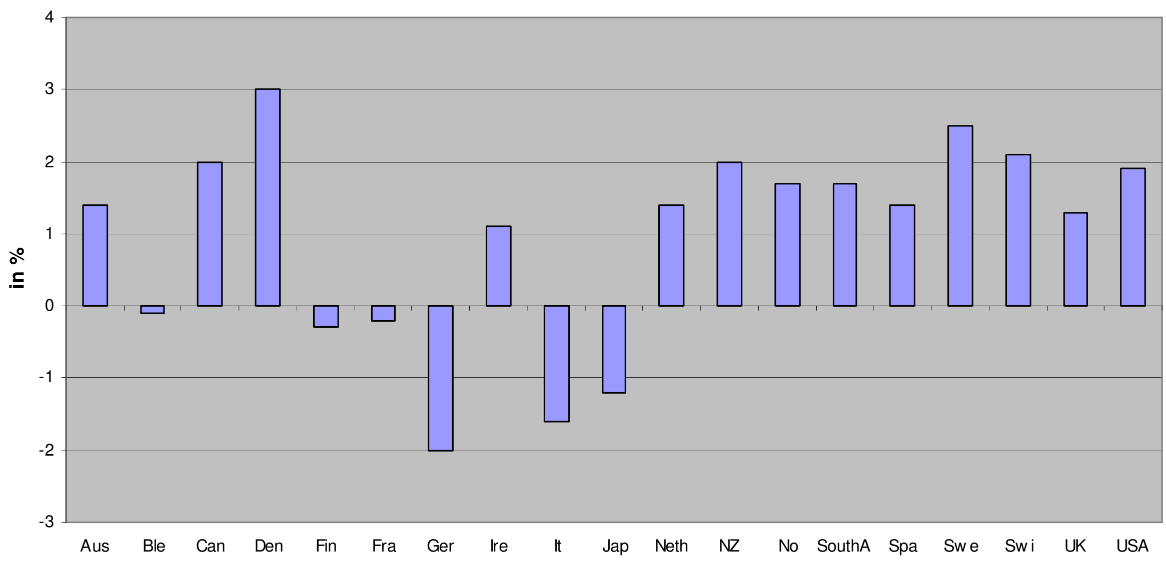
- Standard inflation rate set to 2%: Euro-zone, UK, Norway, Sweden, Denmark, GBP, USD, Poland and Romania
- High inflation rate set to 3%: Turkey
- Low inflation rate set to 1%: Japan, Switzerland

Estimation of the expected real rate of interest

2.25 We expect that the real rates should not differ substantially across economies as far out as 100 years from now. Elroy Dimson, Paul Marsh and Mike Staunton provide a global comparison of annualized bond returns over the last 110 years (1900 to 2009) for the following 19 economies: Belgium, Italy, Germany, Finland, France, Spain, Ireland, Norway, Japan, Switzerland, Denmark, Netherlands, New Zealand, UK, Canada, US, South Africa, Sweden and Australia[6].

Figure 1: Real return on bonds 1900 – 2009

Source: Dimson, Marsh and Staunton – Credit Suisse Global Investment Returns Yearbook



2.26 Figure 1 shows that, while in most countries bonds gave a positive real return, six countries experienced negative returns. Mostly the poor performance dates back to the first half of the 20th century and can be

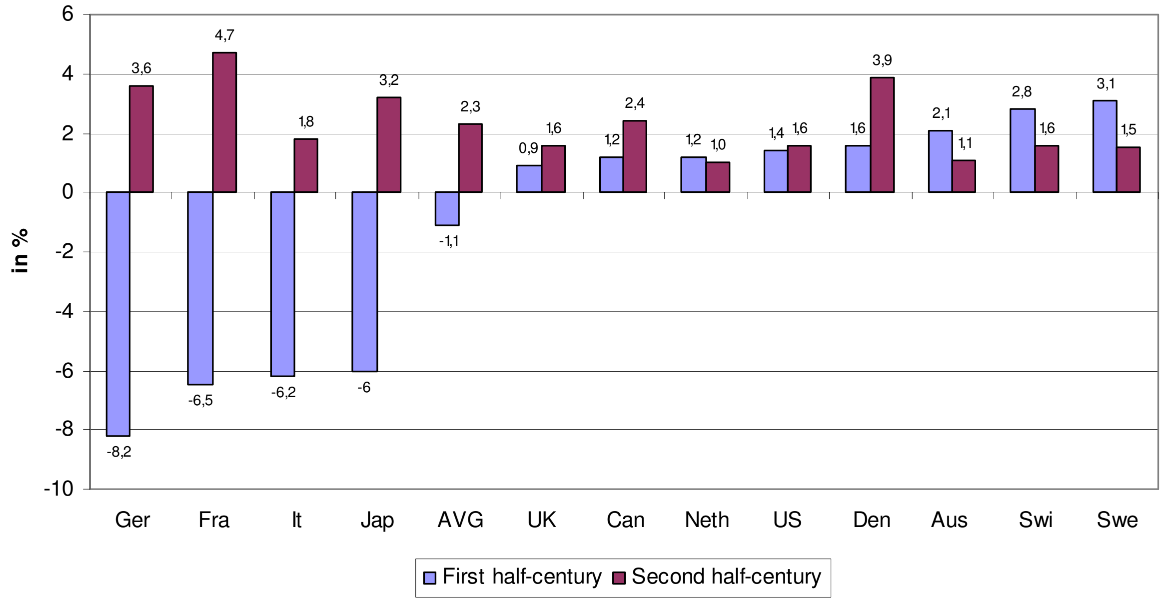
[6] Credit Suisse Global Investment Returns Yearbook 2010, To be found at www.tinyurl.com/DMS2010

explained with times of high or hyperinflation[7]. Aggregating the real returns on bonds for each currency[8] to an annual rate of real return on globally diversified bonds gives a rate of 1.7 per cent.

2.27 In an earlier publication, the same authors compared the real bond returns from the second versus the first half of the 20th century for the following 12 economies: Italy, Germany, France, Japan, Switzerland, Denmark, Netherlands, UK, Canada, US, Sweden and Australia[9]. The average real bond return over the second half of the 20th century was computed as annually 2.3 per cent (compared to -1.1 percent for the first half of the 20th century).

*Figure 2: Real bond returns: first versus second half of 20th century**

Source: Dimson, Marsh and Staunton (ABN- Ambro/LBS)



* Data for Germany excludes 1922-23. AVG = Average

2.28 In light of the above data, 2.2 per cent is an adequate estimate for the expected real interest rate.

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[7] German hyperinflation in 1922/1923, in Italy an inflation of 344% in 1944, in France 74% in 1946 and in Japan 317% in 1946.

[8] Average where each return is weighted by its country's GDP.

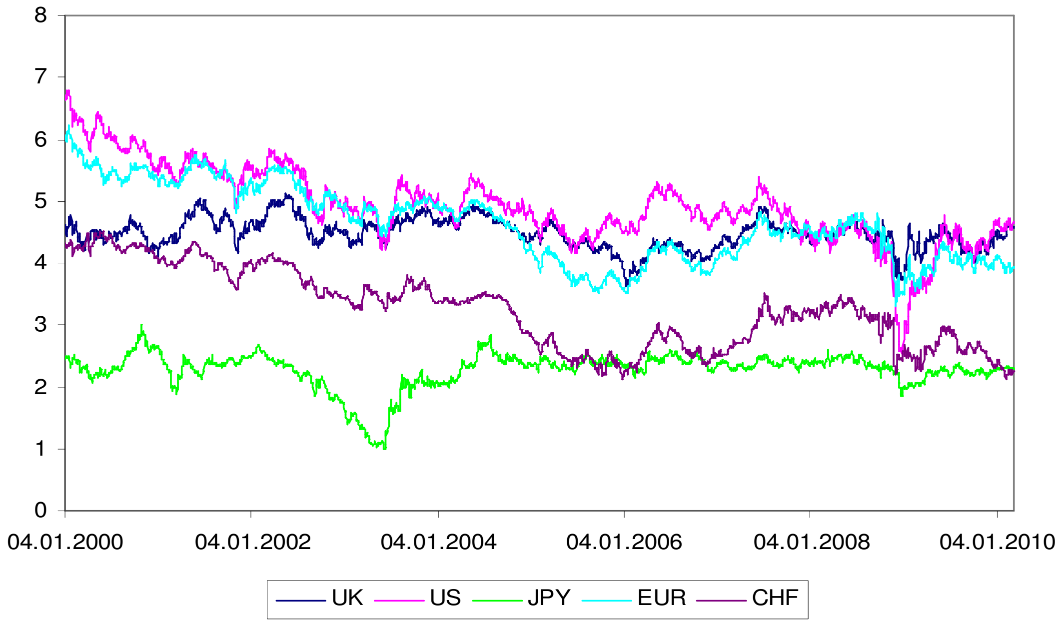
[9] Elroy Dimson, Paul Marsh and Mike Staunton: Risk and return in the 20th and 21th, Business Strategy Review, 2000, Volume 11 issue 2, pp 1-18. See Figure 4 on page 5. The article can be downloaded at: http://docs.google.com/viewer?a=v&q=cache:07V7vM0gu5oJ:citeseerx.ist.psu.edu/viewdoc/download%3Fdoi%3D10.1.1.11.7613%26rep%3Drep1%26type%3Dpdf+Risk+and+return+in+the+20th+and+21th+Centuries&hl=no&gl=no&sig=AHIEtbQbxwuXZNO6ViVlqkV0KZ63LKhB0g

Conclusion

2.29 In light of the above analysis, the macro economically assessed UFR for use in the QIS5 is set to 4.2 per cent (+/-1 percentage points) per anno. This value is assessed as the sum of the expected inflation rate of annually 2 per cent (+/- 1 percentage points) and of an expected short term return on risk free bonds of 2.2 per cent per anno.

2.30 As we can see in figure 3, the development of long term interest rates for the last 10 years supports the proposed differentiation between Euro, GBP, USD in one group and JPY and CHF in another group.

Figure 3: Long term interest rates (30Y) – Source: Bloomberg



2.31 Therefore, for QIS5 the following UFR are used:

Category	Currencies	Macro economically assessed UFR (%)
1	JPY, CHF	3.2
2	Euro, SEK, NOK, DKK, GBP, USD, PLN, RON, HUF, ISK	4.2
3	TRY	5.2

Specification of the transition to the equilibrium rate

2.32 This paragraph considers the issue of how to extrapolate between the estimated forward rates and this unconditional ultimate forward rate, i.e. the question which technique would be the most appropriate to use for all economies.

2.33 Two possible techniques, the linear extrapolation technique as proposed in Annex E of CEIOPS-DOC-34-09 (former CP40) and the Smith-Wilson technique are described below. The technical details for both techniques can be found in the Appendix A.

2.34 For both methods the term structure is fitted exactly to all observed zero coupon bond prices from the liquid market, i.e. all liquid market data points are used without smoothing. The term structure passes through all zero coupon market rates and this can therefore lead to a somewhat bumpy term structure curve in the liquid end of the data for both techniques.

2.35 In the linear interpolation technique the forward rates between the last observable forward rate at maturity T_1 and a predefined maturity T_2 are interpolated linearly. In the Smith-Wilson approach kernel-functions (as many as data points) are defined and the term structure is computed as a linear combination of these kernel functions. The method is based on the assumption that the forward rates converge asymptotically to the UFR at the long end of the term structure. The speed of the convergence can be controlled by choosing an adequate parameter α.

2.36 One of the main differences between the two techniques is that in the linear extrapolation a fixed maturity T_2 has to be assumed at which the unconditional ultimate forward rate will be reached, while in the Smith-Wilson technique the assumption made is on how fast the forward rates converge to the unconditional ultimate forward rate.

2.37 There is no fixed, predefined maturity where the UFR is deemed to be arrived at in the Smith-Wilson approach. But the problem still remains on how to choose the speed of convergence. Thomas[10] proposes $\alpha = 0.1$ for sensible results. The parameter is empirically fitted to give economically appropriate curves.

2.38 Another difference is that in the Smith-Wilson approach both interpolation (for maturities in the liquid end of the term structure where risk-free zero coupon rates are missing) and extrapolation are achieved, while we have to make an additional decision on how to deal with interpolation in the linear method.

2.39 The linear interpolation technique is a simple, extremely intuitive method, easy to explain and easy to apply, but per definition does not give a smooth extrapolated forward curve (forward rate curve is only continuous, but not

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[10] Michael Thomas, Eben Maré: Long Term Forecasting and Hedging of the South African Yield Curve, Presentation at the 2007 Convention of the Actuarial Society of South Africa

differentiable in T_2.) The term structure however is differentiable in all extrapolated points.

2.40 Furthermore, the linear interpolation method is sensitive to the values of the last two forward rates and includes expert opinion when setting the maturity of the UFR.

2.41 The Smith-Wilson approach is more sophisticated but still easy to use (in order to assess the term structure nothing else than an excel-sheet is needed), and gives both a relative smooth forward rate and a smooth spot rate curve in the extrapolated part. It was therefore decided to use the Smith-Wilson approach for extrapolating the interest rate curve in QIS5.

2.42 Nevertheless, alpha will be calibrated to ensure that the extrapolated curve is sufficiently close to the chosen UFR at T2. Furthermore, the linear method has been also run in order to provide a kind of cross-checking, avoiding a full reliance in a single method and enhancing the robustness of results provided by the Smith-Wilson approach.

Transition to the equilibrium rate – Smith-Wilson technique

2.43 The Smith-Wilson approach is a macroeconomic method: a spot (i.e. zero coupon) rate curve is fitted to observed bond prices with the ultimate long term forward rate as input parameter.

2.44 In its most general form, the input data for the Smith-Wilson approach can consist of a large set of different financial instruments relating to interest rates. We will limit the input to zero coupon bond prices, and will only put down the formulae for this simple case.

2.45 In other words: we assume that in the liquid part of the term structure the risk-free zero coupon rates for all liquid maturities are given beforehand. Our task is to assess the spot rate for the remaining maturities. These are both maturities in the liquid end of the term structure where risk-free zero coupon rates are missing (interpolation) and maturities beyond the last observable maturity (extrapolation).

2.46 Let's assume that we have market zero coupon rates for J different maturities: u_1, u_2, u_3, and so on. The last maturity for which market data is given is u_J.

2.47 The market price P(t) for a zero coupon bond of maturity t is the price, at valuing time $t_0 = 0$, of a bond paying 1 at some future date t. Depending on whether the market data spot rates are given as continuously compounded rates $\tilde{R}_{u_j}$ or as rates R_{u_j} with annual compounding, the input zero bond prices at maturities u_j are:

$P(u_j) = \exp(-u_j * \tilde{R}_{u_j})$ for continuously compounded rates, and

$P(u_j) = (1 + R_{u_j})^{-u_j}$ for annual compounding.

The relation between the two rates is given through $R_{u_j} = \ln(1+\tilde{R}_{u_j})$.

2.48 Our aim is to assess the function P(t) for <u>all maturities</u> t, t > 0. From the definition of the price function $P(t) = \exp(-t * \tilde{R}_t)$ for continuously compounded rates and $P(t) = (1+R_t)^{-t}$ for annual compounding, we then can assess the whole risk-free term structure at valuing date $t_0 = 0$.

<u>General on extrapolation technique</u>

2.49 Most extrapolation methods start from the price function, and assume that the price function is known for a fixed number of say J maturities. In order to get the price function for all maturities, some <u>more assumptions are needed</u>.

2.50 The most common procedure is to impose – in a first step - a functional form with K parameters on the price function P[11]. These functional forms could be polynomials, splines, exponential functions, or a combination of these or different other functions[12].

2.51 In some of the methods, in a second step, the K parameters are estimated via least squares at each point in time. In other methods K equations are set up from which the K parameters are calculated. The equations are set up in a manner that guarantees that P has the features desired for a price function: A positive function, with value 1 at time t=0, passing through all given data points, to a certain degree smooth, and with values converging to 0 for large t.

<u>Smith-Wilson approach</u>

2.52 Smith and Wilson[13][14] proposed a pricing function (here reproduced in a restricted form, only for valuing at point t_0 =0) of the following form:

$$P(\tau) = e^{-UFR*\tau} + \sum_{i=1}^{J} \varsigma_i * W(\tau, u_i), \quad \tau \geq 0$$

with the symmetric Wilson-functions $W(\tau, u_i)$ defined as

[11] In their respective models, Svensson for instance imposes a parametric form with 6 parameters and Nelson-Siegel one with 4 parameters.

[12] BarrieHibbert use cubic splines in the liquid part of the term structure and Nelson-Siegel for the extrapolation part.

[13] Smith A. & Wilson, T. – "Fitting Yield curves with long Term Constraints" (2001), Research Notes, Bacon and Wodrow. Referred to in Michael Thomas, Eben Maré: "Long Term Forecasting and Hedging of the South African Yield Curve", Presentation at the 2007 Convention of the Actuarial Society of South Africa

[14] Andrew Smith: Pricing Beyond the Curve – derivatives and the Long Term (2001), presentation to be found at http://www.cfr.statslab.cam.ac.uk/events/content/20001/asmith2001.pdf

$$W(\tau,u_i) = e^{-UFR*(\tau+u_i)} * \left\{\alpha * \min(\tau,u_i) - 0.5 * e^{-\alpha*\max(\tau,u_i)} * (e^{\alpha*\min(\tau,u_i)} - e^{-\alpha*\min(\tau,u_i)})\right\}$$

2.53 The following notation holds:

- *J* = the number of zero coupon bonds with known price function
- u_i, *i*=1, 2, … *J*, the maturities of the zero coupon bonds with known prices
- *τ* = term to maturity in the price function
- *UFR* = the ultimate unconditional forward rate,
- *α* = mean reversion, a measure for the speed of convergence to the UFR
- ζ_i = parameters to fit the actual yield curve

2.54 The so called kernel functions $K_i(\tau)$ are defined as functions of *τ*:

$K_i(\tau) = W(\tau,u_i),\ \tau > 0$ and i=1,2,…J

They depend only on the input parameters and on data from the input zero coupon bonds. For each input bond a particular kernel function is computed from this definition. The intuition behind the model is to assess the function P(t), from which we aim to calculate the term structure, as the linear combination of all the kernel functions. This reminds of the Nelson-Siegel method, where the forward rate function is assessed as the sum of a flat curve, a sloped curve and a humped curve, and the Svensson method, where a second humped curve is added to the three curves from Nelson-Siegel.

2.55 The unknown parameters needed to compute the linear combination of the kernel functions, ζ_i, i= 1, 2, 3 … J are given as solutions of the following linear system of equations:

$$P(u_1) = e^{-UFR*u_1} + \sum_{i=1}^{J} \varsigma_i * W(u_1,u_i)$$

$$P(u_2) = e^{-UFR*u_2} + \sum_{i=1}^{J} \varsigma_i * W(u_2,u_i)$$

……………………………………………………

$$P(u_J) = e^{-UFR*u_J} + \sum_{i=1}^{J} \varsigma_i * W(u_J,u_i)$$

2.56 In vector space notation this becomes:

$$\vec{\mathrm{P}} = \vec{\mathrm{E}} + W * \vec{\zeta} \ ,$$

with:

$\vec{\mathrm{P}} = (P(u_1), P(u_2), ...P(u_J))^T$ (The superscript T denoting the transposed vector)

$\vec{\mathrm{E}} = (e^{-UFR*u_1}, e^{-UFR*u_2}, ...e^{-UFR*u_J})^T,$

$\vec{\varsigma} = (\varsigma_1, \varsigma_2, ...\varsigma_i,)^{T}$,

and

W = $(W(u_i, u_j))_{i=1,...J,\ j=1,...J}$, a JxJ-matrix of certain Wilson functions

2.57 From this notation we see at once that the solution (ζ_1, ζ_2, ζ_3, … ζ_J) is easily calculated by inverting the JxJ-matrix ($W(u_i, u_j)$) and multiplying it with the difference of the P-vector and the E-vector, i.e.

$$\vec{\zeta} = W^{-1} * (\vec{P} - \vec{E}),$$

2.58 We can now plug these parameters ζ_1, ζ_2, ζ_3, … ζ_J into the pricing function and get the value of the zero coupon bond price for all maturities τ, for which no zero bonds were given to begin with:

$$P(\tau) = e^{-UFR*\tau} + \sum_{i=1}^{J} \varsigma_i * W(\tau, u_i), \ \tau>0$$

2.59 From this value it is straightforward to calculate the spot rates by using the definition of the zero coupon bond price. The spot rates are calculated as $\tilde{R}_\tau = 1/\tau * \ln(1/P(\tau))$ for continuous compounded rates and $R_\tau = (1/P(\tau))^{1/\tau} - 1$ if annual compounding is used.

Transition to the equilibrium rate – Linear extrapolation technique

2.60 Interpolation between market data points in the liquid part of the term structure

- Choose reference rates from market data according to the criteria for risk free rate specified in CP40.
- If the market data includes coupon payments, transform the data to zero coupon rates (spot rates) for every reasonably liquid maturity point given as yearly interval of 1, 2, 3,…,years. See specification on risk-free rates.
- Forward rates are calculated from the spot rates. Forward rates are the rates of interest implied by spot rates for periods of time in the future. If R_S and R_T are spot rates for maturities S and T, then the average annual forward rate FR(S,T) for the period from S to T is defined by

$$(1+R_T)^T = (1+R_S)^S \cdot (1+FR(S,T))^{T-S}, \text{so}$$
$$FR(S,T) = \left(\frac{(1+R_T)^T}{(1+R_S)^S}\right)^{1/(T-S)} - 1$$

- If no reliable rates are available for maturity points between e.g. liquid market data for maturities S and T, the intervening zero coupon rates have to be determined based on an additional assumption.

- In QIS4 this additional assumption was that forward rates between S and T are constant, i.e.

  $FR(S, S+1) = FR(S+1, S+2) = ... = FR(T-1, T) = FR(S, T)$.

- In QIS5 (this is now implemented in the Extrapolator) the additional assumption is that the intervening spot rates can be determined by linear interpolation from R_S and R_T, the known spot rates for maturities S and T

2.61 Extrapolation beyond the last liquid data point

- To be able to extrapolate, we have to define two specific points in time:

  - T_1 = the maturity of the last observed liquid spot rate (that meets all the criteria)

  - T_2 = starting point for the ultimate unconditional long term forward rate (UFR).

  - The last observable market forward rate $FR(T_1-1) = FR(T_1-1, T_1)$ is calculated from the last market data points.

- A constant ultimate unconditional forward rate UFR is applied for all maturities beyond T_2. The method to determine this rate and the maturity points T_1 and T_2 can differ between different currencies.

- Linear interpolation is used to arrive at one year forward rates FR(n) for maturities n between T_1 and T_2:

$$FR(n) = FR(T_1 - 1) + \frac{UFR - FR(T_1 - 1)}{T_2 - T_1}(n - T_1 + 1) \text{ for } T_1 \le n \le T_2$$

- The spot rates R_n for durations $n \ge T_1$ are then iterated from the above one year forward rate curve by

$$R_{n+1} = \left((1 + R_n)^n \cdot (1 + FR(n))\right)^{\frac{1}{n+1}} - 1$$

2.2 Cost-of-Capital rate[15]

A general approach for stipulating the Cost-of-Capital rate

2.62 According to Article 77(5) of the Level 1 text the Cost-of-Capital rate "shall be the same for all insurance and reinsurance undertakings and shall be reviewed periodically". Moreover, the Cost-of-Capital rate used

shall be equal to the additional rate, above the relevant risk-free interest rate, that an insurance or reinsurance undertaking would incur holding an amount of eligible own funds, […], equal to the Solvency Capital Requirement necessary to support the insurance and reinsurance obligation […].

2.63 As the "additional rate, above the relevant risk-free interest rate" referred to in Article 77(5) shall be the same for all insurance and reinsurance undertakings, it should be calibrated in a manner that is consistent with the assumptions made for the reference undertaking. In practise this means that the Cost-of-Capital rate should be consistent with the Value-at-Risk-assumption corresponding to a confidence level of 99.5 per cent over the stipulated one-year time horizon as laid down for the calculation of the Solvency Capital Requirement (SCR). Especially, the Cost-of-Capital rate should be independent of the actual solvency position of the original undertaking.

2.64 In the third and fourth Quantitative Impact Study for Solvency II (QIS3 and QIS4) the Cost-of-Capital rate had been fixed at 6 per cent as such a rate has been assumed to reflect the cost of holding an amount of eligible own funds for an insurance or reinsurance undertaking being capitalised corresponding to a confidence level of 99.5 per cent Value-at-Risk over a one year time horizon.

2.65 The required consistency between the stipulated Cost-of-Capital rate and the (Value-at-Risk) assumptions for the SCR-calculations was explained as follows: the 6 per cent Cost-of-Capital rate corresponds to the cost of providing eligible own funds for BBB-rated insurance or reinsurance undertakings, cf. the Cost-of-Capital rate used by the Swiss regulator in its Solvency Test for BBB-rated reference undertakings.

2.66 As part of the QIS4-feedback, questions have been raised regarding the appropriateness of the assumed Cost-of-Capital rate of 6 per cent. Especially, reference was made to the work carried out by the Chief Risk Officer Forum (CRO Forum), and a substantially lower Cost-of-Capital rate has been indicated.

[15] This section follows CEIOPS-DOC-36/09

2.67 However, a critical analysis of the CRO Forum's report[16] – as well as other reports on this issue[17] – does not support the QIS4-feedback referred to above. On the contrary, the analysis which is summarised in the subsection below, indicates that an assumed Cost-of-Capital of 6 per cent or higher could be seen as appropriate – given the information currently available regarding this issue. In this context it should be noted that although the CRO Forum has indicated in its report that its research suggests a Cost-of-Capital rate in the range of 2 ½ - 4 ½ per cent, it also acknowledges that its research did not prove conclusive. Moreover, it seems that the CRO Forum first and foremost has focussed on results leading to the lowest estimates of the Cost-of-Capital rate.

2.68 The analysis summarised in the following subsection does not discuss the required periodical review as referred to in Article 77(5) of the Level 1 text. However, CEIOPS points out that the frequency and procedures to be followed for this review would need to be developed. A possible approach could be to test the appropriateness of the Cost-of-Capital rate every five years. In this context, it should be stressed that due to the long-term nature of the Cost-of-Capital rate, this does not necessarily mean that the rate has to be changed as a consequence of a periodic review.

Assessment of the Cost-of-Capital Rate

(a) Introductory remarks

2.69 The Cost-of-Capital rate is an annual rate applied to a capital requirement in each period. Because the assets covering the capital requirement themselves are assumed to be held in marketable securities, this rate does not account for the total return but merely for the spread over and above the risk free rate.

2.70 The risk margin shall guarantee that sufficient technical provisions for a transfer are available even in a stressed scenario. Hence, the Cost-of-Capital rate has to be a long-term average rate, reflecting both periods of stability and periods of stress. Otherwise, the rate would vary from year to year, and would be higher in times of economic uncertainty (when providers of capital would be expected to seek greater returns for the comparatively higher risk) and would therefore contribute to higher technical provisions than in more stable economic situations.

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[16] CRO Forum: Market Value of Liabilities for Insurance Firms – Implementing Elements for Solvency II (July 2008).

[17] GNAIE (Group of North American Insurance Enterprises): Market Value Margins for Insurance Liabilities in Financial Reporting and Solvency Applications (October 2007),

http://www.insuranceaccounting.org/images/Market%20Value%20Margin10CA985.pdf

2.71 A rate of at least 6 per cent is assessed to be an adequate placeholder for the Cost-of-Capital rate in the current context of the Solvency II regulation. In order to reach this conclusion it may be argued along the following lines:

- Shareholder return models provide the initial input.
- Some objective criteria may cause upward and downward adjustments of the initial input.
- A final calibration of the Cost-of-Capital rate, in order to obtain risk margins consistent with observable prices in the marketplace, may be necessary.

Before discussing this three-step procedure, it will be reflected on the assumptions that would be reasonable to make regarding the funding of the capital requirement.

(b) Funding of the capital requirement

2.72 In CRO Forum's report, the Cost-of-Capital rate is calculated as a weighted average of the cost of equity and the cost of debt. It is assumed that 20 per cent of the capital requirement can be funded by issuing debt and that only the remaining 80 per cent have to be funded by raising equity capital. Moreover, by assuming an effective company rate of taxation of 35 per cent over all jurisdictions, the estimated cost of debt is in practise outweighed by the adjustments for tax relief on interest payments made to service the debt. As a result the Cost-of-Capital rate equals only approximately 80 per cent of the estimated cost of equity rate.

2.73 It should be noted that the assumed funding based on 80 per cent equity and 20 per cent debt cannot be justified in light of the feedback received during the QIS4-exercise. According to the QIS4-report the participating undertakings reported that 95 per cent of their own funds are classified as tier 1 capital of which only 2 per cent are classified as "subordinated loans" and only 4 per cent as "other reserves (with restricted loss absorbency)". Moreover, only 50 per cent of the tier 2 and tier 3 capital are classified as subordinated loans or other hybrid capital.[18] Consequently, the QIS4-results indicate clearly that the assumed debt-funding in any case cannot constitute more than 6-8 per cent of the capital base.[19]

2.74 Moreover, it may be referred to the high-level political guidance to increase the quality of the external funding (subordinated loans, hybrid capital instruments etc.) of financial institutions. It follows from this that subordinated loans and hybrid capital should have a high loss-absorbing capacity rather similar to "core" capital, cf. the revision carried out in the

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[18] Cf. CEIOPS' Report on its fourth Quantitative Impact Study (QIS4) for Solvency II, page 129-132.

[19] In the remainder of the present sub-section it is referred to "the capital base" and not "the eligible own funds" since the first concept is closest to the terminology used in CRO Forum's report.

banking sector. Accordingly, it seems reasonable to expect the cost-differences between equity funding and allowed external funding to diminish.

2.75 In this context it should also be stressed that since the capital base is defined as the solvency capital requirement in an adverse situation, i.e. as the amount of capital that is substantially at risk, it would be inconsistent to assume at the same time that this requirement can be funded by debt investors at costs substantially below equity.

2.76 With respect to the assumed impact of taxation (i.e. the tax relief on interest payments) on the assessment of the Cost-of-Capital rate, this aspect will be less important than assumed in CRO Forum's report due to the QIS4-feedback referred to above.[20] However, it still remains to decide on the tax rate(s) to be used if a more detailed analysis of this aspect of the Cost-of-Capital calculations should be carried out.[21]

2.77 Based on the considerations given in the previous paragraphs CEIOPS finds that an approach based on the market situation (i.e. the actual combination of equity and debt funding) leads to conclusions similar to an approach based on 100 per cent equity funding. This is in particular the case for the purpose of the assessments summarised below.

(c) The three-step procedure for assessing the Cost-of-Capital rate

(c1)Shareholder return models

2.78 The research carried out by both CRO Forum and GNAIE has been analysed. As the most commonly used models in the market seem to be the Capital Asset Pricing Model (CAPM) and versions of the Fama-French multi Factor Model (FFmF), CEIOPS' analysis has been confined to the results given for these models.

- *The Frictional Cost-of-Capital approach*

2.79 In CRO Forum's research the rate of return above the risk free rate that shareholders of insurance undertakings demand in order to assume broadly diversified insurance risks, are estimated using different methods and assumptions. CRO Forum deems that the so-called Frictional Cost of Capital approach is the most appropriate to capture the rate of return an insurance company requires on the capital it deploys to support non-hedgeable risk over

[20] A rather peculiar – and likely unintended – implication of the assumptions made in CRO Forum's report should be mentioned. Since the estimated cost of debt is outweighed by the tax-relief on interest payments made to serve this debt, a logical conclusion seems to be that by increasing the (relative) debt-funding an insurance undertaking will be rewarded by a lower Cost-of-Capital rate. According to CEIOPS' understanding this cannot be in line with the intention of Article 77(5) of the Level 1 text.

[21] It may also be questionable whether an insurance undertaking being in a stressed situation will be in a position to benefit from further tax credits.

a given year. This is likely the reason why they rely so heavily on the results from this method when drawing their conclusions.

2.80 However, CEIOPS has reservations regarding the results based on this approach[22] as reproduced in the CRO Forum' report. Firstly, the results of the method are very dependent on a number of key assumptions – effective tax rate, loss carry forward period and risk free rate – for which it is difficult to assess reasonable parameter estimates in an EU context. Secondly, of the main components of the frictional costs – double taxation costs, financial distress costs[23] and agency costs[24] – only the two first have been modelled.

2.81 Moreover, the CRO Forum has drawn e.g. the following conclusions after having modelled double taxation and financial distress costs:[25]

For highly capitalized companies, the cost of capital rate is determined mainly by the cost of double taxation and the cost of financial distress is negligible. […]

The cost of capital rate depends linearly on a jurisdiction's tax rate for all confidence levels. This means that the cost of capital rate (and therefore the MVM) in a jurisdiction with a tax rate of 10% is only half of that in a jurisdiction with a tax rate of 20%.

In CEIOPS' opinion the result implied by these conclusions does not seem reasonable for Member States in which the effective tax rate is low. Furthermore, CEIOPS also questions the assertion that financial distress costs are negligible for well capitalized companies.

- *The CAPM and the FF2F-method*

2.82 In CRO Forum's research related to the CAPM and the FF2F method, the cost of equity rate above the risk-free rate has been estimated for three markets: the European, the Asian and the US market. From these estimated rates a "Global World" rate has been derived for both methods. The Global World rates are in general lower than the European rates, cf. table 2 below.[26] When concluding on an appropriate level of the Cost-of-Capital rate, CRO Forum has

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[22] Under this approach, the total return required by shareholders may be thought of consisting of the base cost of capital, the frictional costs and the expected economic profit. Only the frictional costs are taken into account in determining the Cost of Capital rate.

[23] These are direct and indirect costs which arise when an insurer has difficulties meeting its financial obligations to policyholders or debt holders.

[24] Agency costs are associated with the misalignment of the interest between management and shareholders or between policyholders and shareholders. The lack of transparency and informational asymmetry are also deemed to be part of agency costs.

[25] Cf. CRO Forum's report, page 36.

[26] In the CAPM-case the reported Global rates are lower than the reported rates for all three markets – a result that could have been better explained in the report.

taken into account only the lower Global World rates without giving any explicit rationale for this choice.

2.83 CEIOPS finds it more appropriate to base the assessment of the Cost-of-Capital rate on CRO Forum's results for the CAPM and the FF2F method for European insurance undertakings. In this context it may also be noted that the FF2F-results for the European non-life insurers are in line with the results referred to in GNAIE's report for US non-life insurers (an equity risk premium of 14.2 per cent).

Table 2. Equity Risk Premiums as assessed in the CRO Forum's report.[27]

	CAPM		FF2F	
	European market	Global market	European market	Global market
Life Non-life	10.0 pct 7.4 pct	5.1 pct 4.2 pct	11.8 pct 12.5 pct	9.4 pct 9.6 pct

2.84 Taking into account only the results from the shareholder return models a Cost-of-Capital rate of 7 ½-10 per cent seems to be adequate. It should, however, be noticed that the figures reproduced in table 2 are based on historical averages during normal times only and do not take into account stressed scenarios in an adequate manner.

(c2) Adjustment of shareholder return

2.85 To the output from the shareholder return models both upward and downward adjustments are needed when assessing the cost of capital rate in a solvency context.

2.86 Downward adjustments: In order to account for the fact that a key source of return that exists for going concerns (the so called franchise value related to expected profit from new business) may not be demanded by capital

[27] Cf. CRO Forum's report, page 58, 60 and 61.

providers in a transfer context, a downward adjustment is needed. No reliable quantitative results are available concerning the size of this adjustment.

2.87 Upward adjustments: Additional costs, i.e. costs beyond those required to compensate investors for the risk they are assuming, make an upward adjustment necessary. These additional costs may stem from:

- Frictional costs of carrying capital. These are additional costs[28] which reflect a variety of indirect costs, as frictional costs related to managers' incentives, information asymmetries, and so on. Again, these costs are very difficult, if not impossible, to quantify.
- Initial costs of raising capital. These are fees for underwriting, listing and regulation, which in most jurisdictions are not negligible[29].
- Corporate income taxes on the risk margin in some tax jurisdictions. This is the case if the risk margin is considered as taxable profit at inception and not as taxable income only over the time of its release from the risk margin.

2.88 As already indicated, the aggregate effect of both upward and downward adjustments is difficult to quantify in a reliable manner. However, as it is unlikely that the downward adjustment outweighs the upward adjustments by a large margin, a range for the Cost-of-Capital rate after these adjustments of 6-8 per cent could be deemed as reasonable given the current market situation/information.

(c3) Calibration to market prices

2.89 The output for the cost of capital rate has to be calibrated further to give final risk margins consistent with observable prices in the marketplace. The risk margin together with the best estimate shall be "equivalent to the amount insurance and reinsurance undertakings would be expected to require in order to take over and meet the insurance and reinsurance obligations" (Article 77(3)).

2.90 In the Solvency II context an allowance may be necessary for the methodologies applied when calculating the capital base (i.e. the future SCRs). This is especially the case for any simplifying methods allowed.[30] All other assumptions equal, especially for unchanged best estimate, it may be argued that the cost of capital rate should be set higher if methods used in the solvency context give systematically lower capital bases than the capital

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[28] Cf. the GNAIE-report, page 30.

[29] Underwriting fees, which generally constitute at least half of the direct IPO costs, amount to about 3.5% of the raised equity in the UK, Germany or France, and to more than 6.5% in the USA. Source: Oxera report (2006), "The Cost of Capital: An International Comparison". Available at www.oxera.com.

[30] In QIS4 a majority of undertakings (independently of their size) used simplifications when making SCR-projections for the risk margin calculations.

bases assessed through the markets in real insurance portfolio transfers. Otherwise the technical provisions will be insufficient.

2.91 As long as the method used in assessing the capital base does not systematically underestimate the needed amount, a Cost-of-Capital rate of 6 per cent could be seen as adequate. In order to avoid procyclical effects, the Cost-of-Capital rate should not be adjusted to follow market cycles.

2.3 Simplified calculation of the Risk Margin

2.92 Similarly to QIS4, CEIOPS' proposal for QIS5 specifications contains the following table for the case where it is possible to calculate the risk margin using the simple method based on percentages of the best estimate:

Line of Business	Percentage of Best Estimate
Direct insurance and accepted proportional reinsurance:	
Accident	12.0 %
Sickness	8.5 %
Workers' compensation	10.0 %
Motor vehicle liability	8.0 %
Motor, other classes	4.0 %
Marine, aviation and transport	7.5 %
Fire and other damage	5.5 %
General liability – Third party liability	10.0 %
Credit and suretyship	9.5 %
Legal expenses	6.0 %
Assistance	7.5 %
Miscellaneous non-life insurance	15.0 %
Accepted non-proportional reinsurance:	
Property business	7.0 %
Casualty business	17.0 %
Marine, aviation and transport business	8.5 %

2.93 The proposed percentages are based on table 69 of the QIS4 report, Annex of selected tables, pages A-74 to A-76, line 'Life+Nonlife+Composites) *(see http://www.ceiops.eu/media/files/consultations/QIS/CEIOPS-SEC-82-08%20QIS4%20Report%20Table%20Annex.pdf]*

2.94 For almost all lines of business, the ratio observed in QIS4 does not show a significant standard deviation around the average ratio. Then and directly, the rounded percentage shown in the aforementioned table has been adopted as proposal.

2.95 Notwithstanding, there are three lines of business where the ratio observed in QIS4 has been considered not usable for the purposes of QIS5. In these cases the same percentages as QIS4 have been maintained, since there is no evidence of any practical problem derived from their application during that exercise.

2.96 The three lines of business where the same percentage as QIS4 is proposed, are:

i) Accident (due to the fact that in QIS4, data concerning this guarantee are embedded in various lines of business, and therefore no isolate and purely specific average ratio is available)

ii) Motor, other class (due to specific heterogeneity in the data provided from some markets, specifically analyzed and identified)

iii) Miscellaneous (due to its obvious heterogeneity)

3. Solvency capital requirement: standard formula

3.1 Market risk

3.1.1 Interest rate risk[31]

3.1 The calibration of the standard formula interest rate capital charge is based on the delta-NAV approach proposed in CEIOPS-DOC-40/09 (former CP47).

3.2 In CEIOPS-DOC-40/09, CEIOPS set out the capital charge arising from this sub-module, termed Mktint, to be based on two pre-defined factors, an upward and downward shock in the term structure of interest rates combined with specific alterations in the interest rate implied volatility. The combination of the instantaneous shift of these factors yields a total of four pre-defined scenarios.

3.3 The first two scenarios will consider an upward shock to interest rates, whilst implied volatility experience an upward and downward parallel shift and will deliver $Mkt_{int}^{Up}{}_{ivol}^{Up}$ and $Mkt_{int}^{Up}{}_{ivol}^{Dn}$. The last two scenarios will consider a downward shock to interest rates and will deliver $Mkt_{int}^{Dn}{}_{ivol}^{Up}$ and $Mkt_{int}^{Dn}{}_{ivol}^{Dn}$.

[31] This section follows CEIOPS-DOC-66/10

The capital charge Mkt_{int} will then be determined as the maximum of the capital charges $Mkt_{int}^{Up}{}_{ivol}^{Up}$, $Mkt_{int}^{Up}{}_{ivol}^{Dn}$, $Mkt_{int}^{Dn}{}_{ivol}^{Up}$ and $Mkt_{int}^{Dn}{}_{ivol}^{Dn}$, subject to a minimum of zero.

3.4 The capital charges Mkt_{int}^{Up} and Mkt_{int}^{Down} will be calculated as

$Mkt_{int}^{Up}{}_{ivol}^{Up} = \Delta NAV|_{upwardshock}$ and $Mkt_{int}^{Up}{}_{ivol}^{Dn} = \Delta NAV|_{up\&downshock}$

$Mkt_{int}^{Dn}{}_{ivol}^{Up} = \Delta NAV|_{down\&upshock}$ and $Mkt_{int}^{Dn}{}_{ivol}^{Dn} = \Delta NAV|_{downwardshock}$

where $\Delta NAV|_{upwardshock}$, $\Delta NAV|_{downwardshock}$, $\Delta NAV|_{up\&downshock}$ and $\Delta NAV|_{down\&upshock}$ are the changes in net values of assets and liabilities due to revaluation of all interest rate sensitive assets and liabilities based on:

a. Specified alterations to the interest rate term structures

combined with:

b. Specified alterations to interest rate volatility.

3.5 The volatility shocks are relevant only where insurers' asset portfolios and/or their insurance obligations are sensitive to changes in interest rate volatility, for example where liabilities contain embedded options and guarantees. Thus, for some non-life obligations, for example, the interest rate volatility stress will be immaterial and on that basis could be ignored.

3.6 The analysis below considers the calibration of the shock scenarios across the interest rate term structure, and also takes into account the impact of corresponding changes in implied volatility, as proposed in CEIOPS-DOC-40/09.

Shocks to interest rate term structure

3.7 The altered term structures used in calculating the capital charge for this sub-module will be composed of several factors, although there will only be one upward shock and one downward shock to be applied at each maturity. As proposed in CEIOPS-DOC-40/09, the analysis below provides a decomposition of the shocks so that the assumptions underlying the calibration are transparent.

3.8 The QIS4 technical specification paper alters the term structure of interest rates using two sets of upward and downward maturity dependent factors. Our analysis attempts to calibrate the relative changes of the term structure of interest rates using the following datasets:

- EUR government zero coupon term structures. The daily data spans a period of approximately 12 years and starts from August 1997 to May 2009. The data, sourced from Bundesbank's website, contains daily zero coupon rates of 1 year to 15 year maturities spaced out in annual intervals. The data is publicly available at www.bundesbank.de/statistik/.

- GBP denominated government zero coupon term structures. The data is daily and sourced from the Bank of England. The data covers a period from 1979 to 2009, and contains zero coupon rates of maturities starting from 6 months up until 25 year whilst the in between data points are spaced on semi-annual intervals. In total, we have 50 data points every day since 1979, albeit some of the longer maturities (i.e., beyond 15 years) are only available at later dates. The data is available at http://www.bankofengland.co.uk/statistics/yieldcurve/archive.htm.

- Euro and GBP libor/swap rates. The daily data is downloaded from Bloomberg and covers a period from 1997 to 2009. The data contains 3-month, 6-month and 12-month libor rates, the 2 to 10 year rates spaced out in one year intervals, as well as the 15 year, 20 year and 30 year rates across both currencies.

3.9 In the spirit of QIS4, the altered term structures are derived by multiplying the current interest rate curve by the upward and downward stress factors. These factors are defined across maturity and currency, as well as type of security.

3.10 Our analysis relies on Principal Component Analysis[32] (PCA) to specify the above tabulated scenarios. PCA is proposed as a tractable and easy-to-implement method for extracting market risk. For a collection of annual percentage rate changes, the number of principal components (PCs) to be retained for further analysis is determined by the variance–covariance structure of each underlying data set (i.e., PCA is applied to each individual dataset).

3.11 We find that four principal components are common across all datasets, and these explain 99.98% of the variability of the annual percentage rate change in each of the maturities in the underlying datasets.

3.12 The derived factors are recognised as the level, slope and curvature of each of the term structures, whilst the fourth factor may represent a "twist" in certain maturity points of the underlying yield curve. The figure below illustrates the associated eigenvectors.

3.13 The position of the yield curve is affected by current short term interest rates, denoted by the 'level', whilst the slope is mainly affected by the difference between long-term and short term interest rates. The curvature of the interest rates is associated with the volatility of the underlying interest or forward rate and the twists represent shocks to specific maturity point on the interest rate yield curve.

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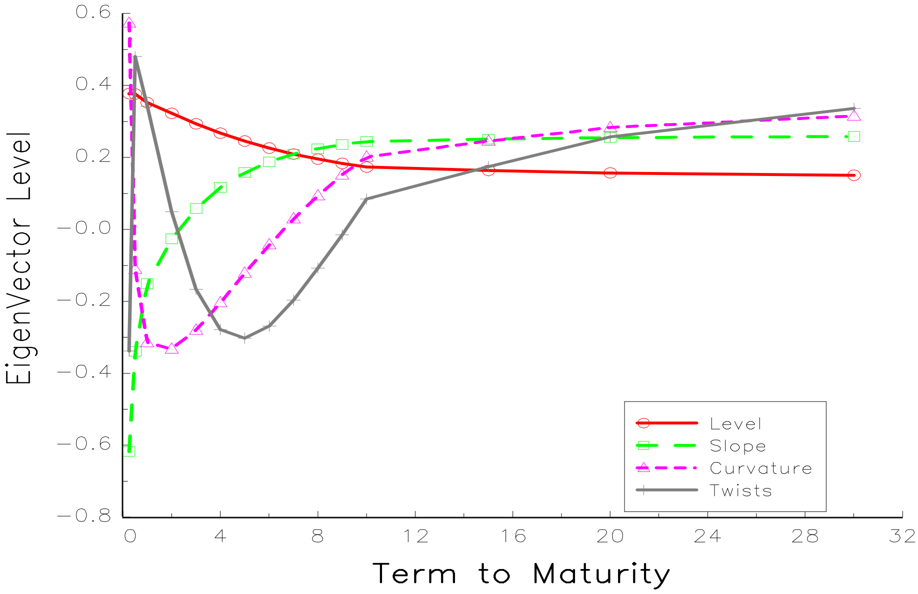
[32] PCA is mathematically defined as an orthogonal linear transformation that transforms the data to a new coordinate system such that the greatest variance by any projection of the data comes to lie on the first coordinate (called the first principal component), the second greatest variance on the second coordinate, and so on. PCA is theoretically the optimum transform for given data in least square terms. For further details, please refer to Jolliffe I.T, (2002), Principal Component Analysis, Springer Series in Statistics, 2nd ed., Springer-Verlag.



3.14 The table below presents the total variance explained by successive principal components (1=level, 2=slope, 3=curvature, 4=twist)

PC's	EU GOV	EUR Swap	GBP GOV	GBP Swap
1	90.32%	89.20%	76.37%	92.04%
2	9.02%	9.00%	20.15%	6.33%
3	0.61%	1.52%	2.88%	1.23%
4	0.04%	0.14%	0.35%	0.21%
Total Variance Explained	**99.99%**	**99.86%**	**99.76%**	**99.81%**

3.15 The derived PC's or factors are standardised (i.e., have zero mean and unit standard deviation) and are subsequently used in a regression model. The purpose of this model is to calculate the 'beta' sensitivity of each yield to maturity, expressed as annual percentage rate changes, to the above four factors[33].

3.16 From this analysis, we obtain stressed rates at the 99.5% level as follows (with the QIS4 stresses also shown, for comparison):

[33] For a maturity, m, we regress the derived annual percentage rate changes on the four PCs to derive the 'beta' sensitivity of each rate to each PC. The combined sum returns the stress factor for maturity m.

	EUR GOV		EUR SWAP		GBP GOV		GBP SWAP		QIS 4	
Maturity in Years	**Up**	**Dn**	**Up**	**Dn**	**Up**	**Dn**	**GBP Up**	**GBP Dn**	**Up**	**Dn**
0.25			78%	-77%			47%	-74%		
0.5			73%	-74%			52%	-71%		
1	86%	-79%	79%	-69%	55%	-87%	59%	-66%	94%	-51%
2	85%	-65%	83%	-59%	53%	-73%	58%	-63%	77%	-47%
3	78%	-54%	75%	-55%	50%	-63%	54%	-54%	69%	-44%
4	70%	-49%	68%	-50%	49%	-56%	50%	-47%	62%	-42%
5	64%	-45%	61%	-46%	49%	-50%	46%	-43%	56%	-40%
6	60%	-41%	57%	-43%	47%	-46%	43%	-39%	52%	-38%
7	58%	-38%	55%	-39%	44%	-42%	39%	-36%	49%	-37%
8	55%	-35%	53%	-37%	41%	-39%	37%	-33%	46%	-35%
9	53%	-33%	52%	-34%	37%	-36%	34%	-31%	44%	-34%
10	51%	-31%	50%	-32%	34%	-33%	32%	-29%	42%	-34%
11	49%	-29%			30%	-31%			42%	-34%
12	47%	-28%			26%	-31%			42%	-34%
13	45%	-27%			23%	-31%			42%	-34%
14	43%	-27%			23%	-31%			42%	-34%
15	42%	-27%	44%	-28%	22%	-31%	24%	-23%	42%	-34%
16					21%	-32%			41%	-33%
17					21%	-32%			40%	-33%
18					20%	-32%			39%	-32%
19					20%	-32%			38%	-31%
20			40%	-33%	20%	-33%	19%	-21%	37%	-31%
21					19%	-33%				
22					19%	-33%				
23					19%	-34%				
24					21%	-43%				
25					23%	-49%				
30			36%	-41%			15%	-22%		

3.17 It should be noted that the results shown above are obtained without recourse to any extrapolation methods. The data input to the PCA process consisted only of market observables; there was no artificial extension of incomplete yield curves where no long-term rates existed.

3.18 The data sets we have chosen for this analysis represent the deepest and most liquid markets for interest rate-sensitive instruments in the European area. Moreover, use of all four data sets together introduces a control against the uncertainties that could result from using just one data set in isolation. For example, using the longer data period available for the GBP government data introduces additional balance and a greater depth of information to the results by covering a wider range of economic conditions and points in the economic cycle than the other three data sets. There are other technical idiosyncrasies in each of the other data sets generating uncertainties that can be balanced out by combining the results from all four data sets appropriately.

3.19 We have therefore arrived at a single generalised stress for each of the up/down directions as follows:

- Linear interpolation has been used to fill in areas missing from the yield curve (for example between 10 and 15 year terms for the EUR swap results). Note, however, that no extrapolation has been performed.
- For each of up/down directions, the mean of the results from the four data sets has been taken.

- The resulting stress structures have been smoothed in order to avoid inconsistencies and to attempt to mitigate potential unintended consequences for the corresponding shocked yield and forward curves. The smoothing has focused on terms less than one year and on terms greater than 15 years, where the average is constructed from fewer data points and arguably the market data is subject to greater technical biases and inconsistencies.

3.20 This leads to the following term structure stresses, shown with the corresponding stresses from QIS4 for ease of comparison:

	QIS 4		Proposed stresses	
Maturity in Years	**Up**	**Dn**	**Up**	**Dn**
0.25			70%	-75%
0.5			70%	-75%
1	94%	-51%	70%	-75%
2	77%	-47%	70%	-65%
3	69%	-44%	64%	-56%
4	62%	-42%	59%	-50%
5	56%	-40%	55%	-46%
6	52%	-38%	52%	-42%
7	49%	-37%	49%	-39%
8	46%	-35%	47%	-36%
9	44%	-34%	44%	-33%
10	42%	-34%	42%	-31%
11	42%	-34%	39%	-30%
12	42%	-34%	37%	-29%
13	42%	-34%	35%	-28%
14	42%	-34%	34%	-28%
15	42%	-34%	33%	-27%
16	41%	-33%	31%	-28%
17	40%	-33%	30%	-28%
18	39%	-32%	29%	-28%
19	38%	-31%	27%	-29%
20	37%	-31%	26%	-29%
21			26%	-29%
22			26%	-30%
23			26%	-30%
24			26%	-30%
25			26%	-30%
30			25%	-30%

3.21 The analysis is based on time series of euro and pound interest rates and therefore reflects the European economic experience of the last 30 years. This experience may not in all cases be representative of future economic conditions. A comparison with other developed economies (e.g. the United States or Japan) shows that financial parameters may develop differently from what was observed in the past in Europe. In particular, there may be deflationary scenarios like in Japan in the 1990s.

3.22 The multiplicative stress approach where the current interest rate is multiplied with a fixed stress factor to determine the stressed rate leads to lower absolute stresses in times of low interest rates. This may underestimate in particular the deflation risk. In order to capture deflation risk in a better way, the floor to the absolute decrease of interest rates in the downward scenario could be introduced. As a pragmatic proposal, the absolute decrease could have a lower bound of one percentage point. If the interest rate for maturity 10 years is 2%, the shocked rate would not be (1 - 34%)·2% = 1.32%, which is likely to underestimate the 200 year event, but 2% - 1% = 1%, which can be considered to be a more reasonable change.

3.23 The downward stress can be defined by the following formula:

$r' = \max(\min((1 + \text{stress factor})\cdot r;\ r\text{-}1\%);0)$,

where r is the unstressed and r' the stressed rate.

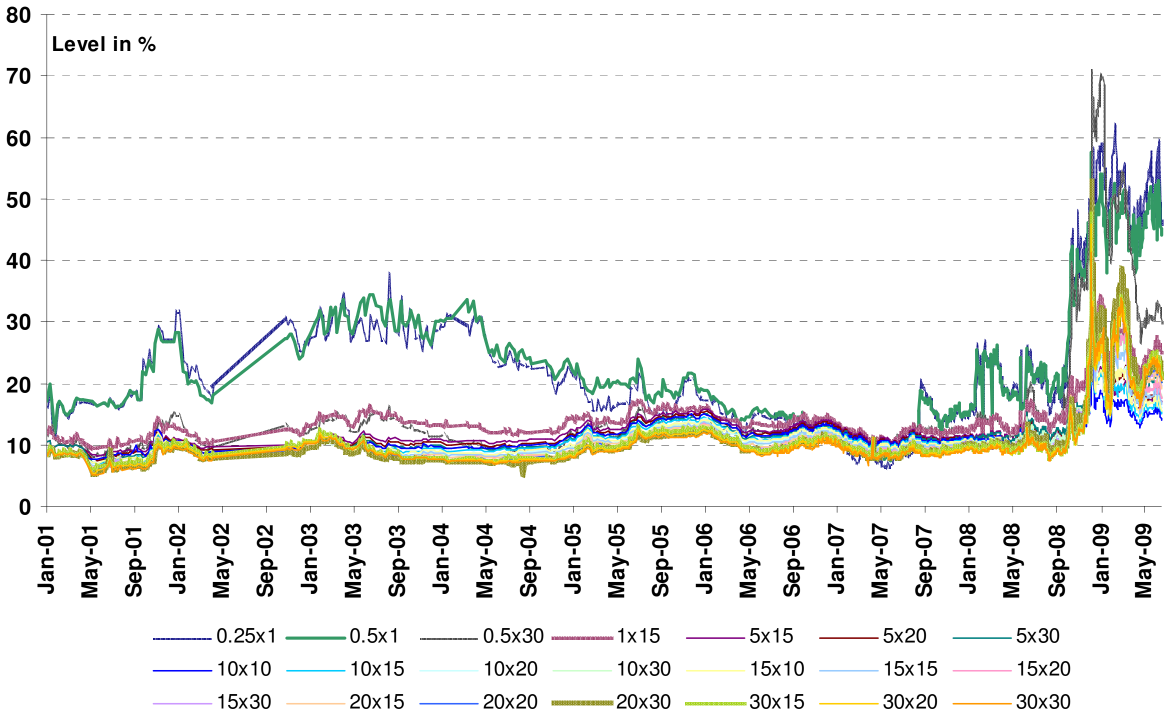
Shocks to interest rate volatilities

3.24 The volatility of forward rates plays a vital role in the determination of the slope and curvature of the underlying yield curve. This particular volatility can be implied from market prices for swaptions, which render the right to the holders to enter into a swap agreement for a specified term at the maturity of the option. In particular, any increase in the implied volatility surface may have subsequent "spill-over" effects onto the shape and curvature of the underlying term structure.

3.25 As a result, interest rate volatility has material impact on the assets and/or liabilities of (re)insurance undertakings that have embedded guarantees in their business. This is likely to affect in particular traditional participating business, certain types of annuity business and other investment contracts.

3.26 Insurers may be sensitive to a reduction in volatility via derivatives they may hold in their asset portfolios for interest rate immunisation purposes. Additionally, and as observed during the recent financial crisis, insurers' assets and liabilities are sensitive to increases in volatility wherever there are embedded guarantees. Stakeholder feedback to both CP70 and QIS4 has generally supported the relevance of interest rate volatility as a significant part of the risk profile to be included in the standard formula.

3.27 We use a set of EUR and GBP implied volatility data covering a daily period of 11 years to deduce the stress factors at the 99.5% level. This data sample starts in April 1998 and ends in May 2009 and spans across 8 option maturities and 8 swap terms. The data is sourced from Bloomberg. The figure below presents historical time series of selected implied volatility series (N-year option x T-year swap, as explained in the next paragraph below).



3.28 Using the above data, we calculate the distribution of the annual percentage changes in the implied volatility. We note that there are two dimensions to the implied volatility data. One dimension is the maturity of the option and the other denotes the term of the swap. For example, a 30 x 30 swaption contract denotes that the maturity of the option is 30 years, whilst the term of swap is 30 years starting from the maturity of option. In the figure above, we use 21 of these contracts, while in our database we have 64 series.

3.29 For the standard formula calibration we have used only at-the-money swaption prices. However, in practice, the optionality in insurers' asset portfolios and in embedded guarantees will exhibit a spectrum of moneyness at any particular point in time. Insurers whose legacy portfolios and new business embeds high guarantees could experience capital shortfalls when implied volatility is shocked upwards.

3.30 The altered implied volatility surfaces are derived by multiplying the current implied volatility term structure by upward and downward stress factors. An analysis of downward volatility stresses leads to the following multiplicative stress factors:

	Swap Term							
Option Maturity	1	2	3	5	10	15	20	30
0.25	-44%	-28%	-25%	-21%	-11%	-8%	-10%	-10%
0.5	-36%	-26%	-23%	-18%	-14%	-13%	-13%	-13%
1	-27%	-23%	-20%	-16%	-20%	-21%	-20%	-21%
5	-23%	-24%	-23%	-22%	-21%	-21%	-20%	-19%
10	-24%	-24%	-23%	-22%	-20%	-20%	-19%	-18%
15	-24%	-23%	-22%	-22%	-21%	-19%	-18%	-17%
20	-23%	-21%	-22%	-20%	-21%	-20%	-18%	-19%
30	-24%	-21%	-22%	-20%	-22%	-20%	-20%	-21%

3.31 In addition, an analysis of the upward volatility stress leads to the following multiplicative stress factors:

	Swap Term							
Option Maturity	1	2	3	5	10	15	20	30
0.25	309%	288%	236%	204%	206%	260%	330%	464%
0.5	253%	241%	198%	180%	173%	219%	263%	378%
1	176%	151%	137%	130%	142%	176%	214%	295%
5	65%	66%	68%	72%	88%	114%	147%	200%
10	55%	58%	60%	70%	95%	155%	171%	222%
15	85%	88%	92%	108%	157%	193%	227%	264%
20	172%	182%	194%	215%	228%	254%	280%	288%
30	245%	250%	243%	229%	253%	256%	251%	251%

3.32 For example in the case of the N x T -year implied volatility the rate in 12 months time in a downward stress scenario would correspond to:

$$R_{12}(N\ x\ T) = R_0(N\ x\ T)x(1 + s_{dn})$$

where N denotes the option maturity and T corresponds to the swap maturity of the specific implied volatility rate. For example, the stressed implied volatility corresponding to an option term of 10 years and to a swap term of 10 years, that is the 10 x 10 contract, is stressed by -20% in a downward scenario, whilst the same contract experiences an upward shock of 95% in an upward scenario.

3.33 To avoid excessive complexity, this matrix can be collapsed to consider only one contract, which may approximate better the characteristics of the guarantees embedded in the (re)insurers' liabilities. This is the most important dimension when considering the impact of volatility on (re)insurers' embedded guarantees. Reduction to one dimension can be achieved by considering the typical duration of (re)insurers' liabilities; the proposal below assumes a duration corresponding to an option term of 10 years and of a swap term of, say, 10 years.

3.34 As a natural extension of the two-sided stress proposed above, we consider using the 10x10 contract as a representative on average of the duration of the guaranteed liabilities embedded in (re)insurer's balance sheets. On an annual implied volatility basis, therefore, the above analysis would therefore lead to the following (multiplicative) volatility stresses:

Up stress (relative)	95%
Down stress (relative)	-20%

3.35 We have noted stakeholder comments that there is evidence to argue that mean reversion exists in interest rate volatility. Based on this premise, and bearing in mind potential procyclicality concerns as raised by stakeholders, we propose the interest rate volatility stress could instead be expressed as an additive stress.

3.36 Use of a multiplicative formulation carries the risk that in times of high volatility the stressed volatility levels could be excessively high and hence procyclical effects could result. However, we note that use of an additive stress formulation could equally carry risks: in this case the stressed volatility could be overly high (from a relative viewpoint) when volatility levels are low.

3.37 Taking data for 10 x 10 swaption volatility over the period from April 1998 to June 2009 leads to an average implied volatility of 13%. This would lead to an upward stressed volatility of 25% and a downward stressed volatility of 10%.

3.38 Hence a stress test defined using additive stress factors can be proposed as follows:

Up stress (additive)	12%
Down stress (additive)	-3%

3.39 As can be seen from the analysis above, the stresses relevant for different points on the volatility surface (and indeed, as mentioned above, for different moneyness) differ in magnitude. However, for the purposes of the standard formula we make the simplifying assumption that the stresses above apply to all interest rate volatilities.

3.40 The consultation text of CP70 (final advice: CEIOPS-DOC-66/10) included a question to stakeholders as to the relevance of the downward volatility stress. Although the response was not unanimous, many stakeholders argued that the downward stress is relevant and should be retained, for example to deal with cases where risks re over-hedged.

3.41 The empirical charge for interest rate risk is derived from the type of shock that gives rise to the highest capital charge including the risk absorbing effect of profit sharing. The capital charge Mkt_{int} will then be determined as the maximum of the capital charges $Mkt_{int}^{Up}{}_{ivol}^{Up}$, $Mkt_{int}^{Up}{}_{ivol}^{Dn}$, $Mkt_{int}^{Dn}{}_{ivol}^{Up}$ and $Mkt_{int}^{Dn}{}_{ivol}^{Dn}$, subject to a minimum of zero. This can be expressed as

$$Mkt_{int} = \text{Max}\left(Mkt_{int}^{Up}{}_{ivol}^{Up}, Mkt_{int}^{Up}{}_{ivol}^{Dn}, Mkt_{int}^{Dn}{}_{ivol}^{Up}, Mkt_{int}^{Dn}{}_{ivol}^{Dn}, 0 \right)$$

3.42 When calculating the four capital charges, an allowance for diversification should be made by first calculating the charge based on the term structure stress, then calculating the charge based on the volatility stress, and combining the outputs using a correlation of 0% (in the case of an upward and a downward volatility stress).

3.43 As an example, to calculate the capital charge $Mkt_{int}^{Up}{}_{ivol}^{Up}$ applying for an interest rate of term 10 years, and given current 10-year rate of r% and volatility of v%, an undertaking would need to calculate the change in net asset value on moving to stressed interest rate of (1+51%)*r% and on moving to stressed volatility of (v+12)%, and then combine these with a correlation of 0%.

3.44 The correlation of 0% is proposed on the basis that, as stakeholders have pointed out, in practice the term structure and corresponding volatility are not perfectly correlated but changes in term structure do tend to correspond with increased volatility. The correlation is postulated on the basis of the 10x10 swaption used as the representative point for the calibration of volatility. However, the correlation may differ if other swap or option terms are chosen. In particular, a shorter term could induce a higher correlation.

3.45 This method of aggregation does not, however, allow for non-linearity in cases where (for example) a change in interest rates combined with a simultaneous increase in volatility could have greater impact on the value of an interest rate option or guarantee than the (diversified) sum of the two separate impacts.

3.1.2 Equity risk[34]

3.46 Since QIS4, the structure of the equity risk sub-module has evolved significantly. Following the Level 1 text, there are two possible ways to calculate the equity risk capital charge: as well as the standard approach there is also the possibility (where permitted, and restricted to certain types of liabilities) to use the "duration dampener" approach of Article 304.

3.47 For the "standard" approach, a symmetric adjustment mechanism applies, as set out in Article 106[35]. The Commission has clarified that this mechanism is required to operate such that the equity shock lies within a band of 10% either side of the underlying standard equity stress.

3.48 The calibration of the "standard" approach as set out below therefore looks firstly at the underlying standard equity stress, which is calibrated to the 99.5% VaR level for both global and other equities. The symmetric adjustment mechanism then overlays the standard charge to arrive at the full standard approach.

3.49 In calibrating the symmetric adjustment mechanism, CEIOPS has considered the following objectives:

- avoid that insurance and reinsurance undertakings are unduly forced to raise additional capital or sell their investments as a result of unsustained adverse movements in financial markets;
- discourage/avoid fire sales which would further negatively impact the equity prices – i.e. prevent pro-cyclical effect of solvency capital requirements which would in times of stress lead to an increase of

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[34] This section follows CEIOPS-DOC-65/10

[35] The Commission has clarified that the symmetric adjustment mechanism does not apply to the equity risk sub-module as calculated in accordance with Article 305b.

capital requirements and hence a potential de-stabilising effect on the economy.

These objectives are discussed in more detail below.

3.50 An additional development to the equity risk sub-module as compared with the approach tested in QIS4 is the inclusion of an equity volatility stress. Some stakeholders considered this to be an important component missing from the SCR standard formula approach – see for example the CRO Forum's paper on Calibration Principles dated May 2009. The calibration of the equity volatility stress is set out towards the end of this paper.

Standard equity capital charge – "global" equities

3.51 The category of "global" equities covers equities listed in EEA or OECD countries. This is the same as the definition used in QIS4.

3.52 Our starting point for the calibration of the "global equities" stress is to consider the standard (underlying) equity stress scenario. In order to calibrate the standard equity stress we have carried out analysis using data from the MSCI World Developed Price Equity Index. This index consists of equities listed in 23 developed countries located across Americas, Europe and Pacific Basin[36]. The use of this index coincides with the QIS4 definition of "global" equities as those listed in EEA and OECD countries.

3.53 In carrying out our analysis we have been able to build on the QIS4 calibration by including data from the stressed market conditions over the last 18 months.

3.54 Simplified facts about the distribution of equity and other financial returns agree that at longer horizons returns appear to be normally distributed. The exact distribution of financial returns remains an open question; however, at weekly, daily and higher frequencies the equity return distribution displays definite non-normal qualities.

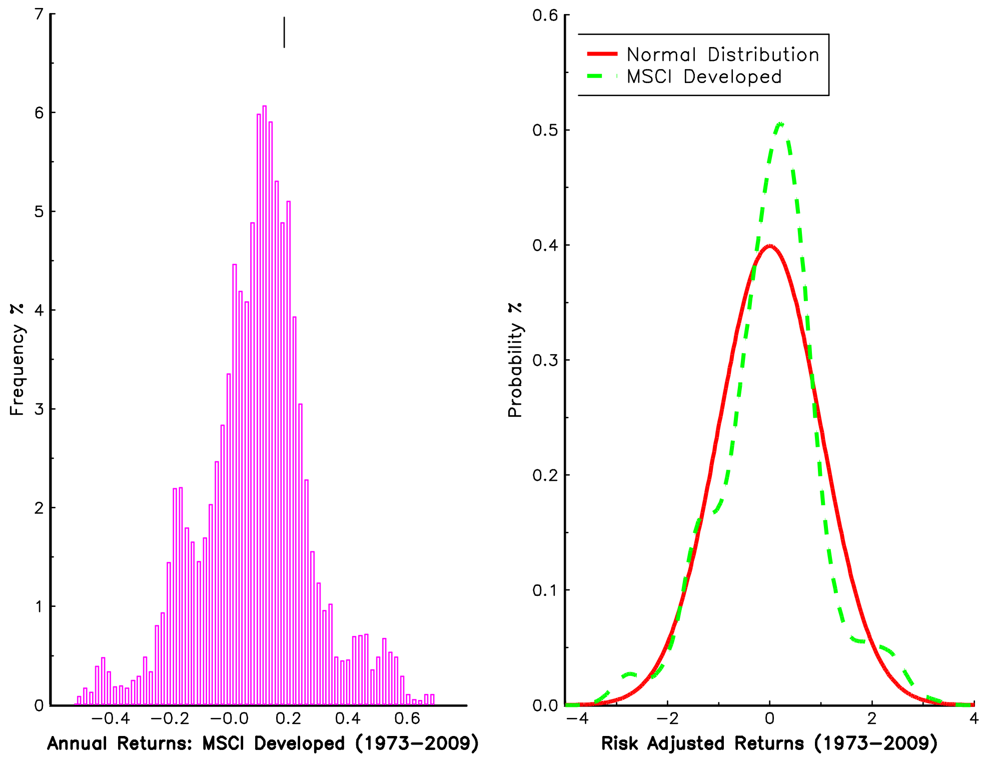
3.55 One such characteristic that arises across financial assets, from foreign exchange returns and property to commodities is "fat tails". Fat tails are defined as tails of the distribution that have a higher density than that predicted under the assumption of normality.

3.56 The graph below demonstrates these distinct differences for annual returns. The graph on the left depicts the frequency distribution of annual holding period returns derived from the MSCI World Developed index. The sample spans a daily period of 36 years starting from the conception of the index in 1973 and ends in 2009. The x-axis graphs the annual holding period returns ranging from a minimum of -51% to a maximum of 69.3%, while the y-axis graphs the probability of occurrence. The graph on the right depicts the

[36] Further information on the MSCI Barra International Equity Indices can be found at http://www.mscibarra.com/products/indices/equity/index.jsp

estimated density, termed the 'empirical density', with the theoretical normal density function. There is a balance to be struck between an analysis based on the richest possible set of relevant data and the possibility of distortion resulting from autocorrelation. In this case, we have chosen to take a rolling one-year window in order to make use of the greatest possible quantity of relevant data .

3.57 We now have clear evidence of the excess leptokurtosis (i.e., "peakness" of the green line) and skewness underpinning our graph. Under the assumption of normality, skewness is set to zero, and kurtosis is equal to 3.



3.58 In addition to the MSCI World Developed price index, we investigate the statistical features of its constituent indices. These are the MSCI Americas, the MSCI Europe and MSCI Pacific Developed Price equity indices. The table below shows selected percentiles and statistical features derived from the corresponding annual returns using daily data:

Percentiles	MSCI World	MSCI Americas	MSCI Europe	MSCI Pacific
100.00%	65.58%	50.44%	62.53%	143.86%
99.95%	63.92%	49.98%	59.76%	141.44%
99.50%	56.96%	44.15%	50.39%	129.38%
99.00%	52.44%	40.06%	45.77%	124.77%
97.50%	46.65%	36.73%	37.61%	114.35%
50.00%	9.47%	10.10%	11.45%	3.81%
2.50%	-32.93%	-35.88%	-46.06%	-33.78%
1.00%	-42.05%	-40.25%	-50.92%	-37.59%
0.50%	**-44.25%**	**-42.42%**	**-52.89%**	**-38.85%**
0.05%	-50.93%	-49.29%	-57.69%	-41.93%
0.00%	-51.94%	-49.93%	-57.95%	-44.03%
Mean	7.43%	8.03%	7.08%	12.03%
St. Deviation	18.16%	17.75%	19.48%	36.21%
Kurtosis	72.01%	22.02%	81.29%	122.08%
Skewness	-17.95%	-66.91%	-81.91%	116.44%
Normal VAR	**39.34%**	**37.69%**	**43.09%**	**81.24%**
Empirical VAR	**44.25%**	**42.42%**	**52.89%**	**38.85%**

3.59 Given the non-normality of equity returns demonstrated in the data above, it can be concluded that the VaR figure of 39%, reflecting the MSCI World equity index, obtained by making the assumption of normality understates the equity stress due to incorrect assumptions about the tails of the distribution.

3.60 We replicate our analysis using the corresponding MSCI total return indices. These are recorded on a monthly as well as quarterly basis commencing at the beginning of 1970. A daily record of these indices is also kept commencing in 2002. Below, we compare selected statistical features and percentiles of annual holding returns computed from the total return and price indices using monthly data:

	MSCI World TR	MSCI World PR
100.00%	65.82%	62.62%
99.95%	63.93%	61.39%
99.50%	53.94%	55.94%
0.50%	**-42.12%**	**-43.70%**
0.05%	-46.16%	-48.83%
0.00%	-46.21%	-49.88%
Mean	**10.04%**	**7.52%**
St deviation	17.31%	18.11%
Kurtosis	94.54%	76.49%
Skewness	-30.62%	-21.71%
Normal VaR	**34.53%**	**39.14%**
Empirical VaR	**42.12%**	**43.70%**

3.61 The obvious difference between the two indices is the reinvested dividend yields, which is equal to 2.52% at the mean level[37] but less than 1.6% at the tail.

3.62 We use further the daily price index series to imply the worst 10 annual and daily holding period returns. The daily returns are set out in the table below. These results emphasise the importance of setting capital requirements of (re)insurance undertakings by making inferences using the tail of the distribution.

	Daily return	**Date**
1	-9.33%	20/10/1987
2	-7.91%	19/10/1987
3	-6.43%	29/09/2008
4	-6.41%	15/10/2008
5	-6.19%	01/12/2008
6	-6.07%	22/10/2008
7	-5.90%	06/10/2008
8	-5.76%	06/11/2008
9	-5.74%	26/10/1987
10	-5.74%	20/11/2008

3.63 Extreme value theory provides further insight into the behaviour of tails of a distribution. Critical questions relating to the probability of a market crash or boom require an understanding of the statistical behaviour expected in the tails. Below, we have estimated the generalised extreme value (GEV) distribution using maximum likelihood based on the daily returns recovered from the MSCI data. Using the estimated parameters, we recovered the tail VAR, which produces a -11.5% result for the one-day stress in the 1 in 200 event or the 99.5th percentile.

Confidence interval	**VaR-GEV**
66.67%	-2.65%
80.00%	-3.28%
85.71%	-3.73%
90.00%	-4.25%
91.67%	-4.54%
93.33%	-4.91%
95.00%	-5.42%
97.50%	-6.84%
99.00%	-9.23%
99.50%	-11.50%

[37] The MSCI total return methodology reinvests dividends in the indices on the day the security is quoted ex-dividend. The above total return series is quoted gross of tax. The amount reinvested is the entire dividend distributed to individuals resident in the country of the company, but does not include tax credits.

3.64 The results of the extreme value theory analysis show that the 99.5% VaR level for daily returns is more extreme than the worst daily return over the period tabulated above.

3.65 Turning to consider annual returns, over the last year, well-diversified equity portfolios (i.e., mimicking the MSCI) have halved in value: as can be seen below, the most severe observation was an equity fall of 52% over the year to 5 March 2009:

	Annual return	Date
1	-51.55%	03/05/2009
2	-51.49%	09/03/2009
3	-51.46%	06/03/2009
4	-51.31%	03/03/2009
5	-51.19%	02/03/2009
6	-50.73%	27/10/2008
7	-50.24%	20/11/2008
8	-49.86%	04/03/2009
9	-49.71%	27/02/2009
10	-49.36%	26/02/2009

3.66 Taken together, the above analysis leads to a stress of 45% for global equities. The majority of CEIOPS' members supports this stress of 45 % for global equities. An alternative equity stress, which consists of applying a 39 % stress to global equities, is being supported by a minority of CEIOPS' Members. One Member State supports a 32 % stress.

3.67 The results above compare with a stress of 32% per the QIS4 Technical Specification.

3.68 In case of a fall of equity returns as defined in the equity stress scenario, the loss of basic own funds of the undertaking may exceed the loss directly connected to the equity portfolio (i.e. loss in market value minus net dividends), because the portfolio may cover discounted liabilities. The run-off of the discounted best estimate over the one year time horizon produces a technical loss in the amount of the discount rate. The discounting of technical provisions is based on the expectation that the undertaking will earn (at least) the discount rate. If the assets have a negative performance, the discount rate usually causes an additional technical loss. This loss is not allowed for in the equity stress for reasons of practicability.

Symmetric adjustment mechanism

3.69 In calibrating the symmetric adjustment mechanism, CEIOPS has considered the following objectives:

- allow sufficient time for undertakings to rebalance their profile in a stressed scenario;
- avoid unintended pro-cyclical effects (in particular a rise in the equity charge in the middle of a crisis);
- ensure that the equity charge remains sufficiently risk sensitive;

- prevent fire sales of assets;
- avoid undertakings having to adjust their risk profile frequently solely as a result of movements in the equity capital charge;
- avoid any incentive to invest in one or the other asset class;
- allow the adjustment to be set independently of the standard equity stress.

3.70 CEIOPS' calibration of the symmetric adjustment mechanism is based on the following formulation:

adjusted capital stress = standard capital stress + adjustment x beta,

where the adjustment term is $\frac{I_t - \frac{1}{n}\sum_{s=t-1}^{t-n} I_s}{\frac{1}{n}\sum_{s=t-1}^{t-n} I_s}$ and the adjusted capital stress is subject to a band of ±10% either side of the standard capital stress.

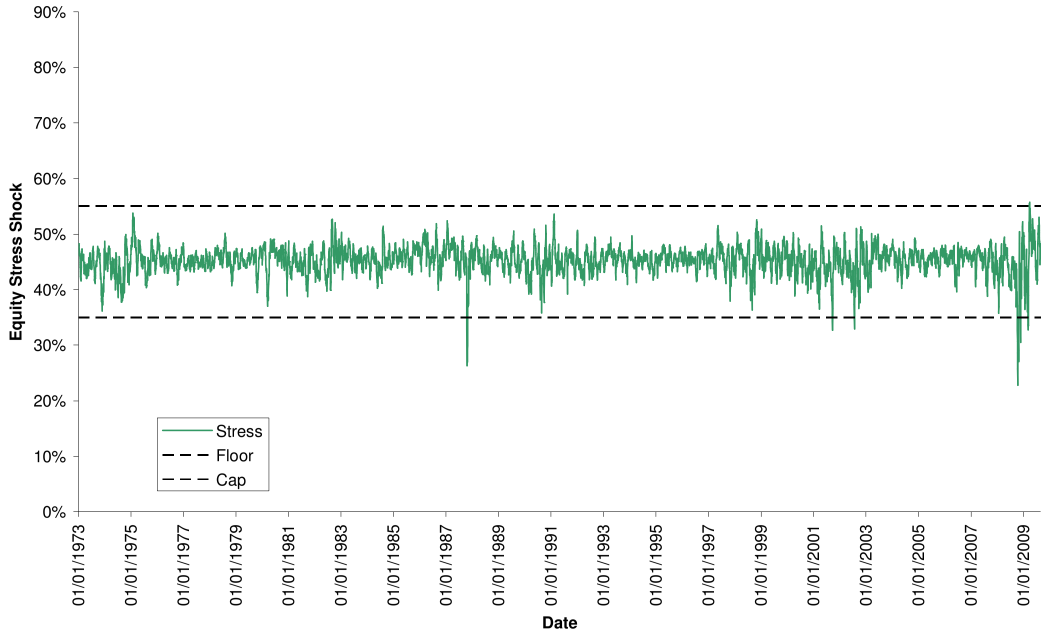
In the adjustment term, I_t is the value of the MSCI Developed index at time t.

The beta is calculated from a regression of the index level on the weighted average index level.

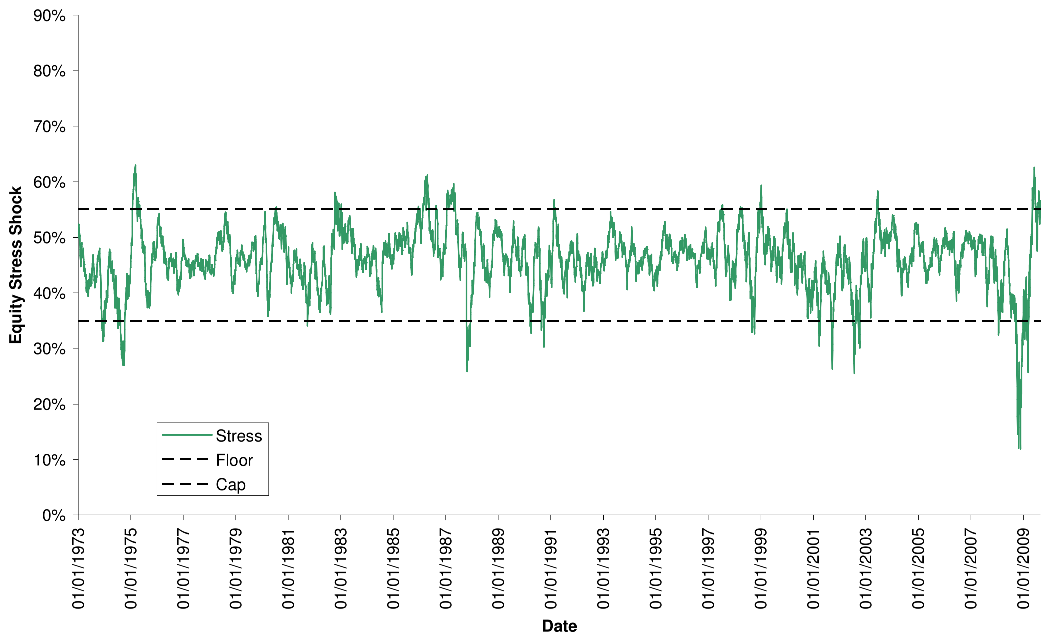
3.71 The formulation above is based on equal weightings for each of the days within the reference period. It would be possible to construct instead a symmetric adjustment mechanism that gives different weighting to different points within the reference period. For example, one possibility could be to apply exponentially decaying weights to data points further back in time. However, this would add a degree of complexity to the approach that is arguably too great for a standard formula methodology.

3.72 CEIOPS has tested four possible reference periods: 22 trading days (1 month), 90 trading days (4 months), 130 trading days (half a year) and 260 trading days (1 year). The results are shown in the charts below. In these charts, the vertical axis represents the equity stress (with underlying standard stress of 45%, although as already explained this starting point is irrelevant). The dashed lines show the ±10% constraints on the adjusted equity stress.

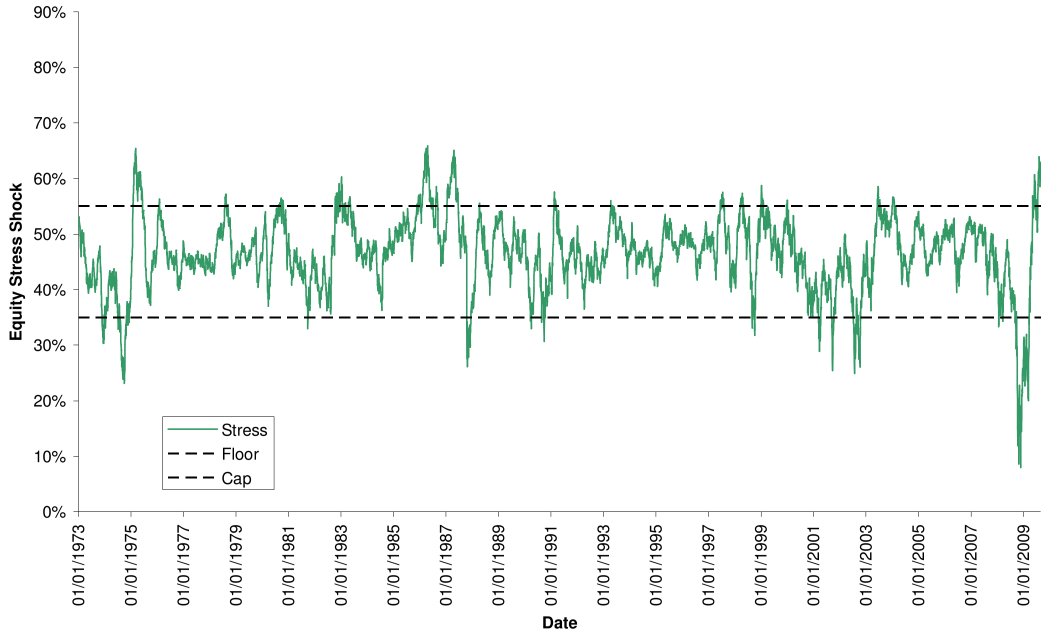
MSCI Symmetric Dampener using 22 day Moving Average



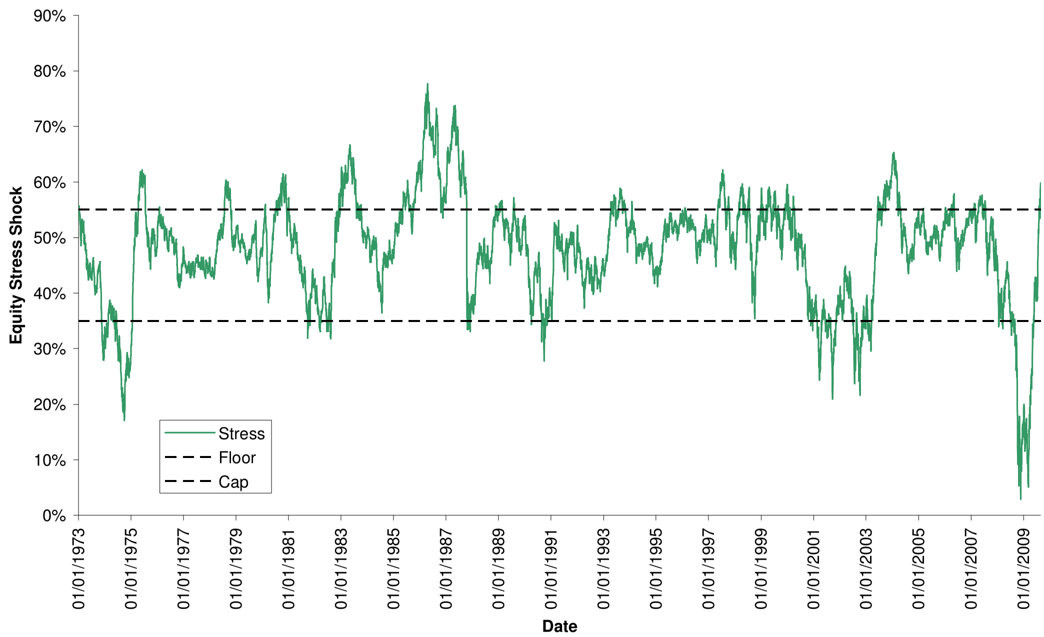
MSCI Symmetric Dampener using 90 day Moving Average



MSCI Symmetric Dampener using 130 day Moving Average



MSCI Symmetric Dampener using 260 day Moving Average



3.73 The betas for these examples are as follows:

Averaging period (days)	**Beta**
22	99.63%

90	98.23%
130	97.21%
260	96.06%

3.74 In practice, the betas will depend on the weighted average quantities at the time of calculation. However, the same beta will apply at any point in time for all firms using the standard formula approach. The simplifying assumption that beta = 1 could be made, although as shown in the table above this is not the exact theoretical calibration.

3.75 One proxy for the risk sensitivity of the calibration is to consider the proportion of time for which the equity stress (after having the symmetric adjustment mechanism applied) remains at the limits of the ±10% band. For example, a calibration of the symmetric adjustment mechanism that results in an equity stress that is 10% above the underlying 99.5% VaR level for a prolonged period could be considered not to be sufficiently risk sensitive during that period.

3.76 The table below shows the proportion of observations falling outside the band of ±10%, based on the period from 1973 to 2009:

Averaging period (days)	**Pr{within 10% band}**
22	99.62%
90	92.90%
130	86.44%
260	67.39%

3.77 These results demonstrate that as the reference period increases, the 10% band is hit more frequently. This is because there is a greater probability of finding more extreme equity returns within a longer averaging period. This idea is explored further below.

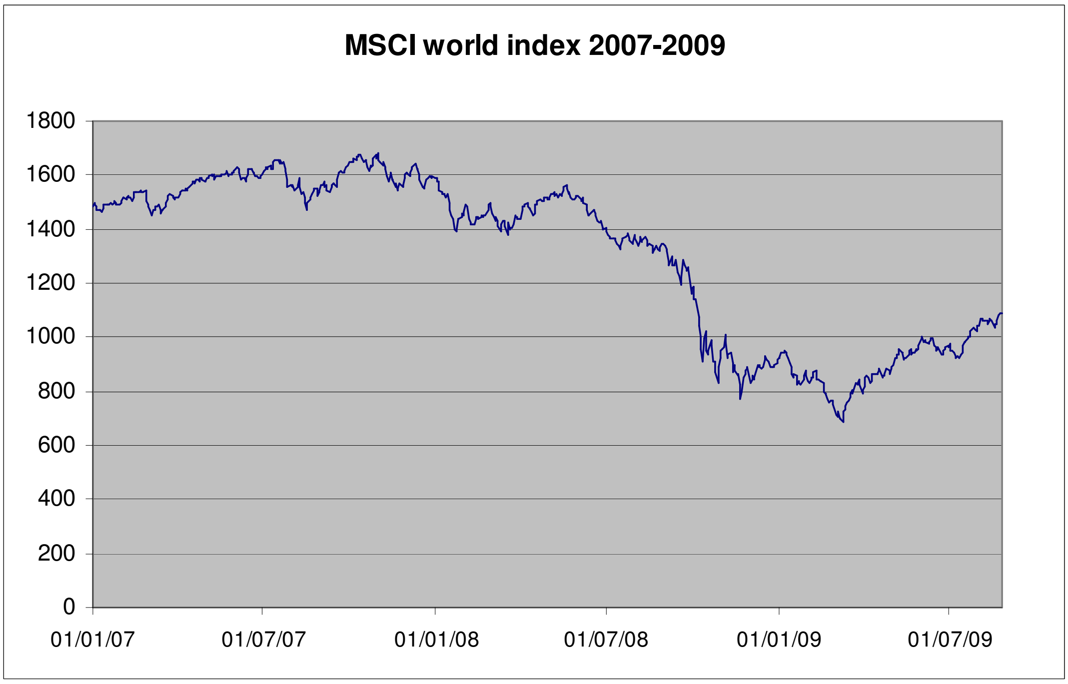
3.78 It is important to note here that due to the construction of the symmetric adjustment mechanism, the choice of averaging period can be made independently of the choice of standard equity stress.

3.79 The analysis discussed above already leads to the conclusion that a shorter reference period leads to greater stability in the adjusted equity charge. Referring back to the objectives set out at the beginning of this subsection, the choice of calibration will need to strike a balance, however, taking into account

- sufficient time for undertakings to rebalance their risk profiles

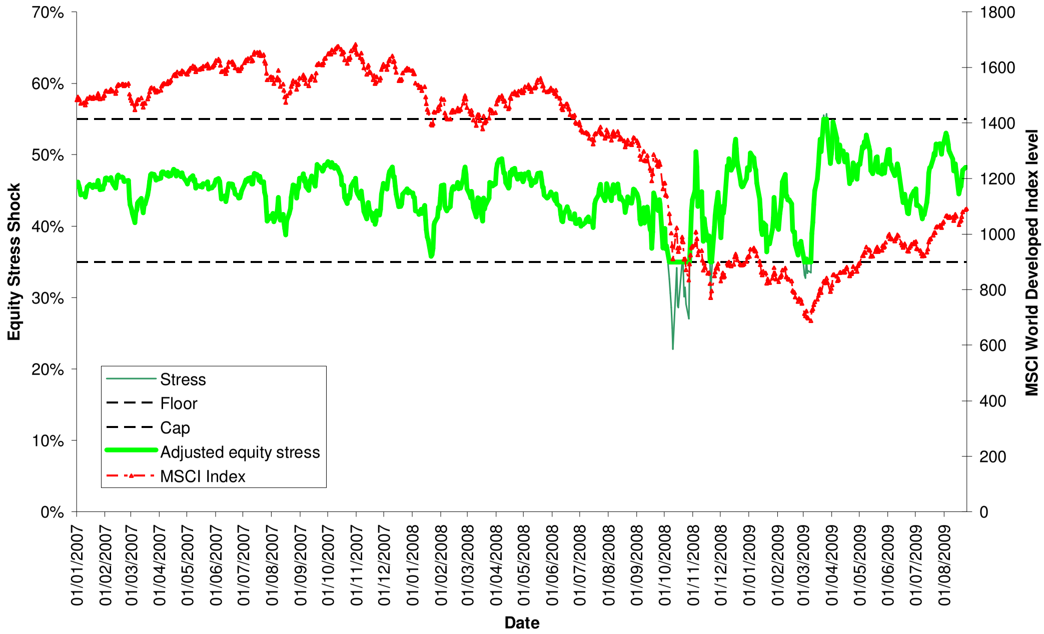
- the need to discourage or avoid fire sales of equities
- retaining adequate risk sensitivity

3.80 CEIOPS also examined how the symmetric adjustment mechanism would have worked during the period of equity market falls during 2007-2009. For reference, the MSCI world index is shown in the chart below:

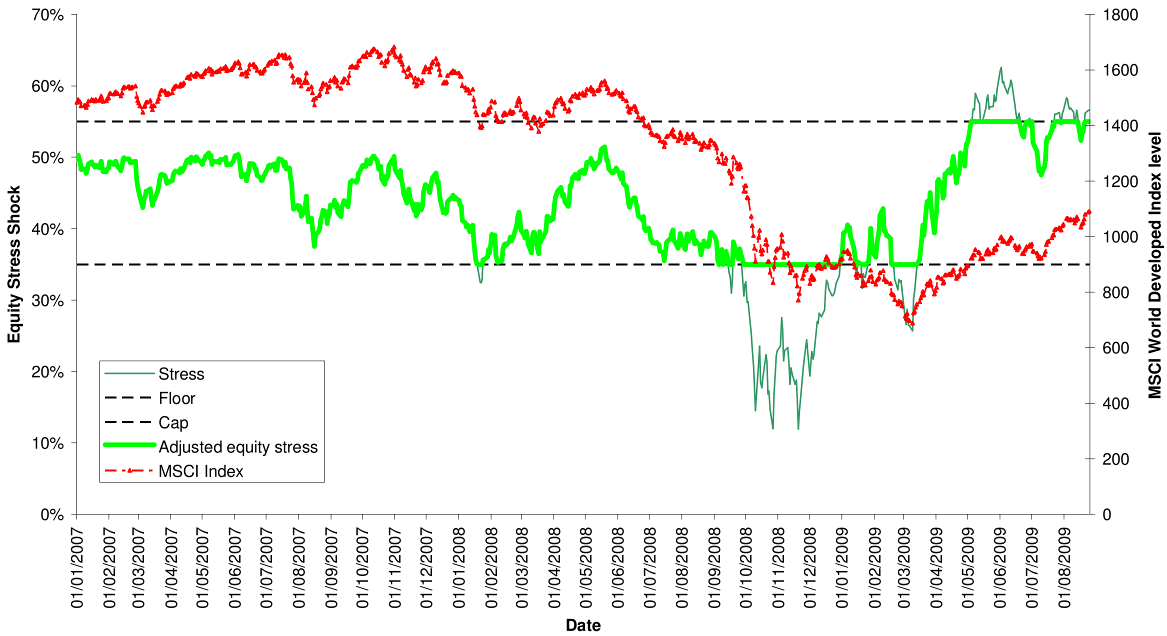


3.81 The results for the equity stress calculated using the four symmetric adjustment mechanisms are plotted below. Here, the vertical axis shows the stress level (unconstrained by the ±10% band) and the horizontal axis covers the same time period as in the chart of the MSCI index in the previous paragraph.

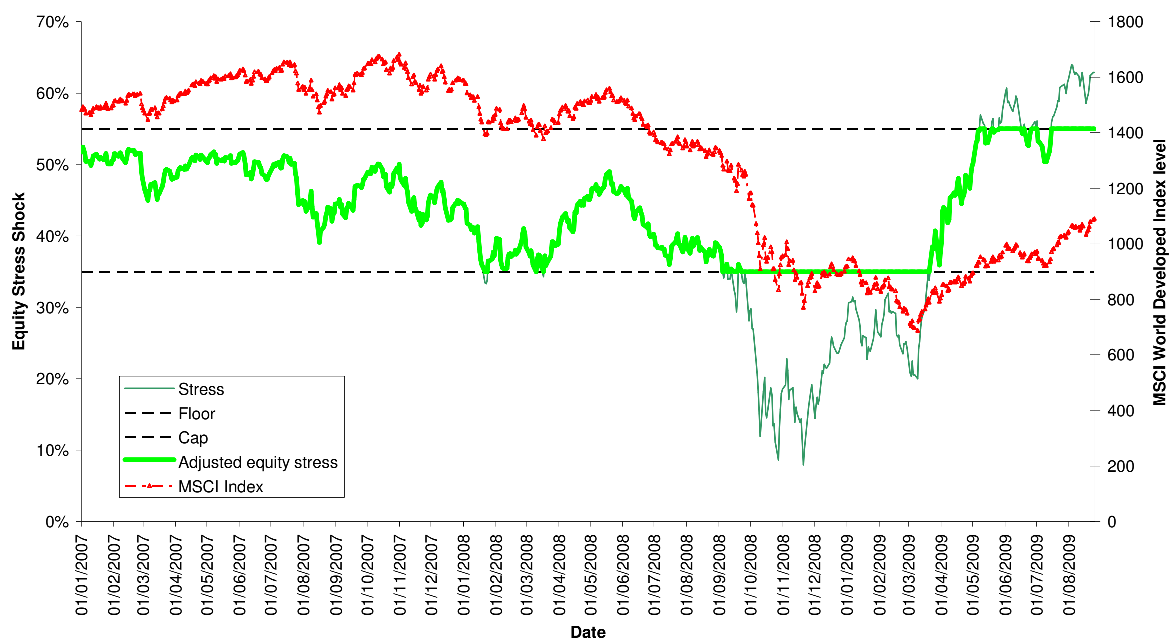
MSCI Symmetric Dampener using 22 day Moving Average



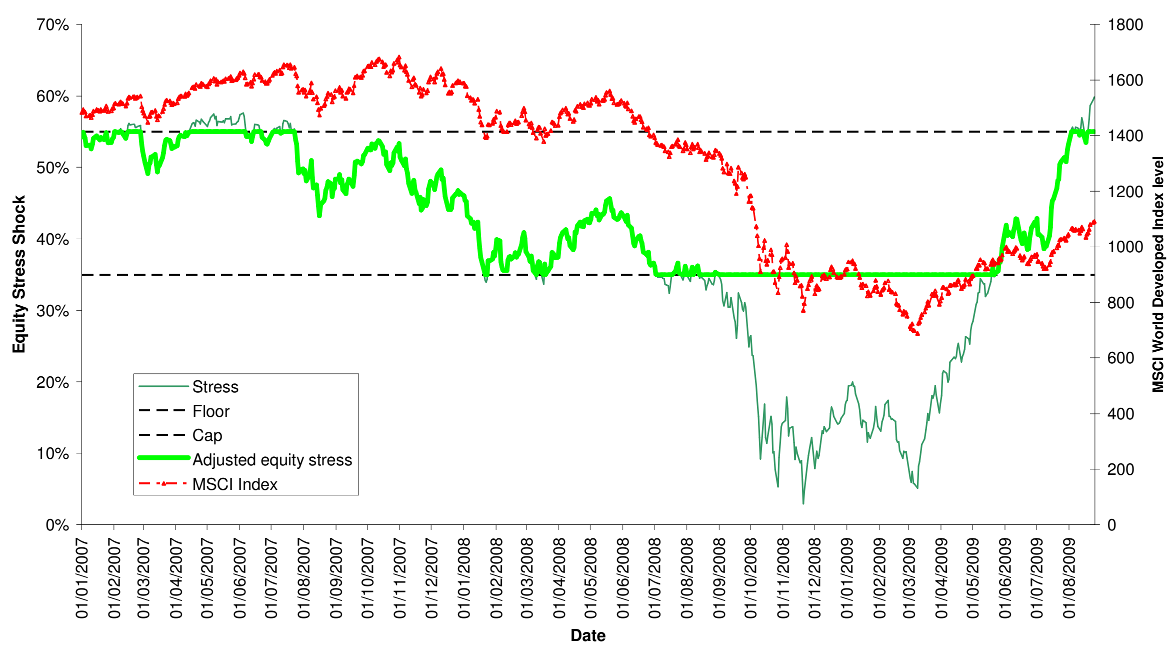
MSCI Symmetric Dampener using 90 day Moving Average



MSCI Symmetric Dampener using 130 day Moving Average



MSCI Symmetric Dampener using 260 day Moving Average



3.82 Averaging periods of 90 days or more tend to capture the "macro" trends, while 22 day or 90 day averaging periods also respond to short-term dips or rises in the index level.

3.83 It is also useful to tabulate the adjustments to the equity capital charge that would have applied at the end of 2008, where a positive number increases the capital charge. As can be seen, a 22 day adjustment period would generate a stress higher than the underlying standard stress, whereas a longer adjustment period would reduce the capital charge (to the minimum possible, for the cases of 130 and 260 day adjustment periods).

	22 days	90 days	130 days	260 days
capped adjustment (within +/-10%)	3%	-10%	-10%	-10%

3.84 The corresponding figures at the end of June 2003, just at the upturn of the equity market after the 2001-3 crash would have been as follows. This case is interesting to examine because it shows how the capital charge behaves as the market begins to lift out of a crash scenario (so may be indicative of a possible year-end 2009 scenario). For all but the 22 day adjustment period, the equity charge would be higher than the underlying standard stress. In the case of the 260 day averaging period, the capital charge would be almost the highest possible, even though undertakings might still be "fragile" as they come out of the equity crash period.

	22 days	90 days	130 days	260 days
capped adjustment (within +/-10%)	-1%	7%	9%	9%

3.85 In this context, CEIOPS notes that where, in a falling market, a longer reference period leads to a lower capital charge, this has potential for moral hazard, in that undertakings may take on inappropriately large equity investments. This would worsen any pro-cyclical effects at low points in the equity cycle.

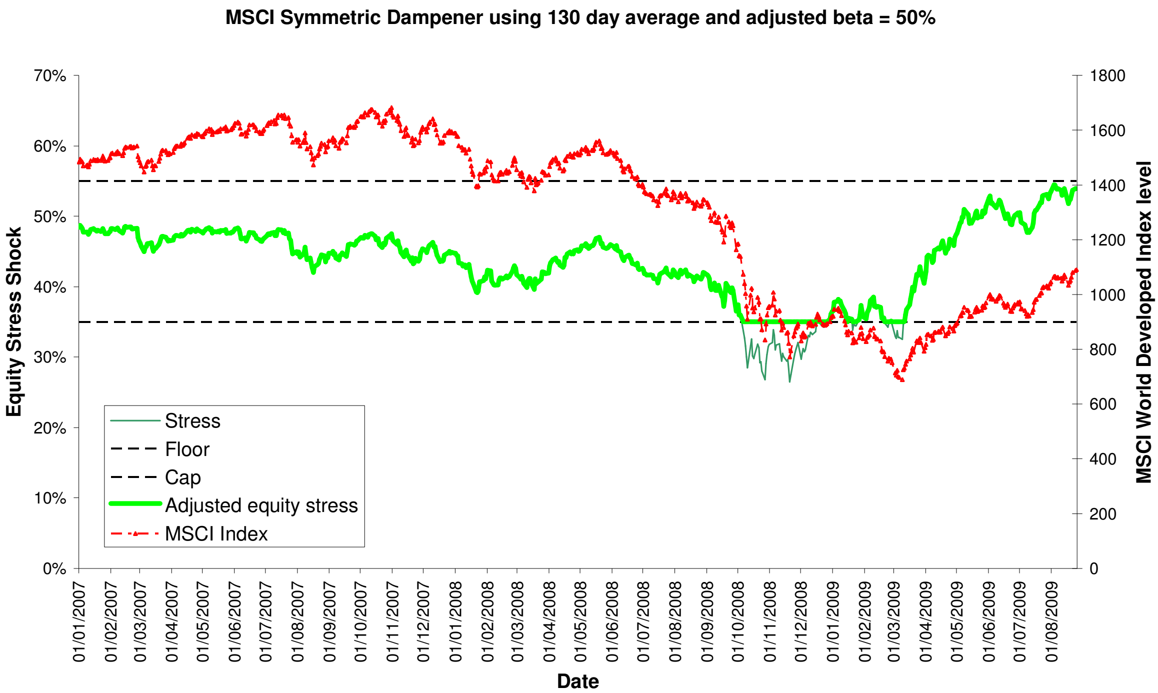
3.86 Further, undertakings may move away from other asset types such as bonds or properties, where there is no counter-cyclical charge, if they know already that the capital charge for equities will provide counter-cyclical relief.

3.87 Finally, it is important to bear in mind the interaction with the ladder of supervisory intervention and processes that would apply while an undertaking recovers its SCR coverage.

3.88 On the basis of the above analysis, an averaging period of one year is proposed.

3.89 It is also possible to vary the beta factor within the calibration of the symmetric adjustment mechanism. A reduction in beta would result in a more stable capital charge. This could be considered advantageous to address the case where markets have begun to rise after a period of depression, as in paragraph 3.84. In such cases it might not be appropriate to apply a disproportionately high adjusted equity charge, as this could result in fire sales and other pro-cyclical consequences. A reduction in beta (applying throughout the cycle) would serve to mitigate this risk.

3.90 The graph below illustrates the application of a beta = 0.5 factor to the 130 day reference period. Compare with the graph on paragraph 3.81.



"Other" equities

3.91 The category "other equities" comprises equities listed in countries other than EEA and OECD countries, non-listed and private equities, hedge funds, commodities and other alternative investments. For collective investment vehicles, line with the requirements set out in CEIOPS-DOC-40/09, a look through test should be used to determine where best to classify the equity.

3.92 Using non-parametric methodology in the same way as for the global equity class, we have analysed indices representative of the "other equities" category.

3.93 The results of this analysis, at the 99.5% empirical VaR level, are as follows:

Equity type	**Index**	**Proposed Stress**
Private Equity	LPX50 Total Return	-68.67%
Commodities	S&P GSCI Total Return Index	-59.45%
Hedge Funds	HFRX Global Hedge Fund Index	-23.11%
Emerging Markets	MSCI Emerging Markets BRIC	-63.83%

3.94 The results demonstrate rather wide variation between the different classes of "other" equities. We note that due to challenges surrounding the composition of the index (particularly relating to the private equity index), the richness of data available, and selection bias within indices, the results must be considered with an overlay of expert judgement.

3.95 CEIOPS notes strong industry feedback on the granularity of the risk charge, however, given the challenges of performing a reliable analysis as detailed above, as well as the difficulty of practically splitting the "other" equity charge into sub-categories; CEIOPS considers that a single stress for 'Other Equities' is appropriate.

3.96 The empirically calculated private equity charge above is likely to be somewhat overstated, and the hedge fund charge understated; there is also likely to be a small (although difficult to quantify) diversification benefit between the four categories. For these reasons, CEIOPS recommends an overall charge of 55% for the other equity category.

3.97 CEIOPS proposes that the same symmetric adjustment mechanism should be applied for "other" equities as for "global" equities. The rationale for this proposal is that

- This avoids introducing undue complexity to the equity risk sub-module;
- The same arguments for the calibration of the symmetric adjustment mechanism apply for "other" equities as for "global" equities;
- The "other" equities category is wide-ranging, and therefore it is unlikely that more granular analysis of the components of this category would lead to any more satisfactory result for the calibration of the symmetric adjustment mechanism.

Aggregation of capital charges for global and other equities

3.98 This Paper also considers the way in which the capital charges for "global" and "other" equities are combined. Below, CEIOPS tabulates the tail correlation between the MSCI World price indices and the specific indices which we consider as included in as 'other equity':

Equity Type	Index	Correlation
Private Equity	LPX50 Total Return	83.59%
Commodities	S&P GSCI Total Return Index	44.72%
Hedge Funds	HFRX Global Hedge Fund Index	77.31%
Emerging Markets	MSCI Emerging Markets BRIC	-52.82%

3.99 CEIOPS notes a potential diversification benefit between the other equity types, but considers it to be low and difficult to calibrate, so proposes that the standard formula contains no diversification benefit within the other equity submodule (an implicit correlation of 1).

3.100 CEIOPS proposes to retain the correlation of 75% between "global" and "other" equities as tested in QIS4. The capital charge for all "other" equity types would be simply added together before being correlated with the capital charge for "global" equities using the above correlation factor.

Equity volatility

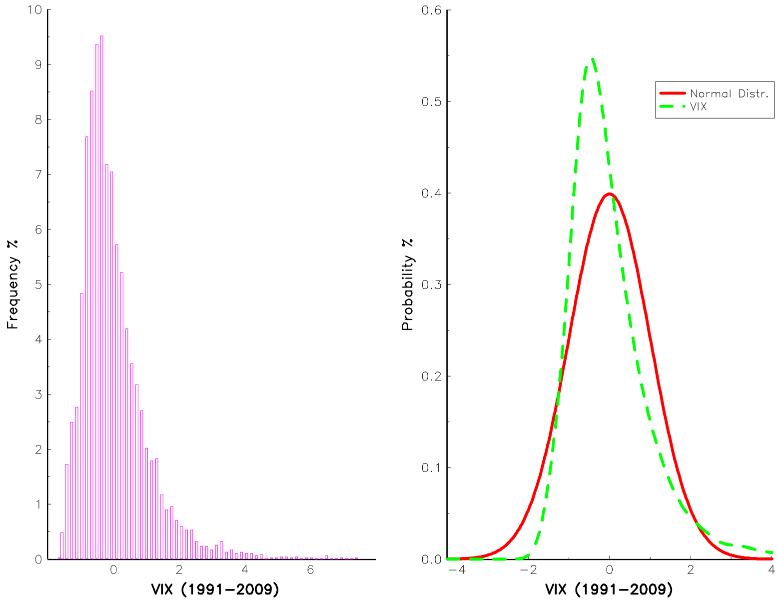
3.101 Many insurers are sensitive to changes in equity volatility whether through the investments they hold (equities and equity derivatives) or through equity-linked options and guarantees embedded in their liability portfolio. As a result, equity volatility has an impact particularly on insurers writing traditional participating business, investment-linked business and other investment contracts.

3.102 CEIOPS recognises the existence of the equity volatility risk during the stressed scenario.

3.103 CEIOPS has used data on the Standard & Poors 500 index (SPX) from the Chicago Board Options Exchange to inform the calibration of the equity volatility stress[38]. This index represents a diversified set of equities listed on developed markets. The volatility data is based on at-the-money 1 month/30 day options.

3.104 The charts below show the empirical distributions for this volatility data, over the period 1991 to 2009. It can clearly be seen that, as with the equity returns, the observed distribution is non-normal.

[38] CBOE SPX Index Volatility reflects a market estimate of future volatility, based on the weighted average of the implied volatilities for a wide range of strikes. 1st and 2nd month expirations are used until 8 days from expiration, then the 2nd and 3rd are used.



3.105 As with the calibration of the standard equity capital charge, rather than making assumptions about parameters in order to calculate the VaR levels, we have worked with the empirical distribution. The results of this analysis are shown in the table below. Note that the percentage changes in the right hand column are relative changes in volatility.

Confidence level	Annual % Changes
1	320%
99.95%	280%
99.5%	186%
99%	158%
97.5%	116%
95%	86%
90%	61%
80%	35%
70%	20%
60%	9%
50%	-1%
40%	-7%
30%	-14%
20%	-22%
10%	-30%
5%	-39%
1%	-51%
0.5%	-53%
0.05%	-58%
0	-59%
mean	9%
vol	42%
skew	1.8268
excess kurtosis	5.7618

3.106 This analysis would lead to relative stresses of -50% (downward direction) and +190% (upward direction) for the volatility of global equities.

3.107 In general, however, the option features embedded in insurers' portfolios are of somewhat longer term – several years. However, data on longer-term equity options is generally sparse and is strictly over-the-counter. The availability of data deteriorates for term longer than 5 years, with only limited data available for terms longer than 10 years.

3.108 The assumption of 5 years as a typical equity option term can be made in order to arrive at an appropriate equity volatility calibration without introducing complexity that is excessive for a standard formula approach. However, where appropriate, an internal model approach could allow for a more granular or sophisticated calibration.

3.109 Limited data[39] available for 5-year at-the-money implied volatility on the Eurostoxx 50 index, for example, indicates approximately doubling of volatility over the period from mid 2007 to mid 2008. Comparison against the 1-month implied volatility shows that in general the 5-year implied volatility is less volatility than the 1-month implied volatility, and tends to suffer comparatively lower shocks.

3.110 An analysis of 5-year at-the-money FTSE100 options produces a 99.5% VaR level of 60% based on daily data covering May 2006 to March 2009. (Note that data limitations restrict the length of data series that can be used here).

3.111 The CRO Forum's report "Calibration Principles for the Solvency II Standard Formula" noted that in their calculations of 99.5% VaR, UK firms were typically assuming a relative equity volatility shock of around 45-55%[40]. However, this survey of undertakings did not incorporate the experience of the financial crisis, and therefore it might be expected that this stress assumption could be revised upwards in the light of recent experience.

3.112 Investigation of the data for 5-year options reveals "step changes", akin to regime shifts, in volatility. A more sophisticated modelling methodology could incorporate these, for example by using a Poisson process to model the arrival of such shifts, but this is beyond the scope of the standard formula.

3.113 In conclusion, the considerations outlined above lead to an equity volatility stress calibration consisting of a relative volatility stress of 50% in the upward direction, by assuming that the relative strengths of the up and down stresses are similar for 5-year options as for 1-month options we arrive at a downward relative stress of 15% where relevant.

3.114 We note that equity volatility and equity stress have a correlation of less than 1, i.e. it can be observed in the market that when equity prices rise, equity volatility does not always also rise. However the correlation is high, especially for the extreme movements which are likely to occur in a 1:200 year event. For this reason we propose a correlation coefficient of 0.75 between equity volatility up and equity level stresses, and a correlation coefficient of 0 between equity volatility down and equity level stresses. We envisage that

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[39] See ***Modelling challenges and Replicating Portfolios*** delivered at the European Actuarial Academy April 2009 by Manuel Sales

[40] The report stated this as an increase to 32%-34.5% over a base assumption of 22% for implied equity volatility.

total global equity capital would be calculated using this correlation, as would total other equity capital. The correlation factors described in paragraph 3.100 would then be applied to create an overall equity capital charge. This would usually entail firms performing separate 'volatility' stress, and 'level' stress runs, and aggregating the results using the correlation matrix approach.

3.115 In line with the arguments set out above CEIOPS proposes that the same calibration for equity volatility be used for "other" equities as for "global" equities, to avoid introducing disproportionate complexity.

Duration approach according to Article 304

3.116 The design of the equity risk submodule referred to in Article 304 should be based on the following principles:

3.117 The directive sets, when considering a 1-year horizon, a level of confidence of 99.5%. Considering a holding period of T years and assuming temporal independence of events, it can be assumed that an equivalent level of confidence is $99.5\%^{T}$.

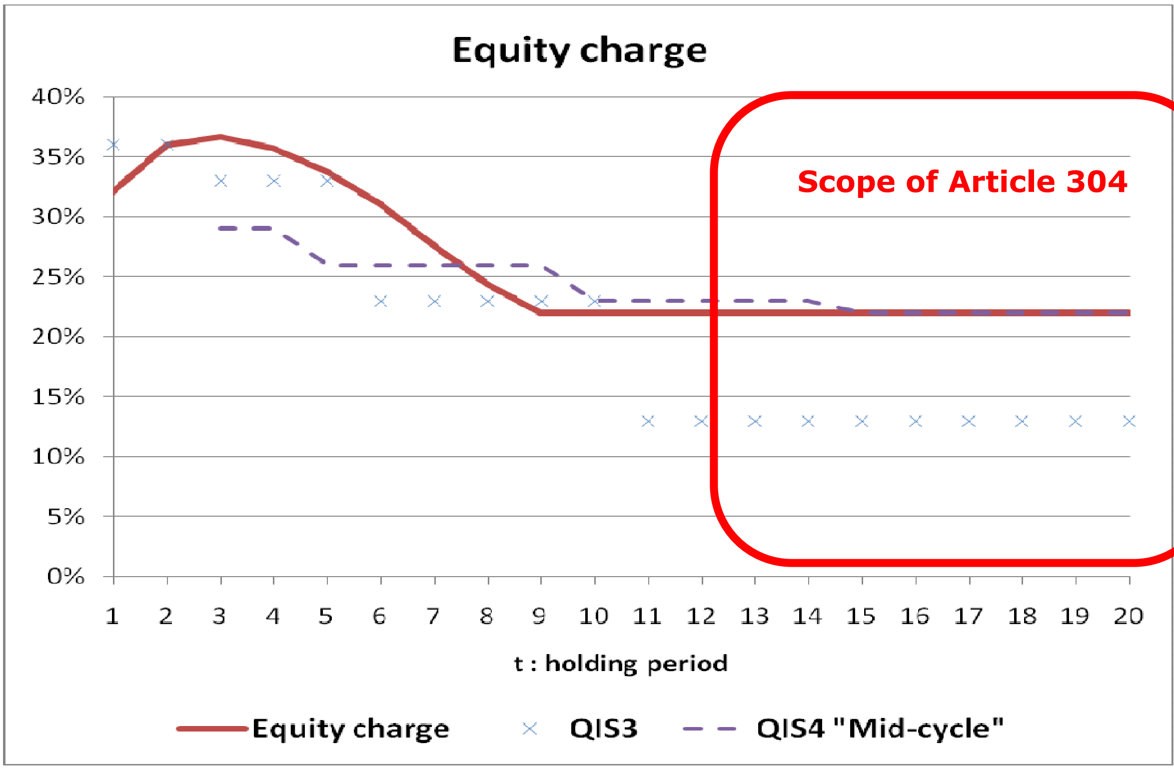
3.118 Considering an insurer collecting a premium S_0 at date t=0 in exchange for the promise to pay a capital $K_T = S_0 e^{rT}$ at date T, where r is the risk free rate. The premium is invested in equity. The model of the value S_t of this asset will be supposed to evolve over time according to a geometric brownian motion: $\frac{dS}{S} = \mu dt + \sigma dw,$

3.119 The equity charge (called SCRT) is derived from these hypothesis (see in the Appendix to this subsection) :

$$\frac{SCR_T}{S_0} = 1 - \exp\left[\left(\mu - r - \frac{\sigma^2}{2}\right)T - \sigma\sqrt{T}Q(T)\right],$$

3.120 For prudence and in order to be consistent with the property submodule calibration, an absolute floor for the equity charge is set at 22%.

3.121 This leads to the following calibration, with μ=10%, r=5%, σ follows the Campbell Viceira pattern (see in the Appendix to this subsection):



Appendix: Article 304 – calculation of the equity capital charge

3.122 Considering an insurer collecting a premium S_0 at date t=0 in exchange for the promise to pay a capital $K_T = S_0 e^{rT}$ at date T, where r is the risk free rate.

3.123 The premium is invested in equity. The value S_t of this asset evolves over time according to a geometric Brownian motion:

$$\frac{dS}{S} = \mu dt + \sigma dw,$$

where μ equals r plus the equity premium and σ is the annual volatility of equity returns. I.e. Log(ST) is normal with mean $(\mu - \sigma^2/2)T$ and variance $\sigma^2 T$.

3.124 The insurer has some reserve at date t=0 that is used as a collateral to the insurer's liability at date T. Let SCRT be the minimum reserve that guarantees that the probability of default at date T be smaller than 0.995T.

3.125 We assume that the reserve is invested in the risk free asset. It implies that SCRT is implicitly defined by the following equality:

$$\Pr\left[\, SCT_T e^{rT} + S_T \geq S_0\, e^{rT} \right] = 0.995^T$$

3.126 We obtain that

$$\frac{SCR_T}{S_0} = 1 - \exp\left[\left(\mu - r - \frac{\sigma^2}{2}\right)T - \sigma\sqrt{T}Q(T)\right],$$

where Q(T) is the 0.995T quantile of the normal distribution.

3.127 σ is calibrated following the Campbell Viceira study :

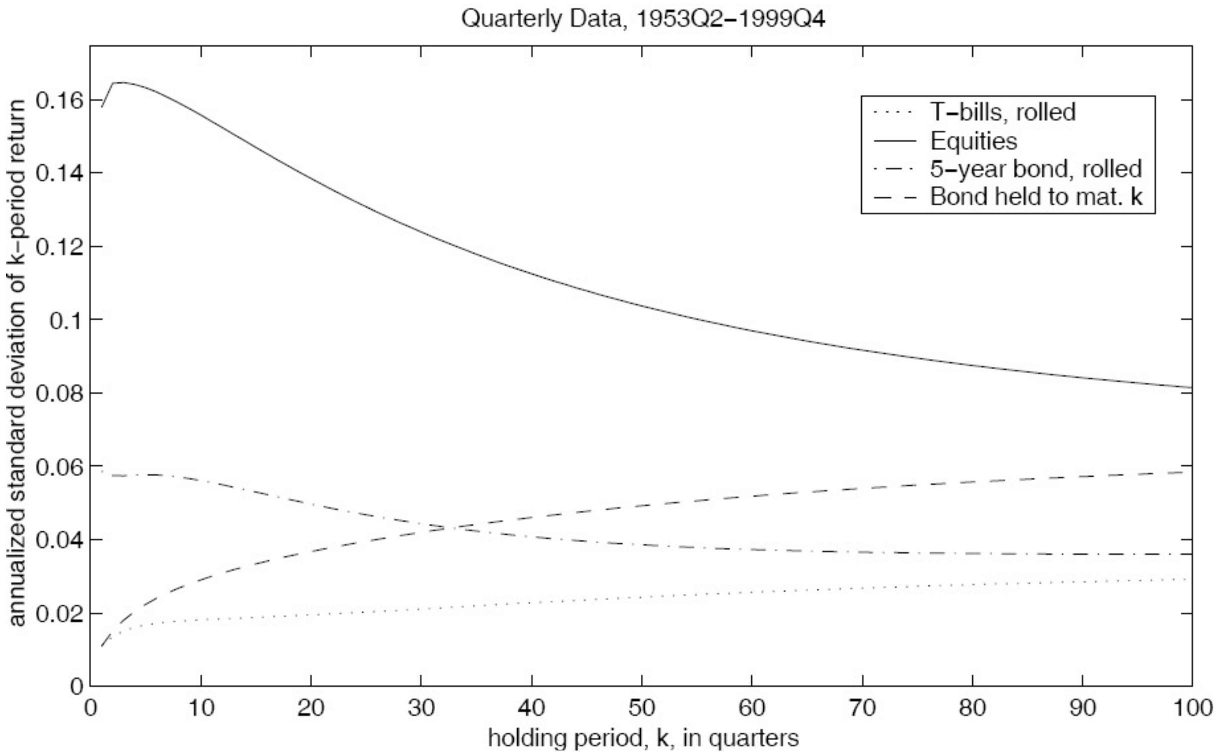


Figure 1 Annualized standard deviations of real returns on US markets, VAR setup, period 1952-1999. Source: Campbell and Viceira (2002).

3.128 Note : in the first years, the impact of the volatility of the equity motion is predominant over the impact of the trend of the motion. After a few years, the trend impact is predominant, leading to a progressive decreased in the risk incurred.

3.1.3 Currency risk[41]

3.129 CEIOPS-DOC-40/09 proposed a scenario-based approach for calculating the capital charge for currency risk.

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[41] This section follows CEIOPS-DOC-66/10

3.130 As set out in that paper, the capital charge arising from this sub-module will be Mkt_{fx} and will be calculated based on two pre-defined scenarios: for each currency C, one scenario will consider a rise in the value of the foreign currency against the local currency and will deliver $Mk_{fx,C}^{Up}$; the other scenario will consider a fall in the value of the foreign currency against the local currency and will deliver $Mkt_{fx,C}^{Down}$. All of the undertaking's individual currency positions and its investment policy (e.g. hedging arrangements, gearing etc.) should be taken into account. For each currency, the contribution to the capital charge $Mkt_{fx,C}$ will then be determined as the maximum of the results $Mkt_{fx,C}^{Up}$ and $Mkt_{fx,C}^{Down}$. The total capital charge Mkt_{fx} will be the sum over all currencies of $Mkt_{fx,C}$.

3.131 We note at this point that currency effects appear only in this sub-module. That is, the calibration of the other market risk sub-modules has been carried out in such a way that currency effects are stripped out.

3.132 The QIS3 technical specification document derived a 20% stress factor for currency risk, in preference to the 25% stress factor proposed in QIS2. Furthermore, for QIS3 the implied stress factor was derived assuming a diversified currency portfolio (i.e., 35% in USD, 24% in GBP, 13% in Argentine Peso, 8% in JPY, 7% in SEK, 7% in CHF and 6% in AUD), which approximates the currency positions held by Dutch financial institutions. In this exercise, currency exposure to emerging markets was approximated by the Argentine Peso.

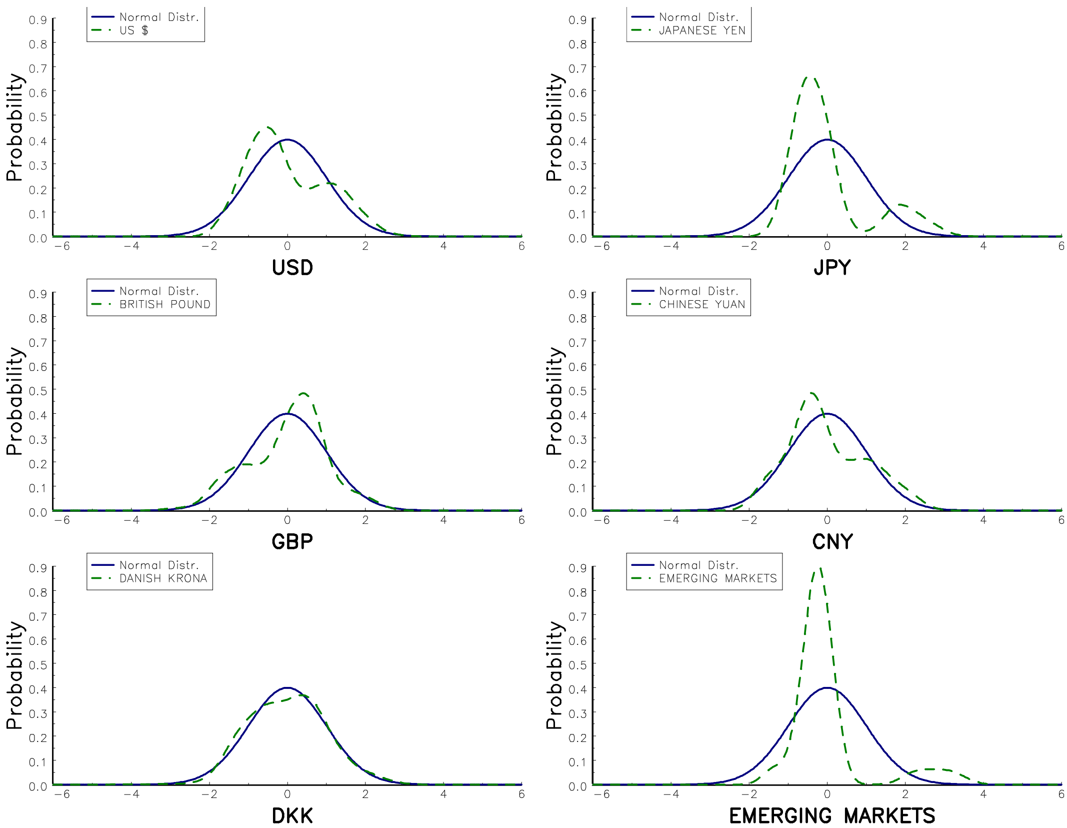
3.133 In our analysis, we show that the risk at the 99.5th percentile is exacerbated above the 20% level proposed for QIS3 in portfolios whose composition is solely in currencies that suffered much stronger moves. Furthermore, we use a currency portfolio diversified across 6 economies as a proxy to currency exposures of emerging markets.

3.134 We use daily data to study the distribution of holding period rate of returns derived from EUR and GBP currency pairs. Our data sample, sourced from Bloomberg, covers a daily period from January 1971 to June 2009, a total of circa 10,000 observations across 14 currency pairs against GBP. In addition, our sample consists of 14 currency pairs expressed against the EUR. For most pairs, this sample covers a daily period spanning a period of 10 years starting in 1999 to 2009. We compute annual holding period returns for the Japanese Yen (JPY), the Brazilian Real (BRL), the Lithuanian Litas (LTL), the Indian Rupee (INR), the Chinese Yuan (CNY), the US, Hong Kong (HKD), the Australian (AUD) and the New Zealand (NZD) Dollars, the Norwegian (NOK), Swedish (SEK) and Danish (DKK) Krone, the Swiss Franc (CHF) and the British Pound (GBP).

3.135 Our proxy to emerging market economies is mainly a proxy to Pacific Basin[42] economies. This is a currency basket expressed against the EUR, and is equally distributed across CNY, INR, HKD, AUD, BRL and ARS. We prefer to extend the definition of the emerging markets to include developed economies, whilst including the dominant Latin American countries, Brazil and Argentina excluding Mexico. The presence of the Australian and Hong Kong economy to our mix balances out the level of the stress as we believe that insurance groups are more exposed to these economies across the Pacific basin region. Below, we refer to this currency mix as EM.

3.136 We estimate the full probability density and especially the lower percentiles using non-parametric methods as described in Silverman (1986). The figures below illustrate the standardised probability density functions of a representative sample of six currency pairs against EUR, which are implied from the annual holding period returns of the corresponding currency pairs.

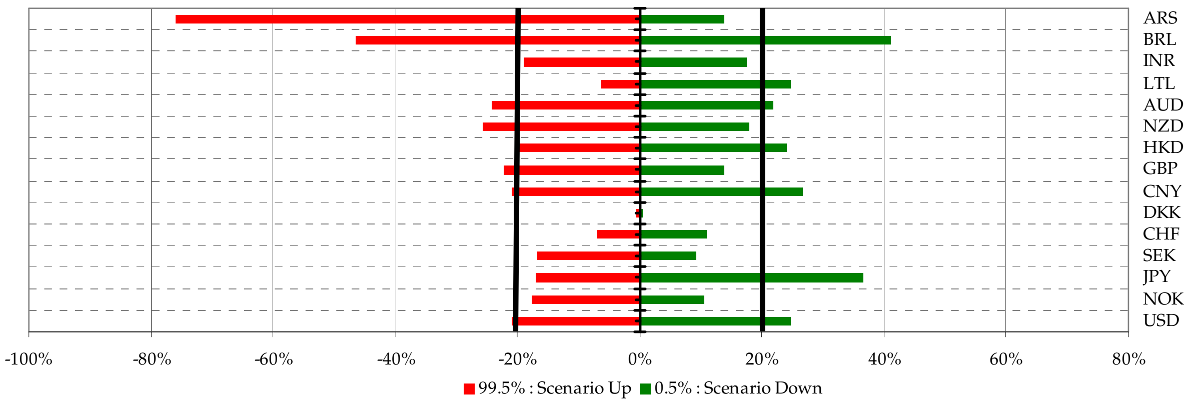
3.137 QIS3 and 4 define a symmetric stress factor on the assumption that the percentage changes in currency rates are normally distributed. A visual inspection of different standardised distributions, which are plotted against the normal distribution shows that the data does not adhere to the laws of normal distribution. Most distributions are skewed and exhibit excess kurtosis.



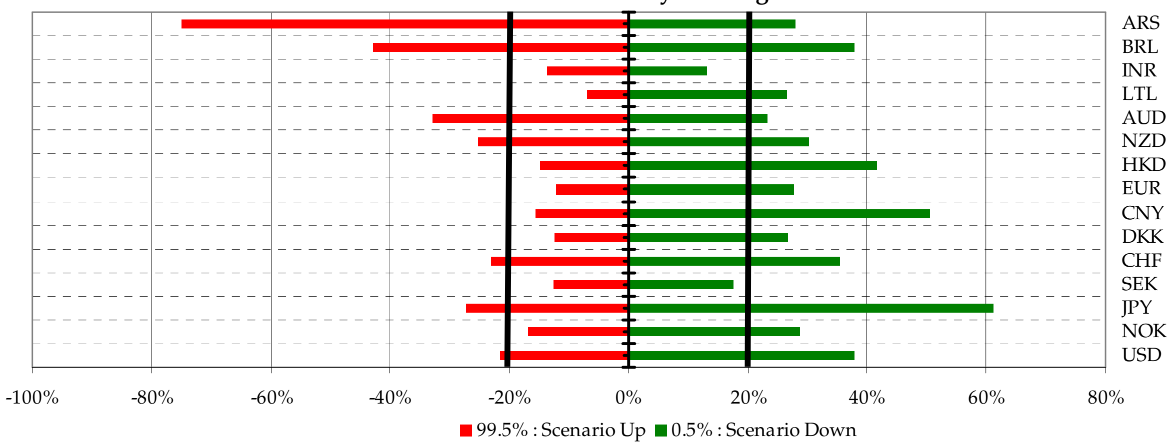
[42] The term Pacific Basin economies mainly refers to all East Asian Economies. In this basket are approximated by Hong Kong dollar, the Chinese Yuan and the Indian Rupee. However, as discussed below, our conclusion would be broadly unchanged if other emerging market currencies, or for example Eastern European currencies, were used instead of Pacific Basin economies.

3.138 The following two charts illustrate the 99.5th percentiles, left and right tail, of the annual holding period returns of currency pairs against the EUR and GBP respectively. The symmetric band proposed by QIS3 is highlighted with a bold black line.

Annual Returns of Currency Pairs Against EUR



Annual Returns of Currency Pairs Against GBP



3.139 The above results indicate that the year-on-year movements in currencies are asymmetric at the tail of the distribution and are likely to fall out of the symmetric 20% band. According to our results, this is equally likely also for currency pairs against the British pound. Most breaches of the proposed band occurred over 2008 to 2009 across both sets of currency pairs.

3.140 The following table illustrates the worst year-on-year percentage currency change estimated within the period covered by our sample (1971 – 2009). In almost all cases, the currency pairs have breached the proposed stress factor of 20%. Exceptions are the Danish krone and the Lithuanian litas.

	EUR	GBP	Band Breach	QIS 3: Portfolio Weights
USD	**-22.44%**	**-29.35%**	Yes	35%
NOK	**-20.05%**	**-21.83%**	Yes	
JPY	*-18.37%*	**-30.30%**	Only in GBP	8%
SEK	*-19.99%*	*-14.72%*		7%
CHF	*-7.93%*	**-25.53%**	Only in GBP	7%
DKK	*-1.64%*	*-13.28%*		
CNY	**-22.39%**	*-16.25%*	Only in EUR	
HKD	**-22.47%**	*-15.84%*	Only in EUR	
NZD	**-26.93%**	**-28.34%**	Only in GBP	
AUD	**-26.20%**	**-36.05%**	Yes	6%
LTL	*-8.43%*	*-7.82%*		
INR	*-19.97%*	*-14.71%*		
BRL	**-48.14%**	**-46.46%**	Yes	
ARS	**-77.66%**	**-83.64%**	Yes	13%
EUR		**-13.21%**		
GBP	**-24.69%**		Only in EUR	24%
Revised Shock	-28.87%	-28.55%		

3.141 Given our analysis, we would not expect the symmetric stress factor of $\pm 20\%$ to be a strict representative of a 1 in 200 stress even for a well diversified currency mix. In this particular case, if we were to combine the above tabulated shocks with the specific currency mix proposed in QIS3 technical specification paper, the currency stress test is closer to 29%.

3.142 The level of the revised stress test crucially depends upon the choice of the optimal currency weights, while the choice of the Argentine peso as a proxy to emerging markets introduces a degree of bias as well as conservatism. We have carried out sensitivity testing on our result by varying both sets of assumptions. The table below presents 16 sets of alternative choices of portfolio weights, whilst we use a well diversified proxy of emerging markets termed EM.

3.143 The results demonstrate the sensitivity of our revised shock to the initial assumptions. Portfolio 1 represents the currency exposures of Dutch financial institutions, as proposed by QIS3 and discussed above. Portfolio 2 tests the sensitivity of the revised shock to the Argentine peso, and uses the alternative EM portfolio as a proxy to currency exposures across different markets. Portfolio 2 produces a 25% shock compared to the 29% shock produced by Portfolio 1.

3.144 Ideally, we would prefer to have an average weight representing the average currency exposures of European insurers to Pacific Basin economies. The lack of aggregate data encourages further testing. We further carried out sensitivity analysis of our results to different weights of EM, testing the sensitivity of the revised shock to concentration in EM of 10%, 20%, 25%, 33% and 50% of the total portfolio. The table below presents the results of this analysis.

	Resulting Shock	Portfolio Weights															
		USD	NOK	JPY	SEK	CHF	DKK	CNY	GBP	HKD	NZD	AUD	LTL	INR	BRL	ARS	EM
1	-28.87%	35%		8%	7%	7%			24%			6%				13%	
2	-24.80%	35%		8%	7%	7%			24%			6%					13%
3	-21.84%	33%		33%					33%								
4	-29.05%	33%		33%													33%
5	-21.02%			33%	33%				33%								
6	-27.96%	25%		25%					25%								25%
7	-18.36%	25%		25%		25%			25%								
8	-22.93%	25%		25%					25%			25%					
9	-28.36%	25%			25%				25%								25%
10	-24.59%	25%	10%	10%	10%		10%		15%								20%
11	-23.57%	50%							50%								
12	-20.41%	50%		50%													
13	-34.39%	50%															50%
14	-24.49%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	
15	-22.26%	80%		10%					10%								
16	-19.68%	10%	10%	10%	10%	10%	10%		10%		10%		10%				10%

3.145 The sensitivity of the revised shock to alternative portfolio allocations to currencies in the emerging market (EM) basket is analysed in portfolios 2, 4, 6, 9, 10, 13 and 16. These results demonstrate that the revised shock could vary from a maximum of 34% to a minimum of 20%. A revised shock of 34% reflects a portfolio composision which is principally dominated by US dollar and emerging market currency exposures. On the other hand a resulting minimum of 20% reflects a small currency exposure of 10% to emerging market currencies, whilst maintaining all other allocations also equal to 10%.

3.146 We have also investigated the sensitivity of the results to USD, JPY, CHF and GBP concentrations as well as permutations of the portfolio in the absence of the emerging market basket. In these cases, the results of the revised shock vary within 18% to 25%.

3.147 On the basis of the above sensitivity stress tests, we propose a revised stress factor of 25%.

3.148 We could further expand our emerging market basket to include other currency pairs and re-test our proposed stress factor. Currency pairs that experience higher volatility than our proposed basket may contribute positively and further increase the stress factor, whilst currencies with more constrained volatility would not dramatically change our results.

3.149 In particular, we have investigated the inclusion of the Russian rouble and the Hungarian forint in the currency basket, as proxy for eastern European currencies. However, there was no substantial change in the overall results on the introduction of these two currencies.

3.150 Exceptions to the above analysis are the member states of the European Exchange Rate Mechanism (ERM II). The mechanism currently includes the

the Danish krone, the Estonian kroon, the Lithuanian litas, and the Latvian lats[43]:

- The Danish krone entered the ERM II in 1999, when the euro was created, and the Denmark's National bank keeps the exchange rate within a narrow range of ± 2.25% against the central rate of EUR 1 = DKK 7.460 38.

- The Lithuanian litas joined the ERM II on 28 June 2004.

- Latvia has a currency board arrangement, whose anchor switched from the IMF's SDR to the euro on 1 January 2005.

- The Estonian kroon had been pegged to the German mark since its re-introduction on 20 June 1992, and is pegged to the euro since 1 January 1999. Estonia joined the ERM II on 28 June 2004.

For the latter 3 currencies, on the basis of ERM II the exchange rate is fixed within a broader nominal band of ± 15%.

3.151 Moreover, for the three baltic currencies the responsible national banks strictly control the exchange rate to the euro:

- According to a commitment of the Bank of Lithuania the Lithuanian litas is pegged to the euro with a fixed exchange rate of 3.4528 since 2 February 2002.[44]

- As of 1 January 2005 the Latvian lats are pegged to the euro (at the rate 1 EUR = 0.702804 LVL. The Bank of Latvia performs interventions when the exchange rate of the lats exceeds the normal fluctuation margins of ±1%.

- According to a commitment of the Bank of Estonia the Estonian kroon is pegged to the euro with a fixed exchange rate of 15.6466 since 1 January 1999.[45]

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[43] For definitions and further details on the exhange rate mechanism (ERM II) between the euro and participating national currencies, please refer to: http://ec.europa.eu/economy_finance/the_euro/joining_euro9407_en.htm

[44] See website of the Bank of Lithuania: http://www.lb.lt/exchange/default.asp?lang=e.

The official fixed exchange rate of the litas against the euro (3.4528 litas per 1 euro), effective as of 2 February 2002, was set by the Resolution of the Government of the Republic of Lithuania (the official gazette "Valstybes zinios", 2002 No. 12-417) and the Resolution of the Board of the Bank of Lithuania (the official gazette "Valstybes zinios", 2002 No. 12-453).

[45] See website of the Bank of Estonia: http://www.eestipank.info/pub/en/dokumendid/dokumendid/oigusaktid/maaruste_register/_1998/_118.html?metadata=yes&content=yes

3.152 Based on these central bank commitments the currency stress for the Lithuanian litas and the Estonian kroon against the euro can be neglected. The stress for the Latvian lats can be reduced to 1%.

3.153 The analysis set out above leads to the following proposal for calibration of the currency stress scenario:

Currency	*FX Stress: Up & Down scenario*	*QIS4 FX Stress*
Danish Krone against any of EUR, Lithuanian litas or Estonian kroon	2.25%	2.25%[46]
Estonian Kroon against EUR or Lithuanian litas	0%	15%
Latvian lats against any of EUR, Lithuanian litas or Estonian kroon	1%	15%
Lithuanian litas against EUR or Estonian kroon	0%	15%
Latvian lats against Danish Krone	3.5%	20%
All other currency pairs	25%	20%

3.154 The proposed currency tests for currencies that are pegged to the euro revert to the standard test of 25% when a country member of ERM II accepts euro as its currency or drops out of the ERM II.

3.1.4 Property risk[47]

3.155 CEIOPS-DOC-40/09, on the design and structure of the market risk module, proposed a delta-NAV approach for the calculation of the property risk capital charge, with the capital charge Mkt_{prop} calculated as the result of a pre-defined scenario(s),

[46] Note, the QIS4 stress quoted here and in the three rows below applied for pegged currencies vs EUR only

[47] This section follows CEIOPS-DOC-66/10

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3.156 The property shock is the immediate effect on the net value of assets less liabilities of an x% fall in real estate values; the paragraphs below set out the analysis underlying CEIOPS' proposal for the calibration of the x% property shock scenario.

3.157 The stress factor for property risk is calibrated below using data extracted from the IPD (i.e., Investment Property Databank) indices. The indices are produced directly from survey data collected from institutional investors, property companies and open-ended investment funds. IPD produces (publicly available) property indices for most European markets and across some counties outside Europe (i.e., Australia, Canada US, Japan and South Africa).

3.158 The IPD index is, according to our understanding, the most widely used commercial property index in most countries. Other available indices include the JLL (Jones Lang LaSalle), the REI (Richard Ellis) indices and several residential indices.

3.159 IPD indices consist of time series of income (i.e., rental yield) and capital growth for main property market sectors – retail, office, industrial and residential. These sub-indices can further be divided into detailed sub-sectors, regions, size bands etc. IPD indices always show annual results, and for some countries there are also quarterly (Netherlands) and monthly indices (UK). IPD indices reporting frequencies are entirely dependent upon the prevailing local market valuation practices.

3.160 One of the most challenging factors of this specific calibration is the lack of long time series across most European markets. The QIS3 technical specification estimates the 99.5% shock "using the shortest common subset of returns", which reflects annual observations recorded over the period from 1998 to 2005. Instead of using the results derived from a market-weighted index of five countries, the final result is conservatively rounded to 20%. In addition, QIS2 offered no distinction between direct and indirect real estate holdings, while both QIS2 and QIS3 ignore different property market sectors.

3.161 We have based our analysis on monthly UK IPD total return indices spanning a period between 1987 to the end of 2008, a total of 259 monthly total returns. This data set provides the greatest and most detailed pool of information. In addition, our analysis aims to distinguish the 99.5% stress test scenario across types of property or property market sectors.

3.162 We recognise that the IPD total return indices are based on appraised market values rather than actual sales transactions. This leads to a degree of smoothing within the index data, as appraisers tend to be "backward-looking", dependent on previous valuation prices as part of the current valuation process.

3.163 A number of approaches have been put forward to de-smooth property returns. The QIS3 technical specification follows the most widely referenced approach, proposed by Fisher, Geltner and Webb (1994)48. This method expresses the "de-smoothed" return as a function of the present and past observable annual returns. The exact weight decomposition between present and past observations depends upon the estimation of an autoregressive model and on the condition that the "true" volatility of property values is approximately half the volatility of the S&P 500 stock market index.

3.164 The de-smoothing procedure proposed by Fisher, Geltner and Webb (1994) is modelled by applying standard time series estimation procedures to the IPD annual "smoothed" returns. A major disadvantage of this approach, however, is that the error term in the regression model does not necessarily have an expectation of zero.

3.165 Chao, Kawaguchi and Shilling (2003)49 attempted to correct the inherent bias in the Fisher, Geltner and Webb approach and proposed to adjust the property returns by inflation. Although, Chao, Kawaguchi and Schilling (2003) limit the extent of the bias, the inflation-adjusted method does not eliminate this completely. Our preliminary analysis demonstrates that property returns are strongly influenced by equity returns, the slope of the government term structure and short-term interest rates. All these factors may also contribute to the appraised market values.

3.166 In fact, Booth and Marcato (2004)50 follow the Fisher, Geltner and Webb (1994) approach to describe a regression model. Their results indicate that de-smoothing the UK IPD index over the period 1977 to 2002 increased the standard deviation of annual returns from 9.3% to 16.7%, whilst the 'de-smoothed' mean return rises by 0.9%. The mean total return from the IPD annual index is 12.5% from 1977 to 2002. When the capital value returns are de-smoothed the mean return increases slightly to 13.4%. Their method is still subjective and does not remove completely the serial correlation in the underlying data.

3.167 Edelstein and Quan (2006)[51] estimate the bias in an index by empirically comparing individual property appraisals to the aggregate index. Their procedure effectively estimates the smoothing effects and derives the corrected moments for commercial real estate. They report that the volatility of commercial real estate appears to be lower than the S&P 500 and the S&P Small Cap 600 indices.

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[48] Fisher, J.D., Geltner, D. & Webb, R.B. (1994), Value indices of commercial real estate: a comparison of index construction methods, Journal of Real Estate Finance and Economics, 9, 137-164

[49] Hoon, C., Y. Kawaguchi, Y. & Shilling, J.D. (2003), Unsmoothing commercial property returns: A revision of Fisher-Geltner-Webb's unsmoothing, Journal of Real Estate Finance and Economics, Vol. 27,3, 393-405

[50] Booth, P.M. and G. Marcato (2004), The measurement and modelling of commercial real estate performance, British Actuarial Journal, Vol. 10, 1,5-61

[51] Edelstein, R.H., & Quan, D. (2006), How Does Appraisal Smoothing Bias Real Estate Returns Measurement? , Journal of Real Estate Finance and Economics, 32, No.1

3.168 Given these drawbacks in attempting to "de-smooth" the index data, our methodology concentrates on deriving the lower percentiles of the distribution of the "smoothed" property returns – that is, the unadjusted index data. We do this by using non-parametric methods, rather than drawing from a particular distribution.

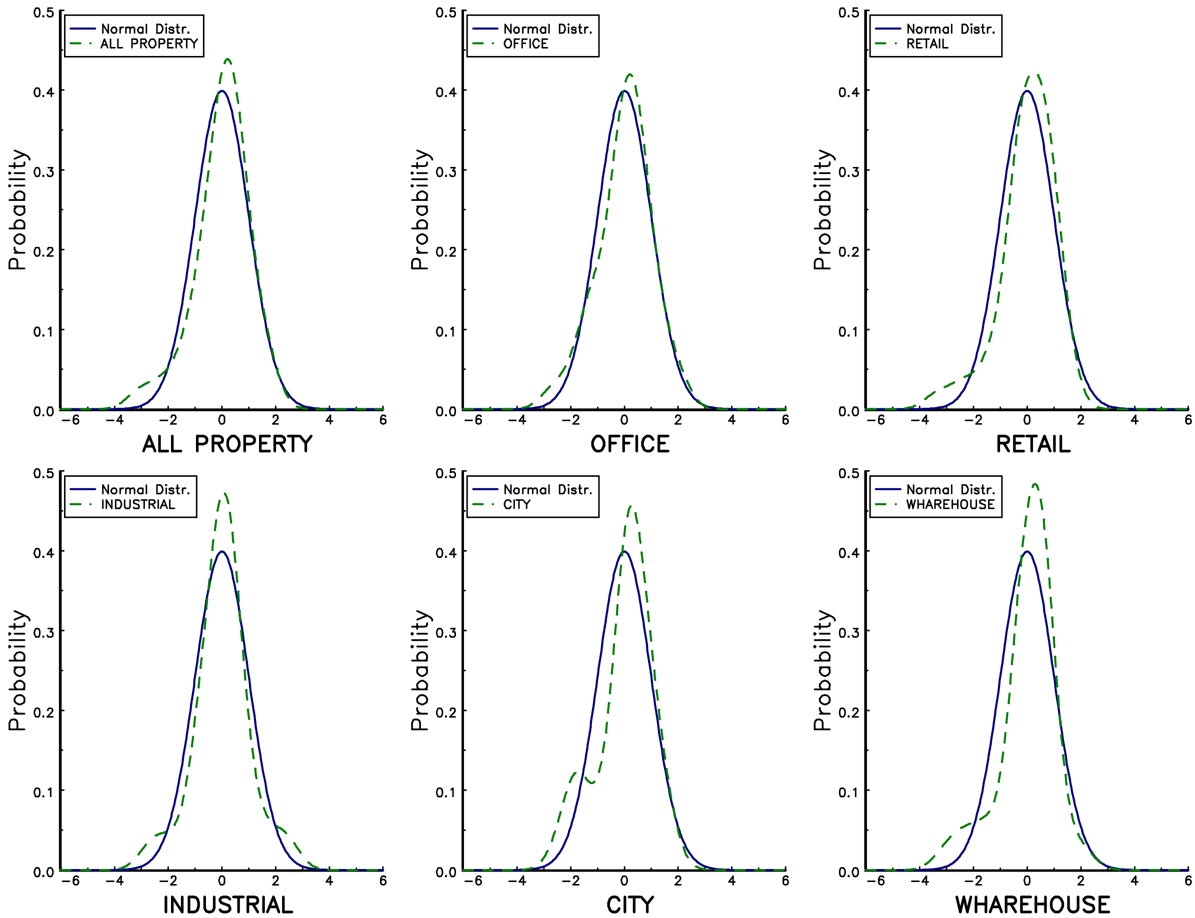
3.169 The table below presents descriptive statistics and the lower percentiles of the distribution of the annual 'smoothed' property returns. These are recovered from the different property sectors throughout the UK. We have extracted annual returns from the data by creating rolling one-year windows from the monthly data.

	ALL Property	Office	City Offices	Retail	Commercial
Maximum	29.51%	34.74%	33.14%	25.84%	40.14%
50%	9.78%	9.92%	8.00%	9.74%	13.54%
Mean	8.79%	8.19%	5.42%	8.56%	11.37%
1 in 10 or 10%	-5.26%	-8.50%	-18.87%	-4.76%	-6.61%
1 in 20 or 5%	-13.63%	-13.60%	-22.13%	-14.40%	-17.89%
1 in 100 or 1%	-25.28%	-25.62%	-29.42%	-26.82%	-27.38%
1 in 200 or 0.5%	**-25.74%**	**-25.93%**	**-30.03%**	**-27.47%**	**-27.67%**
Minimum	-25.88%	-25.96%	-30.10%	-27.69%	-27.71%
Std. Dev.	10.51%	11.93%	13.70%	10.15%	12.08%
Skewness	-0.8973	-0.4506	-0.7526	-1.2395	-1.1113
Excess Kurtosis	1.3527	0.3688	0.0572	2.0621	1.8115
Historical VAR	**25.74%**	**25.93%**	**30.03%**	**27.47%**	**27.67%**

3.170 In the definitions for the IPD datasets, the category "All-property" refers to a portfolio consisting of all-retails, all-offices, all-industrials and other commercials properties across the UK. The exact weight decomposition of this portfolio is 47.2%, 34.6%, 14.8% and 3.4% respectively. The category "Office" refers to offices located in London's West End, in the South East of England and in rest of UK. This category does not include offices in the city of London. The category "City Offices" is analysed separately and reflects offices in prime business location within a major financial area. "Retails" refer to high street shops in the south east England and in the rest of the UK as well as shopping centres and retail warehouses. The last category, "commercial" reflects warehouses other than retail located in different parts of the UK. These categorisations can easily be extended for application to the more general European case.

3.171 The figures below demonstrate the standardised distribution (i.e., mean is zero and unit standard deviation) of annual property returns across alternative property market sectors. All distributions of property returns are characterised by long left fat-tails and excess kurtosis signifying disparity from normal distribution.

3.172 In light of the above results, we further "un-smooth" annual returns using the aforementioned methods, albeit the methods do not eliminate the inherent bias. We find that the method further exacerbates the left tail to result in stress tests that may prove even more onerous, whilst the volatility of the adjusted de-smoothed index is much lower than the volatility of the MSCI developed total return index.



3.173 Our analysis on total return indices incorporates an element of conservatism, since we inherently assume that the rental yield earned on a property portfolio is re-invested back into the same pool.

3.174 In periods of severe stress, we may experience dramatic falls in property values combined with severely depressed rental yields, which in the worst case may collapse to zero. In this environment, the gap risk remains. Insurers may not be able to earn the minimum rental income equal to the risk free rate to match the underlying liabilities.

3.175 On the basis of our analysis of the smoothed data, we therefore recommend a 25% stress for property. No breakdown in different property classes is needed as the historical values at risk for the different classes do not diverge too much.

3.1.5 Spread risk[52]

3.176 Spread risk reflects the change in value of net assets due to a move in the yield on an asset relative to the risk-free term structure. The spread risk sub-module should address changes in both level and volatility of spreads.

3.177 According to CEIOPS-DOC-40/09 (former CP 47), the spread risk sub-module applies to:

- Bonds (including deposits with credit institutions),
- Loans guaranteed by mortgages,
- Structured credit products, such as asset-backed securities and collateralised debt obligations,
- Credit derivatives, such as credit default swaps, total return swaps and credit linked notes.

3.178 The capital charge for spread risk will be determined by assessing the results of a factor-based calculation which considers a rise in credit spreads. Empirically, spreads tend to move in the same direction in a stressed scenario, and therefore the assumption is made that spreads on all instruments increase. This also helps to avoid excessive complexity.

3.179 The spread risk sub-module will not explicitly model migration and default risks. Instead, these risks will be addressed implicitly, both in the calibration of the factors and in movements in credit spreads. For example, the impact of intra-month changes in rating will be reflected in any indices used to inform the calibration of the factors. The factors will also implicitly address not only the change in the level of credit spreads but also the term structure for the level of spreads.

3.180 In that regard, CEIOPS is considering developing risk factors that vary by spread duration to take into account the non-linearity of spread risk across duration and credit rating.

3.181 The factor-based approach will be built from the market value of the instrument in question, and will take into account the credit rating of the instrument and its duration.

Corporate bond investments of European insurance undertakings

3.182 The corporate bond investments of European insurance undertakings are generally of high quality. QIS4 data shows that about 87% is invested in the three most senior rating classes (AAA, AA, and A according to Standard&Poor's nomenclature).

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[52] This section includes significant changes relative to CEIOPS' advice in CEIOPS-DOC-66/10

Table 1: Distribution of bond investments of European insurance undertakings (based on QIS4 data)

Rating class	
AAA	37.8%
AA	27.4%
A	22.2%
BBB	6.7%
BB	0.8%
B	0.5%
CCC or lower	0.1%
Unrated	4.6%

3.183 Durations of these investments tend to be higher in the more senior rating classes as evidence from QIS4 data shows.

Table 2: Durations of bond investments of European insurance undertakings (based on QIS4 data)

Rating class	10th percentile	25th percentile	Median	75th percentile	90th percentile
AAA	1.1	2.7	4.4	6.3	8.9
AA	1.2	2.5	4.3	5.7	7.5
A	1.0	2.5	4.0	5.6	7.6
BBB	1.0	2.5	4.0	5.4	7.1
BB	1.0	1.9	3.7	5.5	6.7
B	0.8	1.9	3.3	4.8	6.4
CCC or lower	1.0	2.3	3.8	4.6	6.7
Unrated	0.8	1.2	3.0	4.0	6.0

QIS4 calibration

3.184 In QIS4 the capital charge for spread risk for bonds was determined by multiplying the market value of the bond with its modified duration and a function F of the rating class of the bond. The values of this function F as well as caps and floors for the duration measure can be found in the following table.

Table 3: QIS4 calibration parameters for corporate bonds

Rating class	$F(Rating_i)$	Duration floor	Duration cap
AAA	0.25%	1	-
AA	0.25%	1	-
A	1.03%	1	-
BBB	1.25%	1	-
BB	3.39%	1	8
B	5.60%	1	6
CCC or lower	11.20%	1	4
Unrated	2.00%	1	4

3.185 In QIS4 the capital charge for spread risk for structured credit instruments was analogously determined by multiplying the market value of the instrument with its modified duration and a function G of the rating class of the instrument. The values of this function G as well as caps and floors for the duration measure can be found in the following table.

Table 4: QIS4 calibration parameters for structured credit products

Rating class	$G(Rating_i)$	Duration floor	Duration cap
AAA	2.13%	1	-
AA	2.55%	1	-
A	2.91%	1	-
BBB	4.11%	1	-
BB	8.42%	1	5
B	13.35%	1	4
CCC or lower	29.71%	1	2.5
unrated	100.00%	1	1

3.186 For credit derivatives, the QIS4 capital charge was determined as the change in the value of the derivative (i.e. as the decrease in the asset or the increase in the liability) that would occur following (a) a widening of credit spreads by 300% if overall this was more onerous, or (b) a narrowing of credit spreads by 75% if this was more onerous. A notional capital charge should then be calculated for each event. The capital charge should then be the higher of these two notional changes.

Data

3.187 Information contained in Corporate Bond Indices from Merrill Lynch was used for the calibration. For EMU Corporates, monthly rebalanced sub-indices covering different maturity buckets (0-3Y, 3-5Y, 5-7Y, 7-10Y, 10Y+) and rating classes (AAA, AA, A, BBB, BB, B) are available back to February 1999. For this calibration exercise, data until February 2010 has been used.

3.188 The monthly index composition for each maturity bucket and rating class was downloaded from Bloomberg and then split up into new maturity buckets with a range of 1 year and a maximum time to maturity of 10.5+ years (0.5-1.5Y, 1.5-2.5Y, ..., 9.5-10.5Y, 10.5Y+). A further breakdown was performed in order to base the calibration on yearly buckets.

3.189 Given the composition at the beginning of each month, the daily yield spread was downloaded for every issuance for the relevant month. All in all, 5,177 unique index members could be identified in the composition lists; for 4,158 of these, daily time series of yield spreads were available in Datastream.

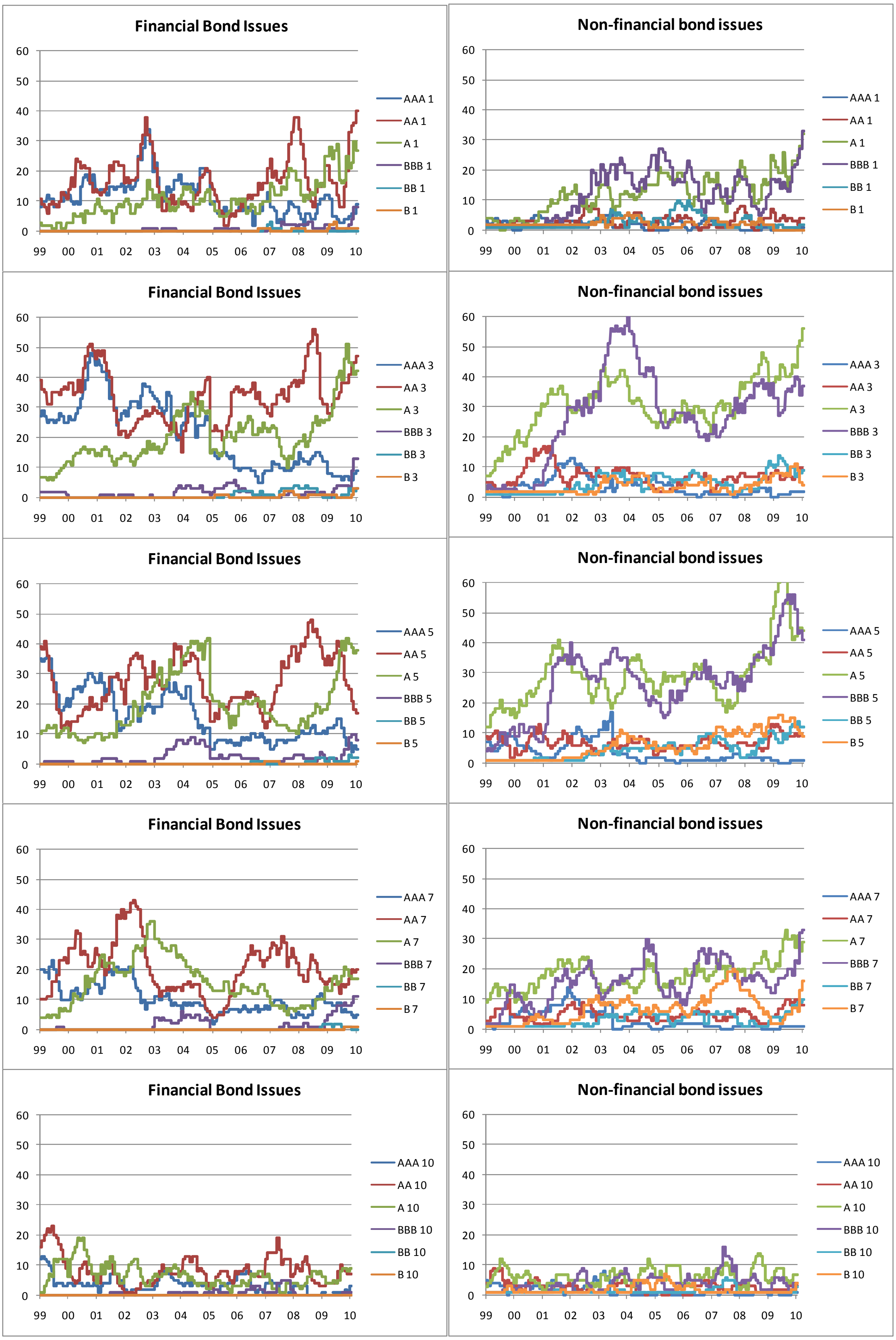

Figure 2: Number of financial and non-financial bond issues in different rating/maturity buckets ("1"=0.5-1.5Y, "3"=2.5-3.5Y...)

3.190 Within some rating buckets (esp. AA and A), strong effects of the spread increases of financial issuers during the financial crisis could be observed. Though financials outnumber non-financials in these rating buckets, the calibration assumes a more balanced investment policy of insurance undertakings. Hence issue-weighted indices have been calculated separately for both financial issues and non-financial issues within each rating/maturity bucket. Both indices were combined weighted by the number of issues in each index with a cap of 33.33% applied for the financials index.

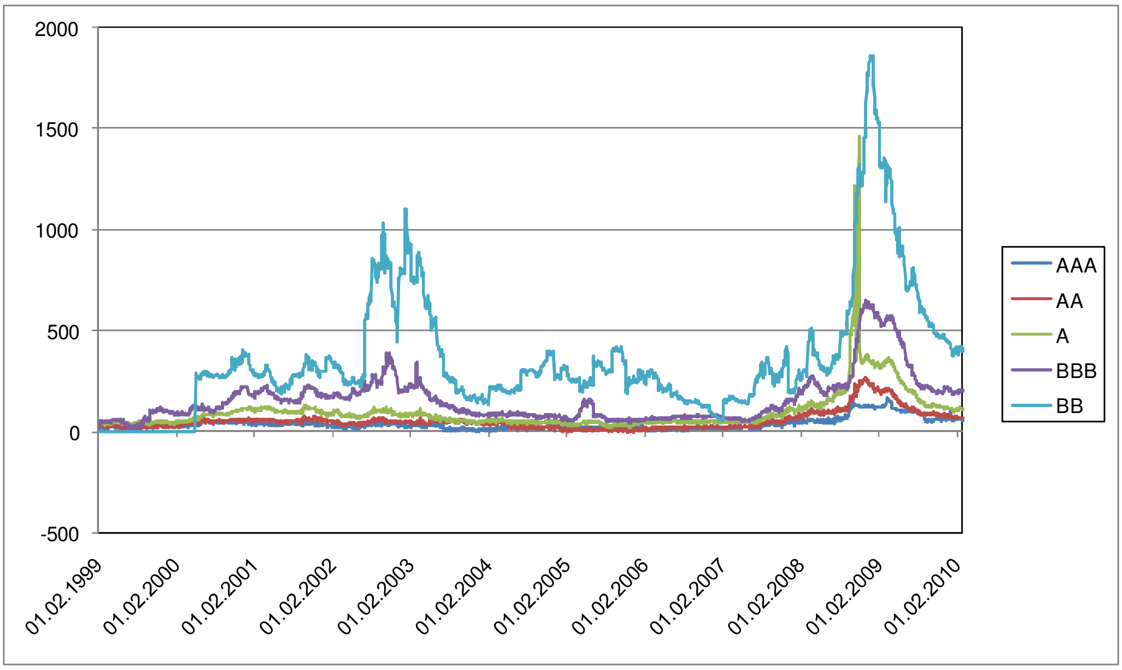

Figure 3: Spreads of bond portfolios (5 year maturity bucket, in basis points)

3.191 Especially for lower rating classes the monthly rebalancing led to severe jumps in the time series, e.g. when a sparsely populated index with only two or three members was amended by a similar number of issues with significantly diverging spreads. For reasons of simplicity, the spread move at the first trading day of each month was therefore set to zero.

Figure 4: 12-month-change in spreads of BB rated bonds, with and without rebalancing jumps (maturity: 6 years)

3.192 Each portfolio spread series (rating & maturity) was first transformed into a 3 month moving average function in order to smooth out short-term spikes. Then the rolling year-on-year difference was computed. Both the 99.5% quantile (for widening spreads) and the 0.05% quantile (for narrowing spreads) were determined.

3.193 Indices of structured credit products exhibit highly diverging performance patterns since the beginning of the crisis. It turned out that not only the tranche rating of a securitisation determines the price, but also (and even primarily) the type and quality of the assets in the securitised asset pool.

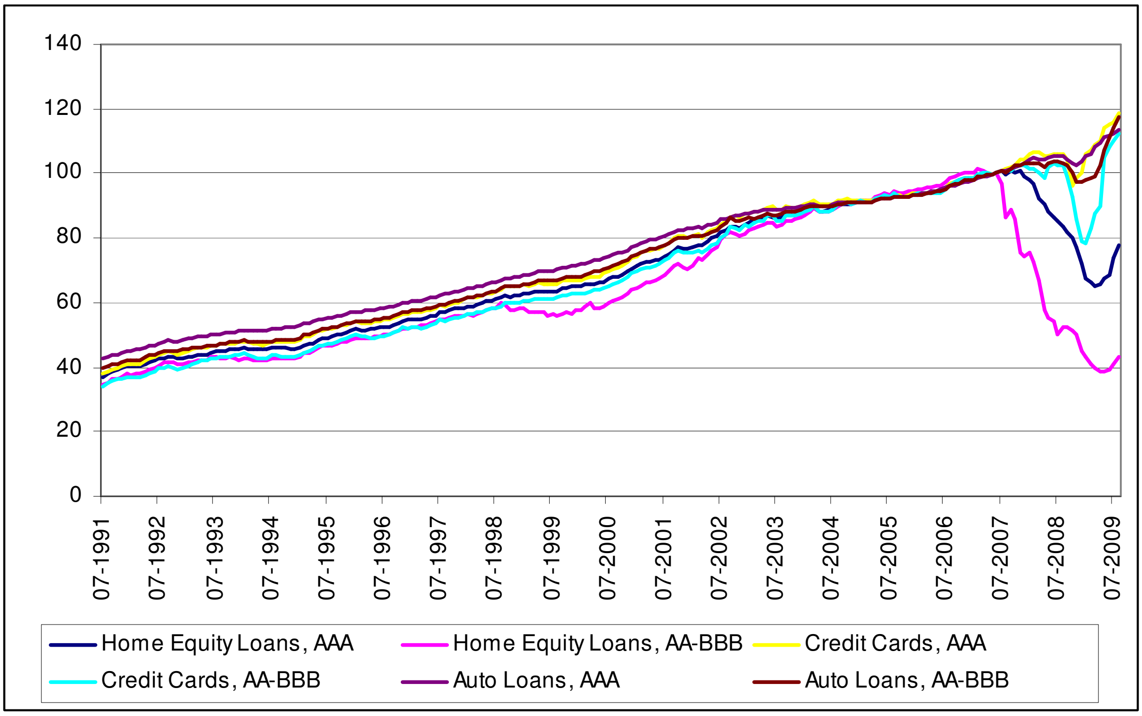

Figure 5: Merrill Lynch total return indices of various ABS structures (30/06/2007 = 100)

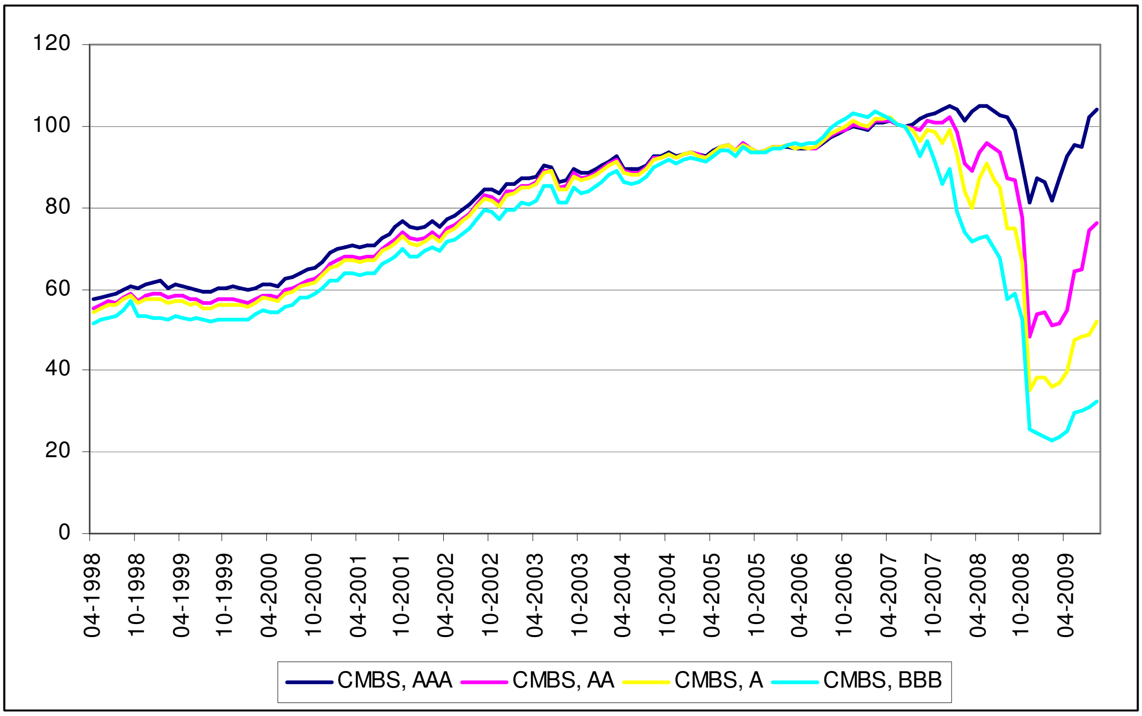

Figure 6: Merrill Lynch total return indices of various CMBS tranches (30/06/2007 = 100)

3.194 Hence, for structured credit products a model-based approach was used for the calibration. Based on the new rating methodology for Collateral Debt Obligations by Standard&Poor's, a set of hypothetical default rates for different rating classes and tenures of the assets within a securitised asset pool is used as model input. These default rates were calculated for highly diversified asset pools.[53]

Table 5: Scenario Default Rates[54]

Tenure (years)	**AAA**	**AA**	**A**	**BBB**	**BB**	**B**	**CCC**
1	0.8%	1.6%	4.7%	8.1%	20.9%	41.5%	65.9%
3	1.6%	3.1%	8.1%	14.7%	34.1%	59.7%	83.3%
5	2.3%	5.0%	10.9%	20.2%	43.0%	68.2%	88.4%
7	3.5%	7.4%	14.0%	25.2%	50.4%	73.3%	90.7%
9	4.7%	9.7%	17.1%	30.2%	56.2%	77.1%	91.9%

3.195 It should be noted that when deriving the calibration for the spread risk submodule, no ratings of structured credit instruments feed into the determination of the capital charge since such ratings were considered to be one of the reasons for the current financial crisis.[55] Instead, ratings of the underlying assets are used which represents a look-through approach to the ultimate risks of a securitised asset. The specific characteristics of the structured credit instrument (especially the subordination of the tranche) feed in as additional inputs.

Results

3.196 The table below summarises the spread shocks for different rating classes and maturity buckets of the bond portfolio.

Table 6: Calibration results for function F

F^{up}	**AAA**	**AA**	**A**	**BBB**	**BB**	**B**
0.50 - 1.49 years	2.63%	1.53%	3.97%	5.16%	15.49%	88.78%
1.50 - 2.49 years	0.95%	1.60%	2.52%	7.47%	15.10%	61.71%
2.50 - 2.49	1.74%	1.74%	3.19%	6.04%	15.87%	20.25%

[53] Standard&Poor's: Update to Global Methodologies And Assumptions For Corporate Cash Flow CDO and Synthetic CDO Ratings, 17 September 2009

[54] Standard&Poor's: Update to Global Methodologies And Assumptions For Corporate Cash Flow CDO and Synthetic CDO Ratings, 17 September 2009

[55] Commission Staff Working Document accompanying the Proposal for a Regulation of the European Parliament and of the Council on Credit Rating Agencies – Impact Assessment, SEC(2008)2745, 12 November 2008

years						
3.50 - 4.49 years	1.64%	1.43%	3.14%	5.88%	23.60%	17.27%
4.50 - 5.49 years	0.83%	1.79%	4.96%	4.42%	11.71%	15.62%
5.50 - 6.49 years	0.64%	1.63%	2.98%	5.07%	6.83%	16.49%
6.50 - 7.49 years	1.91%	1.41%	3.05%	5.74%	4.33%	22.05%
7.50 - 8.49 years	1.11%	1.52%	2.61%	4.46%	4.04%	13.93%
8.50 - 9.49 years	0.65%	1.34%	2.59%	5.58%	4.62%	11.48%
9.50 - 10.49 years	0.61%	1.19%	1.50%	1.79%	9.95%	12.44%
10.50 years+	1.06%	1.45%	1.76%	2.81%	3.42%	n.a.
F^{down}	**AAA**	**AA**	**A**	**BBB**	**BB**	**B**
0.50 - 1.49 years	-0.83%	-1.06%	-2.06%	-2.88%	-13.63%	-14.56%
1.50 - 2.49 years	-0.38%	-1.13%	-1.87%	-5.41%	-17.19%	-18.37%
2.50 - 2.49 years	-0.47%	-1.12%	-1.92%	-3.81%	-16.25%	-13.98%
3.50 - 4.49 years	-0.50%	-1.16%	-1.93%	-1.71%	-8.21%	-5.28%
4.50 - 5.49 years	-0.29%	-1.29%	-3.56%	-3.64%	-7.34%	-11.61%
5.50 - 6.49 years	-0.33%	-1.12%	-1.84%	-4.59%	-5.28%	-9.38%
6.50 - 7.49 years	-0.41%	-1.27%	-1.44%	-3.2%	-4.83%	-7.45%
7.50 - 8.49 years	-0.69%	-0.91%	-2.24%	-3.91%	-5.96%	-19.56%
8.50 - 9.49 years	-0.33%	-1.17%	-0.83%	-2.65%	-3.76%	-1.85%
9.50 - 10.49	-0.36%	-0.64%	-2.55%	-2.60%	-6.60%	-4.85%

years						
10.50 years+	-0.41%	-0.75%	-1.51%	-2.81%	-1.01%	n.a.

3.197 As some of the buckets exhibit some abnormal results due to low representativeness, an asymmetrically truncated mean was calculated by deleting the two highest absolute values and calculating the mean with the results for the nine remaining buckets.

3.198 A duration floor of 1 should be applied to all rating classes as well as duration caps for the lower rating classes, i.e. BBB or lower.

3.199 The final calibration of the functions $F^{up}(Rating_i)$ and $F^{down}(Rating_i)$ looks as follows:

Table 7: Final calibration proposal for function F

	$F^{up}(Rating_i)$	$F^{down}(Rating_i)$	Duration floor	Duration cap
AAA	1.0%	-0.4%	1	-
AA	1.5%	-1.0%	1	-
A	2.6%	-1.7%	1	-
BBB	4.5%	-3.0%	1	7
BB	8.4%	-6.3%	1	5
B or lower	16.2%	-8.6%	1	3.5
Unrated	5.0%	-3.3%	1	7

3.200 For structured credit, function G basically mirrors Table 5, amended by values for unrated assets which are based on the figures for BBB-rated assets with a similar mark-up as used in the sub-module for corporate bonds:

Table 8: Final calibration proposal for function G

$G(ratingdist_i, tenure_i)$	AAA	AA	A	BBB	BB	B	CCC or lower	Unrated
0-1.9 years	0.8%	1.6%	4.7%	8.1%	20.9%	41.5%	65.9%	9.7%
2-3.9 years	1.6%	3.1%	8.1%	14.7%	34.1%	59.7%	83.3%	17.6%
4-5.9 years	2.3%	5.0%	10.9%	20.2%	43.0%	68.2%	88.4%	24.2%
6-7.9 years	3.5%	7.4%	14.0%	25.2%	50.4%	73.3%	90.7%	30.2%
8+ years	4.7%	9.7%	17.1%	30.2%	56.2%	77.1%	91.9%	36.2%

3.201 Recovery rates are taken into account according to function R:

Table 9: Final calibration proposal for function R

R(ratingdist$_i$)	**AAA**	**AA**	**A**	**BBB**	**BB**	**B**	**CCC or lower**	**Unrated**
Recovery rate	50%	45%	40%	35%	30%	25%	20%	35%

3.202 When calculating Mkt_{sp}^{struct}, a cap of 100% of MV_i and a floor of 10% of MV_i are applied. The floor was determined based on a VaR calculation for the itraxx main index.[56] As this time series is only available since 2004, it is not used as the main input for the calibration of the spread risk submodule.

3.203 If the originator of a structure credit product does not comply with the 5% net retention rate foreseen in the CRD (2006/48/EC), the capital charge for the product should be 100%, regardless of the seniority of the position.

3.204 For credit derivatives a scenario-based approach is followed. According to CP 47, credit derivatives encompass credit default swaps (CDS), total return swaps (TRS), and credit linked notes (CLN), where:

- the (re)insurance undertaking does not hold the underlying instrument or another exposure where the basis risk between that exposure and the underlying instrument is immaterial in all possible scenarios; or
- the credit derivative is not part of the undertaking's risk mitigation policy.

3.205 For credit derivatives, the capital charge Mkt_{sp}^{cd} is determined, after netting with offsetting corporate bond exposures, as the change in the value of the derivative (i.e. as the decrease in the asset or the increase in the liability) that would occur following (a) a widening of credit spreads by 600% if overall this is more onerous, or (b) a narrowing of credit spreads by 75% if this is more onerous. A notional capital charge should then be calculated for each event. The capital charge should then be the higher of these two notional changes.

3.206 Exposures secured by real estate should receive a credit risk treatment that is consistent with the treatment under Directive 2006/48/EC, appendix VI section 9. Under spread risk, an additional category Mkt_{sp}^{re} should be introduced. Mkt_{sp}^{re} relates only to direct exposures to borrowers covered by real estate collateral. Exposures via structured products such as Mortgage Backed Securities and exposures through covered bonds do not fall within the scope of this submodule.

3.207 The capital charge for the spread risk of exposures secured by real estate is determined as follows:

[56] Refer to Annex II of CEIOPS-DOC-66/10 for details.

$$Mkt_{sp}^{re} = 8\% \bullet \sum_i \left(RW_i^{\sec} \bullet Secured_i + RW_i^{un\sec} \bullet \max\left(Exposure_i - Secured_i ;0\right)\right)$$

where

$Exposure_i$ = the total mortgage exposure to borrower *i*

$Secured_i$ = the fully and completely secured part of the exposure to borrower *i*, calculated as the part of the exposure covered by real estate collateral after application of the haircut

RW_i^{sec} = the risk weight associated with the fully and completely secured part of the exposure to borrower *i*

RW_i^{unsec} = the risk weight associated with the unsecured part of to exposure to borrower *i*

3.208 The fully and completely secured part of the exposure is that part of the mortgage exposure that is covered by real estate collateral, after application of a haircut to that collateral value. It should also meet the conditions given in Directive 2006/48/EC, appendix VI section 9.

3.209 The haircut to be applied to the value of real estate collateral is 25% for residential real estate and 50% for commercial real estate. Therefore, the fully and completely secured part of the exposure is equal to 75% of the value of residential real estate collateral, and 50% of the value of commercial real estate collateral.

3.210 The applicable risk weights are similar to the risk weights in Directive 2006/48/EC, appendix VI section 9. Any future changes in Directive 2006/48/EC on the risk weights in particular or on the Standardised Approach treatment of exposures secured by real estate in general should also lead to changes in the calculation of Mkt_{sp}^{re}.

3.211 For residential property a risk weight of 35% applies to the fully and completely secured part of exposure *i* in the following circumstances:

- Exposures or any part of an exposure fully and completely secured, to the satisfaction of the competent authorities, by mortgages on residential property which is or shall be occupied or let by the owner, or the beneficial owner in the case of personal investment companies.
- Exposures fully and completely secured, to the satisfaction of the competent authorities, by shares in Finnish residential housing companies, operating in accordance with the Finnish Housing Company Act of 1991 or subsequent equivalent legislation, in respect of residential property which is or shall be occupied or let by the owner.
- Exposures to a tenant under a property leasing transaction concerning residential property under which the insurer is the lessor and the tenant has an option to purchase, provided that the competent authorities are satisfied that the exposure of the insurer is fully and completely secured by its ownership of the property.

3.212 If the secured part of exposure *i* does not fall within the circumstances stated in the previous paragraph, or if the conditions given in Directive 2006/48/EC, appendix VI section 9 are not met, it cannot be treated as fully and completely secured. In that case, a risk weight of 100% will be applied. The unsecured part of exposure *i* also receives a risk weight of 100%.

3.213 For commercial property a risk weight of 100% is applied to both the fully and completely secured part and the unsecured part. A risk weight of 50% is applied to the fully and completely secured part *only* if the conditions given in Directive 2006/48/EC, appendix VI section 9 are met..

3.214 Fully and completely secured exposures receive a risk weight of 0% if these exposures are guaranteed by an OECD or EEA government, and if these exposures are in the currency of the government. This applies to both residential and commercial real estate.

3.215 Note that the market value of exposures secured by real estate is generally subject to interest rate risk. These exposures should therefore also be included in the interest rate risk submodule. Note further that property risk on the collateral value is already included in the Mkt_{sp}^{re} calculation, so that also including it in the property risk submodule would lead to double counting. The property risk submodule does therefore not apply to exposures secured by real estate.

3.1.6 Concentration risk[57]

3.216 The calibration of this sub-module is based on quite simple evidence: the risk (volatility - VaR) of a badly diversified portfolio is higher than in the case of a well-diversified basket of investments.

3.217 The calibration process, detailed below, is based on the comparison of the historical VaR of a well-diversified portfolio and the VaR of a set of portfolios where the representativeness of a concrete exposure is increased step by step by 1 per cent. In other words, the initially well-diversified portfolio is progressively being transformed in a more and more badly diversified portfolio, by increasing successively the importance of a single concrete exposure.

3.218 In each step the initial VaR (well-diversified portfolio) is compared to the VaRs of the progressively worsened portfolios, deriving a raw line charting the 2-dimensional link between the increase in the level of concentration of investments and the increase of VaR. Fitting a straightforward function is the final step to deliver the parameters reflected in this advice.

[57] This section follows Annex A of CEIOPS-DOC-40/09

3.219 The aforementioned process is repeated for each of the exposures of the initially well- diversified portfolio, in order to derive specific parameters for exposures with different credit quality.

3.220 The general goal of this calculation is to provide a workable evidence of the impact that a concentration in a single counterparty may have in the risk profile of a well-diversified portfolio of assets.

3.221 The methodology applied for this purpose is in its essence that used to calibrate QIS4, since it did not pose any practical problem or conveyed misleading results.

3.222 This method may be described as follows:

First step

3.223 **The starting point is the design of a well-diversified portfolio of investments in individual names with the following characteristics:**

- The portfolio has a mix, representative of EU average undertakings' portfolios of investments in bonds and equities. The mix proposed is 80% - 20% corresponding bonds – equities respectively according the data of asset allocation 2008 released by CEIOPs.[58]
- Within each of these two groups, a sector-distribution of investments is built, also according to an EU expected average, as follows:
  a. Investment in bonds: We have assumed that 25 % of total portfolio is invested in risk-free bonds. Then 55% of the total portfolio (55=100-20-25) is invested in corporate bonds of different sectors and ratings as described below.
  b. Investment in equities: To the extent that this exercise assumes as starting point a well-diversified portfolio, consequently it should replicate some equity index sufficiently representative and well-known. In a first instance the selected names were those belonging to the index **Eurostoxx 50**, and the period used to record data of prices, ranges **from 1993-april-1 until 2009-april-30th**. The length of this period guarantees sufficient historical data to derive VaR 99.5% with a high degree of reliability.
  c. After having collected the data prices, an individual assessment of the historical vector of prices for each equity has revealed that for a number of elements of the index the records of data prices are only available for a significantly shorter period than that above mentioned or are not homogeneous[59].

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[58] The mix used in QIS4 was 30-70 according the data existing with reference to 2007.

[59] As part of the initial steps of calibration exercise of concentration risk, a complete set of tentative checking-tests was carried out to optimize the design of the method. The outputs of these preliminary calculations may be summarized as follows:

d. Therefore, to obtain a sufficiently numerous and well-diversified portfolio, after filtering the components of Eurostoxx 50 as mentioned above, other additional names have been added to complete all the buckets of the cross-table resulting from, on one dimension rating categories considered, and on the other dimension economic sectors included in this exercise. These additional elements have been chosen aiming also a wider geographical representativeness than that derived from Eurostoxx 50.

Description of bonds-portfolio

3.224 In order to avoid the effect of the change in Macaulay Duration (as times goes by and the life of the bond shortens), the effect of renewal of the investment once matured[60] and, what is more important, to reflect the whole risk belonging to each sector/rating it was decided:

- Bonds used in the computation are notional bonds, all of them issued at 5% rate and pending 5 years to maturity. At any moment of the simulation each bond maintain these features (which could be accepted as representative average features of the bonds existing in insurance portfolios)
- To capture and summarize market information about each sector/rating, notional bonds described in point 1) are valued with Bloomberg corporate yield curves, according the corresponding sector/rating. The following table lists these yield curves:

1	F888 EUR BANK AAA
2	F462 INDS AA+
3	F890 BANK AA
4	F580 UTIL AA
5	F892 BANK A

- Dealing with concentration risk requires obviously the use, as starting point, of a sufficiently high number of exposures,
- Nevertheless, as important as the number of different exposures is to guarantee that the selected names reflect a variety of behaviours sufficiently disperse, in such a way that almost all existing and possible equities/bonds fall in the range of behaviours considered
- Under the above assumption, increasing the number of names did not have a significant added value (the outputs were rather similar), while the computational burden increases and the analysis of a higher number of names became less transparent.

[60] This avoids contaminating the method with a rather arbitrary decision, since one should have to select a replacing bond to substitute those previously matured.

6	F583 UTIL A
7	F465 INDUS A
8	F898 BANK BBB
9	F625 TELEF A
10	F468 INDUS BBB
11	F469 INDUS BBB-
12	F682 TELEF BBB+
13	F470 INDUS BB

3.225 Finally, the first step of the calibration exercise has calculated the historic 1-year VaR 99.5% of a mixed portfolio (20% invested in the equities portfolio, 25% in risk-free bonds and 55% in corporate bonds). This measure is calculated twice:

- Firstly, taking into account all the names and its corresponding yield curves as listed above:

  VaR (99.5 %) = 21.73 %

- Secondly, excluding worse than BBB names and its corresponding yield curve, as listed above.

  VaR (99.5 %) = 17.27 %

- In both cases, risk-free bonds are priced with the German sovereign curve.

3.226 As one can appreciate, there is sufficient rationale to calibrate firstly BB polynomial using the whole portfolio and afterwards, in a second step, to calibrate BBB, A and AA-AAA polynomial with a less volatile portfolio. Also a calibration using less rating classes may give some confirmation of results obtained with a wider range of ratings.[61]

Second step: Concentrating exposures in the initial portfolio

3.227 First of all, we have established a bijective correspondence between each equity name and one of the interest rates curves above listed, taking into account its sector / rating. This means that when we concentrate the whole portfolio we concentrate at the same time the investment in the selected equity and its correspondent notional bond.

3.228 The exercise begins selecting a concrete name with a certain rating, (i.e. a bank rated AA) and its relevant notional bond (Banks AA). Then, we increase in steps of 1 per cent its total weight in respect of the whole portfolio, obviously reducing simultaneously the participation of the rest of

[61] One has to bear in mind that due their high volatility, considering BB curve and BB-B equities increases (in relative terms) the goodness of the rest of names/ratings.

counterparties (to isolate purely the effect of concentration on the selected name).

3.229 Increases of concentration levels range from the starting weight up to the starting weight plus 70%, (as above mentioned, using 1% steps). For each level of concentration, we calculate the difference between the historic 1-year VaR 99.5% of the starting portfolio (well-diversified) and historic 1-year VaR 99.5% of the concentrated portfolio, and this difference is considered a raw proxy of an eventual concentration charge (it is called *Variation VaR.*)

3.230 Points of raw-concentrations charges obtained in the successive increases of concentration for each name are drawn, interpolating a straight line, and then deriving the parameter g.

3.231 Thus, for each level of rating *i* we will have:

$$Conc_i = Assets_{xl} \bullet XS_i \bullet g$$

Third step: The same procedure is repeated for names rated AA, A, BBB and worse than BBB, and for different sectors

3.232 Note that the initial investment in risk-free bonds remains unchanged. Therefore **concentration** exercise refers to the whole equity portfolio and the non-risk-free bonds portfolio.

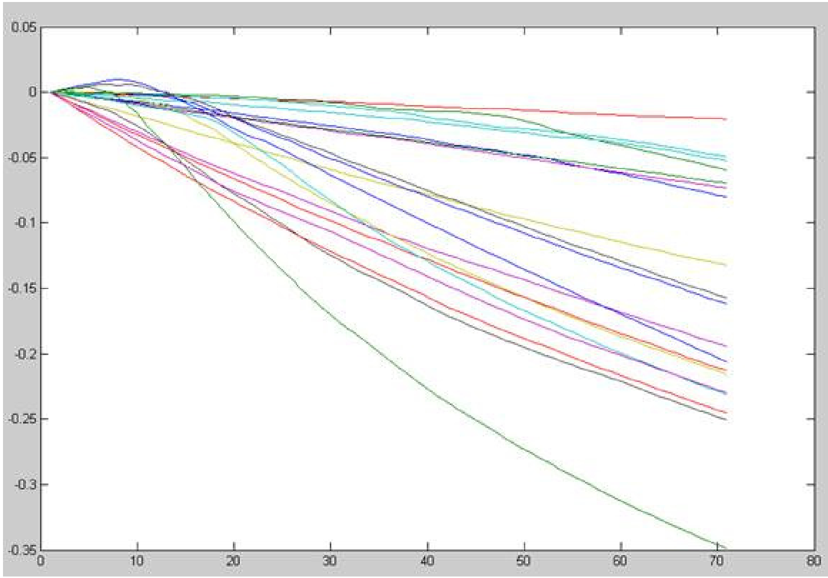
3.233 Once reached this point and analysed the graphs obtained, the interpolation of a straight line is carried out taking into account the worst-behaved names are. This criterion is necessary to guarantee the consistency of the calibration exercise with the rationale grounding the standard SCR formula, which focus on stressed scenarios.[62]

Final result

3.234 The following chart graphs an example of the different runs where all ratings and sectors are considered.

[62] Due to its own characteristics, the mean VaR for each group of rating (BB, BBB, A and AA-AAA), tends to smooth the risk of concentration, thus understating the corresponding capital charge.

Worsening of VaR when a well-diversified portfolio (left common point to all curves) is transformed in badly diversified portfolio



Lines = effect of concentrating in different ratings and sector
Horizontal edge: Degree of concentration in each run

3.235 According the advice, financial concentration risk model for each group of rating *i* is calculated with the following formula:

$$Conc_{\boldsymbol{i}} = Assets * XS_{\boldsymbol{i}} * g + \Delta Liab_{\text{future profits}}$$

where

XS_i = Excess exposure at each group of rating *i*

3.236 The values resulting from the fitting are

$rating_i$	Credit Quality Step	G
AAA	1	0.12
AA		
A	2	0.21
BBB	3	0.27
BB or lower, unrated	4 – 6, -	0.73

3.237 This calibration delivers similar parameters to those used in QIS4 (0.15, 0.18, 0.30 and 0.73, respectively) which gives some cross-check of the quality of the calibration process. This stability of the comparative results of both pre and post-crisis calibrations is reasonable, to the extent that the calibration of this module does not base on the absolute VaR, but on the comparison of the VaR of a well-diversified portfolio and the VaR of concentrated portfolios[63].

3.2 Counterparty default risk[64]

3.238 According to the outset of the counterparty default risk module, the following parameters of the formula need to be specified:

- the parameter-ratio α/τ of the loss distribution for type 1 exposures,
- the factor q, that defines the 99,5%-quantile of the loss distribution for type 1 exposures,
- the probabilities of default assigned to the rating classes of type 1 exposures,
- the probabilities of default assigned to unrated type 1 counterparties that are subject to Solvency II supervision,
- the recovery rates RR_{re} and RR_{fin},
- the risk factors x and y for type 2 exposures, as well as the number of months T, that define the threshold for past-due receivables of intermediaries, and
- the thresholds to define when deposits with ceding institutions and called up but unpaid commitments are treated as type 1 or type 2 exposures.

The parameters α and τ of the loss distribution for type 1 exposures

3.239 The calculation of the SCR for type 1 exposures is based on a model that splits the average default probability p_i of counterparty i in a baseline default probability b_i and a shock-induced component[65]. The shock induced components are assumed to be correlated, connected by an underlying shock-distribution. This correlation is shaped by an parameter-ratio α/τ. The dynamics of the model can be described by the following equations:

The baseline default probability of counterparty *i:*

[63] In the same line, absolute VaR figures on top of page 22 are significantly higher than those obtained in QIS4 (even reducing the mix of equities from 30 to 20 per cent). Once again a cross-check of results in both calibrations shows consistent outputs.

[64] This section follows CEIOPS-DOC-23/09

[65] See CEIOPS-DOC-23/09, Annex A.

$$b_i = \frac{p_i}{\frac{\alpha}{\tau}(1-p_i)+1}$$, and

the correlation between the default probabilities of counterparties *i* and *j*.

$$\omega_{ij} = \frac{\frac{\alpha}{\tau}(1-b_i)(1-b_j)}{\frac{\alpha}{\tau}+b_i^{-1}+b_j^{-1}} - (p_i - b_i)(p_j - b_j).$$

3.240 Note that

$$\frac{db_i}{d\left(\frac{\alpha}{\tau}\right)} < 0 \text{ and } \frac{d\omega_{i,j}}{d\left(\frac{\alpha}{\tau}\right)} > 0.$$

Thus, the higher the ratio α/τ, the higher is the shock-induced component of p_i, and, since the default probabilities of the individual counterparties are only connected via this component, the higher is their correlation.

To get an impression of the impact of α/τ, note that

$$\lim_{p_i -> 0} \frac{p_i}{b_i} = \frac{\alpha}{\tau} + 1.$$

To give an example, if $\alpha/\tau = 0.5$, then $p_i \approx 1.5b_i$, and if $\alpha/\tau = 4$, then $p_i \approx 5b_i$.

3.241 The current financial crisis has shown that

- the default probability of a counterparty can vary significantly over time, and
- there is a significant dependence between defaults.

Empirical data to assess the variance or covariance of reinsurance undertakings and issuers of derivatives is rare. Nevertheless, default statistics of corporate bonds indicate that volatility in market default rates is high[66]. The average default probability of this kind of debt seems to be a multiple of the

[66] See Moody's Investor Service »Moody's Global Credit Policy - Corporate Default and Recovery Rates, 1920-2008«, February 2009:

http://v2.moodys.com/cust/content/content.ashx?source=StaticContent/Free%20Pages/Credit%20Policy%20Research/documents/current/2007400000578875.pdf;

or Standard & Poor's »Default, Transition, and Recovery: 2008 Annual Global Corporate Default Study And Rating Transitions«, April 2009.

baseline default probability. On this basis it appears to be reasonable to set the $\alpha / \tau = 4$.

The quantile factor q

3.242 The model provides a loss distribution for the counterparty default risk of the portfolio of type 1 exposures. While the shape of the distribution may be complex, the mean and the variance of the distribution can easily be calculated. The 99.5% quantile is estimated by multiplying the standard deviation of the distribution with a quantile factor *q*.

3.243 The determination of the quantile factor is not a simple task. The shape of the distribution depends both on the probability of default of the counterparties in the portfolio as well as their number. However, if it is assumed that the portfolio is sufficiently diversified or the credit quality of the counterparties is high, it appears to be appropriate to base the factor on a skewed distribution like the lognormal distribution. In this case, the quantile factor should be set at $q = 3$.

3.244 If the portfolio is dominated by one or a small number of exposures with a high probability of default, the above mentioned assumption cannot be made as the resulting distribution is considerably more skewed than the lognormal distribution. In this case, a higher quantile factor should be chosen. If the standard deviation of the loss distribution exceeds 5% of the overall loss-given-default for type 1 exposures, the quantile factor should be set at $q = 5$. This higher quantile factor applies to portfolios with a credit quality of worse than BBB.

Probability of default p_i per rating class

3.245 CEIOPS-DOC-23/09 does not advise on the probabilities of default (p_i) assigned to the rating classes of type 1 exposures. But since these are required for the calibration of the model, we propose to follow the reasoning of CEIOPS-FS-23/07 and to determine them as in QIS4: [67]

$Rating_i$	**Credit Quality Step**	**p_i**
AAA	1	0.002%
AA		0.01%
A	2	0.05%

[67] Note that the default probabilities are not only required to calculate the SCR of type 1 exposures, but for type 2 exposures as well, because the determination of the risk factor *x* is based on a rating-default-matrix (see CEIOPS-DOC-23/09 Annex B, and below).

BBB	3	0.24%
BB	4	1.20%
B	5	6.04%
CCC or lower	6, -	30.41%

Probabilities of default per solvency ratio rating

3.246 The probability of default PD_i of an unrated type 1 counterparty that is subject to Solvency II supervision is derived via the formula

$$PD_i = \begin{cases} 0.5\% \cdot \left(\frac{OF_i + \lambda \cdot SCR_i}{SCR_i + \lambda \cdot SCR_i} \right)^{-a} & , \frac{OF_i}{SCR_i} \geq 1 \\ 0.5\% \cdot \left(\frac{OF_i}{SCR_i} \right)^{-a} & else. \end{cases}$$

Thus, PD_i is defined by the own funds and the SCR of counterparty *i* and the two parameters λ and a. CEIOPS proposes to set these parameters at $\lambda = 0.5$ and $a = 6$. Thus, the solvency ratio rating can be derived as follows:

OF/SCR	PD
> 200 %	0.025 %
> 175 %	0.050 %
> 150 %	0.1 %
> 125 %	0.2 %
> 100 %	0.5 %
> 90 %	1 %
> 80 %	2 %
≤ 80 %	10 %

Recovery rates

3.247 The recovery rates RR_{re} and RR_{fin} for reinsurance arrangements and derivatives should reflect a prudent estimate of the relative share of the stressed credit exposure that still can be collected in case of the default of the counterparty.

3.248 In QIS4, for both RR_{re} and RR_{fin} a value of 50% was used. This calibration was based on expert opinion because empirical data on recoverable rates of reinsurance arrangements and derivatives is rare. There are indications that support this choice for reinsurance arrangements:

- Long-time studies of corporate bonds indicate that the QIS4 choice would reflect the recovery rate of corporate bonds.[68]

- For defaulted reinsurance counterparties, an assumed recovery rate in the range of 50% seems to reflect best practice.[69]

CEIOPS proposes to keep the recoverable rate for RR_{re} at 50%. However, if the counterparty has tied up an amount for collateralisation commitments (both on and off balance sheet, including commitments to other parties) greater than 60% of the assets on its balance sheet, the recovery rate is assumed to be 10% rather than 50%.

3.249 The current financial crisis has shown that banks and other issuers of derivatives can incur unprecedented losses which significantly diminish their ability to clear debt. In some cases, for example American Insurance Group Inc., the issuance of derivatives and their leverage effect was a main cause of the losses. The recovery rates observed for many banks which defaulted during the crisis are relevantly lower than 50%[70]. For instance, in 2008, Lehman Brothers had a recovery rate of 9.3%, and the three major Icelandic banks had recovery rates of 4.0% and less. For these reasons, the QIS4 calibration should be adapted. A value of 10% for the recovery rate of defaulted derivatives (RR_{fin}) appears to be justified.

The risk factors x,y for type 2 exposures

3.250 For type 2 exposures the capital requirement is calculated by multiplying the market value of the exposure with a fixed risk factor x.

3.251 In order to achieve consistency between the treatment of type 1 and type 2 exposures, the calibration of x applies the approach for type 1 exposures to a model portfolio of type 2 exposures. Based on the assumptions that

- the probability of default of the type 2 counterparties is defined by a rating between BBB and BB,

- the portfolio of type 2 exposures is well diversified, and

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[68] Cf., for example, Moody's Investor Service »Moody's Global Credit Policy - Corporate Default and Recovery Rates, 1920-2008« , February 2009.

[69] Cf., for example, Mark Flower et al. »Reinsurance counterparty credit risk – Practical suggestions for pricing, reserving and capital modelling«, July 2007, page 18: http://www.actuaries.org.uk/__data/assets/pdf_file/0014/31307/BHPrize_Flower.pdf.

[70] See Moody's Investor Service »Moody's Global Credit Policy - Corporate Default and Recovery Rates, 1920-2008« February 2009, page 8.

- a third of the exposure can be collected in case of default

a risk factor of *x* = 15% can be derived:

$$x = \left(1 - \frac{Collectibles}{Exposure}\right) \cdot \frac{1}{2}\left(\frac{SCR_{def,1}(BBB)}{LGD_{def,1}(BBB)} + \frac{SCR_{def,1}(BB)}{LGD_{def,1}(BB)}\right)$$

$$= (1 - 33\%) \cdot \frac{1}{2}(9.3\% + 34.5\%) \approx 15\%,$$

where

$\frac{SCR_{def,1}(.)}{LGD_{def,1}(.)}$: as in Annex B.8 of CEIOPS-DOC-23/09.

3.252 CEIOPS proposes a special treatment for past-due receivables towards intermediaries, in order to allow for the higher probability of default of these exposures. On a 99.5% quantile level, the collection of these receivables is very doubtful. Therefore, a risk factor of *y* = 90% appears to be appropriate. It should be applied to intermediary receivables which are past-due for more than *T* = 3 months.

The threshold to distinguish between type 1 and type 2 exposures

3.253 The assignment of deposits with ceding institutions and called up but unpaid commitments to the classes of type 1 or type 2 exposures should depend on the number of independent counterparties. This decision was based on practicability considerations; if the number of counterparties is too large, the proposed approach for type 1 exposures becomes impracticable.

3.254 An appropriate choice for the threshold could be a number of 15 counterparties. In relation to this threshold, deposits with ceding institutions and called up but unpaid commitments should be assessed independently. For determining the number of independent counterparties, those counterparties that belong to one group should be treated as one independent counterparty.

3.255 The undertaking will still be allowed to classify these deposits with ceding institutions and called up but unpaid commitments as type 1 exposures. However, the undertaking must classify all such exposures as type 1 or as type 2.

3.3 Life underwriting risk

3.256 A number of the life underwriting risk stresses are based on a delta-NAV (change in value of assets minus liabilities) approach. The change in net asset value should be based on a balance sheet that does not include the risk margin of the technical provisions. This approach is based on the assumption that the risk margin does not change materially under the scenario stress.

This simplification is made to avoid a circular definition of the SCR since the size of the risk margin depends on the SCR.

3.257 Furthermore, where a delta-NAV approach is used, the revaluation of technical provisions should allow for any relevant adverse changes in option take-up behaviour of policyholders in this scenario.

3.258 Underwriting risks can affect an undertaking's liabilities as well as its assets. The scope of the life underwriting module is not confined to the liabilities.

3.259 The calibration of the life underwriting parameters should capture changes in the level, trend and volatility of the parameter. However, for QIS3, it was decided to reduce the complexity of the design of the underwriting risk module by maintaining the level and trend risk components only. It is assumed that the volatility risk component is implicitly covered by the level, trend and catastrophe risk components. This is considered to be acceptable since, for QIS2, the volatility risk proved to be considerably lower than the trend risk. CEIOPS therefore proposes to retain this approach.

3.260 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, incorporating the experience from the current crisis. 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.

3.3.1 Mortality risk[71]

Mortality risk in QIS4

3.261 The QIS4 approach to the SCR standard formula included a mortality risk sub-module in the life underwriting risk module (section TS.XI.B of the QIS4 Technical Specifications (MARKT/2505/08)). The calculation of the capital requirement for mortality risk was a scenario based stress. The scenario tested was a permanent 10% increase in mortality rates.

3.262 QIS4 feedback from several Member States suggested that a gradual change to inception rates and trends would be more appropriate than a one-off shock for biometric risks.

3.263 QIS4 feedback on the calibration of the mortality stress was varied. Some undertaking felt that the calibration was too strong and without sufficient granularity whereas other undertakings thought that the calibration was below the 99.5th percentile.

[71] This section follows CEIOPS-DOC-42/09

Calibration of mortality stress

3.264 The basis for the QIS4 calibration of the mortality risk stress is described in the CEIOPS paper "QIS3 Calibration of underwriting risk, market risk and MCR". This paper is available from the CEIOPS website72.

3.265 As mentioned above, QIS4 feedback on the calibration of the mortality stress was varied. However an analysis of the mortality stress parameters provided by firms using internal models indicated that the standard formula parameter was relatively low. Based on a sample size of 21 internal model, the median stress was 22%, with an inter quartile range of 13% to 29%. This is significantly higher than the standard formula calibration of 10%.

3.266 CEIOPS therefore proposes to amend the calibration of the mortality stress to a permanent increase in mortality rates of 15%.

3.3.2 Longevity risk[73]

Longevity risk in QIS4

3.267 The QIS4 approach to the SCR standard formula included a longevity risk sub-module in the life underwriting risk module (section TS.XI.C of the QIS4 Technical Specifications (MARKT/2505/08)). The calculation of the capital requirement for longevity risk was a scenario based stress. The scenario tested was a permanent 25% decrease in mortality rates.

3.268 QIS4 feedback from several Member States suggested that a gradual change to inception rates and trends would be more appropriate than a one-off shock for biometric risks.

3.269 With regard to the calibration of the longevity stress, several undertakings argued for an age and duration dependent treatment of longevity, reinforcing more general comments that a one-off shock is not the most appropriate form of stress for biometric risks. An improvement of x% per annum (over base mortality) was suggested as an alternative by one respondent.

3.270 Some undertakings felt the longevity shock was too conservative.

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[72] http://www.ceiops.eu/media/files/consultations/QIS/QIS3/QIS3CalibrationPapers.pdf

[73] This section follows CEIOPS-DOC-42/09

Calibration of longevity stress

3.271 The basis for the QIS4 calibration of the longevity risk stress is described in the CEIOPS paper "QIS3 Calibration of underwriting risk, market risk and MCR".74

3.272 Subsequent to QIS4, an investigation has been carried out by the Polish FSA which analysed the mortality data for nine countries indicated based both on historic improvements and a stochastic model of future mortality improvements.

3.273 The results of this analysis indicated that, on average (across the nine countries for which data was analysed), historic improvements in mortality rates over 15 years from 1992 to 2006 were higher than 25%. Although the results of the stochastic model of future mortality improvements may imply a lower stress, CEIOPS has attached more weight to the analysis of historic improvements because of the significant uncertainty inherent in modelling mortality.

3.274 Furthermore feedback from internal model firms as part of QIS4 indicates that the median stress was 25%.

3.275 CEIOPS therefore proposes to maintain the QIS4 calibration of the longevity risk stress i.e. the stress shall be based on a permanent 25% decrease in the mortality rates assumed in the calculation of best estimate.

Appendix: Longevity risk calibration analysis

3.276 For the purpose of the longevity risk calibration, CEIOPS has conducted two analyses:

- historic improvements in mortality rates,
- shocks of future improvements in mortality rates.

3.277 The analyses are based on the unisex mortality tables for 9 countries (DE, FR, England & Wales, ES, IT, SE, PL, HU, CZ) from 1992 till 2006 (15 years) from data available at www.mortality.org.

<u>*Historic improvements in mortality rates*</u>

3.278 CEIOPS has analysed historic improvements in mortality rates from 1992 to 2006 as well as for shorter intervals (from 1992 to 1999 and from 1999 to 2006). The results of this analysis are presented below:

Table 1. Improvements in mortality rates from 1992 to 2006

Age	Average	DE	FR	UK[75]	ES	IT	SE	PL	HU	CZ

[74] http://www.ceiops.eu/media/files/consultations/QIS/QIS3/QIS3CalibrationPapers.pdf

band										
30-39	-39%	-46%	-40%	-9%	-46%	-45%	-34%	-34%	-55%	-38%
40-49	-25%	-28%	-19%	-12%	-19%	-29%	-31%	-26%	-28%	-35%
50-59	-22%	-22%	-13%	-23%	-19%	-30%	-23%	-19%	-17%	-29%
60-69	-29%	-32%	-25%	-34%	-26%	-35%	-27%	-26%	-22%	-32%
70-79	-27%	-30%	-25%	-29%	-26%	-31%	-25%	-28%	-22%	-30%
80-89	-20%	-22%	-24%	-19%	-18%	-23%	-16%	-22%	-20%	-20%
90-99	-11%	-7%	-15%	-6%	-9%	-14%	-6%	-15%	-21%	-10%

Table 2. Improvements in mortality rates from 1992 to 1999

Age band	Average	DE	FR	UK[76]	ES	IT	SE	PL	HU	CZ
30-39	-22%	-28%	-26%	-4%	-21%	-23%	-21%	-20%	-30%	-25%
40-49	-11%	-13%	-6%	-4%	-6%	-15%	-13%	-15%	-7%	-22%
50-59	-13%	-16%	-9%	-12%	-9%	-14%	-15%	-13%	-11%	-17%
60-69	-14%	-16%	-11%	-17%	-9%	-17%	-15%	-12%	-10%	-20%
70-79	-10%	-14%	-8%	-8%	-7%	-12%	-12%	-10%	-5%	-13%
80-89	-8%	-11%	-8%	-4%	-3%	-11%	-5%	-8%	-8%	-10%
90-99	-2%	-3%	-1%	-6%	2%	-4%	-1%	-3%	0%	0%

Table 3. Improvements in mortality rates from 1999 to 2006

Age band	Average	DE	FR	UK[77]	ES	IT	SE	PL	HU	CZ
30-39	-22%	-24%	-19%	-5%	-32%	-28%	-16%	-18%	-36%	-18%
40-49	-16%	-17%	-15%	-8%	-14%	-17%	-21%	-14%	-23%	-17%
50-59	-10%	-7%	-4%	-13%	-11%	-18%	-10%	-8%	-7%	-15%
60-69	-17%	-19%	-16%	-21%	-18%	-22%	-13%	-16%	-13%	-15%
70-79	-20%	-19%	-19%	-23%	-20%	-22%	-15%	-20%	-18%	-20%
80-89	-14%	-12%	-18%	-15%	-16%	-14%	-11%	-15%	-14%	-11%
90-99	-6%	-4%	-14%	-11%	-11%	-10%	-4%	-12%	21%	-10%

Shocks of future improvements in mortality rates

3.279 CEIOPS has also built a stochastic model to carry out prediction of future improvements in mortality rates. The model is similar to the stochastic model presented by Towers Perrin to the UNESPA[78].

[75] England&Wales

[76] England&Wales

[77] England&Wales

3.280 CEIOPS has calculated the mean and standard deviation of annual unisex mortality improvements in years 1992-2006 for each age for 9 countries. Assuming annual mortality improvements follow a Normal distribution[79], CEIOPS has simulated future mortality rates (1 000 simulations for each country). For each simulation CEIOPS build prospective mortality tables. Once these simulations have been carried out for different durations, CEIOPS compared the mean and the 99.5% percentile of the probability that someone aged *x* (*x* from given age band) will survive for *t* more years (*t* from coverage duration) - projected mortality improvement shock. Then CEIOPS transformed this shock to an equivalent one-off shock (a permanent change in mortality rates for each age) that probabilities that someone aged *x* will survive for *t* more years in one-off shock and in projected mortality improvement shock are the same.

Table 4. Average one-off shocks for future improvements in mortality rates according to age of insured person and outstanding duration of the contract.

Age band	**Coverage duration**						
	5	**10**	**15**	**20**	**25**	**30**	**WL[80]**
20-24	-18.2%	-17.0%	-17.1%	-15.7%	-15.6%	-15.5%	-21.8%
25-29	-17.6%	-17.0%	-15.0%	-14.1%	-14.6%	-14.6%	-20.9%
30-34	-16.6%	-14.2%	-13.2%	-13.4%	-13.5%	-13.0%	-20.1%
35-39	-13.3%	-11.9%	-12.0%	-12.5%	-11.9%	-10.8%	-19.1%
40-44	-11.0%	-11.1%	-11.7%	-11.1%	-10.1%	-9.1%	-18.3%
45-49	-10.7%	-11.0%	-10.1%	-9.3%	-8.2%	-11.8%	-16.9%
50-54	-11.2%	-9.7%	-8.4%	-7.5%	-11.2%	-15.1%	-15.4%
55-59	-9.3%	-7.9%	-7.2%	-11.1%	-14.5%	-18.1%	-15.1%
60-64	-7.3%	-6.4%	-10.8%	-14.0%	-16.9%	-15.4%	-14.7%
65-69	-6.3%	-10.7%	-13.3%	-15.7%	-13.9%		-12.8%
70-74	-11.3%	-13.2%	-14.2%	-12.2%			-11.8%
75-79	-13.2%	-13.7%	-11.3%				-10.7%
80-84	-13.0%	-9.8%					-9.5%
85-89	-8.8%						-8.7%
90-94							-8.8%

[78] UNESPA Longevity Risk Investigation, Towers Perrin, 21 January 2009.

[79] This assumption was verified in the Towers Perrin paper.

[80] Whole life

Conclusions

3.281 The differences between shocks for different durations are small and are not monotone so CEIOPS rejected the proposal to differentiate shock for duration of the contract.

3.282 The differences between shocks for different ages of insured person are higher than for durations. However they are not monotone for short term contracts. CEIOPS rejected the proposal to differentiate shock for age at the inception mainly due to the simplicity of calculations. The longevity risk concerns mainly pensioners who receive annuities. Differentiating shock would increase the complexity of calculations while the accuracy of results increases slightly because the number of insured person for pure endowment is relatively small compared to number of pensioners.

3.283 CEIOPS leaves the longevity stress unchanged because historic improvements in mortality rates observed in many countries are sometimes higher than 25% and, according to QIS4 report, the median stress in internal models equals 25%, with an interquartile range of 19% to 25%.

3.3.3 Disability-morbidity risk[81]

Morbidity and disability risk in QIS4

3.284 The QIS4 approach to the SCR standard formula included a morbidity and disability risk sub-module in the life underwriting risk module (section TS.XI.B of the QIS4 Technical Specifications (MARKT/2505/08)). The calculation of the capital requirement for morbidity and disability risk was a scenario based stress. The scenario tested was an increase of 35% to "disability rates" for the first year followed by a 25% increase in "disability rates" for all subsequent years.

3.285 An alternative scenario was also proposed by the UK under which the capital charges for critical illness, income protection and long term care obligations were calculated separately and there was an additional capital charge in respect of recovery risk.

3.286 With respect to the calibration of the morbidity and disability stress, some (re)insurance undertakings commented that the calibration was too strong.

Calibration of morbidity and disability stress

3.287 The basis for the QIS4 calibration of the morbidity-disability risk stress is described in the CEIOPS paper "QIS3 Calibration of underwriting risk, market risk and MCR". This paper is available from the CEIOPS website.

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[81] This section follows CEIOPS-DOC-42/09

3.288 Subsequent to QIS4, an investigation by the Swedish FSA indicated that an increase of 50% in morbidity/disability inception rates for the first year would be more appropriate.

3.289 This investigation also suggested that the appropriate calibration of the decrease in morbidity/disability recovery rates was 20%.

3.290 The results of the investigation by the Swedish FSA are explained further below.

3.291 In addition, the UK Actuarial Profession Healthcare Reserving Working Party has undertaken a survey which investigated the levels of 1 in 200 year morbidity stresses used by the major UK life insurance firms.[82]

3.292 The range of stress used by the major UK life insurers for income protection business averaged 27% for inception rates and 15% for termination rates. For critical illness, morbidity margins, intended to represent a 99.5% confidence over 1 year, averaged around 40%.

3.293 Furthermore, on average, the average morbidity margins for statutory reserving for critical illness and income protection (both inceptions and terminations) were about 20%. The margins in a statutory reserving basis are partly to allow for adverse deviations of the inception and termination rates used in the pricing. As such, a 1 in 200 stress should be at least greater than these margins as these margins are not normally set at the same level as a 1 in 200 year scenario.

3.294 Looking at the results of this survey in conjunction with the results of the investigation by the Swedish FSA, we would propose the following calibration of the disability-morbidity stress:

- The change in net asset value (assets minus liabilities) following an increase of 50% in morbidity/disability inception rates for the first year followed by an increase of 25% in morbidity/disability inception rates for all subsequent years.

- Plus, where applicable, the change in net asset value (assets minus liabilities) following a permanent decrease of 20% in morbidity/disability recovery rates. This should be applied together with the above increase in inception rates i.e. it is a combined stress.

Appendix: Estimate of the volatility in disability incidence and recovery (Swedish FSA)

<u>Incidence</u>

3.295 The total incidence rate in terms of incurred and IBNR provisions for new claims has been recorded as a proportion of total volume of active (non-

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[82] http://www.actuaries.org.uk/__data/assets/pdf_file/0006/136707/reserving_survey.pdf

incurred) insurance business, for a number of companies and for up to 6 years (2002-2007).

3.296 The figures also include waiver-of premium insurance. The coefficient of variation (standard deviation divided by average) has been calculated for each company. The results are given in the following table.

Incidence	Var-coeff
Company 1	46%
Company 2	26%
Company 3	127%
Company 4	16%
Company 5	55%
Company 6	69%
Company 7	36%
Company 8	2%
Company 9	31%
Company 10	65%
Company 11	160%
Company 12	89%
Company 13	193%
Company 14	59%
Company 15	36%
Company 16	102%
Company 17	82%
Company 18	27%
Company 19	23%
Company 20	51%
Company 21	76%
Company 22	56%

- *Reservation*

3.297 The figures are based upon annual reports from the companies. The quality of data in some cases may be low. The conclusions must therefore be taken with some consideration.

- *Conclusions*

3.298 The data shows that the annual variation in incident rates ranges from 23% to 127% (discarding outliers) for different companies.

3.299 It is important to note that disability insurance in Sweden is supplementary to social security insurance and there is little room for undertakings to apply their own judgement in respect of claims. During the period of the study, there was a significant trend moving from strong negative outcomes towards strong positive outcomes because of different management actions. This has been caused by limitations to policy conditions combined with external political decisions, for example the definition of accepted disability reasons and claims periods has been changed. Other external circumstances, for instance unemployment, could also have a significant impact on incidence rates.

3.300 Since such circumstances may also occur in future, we believe that the inception rate for the first year may reasonably be stressed by as much as + 50 %.

<u>Recovery</u>

3.301 The total recovery rate (including mortality) has been recorded in terms of provisions released as a result of recovery as a proportion of total provisions for in respect of disability for a number of companies and for up to 6 years (2002-2007). We have calculated the coefficient of variation (standard deviation divided by average) for every company. The results are given in the following table.

Recovery	Var-coeff
Company 1	126%
Company 2	146%
Company 3	69%
Company 4	35%
Company 5	36%
Company 6	4%
Company 7	95%
Company 8	31%
Company 9	51%

3.302 Due to the uncertainty in the data quality, data from only 9 companies has been used in the investigation.

- *Conclusions*

3.303 The reservations described above also apply in respect of the analysis of recovery rates.

3.304 The data shows that the annual variation in recovery rates ranges from 31% to 126% (discarding outliers) for different companies.

3.305 It is clear that there is significant uncertainty in the estimate of the termination rates. Although the relationship is not straightforward, we believe there is sufficient reason to stress this probability by as much as 20%.

3.3.4 Life expense risk[83]

Expense risk in QIS4

3.306 The QIS4 approach to the SCR standard formula included an expense risk sub-module in the life underwriting risk module (section TS.XI.F of the QIS4 Technical Specifications (MARKT/2505/08)). The calculation of the capital requirement for expense risk was a scenario based stress. The scenario tested was:

- An increase of 10% in future expenses compared to best estimate anticipations,
- An increase of 1% per annum of the expense inflation rate compared to anticipations

For policies with adjustable loadings[84], 75% of these additional expenses can be recovered from year 2 onwards by increasing the charges payable by policyholders.

3.307 There was a range of opinions with regard to the calibration of the expense risk as a result of which no useful conclusion could be drawn.

Calibration of expense stress

3.308 The basis for the QIS4 calibration of the expense risk stress is described in the CEIOPS paper "QIS3 Calibration of underwriting risk, market risk and MCR". This paper is available from the CEIOPS website.

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[83] This section follows CEIOPS-DOC-42/09

[84] Policies with adjustable loadings are those for which expense loadings or charges may be adjusted within the next 12 months.

3.309 As mentioned above, QIS4 feedback on the calibration of the expense stress was varied. However the expense risk capital charge from the internal model tended to be, for many undertakings, in line with the standard formula. The median ratio was equal to 100% and the inter quartile range was 85% to 166%.

3.310 CEIOPS therefore proposes to maintain the QIS4 calibration of the expense risk stress i.e. the stress shall be based on:

- An increase of 10% in future expenses compared to best estimate anticipations,
- An increase of 1% per annum of the expense inflation rate compared to anticipations

3.3.5 Revision risk[85]

Revision risk in QIS4

3.311 The QIS4 approach to the SCR standard formula included a revision risk sub-module in the life underwriting risk module (section TS.XI.G of the QIS4 Technical Specifications (MARKT/2505/08)). The calculation of the capital requirement for revision risk was a scenario based stress. The scenario tested was an increase of 3% in the annual amount payable for annuities exposed to revision risk.

3.312 QIS4 feedback indicated that the application of the revision risk module was not universally clear in some member states. This has been addressed by expanding on the application of this sub-module in the introduction above.

3.313 With regard to the calibration of the revision risk stress, one undertaking stated that the shock for revision risk is too low.

Calibration of revision risk stress

3.314 The basis for the QIS4 calibration of the revision risk stress is described in the CEIOPS paper "QIS3 Calibration of underwriting risk, market risk and MCR". This paper is available on the CEIOPS website.

3.315 Only one participant in QIS4 commented on the calibration of this module. CEIOPS has therefore concluded that the calibration adopted in QIS4 is appropriate for the majority of (re)insurance undertakings.

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[85] This section follows CEIOPS-DOC-42/09

3.316 CEIOPS therefore proposes that the revision risk is calculated assuming an increase of 3% in the annual amount payable for annuities exposed to revision risk.

3.3.6 Lapse risk[86]

Lapse risk in QIS4

3.317 The QIS4 approach to the SCR standard formula included a lapse risk sub-module in the life underwriting risk module.[87] The calculation of the capital requirement for lapse risk was based on three scenarios:

- a permanent increase of lapse rates by 50%;
- a permanent decrease of lapse rates by 50%; and
- a mass lapse event where 30% of the policies are surrendered.

Calibration

3.318 As lapse rates are not frequently used for reserving under Solvency I, the empirical basis for a calibration of the permanent shocks lapseshockup and lapseshockdown is poor for most markets.

3.319 The QIS4 calibration of the shocks was based on a study of the UK with-profit life insurance market in 2003 performed by order of the British FSA.[88] The analysis resulted in estimates for quantiles of permanent lapse rate decreases as follows:

Quantile	Relative change of lapse rate
90%	-28.5%

[86] This section follows CEIOPS-DOC-42/09

[87] QIS4 technical specifications, see http://www.ceiops.eu/media/docman/Technical%20Specifications%20QIS4.doc, 31 March 2008, Section TS.XI.E.

[88] Financial Services Authority »Calibration of the Enhanced Capital Requirement for with-profits life insurers«, 2004 (http://www.fsa.gov.uk/pubs/policy/04_16/ww_report.pdf)

91%	-29.3%
92%	-30.3%
93%	-31.7%
94%	-33.0%
95%	-34.5%
97.5%	-39.0%

3.320 The quantile produced in the study are lower than the Solvency II confidence level of 99.5%. Nevertheless, by extrapolation of the above values, the QIS4 calibration of -50% can be justified. The study does not cover the risk of a permanent increase of lapse rates, however, in absence of better evidence it is appropriate to assume a symmetrical stresses for both scenarios and choose +50% for the increase scenario.

3.321 CEIOPS has looked for further evidence from other markets. An analysis of the Polish supervisor on the national life insurance market supports the above calibration assumptions (see further below). The study shows that the 99.5% quantile of annual lapse rate deviations from a long-term mean is between 60% and 100% for increases and between -60% and -90% for decreases. As these values are based on an annual deviation they overestimate the shock of a permanent change. However, the results indicate that the range of the proposed calibration is appropriate.

3.322 The lapse shocks were calibrated on small rates. If the rates are much larger, the calibration may produce excessive results. Moreover, it needs to be avoided that the shocked rates exceed 100%.

3.323 Therefore, the shocked take-up rate should be restricted as follows:

$R_{up}(R) = \min(150\% \cdot R;100\%)$ and

$R_{down}(R) = \min(\max(50\% \cdot R; R - 20\%),0)$,

where

R_{up} = shocked take-up rate in *lapseshock*$_{up}$

R_{down} = shocked take-up rate in *lapseshock*$_{down}$

R = take-up rate before shock

Calibration of the mass lapse event

3.324 The scenario shocks *lapseshock*$_{up}$ and *lapseshock*$_{down}$ cover the risk of a misestimation or of a permanent change of lapse rates. By contrast, the mass lapse event covers the risk of a temporary and drastic rise of lapse rates. The likeliness that policyholders terminate their policies is increased for a limited span of time. The cause for this change in policyholder behaviour can be of an internal or external nature. An internal cause could, for example, be the deterioration of the financial position of the undertaking or any other event that significantly affects the reputation of the undertaking or the group it belongs to. Examples of external events would be changes in the economic situation or changes in the tax regulations that directly or indirectly affect the policies of the undertaking. An event in the banking sector comparable to the mass lapse event would be a "bank run".

3.325 The calibration of the mass lapse event should account for the scenario definition as defined above. Where the change in lapse behaviour is triggered by a change in scenario-based risk like interest rate risk or equity risk, an allowance in the mass lapse event is not necessary. The calibration of the mass lapse event should only cover those changes in behaviour which are not triggered by these risks.

3.326 On the other hand, the calibration of the mass lapse event has to reflect the fact that mass lapse is a "catastrophe" type event.[89] Policyholder behaviour under extreme conditions is difficult to assess as it can be determined by complex phenomena like herd behaviour and self-reinforcing mechanisms. Experience from the banking sector during the current financial crises shows (for example Northern Rock bank run in 2007) that policyholder behaviour can pose a significant risk to financial institutions.

3.327 Under Solvency I insurance and reinsurance undertakings are less affected by lapse risk as the technical provisions for a policy must not be lower than its surrender value. But under Solvency II it may happen that the assets of an undertaking do not cover the surrender values. Such insurers are highly vulnerable to mass lapse events, in particular when their situation becomes public.

3.328 The empirical basis to calibrate the mass lapse event is poor. In the absence of better evidence, CEIOPS proposes to maintain the QIS4 calibration of 30% of the sum of positive surrender strains.

3.329 It has been discussed whether different types of life insurance policies are affected differently by mass lapse events: products with significant guarantees like with-profit products may show a higher persistency than products with low guarantees like many unit-linked policies.

3.330 On the other hand, for non- retail business[90], the risk of a mass lapse is substantially greater for the following reasons:

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[89] The nature of the „catastrophe" event in the lapse risk sub-module is clearly distinct from the nature of the "catastrophe" events in the life CAT risk sub-module.

[90] Non-retail business covers pension fund management as described in Article 2(3) and is a specified class of long term insurance business. It falls within Article 2(3)(b)(iii) where it simply involves the management of investments and assets representing the reserves of bodies that effect payments on death or survival or in the event of discontinuance or

- Institutional investors tend to be better informed and would be quick to withdraw funds if there was any question over the solvency of a firm, particularly if they were aware that the firm did not have sufficient funds to meet all claims;
- There are generally no surrender penalties.

3.331 CEIOPS therefore believes that a higher calibration of the mass lapse stress is appropriate for this business. In the absence of other information, CEIOPS proposes to use the QIS3 calibration of 70% of the sum of positive surrender strains.

3.332 At this stage, taking into account a simple valuation of the mass lapse event, CEIOPS is considering whether to differentiate further between different insurance products for the purposes of the mass lapse stress.

Appendix: Analysis of annual lapse rates in the Polish life insurance market

Risk description

3.333 According to the Article 105 (3) (f) of the Level 1 text, the lapse risk is defined as the risk of loss, or of adverse change in the value of insurance liabilities, resulting from changes in the level or volatility of the rates of policy lapses, terminations, renewals and surrenders.

3.334 According to the QIS4 Technical Specifications (par. TS.XI.E.1), lapse risk relates to the loss, or adverse change in the value of insurance liabilities, resulting from changes in the level or volatility of the rates of policy lapses, terminations, changes to paid-up status (cessation of premium payment) and surrenders.

3.335 In the Draft CEIOPS' Advice for Level 2 Implementing Measures on Solvency II: Treatment of lapse risk in the SCR standard formula, CEIOPS advices to take comprehensive approach in relation to the policyholder options that the lapse sub-module covers. Ideally, the module should take account of all legal or contractual policyholder options which can significantly change the value of the future cash-flows. This includes options to fully or partly terminate, decrease, restrict or suspend the insurance cover as well as options which allow the full or partial establishment, renewal, increase, extension or resumption of insurance cover.

3.336 However due to the lack of historic data on the use of each policyholder option, the following calibration covers only the pure policy lapses for which data are available.

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curtailment of activity. It falls within Article 2(3)(b)(iv) where it is also combined with insurance covering conservation of capital. The insurance covering conservation of capital could be linked business. In that case, the undertaking would be carrying on both Class VII (pension fund management) and Class III (linked long term). In addition, non retail business covers business falling within Class III of Annex II, where the policyholder is a person other than a natural person.

Data used in the analysis

3.337 The analysis is based on the rates of policy lapses in Polish life insurance undertakings from 2004 to 2007. The number and rates of policy lapses for each product of life insurance undertakings are included in the statement of the state of insurance portfolio, which the actuary has to draw up annually and submit it to the supervisory authority according to the Act on insurance activity.

3.338 The statement of the state of insurance portfolio in life insurance undertakings for the particular reporting year contains separately for each product the following information:

- product characteristics:
  - type of policy: main, supplementary;
  - participation clauses: with profit, without profit, unit-linked;
  - type of policy: individual, group;
  - duration of policy: whole life, term;
  - classes of insurance: 1, 2, 3, 4, 5 (according to Polish law);
- number of policies in force;
- number of insured people;
- number and rates of policy lapses in reporting year *R* from policies written (signed):
  - in reporting year *R-i+1* (to be called further as "lapse rate *i*"), *i*= 1, 2, 3, 4, 5 (five rates);
  - at least 5 years before reporting year *R* (lapse rate 5+), *i*>5.

3.339 The above-mentioned information was sometimes not complete because of lack of electronic version of statements for some reporting years, withdrawal of some products or introduction of new products in recent years. The lapse rates were sometimes not reported, the value equaled to "0" or was higher than "1". Therefore only data meeting all the following conditions were chosen for further analysis:

- data on each product were reported in statements for three consecutive years,
- for each reporting year, for at least one *i*, lapse rate *i* was reported and was positive,
- all lapse rates were not higher than „1",
- number of insured people in last reporting year equaled at least 100.

3.340 Let $x_{i,n-r}^{p}$ denote lapse rate *i*, *i*=1,2,3,4,5,5+, for product *p* in reporting year *n-r*, where *n* is the last reporting year and *r*=0,1,2,3.

3.341 For each $i \in \{1, 2, 3, 4, 5, 5+\}$ Let P_i denote the set of those products, for which at least three of the following lapse rate values $x_{i,n}^{p}$, $x_{i,n-1}^{p}$, $x_{i,n-2}^{p}$, $x_{i,n-3}^{p}$ $\in (0;1 >$.

3.342 For each lapse rate i (where $i \in \{1, 2, 3, 4, 5, 5+\}$) and each product $p \in P_i$ let:

$$k_i^p = \frac{n_i^p}{\sum_{r=0}^{3} x_{i,n-r}^p},$$

where n_i^p is the number of lapse rates $x_{i,n-r}^p \in (0;1>$.

3.343 For each $i \in \{1, 2, 3, 4, 5, 5+\}$ the standardized lapse rate i equal

$$y_{i,n-r}^p = x_{i,n-r}^p \cdot k_i^p,, \quad r = 0,1,2,3, \quad p \in P_i$$

3.344 The purpose of calibration is to analyze the volatility of lapse rates. The time series are too short to analyze the volatility for each product. Therefore the calibration is carried out on panel data. Since for given i the sample mean of rates $x_{i,n}^p$, $x_{i,n-1}^p$, $x_{i,n-2}^p$, $x_{i,n-3}^p$ differs among products, the standardization was necessary to remove "between-samples" variability (i.e. variability resulting from the differences among products) from total variability. The standardization provides the same mean of rates $y_{i,n}^p$, $y_{i,n-1}^p$, $y_{i,n-2}^p$, $y_{i,n-3}^p$ for lapse rates i within product p.

3.345 The total variability of lapse rates i, i=1,2,3,4,5,5+ is composed of two variabilities:

$$\forall_{i \in \{1,2,3,4,5,5+\}} \quad \sum_{p \in P_i} \sum_{r=0}^{3} (x_{i,n-r}^p - \overline{\overline{x}}_i)^2 = \sum_{p \in P_i} (\overline{x_i^p} - \overline{\overline{x}}_i)^2 + \sum_{p \in P_i} \sum_{r=0}^{3} (x_{i,n-r}^p - \overline{x_i^p})^2$$

where

$$\overline{x_i^p} = \frac{1}{n_i^p} \sum_{r=0}^{3} x_{i,n-r}^p, \quad \overline{\overline{x}}_i = \frac{1}{n_i} \sum_{p \in P_i} \sum_{r=0}^{3} x_{i,n-r}^p, \quad n_i = \sum_{p \in P_i} n_i^p.$$

3.346 he part of the total variability which equal $\sum_{p \in P_i} (\overline{x_i^p} - \overline{\overline{x}}_i)^2$ results from the different sample means of lapse rates among products. After standardization, for each i the mean from the whole sample $\overline{\overline{y}}_i = \frac{1}{n_i} \sum_{p \in P_i} \sum_{r=0}^{3} y_{i,n-r}^p$, and the sample means for each product $\overline{y_i^p} = \frac{1}{n_i^p} \sum_{r=0}^{3} y_{i,n-r}^p$ equal "1". Hence the total variability of lapse rate i equals

$$\forall_{i \in \{1,2,3,4,5,5+\}} \quad \sum_{p \in P_i} \sum_{r=0}^{3} (y_{i,n-r}^p - \overline{\overline{y}}_i)^2 = \sum_{p \in P_i} \sum_{r=0}^{3} (y_{i,n-r}^p - \overline{y_i^p})^2.$$

3.347 Moreover the standardization does not change the value of variation coefficient for given products

$$\forall_{i\in\{1,2,3,4,5,5+\}} \quad \forall_{p\in P_i} \quad \frac{Sd(x_i^p)}{\overline{x_i^p}} = \frac{Sd(k_i^p \cdot x_i^p)}{\overline{k_i^p \cdot x_i^p}} = \frac{Sd(y_i^p)}{\overline{y_i^p}}.$$

3.348 To sum up, the shocks for lapse rate *i*, *i*=1,2,3,4,5,5+ are calibrated on standardized lapse rates and the results of calibration are the relative changes of lapse rates compared to average level of lapse rate from last *r* years (in QIS4 the shocks refer to assumed future rates of lapsation).

3.349 For each $i\in$ {1, 2, 3, 4, 5, 5+}, standardized values of lapse rate *i* made the data sample to determine shocks. Moreover, for each $i\in$ {1, 2, 3, 4, 5, 5+} subsamples containing lapse rates *i* for products with particular product characteristics were formed.

3.350 The extreme values and outliers for all standardized lapse rates *i* within sample (individually for the whole sample and individually for each subsample) were identified by the programme *Statistica* and were removed from further analyzes.

Methodology assumptions

3.351 On the basis of standardized lapse rates *i*, *i*=1,2,3,4,5,5+, the empirical distribution functions were derived, for the whole sample and for each subsample.

3.352 The downward and upward shocks have been determined as $\frac{VaR_{0.005} - \overline{y_i}}{\overline{y_i}}$ and $\frac{VaR_{0.995} - \overline{y_i}}{\overline{y_i}}$ respectively of the empirical distribution function for lapse rate *i*, where $\overline{y_i} = 1$.

Table 1: The values of downward and upward lapse shocks.

	Sample	—	Type of policy		Participation clauses			Duration		Type of policy	
	Lapse rate	All	Main	Supp	UL	With	Without	Term	Whole	Individ	Group
Downward shock	1	-87.3%	-97.1%	-95.0%	-81.4%	-76.1%	-98.0%	-97.8%	-77.0%	-94.6%	-96.4%
	2	-86.2%	-75.8%	-89.8%	-87.9%	-73.2%	-88.9%	-75.6%	-59.1%	-74.3%	-95.1%
	3	-79.2%	-83.9%	-75.7%	-83.7%	-62.3%	-84.2%	-72.7%	-91.8%	-71.9%	-94.8%
	4	-69.1%	-80.4%	-56.0%	-80.2%	-66.5%	-63.8%	-82.2%	-77.7%	-61.1%	-94.3%
	5	-81.9%	-82.6%	-77.1%	-89.6%	-51.0%	-82.1%	-82.8%	-83.2%	-70.3%	-84.1%
	5+	-68.5%	-66.0%	-67.1%	-58.0%	-65.8%	-68.3%	-65.6%	-55.9%	-51.0%	-96.2%
Upward shock	1	103.6%	108.2%	97.2%	118.6%	75.0%	103.8%	106.0%	117.2%	99.9%	106.2%
	2	83.8%	74.6%	90.7%	81.6%	73.4%	90.3%	76.2%	65.2%	75.5%	98.9%
	3	74.4%	76.1%	68.2%	81.8%	39.1%	74.4%	60.7%	81.7%	66.7%	84.9%
	4	64.9%	63.0%	64.7%	64.7%	41.5%	65.1%	57.0%	62.8%	56.2%	84.2%
	5	74.3%	75.2%	71.1%	75.9%	37.5%	74.3%	74.5%	78.9%	62.8%	104.8%
	5+	67.1%	69.9%	66.6%	45.4%	69.5%	63.0%	62.4%	57.3%	50.8%	113.7%

3.353 The above downward and upward shocks should be interpreted as relative changes of future lapse rates *i* for each product compared to average value of lapse rates or compared to the assumed rates of lapsation, in all future years for policies where the surrender strain is expected to be negative or positive respectively.

3.3.7 Life catastrophe risk[91]

Life catastrophe risk in QIS4

3.354 The QIS4 approach to the SCR standard formula included a catastrophe risk sub-module in the life underwriting risk module (section TS.XI.H of the QIS4 Technical Specifications (MARKT/2505/08)). The calculation of the capital requirement for catastrophe risk was a scenario based stress. The scenario tested was a combination of the following events:

- an absolute 1.5 per mille increase in the rate of policyholders dying over the following year (e.g. from 1.0 per mille to 2.5 per mille)
- an absolute 1.5 per mille increase in the rate of policyholders experiencing morbidity over the following year. Where appropriate, undertakings should assume that one-third of these policyholders experience morbidity for 6 months, one-third for 12 months and one-third for 24 months from the time at which the policyholder first becomes sick.

Calibration of the life catastrophe stress

3.355 The QIS4 calibration of the mortality catastrophe stress was supported by a study carried out by Swiss Re[92] in 2007 which estimated that the 1 in 200 year pandemic stress for most developed countries is between 1.0 and 1.5 per mille within insured lives. This study was based on a sophisticated epidemiological model.

3.356 However, there are a number of potential weaknesses in this model such as not adequately allowing for the probability of flu jumping across species such as from birds to humans, not allowing for non-influenza pandemics (e.g. AIDS, drug resistant TB, Ebola virus / MRSA / SARS) or other causes of mortality catastrophe such as terrorism or physical catastrophes such as earthquakes. If these weaknesses were addressed, it is likely that the estimated stress would increase.

[91] This section follows CEIOPS-DOC-42/09

[92] http://www.swissre.com/resources/bbab850046606bf6b89cfd276a9800c6-SHAN-753GRL_Pandemic%20influenza.pdf

3.357 Furthermore, due to sparse historical data on pandemics, there is a significant degree of uncertainty around the calibration of any pandemic model.

3.358 We also note that the 1918 flu pandemic, which is the most significant mortality catastrophe for which data is available, gave rise to death levels of above 5 per mille.

3.359 The above proposal does not restrict the application of the catastrophe module to (re)insurance obligations which are contingent in mortality i.e. the module may also be applied to (re)insurance obligations, such as annuities, where the increase in mortality leads to a reduction in technical provisions.

3.360 Although this may seem to reflect the economic substance of (re)insurance undertakings' portfolios by allowing for the diversification between different lines of business, there is evidence to suggest that this diversification benefit may not exist in reality. In particular, historic data indicates that primarily young and healthy people died as a result of influenza pandemics.

3.361 CEIOPS is therefore proposing the restriction of the mortality catastrophe module to (re)insurance obligations which are contingent on mortality i.e. where an increase in mortality leads to an increase in techncial provisions.

3.362 CEIOPS believes that this restriction would mean that is is reasonable to consider a lower calibration of the mortality catastrophe stress.

3.363 For joint life policies, the mortality catastrophe loading should be applied separately for each insured person, rather than on a 'per policy' basis.

3.364 Therefore a mortality catastrophe stress constituting an absolute increase of 1.5 per mille is proposed.

3.4 Health underwriting risk

3.365 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)

3.4.1 SLT Health underwriting risk[93]

SLT Health mortality risk

3.366 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

3.367 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

3.368 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)

3.369 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.

3.370 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

[93] This section follows CEIOPS-DOC-68/10

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.[94]

3.371 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

3.372 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

3.373 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

3.374 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).

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[94] 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·σ.

3.375 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.

SLT Health lapse risk

3.376 A statistical study was carried out on basis of comprehensive data in the German Health insurance market.

3.377 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.

3.378 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.[95] 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.

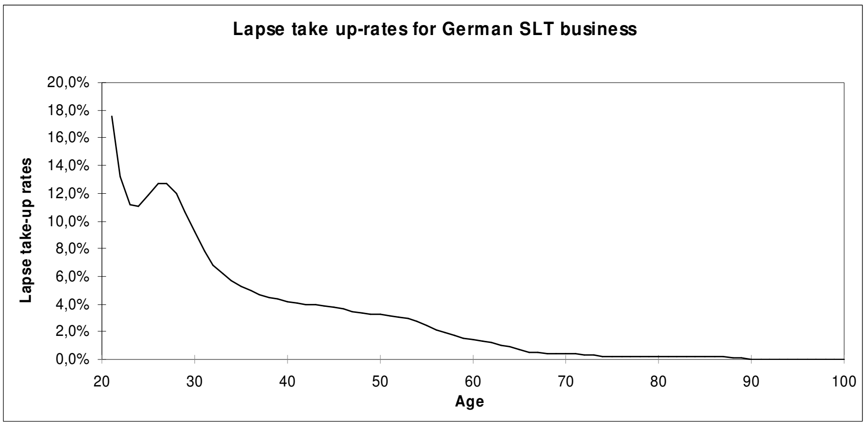
3.379 Overall, this resulted in the following lapse shocks:

Age bands	Lapse shock 99.5% VaR
25	21%
30	13%
35	15%
40	17%
45	21%
50	19%
55	17%

[95] 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.

60	13%
65	13%
70	11%
75	23%
80	47%
85	63%
90	84%
95	104%

3.380 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:



3.381 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.

3.382 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.

3.383 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.

3.4.2 Non-SLT Health underwriting risk - Premium and Reserve risk[96]

3.384 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.

3.385 The capital charge for the combined premium risk and reserve risk is determined as follows:

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

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
$\rho(\sigma_{NonSLT\ Health})$	=	A function of the standard deviation

3.386 The overall volume measure $V_{NonSLT\ Health}$ is determined as follows:

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

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

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

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

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

where

$N_{0.995}$	=	99.5% quantile of the standard normal distribution

3.388 The function $\rho(\sigma_{NonSLT\ Health})$ 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 $\rho(\sigma_{NonSLT\ Health}) \approx 3 \cdot \sigma_{NonSLT\ Health}$.

3.389 The overall net standard deviation σ is determined as follows:

[96] This section follows CEIOPS-DOC-68/10

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

where

r,c	=	All indices of the form (lob)
$CorrLob^{rxc}$	=	the cells of the correlation matrix *CorrLob*
V_r, V_c	=	Volume measures for the individual lines of business, as defined above

3.390 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 σ(prem,LoB)
- Net standard deviation for reserve risk σ(res,LoB)
- correlation factors between LoB (CorrLob)

The corresponding LoBs shall be:

LoB number	
1	Accident
2	Sickness
3	Workers Compensation

General Observations

QIS 3 and QIS 4 calibration

3.391 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.

3.392 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.

3.393 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.

3.394 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.

3.395 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."

3.396 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.

3.397 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

3.398 The previous calibrations were performed using data from an unrepresentatively small set of member states within the EEA.

3.399 Whilst the introduction of more data leads to heterogeneity calibration problems, the resultant parameters should be more appropriate for more undertakings within the EEA.

3.400 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

3.401 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.

3.402 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

3.403 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.

3.404 This issue was not explored in the previous calibrations and could have resulted in a misinterpretation of the certainty of the resultant calibration.

3.405 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

3.406 The approach used a single set of model assumptions. Different, but similar, model assumptions fitted to the same data can give materially different answers.

3.407 This issue was not explored in the previous calibrations and could have resulted in a misinterpretation of the certainty of the resultant calibration.

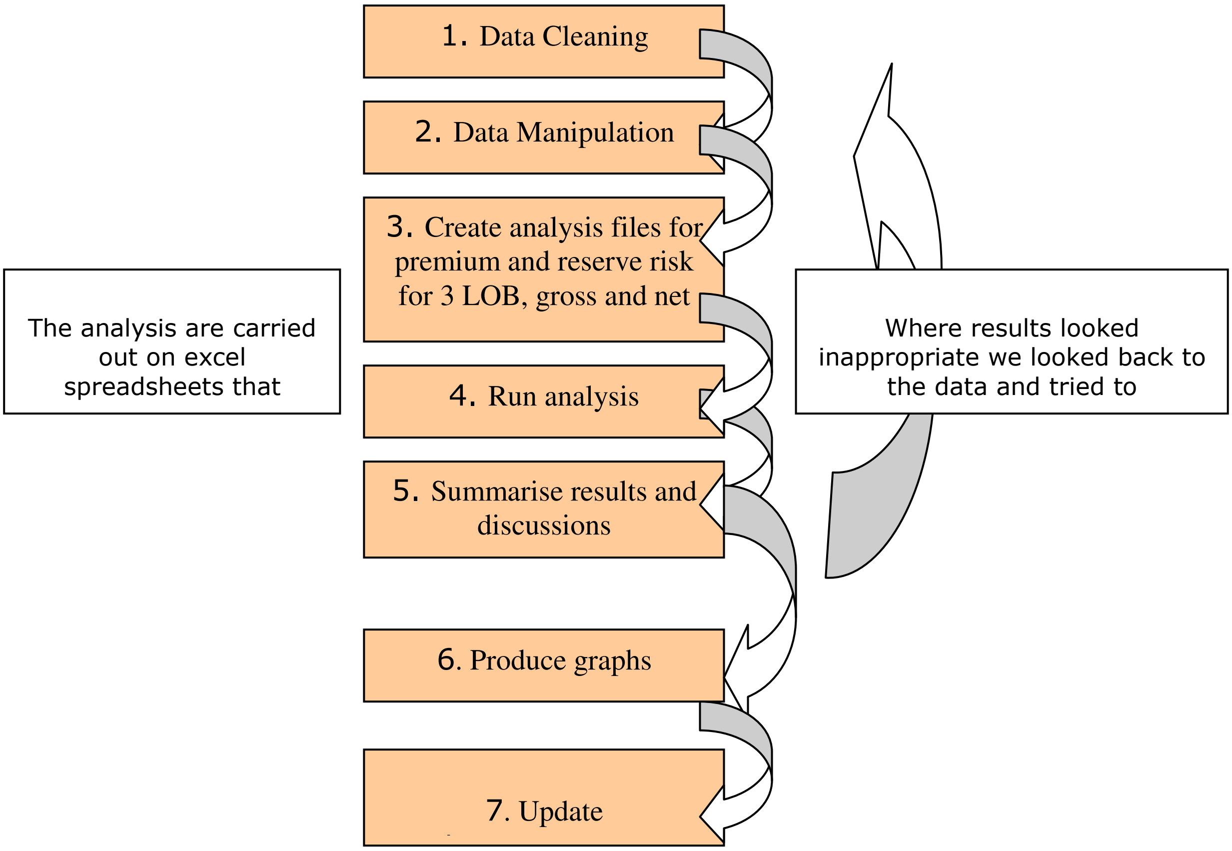
Over-fitting

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

3.409 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

3.410 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.

Premium risk

3.411 This section describes the premium risk calibration and results.

Data

3.412 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

3.413 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..

Assumptions

3.414 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).

3.415 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.

3.416 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.

3.417 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.

3.418 The risk margin does not change after stressed conditions.

3.419 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.

Analysis

3.420 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.

3.421 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.

3.422 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.

3.423 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.

3.424 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.

Methodology

3.425 A variety of methods was used to estimate the factors a set of pan European factor for each line of business.

3.426 CEIOPS carried out the following methods for the estimation of the premium risk standard deviations:

<u>Method 1</u>

3.427 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".

3.428 This involves the firm calculating the average net earned premium and the standard deviation of the loss ratios posted after the first development year.

3.429 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.

3.430 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.

3.431 The second stage fits the premium risk factor to these resultant undertaking specific models.

3.432 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.

3.433 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.

3.434 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

3.435 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

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

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

3.437 If following term is defined:

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

3.438 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

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

3.440 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

3.441 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.

3.442 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.

3.443 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.

3.444 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.

3.445 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.

3.446 If the following terms are defined:

$U_{C,Y,lob}$	=	The posted ultimate after one year by undertaking, accident year and LoB
$\mu_{C,lob}$	=	Expected loss ratio by undertaking and by LoB

β^2_{lob}	=	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:

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

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

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

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

3.448 The resultant simplified log Likelihood becomes

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

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

3.450 The following term is defined:

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

3.451 The $\sigma_{(C,prem,lob)}$ then becomes :

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

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

3.452 If the following term is defined:

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

3.453 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:

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

<u>Method 3</u>

3.454 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.

3.455 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

3.456 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.

3.457 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.

3.458 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.

3.459 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.

3.460 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.

3.461 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:

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

3.462 The parameters of the lognormal distributions are formulated as follows:

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

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

3.463 The resultant simplified log Likelihood becomes

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

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

3.465 If the following term is defined as:

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

3.466 The $\sigma_{(C,prem,lob)}$ then becomes :

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

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

3.467 If the following term is defined as:

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

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

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

- 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

3.469 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.

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

3.471 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.

3.472 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^2_{lob}	=	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:

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

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

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

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

3.474 The resultant simplified log Likelihood becomes

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

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

If the following term is defined as:

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

The $\sigma_{(prem,lob)}$ then becomes :

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

Premium Risk Results

3.476 CEIOPS has presented the results of the analysis though a combination of tables and graphs.

3.477 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.

3.478 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.

3.479 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.

3.480 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.

3.481 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.

3.482 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).

3.483 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

3.484 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).

<u>Accident</u>

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

3.486 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

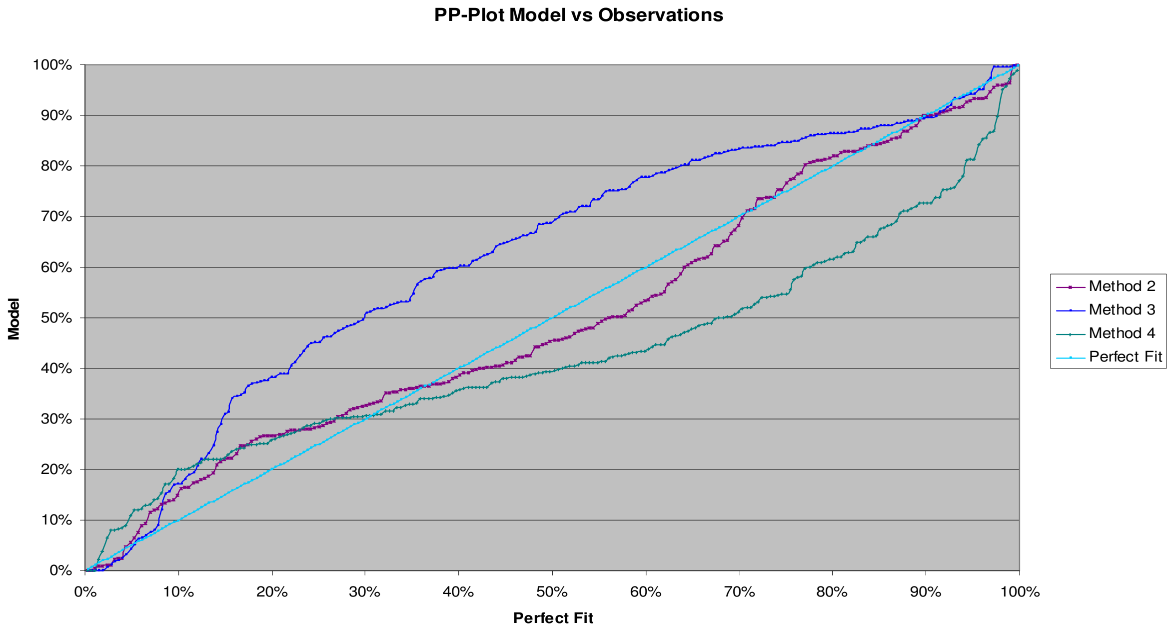
Accident - Euros	6,142	31,281	43,531

GROSS Standard Deviations

Discounted

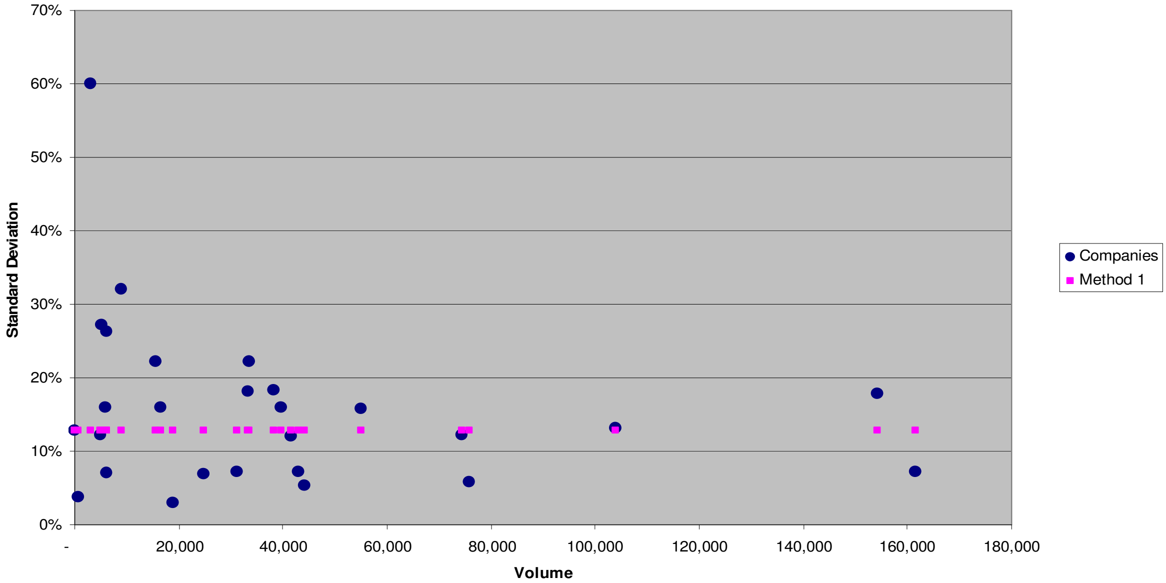
Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result based on VWA	% firms with higher sd
Method 1				12%	**12.5%**	**55.6%**
Method 2	37%	17%	14%	13%		
Method 3	73%	32%	27%	25%		
Method 4				31%		

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



3.488 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.

Method 1 vs Company Volatilities



Overall conclusions:

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

Sickness

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

3.491 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

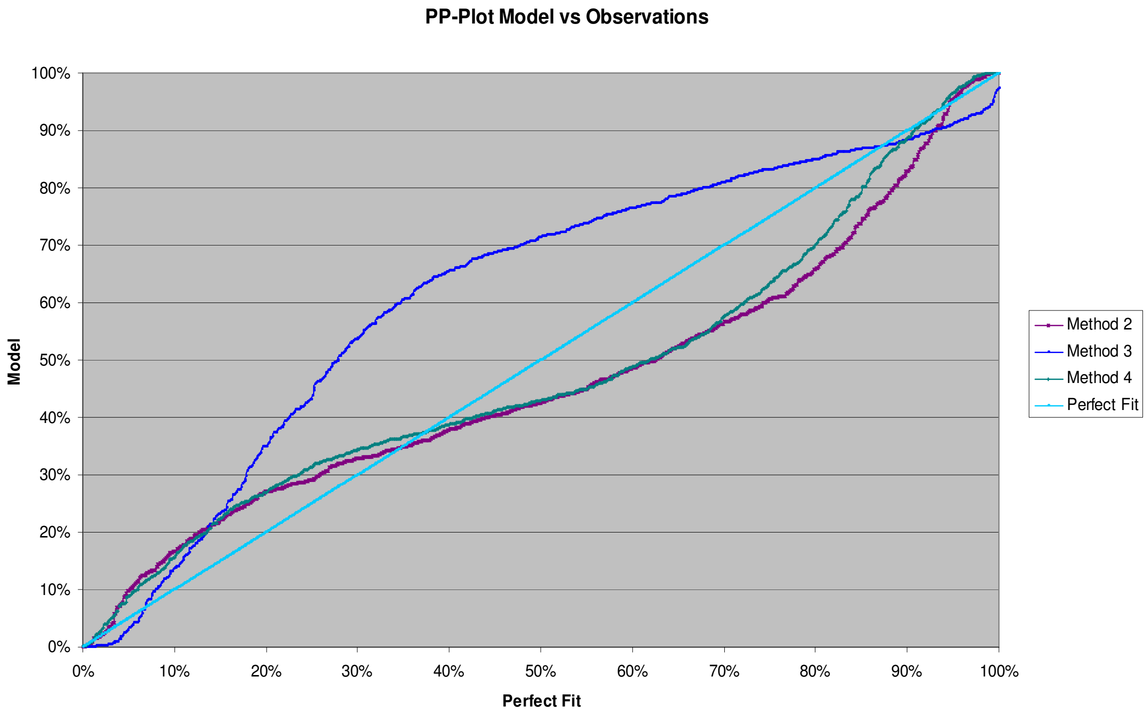
GROSS Standard Deviations

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%		

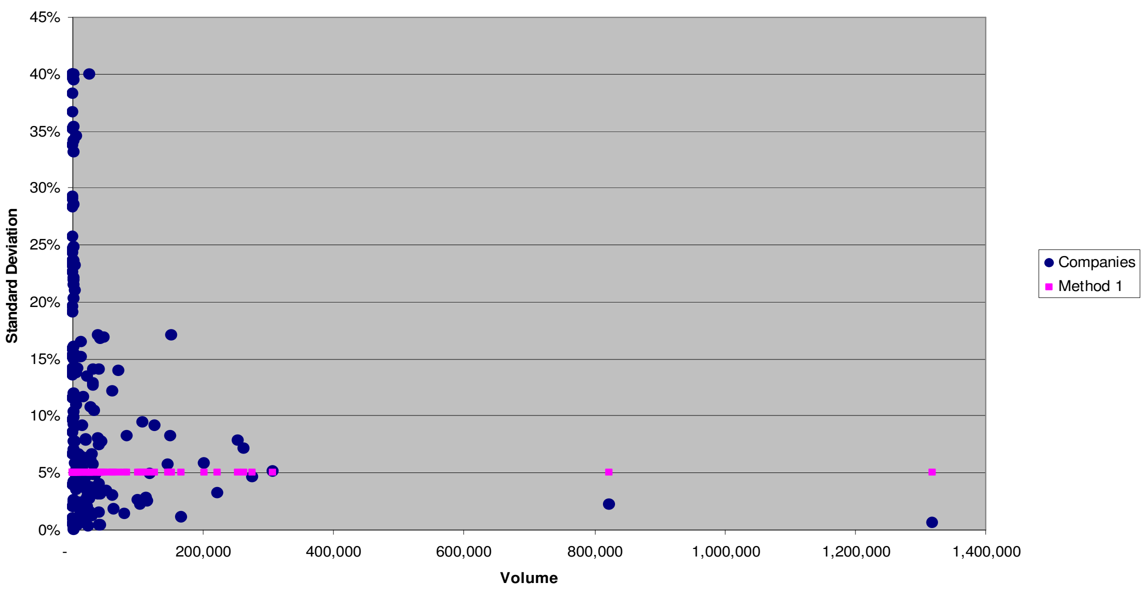
Method 3	271%	103%	50%	28%
Method 4				18%

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



3.493 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.

Method 1 vs Company Volatilities



Overall conclusions:

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

Workers' compensation

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

3.496 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

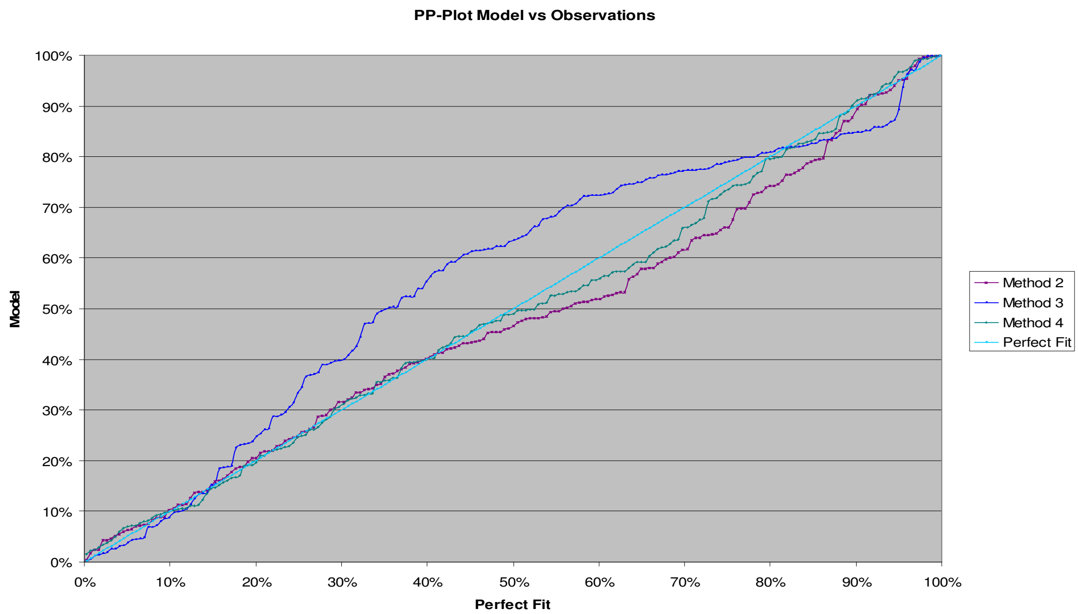
GROSS Standard Deviations

Discounted

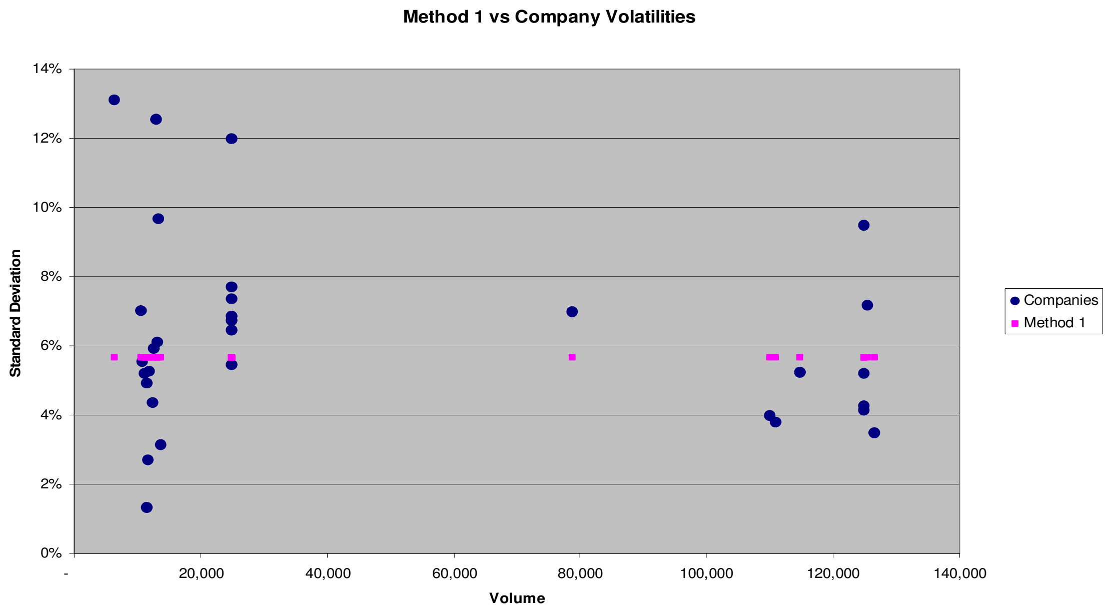
Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result based on VWA	% firms with higher sd
Method 1				5%	**5.3%**	**65.0%**

Method 2	11%	7%	4%	5%
Method 3	36%	25%	12%	16%
Method 4				5%

3.497 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.



3.498 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:

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

Adjusting gross to net for premium risk

3.500 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.

3.501 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 adjustment[97], 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.

3.502 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.

3.503 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.

3.504 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.

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[97] See annex 4 of CEIOPS-DOC-68/10 .

- 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 mis-match 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.

3.505 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.

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

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

3.507 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.

3.508 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 form 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.

Reserve Risk

3.509 The reserve risk calibration and results are presented below:

Data

3.510 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.

3.511 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.

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

Assumptions

3.513 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 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.

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

3.515 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.

3.516 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.

3.517 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.

Analysis

3.518 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.

Methodology

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

Method 1

3.520 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".

3.521 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.

3.522 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.

3.523 Essentially the standard deviation will represent the uncertainty in the expected ultimate claims over the one year time horizon for the same accident years.

3.524 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.

3.525 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.

3.526 The second stage fits the reserve risk factor to these resultant undertaking specific models.

3.527 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.

3.528 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.

3.529 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

Then the following relationships can be defined as:

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

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

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

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

the following relationships are obtained:

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

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

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

3.532 If the following term is defined as:

$\sigma_{(res,lob)}$	=	Standard deviation for reserve risk by LoB

3.533 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

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

3.535 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.

3.536 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.

3.537 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.

3.538 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.

3.539 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.

3.540 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.

3.541 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.

3.542 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
$\varepsilon_{C,Y,lob}$	=	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

3.543 Then the following relationships can be determined as:

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

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

3.544 Then the distribution of losses can be formulated as:

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

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

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

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

3.546 The resultant simplified log Likelihood becomes

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

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

3.548 If the following term is defined as:

$\sigma_{(C,res,lob)}$	=	Standard deviation for reserve risk by Undertaking by LoB

3.549 The $\sigma_{(C,res,lob)}$ then becomes :

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

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

3.550 If the following term is defined as:

$\sigma_{(res,lob)}$	=	Standard deviation for reserve risk by LoB

3.551 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

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

3.553 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.

3.554 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
$\varepsilon_{C,Y,lob}$	=	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 $R_{C,Y,lob}$.

3.555 Then the following relationships are defined:

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

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

3.556 Then the distribution of losses can be formulated as:

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

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

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

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

3.558 The resultant simplified log Likelihood becomes

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

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

$\sigma_{(res,lob)}$	=	Standard deviation for reserve risk by LoB

3.560 Then we can derive a value for $\sigma_{(res,lob)}$ as below:

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

Method 4

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

3.562 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 $E(C_{i,j}|C_{i,j-1})=f_jC_{i,j-1}$ and $Var(C_{i,j}|C_{i,j-1})=s_j^2C_{i,j-1}$.

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.

3.563 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

3.564 Then the following relationship can be defined:

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

3.565 If the following term is defined:

β_{lob}^2	=	Constant of proportionality for the variance of the claims development result by LoB

Then the least squares estimator of the coefficients of variation is the value of β_{lob} which minimises the following function:

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

3.566 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

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

c. Estimating the volume weighted average across all undertakings

3.567 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

3.568 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:

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

<u>Method 5</u>

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

3.570 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 $E(C_{i,j}|C_{i,j-1})=f_jC_{i,j-1}$ and $Var(C_{i,j}|C_{i,j-1})=s_j^2C_{i,j-1}$.

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.

3.571 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

3.572 Then the following relationship can be defined:

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

3.573 If the following term is defined:

$\sigma_{(res,lob)}$	=	Standard deviation for reserve risk by LoB

Then the least squares estimator of standard deviation is the value of $\sigma_{(res,lob)}$ which minimises the following function:

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

3.574 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

3.575 This method involves a two stage process:

- **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 $E(C_{i,j}|C_{i,j-1})=f_jC_{i,j-1}$ and $Var(C_{i,j}|C_{i,j-1})=s_j^2C_{i,j-1}$.
- **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.

3.576 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 $MSEP_{C,lob}$.

3.577 Then we can define the following relationship:

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

3.578 The following term is defined as follows:

$\sigma_{(res,lob)}$	=	Standard deviation for reserve risk by LoB

3.579 Then the least squares estimator of the coefficients of variation is the value of $\sigma_{(res,lob)}$ which minimises the following function:

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

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

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

Reserve Risk Results

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

3.582 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.

3.583 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.

3.584 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.

3.585 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.

3.586 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.

3.587 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

3.588 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

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

3.590 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.

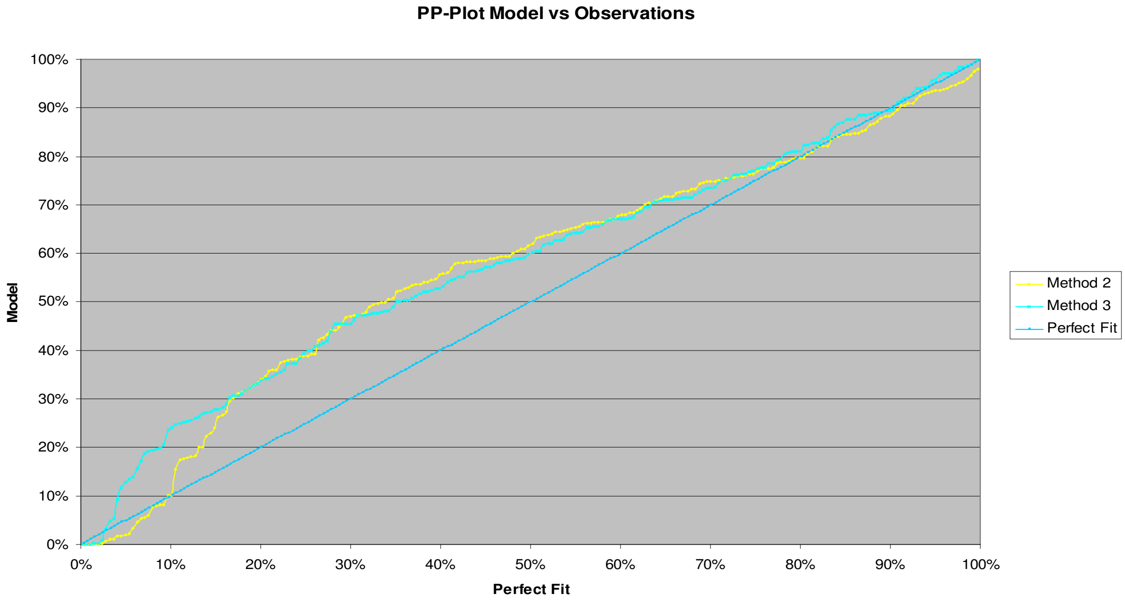
Reference co	Small	Medium	Large
Accident - Euros	5,578	12,625	35,390

GROSS SD

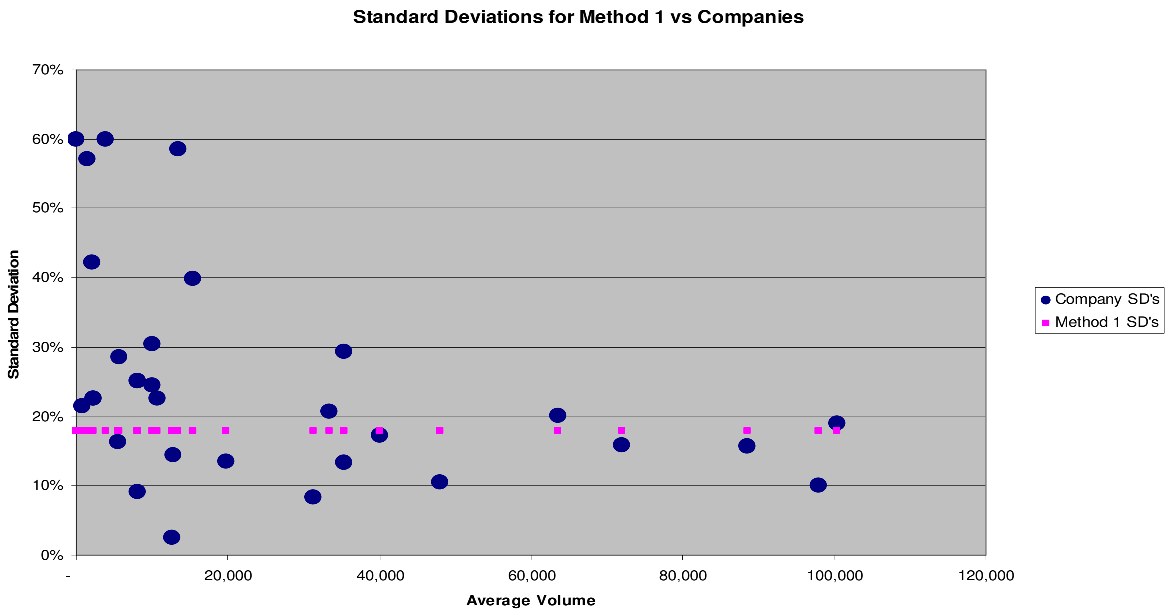
Discounted

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%		

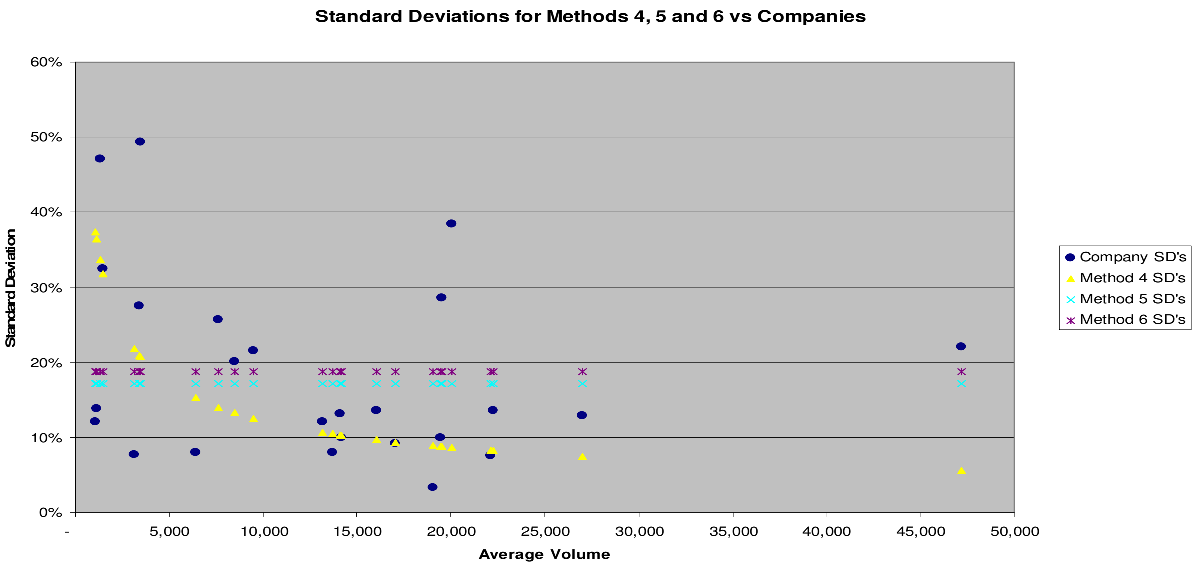
3.591 The graph below shows a pp plot of the fit of the models. Both methods provide a relatively poor fit, although there is some credibility in the tail.



3.592 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.



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



Overall conclusions:

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

Sickness

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

3.596 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

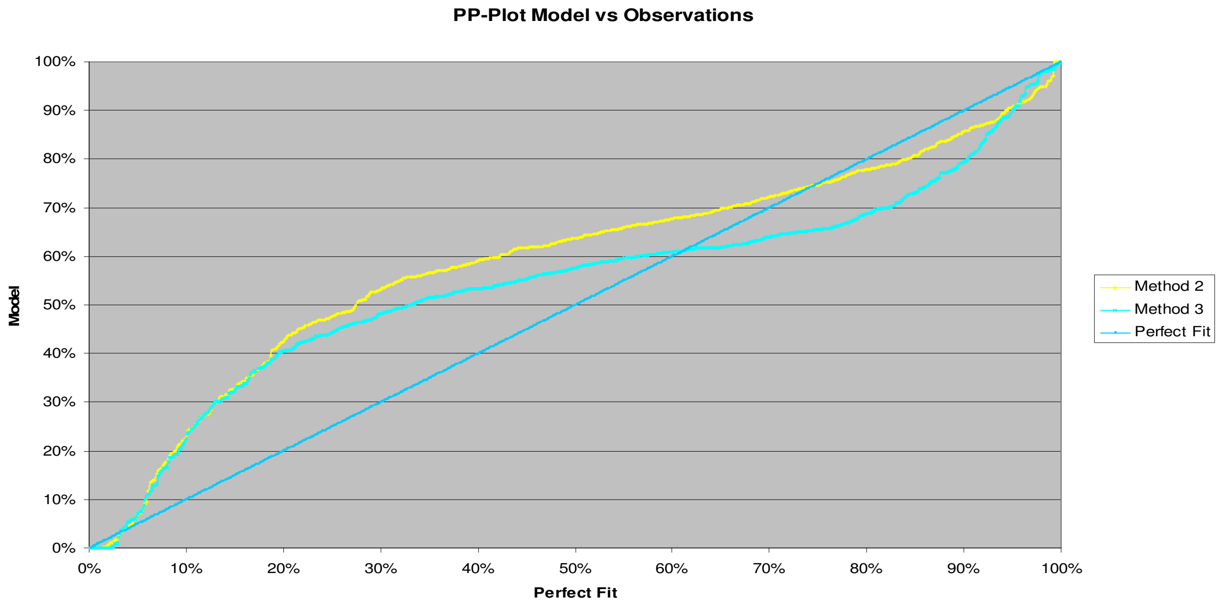
GROSS SD

Discounted

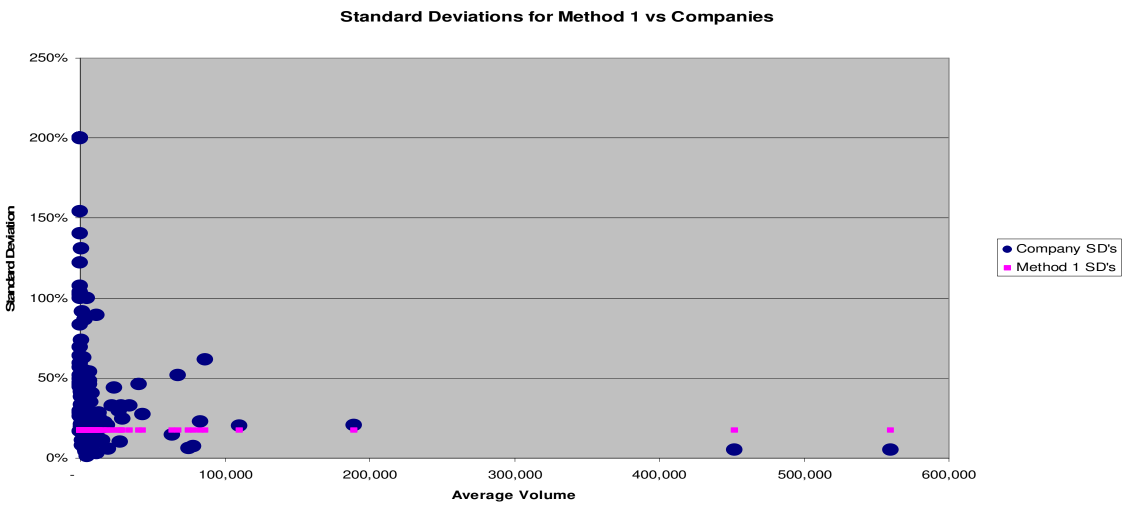
Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result	% firms with higher sd
Method 1	51%	28%	14%	17%	**25.2%**	**54.0%**
Method 2	211%	80%	48%	21%		
Method 3				65%		
Method 4	31%	12%	7%	3%		

Method 5	17%
Method 6	41%

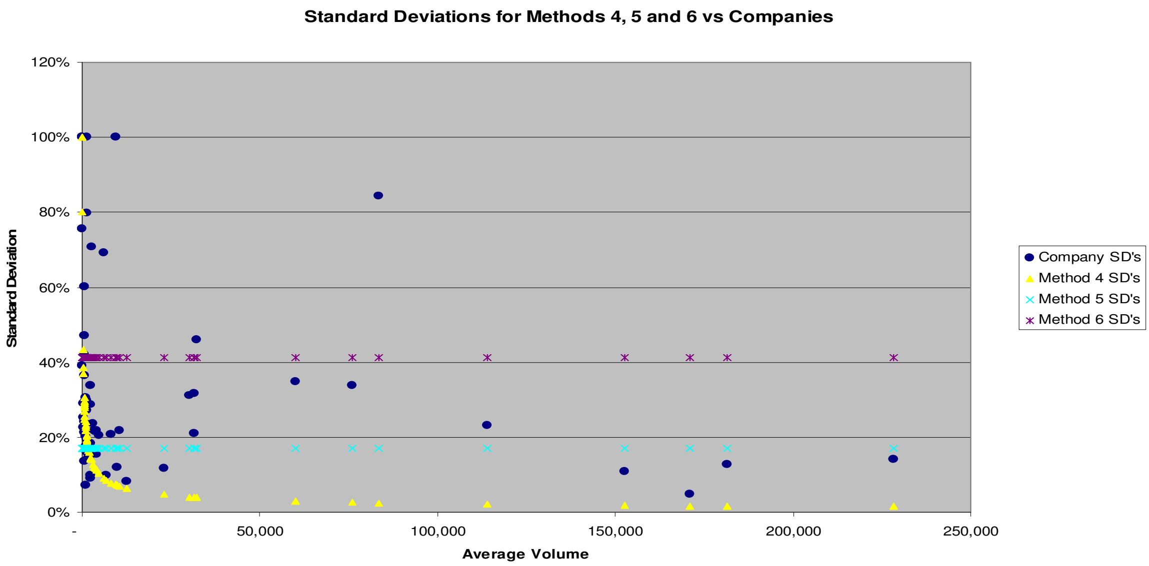
3.597 The graph below shows a pp plot of the fit of the models. Both methods provide a relatively poor fit.



3.598 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.



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



Overall conclusions:

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

Workers' compensation

3.601 CEIOPS recommendation is that for the workers' compensation lob the factor for reserve risk is 25%.

3.602 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

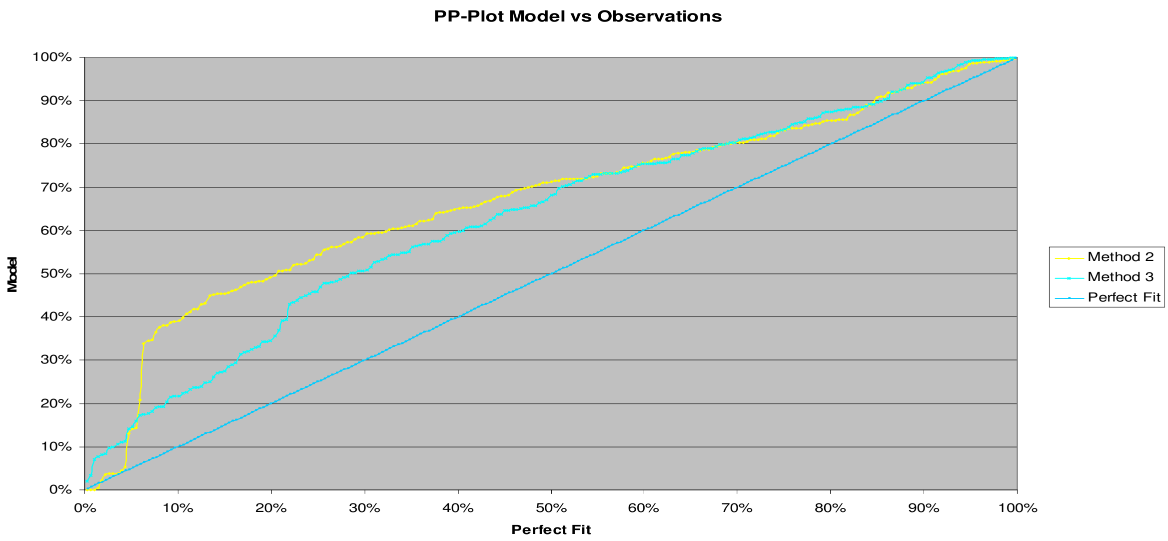
GROSS SD

Discounted

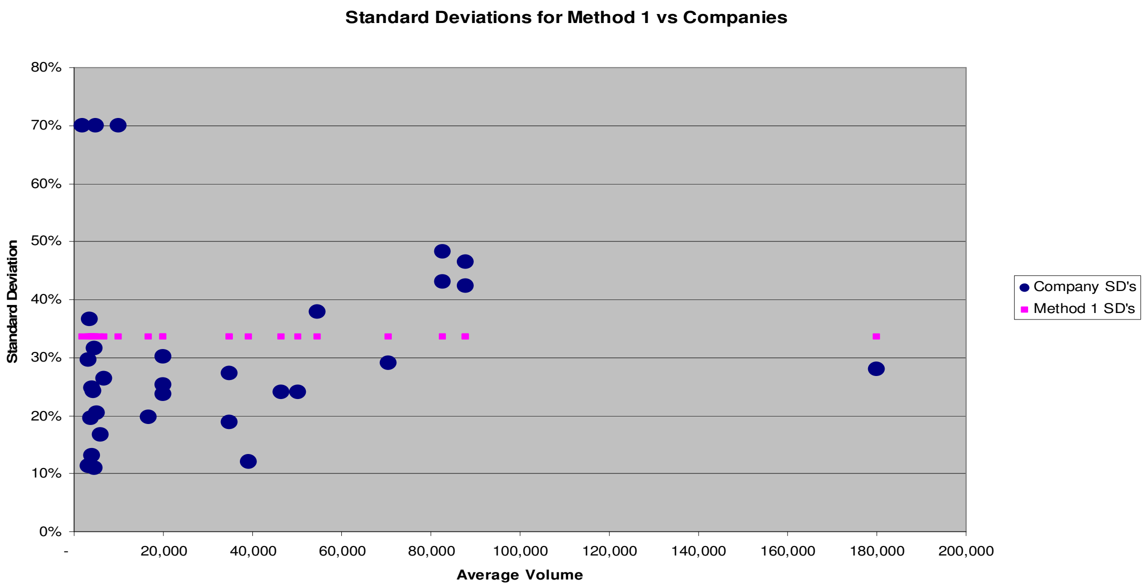
Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result	% firms with higher sd
Method 1	37%	26%	20%	34%	**24.4%**	**65.0%**
Method 2	77%	38%	23%	24%		
Method 3				38%		

Method 4	15%	8%	5%	5%
Method 5				3%
Method 6				11%

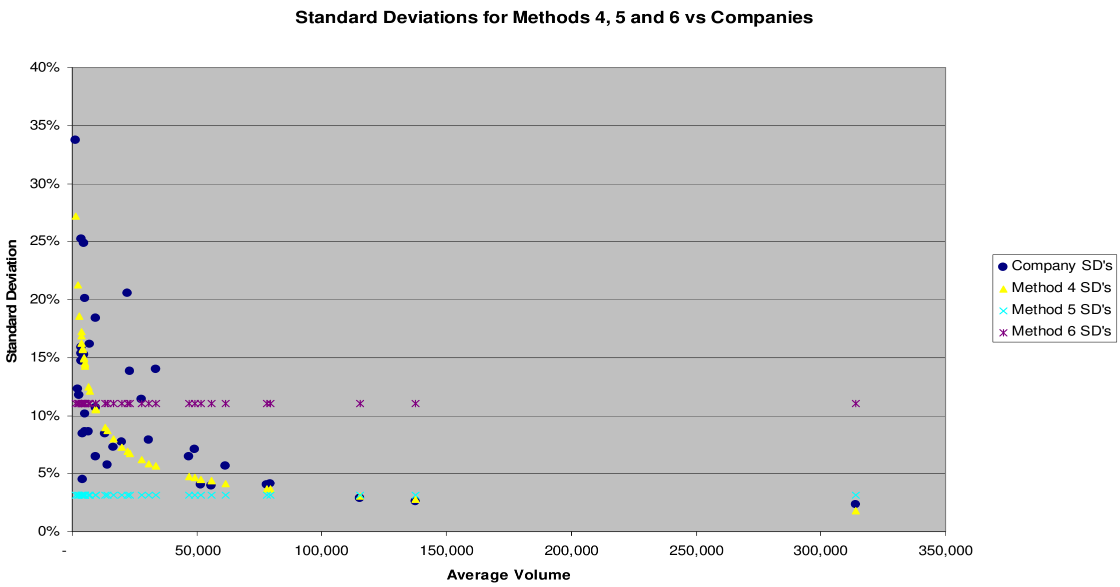
3.603 The graph below shows a pp plot of the fit of the models. Method 3 provides the best fit.



3.604 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.



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



Overall conclusions:

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

Adjusting gross to net for reserve risk

3.607 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.

3.608 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.

3.609 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.

3.610 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%

3.611 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.

3.612 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

3.613 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

3.614 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

3.615 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

3.616 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

3.617 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

3.618 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.

Summary results

3.619 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	5.5%	25%

compensation

3.620 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[98]	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%

Data availability

3.621 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

3.4.3 Health Catastrophe standardised scenarios

3.622 Under the standard formula there is one method that can be used by the undertaking for estimating their catastrophe risk:

- Standardised scenarios

3.623 The method is aimed to provide a calibration of catastrophe risk at the 99.5% VaR for undertakings that are exposed to extreme or exceptional events.

[98] 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

Standardised scenarios

3.624 Under CP48 and CP50, CEIOPS proposed the development of Standardised Scenarios as a method for the estimation of the Catastrophe Risk charge required under Article 111 1(c) of the Level 1 Directive.

3.625 The proposal included the creation of a joint industry and CEIOPS Catastrophe Task Force (CTF). The aim of the CTF would be to provide CEIOPS with input and guidance on the calibration and application of Non Life and Health Catastrophe standardised scenarios in line with the advice provided by CEIOPS in CP48 and CP50. The proposal was welcomed and supported by the European Commission.

3.626 In July 2009, CEIOPS sent a letter to a number of stakeholders inviting them to be part of the CTF. The CTF was established at the end of August 2009.

3.627 The members of the CTF are:

- Swiss Re
- Lloyd's of London
- Munich Re
- CCR
- SCOR
- The Actuarial Profession Health & Care Practice Executive Committee
- Guy Carpenter
- Willis
- RMS
- CEIOPS FinReq members

3.628 It was agreed with CEIOPS and the European Commission that the CTF would provide an interim paper in March 2010 and a final proposal by June 2010.

3.629 The advice presented in this paper is based work carried out by the CTF and supported by CEIOPS.

3.630 The aim was to provide an appropriate and unbiased calibration based on the information that has been selected considering the views and expert opinions of CEIOPS and members of catastrophe task force.

3.631 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

3.632 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.

3.633 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.

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

3.635 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.

3.636 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.

3.637 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

3.638 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)

3.639 A table is included below 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.

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

b) Footprint for a concentration scenario

3.640 The task force modelled footprints for a concentration scenario.

3.641 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

3.642 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.

3.643 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.

3.644 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 (Ip)

3.645 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.

3.646 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 Appendix 1 at the end of this section.

e) Calibration of proportion of lives affected (X_p)

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

3.648 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

3.649 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.

3.650 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.

3.651 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*

3.652 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

3.653 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.

3.654 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.

3.655 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

3.656 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.

3.657 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.

3.658 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.

3.659 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.

- For more detail see appendix 2 at the end of this section.

3.660 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.

3.661 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 ‰ of the capital value of the sums at risk.

3.662 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.

3.663 So the final R factor is 0.075‰

3.664 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. Hoeber, 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

Appendix 1. Health catastrophe: Insurance penetration statistics (I_P)

Health insurance coverage

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	UK	FR	DE	IT	ES	NL	BE	AT	PT	DK	NO	CZ	FI	HE	HU	IE	PO	CH	SK	SE	SI	LU	LT	LV	IS	BG	CR	CY	EE	MT	RO
% population																															
Income protection	5%	64%	21%	39%	48%	92%	39%	0.10%												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%	71.40%										
Medical expenses insurance: reimbursement only			11%																												
Long term care	0%	5%	13%	1%	0.03%			0.10%																							
Standalone critical illness	1%							0.60%							1%																
Personal accident	20%	18%	15%	5%	3%		6%					13%			9%					52%											
Number of persons covered (millions)																															
Income protection	3.7	40.9	17	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	10.8		0.015			0.01																							
Standalone critical illness	0.7							0.1							0.1																
Personal accident	14.6		12	3								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	4.4	38	9.2	5.4	7.7	2	0.5									
Adult population	53.8	52.1	71	51.4	38.9	13.5	8.9	7.1	9	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%					

* 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.

<u>Notes</u>

- 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	IE	PO
	2006	2006	2007		2006	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007
Number of insured	7	54	23		6	15	8	3	2	1	-	-	-			2	-
Penetration	11%	88%	28%		14%	92%	77%	34%	18%	16%	0%	0%	0%	0%	30%	51%	0%
* Medical expenses insurance.																	

Appendix 2. Return Period of Encephalitis Lethargia Scenario

3.665 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.

3.666 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

3.667 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

3.668 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)

3.669 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

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

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

3.672 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.

3.673 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%

3.5 Non-life underwriting risk

3.674 This includes the calibration of the:

- Premium and reserve risk sub module and
- Catastrophe risk sub module

3.5.1 Non-life premium and reserve risk[99]

3.675 CEIOPS' advice on non-life underwriting risk (CEIOPS-DOC-41-09), provides advice in respect of the design of the non life underwriting risk module, in particular the methods, assumptions and standard parameters to be used when calculating this risk module.

3.676 Overall, the premium and reserve risk capital charge is determined as follows:

$$NL_{pr} = \rho(\sigma) \bullet V$$

where

V	=	Volume measure
σ	=	combined net standard deviation, resulting from the combination of the reserve and premium risk standard deviations
$\rho(\sigma)$	=	A function of the standard deviation

3.677 The overall volume measure V is determined as follows:

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

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

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

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

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

---

[99] This section follows CEIOPS-DOC-67/10

where

$N_{0.995}$ = 99.5% quantile of the standard normal distribution

3.679 The function $\rho(\sigma)$ 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, $\rho(\sigma)$ ≈ 3 • σ.

3.680 The overall net standard deviation σ is determined as follows:

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

where

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

$CorrLob^{rxc}$ = the cells of the correlation matrix *CorrLob*

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

3.681 In order to estimate the capital charge for the Non life premium and reserve risk submodule, CEIOPS needs to provide calibrated factors for the following inputs:

- Net standard deviation for premium risk σ(prem,LoB)
- Net standard deviation for reserve risk σ(res,LoB)
- correlation factors between LoB (CorrLob)

3.682 The corresponding LoBs shall be: During the CP71 consultation, stakeholders emphasized that the parameters provided by CEIOPS deviated significantly from previous exercises and that QIS 4 was a better benchmark.

LoB number	
1	Motor, vehicle liability
2	Motor, other classes
3	Marine, aviation, transport (MAT)

4	Fire and other property damage
5	Third-party liability
6	Credit and suretyship
7	Legal expenses
8	Assistance
9	Miscellaneous
10	Non-proportional reinsurance – property
11	Non-proportional reinsurance – casualty
12	Non-proportional reinsurance – MAT

General Observations

QIS 3 and QIS 4 calibration

3.683 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.

3.684 CEIOPS provided the first non-life 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.

3.685 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.

3.686 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."

3.687 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 71 was the result of this work.

3.688 During CP71 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

3.689 The previous calibrations were performed using data from an unrepresentatively small set of member states within the EEA.

3.690 Whilst the introduction of more data leads to heterogeneity calibration problems, the resultant parameters should be more appropriate for more undertakings within the EEA.

3.691 CEIOPS have included Method 1 in CP 71 (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 71, this method also tends to give the lowest calibrations, as expected from the issues identified.

Relationship between volatility and volume measure

3.692 CP 71 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.

3.693 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

3.694 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.

3.695 This issue was not explored in the previous calibrations and could have resulted in a misinterpretation of the certainty of the resultant calibration.

3.696 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

3.697 The approach used a single set of model assumptions. Different, but similar, model assumptions fitted to the same data can give materially different answers.

3.698 This issue was not explored in the previous calibrations and could have resulted in a misinterpretation of the certainty of the resultant calibration.

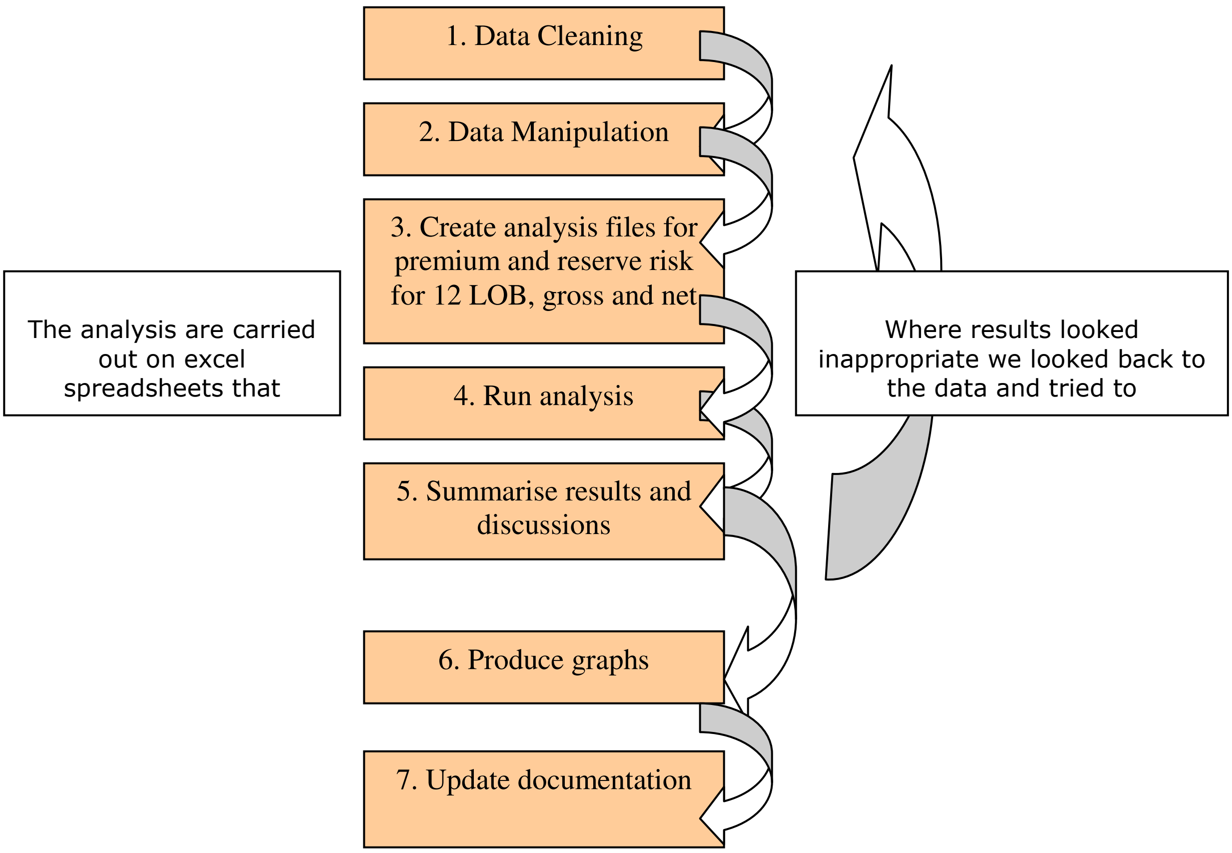
Over-fitting

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

3.700 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 non life calibration

3.701 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. See final advice from CEIOPS on CP 71 for details of the member states that have provided data by LoB gross and net of reinsurance compared to the first version on CP71.
    - There were issues around confidentiality which required standardisation of the data. In order to use the standardised data CEIOPS had to un-standardise 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. Details on how this was carried out is included in the annex of CEIOPS-DOC-67/10.
    - 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 further below. For reserve risk, CEIOPS has proposed to use a more general industry wide adjustment factor, which is explained further below.

Premium risk

3.702 This section describes the premium risk calibration and results.

Data

3.703 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

3.704 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.

3.705 For further details of the process followed see annex 7.3 of CEIOPS-DOC-67/10.

Assumptions

3.706 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).

3.707 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.

3.708 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.

3.709 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.

3.710 The risk margin does not change after stressed conditions.

3.711 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.

Analysis

3.712 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.

3.713 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.

3.714 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.

3.715 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.

3.716 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.

Methodology

3.717 A variety of methods was used to estimate the factors a set of pan European factor for each line of business.

3.718 CEIOPS carried out the following methods for the estimation of the premium risk standard deviations:

Method 1

3.719 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".

3.720 This involves the firm calculating the average net earned premium and the standard deviation of the loss ratios posted after the first development year.

3.721 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.

3.722 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.

3.723 The second stage fits the premium risk factor to these resultant undertaking specific models.

3.724 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.

3.725 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.

3.726 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

3.727 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

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

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

3.729 If following term is defined:

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

3.730 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

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

3.732 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

3.733 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.

3.734 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.

3.735 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.

3.736 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.

3.737 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:

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

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

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

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

3.739 The resultant simplified log Likelihood becomes

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

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

3.741 The following term is defined:

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

3.742 The $\sigma_{(C,prem,lob)}$ then becomes :

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

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

3.743 If the following term is defined:

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

3.744 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:

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

<u>Method 3</u>

3.745 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.

3.746 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

3.747 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.

3.748 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.

3.749 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.

3.750 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.

3.751 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.

3.752 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 the distribution of losses can be formulated as follows:

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

3.753 The parameters of the lognormal distributions are formulated as follows:

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

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

3.754 The resultant simplified log Likelihood becomes

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

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

3.756 If the following term is defined as:

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

3.757 The $\sigma_{(C,prem,lob)}$ then becomes :

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

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

3.758 If the following term is defined as:

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

3.759 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:

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

<u>Method 4</u>

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

3.761 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

3.762 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.

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

3.764 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.

3.765 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:

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

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

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

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

3.767 The resultant simplified log Likelihood becomes

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

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

3.769 If the following term is defined as:

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

3.770 The $\sigma_{(prem,lob)}$ then becomes :

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

Premium Risk Results

3.771 CEIOPS has presented the results of the analysis though a combination of tables and graphs.

3.772 The table presents the results of methods 1 to 4 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.

3.773 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.

3.774 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.

3.775 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.

3.776 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.

3.777 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).

3.778 The selection of the final 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

3.779 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).

3.780 See annex 7.3 of CEIOPS-DOC-67/10 for further details of the process followed.

Motor, vehicle liability

3.781 CEIOPS recommendation is that for the motor vehicle liability lob the gross factor for premium risk should be 11.5%.

3.782 The data sample included data from 209 undertakings, was gross of reinsurance and included data from the following member states: PO, LU, PT, SI, SK, IS, IT, LT, FI, DK, SE and HU.

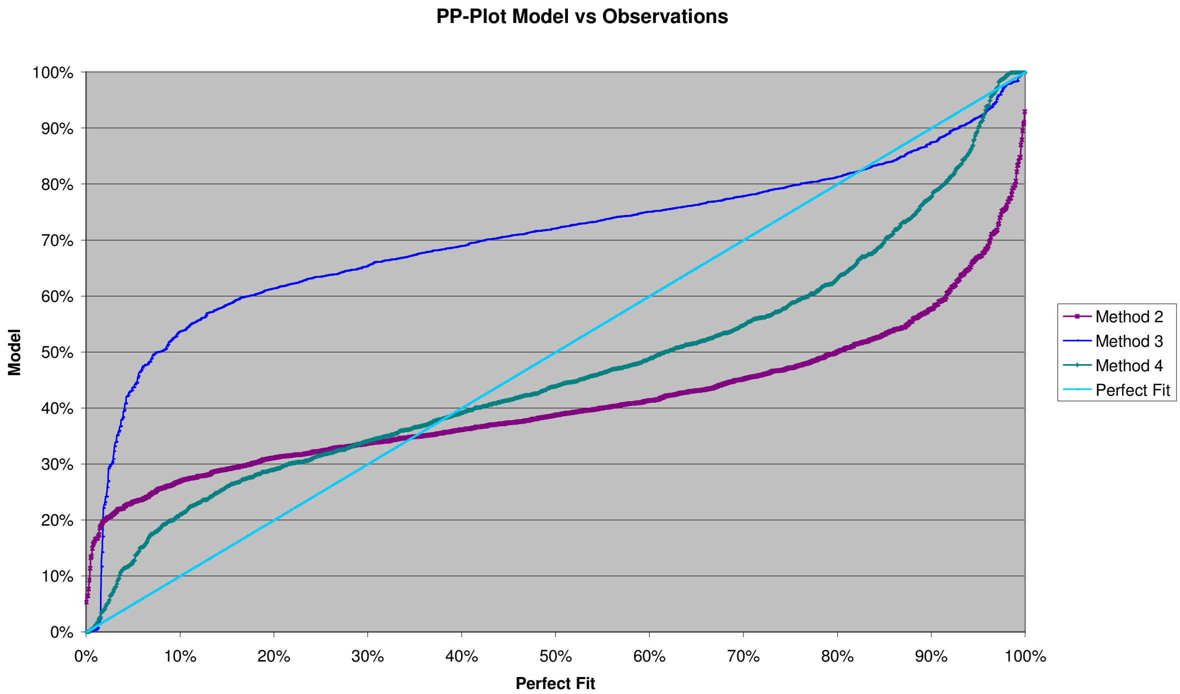
Reference co	Small	Medium	Large
Motor, third-party liability	12,500	48,879	134,604

GROSS Standard Deviations

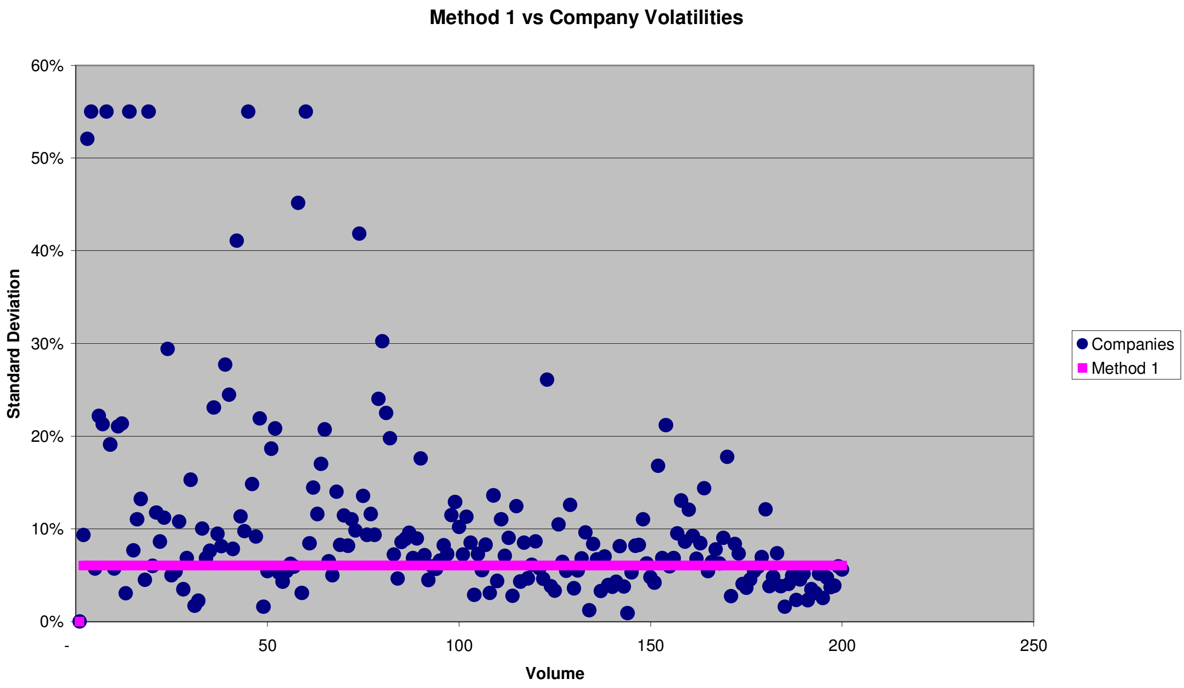
Discounted

Method	**Small (75th perc)**	**Medium (50th perc)**	**Large (25th perc)**	**VWA**	**Technical result based on VWA**	**% firms with higher sd**
Method 1				6%	**11.3%**	**26.1%**
Method 2	129%	65%	39%	25%		
Method 3	96%	49%	29%	18%		
Method 4				17%		

3.783 The graph below shows a pp plot of the fit of the models. None of the methods fit particularly well, but method 4 is probably the best.



3.784 The result on the graph below shows signs of diversification credit. It also shows the volatility of the individual observation compared to the fitted selection for method 1.



Overall conclusions:

3.785 The selected technical factor was chosen as the average of the results from methods 1 and 4 – result 11.3%

<u>Motor, other classes</u>

3.786 CEIOPS recommendation is that for the motor other lob the gross factor for premium risk should be 8.5%.

3.787 The data sample included data from 107 undertakings, was gross of reinsurance and included data from the following member states: PO, LU, SI, PT, SK, IS, LT, FI, DK and SE.

Reference co	**Small**	**Medium**	**Large**
Motor, other classes	9,112	16,225	49,698

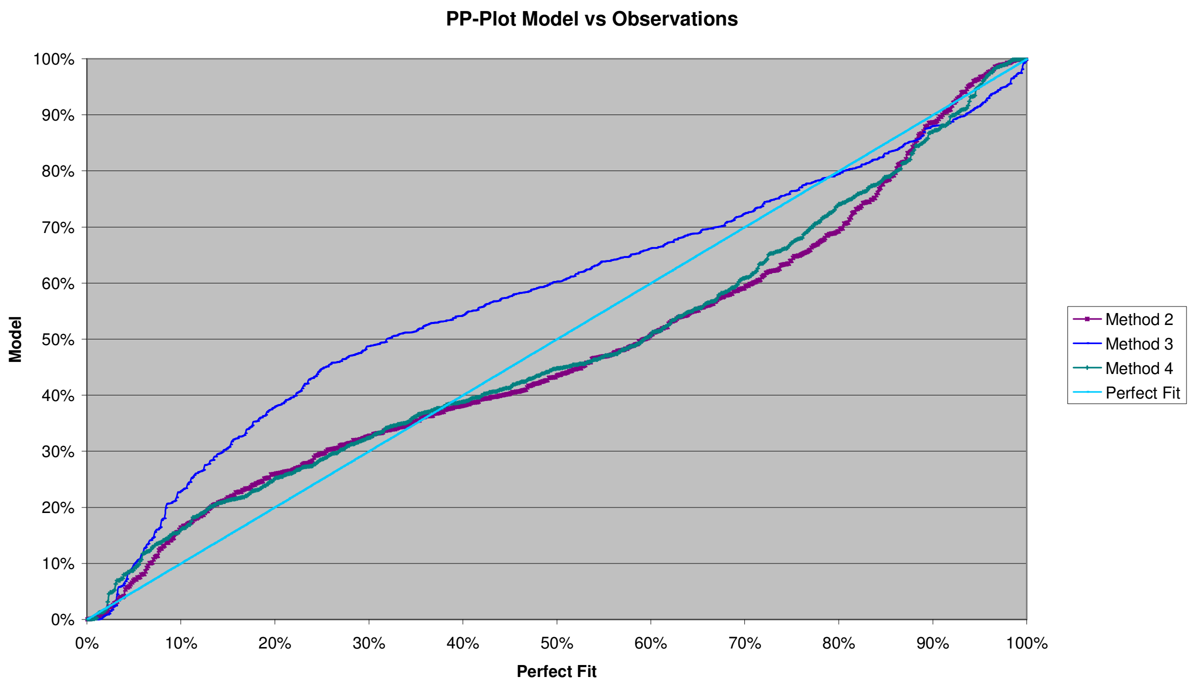
GROSS Standard Deviations

Discounted

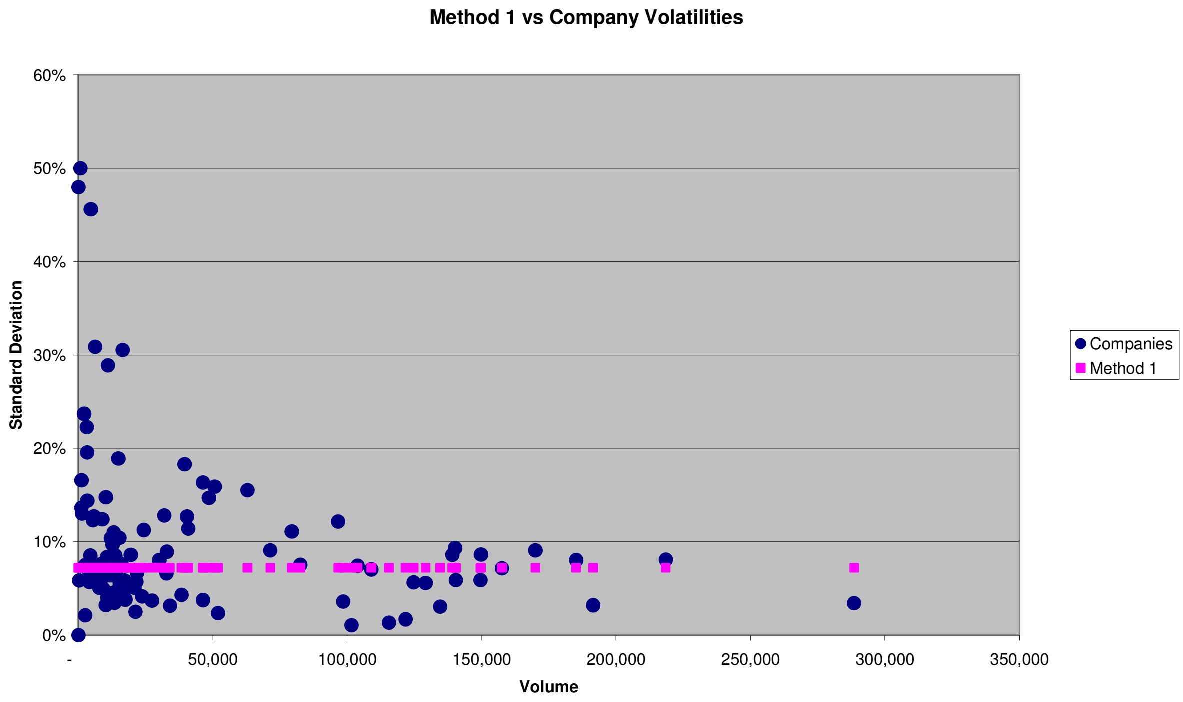
Method	**Small (75th perc)**	**Medium (50th perc)**	**Large (25th perc)**	**VWA**	**Technical result based on VWA**	**% firms with higher sd**
Method 1				7%	**8.3%**	**43.0%**

Method 2	18%	14%	8%	7%
Method 3	51%	38%	22%	19%
Method 4				11%

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



3.789 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:

3.790 The selected technical factor was chosen as the average of the results from methods 1, 2 and 4 – result 8.3%

Marine, aviation, transport (MAT)

3.791 CEIOPS recommendation is that for the MAT lob the gross factor for premium risk should be 23%.

3.792 The data sample included data from 37 undertakings, was gross of reinsurance and included data from the following member states: PO, LU, SK, IS, DK and SE.

Reference co	Small	Medium	Large
Marine, aviation, transport (MAT)	414	3,343	6,077

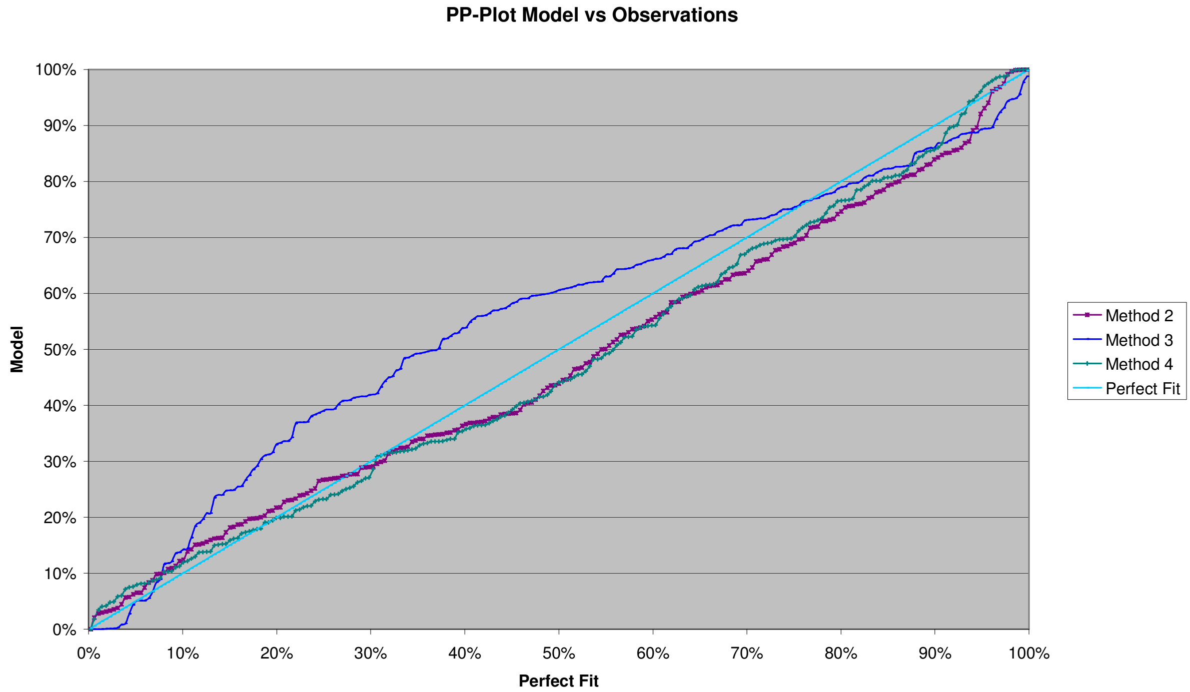
GROSS Standard Deviations

Discounted

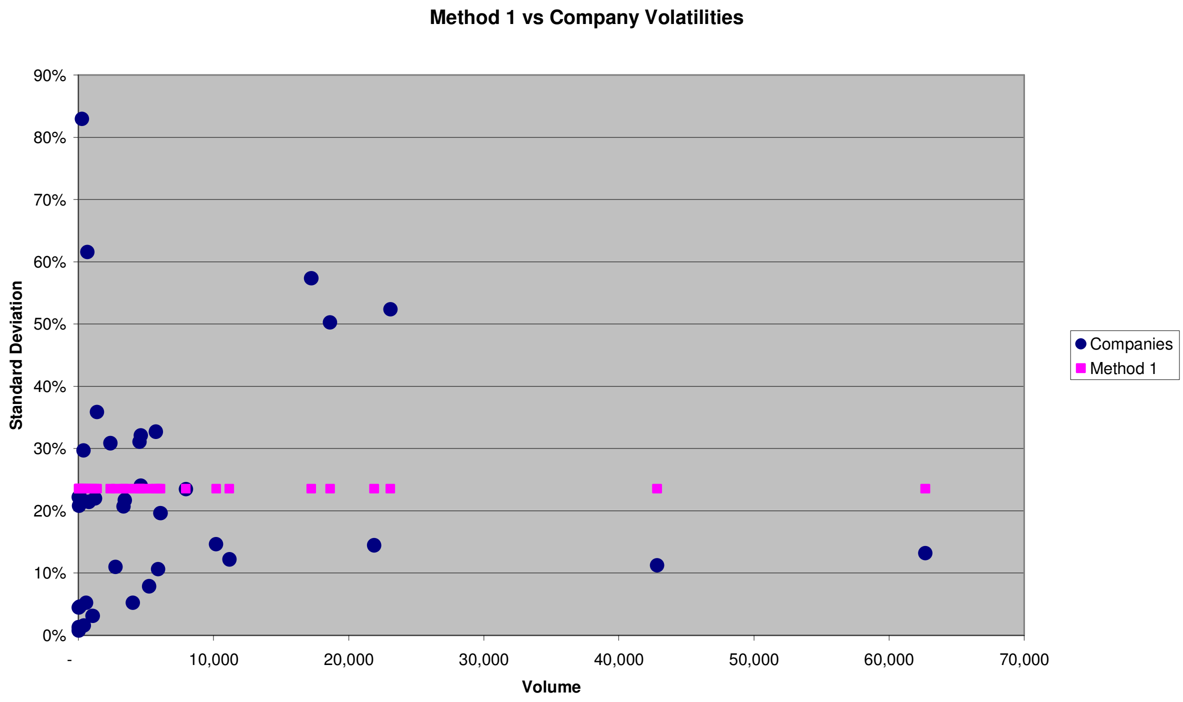
Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result based on VWA	% firms with higher sd

Method 1				22%	**22.8%**	**35.1%**
Method 2	109%	38%	28%	19%		
Method 3	334%	117%	87%	59%		
Method 4				27%		

3.793 The graph below shows a pp plot of the fit of the models. It is clear that methods 2 and 4 are the best fits to the models, with little to choose between them.



3.794 The result on the graph below does show some signs of diversification credit, but it is not clear from the presence of some outliers.



Overall conclusions:

3.795 The selected technical factor was chosen as the average of the results from methods 1, 2 and 4 – result 22.8%

<u>Fire and other property damage</u>

3.796 CEIOPS recommendation is that for the fire and other property damage lob the gross factor for premium risk should be 15%.

3.797 The data sample included data from 138 undertakings, was gross of reinsurance and included data from the following member states: PO, LU, UK, SK, IS, FI, DK and SI.

Reference co	Small	Medium	Large
Fire and other property damage	6289	33,919	95,277

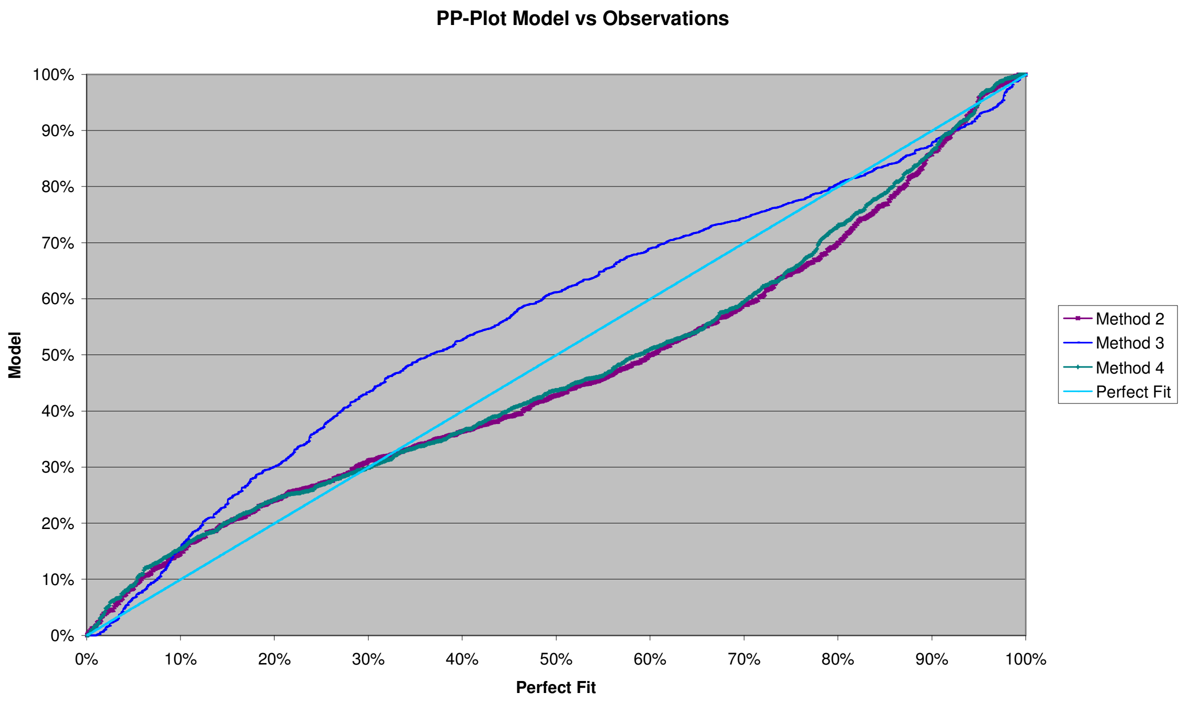
GROSS Standard Deviations

Discounted

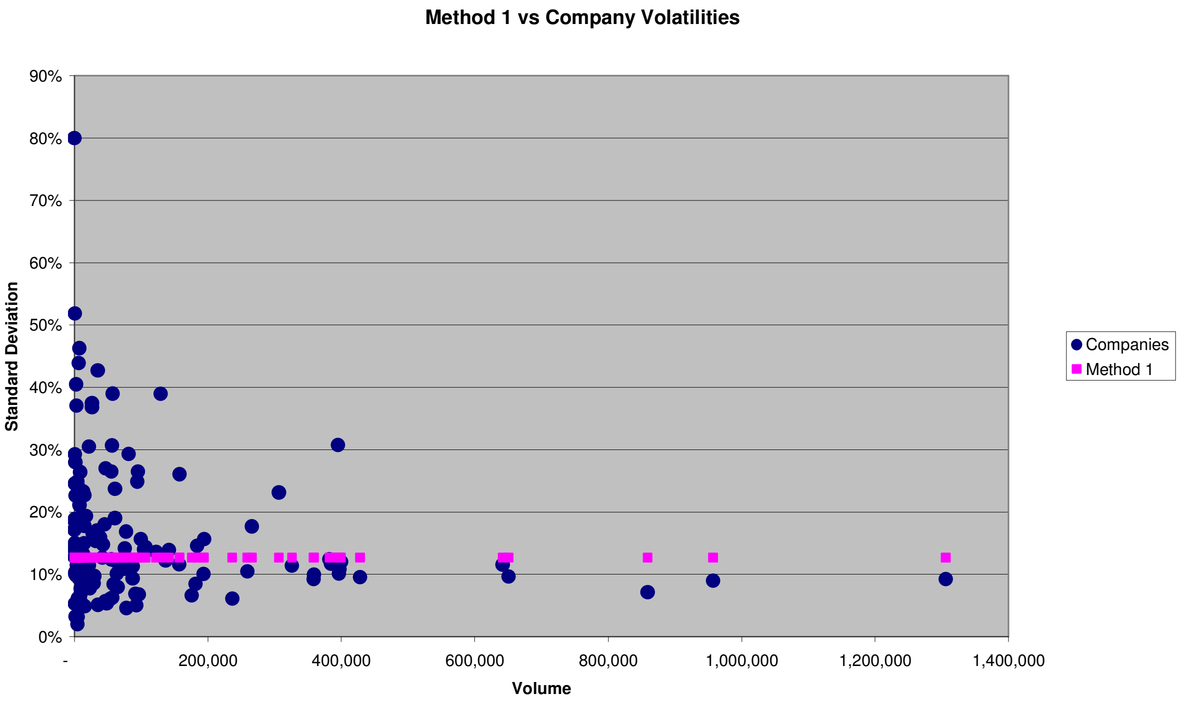
Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result based on VWA	% firms with higher sd
Method 1				12%	**15.2%**	**38.7%**

Method 2	61%	26%	16%	11%
Method 3	96%	41%	25%	18%
Method 4				20%

3.798 The graph below shows a pp plot of the fit of the methods. None of the methods fits particularly well, and there is little to choose between them.



3.799 The result on the graph below shows significant evidence of diversification credit.



Overall conclusions:

3.800 The selected technical factor was chosen as the average of the results from all four of the methods – result 15.2%.

Third-party liability

3.801 CEIOPS recommendation is that for the third party liability lob the gross factor for premium risk should be 17.5%.

3.802 The data sample included data from 101 undertakings, was gross of reinsurance and included data from the following member states: PO, LU, UK, SK, IS, DK and SI.

Reference co	**Small**	**Medium**	**Large**
Third-party liability	1466	8,850	21,276

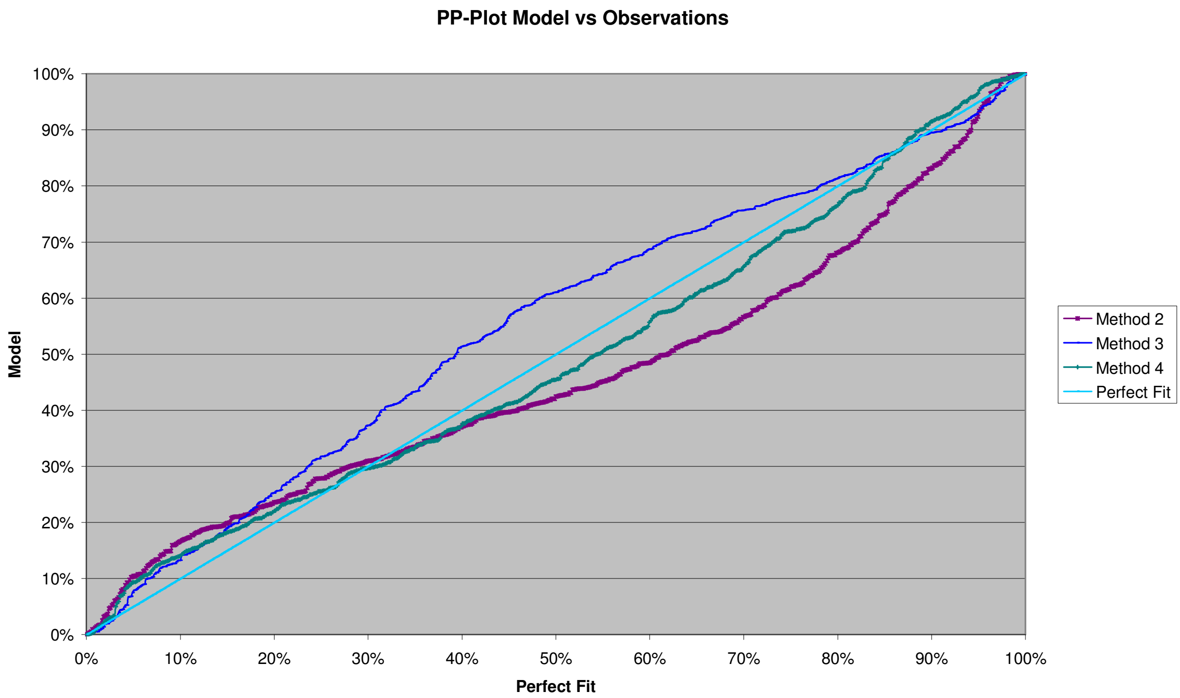
GROSS Standard Deviations

Discounted

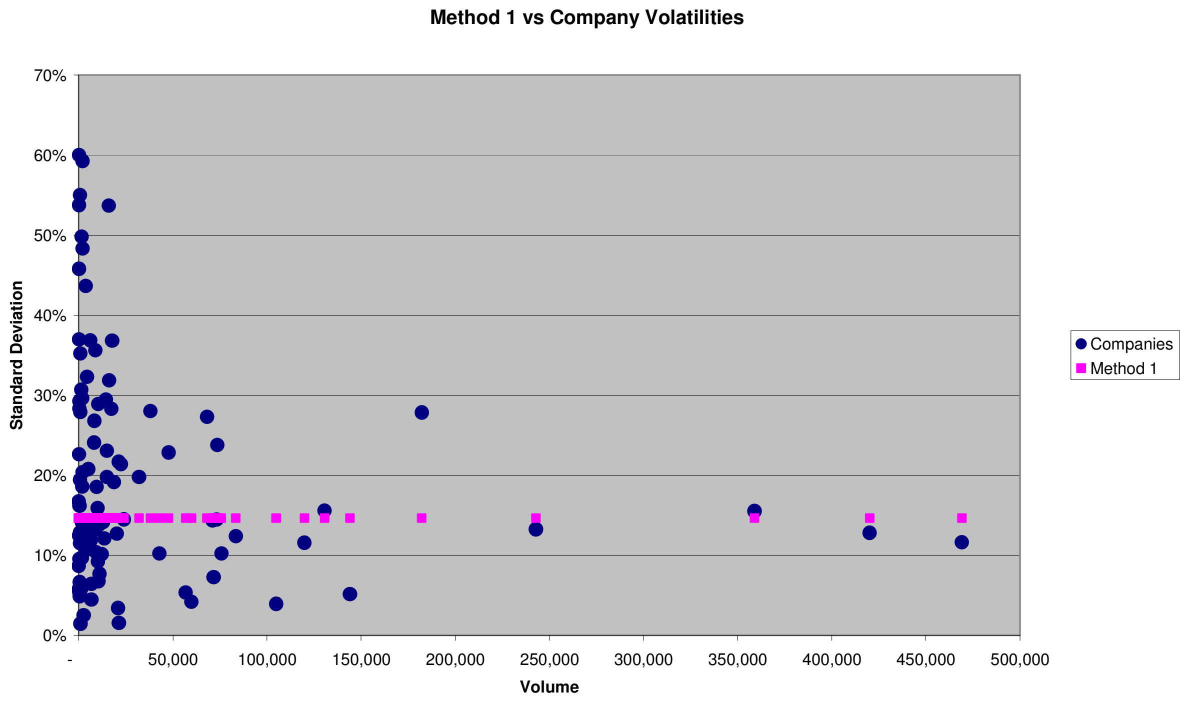
Method	**Small (75th perc)**	**Medium (50th perc)**	**Large (25th perc)**	**VWA**	**Technical result based on VWA**	**% firms with higher sd**

Method 1				13%	**17.2%**	**42.6%**
Method 2	86%	35%	23%	12%		
Method 3	140%	57%	37%	20%		
Method 4				21%		

3.803 The graph below shows a pp plot of the fit of the methods. Method 4 is probably the best fit.



3.804 The result on the graph below shows evidence of diversification credit.



Overall conclusions:

3.805 The selected technical factor has been taken as the average of methods 1 and 4 – result 17.2%.

Credit and suretyship

3.806 CEIOPS recommendation is that for the credit and suretyship lob the gross factor for premium risk should be 28%.

3.807 The data sample included data from 58 undertakings, was gross of reinsurance and included data from the following member states: PO, UK, SK, DK, SE and SI.

Reference co	Small	Medium	Large
Credit and suretyship	861	4,069	8,297

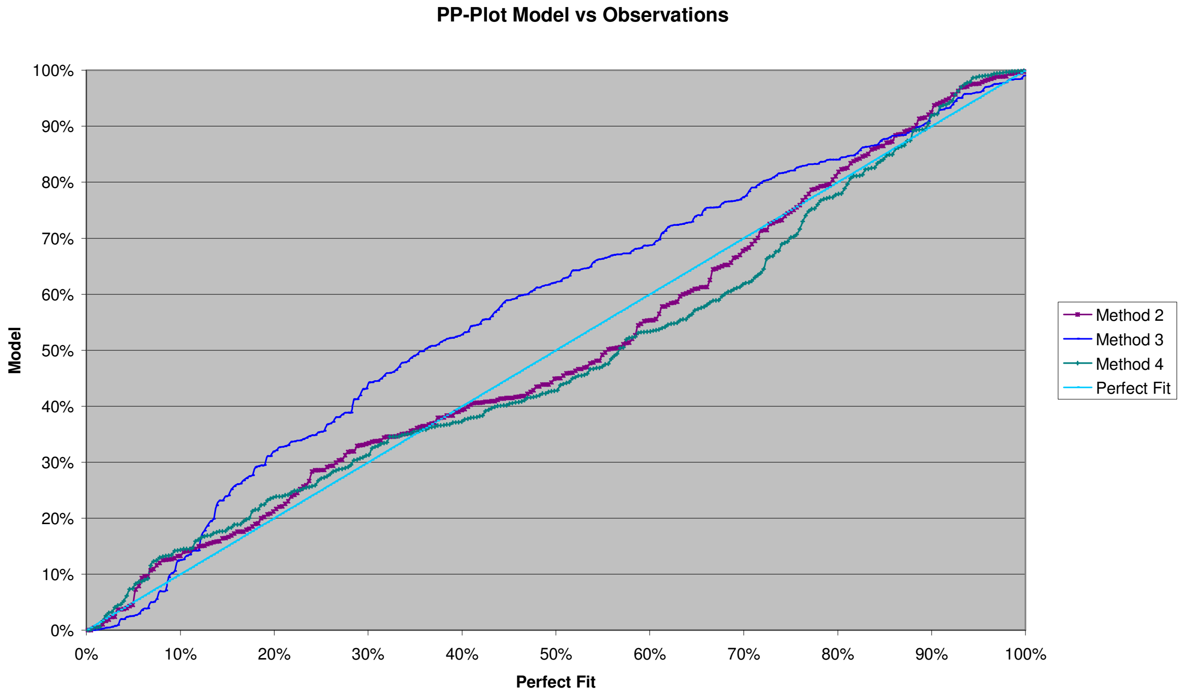
GROSS Standard Deviations

Discounted

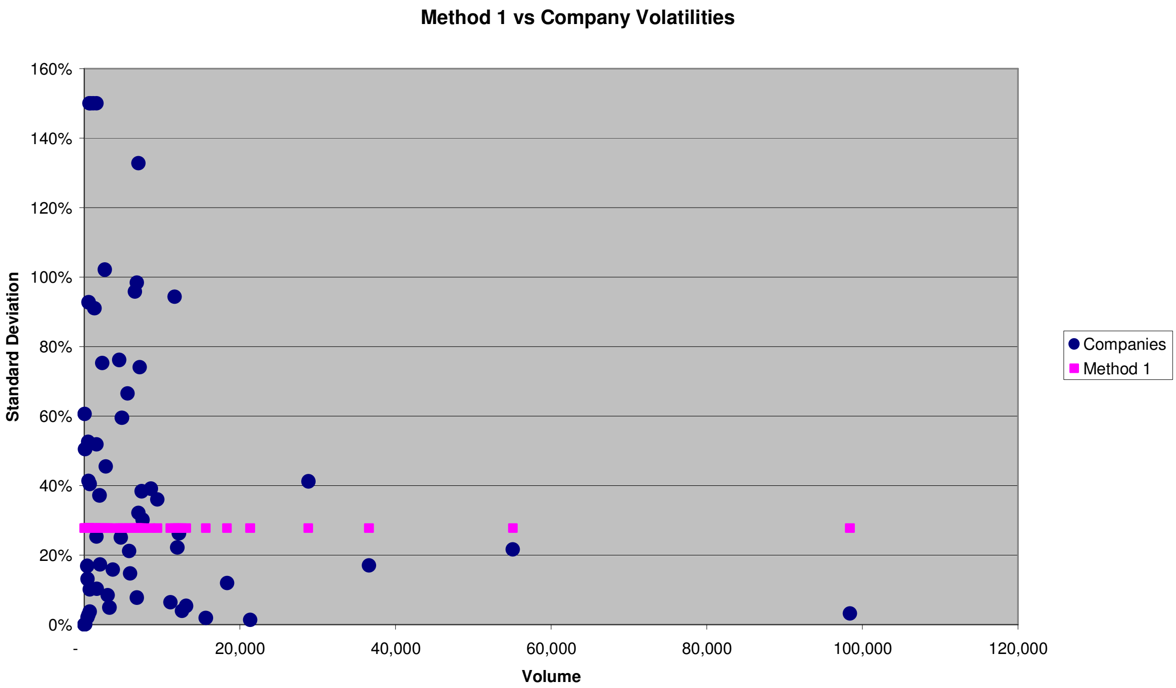
Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result based on VWA	% firms with higher sd

Method 1				25%	**28.1%**	**51.7%**
Method 2	124%	57%	40%	31%		
Method 3	313%	144%	101%	79%		
Method 4				66%		

3.808 The graph below shows a pp plot of the fit of the methods. Methods 2 and 4 are the best fits, but method 2 appears to be better than method 4.



3.809 The graph below shows evidence of diversification credit.



Overall conclusions:

3.810 The selected technical factor has been taken as the average of methods 1 and 2 – result 28.1%

Legal expenses premium risk

3.811 CEIOPS recommendation is that for the legal expenses lob the gross factor for premium risk should be 8%.

3.812 The data sample included data from 18 undertakings, was gross of reinsurance and included data from the following member states: PO, SK, FI and UK.

Reference co	Small	Medium	Large
Legal expenses	4,099	14,873	26,990

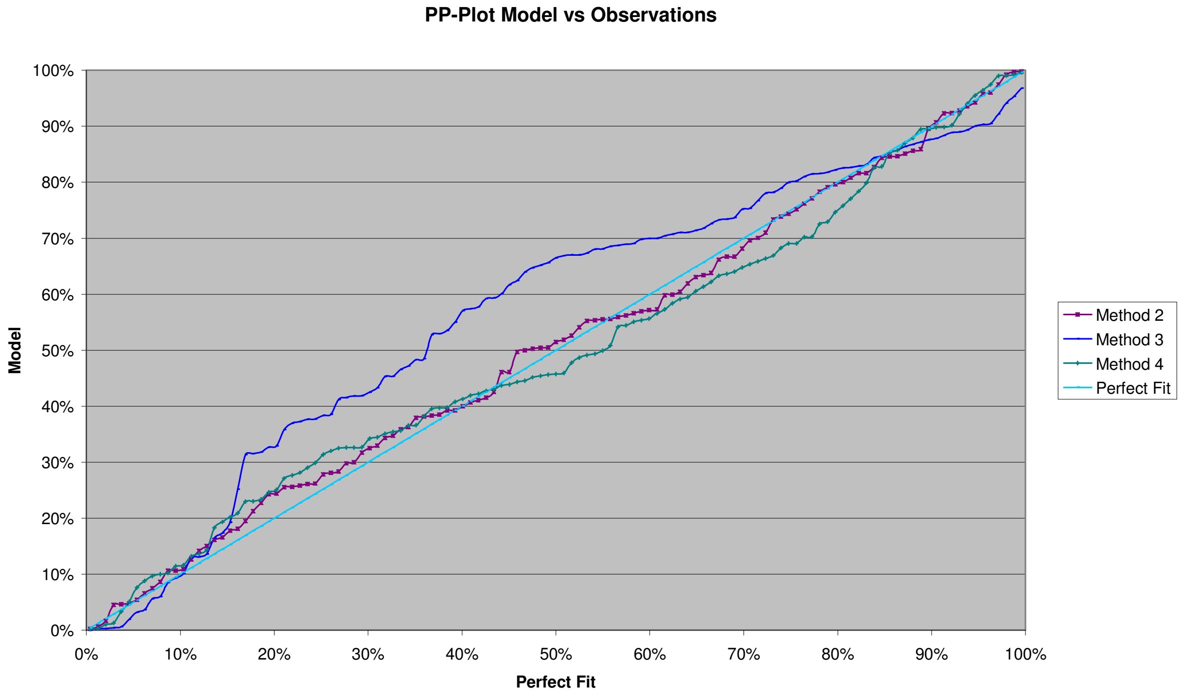
GROSS Standard Deviations

Discounted

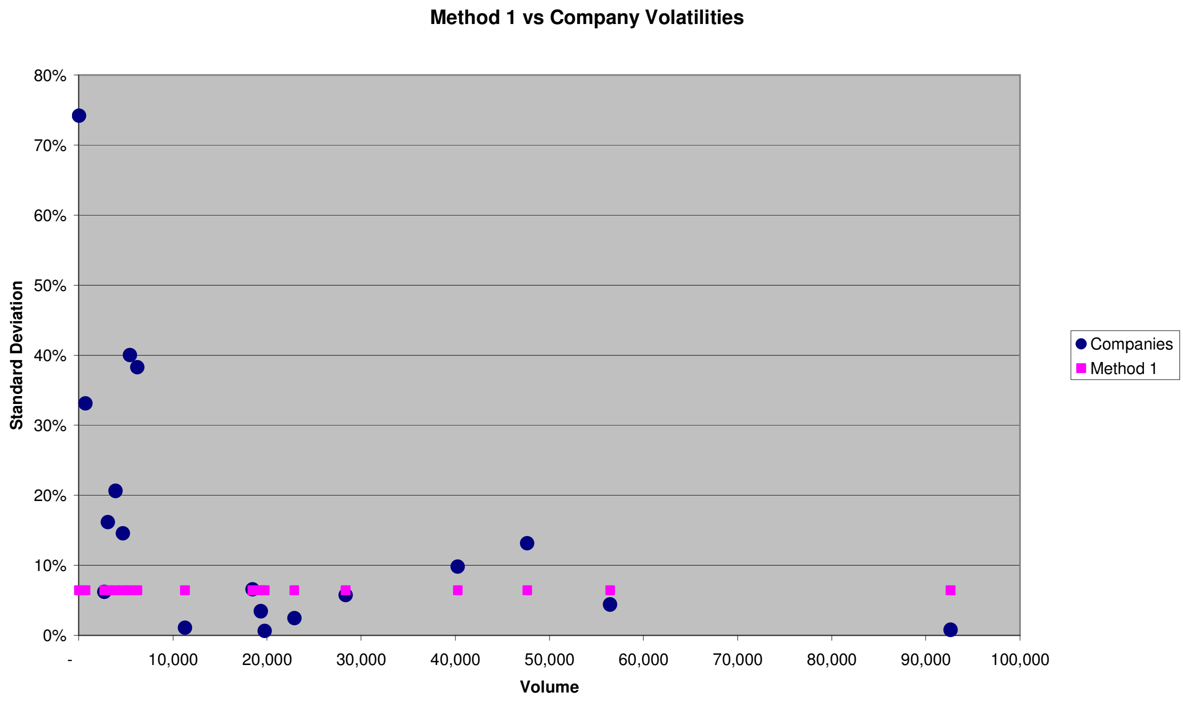
Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result based on VWA	% firms with higher sd

Method 1				6%	**8.0%**	**50.0%**
Method 2	27%	14%	11%	10%		
Method 3	280%	147%	109%	104%		
Method 4				27%		

3.813 The graph below shows a pp plot of the fit of the methods. Methods 2 and 4 are the best fits, but method 2 appears to be better than method 4.



3.814 The graph below shows evidence of diversification credit.



Overall conclusions:

3.815 The selected technical factor has been taken as the average of methods 1 and 2 – result 8.0%

Assistance

3.816 CEIOPS recommendation is that for the assistance lob the gross factor for premium risk should be 5%.

3.817 The data sample included data from 20 undertakings, was gross of reinsurance and included data from the following member states: PO, SK, DK and UK.

Reference co	Small	Medium	Large
Assistance	4,245	7,018	23,823

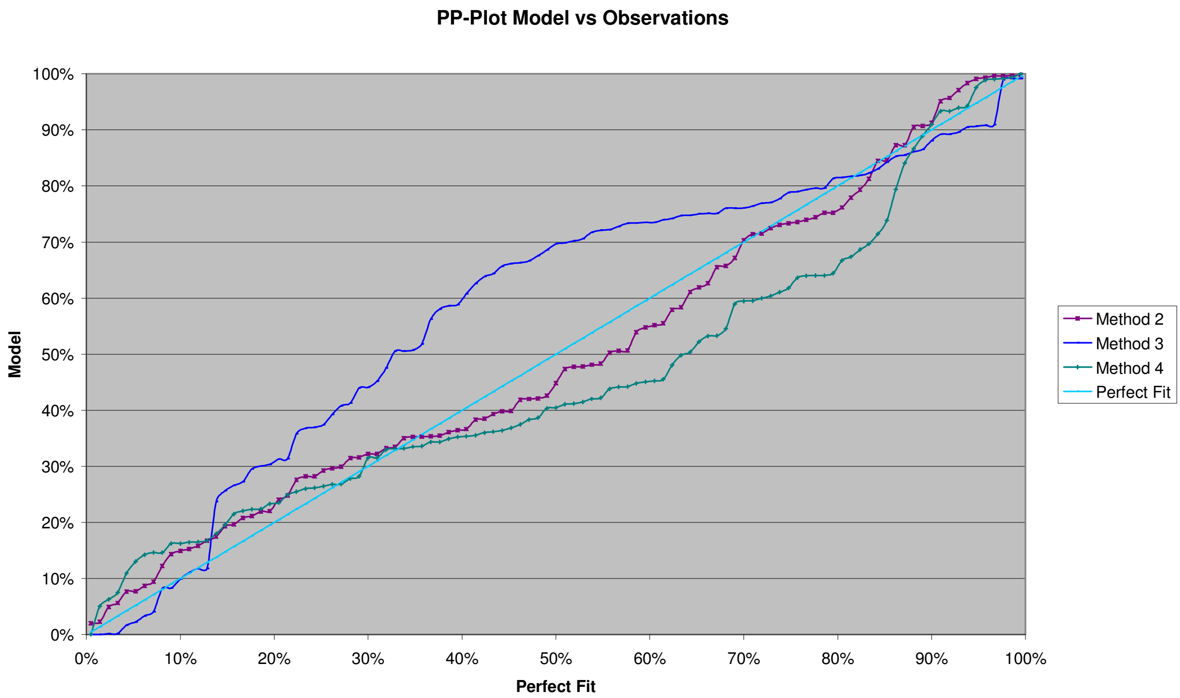
GROSS Standard Deviations

Discounted

Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result based on VWA	% firms with higher sd

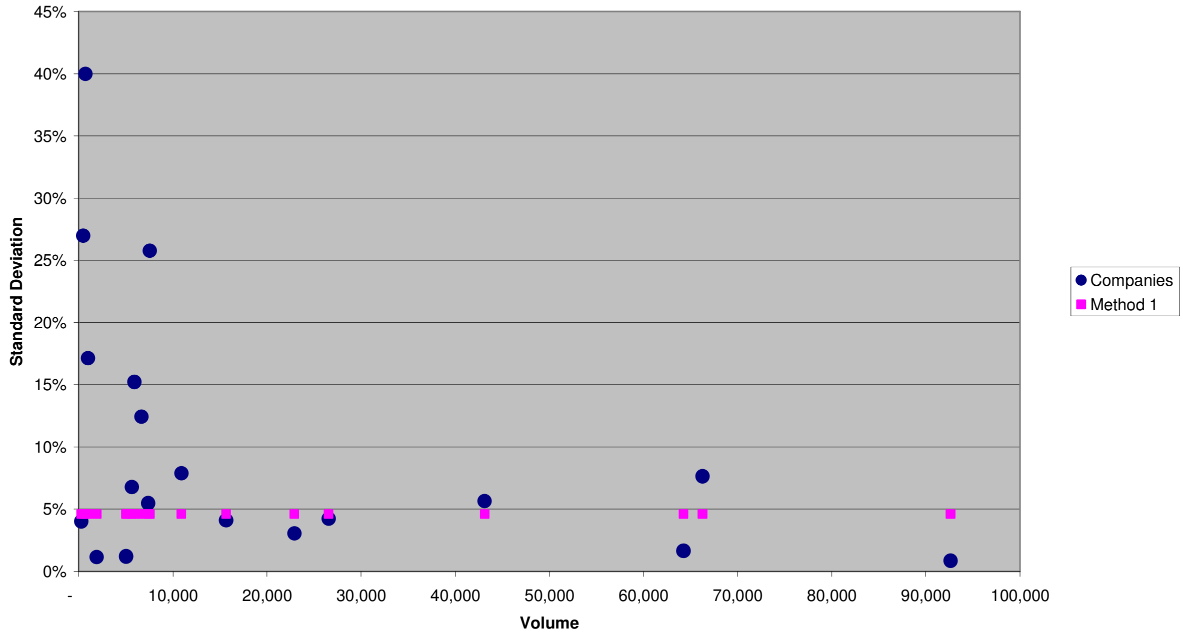
Method 1				4%	**4.9%**	**55.0%**
Method 2	14%	11%	6%	5%		
Method 3	59%	46%	25%	22%		
Method 4				14%		

3.818 The graph below shows a pp plot of the fit of the methods. Method 2 is the best fit.



3.819 The graph below shows evidence of diversification credit.

Method 1 vs Company Volatilities



Overall conclusions:

3.820 The selected technical factor has been taken as the average of methods 1 and 2 – result 4.9%

Miscellaneous

3.821 CEIOPS recommendation is that for the miscellaneous lob the gross factor for premium risk should be 15%.

3.822 The data sample included data from 75 undertakings, was net of reinsurance and included data from the following member states: PO, DK and UK.

Reference co	**Small**	**Medium**	**Large**
Miscellaneous	1,486	10,603	37,819

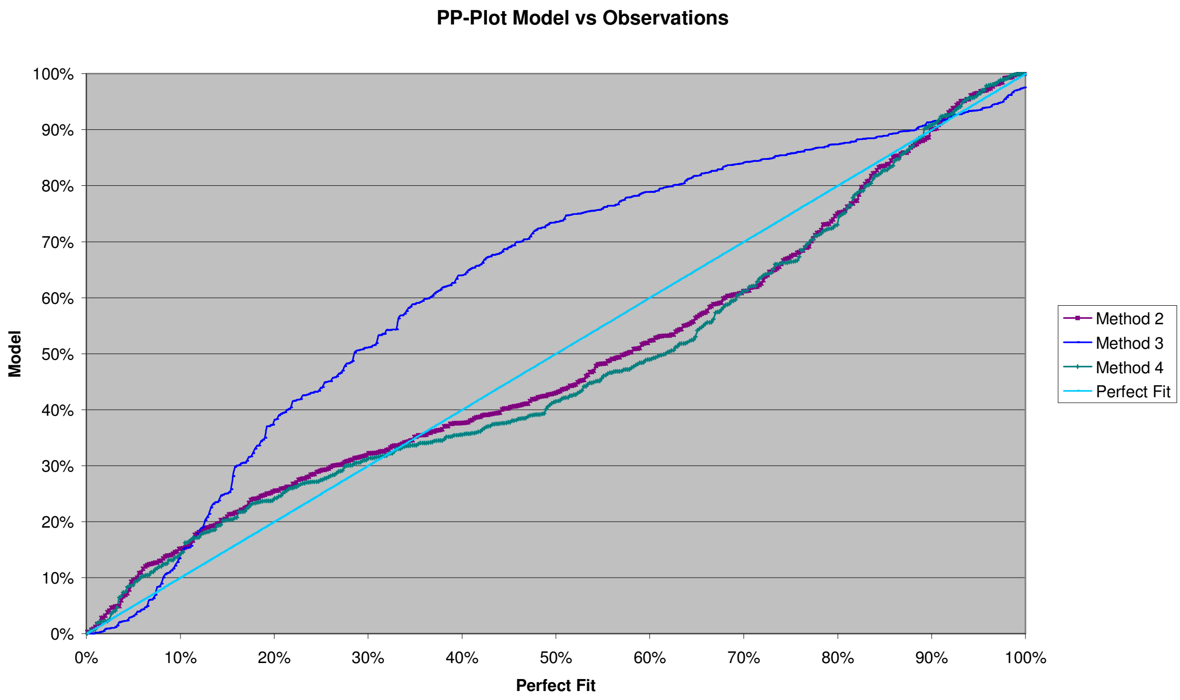
GROSS Standard Deviations

Discounted

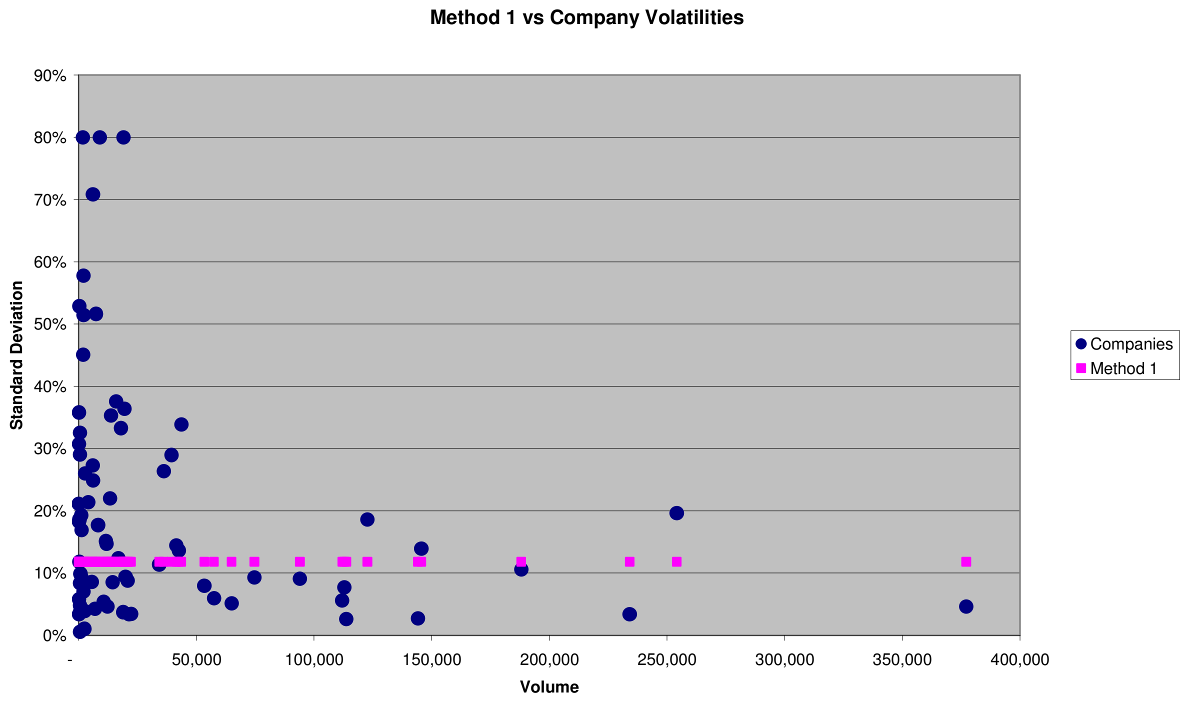
Method	**Small (75th perc)**	**Medium (50th perc)**	**Large (25th perc)**	**VWA**	**Technical result based on VWA**	**% firms with higher sd**

Method 1				11%	**15.4%**	**44.0%**
Method 2	77%	29%	15%	11%		
Method 3	313%	117%	62%	45%		
Method 4				24%		

3.823 The graph below shows a pp plot of the fit of the methods. Methods 2 and 4 are the best fits, with little to choose between them.



3.824 From the graph below, we can see signs of diversification credit.



Overall conclusions:

3.825 The selected technical factor has been taken as the average of methods 1, 2 and 4 – result 15.4%.

Non-proportional reinsurance – property

3.826 CEIOPS recommendation is that for the non-proportional reinsurance - property lob the gross factor for premium risk should be 37.5%.

3.827 The data sample included data from 9 undertakings, was gross of reinsurance and included data from the following member states: UK.

Reference co	Small	Medium	Large
NPL Property	3,724	6,339	16,497

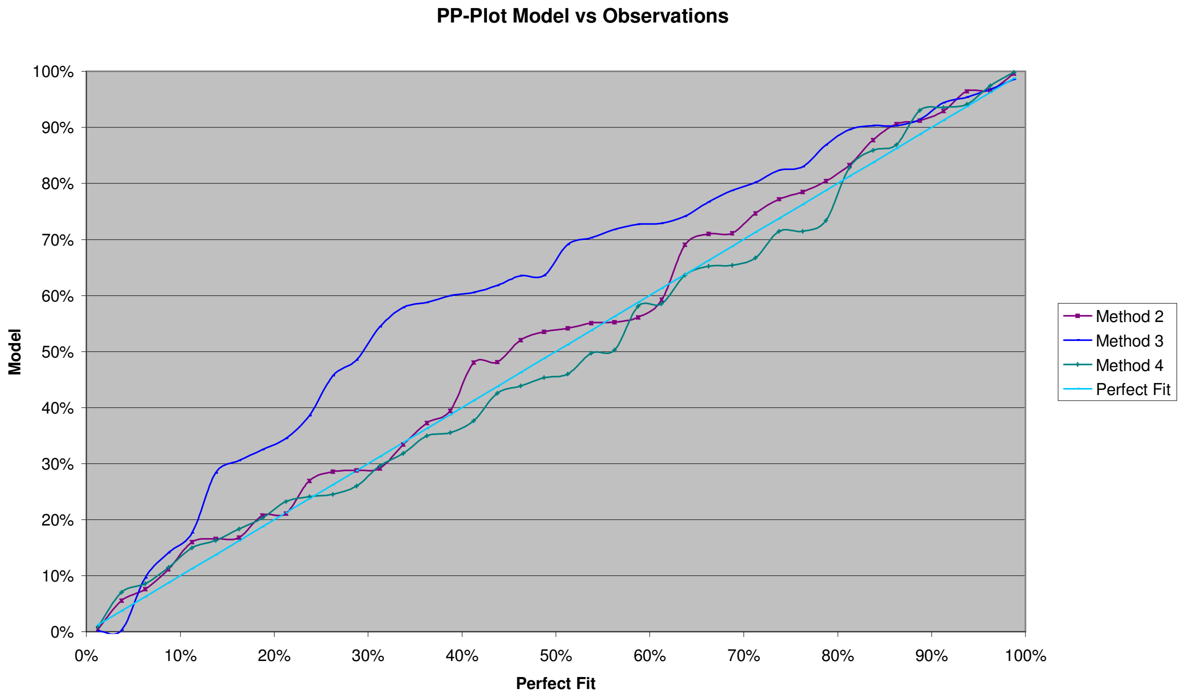
GROSS Standard Deviations

Discounted

Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result based on VWA	% firms with higher sd
Method 1				37%	**37.0%**	**44.4%**

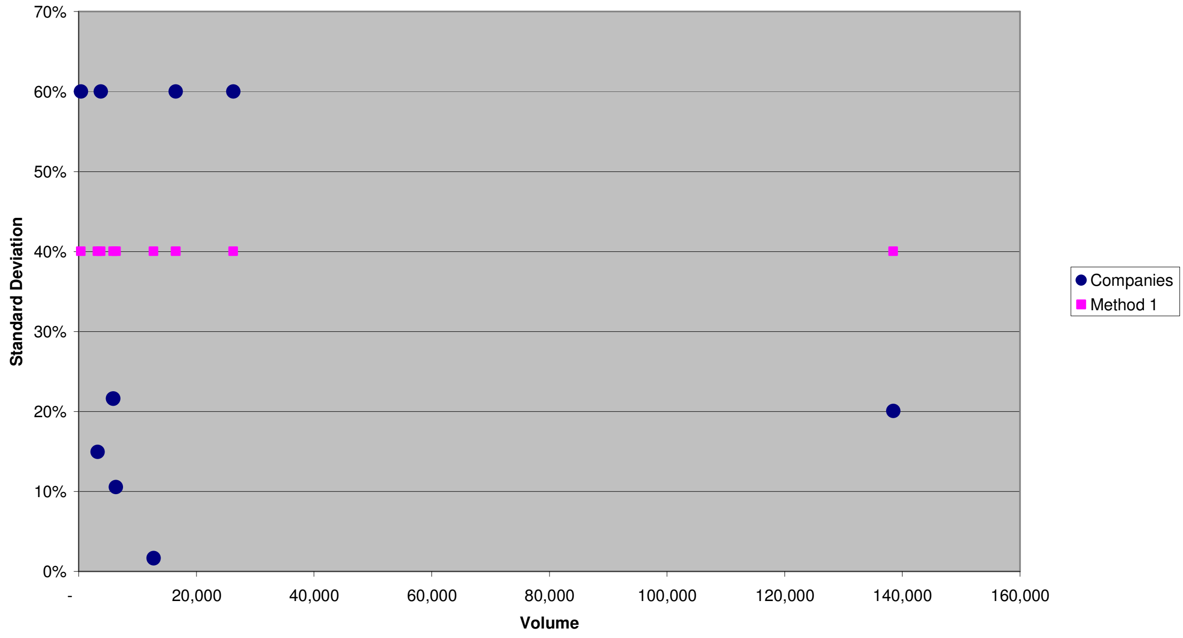
Method 2	161%	124%	77%	49%
Method 3	304%	233%	145%	93%
Method 4				79%

3.828 The graph below shows a pp plot of the fit of the methods. Methods 2 and 4 show the best fit with little to choose between them, although the fit is not great.



3.829 Because there not many observations the graph below does not show clear evidence of diversification credit. It also shows that 4 undertakings out of 9 are above the fitted factor under method 1.

Method 1 vs Company Volatilities



Overall conclusions:

3.830 It is difficult to draw conclusions based on the lack of data and the volatility of the results provided by the analysis. The selected technical factor has been taken just from Method 1 – result 37.0%

Non-proportional reinsurance – casualty

3.831 CEIOPS recommendation is that for the non-proportional reinsurance - casualty lob the gross factor for premium risk should be 18%.

3.832 The data sample included data from 6 undertakings, was gross of reinsurance and included data from the following member states: UK.

Reference co	Small	Medium	Large
NPL Casualty	5,500	13,939	18,919

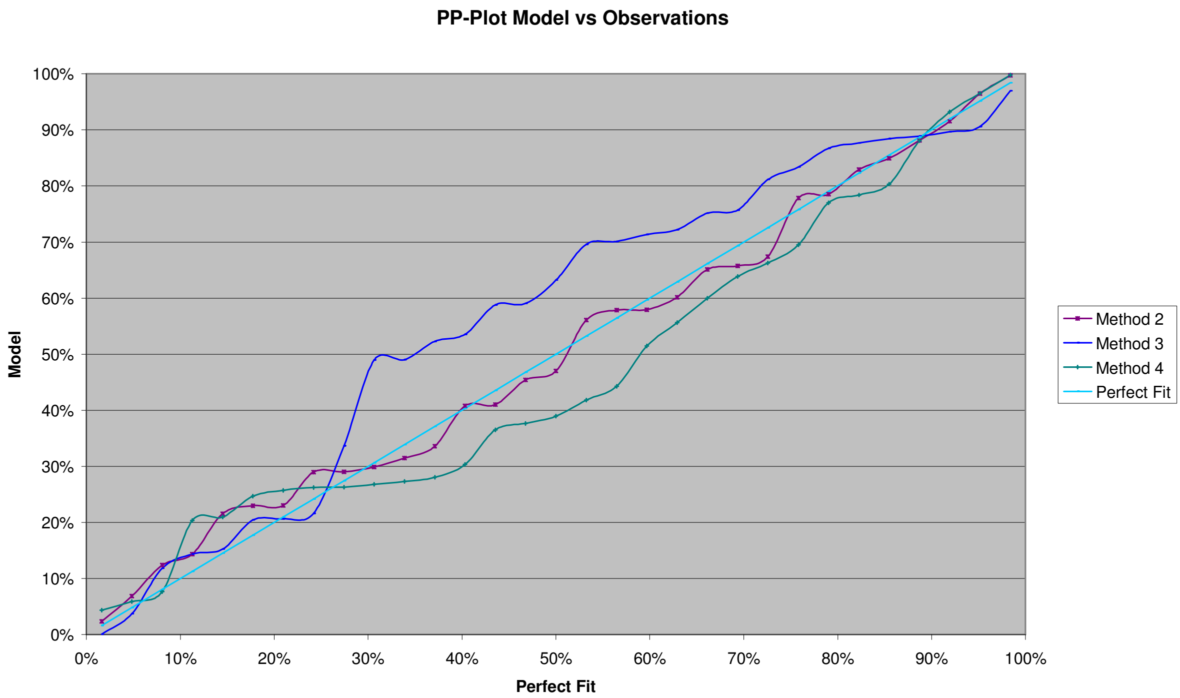
GROSS Standard Deviations

Discounted

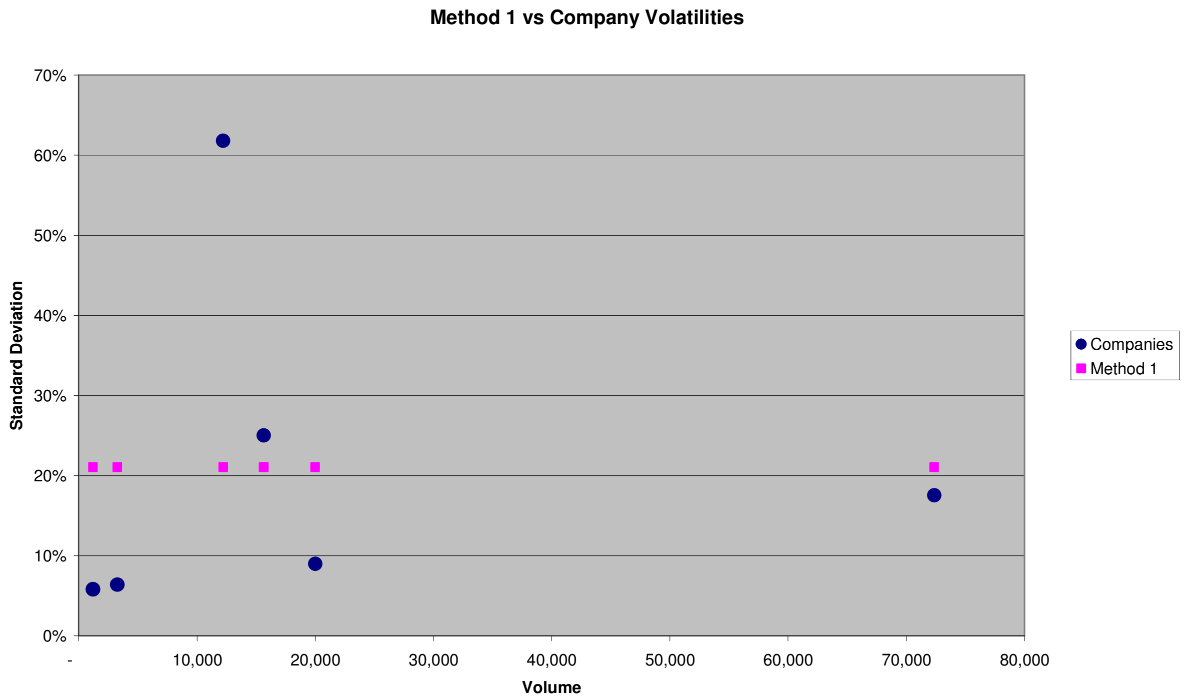
Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result based on VWA	% firms with higher sd

Method 1				18%	**18.4%**	**33.3%**
Method 2	42%	27%	23%	19%		
Method 3	77%	48%	41%	34%		
Method 4				23%		

3.833 The graph below shows a pp plot of the fit of the methods. Method 2 shows the best fit.



3.834 Because there not many observations the graph below does not show clear evidence of diversification credit. It also shows that 2 undertakings out of 6 are above the fitted factor under method 1.



Overall conclusions:

3.835 It is difficult to draw conclusions based on the lack of data and the volatility of the results provided by the analysis. The selected technical factor has been taken as the average of methods 1 and 2 – result 18.4%.

Non-proportional reinsurance – MAT

3.836 CEIOPS recommendation is that for the non-proportional reinsurance - MAT lob the gross factor for premium risk should be 16%.

3.837 The data sample included data from 10 undertakings, was gross of reinsurance and included data from the following member states: UK.

Reference co	Small	Medium	Large
NPL MAT	1,046	2,780	8,259

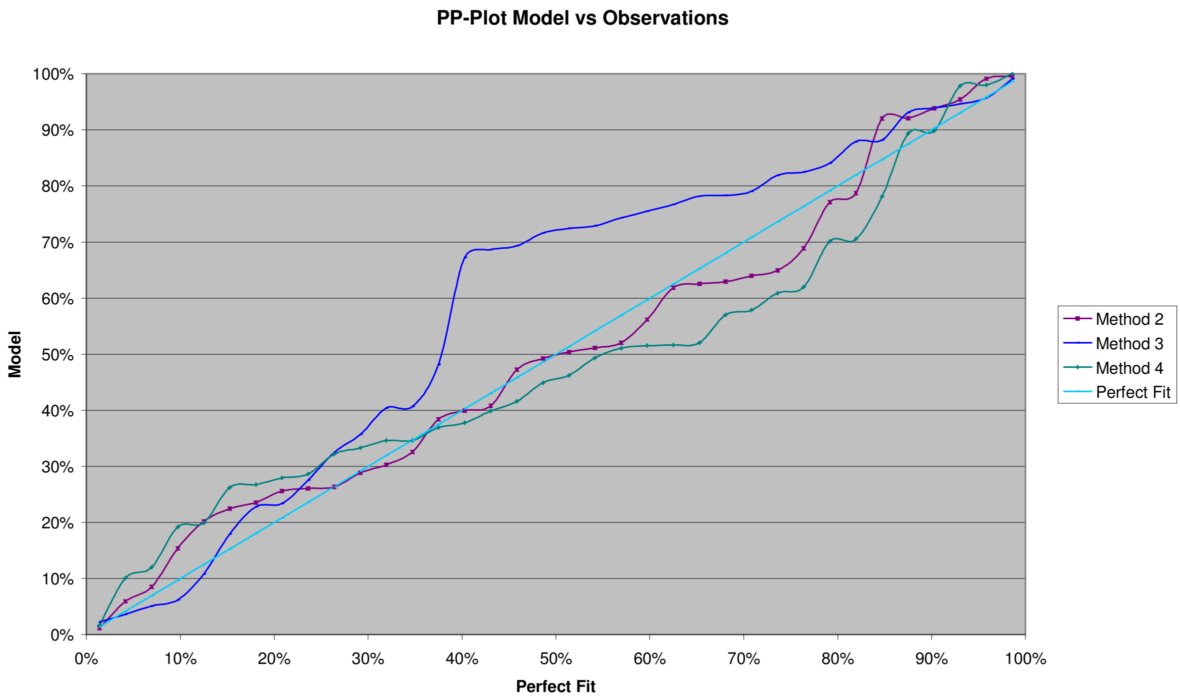
GROSS Standard Deviations

Discounted

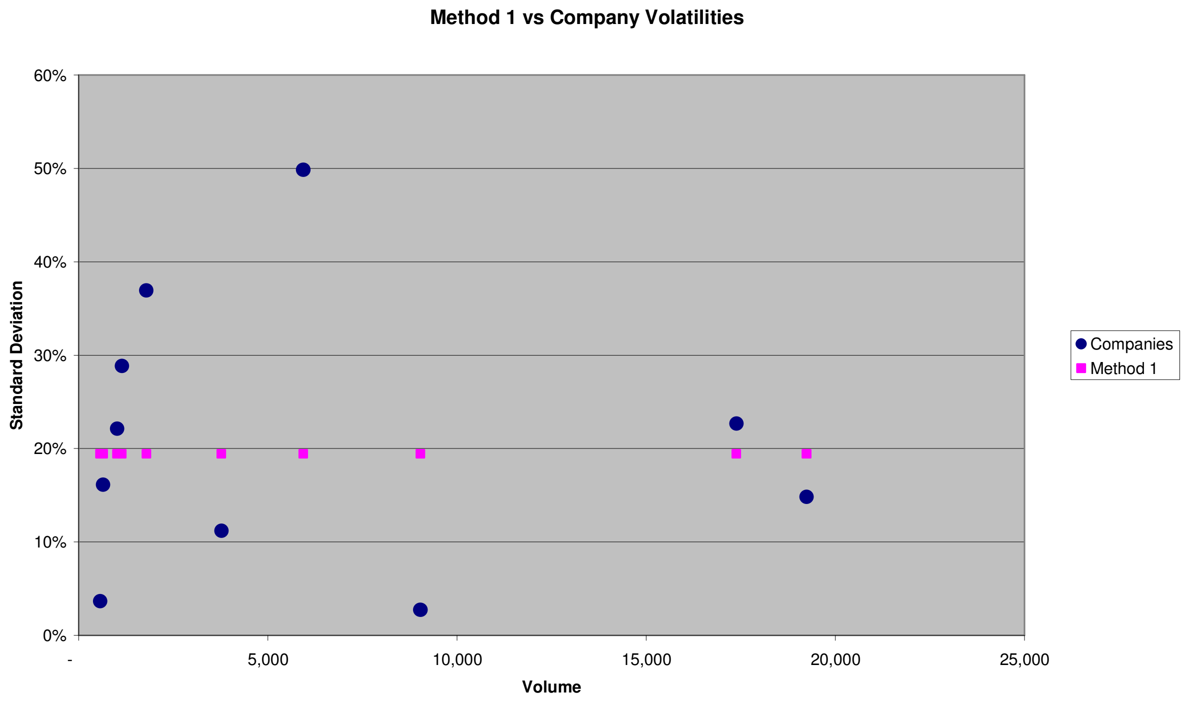
Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result based on VWA	% firms with higher sd

Method 1				18%	**16.5%**	**50.0%**
Method 2	41%	25%	15%	15%		
Method 3	51%	31%	18%	18%		
Method 4				26%		

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



3.839 The graph below shows little evidence of diversification, but again there are very few observations. Furthermore 5 undertakings lie above the method 1 fitted factor.



Overall conclusions:

3.840 It is difficult to draw conclusions based on the lack of data and the volatility of the results provided by the analysis. The selected technical factor has been taken as the average of methods 1 and 2 – result 16.5%.

Adjusting gross to net for premium risk

3.841 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-sensitivenss of the standard formula in this respect, CEIOPS suggests to introduce 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.

3.842 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 adjustment[100], which focuses on a specific

[100] See annex 7.5 of CEIOPS-DOC-67/10

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.

3.843 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.

3.844 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.

3.845 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 mis-match 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.

3.846 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.

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

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

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

- 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.

3.848 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.

3.849 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 form 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.

Reserve Risk

3.850 The reserve risk calibration and results are presented below:

Data

3.851 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)

3.852 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.

3.853 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.

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

Assumptions

3.855 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 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.

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

3.857 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.

3.858 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.

3.859 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. However, no adjustment to the factors has been made for this feature.

Analysis

3.860 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.

Methodology

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

Method 1

3.862 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".

3.863 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.

3.864 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.

3.865 Essentially the standard deviation will represent the uncertainty in the expected ultimate claims over the one year time horizon for the same accident years.

3.866 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.

3.867 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.

3.868 The second stage fits the reserve risk factor to these resultant undertaking specific models.

3.869 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.

3.870 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.

3.871 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

3.872 Then the following relationships can be defined as:

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

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

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

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

the following relationships are obtained:

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

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

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

3.875 If the following term is defined as:

$\sigma_{(res,lob)}$	=	Standard deviation for reserve risk by LoB

3.876 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

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

3.878 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

3.879 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.

3.880 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.

3.881 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.

3.882 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.

3.883 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.

3.884 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.

3.885 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
$\varepsilon_{C,Y,lob}$	=	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

3.886 Then the following relationships can be determined as:

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

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

3.887 Then the distribution of losses can be formulated as:

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

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

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

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

3.889 The resultant simplified log Likelihood becomes

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

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

3.891 If the following term is defined as:

$\sigma_{(C,res,lob)}$	=	Standard deviation for reserve risk by Undertaking by LoB

3.892 The $\sigma_{(C,res,lob)}$ then becomes :

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

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

3.893 If the following term is defined as:

$\sigma_{(res,lob)}$	=	Standard deviation for reserve risk by LoB

3.894 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

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

3.896 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.

3.897 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
$\varepsilon_{C,Y,lob}$	=	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 $R_{C,Y,lob}$.

3.898 Then the following relationships are defined:

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

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

3.899 Then the distribution of losses can be formulated as:

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

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

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

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

3.901 The resultant simplified log Likelihood becomes

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

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

$\sigma_{(res,lob)}$	=	Standard deviation for reserve risk by LoB

3.903 Then we can derive a value for $\sigma_{(res,lob)}$ as below:

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

Method 4

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

3.905 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 $E(C_{i,j}|C_{i,j-1})=f_jC_{i,j-1}$ and $Var(C_{i,j}|C_{i,j-1})=s_j^2C_{i,j-1}$.

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.

3.906 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

3.907 Then the following relationship can be defined:

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

3.908 If the following term is defined:

β_{lob}^{2}	=	Constant of proportionality for the variance of the claims development result by LoB

Then the least squares estimator of the coefficients of variation is the value of β_{lob} which minimises the following function:

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

3.909 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

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

c.Estimating the volume weighted average across all undertakings

3.910 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

3.911 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

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

3.913 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 $E(C_{i,j}|C_{i,j-1})=f_jC_{i,j-1}$ and $Var(C_{i,j}|C_{i,j-1})=s_j^2C_{i,j-1}$.

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.

3.914 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

3.915 Then the following relationship can be defined:

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

3.916 If the following term is defined:

$\sigma_{(res,lob)}$	=	Standard deviation for reserve risk by LoB

Then the least squares estimator of standard deviation is the value of $\sigma_{(res,lob)}$ which minimises the following function:

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

3.917 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

3.918 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 $E(C_{i,j}|C_{i,j-1})=f_jC_{i,j-1}$ and $Var(C_{i,j}|C_{i,j-1})=s_j^2C_{i,j-1}$.

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.

3.919 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 $MSEP_{C,lob}$.

3.920 Then we can define the following relationship:

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

3.921 The following term is defined as follows:

$\sigma_{(res,lob)}$	=	Standard deviation for reserve risk by LoB

3.922 Then the least squares estimator of the coefficients of variation is the value of $\sigma_{(res,lob)}$ which minimises the following function:

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

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

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

Reserve Risk Results

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

3.925 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.

3.926 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.

3.927 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.

3.928 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.

3.929 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.

3.930 The selection of the final factors was based on the following:

- The evidence of diversification by size was not been given full allowance. 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

3.931 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).

Motor, vehicle liability

3.932 CEIOPS recommendation is that for the Motor TPL lob the gross factor for reserve risk should be 11%.

3.933 The data sample included data from 327 undertakings, was gross of reinsurance and included data from the following member states: PO, LU, SI, PT, SK, IS, IT, LT, DK, SE, HU, FI and DE.

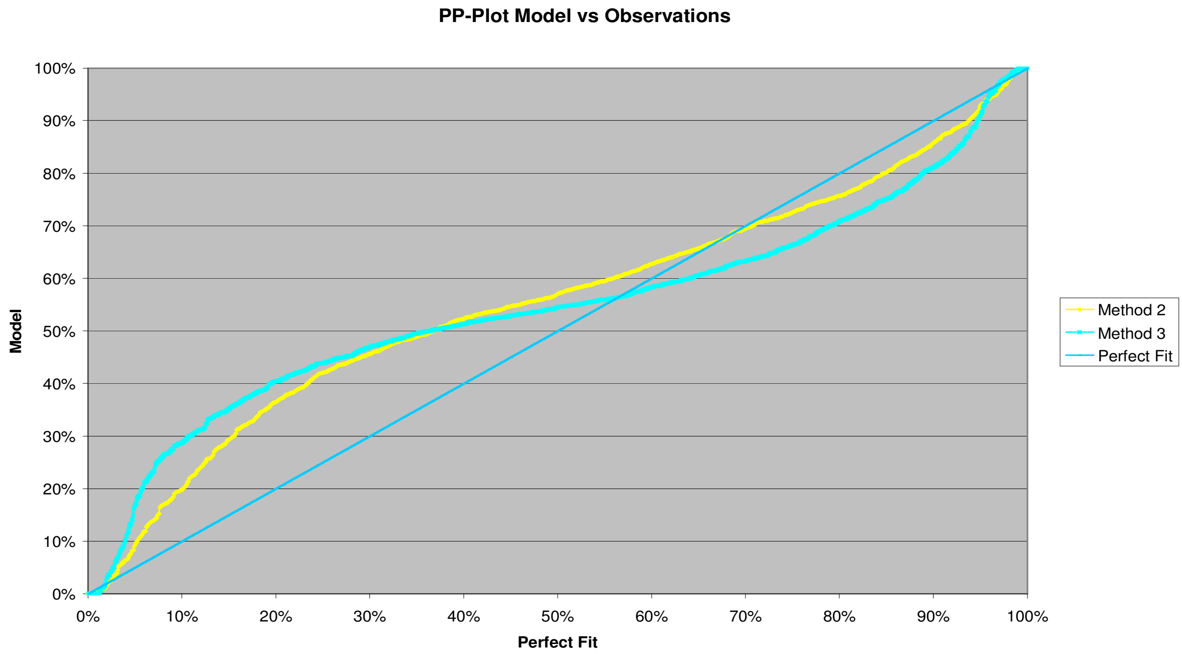
Reference co	Small	Medium	Large
Motor, third-party liability	15,308	68,037	219,317

GROSS SD

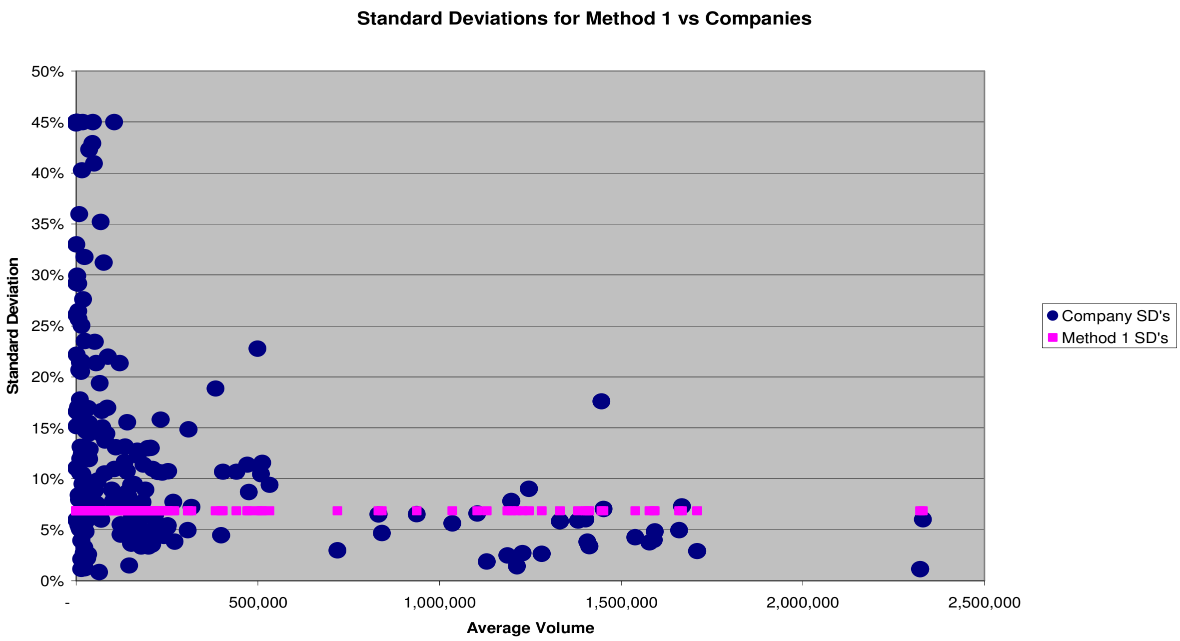
Discounted

Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result	% firms with higher sd
Method 1	17%	10%	6%	6%	**10.8%**	**44.9%**
Method 2	40%	19%	10%	7%		
Method 3				25%		
Method 4	9%	4%	2%	2%		
Method 5				6%		
Method 6				11%		

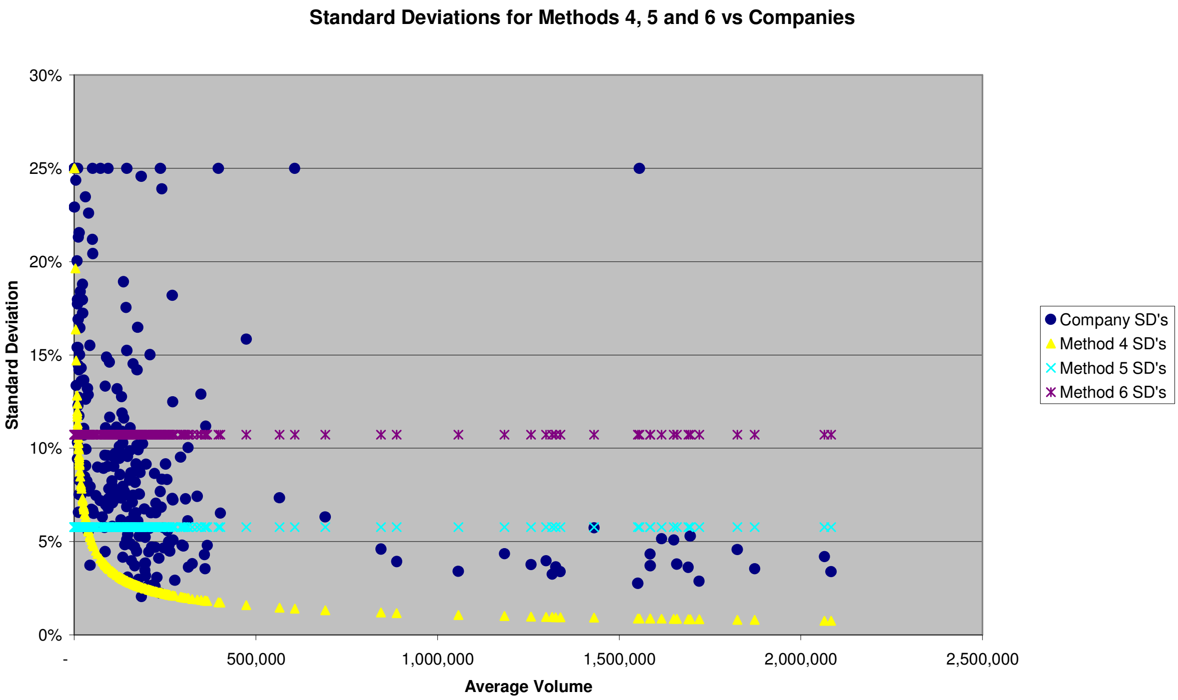
3.934 The graph below shows a pp plot of the fit of the models. Both methods provide a relatively poor fit, although there is some credibility in the tail.



3.935 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.



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



Overall conclusions:

3.937 The selected technical factor was chosen as the average of methods 1, 2, 3 5 and 6 – result 10.8%.

Motor, other classes

3.938 CEIOPS recommendation is that for the Motor other the gross factor for reserve risk should be 20%.

3.939 The data sample included data from 106 undertakings, was gross of reinsurance and included data from the following member states: PO, LU, SI, PT, SK, IS, LT, FI, DK and SE.

Reference co	Small	Medium	Large
Motor, other classes	1,460	4,054	16,170

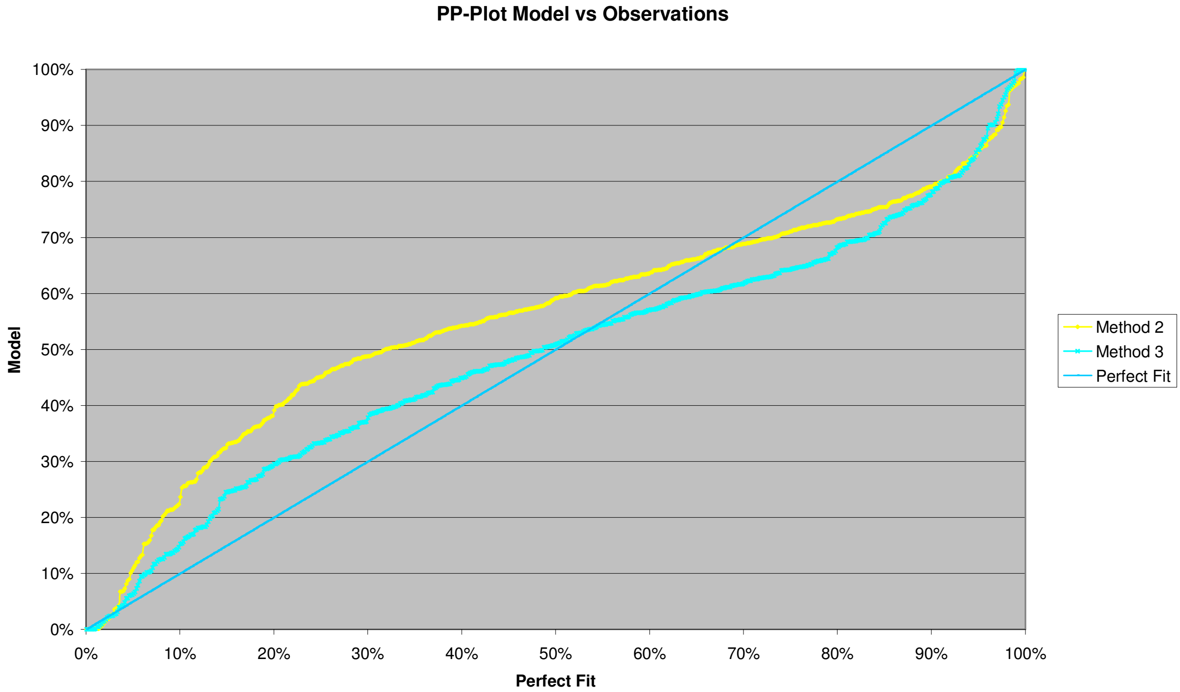
GROSS SD

Discounted

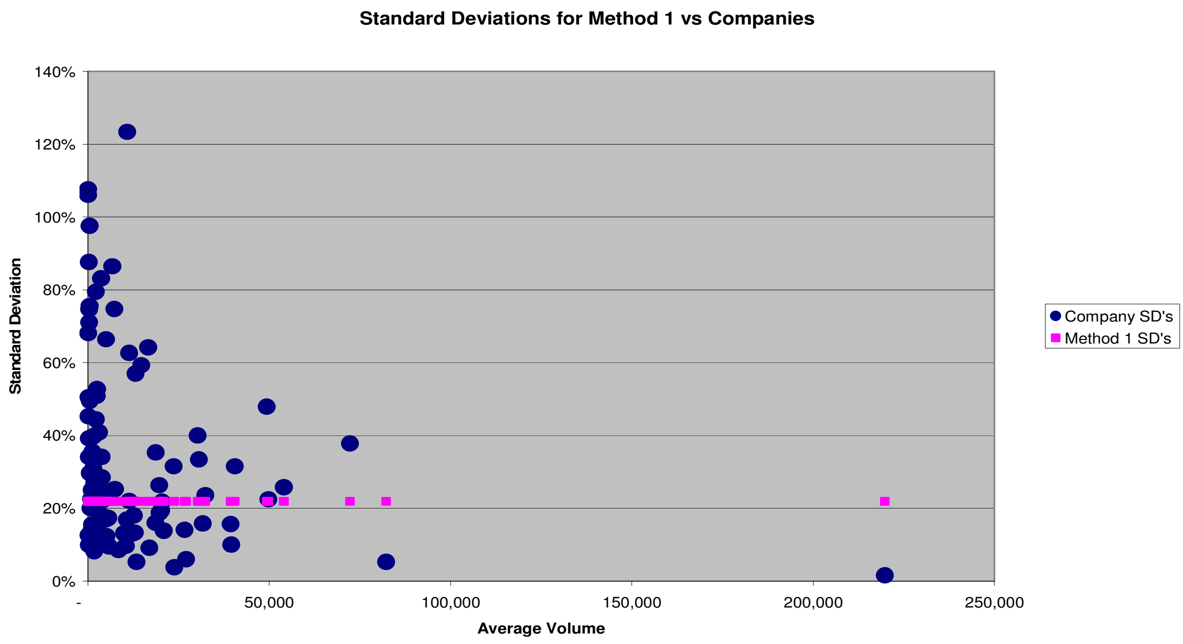
Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result	% firms with higher sd
Method 1	40%	23%	14%	22%	**19.9%**	**59.4%**

Method 2	112%	67%	34%	29%
Method 3				42%
Method 4	23%	14%	7%	6%
Method 5				12%
Method 6				26%

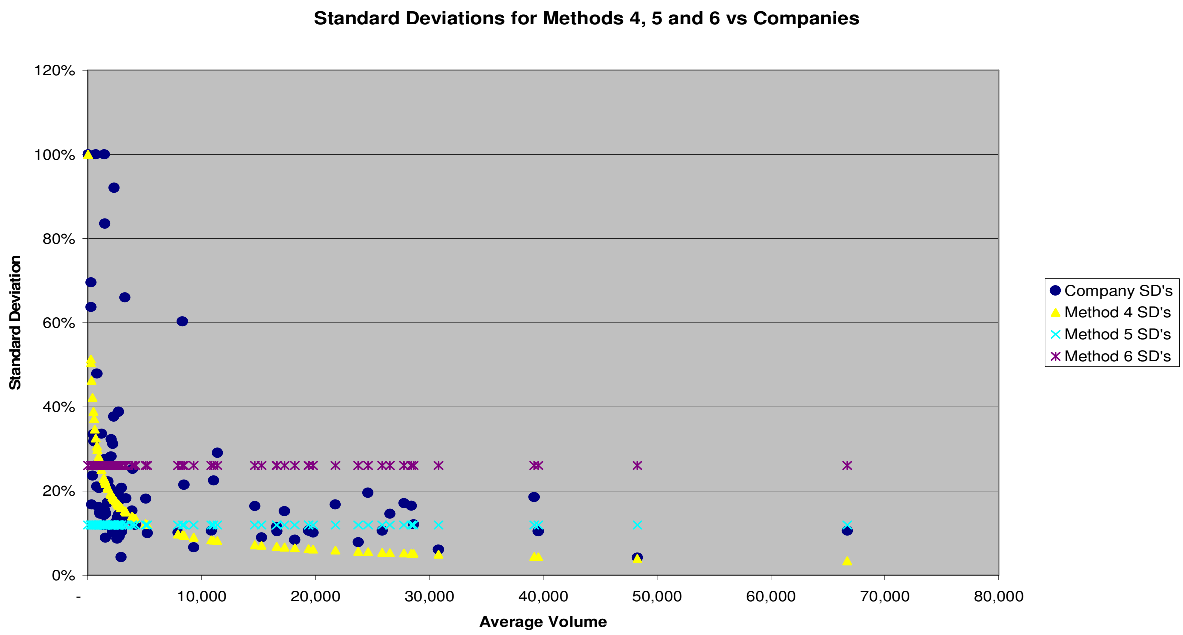
3.940 The graph below shows a pp plot of the fit of the models. Both methods provide a relatively poor fit, although method 3 appears to be a bit better than method 2.



3.941 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.



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



Overall conclusions:

3.943 The selected technical factor was chosen considering the average of methods 1, 5 and 6 – result 19.9%.

<u>Marine, aviation, transport (MAT)</u>

3.944 CEIOPS recommendation is that for the MAT lob the gross factor for reserve risk is 40%.

3.945 The data sample included data from 36 undertakings, was gross of reinsurance and included data from the following member states: PO, LU, SI, IS, DK and SE.

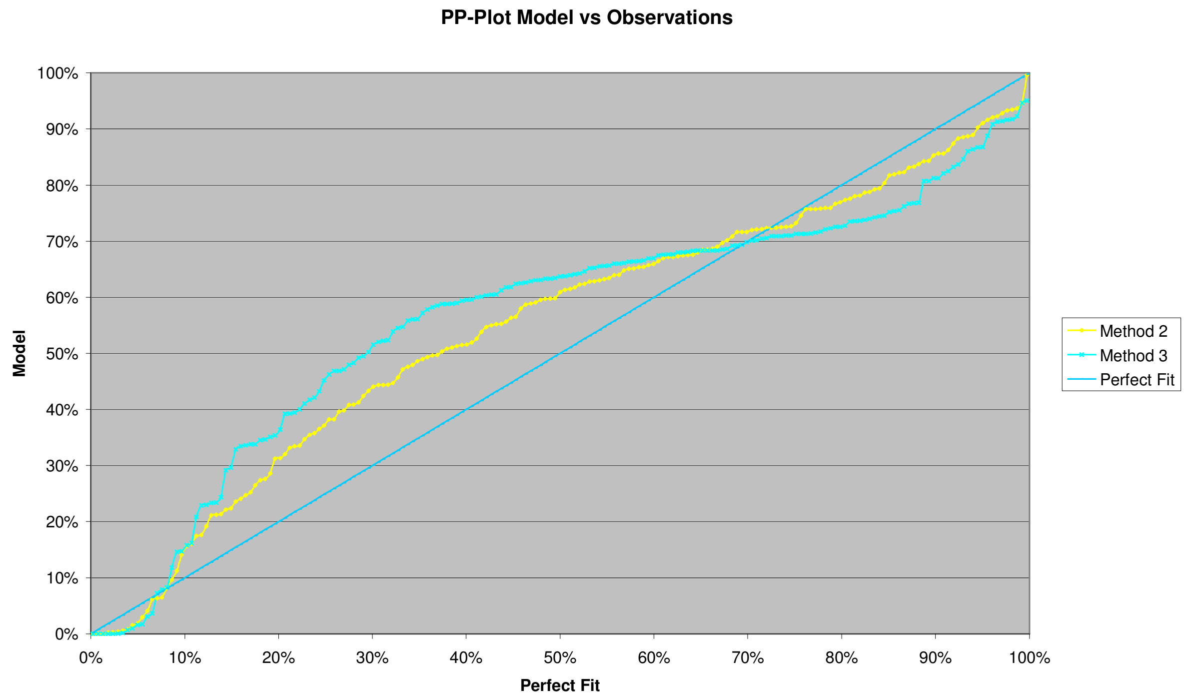
Reference co	Small	Medium	Large
Marine, aviation, transport (MAT)	158	1,311	11,289

GROSS SD

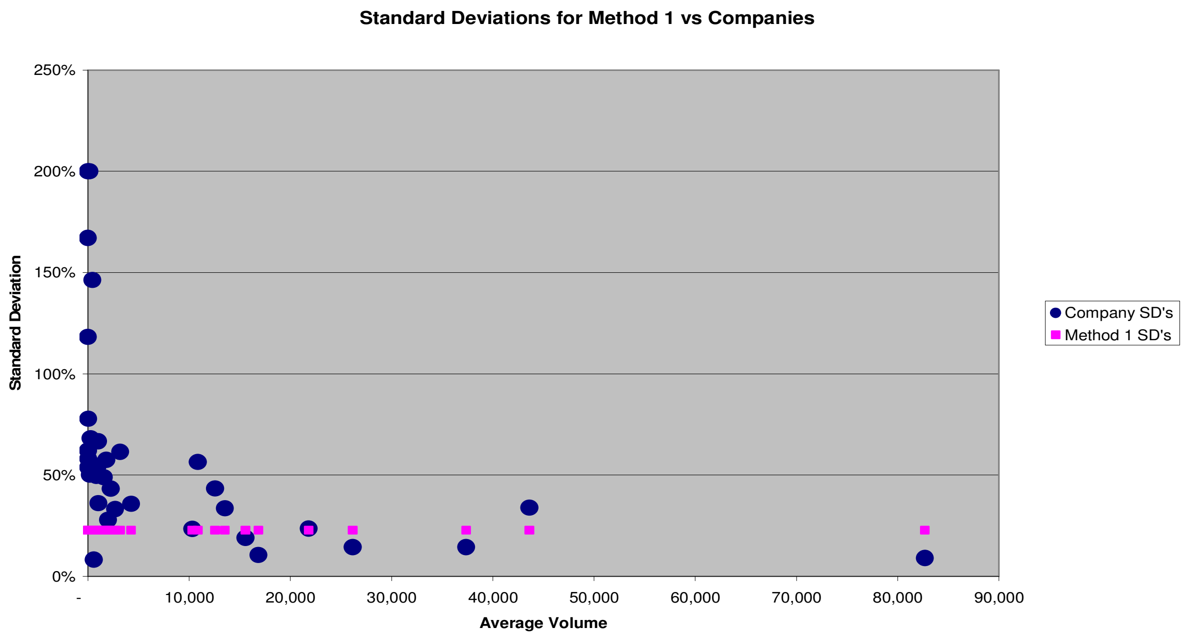
Discounted

Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result	% firms with higher sd
Method 1	63%	50%	32%	23%	**38.7%**	**61.1%**
Method 2	365%	127%	43%	33%		
Method 3				121%		
Method 4	192%	67%	23%	18%		
Method 5				31%		
Method 6				68%		

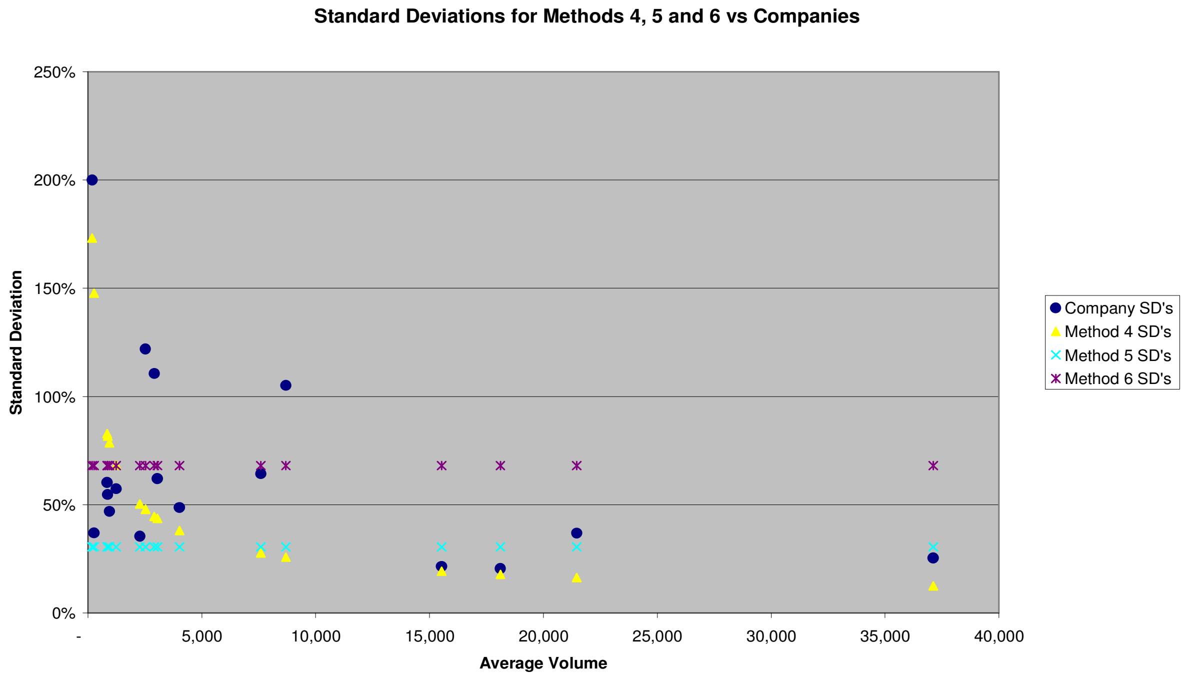
3.946 The graph below shows a pp plot of the fit of the models. Both methods provide a relatively poor fit, although method 2 appears to be just about acceptable.



3.947 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.



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



Overall conclusions:

3.949 The selected technical factor was chosen considering the average of methods 1, 2, 5 and 6 – result 38.7%.

<u>Fire and other property damage</u>

3.950 CEIOPS recommendation is that for the Fire and other property damage lob the gross factor for reserve risk is 25%.

3.951 The data sample included data from 86 undertakings, was gross of reinsurance and included data from the following member states: PO, LU, UK, SK, IS, FI, DK and SL.

Reference co	Small	Medium	Large
Fire and other property damage	7,893	35,211	89,540

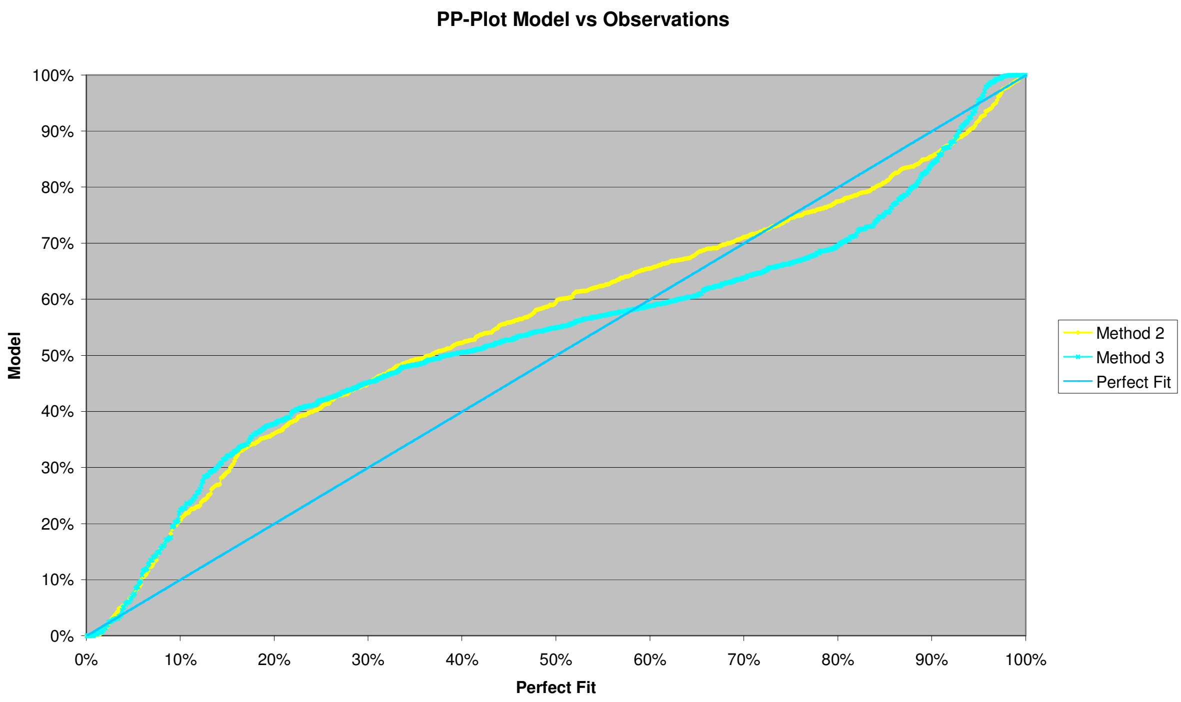
GROSS SD

Discounted

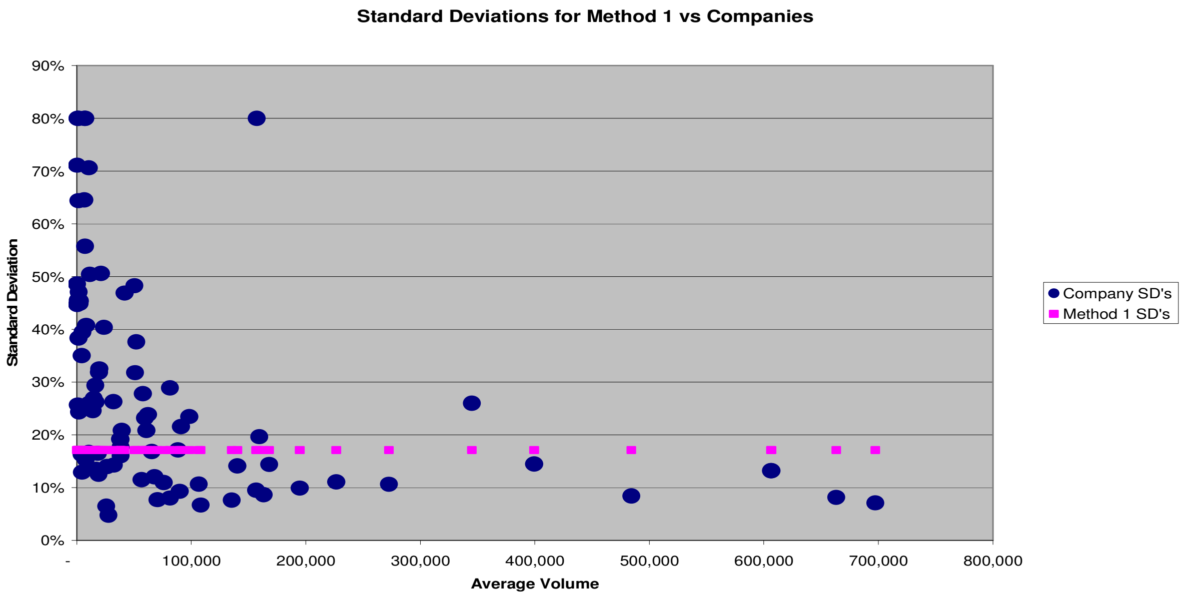
Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result	% firms with higher sd
Method 1	40%	22%	13%	17%	**25.1%**	**45.3%**

Method 2	81%	38%	24%	18%
Method 3				55%
Method 4	24%	11%	7%	5%
Method 5				21%
Method 6				44%

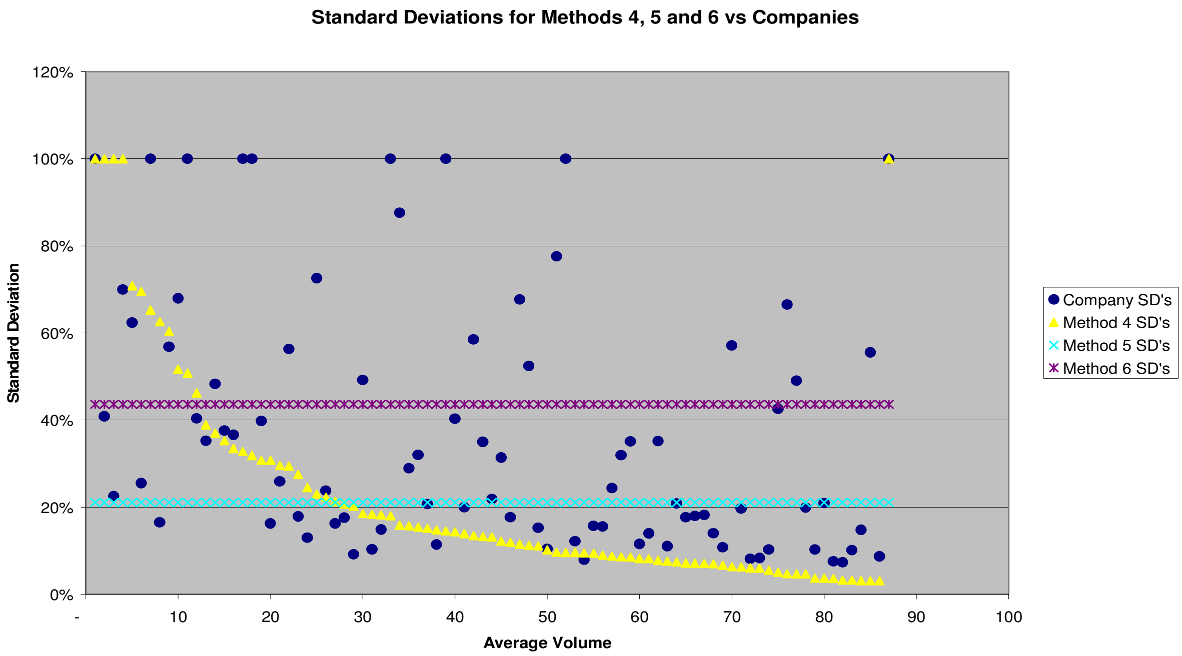
3.952 The graph below shows a pp plot of the fit of the models. Both methods provide a relatively poor fit, although method 2 appears to be just about acceptable.



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



3.954 The graph below shows the results for the Merz methods



Overall conclusions:

3.955 The selected technical factor was chosen considering the average of methods 1, 2, 5 and 6 – result 25.1%.

Third-party liability

3.956 CEIOPS recommendation is that for the third party liability lob the gross factor for reserve risk is 23%.

3.957 The data sample included data from 219 undertakings, was gross of reinsurance and included data from the following member states: PO, LU, DE, UK, SK, IS, DK and SI.

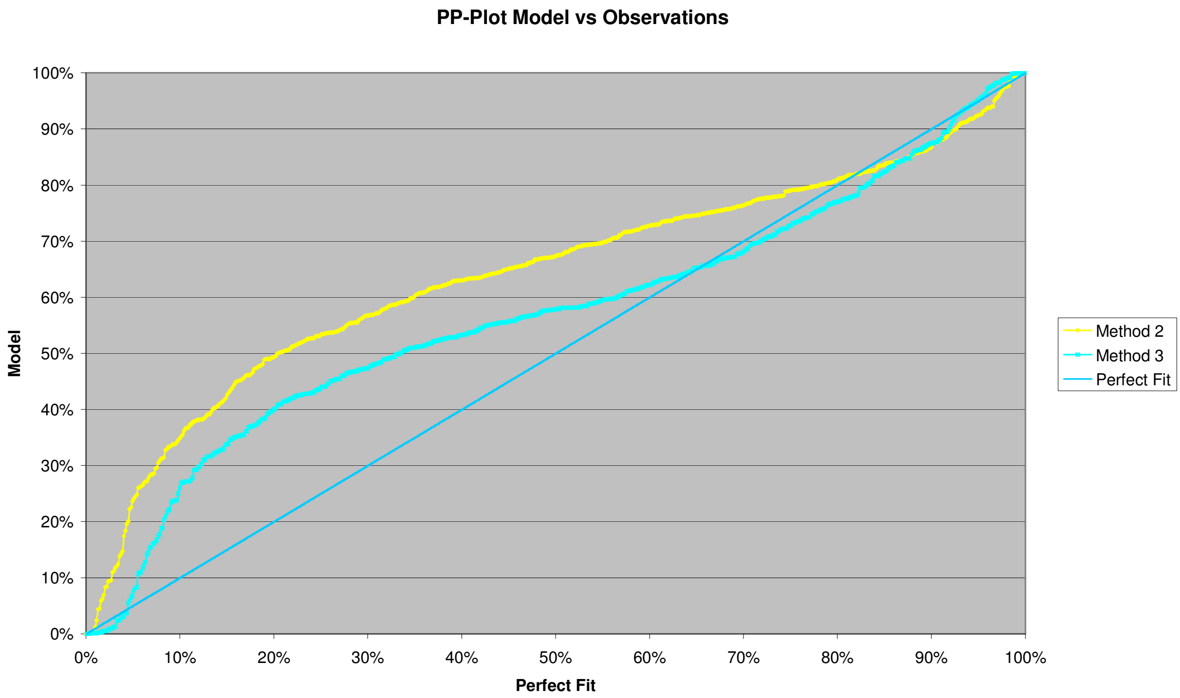
Reference co	**Small**	**Medium**	**Large**
Third-party liability	1,467	13,129	48,521

GROSS SD

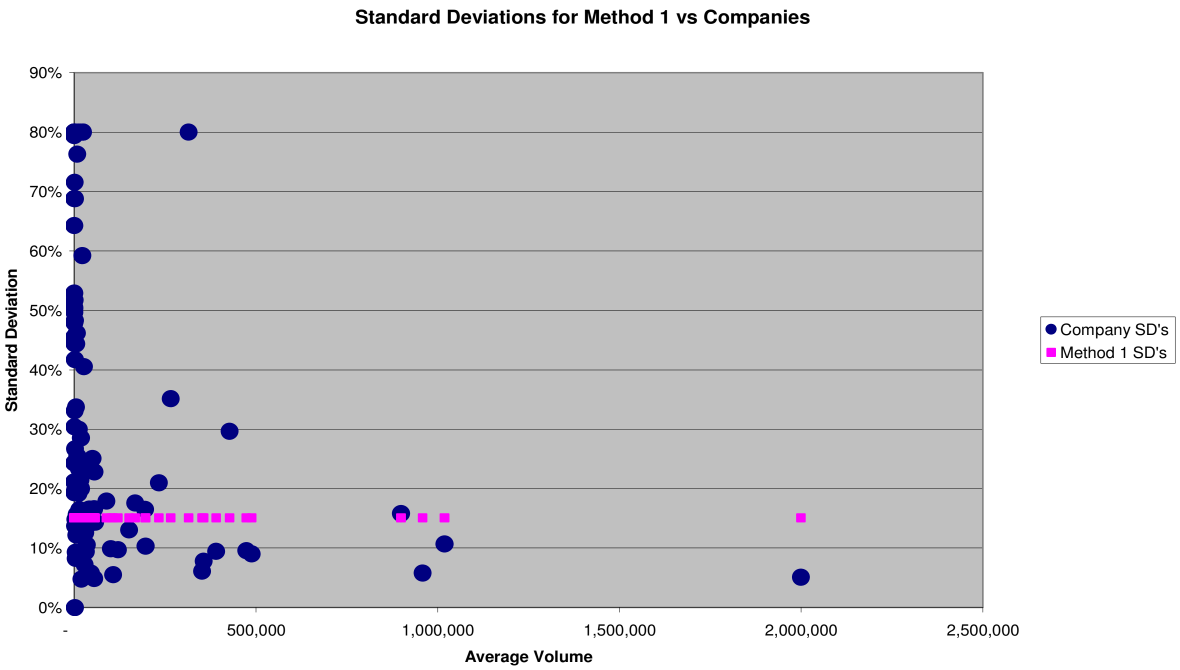
Discounted

Method	**Small (75th perc)**	**Medium (50th perc)**	**Large (25th perc)**	**VWA**	**Technical result**	**% firms with higher sd**
Method 1	50%	21%	13%	15%	**23.3%**	**47.6%**
Method 2	221%	74%	38%	17%		
Method 3				43%		
Method 4	25%	8%	4%	2%		
Method 5				14%		
Method 6				22%		

3.958 The graph below shows a pp plot of the fit of the models. Both methods provide a relatively poor fit, although method 3 appears to be just about acceptable.

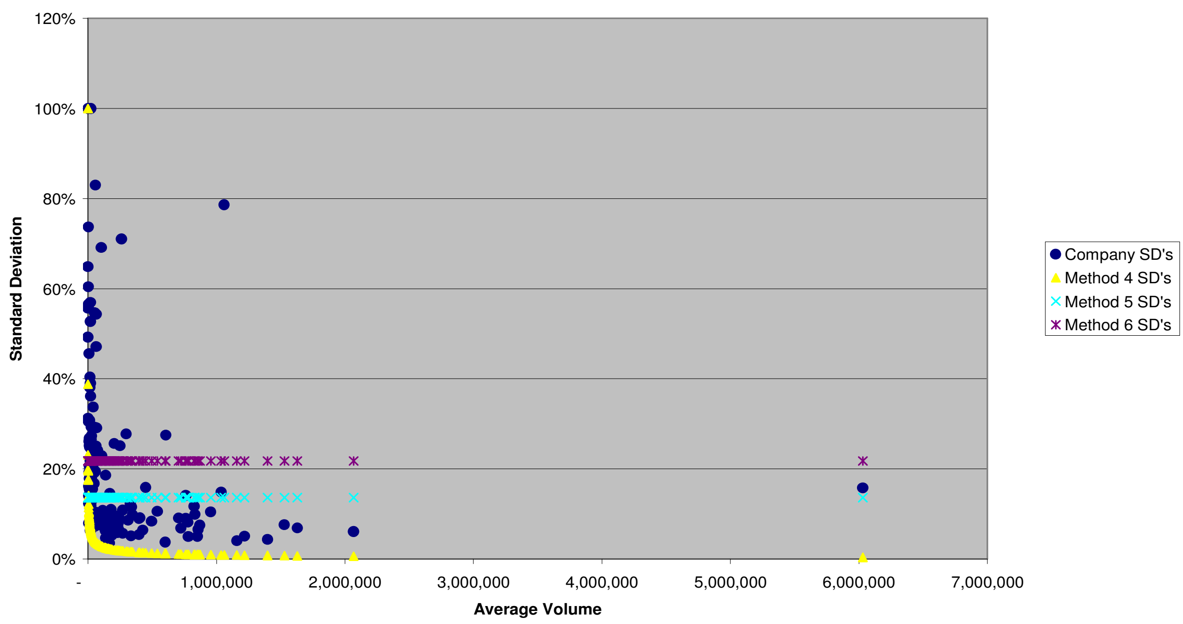


3.959 The result of the graph below shows evidence for diversification credit. It also shows the volatility of the individual observations compared to the fitted selection for method 1



3.960 The graph below shows the results for the Merz methods

Standard Deviations for Methods 4, 5 and 6 vs Companies



Overall conclusions:

3.961 The selected technical factor was chosen considering the average of methods 1, 3, 5 and 6 – result 23.3%.

Credit and suretyship

3.962 CEIOPS recommendation is that for the credit and suretyship lob the gross factor for reserve risk is 50%.

3.963 The data sample included data from 53 undertakings, was gross of reinsurance and included data from the following member states: PO, UK, SK, DK, SE, LU and SI.

Reference co	Small	Medium	Large
Credit and suretyship	560	2,695	8,626

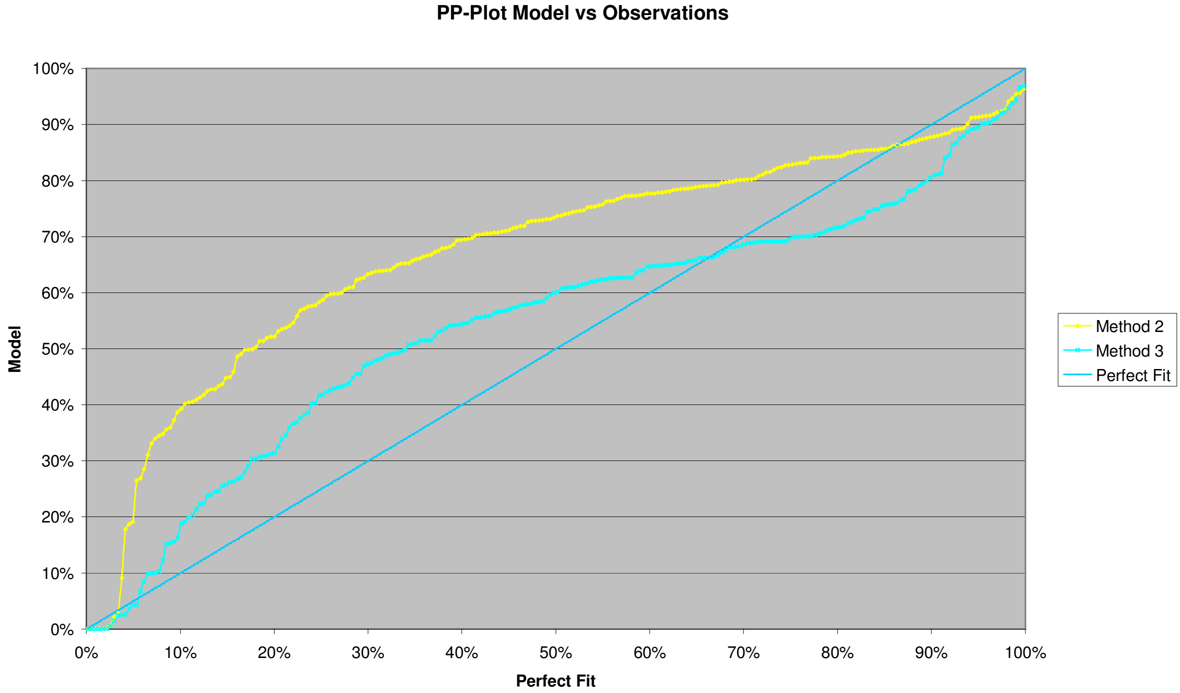
GROSS SD

Discounted

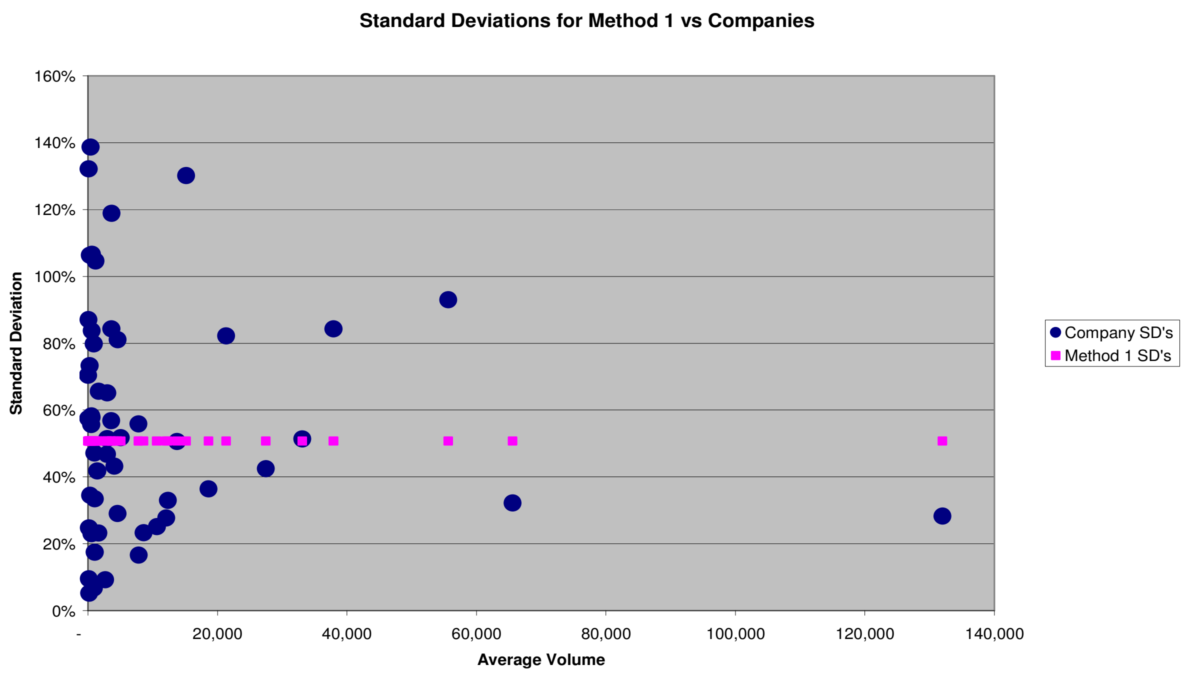
Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result	% firms with higher sd
Method 1	81%	51%	29%	51%	**50.7%**	**52.8%**

Method 2	672%	306%	171%	112%
Method 3				131%
Method 4	32%	15%	8%	5%
Method 5				49%
Method 6				298%

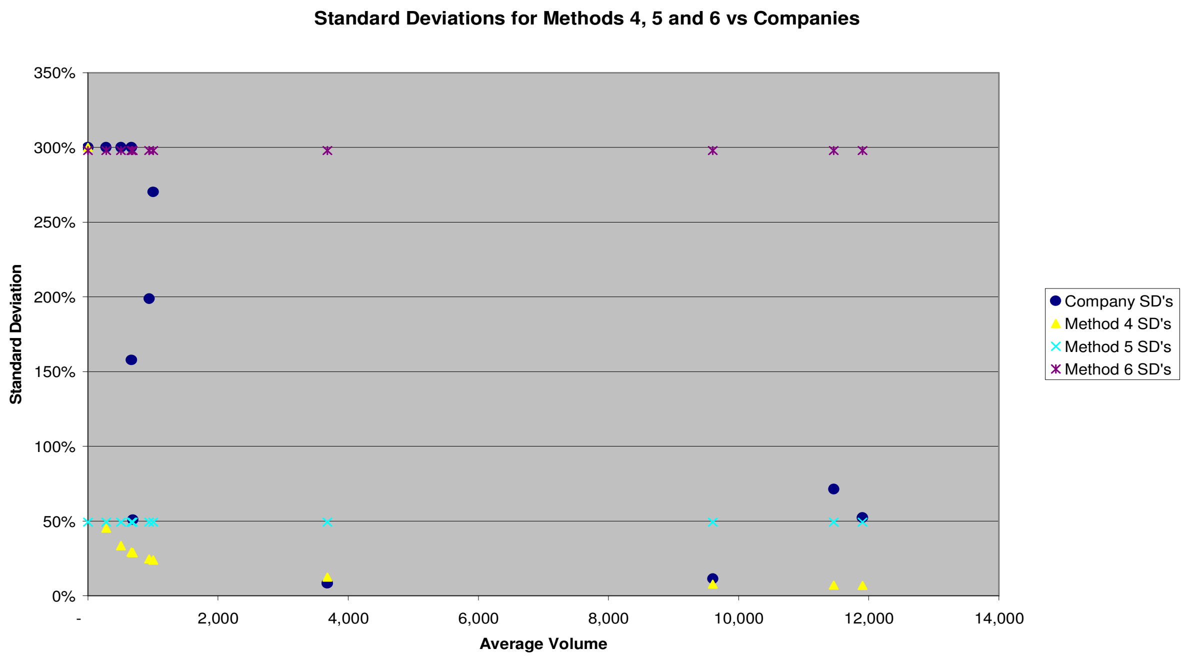
3.964 The graph below shows a pp plot of the fit of the models. Both methods provide a poor fit.



3.965 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



3.966 The graph below shows the results for the Merz methods



Overall conclusions:

3.967 The selected technical factor was chosen considering method 1 alone – result 50.7%.

<u>Legal expenses</u>

3.968 CEIOPS recommendation is that for the legal expenses lob the gross factor for reserve risk is 9%.

3.969 The data sample included data from 68 undertakings, was gross of reinsurance and included data from the following member states: PO, DE, SK, FI and UK.

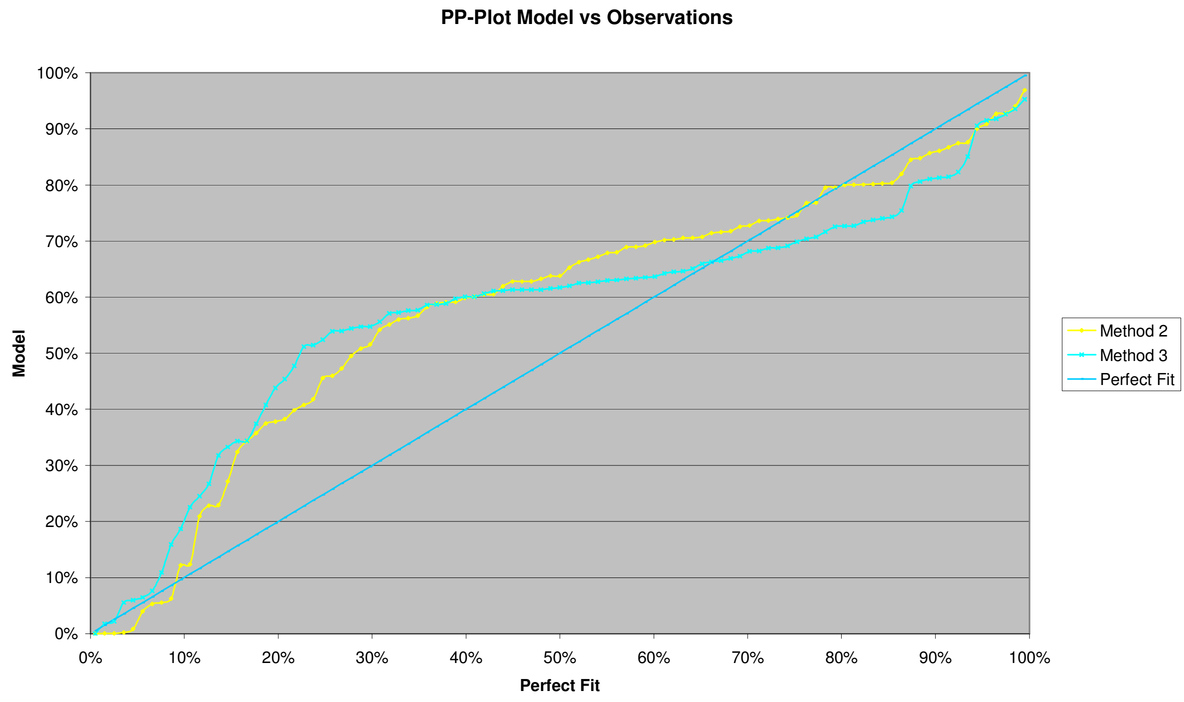
Reference co	Small	Medium	Large
Legal expenses	556	2,892	11,541

GROSS SD

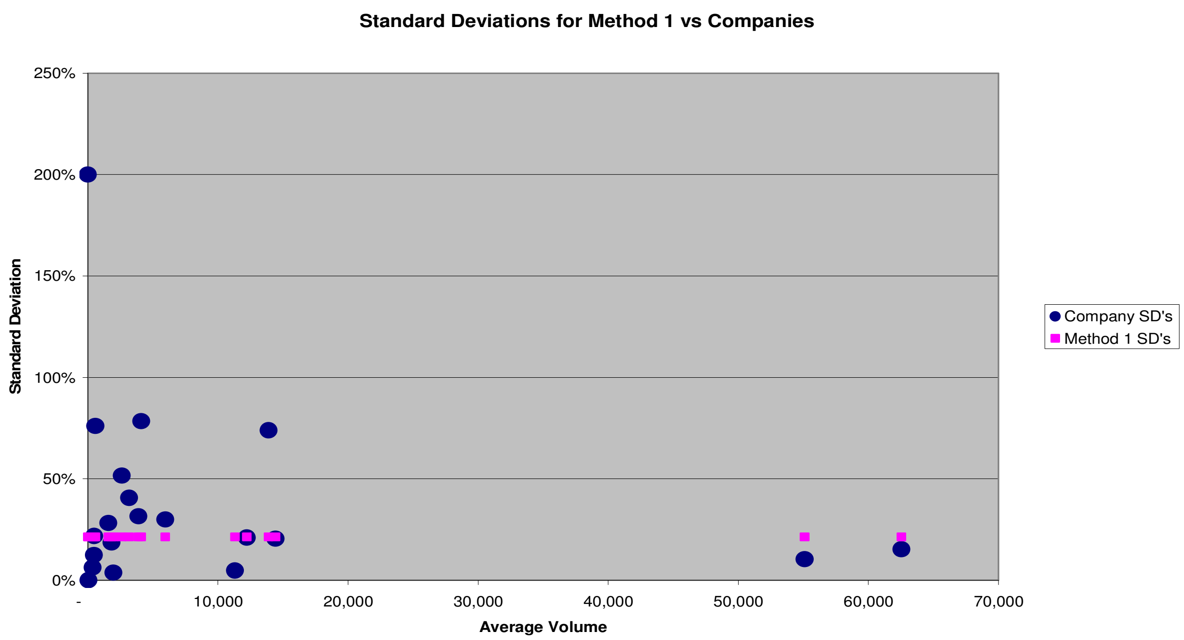
Discounted

Method	**Small (75th perc)**	**Medium (50th perc)**	**Large (25th perc)**	**VWA**	**Technical result**	**% firms with higher sd**
Method 1	43%	21%	12%	21%	**9.1%**	**80.0%**
Method 2	115%	51%	25%	20%		
Method 3				63%		
Method 4	63%	27%	14%	11%		
Method 5				4%		
Method 6				14%		

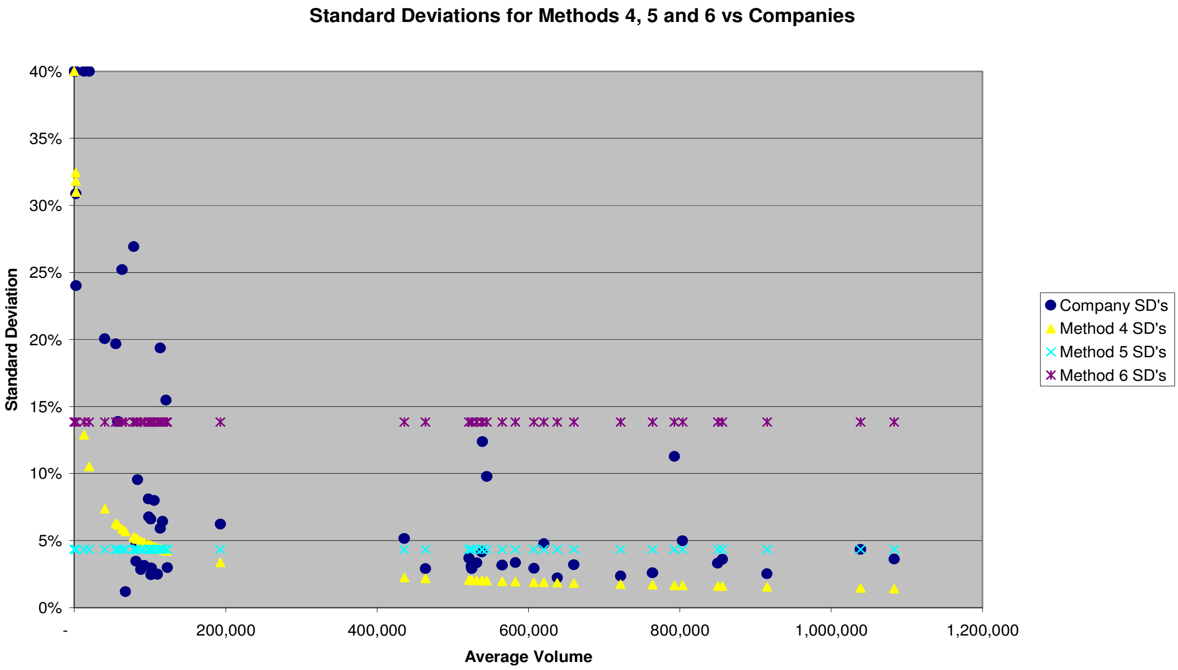
3.970 The graph below shows a pp plot of the fit of the models. Both methods provide a poor fit.



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



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



Overall conclusions:

3.973 The selected technical factor was chosen considering the average of methods 5 and 6 – result 9.1%.

Assistance

3.974 CEIOPS recommendation is that for the Assistance lob the gross factor for reserve risk is 45%.

3.975 The data sample included data from 20 undertakings, was gross of reinsurance and included data from the following member states: PO and UK.

Reference co	Small	Medium	Large
Assistance	560	1,287	4,305

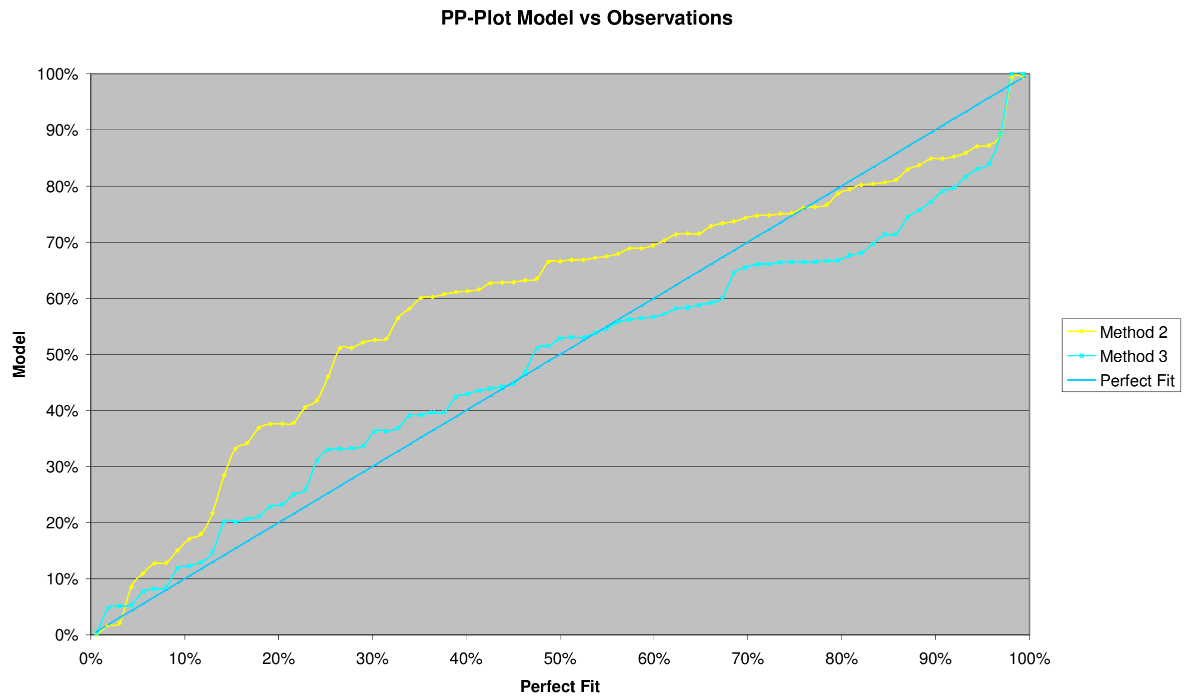
GROSS SD

Discounted

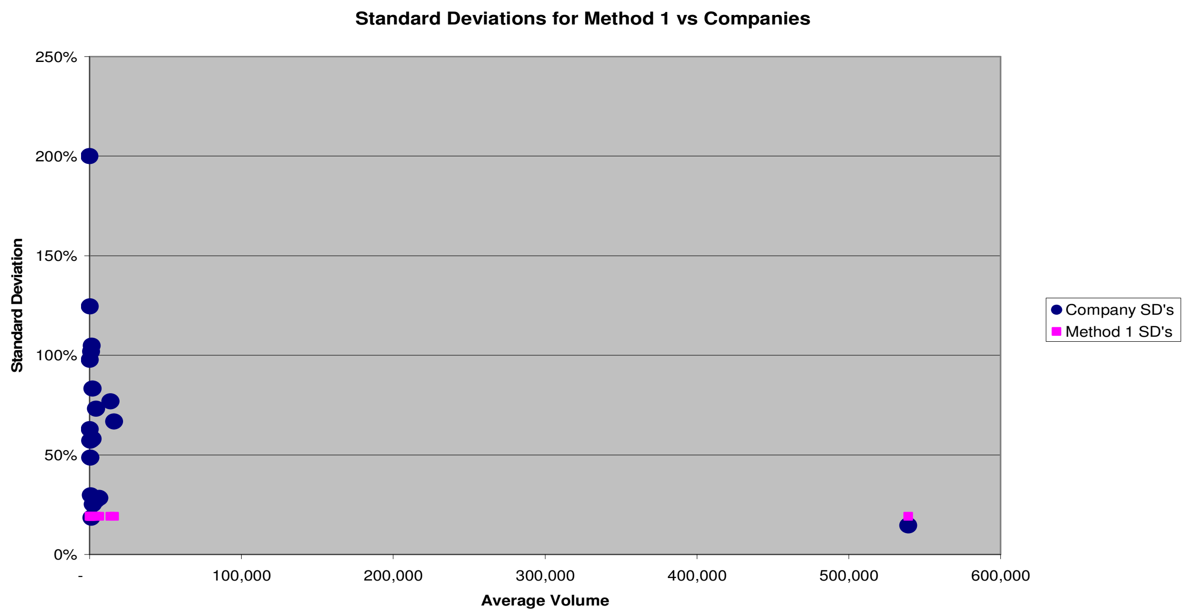
Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result	% firms with higher sd
Method 1	87%	60%	29%	19%	**44.7%**	**70.0%**
Method 2	327%	215%	118%	20%		

Method 3	103%	103%	103%	103%
Method 4	57%	38%	21%	4%
Method 5	41%	41%	41%	41%
Method 6	74%	74%	74%	74%

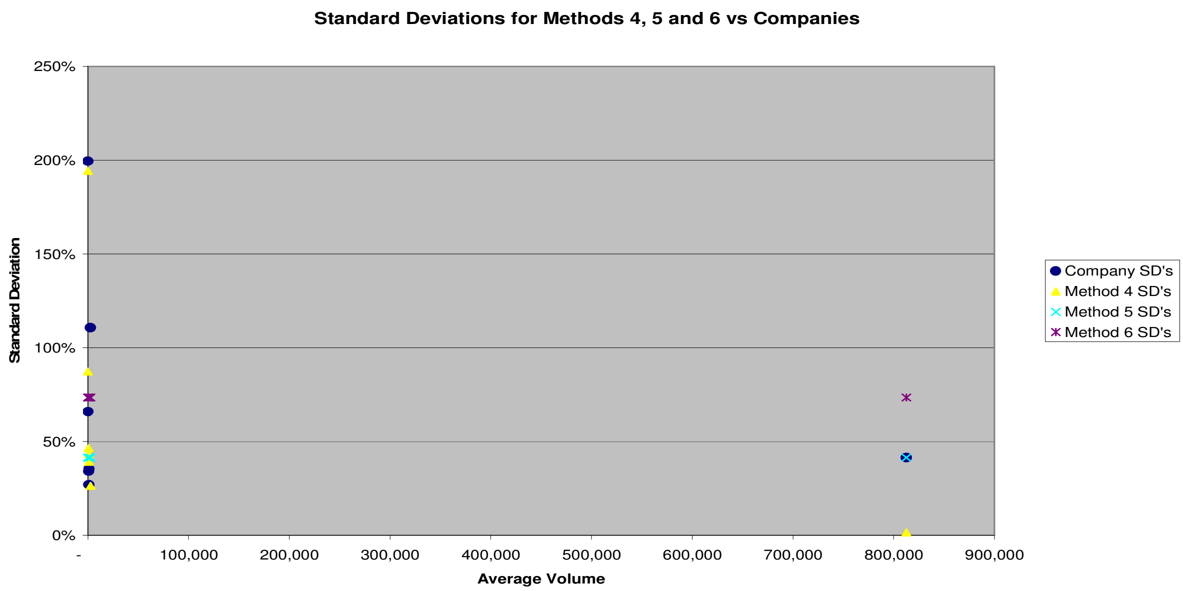
3.976 The graph below shows a pp plot of the fit of the models. Both methods provide a poor fit.



3.977 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.



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



Overall conclusions:

3.979 The selected technical factor was chosen considering the average of methods 1, 5 and 6 – result 44.7%.

Miscellaneous

3.980 CEIOPS recommendation is that for the Miscellaneous lob the gross factor for reserve risk is 40%.

3.981 The data sample included data from 71 undertakings, was gross of reinsurance and included data from the following member states: PO, UK and DK.

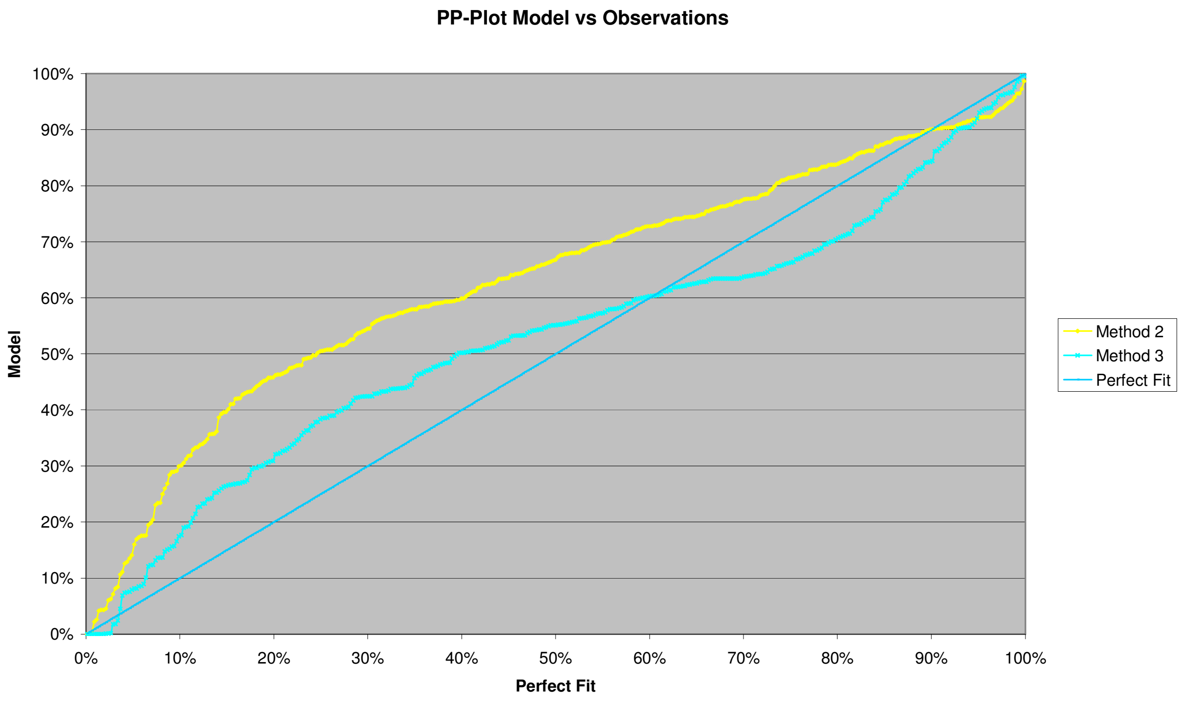
Reference co	Small	Medium	Large
Miscellaneous	561	4,445	16,603

GROSS SD

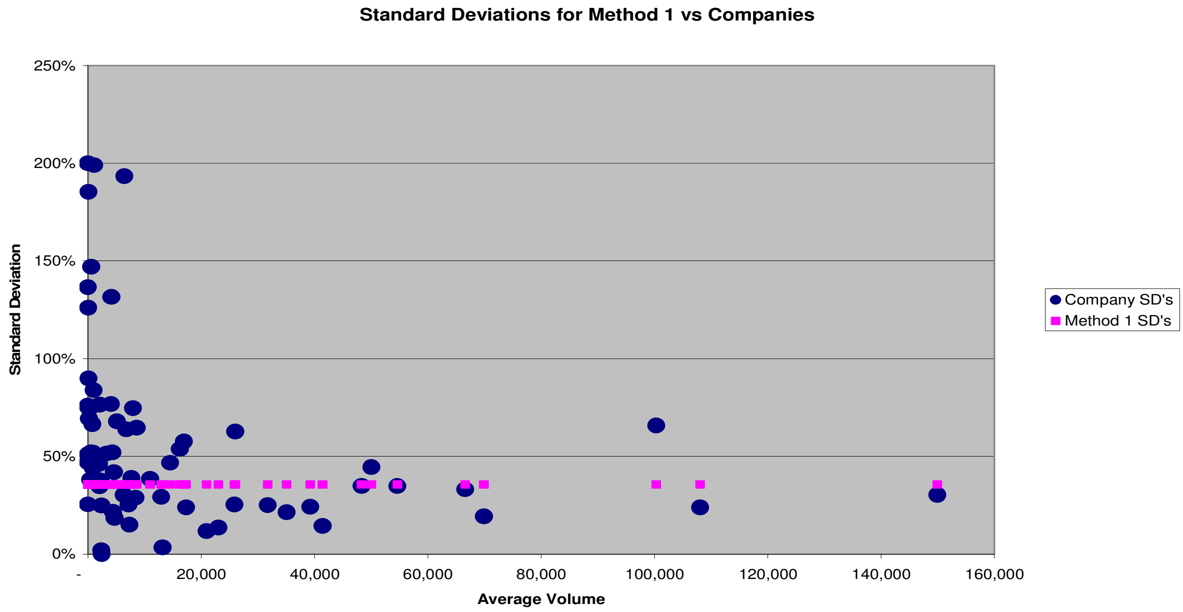
Discounted

Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result	% firms with higher sd
Method 1	72%	47%	25%	36%	**41.5%**	**56.3%**
Method 2	435%	154%	80%	59%		
Method 3				78%		
Method 4	26%	9%	5%	4%		
Method 5				36%		
Method 6				53%		

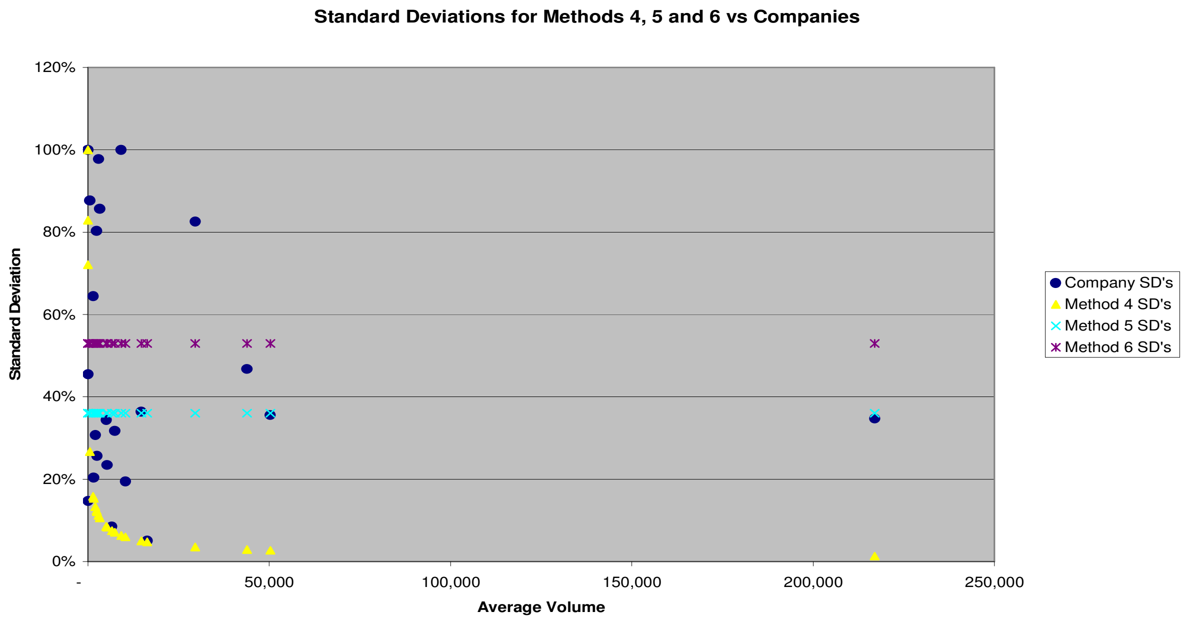
3.982 The graph below shows a pp plot of the fit of the models. Both methods provide a poor fit, but Method 3 is slightly better than Method 2.



3.983 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.



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



Overall conclusions:

3.985 The selected technical factor was chosen considering the average of methods 1, 5 and 6 – result 41.5%.

Non-proportional reinsurance - property

3.986 CEIOPS recommendation is that for the non-proportional reinsurance property lob the gross factor for reserve risk is 45%.

3.987 The data sample included data from 8 undertakings, was gross of reinsurance and included data from the following member states: UK. Lack of data in respect of provisions, did not allow application of methods 4, 5 and 6.

Reference co	Small	Medium	Large
Non-proportional reinsurance – property	2,631	12,516	31,254

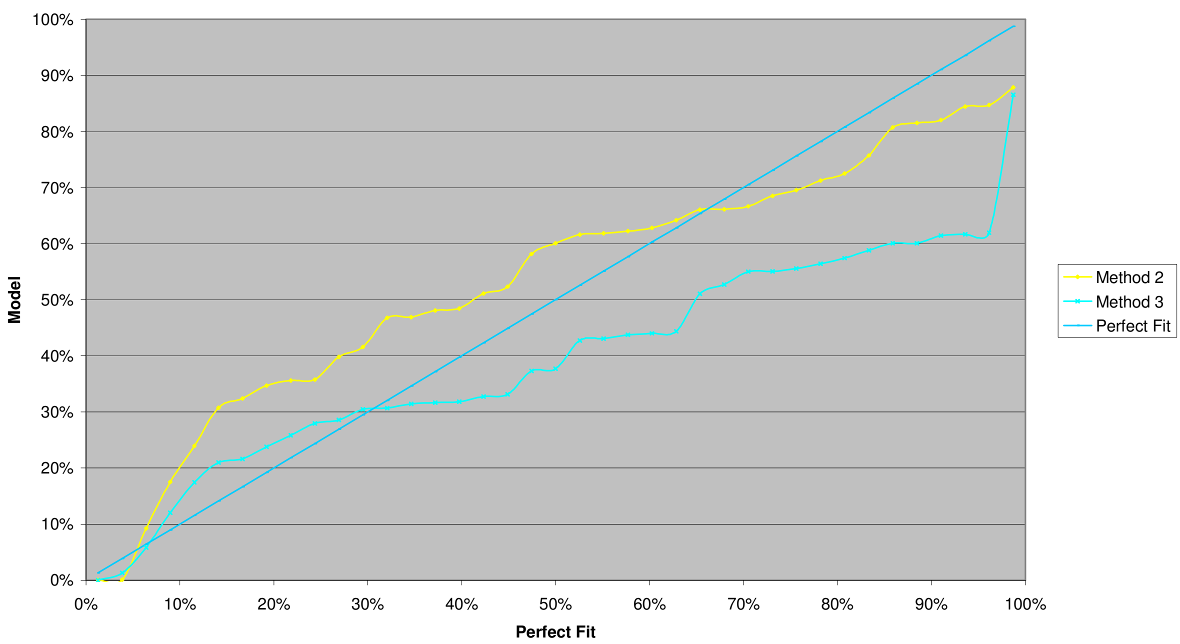
GROSS SD

Discounted

Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result	% firms with higher sd
Method 1	46%	41%	32%	46%	**46.3%**	**25.0%**
Method 2	289%	132%	84%	64%		
Method 3				54%		
Method 4						
Method 5						
Method 6						

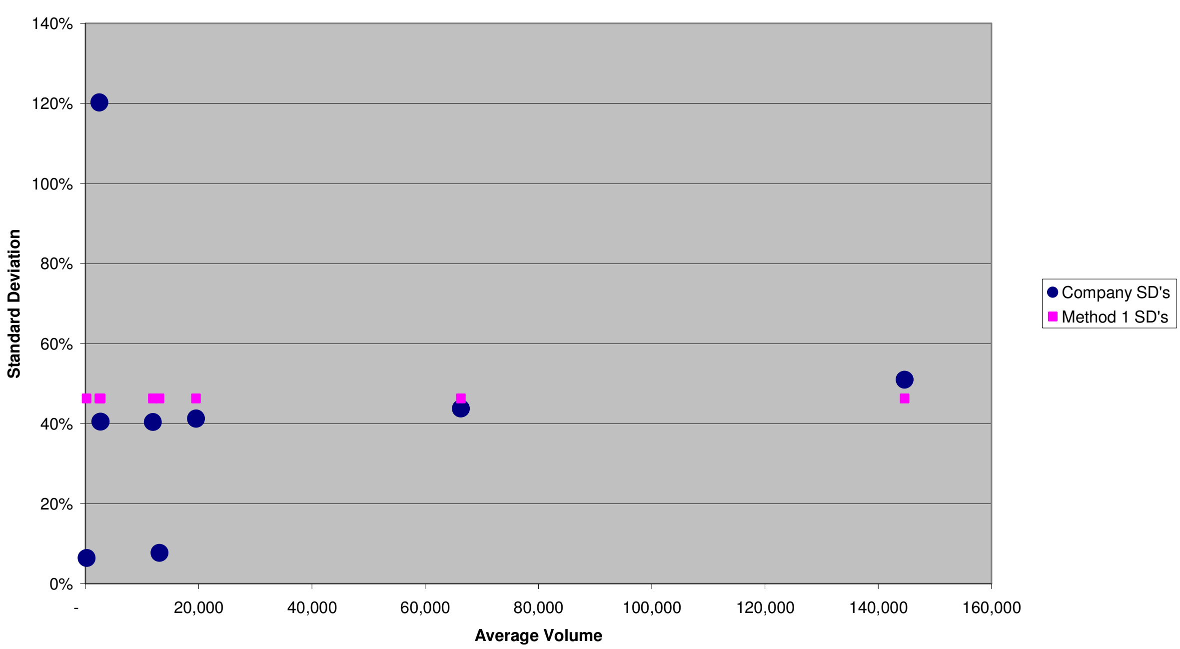
3.988 The graph below shows a pp plot of the fit of the models. Both methods provide a poor fit.

PP-Plot Model vs Observations



3.989 The result of the graph below shows no 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



Overall conclusions:

3.990 The selected technical factor was chosen considering method 1 – result 46.3%.

Non-proportional reinsurance - casualty

3.991 CEIOPS recommendation is that for the non-proportional reinsurance casualty lob the gross factor for reserve risk is 40%.

3.992 The data sample included data from 5 undertakings, was gross of reinsurance and included data from the following member states: UK. Lack of data in respect of provisions, did not allow application of methods 4, 5 and 6.

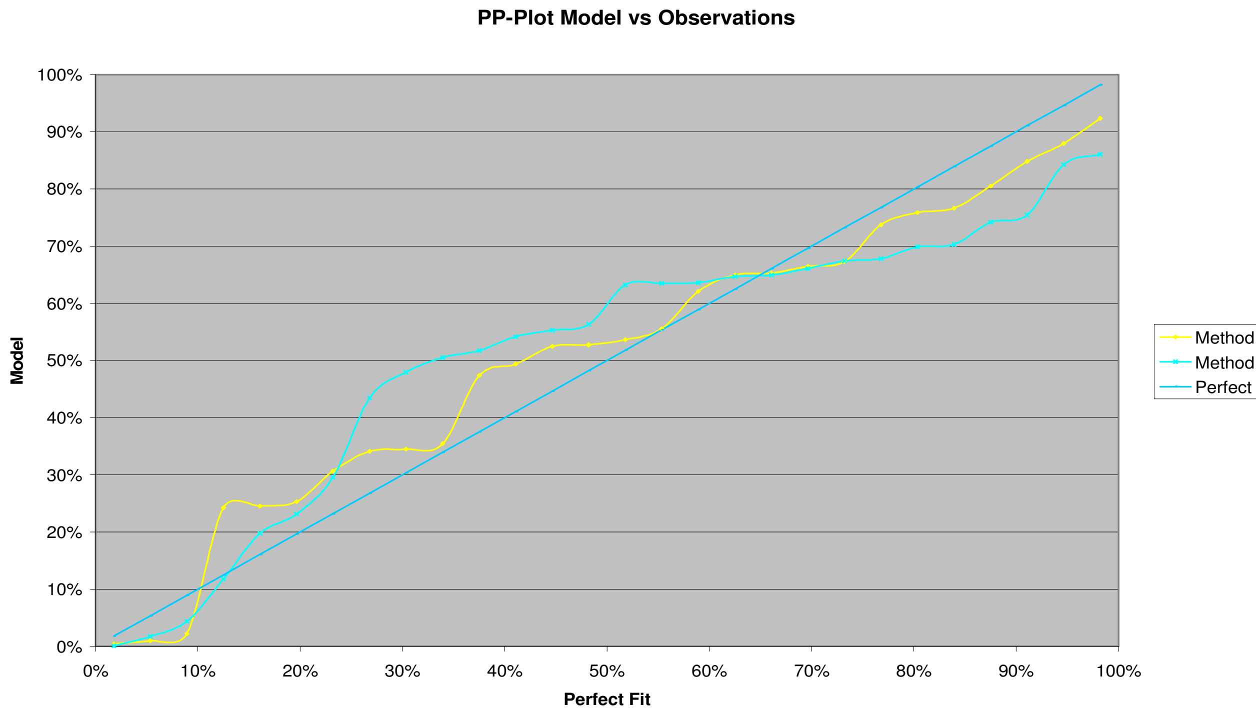
Reference co	Small	Medium	Large
Non-proportional reinsurance – casualty	32,328	34,099	92,418

GROSS SD **5 undertakings**

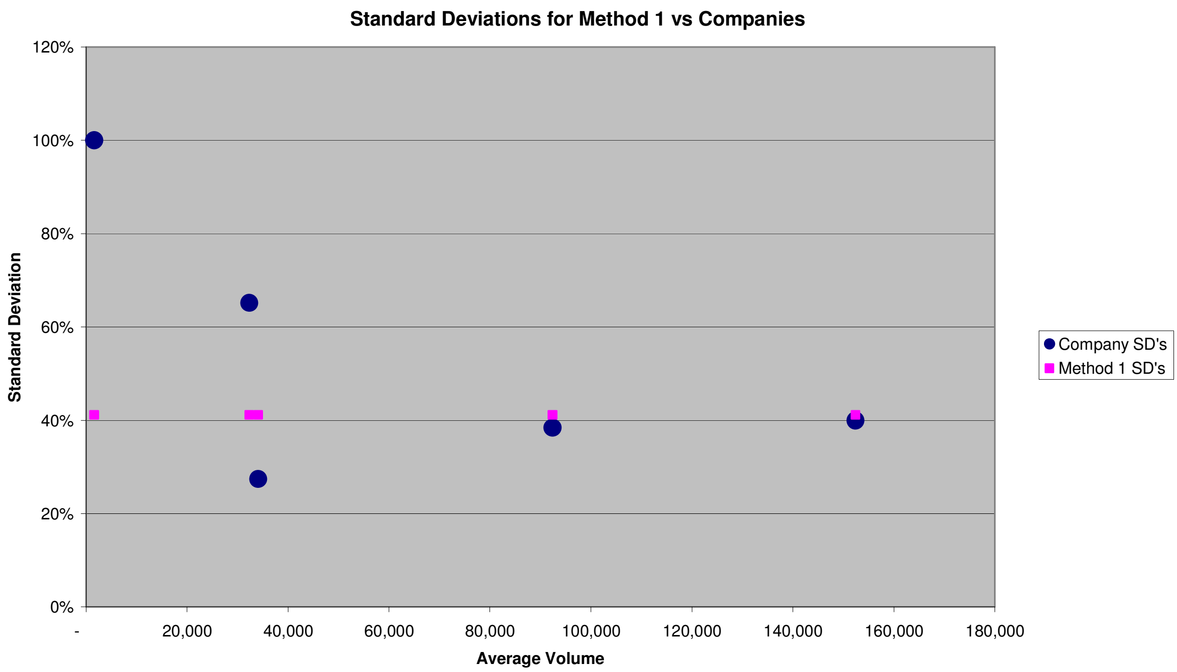
Discounted

Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result	% firms with higher sd
Method 1	65%	40%	38%	41%	**41.1%**	**40.0%**
Method 2	93%	91%	55%	59%		
Method 3				112%		
Method 4						
Method 5						
Method 6						

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



3.994 The result of the graph below shows no evidence for diversification credit. It also shows the volatility of the individual observations compared to the fitted selection for method 1.



Overall conclusions:

3.995 The selected technical factor was chosen considering method 1 – result 41.1%.

Non-proportional reinsurance - MAT

3.996 CEIOPS recommendation is that for the non-proportional reinsurance MAT lob the gross factor for reserve risk is 70%.

3.997 The data sample included data from 8 undertakings, was gross of reinsurance and included data from the following member states: UK. The lack of data did not allow the application of methods 4, 5 and 6.

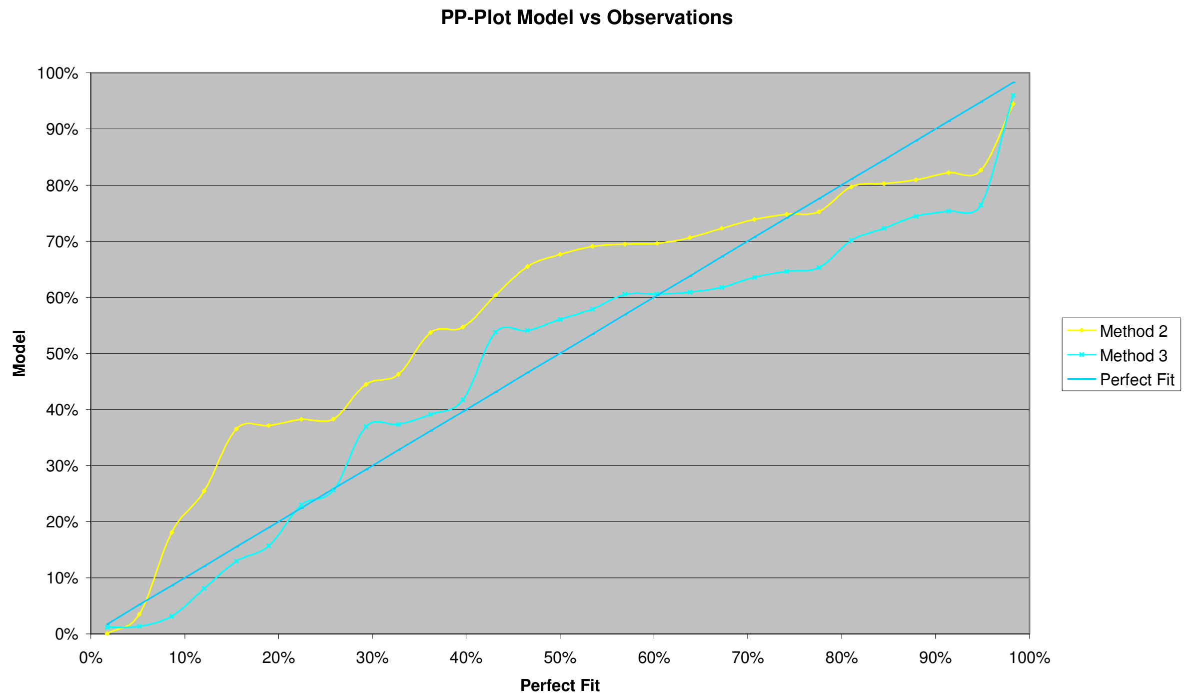
Reference co	Small	Medium	Large
Non-proportional reinsurance – MAT	1,659	3,718	4,947

GROSS SD

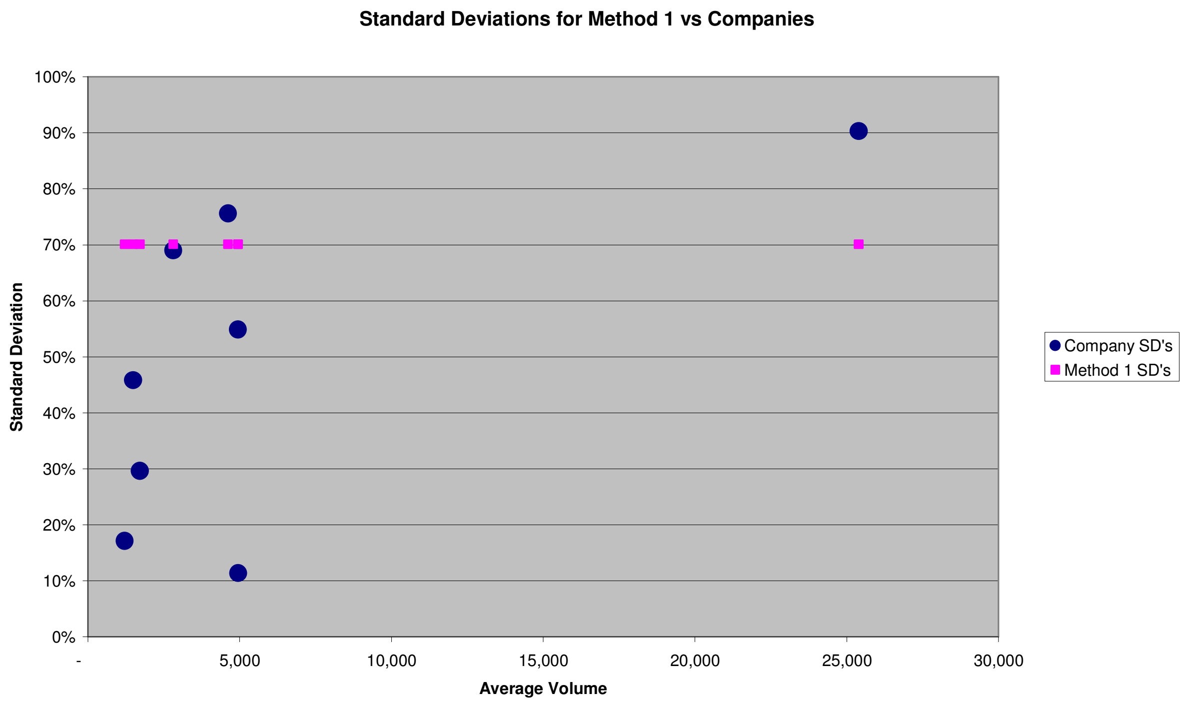
Discounted

Method	Small (75th perc)	Medium (50th perc)	Large (25th perc)	VWA	Technical result	% firms with higher sd
Method 1	71%	50%	27%	70%	**70.1%**	**25.0%**
Method 2	257%	172%	149%	119%		
Method 3				105%		
Method 4						
Method 5						
Method 6						

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



3.999 The result of the graph below shows no evidence for diversification credit. It also shows the volatility of the individual observations compared to the fitted selection for method 1.



Overall conclusions:

3.1000 The selected technical factor was chosen considering method 1 – result 70.1%.

Adjusting gross to net for reserve risk

3.1001 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.

3.1002 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.

3.1003 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.

3.1004 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
Motor TPL	9.5%	12.0%	12.5%
Motor Other	17.5%	7.0%	12.5%
MAT	24.7%	10.0%	17.5%
Fire	12.0%	10.0%	15.0%
TPL	15.8%	15.0%	20.0%
Credit & Suretyship	25.1%	15.0%	20.0%
Assistance	25.3%	10.0%	15.0%
Legal Expenses	8.9%	10.0%	12.5%
Miscellaneous	23.0%	10.0%	20.0%
NPL - property	25.4%	15.0%	30.0%
NPL - Casualty	25.1%	15.0%	30.0%
NPL - MAT	41.2%	15.0%	30.0%

3.1005 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.

For example: for TPL, the gross volatility factor was 23.5%. If gross reserves were 1,000, this would imply a gross capital requirement of 235. Since net reserves may only be 780, the factor needs to be uplifted to 30.1% to get the same level of capital requirement.

- 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.

  For example; for TPL, the analysis suggested that the effect of reinsurance (at the relatively more extreme levels) would be around 53% rather than 78% at the mean.

- 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.

- The resulting net reserving factor for TPL, to be applied to net reserves, would then be 30.1% * 53%= 16%.

3.1006 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 – i.e. consistent with the scenario effectively identified by the gross calibration.

Data

3.1007 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

3.1008 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

3.1009 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

3.1010 The volume weighted average net to gross ratio was selected. This was the volume weighted average of the third time series divided by the first time series.

Calibration Step 2

3.1011 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

3.1012 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.

Summary results

3.1013 CEIOPS has selected the following gross factors as the calibration for the Non life underwriting module for the purpose of the standard formula:

LOB	Gross Premium factor	Gross Reserve Factor
Motor, Vehicle Liability	11.5%	11%

Motor, Other Classes	8.5%	20%
MAT	23%	38.5%
Fire and Other damage	15%	25%
Third party liability	17%	23.5%
Credit and suretyship	28%	50.5%
Legal expenses	8%	9%
Assistance	5%	44.5%
Miscellaneous	15.5%	41.5%
NPL Property	37%	46.5%
NPL Casualty	18.5%	41%
NPL MAT	16.5%	70%

3.1014 After adjusting for reinsurance as recommended above, the net technical factors for the calibration for the Non life underwriting module for the purpose of the standard formula would be as follows:

LOB	Net premium factor[101]	Net reserve factor
Motor vehicle liability	11.5%*(NCR_i/GCR_i)	9.5%
Motor Other	8.5%*(NCR_i/GCR_i)	17.5%
MAT	23%*(NCR_i/GCR_i)	25%
Fire and Other damage	15%*(NCR_i/GCR_i)	12%
Third party liability	17%*(NCR_i/GCR_i)	16%
Credit and suretyship	28%*(NCR_i/GCR_i)	25%
Legal expenses	8%*(NCR_i/GCR_i)	9%
Assistance	5%*(NCR_i/GCR_i)	25.5%
Miscellaneous	15.5%*(NCR_i/GCR_i)	23%
NPL Property	37%*(NCR_i/GCR_i)	25.5%

[101] 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

NPL Casualty	18.5%*(NCR_i/GCR_i)	25%
NPL MAT	16.5%*(NCR_i/GCR_i)	41%

3.1015 CEIOPS members have considered the technical results produced from the analysis along with results and other evidence produced by individual CEIOPS members and other interested parties. These are discussed in section 4.5 (Other Analyses).

3.1016 CEIOPS believes it is important to consider this additional evidence, along with other judgements made with the benefits of a wider understanding of the business along with the pure technical analysis described above. Particularly in cases where the volume of data is not as large as might be desired for such an analysis, it is then desirable to take this other information into account before arriving at the final recommendations.

3.1017 In general, CEIOPS members have not identified any significant issues with the proposed net technical factors for premium risk apart from the non-proportional reinsurance property lob. For reserve risk, there are 5 lines of business where particular concerns were raised over the results produced by the pure technical analysis. These were mainly associated with issues around the volume of data available for analysis. However, not all lines of business with smaller volumes raised particular concerns.

3.1018 In these instances, CEIOPS members have taken into account the factors used for QIS4, those proposed as part of the earlier CP71 analysis102, the information from the other analyses (as noted in section 4.5), as well their wider knowledge of the underlying business characteristics and its performance. This assessment has taken into account the known shortcomings in those analyses so as to not put undue weight on any one source.

3.1019 The results of this assessment are as follows:

LOB	Technical net premium risk factor	Recommended net premium risk factor
NPL Property	37%*(NCR_i/GCR_i)	20%*(NCR_i/GCR_i)

LOB	Technical net reserve risk factor	Recommended net reserve risk factor
Motor other	17.5%	12.5%

[102] CEIOPS-CP71-09

MAT	25%	17.5%
Assistance	25.5%	12.5%
Miscellaneous	23%	20%
NPL MAT	41%	25%

Other analysis

3.1020 To get a further insight and consider other information available, CEIOPS reviewed additional exercises provided by CEIOPS or the industry as part of the final selection.

3.1021 These additional exercises also suggest that factors proposed for QIS4 may not be appropriate at least for some lines of business.

Spain Analysis

3.1022 Spain shared with CEIOPS an analysis based on the Spanish market. The analysis was:

- Carried out in respect of third party liability and motor third party liability and only for reserve risk.
- The analysis was gross
- Carried out consistently with the requirements of the standard formula.
- The results are aligned with the conclusions made in this analysis, considering that the calibration was based on only one member state.

Portugal Analysis

3.1023 Portugal has shared with CEIOPS an analysis based on the EU database collected by CEIOPS. Details on how this was carried out is included in annex 7.6 of CEIOPS-DOC-67/10.

3.1024 This analysis was not performed for other LoBs because the assumptions underlying this particular methodology require triangles of a sufficiently high size, where the sum of each column is non-negative, and where a reasonable degree of proportionality between columns is observed. The data available for these other LoBs was not considered to fully satisfy these requirements.

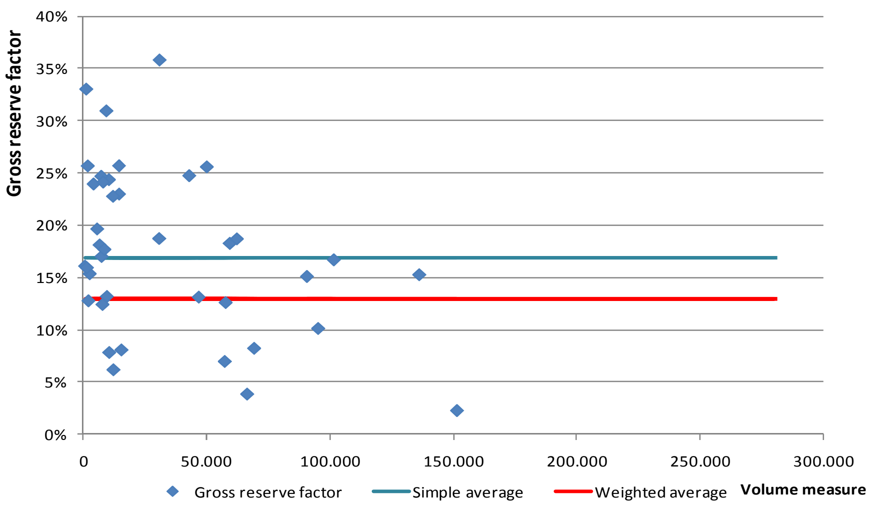
3.1025 The analysis was made for Sickness, Workers' Compensation, Motor Other Classes and Motor Third-Party Liability.

3.1026 Portugal proposes the following gross reserve factors:

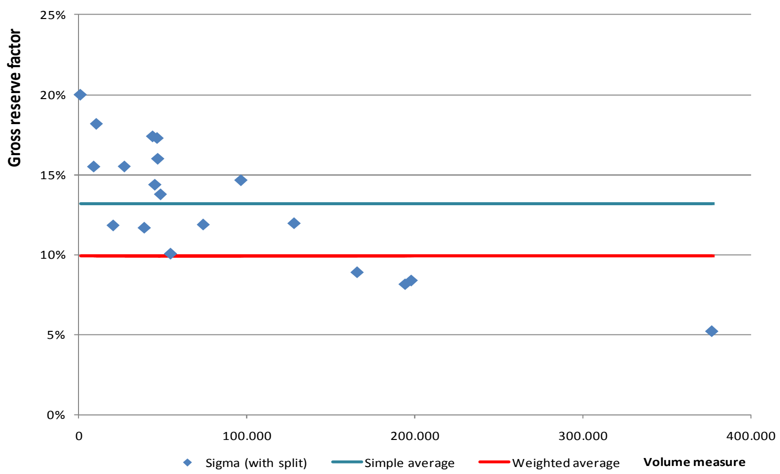
LOB	Gross Reserve Factor	
	Poisson Method (Simple average)	Poisson Method (Weighted average)
Motor, Other Classes	16.9%	12.9%
Mtor, TPL	13.2%	10.0%

3.1027 The following graphs show the adjustment obtained with the application of the methodology for these 4 lines of business. Each point represents the gross reserve factor calculated and the volume measure of each undertaking.

Motor Others



Motor TPL



QIS4 factor benchmarking analysis

3.1028 CEIOPS did some additional analysis based on the information provided as a result of the QIS 4 results.

3.1029 In order to calculate the non-life premium and reserve risk module (and the non-life part of the health underwriting risk module) QIS4 participants where requested to provide a time series of net loss ratios per line of business. (Cf. TS.XIII.B.30 of the QIS4 Technical Specifications.) All in all, about 3400 time series of European insurance and reinsurance undertakings were collected in this way.

3.1030 CEIOPS carried out an analysis of the QIS4 database for the purpose of the calibration of the premium risk factors σ (prem, lob) as defined in *CEIOPS' Advice on the non-life underwriting risk module*. Details on how this was carried out is included in annex 7.3 of CEIOPS-DOC-67/10.

3.1031 It is important to note for the purpose of making conclusions, that this analysis suffers from some shortcomings:

- The standard deviations are derived from time series of loss ratios. Conceptually, premium risk covers the volatility of claims and expenses. Loss ratios only reflect the volatility of claims. In order to estimate the volatility of claims and expenses, either combined ratios instead of loss ratios need to be studied or the loss ratios (or the resulting standard deviation) need to be scaled up to take the extra volatility of expenses into account. As this was not possible so far, the results are likely to underestimate the real risk.

- The distribution of loss ratios is likely to be skewed. In this case, the estimator is biased and underestimates the real standard deviation.

- The time series provided in QIS4 may not reflect the risk of the undertaking. The time series may be distorted, for example because of smoothing of held reserves, portfolio transfers, change of reinsurance programme or catastrophic losses.

- For some EU countries, most QIS4 responses where provided by the larger medium undertakings, and therefore any results will not be very representative of the smaller undertakings.

3.1032 Because of these shortcomings, the results of the analysis should rather be considered as lower boundaries of the final net standard deviations.

GDV analysis

3.1033 GDV shared with CEIOPS analysis and data based on the German market. We understand the analysis was:

- Carried out in respect of six lines of business for reserve and premium risk.

- The analysis was gross.
- Carried out consistently with the requirements of the standard formula.
- CEIOPS was unable to incorporate the data into the analysis due to time constraints for premium risk. However the results were compared as a benchmark.
- However German data is included for reserve risk.

AON Benfield Analysis

3.1034 CEIOPS also made reference to The Insurance Risk Study, Fourth edition 2009.

3.1035 We understand from discussions with AON that the analysis was carried out for premium risk. The underlying assumptions and methodologies used are not totally consistent with the underlying assumptions of the standard formula.

3.1036 Nevertheless we can draw some broad conclusions from the analysis for example including evidence of diversification by size of portfolio and the general magnitude of the underlying systemic volatility of the classes.

3.5.2 Non-life catastrophe risk

3.1037 Under the standard formula there are two methods that can be used by the undertaking for estimating their catastrophe risk.

- Catastrophe Standardised scenarios
- Factor method

3.1038 Each method is aimed to provide a calibration of catastrophe risk at the 99.5% VaR for undertakings that are exposed to extreme or exceptional events.

Standardised scenarios

3.1039 Under CP48 and CP50, CEIOPS proposed the development of Standardised Scenarios as a method for the estimation of the Catastrophe Risk charge required under Article 111 1(c) of the Level 1 Directive.

3.1040 The proposal included the creation of a joint industry and CEIOPS Catastrophe Task Force (CTF). The aim of the CTF would be to provide CEIOPS with input and guidance on the calibration and application of Non Life and Health Catastrophe standardised scenarios in line with the advice provided by CEIOPS in CP48 and CP50. The proposal was welcomed and supported by the European Commission.

3.1041 In July 2009, CEIOPS sent a letter to a number of stakeholders inviting them to be part of the CTF. The CTF was established at the end of August 2009.

3.1042 The members of the CTF are:

- Swiss Re
- Lloyd's of London
- Munich Re
- CCR
- SCOR
- The Actuarial Profession Health & Care Practice Executive Committee
- Guy Carpenter
- Willis
- RMS
- CEIOPS FinReq members

3.1043 It was agreed with CEIOPS and the European Commission that the CTF would provide an interim paper in March 2010 and a final proposal by June 2010.

3.1044 The advice presented in this paper is based on the work carried out by the CTF and supported by CEIOPS.

The aim was to provide an appropriate and unbiased calibration based on the information that has been selected considering the views and expert opinions of CEIOPS and members of catastrophe task force

3.1045 The non life Catastrophe Standardised scenarios considered in this document are:

- Natural Catastrophes: extreme or exceptional events arising from the following perils:
    - Windstorm
    - Flood
    - Earthquake
    - Hail
- Man Made Catastrophes: extreme or exceptional events arising from:

- Motor
- Fire
- Marine
- Aviation
- Liability
- Credit & suretyship
- Terrorism

3.1046 Storm surge was also considered as an important peril. Where Storm surge is covered and is considered to be a material peril, this has been combined with the windstorm peril due to the inherently coupled nature.

3.1047 This section provides the detailed information in respect of how Natural and Man made catastrophe scenarios have been calibrated.

Calibration of Natural Catastrophes

3.1048 A number of options were considered for the calibration of natural catastrophe and pros and cons of each were assessed in turn. After careful thought and consideration it was decided that:

- that the Catastrophe standardised scenarios should be driven by undertakings' exposure,
- that aggregate country level exposure data is inadequate to properly reflect the variability in natural catastrophe risk – especially for large countries with strong gradients of risk, hence
- the Catastrophe standardised scenarios should be based on exposure at a sub-country level and use something akin to CRESTA zones which are an existing industry standard (or something similar if CRESTA are not available).

3.1049 On that basis the following proposal was agreed for the estimation of a catastrophe charge for natural catastrophes:

$$WTIV_{ZONE} = F_{ZONE} * TIV_{ZONE}$$

$$CAT_{Peril} = Q_{CTRY} \sqrt{\sum_{rxc} AGG_{r,c} * WTIV_r * WTIV_c}$$

Where

CAT_{Peril} The estimation of cat capital charge for a specific country

Q_{CTRY} = 1 in 200 year factor for each country and peril

F_{ZONE} = relativity factors for each zone by country

$AGG_{r,c}$ = Rows and columns of the aggregation matrix AGG by country.

$WTIV_{ZONE}$= Geographically weighted total insured value by zone

TIV_{ZONE}= Total insured value for the Fire and other damage line of business exposures by each CRESTA zone.

A) Calibrate the 1 in 200 year factor for each country and peril

3.1050 The country factor represents the cost of a 1 in 200 loss to the industry as a whole, expressed as a percentage of sum insured. This is a measure that will be readily understood by the industry. It is also readily comparable between countries, which helps transparency.

3.1051 Each participant of the CTF provided their own industry view of what a 1 in 200 year loss could be as a percentage of Total insured value for a particular country. Where views diverged the CTF discussed further before making a final decision. The final selection is provided in Appendix 2 at the end of this section.

3.1052 It is important that when looking at the factors readers interpret these correctly. The factors are not only a measure of the intensity of the hazard in a region, but also a measure of the vulnerability of the building stock and concentrations of exposure at risk. For countries with high earthquake risk and a history of damaging earthquakes, they typically have strong building-codes that would moderate the impact compared to countries with weaker buildings.

3.1053 If stakeholders do not agree with the loss damage ratios provided, CEIOPS welcomes written justification and explanation of why that is the case.

3.1054 Where information was not available for a particular country, the task force requested CEIOPS input or used an extrapolation technique between neighbouring countries.

B) Construct CRESTA relativities: relativity factors for each zone by country

3.1055 Solvency II specifies that the required capital be calibrated to a 1 in 200 level for each undertaking. As natural catastrophe risk can vary considerably depending on where you are in a country, taking a single country level factor is not risk sensitive enough and will not treat undertakings fairly.

3.1056 As a result a simple way was designed to allow for the differing risk in the different zones in each country given the spatially varying nature of natural perils. The cresta relativities represent the level of damage relative to the 1 in 200 on a national basis. Thus reflecting the fact that in some areas within a country you will be more exposed and the level of damage may be greater than others.

3.1057 In doing so the following two approaches were considered by the CTF in providing guidance to CEIOPS:

- **Applying an event footprint approach**: Using a single event footprint that generates a national 1-in-200 year loss, and calculating the damage ratio in each zone that is impacted by that event.

- **Applying a »Hazard Map«[103] approach:** The loss damage ratio in each cresta zone corresponding to equivalent to the 1-in-200 year loss in that zone on a national basis.

3.1058 The approaches reflect opposite extremes of the trade off between different levels of hazard in different local areas and allowance for geographic diversification across wider areas.

3.1059 The main disadvantage of a single-event footprint approach is that it is often only one of a range of many possible events that could cause a 1-in-200 loss, and will not represent the 1-in-200 loss for many undertakings: especially for those whose exposure lies partly or predominantly outside the scenario event footprint.

3.1060 In principle the hazard map approach better reflects the physical reality of the pattern and gradients of natural perils across Europe, and would better reflect a company's exposure to that pattern of risk. Thus for a particular undertaking, we can assess the suitability of each approach for different undertakings as follows:

Undertaking	**Footprint**	**Hazard Map**
Geographically well diversified	Will work well	Will over-estimate
Locally concentrated	Will under or overestimate	Will work well

3.1061 In order to decide the best way forward, the CTF proceeded to test and analyse the bias introduced by applying each approach and exploring any adjustments that could be made to each approach to make it more appropriate for all undertakings. The analysis was performed on Windstorm and was assessed on the market exposures of a few member states.

[103] Other definitions of hazard map exist –e.g. annual average loss, which is more appropriate for pricing. The definition here seems to be best suited to our purpose.

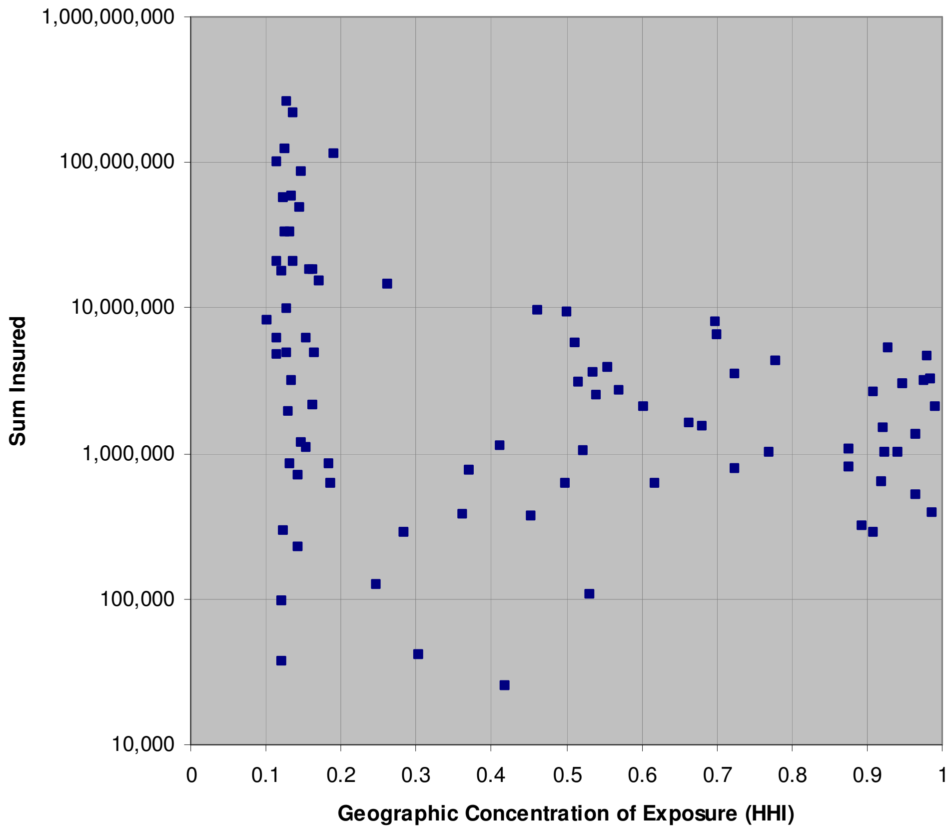
3.1062 For illustration, we present the steps followed for one particular case for the Netherlands, though the preferred method was then tested on additional countries:

- The CTF used an anonymised data set of 86 companies at province level (12 provinces based on the risk based reporting data of the current Dutch framework). The data included buildings sum insured information.
- The CTF used a Windstorm Cat model to carry out the necessary calculations. It is important to note that this model was selected for the purpose of testing for bias, rather than to calibrate the actual scenarios. The CTF do not believe that the conclusions of this assessment would differ materially if a different Cat model had been used. The final catastrophe standardised scenarios themselves are not based on this Cat model but reflect the views of task force as whole.
- A »ground-up« perspective of the loss was used to test the relative methodologies: that is without the application of insurance policy conditions or reinsurance treaties, again simply to compare the validity of each approach.

3.1063 The steps followed were:

3.1064 Selected a hypothetical 1 in 200 year market loss.

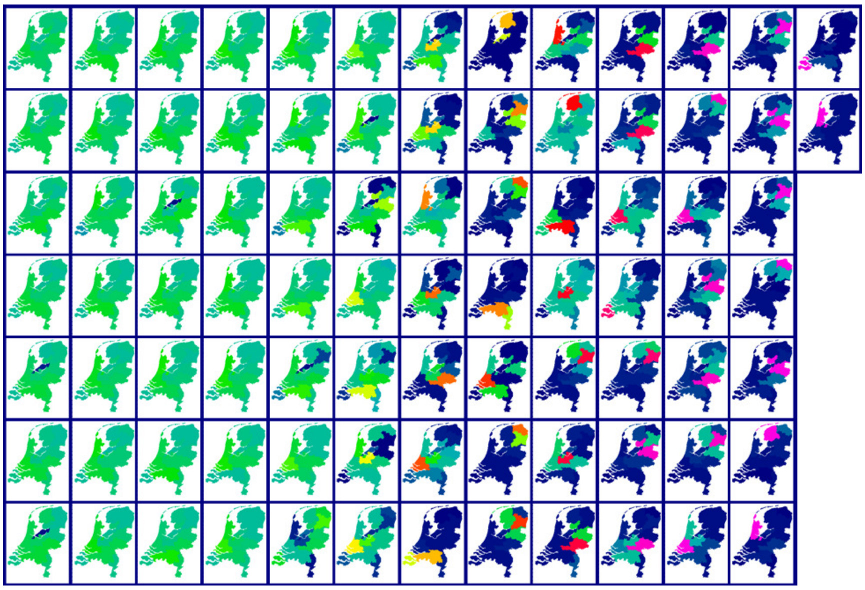
3.1065 The CTF run a range of models for each of the 86 companies' actual exposure data. Below is a graph which illustrates the structure of the market for this anonymised market as well as highlights some of the problems the CTF was faced when selecting a methodology which provided results that where adequate for all the market participants.



3.1066 Each dot represents a single company. A concentration equal to 1 means that all of a company's exposure is in a single province. The market portfolio has a concentration roughly equal to 0.12, indicating that as a whole it is quite a concentrated market. This chart shows that the largest 20 companies (representing around 87% of the exposure) are well geographically diversified. However, 43 companies have more than 80% of their exposure concentrated in just two provinces.

3.1067 Below we see the same issue from a spatial perspective. Each chart represents a single company (in order of concentration). It shows where (geographically) their exposure is proportionally more or less than their market share:

- green= share of exposure in province roughly equals national market share
- blue= share of exposure in province less national than market share
- yel/ora/red/pur= share of exposure in province greater than national market share

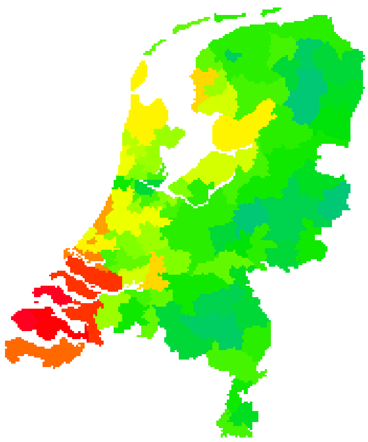


3.1068 The chart shows that many companies have strong geographical skews to where they are writing business, which would intuitively indicate that the use of a single scenario footprint would not effectively represent their exposure to natural hazard risk.

3.1069 Apply footprint and hazard map approach and compare results from the model, as follows:

Footprint approach

3.1070 The scenario was based on a footprint with mean loss closest to selected 1-in-200 market loss.



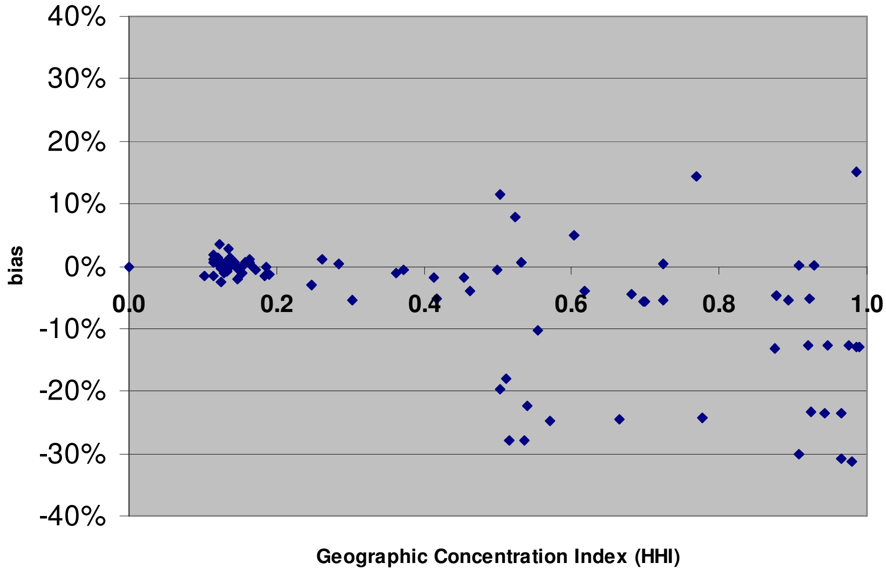
3.1071 The relativity between the highest and lowest zonal factors was around 4.

3.1072 The modelling results provided the following results:

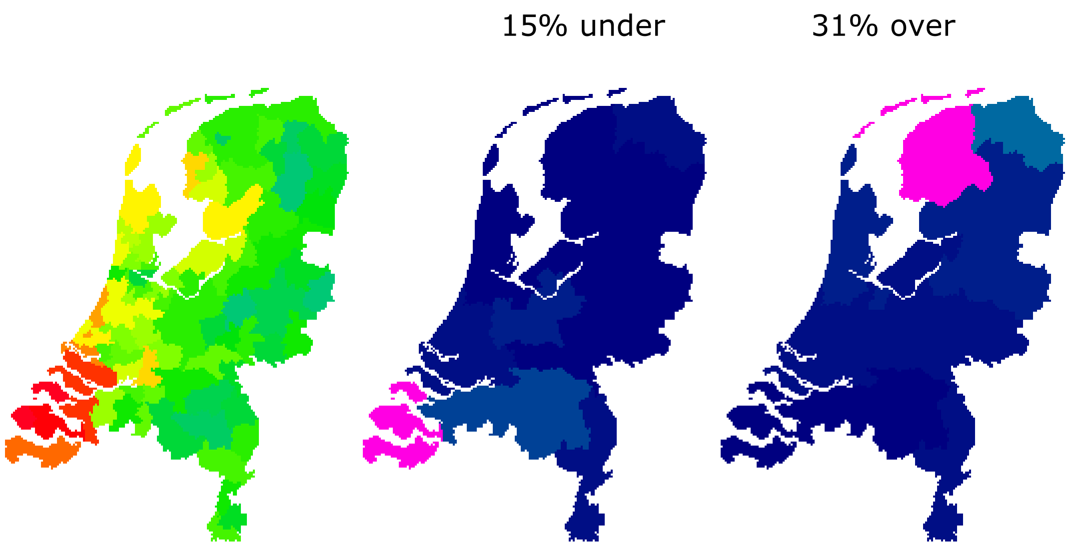
- The aggregate Cat Risk Charge = 100% of selected
- Aggregate Bias = 0%

- Company Bias = 31% under to 15% over

3.1073 Below is a graph which shows the level of bias across the firms under this approach:



3.1074 So why the range of results? The three pictures below show why:



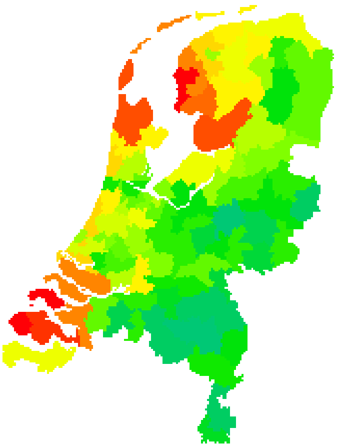
3.1075 As expected, companies with geographically diversified portfolios are handled well whilst companies with concentrated portfolios can be materially under-or over-estimated, as their exposure falls in or outside the selected scenario footprint.

3.1076 The CTF identified the following solutions to these problems, and analysed the pros and cons for each one:

Possible Fixes	**CTF conclusions**
Option a) More careful selection of footprint	- not easy to specify how - almost all will have some bias (one particular selection gives a bias range *81% under* to *130% over*!) - even harder for larger countries Conclusion: not possible in practice
Option b) Select footprint to give narrowest range of bias	- The event was scaled to chosen €4.08bn - The results where good, with company bias 7.8% down to 5.7% up. - However this resembles a hazard map. - Possible that no footprint will give good enough range. - Need per company zonal data to derive and this is not available. Conclusion: not possible in practice
Option c) Combine multiple footprints	- How to select which ones? - Need to define method for combining different footprint losses. - If too many then effectively moving towards hazard map approach. Conclusion: possible but very subjective

3.1077 Overall the CTF concluded that a footprint-based method would not meet the stated objectives of providing a fair method that is harmonized across countries.

Hazard Map Approach



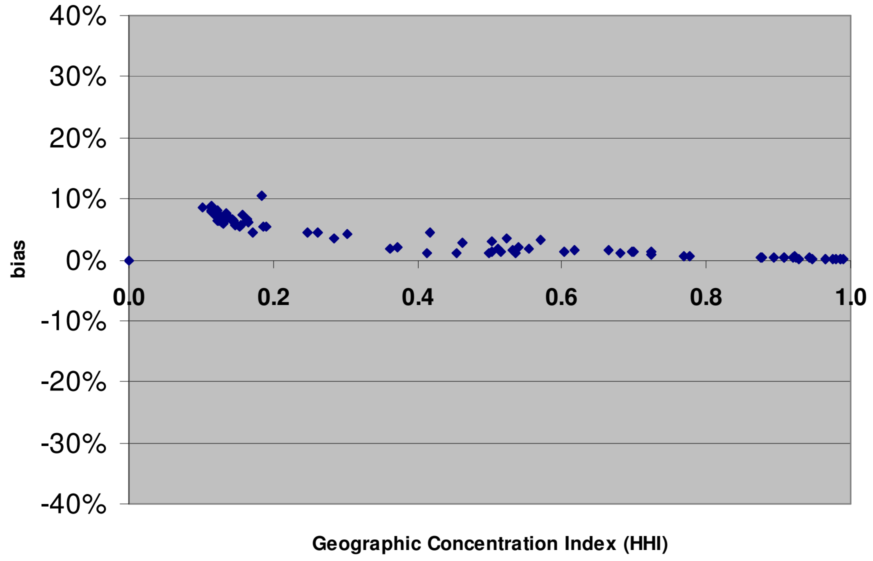
3.1078 A probabilistic event set was utilized to calculate the 1-in-200 damage ratio for each individual CRESTA zone:

- The relativity between the highest and lowest zone damage factors was around 3.
- Highest factors in coastal regions including Friesland and Flevoland, which are the most high-risk parts of the country. Thus this method seems to reflect the actual risk across the country well, compared to the footprint method.

3.1079 The modelling results provided the following results:

- Aggregate Cat Risk Charge = 107% of selected
- Aggregate Bias = 7% overestimate
- Company Bias = level to 10% over

3.1080 Below is a graph which show the level of bias across firms:



3.1081 As expected, companies with concentrated portfolios are handled well whilst geographically diversified portfolios are overestimated. While on balance, this method is clearly favourable to the footprint method, a solution was needed to address the overestimation of geographically diverse portfolios. This was done as follows:

Possible Fixes	**CTF conclusions**
Option a) Do nothing (i.e. no within-country geographic diversification allowed)	Although an aggregate 7% overestimation might be considered acceptable (given the uncertainty in the starting factors), a preliminary exercise based on other larger countries would give aggregate overestimates in the range 25% to 50%. These are unlikely to be considered reasonable by the industry. Also the 7% overestimation is based on province level data. This is likely to be higher with more detailed CRESTA zone exposure information. Conclusion: probably not an option
Option b) Scale down to fix aggregate bias	Although this will eliminate any aggregate bias and reduce the overestimate for diversified companies, it will produce an underestimation for less well diversified companies. As with option a, in other countries the aggregate bias may

	be much larger. This could cause underestimates for individual companies by as much as 33%. This is probably not desirable from a regulatory point of view. Conclusion: better than option A, but still not desirable
Option c) Explicitly build in geographic diversification	The simplest approach would be to adopt the same type of correlation structure as used elsewhere in the QIS exercises. i.e. include a matrix to allow for aggregation/diversification between CRESTA zones. Although seemingly complex it is not insurmountable. Conclusion: Possible but need to see in practice

Option c - Explicitly build in geographic diversification

3.1082 The CTF decided to test this alternative and create a matrix to allow for aggregation/diversification between CRESTA Zones.

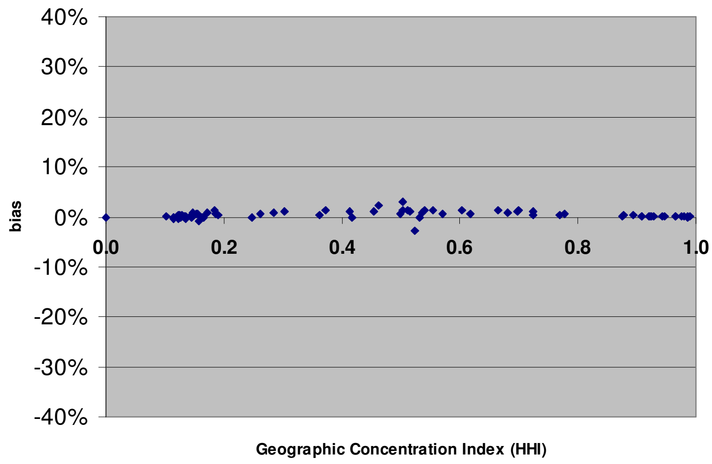
3.1083 As before, the ratios are based on 1-in-200 loss ratio for each CRESTA zone in isolation.

- Factors in range 0.18% to 0.55%
- CRESTA “correlation” matrix (entries either 0, 0.25, 0.5, 0.75 or 1)

3.1084 The integration of this additional step gives decent results for most companies:

- Aggregate Cat Risk Charge = 101% of selected
- Aggregate Bias = 1%
- Company Bias = 2.7% under to 3.1% over

3.1085 Below is a graph which shows the level of bias across firms under this approach:



Conclusions:

3.1086 To summarise, the CTF assessment of the two approaches is:

3.1087 Footprint (multiple with combination method)

- quite subjective as to choice of the actual footprint scenario
- difficult to avoid obvious biases (credibility issue)
- harder to ensure consistency between countries
- need to detach from any actual model footprints

3.1088 Hazard Map (with geographical diversification)

- less subjective
- diversification matrix hardest part, but proven achievable

3.1089 The CTF chose unanimously, Hazard Map over Footprint and to explicitly incorporate geographical diversification as the method for calibrating the CRESTA zone factors.

3.1090 To build in explicitly geographical diversification, the CTF had to estimate aggregation matrices for each country. These matrices are designed to reflect the geographic extent and nature of the damage caused by events giving risk to 1-in-200 year losses and also the geographic relationship between the zones. And the distribution of building values by CRESTA within the country. For example, the tracks of windstorms in Europe tend to track in an easterly direction. This means that there should be more diversification between 2 zones located 200 km apart in a north-south directions than then 2 zone located 200 km apart in an east-west direction.

3.1091 Ultimately this was rebased to make sure that, if you apply the method (factor*relativity aggregated using matrix) to market TIVs, the calculated loss divided by the sum of TIVs gives you the desired national 1 in 200 damage ratio you want.

3.1092 Catastrophe models developed by members of the task force were used in part of this estimation process. However, in most cases adjustments were made to reflect the collective expert judgement and experience so that the Catastrophe standardised scenarios being proposed reflected the consensus view of the CTF not any of the particular cat models. The correlation matrices have all been approved by the collective expert judgement of the CTF to make sense, and could be reviewed in future if required, for example if a new type of storm or earthquake occurred that altered the previous-held scientific viewpoint of the pattern of natural perils across Europe.

3.1093 Having developed the hazard-map approach for windstorm, the CTF felt that applying the same approach for Flood and Earthquake would be most appropriate, to ensure consistency across all perils and a level playing-field.

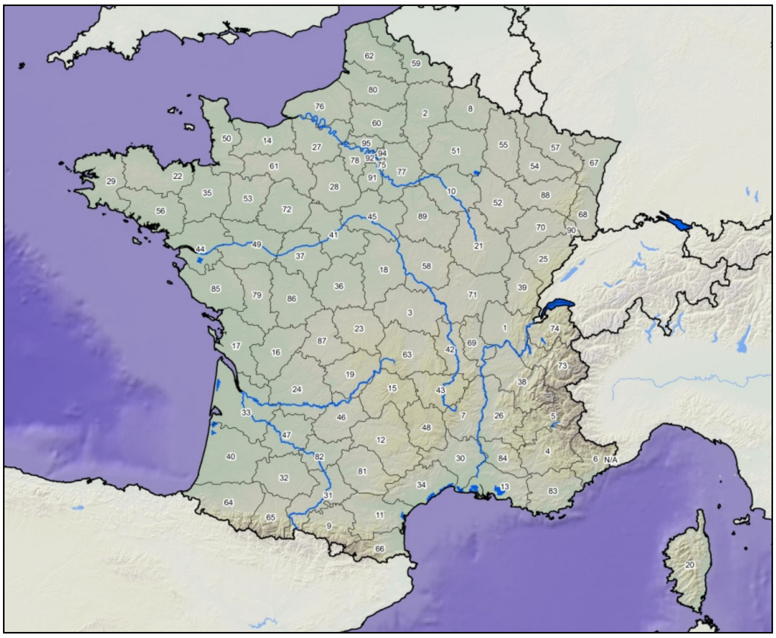
3.1094 For earthquake and flood, the procedure was repeated to derive a hazard map and to explicitly incorporate geographical diversification as the method for calibrating the CRESTA zone factors. The geographical distribution of flood and earthquake perils across Europe is quite different to Windstorm, however. Windstorm risk across Europe shows a strong, and yet quite smooth gradient from northwest to southeast, as large damaging windstorms are driven in from the Atlantic, with Ireland and the UK having the highest risk from both frequency and severity. Further west, fewer storms penetrate and thus the risk decreases. Thus correlation between risks is quite closely related to their physical proximity, on a roughly west to east axis, and with less correlation in the north-south dimension, as previously mentioned.

3.1095 For flood, catastrophe risk is more associated with the course of the major river systems throughout Europe, which drives most types of 1 in 200 river flood losses, along with some flash-flooding risk.

3.1096 For Earthquake, risk is mostly connected with the collision of the Eurasian and African tectonic plates, with lower amounts of risk associated with smaller fault systems spreading through Germany. The highest earthquake risk areas are associated with fault systems that pass through Switzerland, Italy and through the south-east European countries towards Greece and Turkey, and towards the western margin of the Eurasian plate, through Portugal.

3.1097 Thus for these perils, the correlation between risks is less straightforward, plus earthquakes in particular generate occasional but very damaging events, compared with windstorms: and the shape of the frequency-severity distribution is quite different. Thus for earthquake in particular, and to a certain extent flood, a problem can occur when assessing the risk in two widely distant cities, each exposed to rare severe events, but little risk otherwise. Thus, using an earthquake example, if the return period for large damaging events is high for both cities, e.g. about 500 years, the 1in 200 year loss for each city would be low, because the more common seismic events would be just tremors. However the 1 in 200 year loss for the joint portfolio would be substantial, because this would correspond to either of the two cities suffering damage from one of the rare major local earthquakes. A different approach to properly assess diversification benefits is required, to overcome this combination problem, as this effect could otherwise promote concentration of risk in one location where the loss distribution has a long tail may perversely seem preferable to splitting it between distant independent locations. A standard choice in catastrophe risk management is to use a weighted-average of tail losses to overcome this problem, particularly for perils dominated by rare but highly damaging events. For this reason, the CTF used a TVar approach, using tail losses above 1 in 200 level, in order to derive the most appropriate CRESTA relativity factors zone level aggregation matrices.

Figure 1: France CRESTA zones. Five largest rivers are shown.



C) Loading for multiple events

3.1098 The above calibration only considers the possibility of one event occurring during the year (i.e. it is based on an occurrence not annual aggregate loss view). In reality extreme scenarios such as Windstorms and Floods can happen more than once in a year. As a result the net cat risk charge needs to take into account two different drivers of risk – the risk associated with a single very large occurrence and also the risk posed by multiple more moderately sized occurrences. The former tests the resilience of vertical reinsurance protections and the latter the resilience of reinsurances to multiple large occurrences (sideways protection). As a result, a calibration based on one event could result in an underestimation compared to a calibration based on more than one event occurring in a year.

3.1099 For the perils of windstorm and flood the calculation of Catastrophe Risk charge therefore takes into account the possibility of multiple insured events in any given year. This is addressed in the template by calculating a Catastrophe Risk charge under both of the following circumstances:

- one large event, at 1 in 200 level occurrence basis, plus a second, smaller event
- two moderate events
- the larger of the results for the two sets of circumstance being used.

3.1100 Both calculations result in equivalent total gross losses for each undertaking, while testing the efficacy of undertaking risk transfer instruments to determine the appropriate net Catastrophe Risk charge as follows:

- For Wind: 0.8 for the first event and 0.4 for the second or 1 for the first and 0.2 for the second.
- For Flood: 0.65 for the first event and 0.45 or 1 for the first and 0.10 for the second.

3.1101 Undertakings would then pass these losses through their respective reinsurance programmes and take the maximum net Cat charge of the two for each of flood and wind.

D) Other LOB

3.1102 The calibrations provided for Natural catastrophe only consider the impact of such events on the 'Fire and other damage' line of business. In reality such events when they occur can often impact several lines of business at once.

3.1103 Two areas were this was considered material and thus should be taken into account in the estimation of catastrophe risk for natural hazards are:

- MAT: the TIV for static marine exposures should be included for all perils
- Motor own damage: for Flood and Hail the TIV for the "motor, other" line of business should be included

3.1104 The approach taken provides a simple way to allow for this risk. A more sophisticated approach would require substantial further work and would most likely introduce an additional layer of complexity into the calibration and calculation in the standard formula, and would therefore contravene the underlying principles of the standard formula approach. Undertakings should consider applying for a partial internal model (PIM) if a more risk sensitive approach was considered appropriate.

Calibration of Man Made Catastrophes

3.1105 Unlike natural catastrophes, where the gross insured loss will be shared by market participants, man made events are more likely to hit a single (or at most a very small number) of policies and so undertakings.

3.1106 Furthermore, while a company market share approach would reflect the frequency of the scenario, it would not adequately reflect the potential severity.

3.1107 Below is a description of the guidance received from the CTF on the calibration of the man made scenarios. This guidance has been accepted by CEIOPS:

Fire

3.1108 The CTF has provided below a illustration of what they have considered to be a possible Fire man made scenario: Actual historic examples would include for example Buncefield and Toulouse.

Scenario Rotterdam

Consider an explosion or fire in the oil refineries at the port of Rotterdam – one of the largest ports in the world. Large volumes of crude oil are stored around the port, and these catch fire as a result of the explosion. The fire causes a large number of fatalities, closure of the whole port (business interruption), almost complete destruction of port buildings and machinery as well as generating a highly toxic cloud of fumes.

Scenario Armament company

Due to a short circuit in an army aircraft a fire occurs in the premises of an armament company. In the building are 10 highly developed fighter jets, which are destroyed along with the hall and machinery.

3.1109 When considering the calibration of the Fire scenario the CTF considered the impact of a fire scenario on two types of exposure: Fire and Business Interruption as well as a split between residential, industrial and commercial business sub-lines would provide a more risk sensitive result, as the risk of fire/explosion differs materially between them.

3.1110 A split according to residential, industrial and commercial provides a more risk sensitive result. For residential risks, the underlying catastrophic scenario is a clash of many individual risks, whereas for industrial risks, the catastrophic scenario can be one single industrial plant suffering a large loss.

3.1111 A split according to Fire (property damage) and Business Interruption would provide a more risk sensitive result. Still, since the CTF expects that most undertakings can not differentiate between TSI for Fire and BI, the decision was taken to consider both sub-lines together.

3.1112 The scenario incorporates both an extreme single as well as a market loss event. The capital charge is estimated as follows:

$$CAT_{FIRE} = \sum^{sub-lines} E_X * F_X$$

$$SCR\_CAT_{FIRE} = Max(LSR, CAT_{FIRE})$$

Where,

E_x = is the sum insured by for residential, commercial and industrial respectively

F_x = are the Fire/BI market wide factors for residential, commercial and industrial respectively

LSR = is the single largest risk across all sub lines

Corr = is the correlation matrix, correlations between residential/commercial/industrial business

3.1113 The factors ***F_x*** were calibrated as follows:

- In a first step, the CTF used internal risk models of re-insurers and modelling companies to identify a ratio between capital needs for Fire and BI vs. European-wide windstorm risk.

- This ratio was applied to the market-wide 1:200 LDR ratio for wind, derived by applying the standard scenario's for wind to a market portfolio. The result of this approach is a factor, independent of residential/commercial/industrial business.

- To have separate factors for R/C/I, assumptions were made on average risk sizes (R=EUR 500'000, C=EUR 5mn, I=EUR 100mn) and typical exposure clusters that would represent a catastrophic scenario. These clusters were assumed as 100 for residential, 10 for commercial and 1 for industrial (i.e. complete destruction of a large industrial complex can be a 1:200y loss).

- Resulting from these considerations are the following factors

  1:200 Loss Damage Ratio

  - Residential 0.004%
  - Commercial 0.010%

- Industrial 0.073%

3.1114 The CTF expects that for smaller undertakings, the capital charge will be largely dominated by the largest single risk.

3.1115 The factors are EU representative, i.e. it is assumed that the impact would not differ materially by location.

3.1116 Limitations of the approach

- As the factors are to be applied to the total sums insured, the method will fail in cases where TSI is an imperfect measure for the exposure (e.g. re-insurance, excess primary insurance).

Motor

3.1117 The CTF has provided below a illustrations of a possible Motor man made scenario:

Motor Scenario 1 – Selby like

Consider a car, which falls off a bridge onto a railway and causes a collision of two trains. Assume 10 fatalities and 80 injured persons as well as a high degree of material damage to the car, the trains and the bridge.

Motor Scenario 2 – Mont Blanc tunnel like

Consider a collision of two trucks in a tunnel of 500 meter length. Both trucks catch fire and cause the quick development of heat and smoke. Assume 40 fatalities, 40 injured persons as well as a high degree of damage to the tunnel and the vehicles. There are also associated Business Interruption losses.

Motor Scenario 3 –Extreme crash

Consider a major collision of a car with a coach killing all passengers on board the coach. Assume coach passengers are Premier League / Bundesliga / Serie A football players travelling to international football match.

3.1118 The CTF do not believe that catastrophic Motor man made scenarios are limited the events described above. Therefore the calibration is not intended to represent any particular one of these.

3.1119 The motor insurance market in Europe is complex with some very specific national differences between countries with some EEA wide common features.

3.1120 Some factors which should be borne in mind are:

- Cross-border nature of motor vehicle transportation.

- Although registered and insured in one country, vehicles may readily travel into other countries. This applies particularly to commercial vehicles.

- Local legal / compensatory / health system
  - There are large differences between bodily injury awards in different countries
  - Different healthcare practices can affect the impact on the insurers.
  - Local policy limits
  - As MTPL is a compulsory insurance, most countries specify a minimum level of cover that policies must provide.
  - These limits can change over time.
  - In particular the 5th Motor Directive (2005/14/EC) introduces a minimum level across Europe and obliged member to states to transition by 2012 to national minima that are compatible with the directive.
  - This will result in significant increases in limits in some countries.
  - In addition, some countries require that insurance cover must be unlimited for some or all types of loss.

- Local market practice
  - Insurance companies often offer cover in excess of the legal minima for marketing or other reasons.

- Green card" exposures.
  - The first motor directive requires that every motor insurance policy issued in the EEA must provide the minimum insurance cover required by law in any other EEA country.
  - This means that in the event of an accident the policy will provide cover up to the higher of (a) the policy limit and (b) the legal minimum. e.g. an Italian insured vehicle with a €2m policy limit will have unlimited cover in the UK for third party bodily injury

- Reinsurance purchase
  - Usually purchased on an unlimited basis where this is offered on original policy

- Where original policies do have a limit, "green card" reinsurance will often be bought to cover these potential unlimited overseas exposures.
- In practice, reinsurance means that the overall net cat charge for MTPL will consist of the retention of the reinsurance programme plus, elsewhere in the standard formula, an allowance for reinsurance credit default risk on the recoveries. This makes that the overall cat risk charge for MTPL is relatively insensitive to values of individual parameters in the calibration.

- Per country scenarios are particularly troublesome here as the mode of loss the types of scenario we are considering is different from most 'normal' MTPL claims and this means that extrapolation/curve fitting is unlikely to produce a harmonized cat risk charge.

3.1121 Unlike natural catastrophes, an extreme motor vehicle accident is likely to hit a single (or at most a very small number of) policies. Hence the *severity* of a given scenario will not depend on how many policies an undertaking issues. Instead, it is the *frequency* of the scenario that will vary by undertaking according to the volume of business written.

3.1122 With all these factors in mind, the CTF decided to try to design as simple top-down formula as possible whilst reflecting the key features of the market. Although it would probably be possible to construct a substantially more complex approach, this would have been at the likely expense of transparency.

3.1123 The calibration is based on a Pan European loss scenario as follows:

GL_{MTPL} Gross Loss of Europe-wide Scenario = €275m

RP_{MTPL} Return Period of Europe-wide Scenario = 20 years

3.1124 The CTF believed that this return period of 20 years should be amenable to some form of subjective real-world judgment when considered against the historic events. In addition, a 1-in-20 year pan European loss should exceed the 1-in-200 year loss for any individual undertaking.

3.1125 The underlying model for these extreme losses is being assumed to be a Poisson / Pareto with vehicle years driving the Poisson frequency and the pan-Europe scenario some pareto parameters. The only other parameter needed is the pareto shape parameter, alpha.

ALPHA Pareto shape parameter = 2

3.1126 The value of this parameter was discussed by the CTF. It was agreed that there is little data on these types of extreme losses to determine with any great accuracy a particular value. The value chosen was based on expert judgement combining the views of the CTF members. It should be noted that, in the absence of policy limits, a selection of the value 2 means that the pan-EEA calculation will give the same results as if the calculation was made at a country level with the country results being aggregated assuming independence between countries.

3.1127 The underlying vehicle base is assumed to be:

$TVY_{COUNTRY}$	Vehicle years for Motor TPL by country

3.1128 There is then a weighting factor used to apportion the likelihood that the base loss scenario is caused by a vehicle insured by each country.

$W_{COUNTRY}$	Europe-wide scenario weight for each country.

3.1129 The weighting factors selected are proportional to the number of vehicles in each country. Other sources of information were discussed by the CTF but it was considered that the approach chosen had the merit of simplicity and transparency.

$$W_{COUNTRY} = TVY_{COUNTRY} / \Sigma_{COUNTRY} (TVY_{COUNTRY})$$

3.1130 In addition, the scenario considers limits of coverage provided by undertakings in different countries. However, allowance must be made for losses caused outside the 'home' country of the insurance. The scenario therefore includes a 'limit failure factor' for each country which represents a proportion of the extreme losses that are considered to occur in such a way that the cover under the original policy is unlimited.

$F_{COUNTRY}$	Proportion of 'limit failure losses' amongst the extreme losses for each country.

3.1131 The suggested value of this parameter is 6% for all countries except Iceland and Malta where 0% was chosen. (Note that this parameter has no effect for countries with unlimited exposures.) This value of the parameter was estimated by comparing the results of this approach against a study performed by the GDV.

3.1132 The Gross Risk Charge "GRC" is then given by the solution to

$$0.005 = F_{MTPL} * \Sigma_{COUNTRY} (F_{COUNTRY} * W_{COUNTRY} * VY_{COUNTRY} / TVY_{COUNTRY}) * (GL_{MTPL} / GRC)^{ALPHA} + F_{MTPL} * \Sigma_{COUNTRY\ (where\ GRC<LIMCOUNTRY)} [((1-F_{COUNTRY}) * W_{COUNTRY} * VY_{COUNTRY} / TVY_{COUNTRY}) * (GL_{MTPL} / GRC)^{ALPHA}]$$

Marine

3.1133 The CTF has provided below a illustration of a possible Marine man made scenarios:

Marine Scenario 1 – Collision

A Collision between a gas/oil tanker and a cruise ship causing 100 deaths and 950 seriously injured people. The cruise ship is operated out of Miami and claims are litigated in the US. The tanker is deemed at fault, is unable to limit liability and has cover with a P&I club for four/fourths liability

Marine Scenario 2 – Loss of major platform/complex

A total loss to all platforms and bridge links of a major complex

3.1134 Undertakings with exposures under MAT, in particular Marine property and liability are exposed to this scenario.

3.1135 Two distinct Marine scenarios are considered in calculating CAT_{Marine} charge, part of $NL\_CAT_{ManMade}$:

$CAT_{Marine1}$ = Major marine collision event, and

$CAT_{Marine2}$ = Loss of major offshore platform/complex

Marine Collision

Description: Collision between a gas / oil tanker and a cruise ship causing 100 deaths and 950 seriously injured persons.

The cruise ship is operated out of Miami and claims are litigated in the US.

The tanker is to blame, is unable to limit liability, and has cover with a P&I club for four fourths collision liability.

Costing Info:

$m	Unit cost	Number	Gross Loss
Death	2	100	200
Injury	3	950	2,850
Oil Pollution	550	1	550
Total			3,600

Notes for undertakings: P&I clubs and their reinsurers should note that this scenario exhausts the Collective Overspill P&I Protection and First Excess layer of the Oil Pollution protection under the Intl Grp reinsurance programme

Hull insurers should consider their largest gross lines in respect of both Tankers and Cruise ships

Marine Reinsurers will need to consider carefully their potential for accumulation under this scenario and document any methodology or assumptions when calculating their gross loss position.

3.1136 The formula to be applied by undertakings in calculating their respective gross exposures is as follows:

$$\text{CAT}_{\text{Marine1}} = \sum SI_{Ht}, SI_{Hc}, SI_{Lt}, SI_{Lo}$$

Where,

SI_{Ht}, SI_{Hc} undertakings maximum gross marine hull exposures to tankers (t) and cruise ships (c)

SI_{Lt}	Undertakings max gross exposure to marine liability, subject to scenario specification, and
SI_{Lo}	Undertakings gross exposure to liability in respect of Oil pollution

Loss of Major Platform/Complex

Description: This scenario contemplates a Piper Alpha type total loss to all platforms and bridge links of a major complex

All coverages in respect of property damage, removal of wreckage, liabilities, loss of production income and capping of well/making well safe

Notes for undertakings: Only consider Marine lines of business in calculating gross and net losses; A&H, Personal Accident & Life catastrophe risk charges are handled separately.

Marine Reinsurers will need to consider carefully their potential for accumulation under this scenario and document any methodology or assumptions when calculating their gross loss position.

3.1137 The formula to be applied by undertakings in calculating their respective gross exposures is as follows:

$$\mathrm{CAT}_{\mathrm{Marine2}} = \sum_i SI_i$$

Where,

SI_i	undertakings gross exposures by subclass *i* (for example: property damage, removal of wreck, loss of production income, making wells safe) to the undertakings largest offshore complex accumulation

3.1138 Undertakings should then net down each CAT_{Marine} scenario for reinsurance per section 3

The $\mathrm{CAT}_{\mathrm{Marine}}$ charge is calculated as:

$$CATMarine = \sqrt{(NetCAT_{Marine1})^2 + (NetCAT_{Marine2})^2}$$

Aviation

3.1139 CEIOPS will provide further advice on this scenario by June 2010.

3.1140 The CTF has provided below a illustration of a possible Aviation man made scenarios:

Aviation Collision

Consider a collision of two fully laden Airbus A380 with European passengers over a dense populated area, e.g. London, Madrid or Paris. Assume 1100 facilities in the airplanes, a total damage of the airplanes as well as 200 facilities on the ground. Furthermore, assume great damages on the ground, i.e. destroyed residential houses, destroyed commercial places and destroyed or damaged industry. Moreover, consider business interruption as well as fire following. At last, consider accident claims.

Space

A single large proton flare affects all synchronous satellites and results in a loss of power by all satellites.

An undetected generic defect in a number of operational satellites causes significant losses. During the time it takes for a generic defect to emerge, many more satellites with the same defect have been launched.

Liability

3.1141 CEIOPS will provide further advice on this scenario by June 2010.

3.1142 The CTF has provided below a illustration of a possible Liability man made scenarios:

Pharmaceuticals and Chemicals – Scenario 1

Consider a major pharmaceutical and chemical company, which produces a high volume of pharmaceuticals. After several year the company realizes that one of its major (widely used) products, e.g. Aspirin, causes significant harmful side effects. Due to this, the company initiates a recall programme. Assume a large number of people have already died as a result of using the product as well as costs associated with for rehabilitation of those sick as a result of use. Furthermore, allow for the costs of the recall programme.

Pharmaceuticals and Chemicals – Scenario 2

Consider a major chemical company, which has a leak in one of their gas pipe lines. Toxic or acid gas leaks from that pipeline and is not immediatley noticed. A gas cloud builds up which causes a large number of fatalities and of serious injuries people. Assume 5.000 dead and 20.000 injured people with serious health problems. This scenario also leads to business interruption losses, damage to surrounding properties and vehicles and motor accidents.

Architecture

Consider a big bridge building project or skyscraper building project in Europe. The architect does not plan the bridge or the building correctly, what leads to a crash of the object. In the moment of the crash the bridge is fully crowded resp. the skyscraper has a degree of capacity utilization of 90%. Assume 200 facilities and 1000 serious injured people with the bridge crash resp. 2.500 facilities and 2.000 serious injured people with the skyscraper crash. Assume as well a complete abridgment of the bridge or the skyscraper and furthermore a rebuilding of the objects.

Serious injured people with the skyscraper crash. Assume as well a complete abridgment of the bridge or the skyscraper and furthermore a rebuilding of the objects.

Credit & Suretyship[104]

3.1143 In light of the credit crisis, due attention was given to concerns regarding pro-cyclicality of financial systems and their regulatory regimes. One particular insurance field on which this concern has focused is credit insurance and surety ship (C&S).[105] For instance, the EFC report to the Council of the European Union states that "credit insurance is, in terms of its risks, substantially similar to the banking business and faces the same pro-cyclical challenges. Credit insurance could therefore also benefit from a dampening mechanism, such as dynamic reserving or provisioning."[106]

3.1144 Credit insurers' operations are cyclical in nature: demand for payments increase as economic growth slows down. From the point of view of the credit insurer, dynamic limit management ensures that risks can be reduced rapidly and efficiently. From a micro-prudential stance, this is an important mechanism, because the risks run by credit insurers can rapidly be reduced. From a macro-prudential viewpoint, this has the consequence that the risks return to the policyholders at the moment that this insurance is needed most. This may mean that parties incur major losses or that some transactions cannot be effected. This is undesirable from a macro-economic viewpoint if the losses lead to bankruptcies or trade grinds to a halt.

3.1145 Therefore, next to micro-prudential risk (insolvency risk vis-à-vis its individual policyholders), as faced by any other insurance business, C&S is also exposed to significant macro-prudential risk: a contraction of credit coverage has domino effects which weaken business activity and the economic system as a whole. This macro consideration necessitates actions to take on board counter-cyclicality.

3.1146 The EFC report noted above refers to a "dampening mechanism" and mentions dynamic provisioning or reserving in this context. However, the Directive text does not foresee in the possibility to create dynamic provisions for solvency purposes. Two other options are then a dynamic reserving requirement or a dampening mechanism in the SCR.

3.1147 CTF feels that the treatment of credit insurance in the calculation of the SCR standard formula could create a more accurate risk assessment than that provided by the mechanisms applied in Solvency I. This could be achieved through a specific catastrophe scenario for C&S. CTF considers

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[104] It should be noted that the Credit and Suretyship scenarios have been developed independently of the CTF and incorporated into this document for completeness. This is because the appropriateness of a *fixed* 99.5% VaR measure, i.e. cycle insensitive, is subject to ongoing discussions at a higher EC level.

[105] For ease of reference, credit insurance and surety ship will be referred to as 'C&S'.

[106] Final Report of the EFC Working Group on Pro-Cyclicality, p18, Brussels, 29 June 2009.

that the approach proposed in this document adequately addresses pro-cyclicality and that it provides an adequate incentive to implement effective forward looking monitoring controls.

3.1148 An advantage of this approach is its natural alignment with the design of the standard calculation of the SCR in Solvency II. Nevertheless, the relevance of this approach depends to a great extent on its design. A simple design of the catastrophe scenario would not present any significant advantage compared to other simple mechanisms. A sufficiently risk sensitive design accompanied with a counter-cyclical calibration of the catastrophe scenario would meet the goals targeted above.

Proposal

3.1149 $SCR_{CAT\_credit\_net}$ shall be calculated as:

$$SCR_{CAT\_credit\_net} = \sqrt{(SCR_{CAT\_individual\_\max\_loss\_net})^2 + (SCR_{CAT\_recesion\_net})^2}$$

3.1150 The $SCR_{CAT\_credit\_net}$ scenario is designed to adequately consider the risk at a gross level and the mitigating effects of proportional and non-proportional reinsurance as well. The $SCR_{CAT\_recession\_net}$ scenario addresses the pro-cyclical nature of the C&S line of business.

3.1151 $SCR_{CAT\_individual\_max\_loss\_net}$ shall be amounted as the maximum loss derived from one of the two following cases:

- The default of the largest three exposures using a PML% of 14% and a recourse rate of 28%. These assumptions are reflecting a loss given default of approximately 10% for the large risks. The largest exposure shall be identified according the sum of the following magnitudes:

  I. + Ultimate gross loss amount after PML and recourse.

  II. - Recovery expected from reinsurance

  III. + Increase of risk associated to reinsurance recovery considered in letter (b), to the extent this increase has not already been considered in counterparty default risk SCR

  IV. +/- any other variation based on existing legal or contractual commitments, which modify the impact of the failure of the exposure on the undertaking (an example might be the reinstatements in respect of existing reinsurance contracts)

  This sum shall identify the amount to compare with the output of paragraph 8.2 in order to derive $SCR_{CAT\_individual\_max\_loss\_net}$.

- The default of the largest three group exposures using a PML% of 14% and a recourse rate of 28%. For the identification of the largest group exposure and the assessment of the losses the undertaking shall apply the methodology described in paragraph 8.1.

3.1152 $SCR_{CAT\_recession\_net}$ = $SCR_{CAT\_recession\_ratio\_net}$ * *Net earned premium* including a dampening mechanism based on the *net loss ratio* of the undertaking.

3.1153 $SCR_{CAT\_recession\_net}$ shall be calculated according the following method and assumptions:

- Exposures shall be classified into homogeneous groups of risks based on the nature of the exposures.

- For each group of exposures the undertaking shall calculate the net loss ratio, $SCR_{CAT\_recession\_ratio\_net}$ and $SCR_{CAT\_recession\_net}$ based on the failure rates, recourse rate and loss given default as described below in (9.3). The percentages refer to the original assured amounts (gross exposures). However the aggregated $SCR_{CAT\_recession\_ratio\_net}$ and $SCR_{CAT\_recession\_net}$ are based on the overall *net loss ratio*.

- With the failure rates the $SCR_{CAT\_recession\_net}$ can be calculated for the current scenario and the worst case scenario:

    a. *Fail_rate_max* = the maximum value observed in the selected index of failures rates in a long period of observation. With the *Fail_rate_max* the worst case scenario can be calculated in case *Fail_rate_current* = *Fail_rate_max.*

    b. *Fail_rate_min* = the minimum 3 years average observed in the same data.

    c. *Fail_rate_current* = the current failure rate.

    d. *Failure rate max(min;current)* = maximum of the *fail_rate_min* and *fail_rate_current.*

    e. *Recourse rate* must correspond with the current scenario and the worst case scenario.

    f. *Loss given default* is the result of the ultimate gross loss amount compared to the gross exposure.

  The above-mentioned rates shall be derived from the failure rates observed and periodically updated (see below the specific item at this respect).

- The dampening mechanism is limited to a $SCR_{CAT\_recession\_ratio\_net}$ of 200% of the net earned premium with a *net loss ratio* lower than 25% and to a $SCR_{CAT\_recession\_ratio\_net}$ of 100% of the net earned premium with a *net loss ratio* higher than 125%. Within the limits the $SCR_{CAT\_recession\_ratio\_net}$ = 225% minus *net loss ratio*. This mechanism aims to ensure that at the peak of the cycle (low *failure* rates), the $SCR_{CAT\_recession\_net}$ shall reach its highest value and C&S undertakings shall be required to have enough own funds to cover a higher SCR. On the other hand, at the trough of the cycle, SCR will be at its lowest value, so that own funds will be released. In other words, as undertakings face harder net claims ratio due to an increase of failure rates, the SCR decreases.

3.1154 A summary of 10 possible scenario´s is included with the following additional assumptions:

- The *fail_rate_max* is 0,50%, the *fail_rate_min* is 0,05% and the current failure rate varies from 0,05% up to 0,50%.

- The retention after reinsurance recovery for $SCR_{CAT\_individual\_max\_loss\_net}$ will be € 10 million per risk (both single and group exposures) and for $SCR_{CAT\_recession\_net}$ 50% based on a 50% Quota Share.

Failure rates

3.1155 One of the main inputs of the model proposed in this paper is the 'failure rates'. CTF prefer the use of undertaking specific 'failure rates'. For the time being this is a point under analysis where industry's views are welcomed.

3.1156 From a legal perspective, it is necessary to ascertain that this way is possible under the umbrella of the standard calculation of the SCR, and these undertaking specific 'failure rates' should meet and be based on methods and information satisfying the requirements developed in the other level 2 advice, such as verifiability, objectivity, consistency, etc. (i.e. see level 2 advice on data quality, statistical standards and methodologies).

3.1157 The alternative is the use of publicly disclosed and updated 'failure rates' provided by official institutions. For example, ECB publishes in its monthly bulletin a set of indexes regarding written-offs and written-downs (example copied from page 122 2009-06 bulletin, link *http://www.ecb.int/pub/mb/html/index.en.html*).

2.7 Revaluation of selected MFI balance sheet items [1), 2)]
(EUR billions)

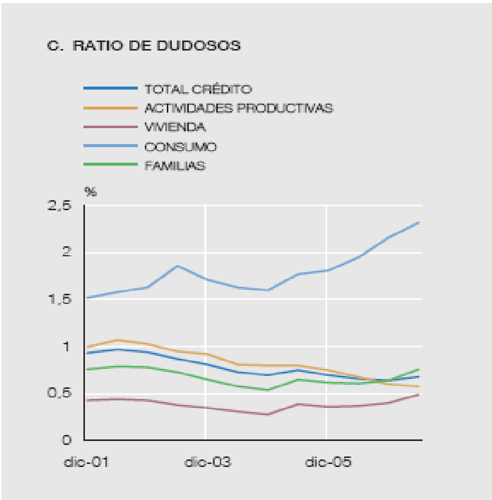
1. Write-offs/write-downs of loans to households [3)]

	Consumer credit				Lending for house purchase				Other lending			
	Total	Up to 1 year	Over 1 year and up to 5 years	Over 5 years	Total	Up to 1 year	Over 1 year and up to 5 years	Over 5 years	Total	Up to 1 year	Over 1 year and up to 5 years	Over 5 years
	1	2	3	4	5	6	7	8	9	10	11	12
2006	-3.9	-1.5	-0.9	-1.6	-2.7	-0.1	-0.1	-2.5	-6.7	-1.1	-2.0	-3.6
2007	-4.2	-1.2	-1.4	-1.6	-2.7	-0.2	-0.2	-2.3	-6.9	-0.8	-2.3	-3.7
2008	-4.5	-1.1	-1.5	-1.9	-2.7	0.0	-0.2	-2.5	-6.7	-1.2	-2.3	-3.2
2008 Q4	-1.5	-0.3	-0.5	-0.7	-0.6	0.0	-0.1	-0.5	-2.1	-0.4	-0.8	-1.0
2009 Q1	-1.7	-0.4	-0.5	-0.8	-1.2	0.0	-0.1	-1.1	-2.1	-0.7	-0.2	-1.3
2009 Jan.	-0.6	-0.2	-0.2	-0.3	-0.6	0.0	0.0	-0.6	-0.9	-0.5	0.0	-0.4
Feb.	-0.5	0.0	-0.2	-0.3	-0.1	0.0	0.0	-0.1	-0.5	-0.1	-0.1	-0.4
Mar.	-0.6	-0.1	-0.2	-0.3	-0.5	0.0	0.0	-0.4	-0.7	-0.1	-0.1	-0.5
Apr. [(p)]	-0.6	0.0	-0.2	-0.3	-0.2	0.0	0.0	-0.2	-0.2	0.0	0.0	-0.2

2. Write-offs/write-downs of loans to non-financial corporations and non-euro area residents

	Non-financial corporations				Non-euro area residents		
	Total	Up to 1 year	Over 1 year and up to 5 years	Over 5 years	Total	Up to 1 year	Over 1 year
	1	2	3	4	5	6	7
2006	-13.2	-3.5	-4.6	-5.1	-0.8	-0.1	-0.7
2007	-12.5	-2.1	-5.4	-4.9	-5.2	-3.4	-1.8
2008	-17.7	-4.0	-9.1	-4.5	-6.6	-3.4	-3.2
2008 Q4	-5.5	-1.2	-2.7	-1.6	-2.9	-0.8	-2.1
2009 Q1	-4.7	-1.9	-1.0	-1.8	-2.6	-1.3	-1.3
2009 Jan.	-1.8	-0.8	-0.4	-0.6	-1.3	-0.9	-0.5
Feb.	-1.4	-0.6	-0.3	-0.4	-0.4	-0.1	-0.3
Mar.	-1.6	-0.5	-0.3	-0.7	-0.9	-0.3	-0.6
Apr. [(p)]	-1.8	-0.7	-0.6	-0.6	0.1	-0.6	0.2

3.1158 Some national central banks also disclosure similar indexes. For example, see Banco de España, page 26, Financial Stability Report)



3.1159 Eurostat also provides numerical information that might be used for this purpose in the following link and paths : http://epp.eurostat.ec.europa.eu/portal/page/portal/living_conditions_and_social_protection/data/database

- Living conditions and welfare / Income and living conditions / Material deprivation/ Economic strain / Arrears (mortgage or rent, utility bills or hire purchase) from 2003 (Source: SILC) (ilc_mdes05)

- Economic strain linked to dwelling (ilc_mded)/ Financial burden of the repayment of debts from hire purchases or loans (Source: SILC) (ilc_mded05)

3.1160 The appropriateness of these indexes to the features of the business of C&S undertakings should be based on supervisory approval.

3.1161 While these public indexes may provide a suitable solution for credit undertakings with a localized business, worldwide credit undertakings would need to ascertain that specific indexes for the most relevant areas of business are used.

Summary results standard formula Credit & Surety - Concept

Assumptions	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**	**Scenario 7**	**Scenario 8**
PML % 200 year	14,00%	14,00%	14,00%	14,00%	14,00%	14,00%	14,00%	14,00
Recourse %	28,00%	27,00%	26,00%	25,00%	24,00%	23,00%	22,00%	21,00
Failure rate max	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50
Failure rate min	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05
Failure rate current	0,05%	0,10%	0,15%	0,20%	0,25%	0,30%	0,35%	0,40
Failure rate max(min;current)	0,05%	0,10%	0,15%	0,20%	0,25%	0,30%	0,35%	0,40
SCR Cat Individual max loss single	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**	**Scenario 7**	**Scenario 8**
Insured loss amount	1.000.000.000	1.000.000.000	1.000.000.000	1.000.000.000	1.000.000.000	1.000.000.000	1.000.000.000	1.000.000.00
PML % 200 year	14,00%	14,00%	14,00%	14,00%	14,00%	14,00%	14,00%	14,00
PML loss amount	140.000.000	140.000.000	140.000.000	140.000.000	140.000.000	140.000.000	140.000.000	140.000.00
Recourse %	28,00%	27,00%	26,00%	25,00%	24,00%	23,00%	22,00%	21,00
Ultimate gross loss amount	100.800.000	102.200.000	103.600.000	105.000.000	106.400.000	107.800.000	109.200.000	110.600.00
LGD 200 year	10,08%	10,22%	10,36%	10,50%	10,64%	10,78%	10,92%	11,06
SCR Cat Individual max loss single - Gross	100.800.000	102.200.000	103.600.000	105.000.000	106.400.000	107.800.000	109.200.000	110.600.00
SCR Cat Individual max loss single - Net	30.000.000	30.000.000	30.000.000	30.000.000	30.000.000	30.000.000	30.000.000	30.000.00
SCR Cat Individual max loss group	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**	**Scenario 7**	**Scenario 8**
Insured loss amount	2.000.000.000	2.000.000.000	2.000.000.000	2.000.000.000	2.000.000.000	2.000.000.000	2.000.000.000	2.000.000.00
PML % 200 year	14,00%	14,00%	14,00%	14,00%	14,00%	14,00%	14,00%	14,00
PML loss amount	280.000.000	280.000.000	280.000.000	280.000.000	280.000.000	280.000.000	280.000.000	280.000.00
Recourse %	28,00%	27,00%	26,00%	25,00%	24,00%	23,00%	22,00%	21,00
Ultimate gross loss amount	201.600.000	204.400.000	207.200.000	210.000.000	212.800.000	215.600.000	218.400.000	221.200.00
LGD 200 year	10,08%	10,22%	10,36%	10,50%	10,64%	10,78%	10,92%	11,06
SCR Cat Individual max loss group - Gross	201.600.000	204.400.000	207.200.000	210.000.000	212.800.000	215.600.000	218.400.000	221.200.00
SCR Cat Individual max loss group - Net	30.000.000	30.000.000	30.000.000	30.000.000	30.000.000	30.000.000	30.000.000	30.000.00
SCR Cat Recession	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**	**Scenario 7**	**Scenario 8**
Exposure	400.000.000.000	400.000.000.000	400.000.000.000	400.000.000.000	400.000.000.000	400.000.000.000	400.000.000.000	400.000.000.00
Failure rate max(min;current)	0,05%	0,10%	0,15%	0,20%	0,25%	0,30%	0,35%	0,40
Failure loss amount	200.000.000	400.000.000	600.000.000	800.000.000	1.000.000.000	1.200.000.000	1.400.000.000	1.600.000.00
Recourse %	28,00%	27,00%	26,00%	25,00%	24,00%	23,00%	22,00%	21,00
Ultimate gross loss amount	144.000.000	292.000.000	444.000.000	600.000.000	760.000.000	924.000.000	1.092.000.000	1.264.000.00
LGD	0,04%	0,07%	0,11%	0,15%	0,19%	0,23%	0,27%	0,32
Gross earned premium	1.000.000.000	1.000.000.000	1.000.000.000	1.000.000.000	1.000.000.000	1.000.000.000	1.000.000.000	1.000.000.00
Ultimate gross loss amount	144.000.000	292.000.000	444.000.000	600.000.000	760.000.000	924.000.000	1.092.000.000	1.264.000.00
Fixed costs	350.000.000	350.000.000	350.000.000	350.000.000	350.000.000	350.000.000	350.000.000	350.000.00
Gross result	506.000.000	358.000.000	206.000.000	50.000.000	-110.000.000	-274.000.000	-442.000.000	-614.000.00
Gross loss ratio	14,40%	29,20%	44,40%	60,00%	76,00%	92,40%	109,20%	126,40
SCR cat recession ratio gross	200,00%	195,80%	180,60%	165,00%	149,00%	132,60%	115,80%	100,00
SCR Cat Recession - Gross	2.000.000.000	1.958.000.000	1.806.000.000	1.650.000.000	1.490.000.000	1.341.500.000	1.194.500.000	1.062.100.00
Net earned premium	500.000.000,00	500.000.000,00	500.000.000,00	500.000.000,00	500.000.000,00	500.000.000,00	500.000.000,00	500.000.000,0
Net loss amount	72.000.000,00	146.000.000,00	222.000.000,00	300.000.000,00	380.000.000,00	462.000.000,00	546.000.000,00	632.000.000,0
Net result	253.000.000,00	179.000.000,00	103.000.000,00	25.000.000,00	-55.000.000,00	-137.000.000,00	-221.000.000,00	-307.000.000,0
Net loss ratio	14,40%	29,20%	44,40%	60,00%	76,00%	92,40%	109,20%	126,40
SCR cat recession ratio net	200,00%	195,80%	180,60%	165,00%	149,00%	132,60%	115,80%	100,00
SCR Cat Recession - Net	1.000.000.000	979.000.000	903.000.000	825.000.000	745.000.000	663.000.000	579.000.000	500.000.00
SCR Cat Credit & Surety - Gross	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**	**Scenario 7**	**Scenario 8**
SCR Cat Individual maximum loss - Gross	201.600.000	204.400.000	207.200.000	210.000.000	212.800.000	215.600.000	218.400.000	221.200.00
SCR Cat Recession - Gross	2.000.000.000	1.958.000.000	1.806.000.000	1.650.000.000	1.490.000.000	1.341.500.000	1.194.500.000	1.062.100.00
SCR Cat Credit & Surety - Gross	2.010.134.961	1.968.639.977	1.817.847.034	1.663.309.953	1.505.119.211	1.358.714.690	1.214.301.779	1.084.889.78
SCR Cat Credit & Surety - Net	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**	**Scenario 7**	**Scenario 8**
SCR Cat Individual maximum loss - Net	30.000.000	30.000.000	30.000.000	30.000.000	30.000.000	30.000.000	30.000.000	30.000.00
SCR Cat Recession - Net	1.000.000.000	979.000.000	903.000.000	825.000.000	745.000.000	663.000.000	579.000.000	500.000.00
SCR Cat Credit & Surety - Net	1.000.449.899	979.459.545	903.498.201	825.545.274	745.603.782	663.678.386	579.776.681	500.899.19

Terrorism

3.1162 CEIOPS will provide final advice on this scenario by June 2010.

3.1163 However initial thoughts would be to apply the same approach as that adopted in the Concentration Scenario in the Health section.

3.1164 The total capital charge is estimated as follows:

$$CAT_{TERR} = P * x_P$$

Where

CAT_{TERR} = is the capital charge for the terrorism scenario.

P = Sum insured of largest concentration of exposures under the fire and other damage line of business in a 500m radius.

X_P= proportion of damage caused by scenario

3.1165 Undertakings should define P based on their largest known concentration of sum insured exposures that fall under the fire and other damage line of business, in a 500m radius. The concentration may cover densely populated office blocks as found in financial hubs.

Appendix

1.List of countries that are materially affected by perils

Country	**Windstorm**	**Earthquake**	**Flood**	**Hail**
AT	complete	june	complete	june
BE	complete	june	complete	june
BG	**n/a**	complete	**n/a**	**n/a**
CR	n/a	complete	n/a	**n/a**
CY	**n/a**	complete	**n/a**	**n/a**
CZ	june	**n/a**	complete	**n/a**
CH	complete	june	**n/a**	june
DK	complete	**n/a**	**n/a**	**n/a**
EE	**n/a**	**n/a**	**n/a**	**n/a**
FI	**n/a**	**n/a**	**n/a**	**n/a**
FR	complete	june	june	june
DE	complete	june	complete	june
HE	**n/a**	june	**n/a**	**n/a**

HU	complete	complete	june	n/a
IS	june	n/a	n/a	n/a
IE	complete	n/a	n/a	n/a
IT	n/a	june	june	june
LV	n/a	n/a	n/a	n/a
LT	n/a	n/a	n/a	n/a
LU	complete	n/a	n/a	june
MT	n/a	n/a	n/a	n/a
NL	complete	n/a	n/a	june
NO	complete	n/a	n/a	n/a
PO	june	n/a	june	n/a
PT	n/a	complete	n/a	n/a
RO	n/a	complete	june	n/a
SK	june	complete	complete	n/a
SI	n/a	complete	june	n/a
ES	n/a	n/a	n/a	n/a
SE	complete	n/a	n/a	n/a
UK	complete	n/a	complete	n/a

3.1166 In table above

- "N/a" means that the CTF believes that this peril is not material for this particular country when compared to other perils.
- "Complete" means that the CTF has provided a complete scenario for this particular peril and country
- "June" means that the CTF will finalise this scenario for June. However please note that the CTF has already started to work on this scenario and some information is already included in this document.

2. List of 1 in 200 gross loss damage ratios by member state

Country	Windstorm	Earthquake	Flood
AT	0.08%	0.10%	0.15%
BE	0.16%	0.02%	0.10%
BG		1.60%	0.15%
CR		1.60%	
CY		2.35%	
CZ	0.03%	0.10%	0.40%
CH	0.08%	0.25%	0.15%
DK	0.25%		
EE			
FI			
FR	0.12%	0.06%	0.10%
DE	0.09%	0.10%	0.20%
HE			
HU	0.02%	0.20%	0.40%
IS	0.03%		
IE	0.20%		
IT		0.80%	0.10%
LV			
LT			
LU	0.10%		
MT			
NL	0.18%		
NO	0.08%		
PO	0.04%		0.30%
PT		1.20%	
RO		1.70%	0.40%
SK		0.2%/0.1%	0.45%
SI		1.00%	0.30%
ES	0.03%		
SE	0.09%		
UK	0.17%		0.10%

3. List of CRESTA relativity factors by country and peril for Nat cat scenarios

3.1167 Due to the size of the tables this information has been included as a excel file:

CEIOPS CRESTA Relativities Info - AGGrc Fzone v3.xls

Factor method[107]

3.1168 In line with the advice presented in CEIOPS-DOC-41/09 and CEIOPS-DOC-71/09, CEIOPS needs to provide undertakings with a set of factors

[107] This section follows CEIOPS-DOC-67/10

per event to estimate a capital charge for the standard formula catastrophe risk sub module. This is called the “Factor Method”.

3.1169 CEIOPS has revised the calibration provided during QIS4.

3.1170 A factor is required for the following events:

Events	Lines of business affected
Storm	Fire and property; Motor, other classes
Flood	Fire and property; Motor, other classes
Earthquake	Fire and property; Motor, other classes
Hail	Fire and property; Motor, other classes
Mayor fires, explosions	Fire and property
Major MAT disaster	MAT
Major motor vehicle liability disasters	Motor vehicle liability
Major third party liability disaster	Third party liability
Miscellaneous	Miscellaneous
NPL Property	NPL Property
NPL MAT	NPL MAT
NPL Casualty	NPL Casualty
Major claim	Credit and Suretyship

3.1171 Estimating a factor by event across all EU countries and for valid all undertakings has resulted in a very difficult task:

- Lack of data. CEIOPS required 1 in 200 year loss equivalents by lob. Only data from a limited number of markets was available.
- Due to the nature of catastrophe business it is extremely difficult to come up with a single factor that represents a 1 in 200 year loss for all undertakings, across all countries in the EU and by LoB.
- The risk profile of undertakings is very different across countries and within a LoB.
- Some countries provide pooling arrangements to cover catastrophe risk. This was not taken into account in selecting the final factor.

- Different countries and undertakings cover different risks and therefore have different risk profiles. We have not been able to select a factor taking this into account.

3.1172 For some of these reasons listed above, the factor method has been characterised for its lack of risk sensitivity if compared to other methods such as Standardised scenario or a Partial internal model.

3.1173 More importantly, the factor method is unlikely to represent a 1 in 200 year loss for every undertaking, as required by the Level 1 text.

3.1174 However, CEIOPS considers that a factor is necessary under the standard formula, in particular when a standardised scenario is not appropriate and when the use of a Partial internal model is not proportionate. Examples when a factor could be used are:

- When the risk profile of the undertaking is not well represented by the standardised scenario.
- The undertaking writes Miscellaneous Catastrophe business.
- The undertaking writes material Non proportional reinsurance
- The undertaking writes material business outside the EEA

3.1175 CEIOPS acknowledges that possible further analysis could be performed to further improve such method. For example we could provide factor at country or regional level rather than one factor for all EU. However this would require further work and liaising with the industry to get the necessary data.

3.1176 CEIOPS would like to highlight that this is an area where both the undertaking and supervisor will need to assess whether indeed the capital estimated is sufficient to cover a 1 in 200 year loss and that possible supervisory measures may need to be applied.

3.1177 Compared to QIS4, CEIOPS has tried to improve the calibration of the factor method by introducing the following changes:

- The factor has been calibrated gross of reinsurance. This allows undertakings to apply their respective reinsurance programme in order to estimate the net amount.
- The factor has been calibrated by peril for the property line of business, in order to introduce further segmentation at a LoB level.

3.1178 CEIOPS carried out two main analysis and used some external benchmarking information obtained through consultation.

Analysis 1

3.1179 This analysis was the result of a CEIOPS exercise.

Methodology

3.1180 The analysis was performed by the FSA using data based on firms regulated in the UK.

3.1181 We collated empirical loss ratio distributions for the respective LoBs for various firms.

3.1182 The LoB for which we had most data was Property, where we had many different undertaking distributions. The data was increasingly scanty for other classes of business.

3.1183 We were provided with empirical distributions consisting of approximately 5-6 points. LogNormal distributions were fitted using the 75th and 99.5th percentiles. If the fit was not reasonable then the data was discarded.

3.1184 If the fit was reasonable, we generated an aggregate distribution by simulating correlated samples from each of the distributions using a Normal (Gaussian) copula. The same correlation coefficient was chosen across all data sets.

3.1185 After 25,000 simulations we deducted the mean from the 99.5th percentile (except in the case where the data was purely cat related) to remove attritional claims.

Analysis 2

3.1186 It involved the calibration of the factor-based non-life CAT sub-module based on German data.

Results

LoB	**Gross loss in % of gross premium**	**Risks covered**
Fire and property (storm)	250%	Storm and hail
Fire and property (earthquake)	155%	Earthquake
Fire and property (flood)	140%	Flooding rivers

Fire and property (fire)	215%[108]	Fire and explosion
Motor, other classes	30%	Hail, flood, storm, lightning
Motor vehicle liability	25%	Large single accident
Third party liability	80%	Large single liability claim
MAT	95%	Large single MAT claim

Methodology natural catastrophes

3.1187 The factors are derived from the CAT models that were used for German exposure in QIS4. The models were developed by a GDV working group in cooperation with BaFin and are based on data from reinsurers and claims data collected by GDV.

3.1188 The models produce average gross claims as follows:

- property/storm: 1.15‰ of sum insured
- property/earthquake: 0.93 ‰ of sum insured
- property/flood: 0.84‰ of sum insured
- other motor: 65 euro per risk

3.1189 We think that for the German market the risk-sensitivity of the approach for the natural catastrophes in property insurance can be improved by applying the volume measure 'sum insured' instead of 'premiums'.

3.1190 The model takes into account a discount for basis claims. (The discount amounts to the average annual claims relating to the risk modelled.) If such a discount is not allowed, the factors need to be increased.

Methodology man-made catastrophes

3.1191 The factors were derived from CAT models for severity risks which were developed by a GDV working group in cooperation with BaFin. The models were calibrated on claims data collected by GDV.

3.1192 For each risk, the model follows a generalised Pareto distribution as follows:

[108] This value is still under discussion with our industry. The overall range of the value is confirmed though.

$$\text{gross claim} = u + (M - u) \cdot \frac{\left(\frac{200 \cdot c}{t}\right)^{1/a} - 1}{\left(\frac{200}{t}\right)^{1/a} - 1},$$

where

M one in 200 year market loss

u threshold claim size

c market share of undertaking

t recurrence period (corresponding to threshold claim size)

a Pareto exponent

3.1193 Depending on the risk, the parameters are chosen as follows:

LoB	u	t	a	M
MTPL	5 million	0.18	2.9	70 million
TPL	2.5 million	0.12	2.1	500 million
MAT	2.5 million	0.14	2.6	50 million
Household	1.25 million	0.22	3.1	20 million
Fire	20 million	0.12	4.8	500 million

3.1194 The gross claim depends (in a non-linear way) on the market share of the undertaking. For the derivation of the risk factors a medium size market share (depending on the LoB) was chosen.

External benchmarks

3.1195 We have worked closely with some major market participants (a large broker, catastrophe modelling agency, other industry data) and have compared our results to the information provided by them.

3.1196 The information provided by the catastrophe modelling agency and the major broker focussed on the property line of business. Where they were able to provide more detailed results, down to peril and region.

3.1197 They applied their models to their best estimates of industry insured exposures to generate industry insured losses. This was done for each territory and peril where an appropriate model was available.

3.1198 Where a particular territory was not covered by a model, the territory was judgementally classified by its main peril and assigned a rating (High, Medium or Low) depending on the estimated level of risk that territory posed. The closest match was then used from territories where models do exist as proxies for the non-modelled territories.

3.1199 The output from the modelling exercise was a list of simulated events which could be used to calculate a 1 in 200 year loss estimate.

3.1200 These 1 in 200 losses estimates were then compared with industry premium amounts to produce loss ratios.

Results

3.1201 A summary of the results carried out by CEIOPS:

	Net	Gross				
	QIS4	UK	Germany	Netherlands	Benchmarking	
Property	75%	150%		130%	95%	
Property - Windstorm			250%		100%	
Property - Earthquake			155%		85%	
Property - Flood			140%		85%	
Property – Fire			215%			
Credit & Surety ship	60%	150%				145%
MAT	50%	100%	95%			104%
Third Party Liability	15%	85%	80%			91%
Miscellaneous	25%	35%				39%
Motor, other classes	8%	30%	30%			
Motor vehicle liability	15%	50%	25%			219%
Non Proportional - Casualty	50%	85%				
Non Proportional - MAT	150%	150%				
Non Proportional - Property	150%	150%				

3.1202 CEIOPS proposes the following factors for the Factor method:

Events	Lines of business affected	Factor
Storm	Fire and property; Motor, other classes	**175%**

Flood	Fire and property; Motor, other classes	**113%**
Earthquake	Fire and property; Motor, other classes	**120%**
Hail	Motor, other classes	**30%**
Major fires, explosions	Fire and property	**175%**
Major MAT disaster	MAT	**100%**
Major motor vehicle liability disasters	Motor vehicle liability	**40%**
Major third party liability disaster	Third party liability	**85%**
Miscellaneous	Miscellaneous	**40%**
NPL Property	NPL Property	**250%**
NPL MAT	NPL MAT	**250%**
NPL Casualty	NPL Casualty	**250%**
Major claim	Credit and suretyship	**150%**

3.6 Operational risk[109]

3.1203 The design of the Operational risk module requires the calibration of the following factors:

P_{life_f}

P_{nl_f},

TP_{life_f}

TP_{nl_f}

UL_f

3.1204 The calibration of the Operational risk factors has resulted in a particular challenging task mainly due to the lack of information available.

3.1205 In producing a revised standard formula charge CEIOPS has aimed at setting the operational risk charge at a level of 99.5% VaR as required by the Level 1 text.

[109] This section follows CEIOPS-DOC-45/09

3.1206 As there is no explicit way of measuring operational risk at the tail of the distribution, CEIOPS has used the responses from the internal model operational risk charges as a benchmark for where firms believe their 99.5% VaR for operational risk lies.

3.1207 Factors should be chosen so that the standard formula operational risk charge is broadly in line with the undiversified operational risk from a firm's internal model. This is because it is CEIOPS interpretation that the level 1 text does not allow for diversification within the standard formula.

3.1208 The CEIOPS QIS4 report also states that "Only 25% of respondents believed that the data used in their internal model for operational risk is sufficiently accurate, complete and appropriate. Operational risk data used is collected annually and is entity specific". Where there is insufficient data to estimate the capital charge accurately, it is possible that many undertakings may underestimate the risk in their models, especially given that the QIS4 results were not subject to regulatory challenge.

3.1209 CEIOPS has carried out several analysis as well as refered to external information for validation and benchmarking purposes:

Analysis 1

3.1210 Was based on 5 EU countries and 32 entities in total, including both data on the pre-diversification and post-diversification charges. The sample of undertakings providing post-diversification charges was different than the sample providing pre-diversification charges.

3.1211 Post-diversification data were disregarded since, unexpectedly, they resulted in higher capital charges than pre-diversification data, making evident that the sample of undertakings providing post-diversification data was biased in respect of the sample of undertakings informing pre-diversification data.

3.1212 The following data is presented:

- Internal models operational pre-diversification charge in relation to non-life technical provisions (Table 1 below).
- Internal models operational pre-diversification charge in relation to non-life earned premiums (Table 2 below).
- Internal models operational pre-diversification charge in relation to life technical provisions excluding unit-linked business (Table 3 below).
- Internal models operational pre-diversification charge in relation to life earned premiums excluding unit-linked business (Table 4 below).

3.1213 The following analysis was carried out:

- Production of summary statistics for each of the data subsets above.
- A charge was selected based on the 50 percentile of the pre-diversification charge of the internal models.

Table 1		
mean		5,19%
standard deviation		5,62%
Pearson coefficient		108,29%
Percentiles	10	1,24%
	20	2,27%
	30	2,79%
	40	2,98%
	50	**3,55%**
	60	4,31%
	70	4,98%
	80	5,94%
	90	9,86%
	100	29,02%

Table 2		
mean		4,34%
standard deviation		3,01%
Pearson coefficient		69,41%
Percentiles	10	1,08%
	20	2,25%
	30	2,83%
	40	3,33%
	50	**3,80%**

	60	4,10%
	70	4,89%
	80	5,37%
	90	7,91%
	100	13,41%

Table 3		
mean		1,01%
standard deviation		1,26%
percentile	10	0,13%
	20	0,17%
	30	0,30%
	40	0,49%
	50	**0,59%**
	60	0,89%
	70	1,09%
	80	1,57%
	90	1,84%
	100	6,43%
Pearson coefficient		124,18%

Table 4		
mean		11.17%
standard deviation		15.29%
percentile	10	1.64%
	20	2.22%
	30	3.01%

	40	4.21%
	50	**5.44%**
	60	7.51%
	70	9.68%
	80	14.84%
	90	27.97%
	100	75.60%
Pearson coefficient		136.90%

3.1214 The overall conclusion of this analysis is that operational risk in the QIS4 standard formula was under-calibrated.

3.1215 The revised factors rounded to the first decimal are presented below:

	New Factors	**QIS4 Factors**
TP – life	0.6%	0.30%
TP - non-life	3.6%	2.00%
Prem - life	5.5%	3.00%
Prem - non-life	3.8%	2.00%

3.1216 For unit-linked business, CEIOPS has assumed that the characteristics are similar to those of other life products. Therefore the QIS4 parameter will evolve in line with the life parameter.

Analysis 2

3.1217 CEIOPS considered: If we assume that the allowance for diversification credit between operational risk and other risks in models may be around 50%, then the size of the diversified component for operational risk would be around one half of the size of the undiversified component. This undiversified component should in principle meet the 99.5% VaR criterion. Thus a proxy could be to simply double the parameters for operational risk in the standard approach SCR for life and non-life undertakings.

3.1218 Based on the CRO Forum results, this would then seem to make the operational risk charge in the standard formula, on average, closer to the operational risk charge produced from an undiversified internal model, and hence to meet a 99.5% VaR criterion.

	New Factors	**QIS4 Factors**
TP – life	0.6%	0.3%
TP - non-life	4.0%	2.0%
Prem - life	6.0%	3.0%
Prem - non-life	4.0%	2.0%
UL factor	50%	25%

CRO Forum Study

3.1219 The analysis from the Chief Risk Officers (CRO) Forum QIS4 benchmarking study dated 30 October 2008[110] shows diversified internal model operational risk results to be a similar percentage of total capital required as the standard formula operational risk results.

3.1220 As noted by the study, the QIS4 requirements for operational risk in the standard approach are significantly lower than the pre-diversification allowance in internal models. In contrast to many internal models, though, the standard approach does not allow for diversification between the operational risk capital requirements and the remaining capital requirements. The net result is that the parameters in the QIS4 standard formula are broadly equivalent to those set by firms for their internal model operational risk charge after applying their diversification assumptions (with the exception of health business).

3.1221 The CRO Forum results have not been subject to supervisory challenge so the firms in the analysis could have allowed for too much diversification rather than too little. It is not yet clear how much diversification benefit will be allowed for internal models. In line with the banking experience, internal model numbers may increase due to supervisory challenge. In addition, to encourage internal model development and to address the issue of the standard formula not providing incentives to manage operational risk, the undiversified standard formula charge should be higher than the diversified internal model charge and not the same.

[110] http://www.croforum.org/publications.ecp

3.1222 The CRO Forum results support the view that the standard formula operational risk parameters have not been set high enough to meet a 99.5% VaR criterion for most undertakings.

ABI Study – Calibration

3.1223 The ABI has also shared with CEIOPS an analysis based on a small sample of firms.

3.1224 The ABI asked their members to provide the information such as:

- QIS4 Operational Risk Capital Requirement
- ICA Capital Charge for Operational Risk – Diversified
- ICA Capital Charge for Operational Risk – Undiversified
- Gross Premiums - Gross premiums written per financial statements (this is the best indicator of actual activity). It excludes taxes but includes brokerage and commission. Earned premiums reflect prior years so not appropriate. Net premiums could be unduly low where there is a high proportion of reinsurance.
- Technical Provisions - Gross insured liabilities (claims plus IBNR) before reinsurance but excluding provisions for unearned premiums - per financial statements.
- Net Income – Net premiums.
- Total Expenses - All administrative expenses excluding costs associated with sales/acquisitions (e.g. brokerage), and excluding reinsurance costs. It should include exception and non-operating costs as these are an indicator of the operational risks faced by firms. This number can be extracted from financial statements.
- Total Insured Value - For property lines - sum of policy limits net of reinsurance; for liability lines - sum of exposures (net of reinsurance) based on single claim per policy. (For many PI lines, exposure is potentially unlimited as there are no limits to the number of claims.)
- No of Employees (FTE) - FTE - Per financial statements (i.e. excludes contractors and outsourcers)

3.1225 Data was received from 7 life and 6 non-life firms.

3.1226 The data provided by firms was then turned into ratios firstly to check whether the standard formula for operational risk gave results that were in line with the current parameters.

3.1227 By looking at the Table below, it is clear that further calibration of the current formula is required. The ratios of QIS4/ Gross Premium and QIS4/ Technical provisions should be close to the current standard formula parameters. Even a sample size this small shows a divergence from these figures of 0.03 and 0.003 respectively for gross premiums (or earnings) and technical provisions for life firms and 0.02 and 0.02 respectively for gross premiums (or earnings) and technical provisions for non-life firms.

3.1228 The differences between the diversified and undiversified ICA figures demonstrate that diversification is key to many firms for operational risk. However, the standard formula is supposed to be the undiversified operational risk figure according to the Solvency II Level 1 text.

3.1229 The undiversified ICA figures demonstrate that the life parameters should be 0.0322 for gross premiums and 0.0051 for technical provisions for life firms. In terms of non-life companies, the parameter for gross premiums is 0.0458 while that for technical provisions is 0.0349. It should be noted that this is a small sample, so is indicative only.

3.1230 Table 1. OP risk analysis results – ABI

LIFE									
Analysis	**QIS4/Gross Premium**	**ICA - diversified/ Gross Premium**	**ICA - undiversified/ Gross Premium**	**QIS4/ Technical Reserves**	**ICA - diversified/ Technical Reserves**	**ICA - undiversified/ Technical Reserves**	**QIS4/Net Income**	**ICA - diversified/ Net Income**	**ICA - undiversified/ N Income**
Average	1.938%	2.140%	3.220%	0.356%	0.190%	0.511%	26.157%	23.449%	22.890
Min	0.071%	0.071%	0.071%	0.021%	0.000%	0.021%	0.818%	1.289%	2.596
Max	5.039%	5.282%	9.184%	1.242%	0.343%	0.944%	123.143%	80.815%	80.815
Median	1.663%	1.269%	2.567%	0.175%	0.249%	0.549%	7.033%	15.714%	11.363
75th percentile	0.026348	0.033068	0.031868	0.003197	0.002712	0.007194	0.15433	0.18	0.2499

NON-LIFE									
Analysis	**QIS4/Gross Premium**	**ICA - diversified/ Gross Premium**	**ICA - undiversified/ Gross Premium**	**QIS4/ Technical Reserves**	**ICA - diversified/ Technical Reserves**	**ICA - undiversified/ Technical Reserves**	**QIS4/Net Income**	**ICA - diversified/ Net Income**	**ICA - undiversified/ N Income**
Average	2.935%	2.881%	4.577%	2.675%	2.572%	3.487%	14.851%	15.700%	14.505
Min	2.001%	0.643%	2.614%	1.934%	0.459%	1.367%	3.056%	0.725%	3.487
Max	4.661%	6.161%	8.807%	4.004%	5.254%	5.254%	38.514%	27.978%	27.027
Median	2.603%	2.356%	4.054%	2.281%	2.567%	3.860%	5.517%	17.048%	13.000
75th percentile	3.471%	3.645%	4.319%	3.330%	3.262%	4.748%	26.224%	25.745%	20.014

3.1231 The ABI also considered other variables that could be used to model operational risk. However in terms of the Directive text for Solvency II it is explicitly stated that earning (or gross premiums) and technical provisions should be used. Nevertheless for information we provide a summary of their conclusions:

- The results for Net Income and Employees were treated differently by member firms so any analysis of these figures would not be meaningful.

- In the case of Employees, firms were not unanimous in their views as to the treatment of outsourcing since the firm is still responsible for outsourcing contracts, but it is difficult to find the exact numbers of outsourced staff.

- The variable Total Insured Value also caused much confusion. Although some firms were eager to collect this data, other firms, both life and non-life either felt this was not relevant to their business or were not able to provide this information. The low amount of data provided meant that for non-life firms, no meaningful analysis of the data was possible.

- Total Expenses was probably the most successful variable of the data collected and this may be useful in other analyses of operational risk. This could be a parameter that is used together with gross premiums and technical provisions in business areas other than just unit-linked ones. It may not be particularly useful on its own, but combined with other measures, it may refine the risk sensitivity of the standard operational risk measure. On the other hand, it may be more complicated and so be a better measure for an internal model for operational risk as it reflects a way of measuring the cost of replacing business processes that are currently in place.

- Other methods of valuing operational risk including using past loss data, such as that collected in the ORIC database, are also very useful both to compare with ICA and QIS4 figures and in their own right for use in internal models. ORIC will also be doing work on this area in the future.

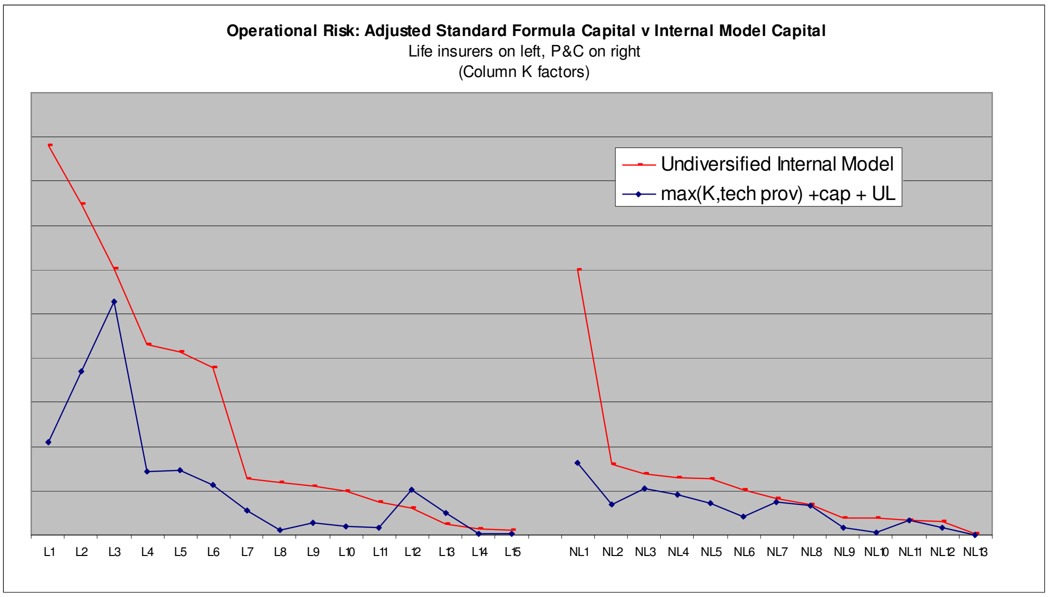
FSA UK Analysis

3.1232 The UK FSA carried out a small analysis based on internal ICA data: 15 life firms and 13 non life firms.

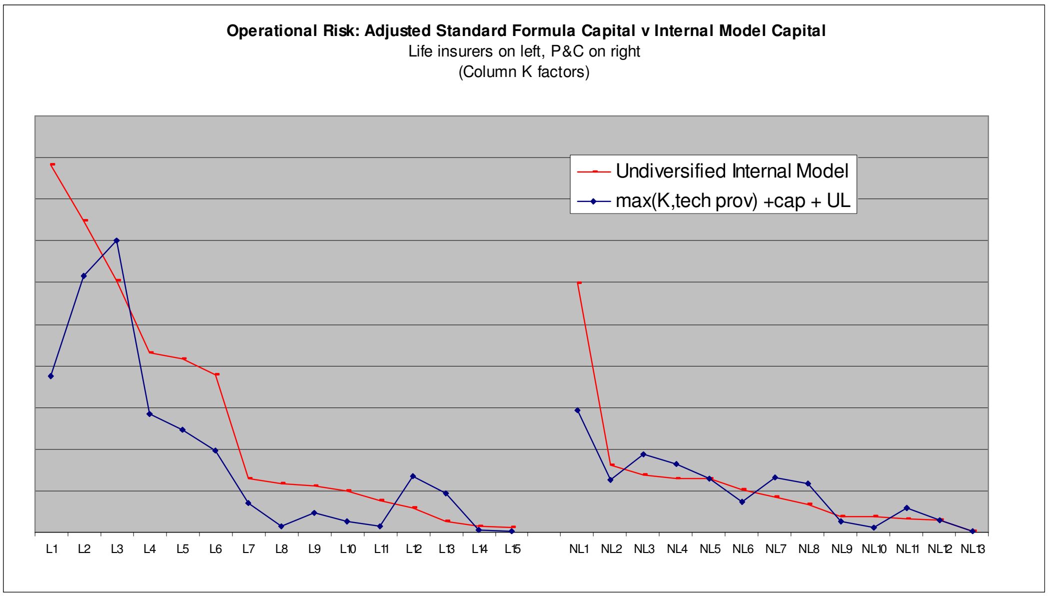
3.1233 The FSA compared the adequacy of the range of factors from the different analysis and proposals and illustrated the results on graphs as presented below.

Parameters	QIS 4	FSA	FSA1	FSA2	FSA3	Analysis 1	ABI
TP - life	0.3%	0.60%	1.25%	1.25%	1.10%	0.60%	0.51%
TP - non-life	2.0%	4.00%	2.00%	2.00%	4.00%	3.60%	3.49%
TP - health	0.2%	0.40%	0.20%	0.20%	0.20%		
Prem - life	3.0%	6.00%	8.00%	8.00%	8.00%	5.50%	3.22%
Prem - non-life	2.0%	4.00%	6.00%	6.00%	5.00%	3.80%	4.58%
Prem - health	2.0%	4.00%	2.00%	2.00%	2.00%		
L BSCR cap	30.0%	30.00%	60.00%	20.00%	20.00%	30.00%	30.00%
NL BSCR cap	30.0%	30.00%	60.00%	20.00%	20.00%	30.00%	30.00%
UL factor	25.0%	25.00%	50.00%	25.00%	25.00%	25.00%	25.00%

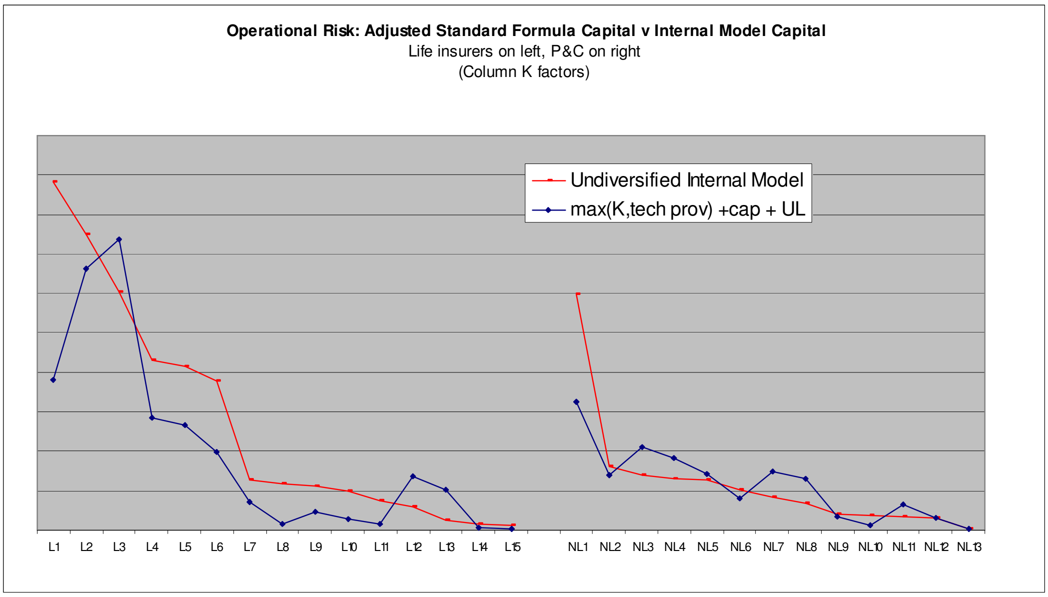
Graph 1. QIS 4 vs Internal Model



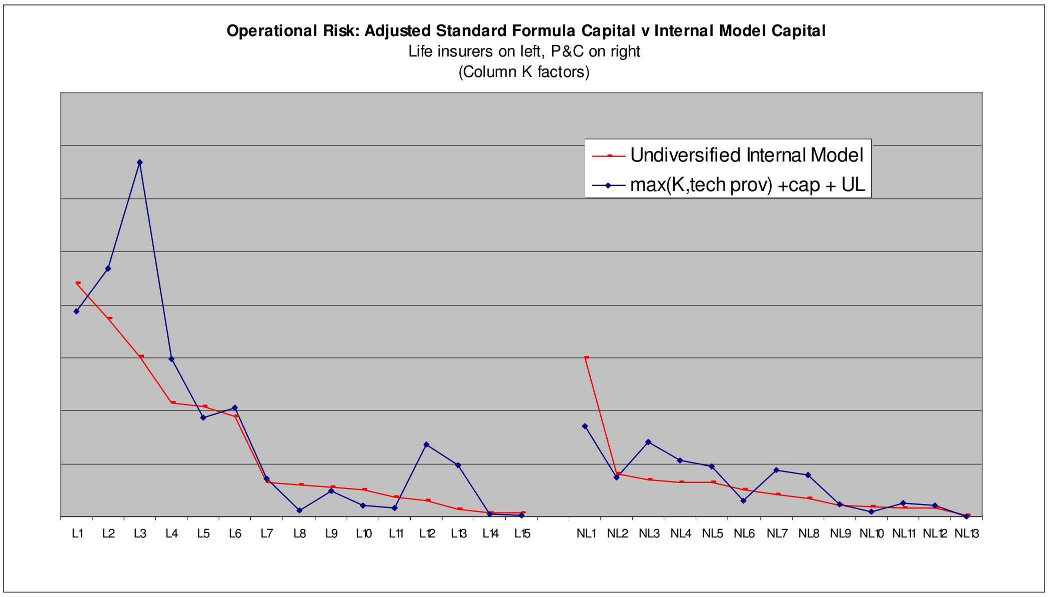
Graph 2. Analysis 1 vs Internal Model



Graph 3. FSA vs Internal Model



Graph 4. FSA 1 vs Internal Model



3.1234 The results of the analysis show clearly that the QIS 4 factors are too low.

Results

3.1235 After considering the above analysis and reports, CEIOPS recommends the final factors to be as follows:

	New Factors	**QIS4 Factors**
TP – life	0.6%	0.3%

TP - non-life	3.6%	2.0%
Prem - life	5.5%	3.0%
Prem - non-life	3.8%	2.0%
UL factor	25%	25%
BSCR cap –life	30%	30%
BSCR cap non-life	30%	30%

3.1236 Irrespective of the source, the calibration has shown that the QIS 4 factors were too low.

3.1237 CEIOPS has selected the final factors from Analysis 1. The underlying reason behind the choice is that this is based on a larger sample of data. It is important to note that the results are not far different from those produced by other analysis or reports.

3.7 Correlations [111]

Background

3.1238 The SCR standard formula as defined in the Level 1 text follows a modular approach. The overall risk which the insurance or reinsurance undertaking is exposed to is divided into sub-risks. For each sub-risk a capital requirement $SCR_{sub\text{-}risk}$ is determined. The capital requirements on sub-risk level are aggregated in order to derive the capital requirement for the overall risk.

3.1239 A simple technique to aggregate capital requirements is the use of correlation matrices. The capital requirement for the overall risk is calculated as follows:

$$SCR_{overall} = \sqrt{\sum_{i,j} Corr_{i,j} \cdot SCR_i \cdot SCR_j}$$

where i and j run over all sub-risks and $Corr_{i,,j}$ denotes the entries of the correlation matrix, i.e. the correlation parameters.

3.1240 According to Articles 104(1) and 105 of the Level 1 text, the aggregation of the capital requirements for the sub-risks of at least the following parts of the standard formula are done by means of correlation matrices:

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[111] This section follows CEIOPS-DOC-70/10

- the Basic SCR,
- the capital requirement for non-life underwriting risk,
- the capital requirement for life underwriting risk, and
- the capital requirement for market risk.

3.1241 Moreover, the Level 1 text does not specify the aggregation method for certain other parts of the standard formula, for example for the health underwriting module or regarding any further subdivision of sub-modules for the above mentioned modules. Correlation matrices could also be used for these aggregation tasks.

3.1242 The selection of the correlation parameters has a significant influence on the result of the SCR calculation. For example, if five capital requirements of equal size are aggregated, the result is 55% lower if the correlation parameter 0 instead of the parameter 1 is used to describe the relation between each pair of risks. Hence, the choice of correlation parameters has an impact on the level of diversification to be obtained within the SCR standard formula.

3.1243 Having regard to the complexity and materiality of setting correlation parameters in the standard formula, CEIOPS will continue to explore this issue in its future technical work.

Mathematical analysis of the aggregation technique

3.1244 In the mathematical science, correlation matrices are used to aggregate standard deviations of probability distributions or random variables. In this case, the entries of the matrix are defined as linear correlation coefficients, i.e. for two random variables X and Y, the entry is

$$\rho = \frac{Cov(X,Y)}{\sqrt{Var(X)Var(Y)}}.$$

3.1245 The capital requirements that are aggregated in the standard formula are, from a mathematical point of view, not standard deviations but quantiles of probability distributions.[112] However, this does not imply that it is an abuse of the concept of correlation matrices to apply it in the context of the standard formula. This is because it can be shown that for multivariate normal distributions (or more general: for elliptic

[112] The only exception to this rule are the correlation coefficients applied within the premium and reserve risk sub-module of the standard formula, to which the considerations set out in this sub-section are not intended to apply.

distributions), the aggregation with correlation matrices produces a correct aggregate of quantiles.[113]

3.1246 On the other hand, only for a restricted class of distributions the aggregation with linear correlation coefficients produces the correct result. In the mathematical literature a number of examples can be found where linear correlations in themselves are insufficient to fully reflect the dependence between distributions and where the use of linear correlations could lead to incorrect aggregation results, i.e. to either an under- or an over-estimation of the capital requirements at the aggregated level.114

3.1247 Two main reasons can be identified for this aggregation problem:

- The dependence between the distributions is not linear; for example there are tail dependencies.

- The shape of the marginal distributions is significantly different from the normal distribution; for example the distributions are skewed.

3.1248 Unfortunately, both characteristics are shared by many risks which an insurance or reinsurance undertaking is exposed to. Tail dependence exists both in underwriting risks (e.g. catastrophe events) and in market and credit risks. The current financial crisis is a good example of this. Market parameters (like credit spreads, property prices and equity prices) which have revealed no strong dependence under benign economic conditions simultaneously showed strong adverse changes in the last two years. Moreover, it became apparent that a change in one parameter had a reinforcing effect on the deterioration of the other parameters.

3.1249 As to the second characteristic, it is known of the relevant risks of an insurance or reinsurance undertaking that the underlying distributions

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[113] In case the expected values of the marginal distributions are zero. This simplifying assumption is made in the standard formula which intends to quantify unexpected losses.

[114] See for example: P. Embrechts, A. McNeil, D. Strautmann: "Correlation and Dependence in Risk Managemement: Properties and Pitfalls" (2002) In: Risk Management: Value at Risk and Beyond, ed. M.A.H. Dempster, Cambridge University Press, Cambridge, pp. 176-223 (http://www.math.ethz.ch/~strauman/preprints/pitfalls.pdf). The authors provide a general analysis of the problems connected with linear correlations.

D. Pfeifer, D. Straßburger: "Solvency II: Stability problems with the SCR aggregation formula", Scandinavian Actuarial Journal (2008), No. 1, pp. 61-77 (http://www.staff.uni-oldenburg.de/dietmar.pfeifer/SCR_Pfeifer_Strassburger.pdf). The authors give examples for beta distributions.

A. Sandström: "Solvency II: Calibration for Skewness", Scandinavian Actuarial Journal (2007), No. 2, pp. 126-134. Sandström discusses a modification of the aggregation method to better allow for skewed distributions.

are not normal. They are usually skewed and some of them are truncated by reinsurance or hedging.

3.1250 Because of these shortfalls of the correlation technique and the relevance of the shortfalls to the risks covered in the standard formula, the choice of the correlation factors should attempt to avoid misestimating the aggregate risk. In particular, linear correlations are in many cases not an appropriate choice for the correlation parameter.

3.1251 Instead, the correlation parameters should be chosen in such a way as to achieve the best approximation of the 99.5% VaR for the aggregated capital requirement. In mathematical terms, this approach can be described as follows: for two risks X and Y with $E(X)=E(Y)=0$, the correlation parameter ρ should minimise the aggregation error

$$\left| VaR(X+Y)^2 - VaR(X)^2 - VaR(Y)^2 - 2\rho \cdot VaR(X) \cdot VaR(Y) \right|.$$

3.1252 This approach is a consequence of Article 104 of the Level 1 text. According to paragraph 3 of Article 104,

"the correlation coefficients for the aggregation of the risk modules referred to in paragraph 1, as well as the calibration of the capital requirements for each risk module, shall result in an overall Solvency Capital Requirement which complies with the principles set out in Article 101."

Article 101 stipulates that the SCR corresponds to the Value-at-Risk with a confidence level of 99.5%.

3.1253 CEIOPS acknowledges that achieving this overall conceptual aim is likely to present a number of practical challenges:

- In most cases[115] the standard formula does not set out explicit assumptions on the type or shape of the risk distributions of X and Y, nor on the dependence structure between X and Y. In these cases the risk distribution of the aggregated risk X + Y will not generally be known, so that its Value-of-Risk cannot be estimated or observed directly;

- In the scenario-based sub-modules, the standard formula pre-scribes shocks to the underlying risk drivers of the sub-risk considered.[116] The risk variables X and Y – representing the change of the level of own funds of the insurer resulting from a change of the underlying risk driver – then also depend on the risk characteristics of the insurer's individual portfolios. Hence in these

[115] With the exception of the premium and reserve risk sub-module, where a lognormal distribution is assumed.

[116] For example, in the interest rate sub-module the underlying risk drivers would be the level and the volatility of the term structure of risk-free interest rates.

cases the relationship between the Value at Risk for the aggregated risk X+Y in respect to the Value at Risk for the individual risks X and Y would likely be different across different insurers: and

- where more than two risks are aggregated, the minimisation of the aggregation error has to go beyond only considering individual pairs of risks.

3.1254 As was observed in the above, where it can be assumed that the considered risks follow a multivariate normal (or elliptical) distribution, minimising the aggregation error can be achieved by calibrating the correlation parameters in the standard formula as linear correlations. Hence in this special case, the challenges described above could be met in case linear correlation coefficients can be reliably derived.

3.1255 However, where such a simplifying assumption cannot be made – for example, where there is tail-dependency between the risks or where the shape of the marginal risk distributions is significantly different from the normal distribution - the use of linear correlations may not be adequate for the purpose of minimising the aggregation error. In these cases, it may be necessary to consider other dependence concepts for deriving the correlation parameters in the standard formula.

3.1256 For example, in this case it may be more adequate to derive the standard formula correlation parameter for two risks X and Y as the coefficient of (upper) tail dependence of X any Y, which is defined as:[117]

$$\rho = \lim_{\alpha \to 1-} P\left(Y > F_Y^{-1}(\alpha) \,\middle|\, X > F_X^{-1}(\alpha)\right),$$

where F_X and F_Y are the distribution functions of X and Y, respectively. Note that this coefficient measures the asymptotic degree of dependence in the "tail" of the risk distributions of X and Y, i.e. the likelihood of simultaneous occurrences of extreme events in both risks.

3.1257 We note that such a use of "tail correlations" has been proposed in the "Global Framework for Insurer Solvency Assessment" of the International Actuarial Association: [118]

"This 'correlation' need not be the standard linear correlation found in statistics text books. In particular, it could be a 'tail correlation' to incorporate the possibility of simultaneous adverse outcomes in more than one LOB…"

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[117] Cf. the above-mentioned article of Embrechts et al. for a definition of this concept and further analysis.

[118] See paragraph 6.20 (http://www.actuaries.org/LIBRARY/Papers/Global_Framework_Insurer_Solvency_Assessment-public.pdf).

Independent risks

3.1258 Several risks covered in the standard formula are believed to be independent. Often, a correlation parameter of 0 is considered to be the best choice for the aggregation of independent risks. However, this is not always the case. The following example illustrates this point.

3.1259 Example: Let *X* and *Y* be independent random variables, and assume that both follow a centralised and truncated lognormal distribution. The underlying non-truncated lognormal distribution has a mean of 1 and a standard deviation of 0.1. It is capped at 0.2; this corresponds approximately to the 98% quantile of the distribution. The risks *X* and *Y* could be underwriting risks mitigated by non-proportional reinsurance or hedged investment risks. Because of the capping at a quantile lower than 99.5%, VaR(*X*) = VaR(*Y*) = 0.2. By simulation, VaR(*X*+*Y*) can be determined as about 0.34. The value for VaR(*X*+*Y*) that is calculated by aggregating VaR(*X*) and VaR(*Y*) with the linear correlation coefficient of 0 is 0.28 and therefore lower than the correct result. In order to achieve an aggregation result of 0.34, a correlation parameter of 0.445 instead of 0 needs to be used.

3.1260 It should be stressed that, whereas in the example above setting a correlation parameter of zero would result in an under-estimation of the aggregated risk, such a setting may also lead to an over-estimation of the required capital on the aggregated level. For example, if in the example a higher "cap" of e.g. 0.3 is selected, a negative correlation parameter would have to be set in order to reflect the aggregated risk.

3.1261 The example illustrates that the choice of the correlation parameter for independent risks is not straightforward. If the underlying distributions are not normal, setting a correlation parameter of zero may lead to a mis-estimation of the aggregated risk.

3.1262 Where the shape or type of the marginal risk distributions are known, it may sometimes be possible to determine a correlation parameter which more closely reflects the aggregated risks. However, in practice, this may often be difficult. Often the shape of the underlying distribution is not known or it differs from undertaking to undertaking and over time. For example, even if the distribution of an underlying risk driver is known, hedging and reinsurance may have modified the net risk in an undertaking-specific way.

3.1263 Hence where a standard formula correlation parameter has to be specified between two risks which can be assumed to be independent but such uncertainties exist, it appears to be acceptable to choose a low correlation parameter, reflecting that model risk may lead to an over- or under-estimation of the combined risk.

Market risk

3.1264 CEIOPS has carried out extensive both qualitative and quantitative analysis to revise the correlation parameters of the market risk model in line with the 1:200 VaR target level for the calculation of the SCR.

3.1265 In its draft advice, CEIOPS set out a qualitative assessment of the "lessons learned" from the financial crises with regards to this issue; and has proposed to increase the correlation coefficients for a number of risk pairs.

3.1266 In the consultation, stakeholders have commented that such qualitative analysis in itself would be insufficient to derive an appropriate a revision of the factors. They took the view that it would not be sound from a statistical perspective if a calibration of correlations should be based exclusively on the observations derived from the current crises, and suggested that CEIOPS should undertake a more thorough statistical analyses based on historic data from a longer period of time.

3.1267 CEIOPS acknowledges these concerns and has undertaken such further statistical analysis on basis of a methodology which is consistent with the general aims of setting correlation parameters. This intended

- to determine the overall level of diversification implied by the correlation matrix proposed, and to assess its appropriateness; and
- to statistically assess the correlation between individual pairs of risks in the market risk module using historical data.

3.1268 The following sets out the results of CEIOPS analysis on this issue. More detailed background information on the statistical quantitative analysis undertaken is provided further below.

General considerations and lessons learned from the financial crises

3.1269 The current financial and economic crisis provided further strong empirical evidence that the dependence structure of market risk changes in stressed situations.[119] Risk factors that have not revealed a significant correlation during ordinary market conditions showed a strong dependence in the crisis. It could also be observed that the risks had a reinforcing effect on each other.

3.1270 For all risks that are covered by the market risk module a strong simultaneous change in market parameters was observed:

- Credit spreads widened in an unprecedented manner.

[119] We note that such a change in the dependence structure of market risks in stressed situations could also be observed during previous crises, for example during the dot.com crisis after the turn of the century or during the crisis in Southeast Asia in 1997.

- The market price for equity fell stronger than during the crises in 1973 or at the beginning of the century. The MSCI world index dropped by 40% and the STOXX 600 by 46% in 2008.

- Interest rates fell sharply, for example for German 10 year Government bonds by 30% in the second half of 2008. The key interest rates of the U.S. Federal Reserve System and the Bank of England were set to historic lows.

- Property prices in some markets strongly decreased. In the United States the Case Shiller Index dropped by 19% in 2008. Similar declines could be observed in some European markets.[120]

- Exchange rates were also quite volatile. For instance, the British Pound lost 24% against the Euro in 2008. Also the currencies of Iceland and some other states outside of the Euro zone came under pressure.

3.1271 This simultaneous adverse change across a range of market risk drivers left only limited scope for diversification, i.e. it was very difficult for market participants to offset losses with respect to one risk category with gains in other risk categories. Only where risks have a two-sided nature like interest rate risk or currency risk, market participants were able to offset risks if they were on the "right" side (for example short in Icelandic króna or short in interest rates).

3.1272 CEIOPS considers that for the calibration of the correlation parameters in the market risk module of the SCR standard formula the empirical evidence provided by the current crisis on the existence of a significant degree of tail correlations between different market risk drivers should not be ignored. In line with its general observations on the calibration of correlation parameters, CEIOPS has reflected this tail dependency in its statistical analysis for setting the correlation parameters in order to ensure that the aggregated capital requirements are in line with the 99.5% confidence level for the calculation of the SCR.

Overall diversification benefit implied by proposed correlation matrix

3.1273 To test the overall appropriateness of the correlation matrix proposed in its draft advice, CEIOPS has carried out a statistical "top down" modelling analysis to assess whether the overall diversification benefit implied by the matrix is consistent with the 1:200 year confidence level targeted for the determination of the capital charge for market risk as a whole.

3.1274 The diversification benefit implied by the matrix can be measured as

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[120] However real estate markets in other countries (e.g. Germany) were less affected.

$$1 - \frac{SCR_{mkt}}{\sum_r Mkt_r}$$

where SCR_{mkt} denotes the capital charge for market risk, Mkt_r denote the capital charges for the individual market risks, and where

$$SCR_{mkt} = \sqrt{\sum_{rxc} CorrMkt_{r,c} \bullet Mkt_r \bullet Mkt_c}$$

is derived from the capital charges for the individual sub-risks by using the proposed correlation matrix $CorrMkt_{r,c}$.

3.1275 This diversification benefit as implied by the aggregation matrix is consistent with the targeted confidence level of 99.5% for market risk if it coincides with the risk-theoretic diversification benefit which is given as

$$1 - \frac{VaR_{mkt}}{\sum_r VaR_r}$$

where VaR_{mkt} denotes the Value-at-Risk 99.5% capital charge for market risk as a whole and VaR_r denote the Value-at-Risk capital charges for the individual sub-risks of market risk.

3.1276 Assuming that the calculation of the capital charges Mkt_r of the individual sub-risks are commensurate with the 99.5% Value-at-Risk confidence level, it follows that the diversification benefit implied by the matrix is consistent with the 99.5% confidence level if the capital charge SCR_{mkt} derived from aggregating the individual charges with the correlation matrix coincides with the risk-theoretic 99.5% Value-at-Risk capital charge VaR_{mkt} for market risk as whole, i.e. if the aggregation error

$$\left| VaR_{mkt} - \sqrt{\sum_{r \times c} CorrMkt_{r,c} \bullet Mkt_r \bullet Mkt_c} \right|$$

is zero.[121]

3.1277 To carry out the analysis, a model of a 'typical' European insurer as described in QIS4 was created with a standalone capital for market risks of 100. This is made up of:

Interest rates	29.36

[121] We note that this observation is consistent with CEIOPS' overall aim to determine the correlation parameters in the standard formula such that the aggregation error is minimised, cf. section 3.1.3, above.

Equity	39.24
Property	8.39
Spread	11.00
Currency	5.22
concentration	6.80

3.1278 Using 12 years[122] of historical data for year on year falls in indices relating to each of the market risks, a simulated empirical calculation of the Value-at-Risk capital charges for the individual market sub-risks as well as for market risk as a whole was undertaken. This empirical simulation exercise then allowed a comparison of the risk-theoretic diversification benefit with the diversification benefit implied by the proposed correlation matrix.[123]

3.1279 Under this empirical analysis, the risk-theoretic diversification benefit for the aggregated market risk (in relation to its sub-risks) was determined as 17.3%, whereas according to the analysis the diversification benefit implied by the proposed correlation matrix was measured as 16%. This indicates that the correlation matrix proposed in CEIOPS' draft advice provides overall capital figures which are broadly consistent with the targeted 99.5% Value-at-Risk confidence level._The analysis also included sensitivity testing of key assumptions, which indicated that the results of the analysis are relatively robust.

3.1280 Notwithstanding this overall indication that its proposed pre-consultation correlation matrix for market risk appears to be broadly adequate, CEIOPS has undertaken further analysis on specific correlation pairs, as explained below. The revised proposal for a correlation matrix as set out in this paper is expected to lead to higher diversification benefits than estimated above.

3.1281 For further detail on the analysis we refer to Annex A of CEIOPS-DOC-70/10.

Statistical analysis on correlation between specific sub-risks

3.1282 For the setting of correlation parameters between specific pairs of sub-risks in the market risk module, CEIOPS has complemented its qualitative assessment set out in its draft advice by a quantitative

[122] 12 years was chosen, as this was the longest time period for which data existed for all of the main risks con-sidered.

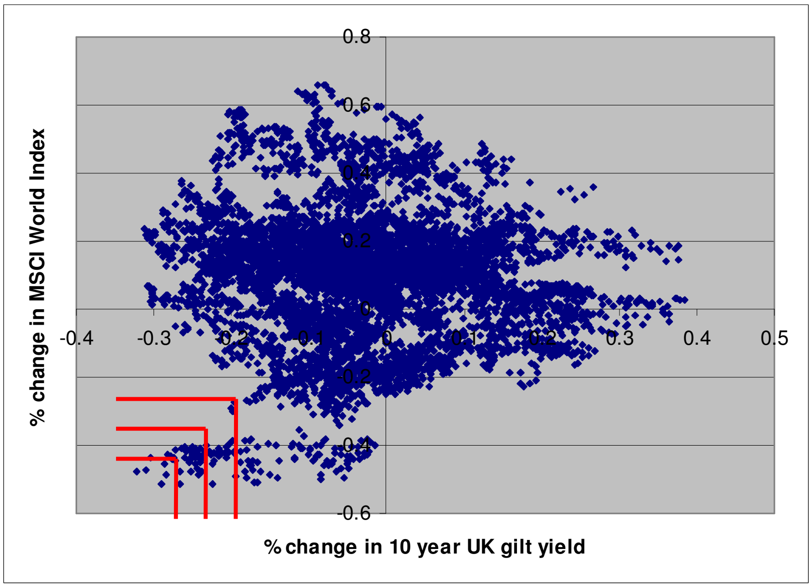
[123] This was computed as shown in the formula, above, where the individual charges Mkt_r were estimated by the empirical Value-at-Risk capital charges for the individual sub-risks.

statistical analysis. This was based on an analysis of historical data on the year on year percentage changes in the underlying risk drivers.

3.1283 For example, to consider the correlation between interest rate risk and equity risk, the analysis was based on the MSCI world equity index from 1970, compared with UK 10 year spot.

3.1284 As was noted above, in view of the assumed tail dependence of market risks in stressed situations the correlation analysis was based on "cutting out" adequate subsets of data pairs in order to obtain a measure of the tail correlation, as well as a measure of the 'weight' in the tail as opposed to that expected by a simulated Gaussian copula.

3.1285 Typically this involved a cut along various percentiles in each of the two variables. For example, the red boxes in the diagram below represent the data in the 99th percentile for equity and interest, the 95th percentile for both, and the 90th percentile for both:



Overall dependence between market sub-risks in stressed situations

3.1286 A strong fall of equity prices as reflected in the equity sub-module (-45%/-60%) does not leave the other market parameters unaffected. A drastic change in equity prices of this scale indicates an economic recession and a severe reduction of undertakings' expected profit. Such a situation is usually accompanied with an increase of risk-aversion and higher default probabilities. Therefore, credit spreads can be expected to increase sharply as well. For the same reason the demand for property, in particular commercial property, can be expected to decrease leading to vacancies and lower property prices. On the other hand, if credit spreads widen as greatly as in the spread risk sub-module, it signals an increased risk aversion and higher default probabilities. These circumstances would certainly affect directly or indirectly the expected profits and the market value of stock corporations in a relevant way, causing a fall in equity prices. Similar arguments apply to property risk.

All three risks are intrinsically connected via the economic conditions, so that in extreme situations, they relate to each other in a similar way as in a causal relationship. These considerations indicate that a higher correlation factors between these risks might be appropriate.

3.1287 Concerning the dependence between interest rate risk and other sub.-risks, we note that the monetary policy of the relevant central banks usually reacts to an economic downturn (and in particular to a fall in equity markets) by lowering the key interest rates. This can be observed for example in the 2001-2003 downturn where the ECB changed the key interest rate for the euro from 4.75% to 2% or the current crisis where rates fell from 4.25% to 1%. Similar reactions took place in the UK (6% to 3.5% and 5.75% to 0.5% resp.) and the US (6.5% to 1% and 5.25 to 0.25% / 0% resp.). These are direct reactions to the adverse movements of the market parameters which are addressed in the market risk module, such as equity prices, credit spreads, property prices and exchange rates. The central banks attempt to flood the market with cheap money in order to mitigate the worsening of these parameters. If key interest rates fall sharply in economic crisis situations, then so do the risk-free interest rates. Therefore a high correlation of a fall in interest rates with an adverse change in the other market risks can be appropriate.

Correlation between interest rate risk and equity risk

3.1288 CEIOPS has carried out additional statistical analysis on the correlation between interest rate risk and equity risk as described above.

3.1289 The results of this analysis indicate that the proposed correlation of 50% does not appear unreasonable. There is clearly a positive correlation between equity and interest rates.

3.1290 On the other hand, a distinction should be drawn between correlations between a fall in interest rates and a fall in equity prices on the one hand, and between a rise in interest rates and a fall in equity prices on the other hand. Whereas there is clear statistical evidence of a positive correlation (in the range of 40% to 50%) between the first, much less data is available to support an analysis of the correlation between a rise in interest rates and a fall in equity prices.

3.1291 In light of these conclusions, a two-sided correlation between interest rate risk and equity risk in the standard formula is introduced:

- In case the insurer is exposed to a fall in interest rate risk, a correlation parameter of 50% between interest rate risk and equity risk should be applied to aggregate the respective capital charges;

- In case the insurer is exposed to a rise in interest rate risk, a correlation parameter of 0% between interest rate risk and equity risk should apply.

- The correlation parameter then results from the decisive risk for the undertaking. Therefore the application of the two-sided correlation depends on whether a fall or rise in interest rates is the crucial factor.

Correlation between interest rate risk and property risk

3.1292 The results of this analysis indicate that a correlation of 50% does not appear unreasonable. It could even be argued that the data at the 80th and 85th percentile indicates that the correlations between property and interest rates should be closer to 75% than to 50%.

3.1293 On the other hand, as in the case for the correlation between interest rate risk and equity risk, a distinction should be drawn between correlations between a fall in interest rates and a fall in property prices on the one hand, and between a rise in interest rates and a fall in property prices on the other hand. Whereas there is clear statistical evidence of a positive correlation between the first, this is less strong in the case of a correlation between rising interest rates and falling property prices, where in some instances even a negative correlation can be observed.

3.1294 In light of these conclusions, a two-sided correlation between interest rate risk and property risk in the standard formula is introduced:

- In case the insurer is exposed to a fall in interest rate risk, a correlation parameter of 50% between interest rate risk and property risk should be applied to aggregate the respective capital charges;

- In case the insurer is exposed to a rise in interest rate risk, a correlation parameter of 0% between interest rate risk and property risk should apply.

- The correlation parameter then results from the decisive risk for the undertaking. Therefore the application of the two-sided correlation depends on whether a fall or rise in interest rates is the crucial factor.

Correlation between interest rate risk and spread risk

3.1295 The results of this analysis indicate a correlation of 50% does not appear unreasonable, especially in view of an increased dependence in the tail of the distributions.

3.1296 As was the case for the correlation between interest rate risk and equity risk or property risk, the analysis indicates that there is stronger support for a positive correlation in case of falling interest rates than in the case of rising interest rates.

3.1297 In light of these conclusions, a two-sided correlation between interest rate risk and spread risk in the standard formula is introduced:

- In case the insurer is exposed to a fall in interest rate risk, a correlation parameter of 50% between interest rate risk and spread risk should be applied to aggregate the respective capital charges;

- In case the insurer is exposed to a rise in interest rate risk, a correlation parameter of 0% between interest rate risk and spread risk should apply.

- The correlation parameter then results from the decisive risk for the undertaking. Therefore the application of the two-sided correlation depends on whether a fall or rise in interest rates is the crucial factor.

Correlation between equity risk and spread risk

3.1298 In the analysis it was observed that year on year changes to credit spreads tend to be relatively stable, except for a few events (two in the last 12 years), where they jump rapidly. It seems plausible that such a jump would be seen in a general 1:200 year event (such as 2008).

3.1299 Hence in the analysis of empirical correlations between equity and spreads were assessed at higher percentiles, and on condition of extreme movements in credit spreads. The results of this analysis indicate that empirical correlation between equity risk and property risk rises rapidly in the tail.

3.1300 Given this tendency for very high correlations during periods of market stress, we can conclude that a correlation factor of 75% is reasonable.

Correlation between property risk and spread risk

3.1301 In the analysis similar anomalies between spread risk and property risk were observed as between spread risk and equity risk. Correlations between spread and property approach 50% in the 95th percentile..

3.1302 Given these results, CEIOPS proposes to apply a correlation factor of 50% (rather than as 75% as suggested in the draft advice) between property risk and spread risk.

Correlation between equity risk and property risk

3.1303 The statistical analysis indicates that the correlation of 75% as proposed in the draft advice would seem justified.

Correlation between currency risk and other risk types

3.1304 If these drastic changes in key market parameters take place it is likely that not all markets are affected in the same way and that currency exchange rates between the markets become volatile. On the other hand, strong movements in the exchange rates of main currencies can cause or reinforce the movements of other market parameters. These connections can be observed in the 1973 dollar crisis, the 1997 Asian crisis or the current financial crisis. Therefore, high correlation factors between currency risks and the other market risks can be adequate. On the other hand, currency risk is a two-sided risk. Depending on the currency mismatch, a fall in a currency exchange rate can cause a loss or a profit in the balance sheet of an undertaking. Taking this nature of currency risk into account, a medium correlation factor seems to be justified.

Correlation between concentration risk and other risk types

3.1305 The correlation factors of concentration risk in relation to equity risk, spread risk and property risk depend on the definition of concentration risk. The concentration risk sub-module covers the additional loss (compared to a well-diversified portfolio) that the undertaking may incur if concentrations in the equity, bond or property portfolio in respect to a single counterparty exist.[124] Therefore, because of the definition of the concentration risk sub-module, the correlation factors should properly describe the dependence between the risk of concentrations with respect to counterparty exposure, and the equity, spread and property risk. The correlation factors of concentration risk in relation to equity, spread and property risk should allow for diversification between property and equity/spread risk. For example, there is diversification between equity risk and property concentration risk or between property risk and the risk of concentration in names. Hence the correlations factors of concentration risk in relation to equity risk, spread risk and property risk should be 0.50.

3.1306 The correlation factors of concentration risk in relation to the other risks, namely interest rate risk and currency risk, should be set in a consistent manner, reflecting the dependence of these risks and the triple consisting of equity risk, spread risk and property risk.

3.1307 Based on the analysis above, the correlation factors for market risk should be chosen as follows:

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[124] Cf. CEIOPS' Advice on SCR market risk module (CEIOPS-DOC-40/09). The calibration procedure defined in Annex A determines the additional loss caused by the concentration. There is no diversification between this loss and the loss of the well-diversified portfolio.

	interest rate	equity	property	spread	currency	concen-tration
interest rate	1					
equity	0.5/0	1				
property	0.5/0	0.75	1			
spread	0.5/0	0.75	0.5	1		
currency	0.5	0.5	0.5	0.5	1	
concentration	0.5	0.5	0.5	0.5	0.50	1

3.1308 It should be noted that in many cases (and nearly all cases between the four largest risks of interest, equity, property, and spread), the CEIOPS analysis gives a proposal consistent with the recent paper published by the CRO forum.[125]

Life underwriting risk module

3.1309 There is no appropriate data base for the calibration of the life underwriting risk correlation factors. For the time being, the choice of these factors needs to be based on expert opinion.

Mortality risk and longevity risk

3.1310 Between mortality risk and longevity risk, a high diversification can be assumed to exist. For one insured person, both risks can completely hedge each other. However, the same may not apply to sub-portfolios under mortality risk and sub-portfolios under longevity risk commonly held by insurance undertakings for the following reasons:

- The insured persons of both sub-portfolios may differ significantly. In particular, the sub-portfolio under mortality risk may relate to a different age cohort than the sub-portfolio under longevity risk. For example, the insured with a mortality cover may be young while the insured with a longevity cover may be old. A change in the mortality table may affect both sub-portfolios in such a way that losses in one sub-portfolio are not offset by profits in the other.

- Different tables may apply to the two sub-portfolios. For example, the tables may be based on different data bases and they may be updated independently. In this case, one table may be changed while the other one may remain unchanged. Again, no offset between profit and loss would be observed in such a case.

[125] Calibration recommendation for the correlations in the Solvency II standard formula.

3.1311 However, we note that such restrictions to an off-setting between mortality risk and longevity risk may be limited in case of a more severe systematic shock to mortality experience (e.g. an earthquake, a medical advance) which would have an "across the board" impact on mortality that affects a wide cross-section of policyholders.

3.1312 For these reasons, the correlation factor should not be -1. A low negative value like -0.25 appears to be appropriate.

Expense risk

3.1313 Some insurance events like lapse, disability and revision can lead to additional expenses for the undertaking. For example, in case of a mass lapse event the number of transactions increases drastically and the internal processes of the undertaking would need to be adjusted accordingly. Moreover, a revision of the economies for scale in relation to the future expensed would need to be made. In case of an increased probability of disability events or annuity revisions, the expenses for the assessment and management of these events will rise.

3.1314 In order to allow for this causal connection, a medium correlation factor of 0.5 for lapse, disability and revision risk in relation to expense risk seems to be appropriate.

Correlations with CAT risk

3.1315 Catastrophe risk stems from extreme or irregular events whose effects are not sufficiently captured in the other life underwriting risk sub-modules. Examples could be a pandemic event or a nuclear explosion.[126]

3.1316 It seems likely that a crystallisation of such an extreme event will have an effect on mortality, disability, lapse and expense experience. Hence it seems appropriate to set a correlation coefficient of 25% between CAT risk and either one of these other four sub-risks.

Other correlation factors

3.1317 For all other pairs of risks, there is likely to be a low dependence or independence. In the case where the two risks can be assumed independent, following the analysis carried out in this paper, a correlation factor of zero seems to be appropriate, since no general assumption on the shape and type of the distributions of the sub-risks is made. In relation to the other pairs where there is low correlation, a coefficient of 25% appears to be adequate.

[126] Cf. CEIOPS-DOC-42/09

3.1318 The correlation factors for life underwriting risk should be chosen as follows:

	mortality	Longevity	disability	lapse	expenses	revision	CAT
mortality	1						
longevity	-0.25	1					
disability	0.25	0	1				
lapse	0	0.25	0	1			
expenses	0.25	0.25	0.5	0.5	1		
revision	0	0.25	0	0	0.5	1	
CAT	0.25	0	0.25	0.25	0.25	0	1

Non-life underwriting risk module

3.1319 The non-life underwriting risk module consists of two sub-modules: the non-life premium and reserve risk sub-module and the non-life catastrophe sub-module. The scope of the catastrophe sub-module is defined to cover extreme or exceptional events. If the sub-module fully captures the loss caused by these events and they occur independently from other loss events, the premium and reserve risk and catastrophe risk are independent.

3.1320 However, the clear distinction between both risks may not be feasible in practice. For example, the catastrophe sub-module may cover an extreme event regarding the main lines of business that it affects, but side-effects of the event on other lines of business may not be modelled explicitly for reasons of practicability. Instead they may be addressed in the premium and reserve risk module, causing dependence between both sub-modules. These concessions to practicability should be taken into account in the choice of the correlation factor.

3.1321 Also, whilst we would agree that there should be a low or zero correlation between CAT and reserving risk, it would seem plausible to assume a higher correlation between CAT and premium risk. For example, when premiums are soft, weak terms and conditions are likely to increase CAT exposure; conversely, where CAT events crystallise, this may lead to further losses associated with premium risk. .

3.1322 Based on these reasons, the correlation factors for non-life underwriting risk should be chosen as follows:

	premium and reserve	CAT
premium and reserve	1	
CAT	0.25	1

Calibration of correlation parameters across lines of business

3.1323 The premium and reserve risk module also uses correlations between different lines of businesses (LOB's) to estimate the combined standard deviation of premium and reserve risk. We note that these correlations, in contrast to all other correlations considered in this paper, are intended to directly aggregate standard deviations instead of capital requirements. Therefore, in this case the correlation parameters should be set as linear correlation coefficients.

3.1324 In order to estimate the combined standard deviation, a correlation matrix defined as follows needs to be provided:

$CorrLob^{rxc}$ = the cells of the correlation matrix *CorrLob*

3.1325 In QIS4, the following correlation matrix was specified:[127]

CorrLob	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
1: M (3rd party)	1											
2: M (other)	0.5	1										
3: MAT	0.5	0.25	1									
4: Fire	0.25	0.25	0.25	1								
5: 3rd party liab	0.5	0.25	0.25	0.25	1							
6: credit	0.25	0.25	0.25	0.25	0.5	1						
7: legal exp.	0.5	0.5	0.25	0.25	0.5	0.5	1					

[127] CEIOPS has also published a calibration paper which includes a description on the derivation of these correlations, which is available on CEIOPS' website under http://www.ceiops.eu/media/files/consultations/QIS/QIS3/QIS3CalibrationPapers.pdf

8: assistance	0.25	0.5	0.5	0.5	0.25	0.25	0.25	1				
9: misc.	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1			
10: reins. (prop)	0.25	0.25	0.25	0.5	0.25	0.25	0.25	0.5	0.25	1		
11: reins. (cas)	0.25	0.25	0.25	0.25	0.5	0.5	0.5	0.25	0.25	0.25	1	
12: reins. (MAT)	0.25	0.25	0.5	0.5	0.25	0.25	0.25	0.25	0.5	0.25	0.25	1

3.1326 CEIOPS has considered a number of policy options with respect to the calibration of correlation parameters across lines of business[128]. On basis of this analysis, it seems appropriate to keep the correlation coefficients at their current level until sufficient data across the European area is available to carry out a more detailed analysis of non-life correlations.

Health underwriting risk module

3.1327 At current, there is no appropriate data base for the calibration of the health underwriting risk correlation factors. Therefore, for the time being, the choice of these factors needs to be based on expert opinion.

3.1328 CEIOPS acknowledges that due to the specific risk characteristics of health insurance it may not always be appropriate to use the same correlation parameters in the $Health_{SLT}$ and $Health_{Non\text{-}SLT}$ sub-modules as they are applied in the Life and Non-Life modules, respectively. Further technical work should be carried out to assess the appropriateness of the proposed factors, based on relevant data across the European area.

Correlations between "Health SLT", "Health Non-SLT" and $Health_{CAT}$

3.1329 The structure of the health module has been reconsidered. The CAT sub-module is integrated besides the $Health_{SLT}$ and $Healt_{NonSLT}$ modules. The following matrix is specified for aggregating the capital charges for $Health_{SLT}$, $Health_{Non\text{-}SLT}$ and health CAT risk to a combined Health charge:

CorrHealth	$Health_{SLT}$	$Health_{Non\,SLT}$	$Health_{CAT}$
$Health_{SLT}$	1		

[128] See Annex B of CEIOPS-DOC-70/10

$Health_{Non\ SLT}$	0.75	1	
$Health_{CAT}$	0.25	0.25	1

3.1330 The correlation factor between $Health_{SLT}$ and $Health_{Non\text{-}SLT}$ has been lowered to 75% to acknowledge that there are some indications for different risks in Health SLT and Health Non-SLT.

Correlations between u/w risk components in "Health SLT"

3.1331 No health-specific analysis for the calibration of the correlation factors was made. As there are no indications that the dependence between the sub-risks for health obligations differs substantially from the dependence for life obligations, the calibration is the same as the one used for the life underwriting risk module.

$CorrHealth^{SLT}$	$Health^{SLT}_{mortality}$	$Health^{SLT}_{longevity}$	$Health^{SLT}_{ldisability/morbidity}$	$Health^{SLT}_{lapse}$	$Health^{SLT}_{expense}$	$Health^{SLT}_{revision}$	
$Health^{SLT}_{mortality}$	1						
$Health^{SLT}_{longevity}$	-0.25	1					
$Health^{SLT}_{ldisability/morbidity}$	0.25	0	1				
$Health^{SLT}_{lapse}$	0	0.25	0	1			
$Health^{SLT}_{expense}$	0.25	0.25	0.50	0.5	1		
$Health^{SLT}_{revision}$	0	0.25	0	0	0.50	1	

Correlation between disability risk for medical insurance and disability risk for income insurance

3.1332 The calculation of the disability/morbidity sub-risks introduces a distinction between disability risk for medical insurance and disability risk for income insurance. As there is no evidence of a material diversification between these two sub-risks, this factor is set to 100%.

Correlations between Lob in "Health Non-SLT premium & reserve risk"

3.1333 Correlation coefficients have to be determined between the LOB's accident, sickness and workers' compensation. The following factors – in line with the assumptions used in QIS3 - are suggested for this purpose:

$CorrLob_{Non\ SLT}$	Accident	Sickness	WC
Accident	1		
Sickness	0.5	1	
Workers' Compensation	0.5	0.5	1

Correlation between premium and reserve risk in "Health Non-SLT premium & reserve risk"

3.1334 As there are no indications that the risks of health lines of business differs substantially each other, the QIS4 factor of 50% for the correlation factor between premium and reserve risk is kept.

Appendix: Template for analysis of market risk correlations

3.1335 In Article 104 the level one text specifies that the standard formula approach to the SCR must be based on a correlation matrix with correlations being set such that the overall capital requirement is equivalent to a 99.5% one-year VaR stress.

3.1336 This specification implies that a correlation matrix be chosen which has higher correlations than those which would be observed in normal market conditions. Intuitively, this can be understood as reflecting the fact that in stressed conditions, market risks generally take on a higher dependence (for example in the recent dislocation, equities and properties fell, spreads widened, and interest rates dropped: all to a large extent, and all at the same time).

3.1337 To assess whether a correlation matrix provides a capital in line with a stress at the 99.5% VaR, we need to consider the matrix as a whole, and consider whether the diversification benefit it provides is consistent with that we would expect in a 99.5% VaR event.

3.1338 In order to do this, we have created a model which calculates a market risk capital requirement based on actual historical market risk data. We can then compare this requirement against that calculated with reference to a correlation matrix.

Description of model

3.1339 The model focuses on the impacts of the correlations, rather than the market risks themselves. As such it aims to check that the correlation matrix provides a figure consistent with a 99.5% VaR shock. It makes no assumptions regarding the distribution of risks, taking empirical historical values.

3.1340 The steps to produce the model are as follows:

- Obtain a set of indices for the risks to which the company is exposed.
- Calculate the year on year percentage change for each of these indices.
- Multiply the value derived in 2 by a factor designed to reflect the normalised capital required on a standalone basis in respect of that risk. So, for example, the observed 99.5th percentile year on year change for property is -25%. For the typical QIS4 firm we expect 8.4% of total capital to be in respect of property risk, so we multiply each year on year change in the property index by a factor of 100 * 8.4%/25%. 100 is the normalising value.Performing this will ensure that the undiversified sum of the 99.5% VaR capital levels for all risks is 100.
- For each observation, sum the capital required to get a total capital requirement for that observation.
- Order the observations by total capital requirement.

3.1341 We can observe the 99.5th worst capital result, which would correspond to a modelled 99.5% VaR event. This figure can give us an estimate of the diversification benefit deriving from the model.

3.1342 We can then compare against an approach using a correlation matrix combined with the 99.5% VaR standalone capital requirements as defined for our typical firm. This figure shows us the diversification benefit implied by the matrix.

3.1343 Comparing the two diversification benefit figures shows us whether the benefit implied by the matrix is too strong, or not strong enough.

Limitations

3.1344 There are a number of limitations to this model which need to be considered. Where possible we have examined the limitations of the model using sensitivities as described below.

- Choice of Indices: The indices used may not be appropriate for each firm. The difficulty in calibrating data to concentration risk and FX risk means that analysis involving these two risks needs to be treated with caution, although as these are the least material of the market risks for a typical European firm, the importance is perhaps less high.

- Data period: Our analysis only looks at a 12 year data period. This gives extra weight to the 2008 market crisis which may be unwarranted. Although we note that the level of increased correlations in 2008 could be interpreted as a reasonable 99.5%-level assessment of heightened correlations in times of extreme risk.

- Overlapping data period: We have considered daily overlapping data periods. Preliminary analysis indicates that the auto correlation bias this introduces does not have a radical effect, and we consider the extra data gained from considering overlapping periods outweighs the bias.

- Linear losses: The model assumes that a firm has linear losses, i.e. if a 10% fall in the equity index costs $10m, a 20% fall would cost $20m. This may not be accurate for many firms.

- Structure of the firm: The model assumes a firm with capital requirements identical to those of a 'typical' QIS4 firm. It thus blurs national, and sectoral distinctions, and only gives a high level view.

Results of the analysis

3.1345 The analysis hypothesises a 'typical' European firm as described in QIS4 with a standalone capital for market risks of 100. This is made up of:

Interest rates	29.36
Equity	39.24
Property	8.39
Spread	11.00
Currency	5.22
Concentration	6.80

3.1346 Under the empirical model, the 99.5th percentile capital requirement is 82.5, and under the Level 2 proposed matrix, the 99.5th percentile capital requirement is 83.7. The difference is low, with the level 2 matrix being slightly too prudent by approximately 1.2%.

3.1347 This indicates that the correlation matrix proposed by CEIOPS provides overall capital figures broadly consistent with a 99.5% VaR stress.

Sensitivities to the analysis

3.1348 The analysis may have the criticisms:

- The analysis is based on only 12 years of data.
- The analysis is based on a typical QIS4 firm, and a firm's exposure to different risks may differ materially from this.
- The risk factors used in the analysis do not represent an accurate proxy for a firm's own risks.

3.1349 We have run some sensitivities on the model to assess the validity of these criticisms:

Percentiles Sensitivity

3.1350 It could be charged that a 99.5% VaR event over the reference period of the last 12 years would not equate to a 'standard' 99.5% VaR event, as the last twelve years has seen an unusually high shock to market risk.

3.1351 We can perform the same calculation as above with a number of percentages with the following results:

Percentile	Model	Matrix	Difference	% Difference
99.9	86.37	89.48	3.11	3.5%
99.5	83.74	82.53	-1.21	-1.5%
99	79.60	79.73	0.13	0.2%
98	76.13	75.23	-0.90	-1.2%
97	70.82	71.25	0.43	0.6%
96	65.22	68.23	3.01	4.4%
95	55.61	63.65	8.04	12.6%
90	35.35	49.98	14.63	29.3%
80	23.34	28.74	5.40	18.8%

3.1352 As can be seen, at the 97th percentile and above, the model produces results which are very similar to the proposed correlation matrix. The correlation matrix gives appropriate results for any stress greater than a 1:30 event over the last 12 years. This can give us confidence that the model would be robust to longer periods of data.

3.1353 The event which drives the model in the tail is the 2008 market dislocation, as described above. The correlation matrix proposed gives a similar diversification benefit as firms would have been able to take account of in 2008.

Sensitivity to different risk factors

3.1354 The analysis is performed using the following proxies for risk factors:

- Equity: MSCI World Index
- Interest: UK 10 year swap rates
- FX: GBP / USD currency rates
- Property: A large portfolio of UK investment grade property (assessed monthly)
- Spread: The spread to gilts on UK AA rated corporate bonds
- Concentration: A simulated set of variables with a relatively high correlation with Equities.

3.1355 We note that the proxies used may not accurately reflect the market risk holdings of various European insurance firms, so have provided the following analysis to show the sensitivity to different proxies.

- Using MSCI Europe index instead of MSCI world index
- Using DEM/EUR 10 year swap rates instead of UK rates
- Using spreads to gilts on European firms instead of UK firms

Sensitivity	**Model**	**Matrix**	**Difference**	**%**
Equity	84.3	82.5	-1.8	-2%
DEM Interest	80.6	82.5	1.9	2%
European Spreads	82.4	82.5	0.1	0%

3.1356 As can be seen, whilst using different risk proxies has an effect on the overall result, the effect is not huge and the sign appears to be unbiased.

Sensitivity to different weightings

3.1357 The analysis considers a 'typical' European insurance firm as calculated in QIS4, and so the relative weightings for the risk factors are based on this analysis.

3.1358 We note that under CEIOPS' proposed new market risk stresses, the relative importance of the market risk factors may change, with some risks, such as equity and credit spreads adopting more relative importance.

3.1359 We do not attempt to pre-empt the relative importance of these changes, but attach a sensitivity to increasing each relative weight by 50%. For example the equity stress assumes that the proportion of market risk capital due to equity increases from c40% to c60%.

Sensitivity	Model	Matrix	Difference	%
Equity	83.7	85.2	1.50	1.8%
Spread	79.8	83.6	3.80	4.5%
Property	82.8	83.6	0.80	1.0%
Interest	82.7	83.5	0.80	1.0%
FX	82.8	83.2	0.40	0.5%
Concentration	82.0	84.0	2.00	2.4%

3.1360 We note a small change, especially for firms who have a larger exposure to equity or concentration than under QIS4. We note that where relative weights decrease, the change would be in the opposite direction.

QIS4 results on model

3.1361 Under QIS4 correlation assumptions, the capital requirement would be 61.9. This compares with a model value of 82.5, and a matrix value of 83.7.

Undiversified	100
Model	82.5
Matrix	83.7
QIS4	61.9

3.1362 On this analysis the QIS4 correlations are clearly too weak.

Conclusion

3.1363 As can be understood by the tables showing the three sensitivities above, the analysis is relatively robust. The correlations as proposed appear to produce a capital requirement for market risk which is approximately appropriate for a 99.5% VaR stress under a range of different plausible scenarios.

Correlation pairs

3.1364 Having concluded that the correlation matrix is of an appropriate strength, it is now important to consider some of the individual correlation factors between key pairs of risks, to ensure that the pairs are not too high in some areas, and too low in others.

3.1365 We focus particularly on the interest rate v equity and equity v spread pairs. This is because these pairs are amongst those with the generally highest impact to European firms. It should be noted that for both of these pairs, the CEIOPS final advice is consistent with the recommendation published by the CRO forum in their recent calibration document[129].

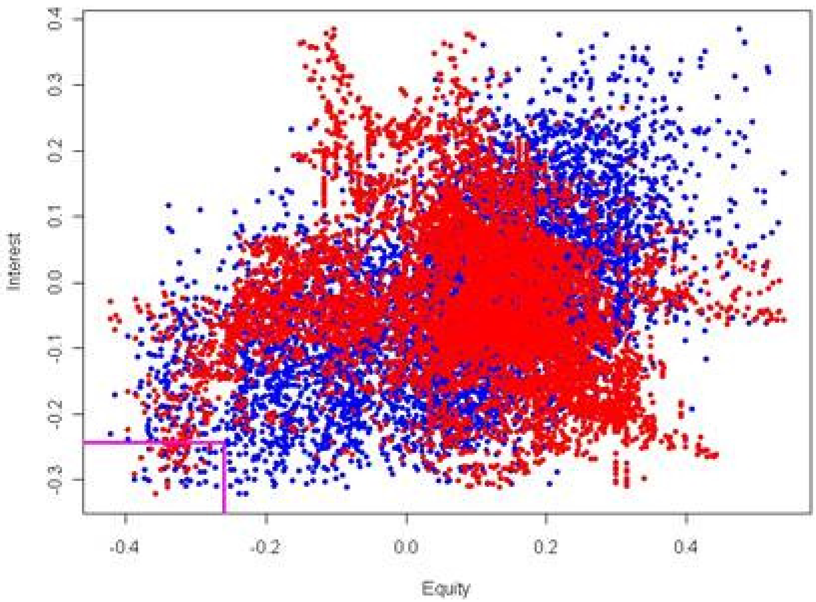
Equity / Interest

3.1366 For this analysis, we consider MSCI world equity index from 1970, and FTSE index from 1986, compared with the UK 10 year spot rate: the significantly longer time period (using all available reliable data) should be noted.

'Weight analysis'

3.1367 We simulate a Gaussian copula with empirical marginal distributions as described by the indices (using FTSE), and a correlation coefficient of 0.5 (in blue). On to this we overlay the empirical distribution of year on year changes (in red).

[129] CRO Forum: Calibration recommendation for the correlations in the Solvency II standard formula. 2009



3.1368 The figure shows us that the shape of dependency is very different to that implied by a Gaussian copula. We can examine the tail at varying percentiles to examine whether the 'weight' of data points in the tail, is similar to that predicted by the Gaussian copula.

3.1369 Taking the 38 worst data points, (where 38 is the total number of data points/200), and applying different correlation coefficients we see the following results:

Correlation coefficient of copula	*Observed data points*	*Expected data points*
0%	*38*	*2*
50%	*38*	*38*
90%	*38*	*123*

3.1370 The values predicted by a simulated Gaussian copula with correlation of 0.5 are similar (in fact the same) to those we have OBSERVED, indicating that a correlation of 0.5 seems reasonable. Simulated copulas with radically different correlation coefficients predict radically different numbers of data points in the tail.

Strength analysis

3.1371 We have performed a strength analysis for a company exposed just to equity and interest rate risks, in the same way that we performed our overall strength analysis for all risks above.

3.1372 Looking at equity and 10 year yield indices for as much data as is available, and for three separate markets, we see the following results:

Data set	Data period		Equity weight	Interest weight	Model result	Matrix (50%)	Implied correlation
S&P 500 v US 10 yr Treasury	1983-2009		50	50	92	86.6	**69%**
S&P 500 v US 10 yr Treasury	1983-2009		70	30	94.5	88.9	**74%**
S&P 500 v US 10 yr Treasury	1983-2009		30	70	90.1	88.9	**55%**
Nickei 225 v JPY 10 yr	1982-2009		50	50	81.4	86.6	**30%**
Nickei 225 v JPY 10 yr	1982-2009		70	30	78.2	88.9	**7%**
Nickei 225 v JPY 10 yr	1982-2009		30	70	88.3	88.9	**47%**
FTSE AS v 10 yr UK BM Bond	1986-2009		50	50	92.8	86.6	**69%**
FTSE AS v 10 yr UK BM Bond	1986-2009		70	30	94	88.9	**72%**
FTSE AS v 10 yr UK BM Bond	1986-2009		30	70	93.2	88.9	**69%**

3.1373 Note that we have theorised a company exposed to the two risks in three proportions: (1) 70% Equity v 30% Interest, (2) 50%/50% and (3) 30%/70%.

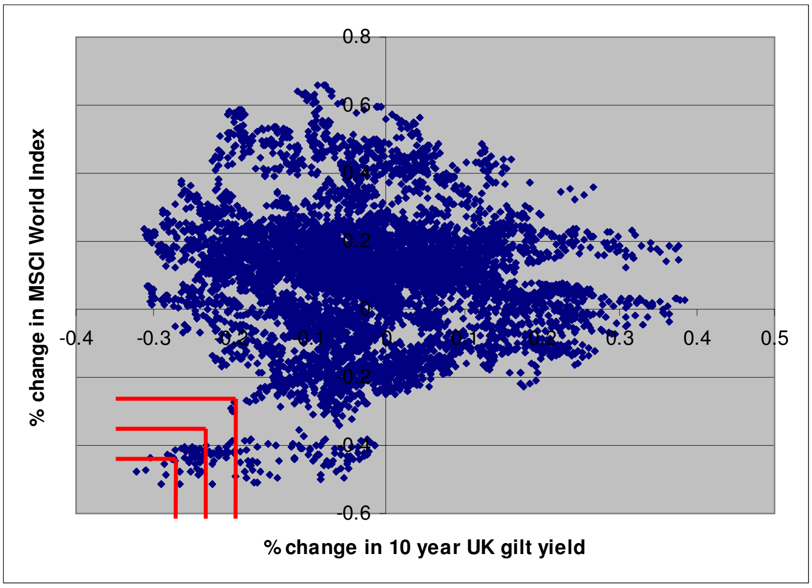
3.1374 The results indicate a wide variety of implied correct correlations, depending on make up of company as well as the market examined. Many of the implied correlations are significantly greater than 0.5, and some much lower (note particularly the unique features of the Japanese market over the time period).

3.1375 Given the range of results and the dependence on the assumptions used, CEIOPS considers this analysis does not give strong evidence to move away from a correlation of 50%, however it could be argued on the basis of these results that the correlation could be somewhat higher.

Data Cutting analysis

3.1376 We calculated the year on year percentage change in both factors, and used these figures to calculate correlations.

3.1377 A scatter chart showing the shape of the correlation can be seen:



3.1378 We can cut the data in various ways to get a measure of the tail correlation. The red boxes represent the data in the 99th percentile for equity and interest, the 95th percentile for both, and the 90th percentile for both. The bottom left hand corner of the graph represents a fall in both equity and interest rates. The bottom right hand corner represents a fall in equity and a rise in interest rates.

Results

3.1379 The percentiles of the equity and interest rate movements are:

Percentiles	Interest	Equity
99	-28%	-43%
95	-22%	-21%
90	-18%	-16%
80	-13%	-5%

3.1380 Cutting the data to include only these percentiles provides the following results, and attendant correlations

Percentiles	Interest	Equity	Correlation
95	-22%	-21%	16%
90	-18%	-16%	37%

80	-13%	-5%	53%

3.1381 There are only 6 data points in the 99th percentile for both equity and interest, and as such the correlation measure is unreliable.

<u>*Conclusions*</u>

3.1382 As we can see, there is evidence to back up the assumption of a 50% correlation between equity and interest rates (especially if the '80%' percentile is chosen).

3.1383 There are a few problems with relying on this data cutting analysis though:

- It is difficult to understand what percentile should be taken as an accurate tail correlation.
- Only data points from a relatively small period of time are driving the correlation calculations.

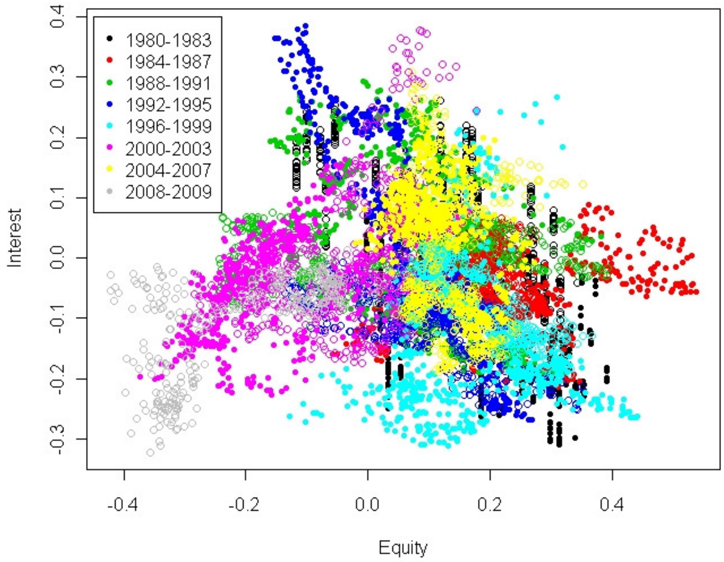
Choice of percentile for tail correlation analysis

3.1384 As can be seen from the results, the choice of percentile is important in determining the correct correlation coefficient.

3.1385 It is key to strike a balance between being adequately in the tail, and having enough data points for a reliable analysis. As described above the overall correlation matrix should produce a level of stress equivalent to a 99.5% VaR event, so each individual pair can be equivalent to significantly less than a 99.5th percentile stress, but still should be firmly in the tail. The analysis must be subject to sensitivities for different percentiles, and should be taken as providing an indication of the correct correlation.

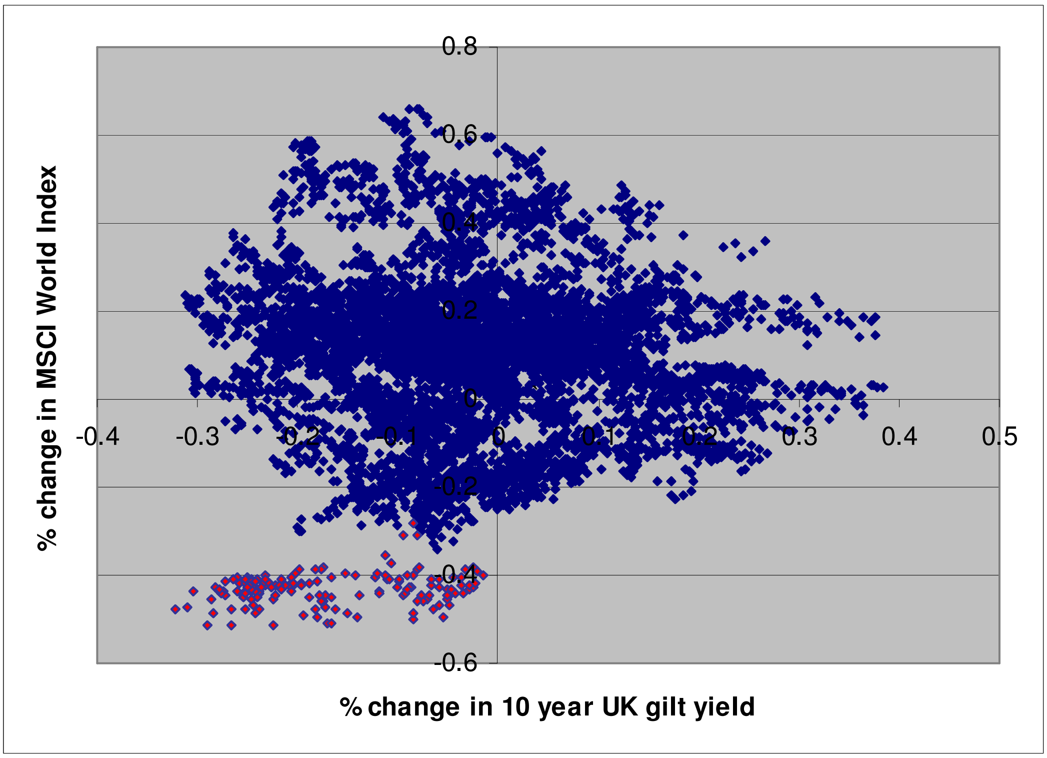
Data points from only one risk event

3.1386 The following chart shows a plot of year on year FTSE and UK interest rate changes, coloured according to time period. As can be seen different time periods show different patterns of correlation and are generally grouped in different areas of the chart.



3.1387 Ideally our analysis would be able to capture the effect of more than one period, and not just rely on the 2008 market crisis.

3.1388 The below graph shows all data points of MSCI equity plotted against interest rates. Those with a red centre are from the period October 2008 to April 2009.



3.1389 The data points from this six month period are by far the most extreme, and therefore dictate nearly all of the analysis performed on correlations with this method.

3.1390 Removing these data points and performing the same analysis results in a tail correlation factor of 58% at the 90th percentile, and 63% at the 80th percentile. This could indicate that the 50% proposed by CEIOPS is, if anything, prudent.

Equity/Interest Conclusion

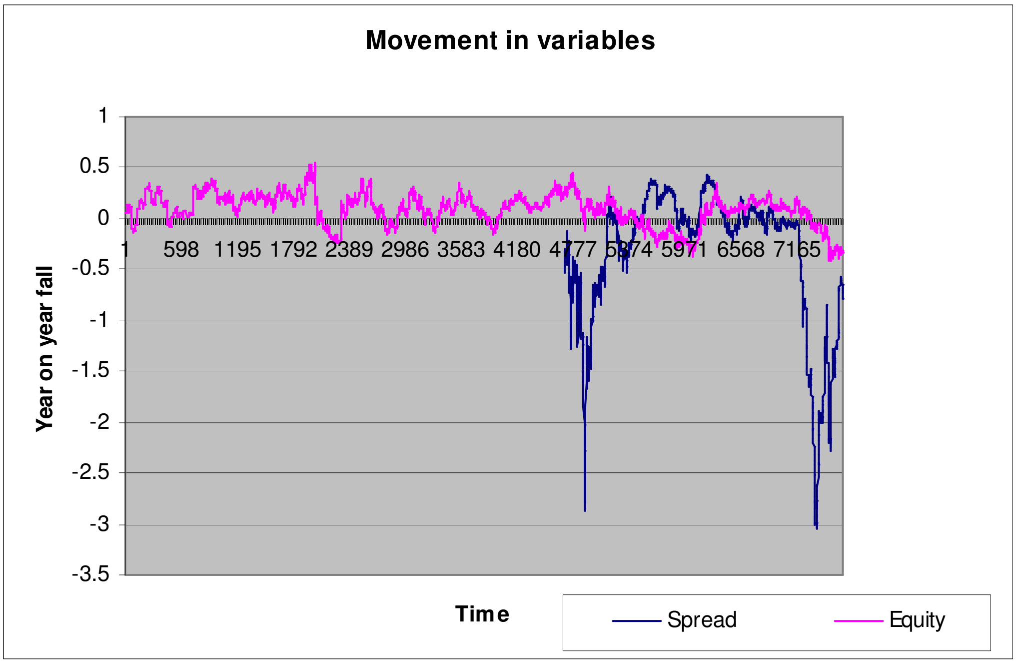
3.1391 The proposed stress of 50% does not appear unreasonable, we have used three separate methods to analyse the correlation, and all provide results which are not inconsistent with 50%, some seem to indicate a slightly higher value is appropriate, and others that a slightly lower value is appropriate.

3.1392 We note a further method, the so-called 'rolling correlation' method as described in the recent CRO Forum paper amongst others. For the equity/interest pair, this analysis places 50% firmly within the plausible range of correlations.

Equity/Spread

3.1393 In order to analyse this pair, we have considered the return on an MSCI world index as compared to the spread to gilts on UK AA rated corporate bonds. This analysis is performed on just 12 years, as data on UK spreads (as for spreads in most other markets) does not exist for longer periods than this. All things being equal, the tail results we see over a short period should be less extreme than those we would see over a longer period.

3.1394 The following chart displays the year on year percentage change for equities and spreads over the last 12 years (with higher spreads being seen as negative)



3.1395 As can be seen there have been two large credit spread events in the last 12 years, the recent credit crisis, and the LTCM crisis, the second of these crisis corresponded to a large fall in equities, whilst the first corresponded to a somewhat smaller (and lagged) fall.

3.1396 We can calculate the empirical correlations at different tail percentiles in the method described above:

Percentile	Correlation
75	-51%
80	-46%
85	-28%
90	23%

3.1397 *Prima facie* this would indicate that the correlation is relatively low, and maybe even negative between equity and spread. However we can look at the quantiles these percentiles correspond to for a fuller picture:

	Equity	Spread
99.5	-34.6%	-285.0%
99	-33.0%	-270.1%
95	-21.9%	-190.1%
90	-13.9%	-137.0%
80	-4.3%	-73.1%

3.1398 As we can see both in the above graph and the table, year on year changes to credit spreads tend to be relatively stable, except for a few events (two in the last 12 years), where they jump rapidly.

3.1399 It is entirely plausible that such a jump would be seen in a general 99.5% VaR year event (such as 2008), and so we should examine the correlations between equity and spreads at more extreme percentiles, and particularly, we should condition on extreme movements in credit spreads, and calculate empirical correlations.

3.1400 The following tables perform this analysis:

Percentile	Correlation

89	-4%
90	23%
91	41%
92	57%
95	72%

Periods of extreme credit stress movements

			Data points	Correlation
02/11/2007	to	27/02/2009	346	-21%
25/08/1998	to	29/01/1999	114	32%

Periods of very extreme credit stress movements

12/02/2008	to	08/05/2008	81	54%
30/09/1998	to	28/10/1998	21	75%

3.1401 The first table indicates that empirical correlation rises rapidly in the tail. The second table, which conditions on extreme (2x year on year change) and very extreme (3x year on year change), demonstrates for what kind of events we can see high correlations.

3.1402 In the last 12 years we have seen two periods of 'very extreme' changes to year on year credit spreads. The empirical correlations with equities we have seen for these times have been 54% for 2008, and 75% for 1998. Given this tendency for very high correlations during periods of market stress, we can conclude that the CEIOPS proposed correlation factor of 75% is reasonable.

3.1403 We note the CRO Forum's support for this calibration based on a macroeconomic argument that spread and equity shocks often come together. We further note a stakeholder appeal for additional granularity for cross country and rating weaker correlations. It is considered that the extra complexity this would bring would be inappropriate for the standard formula, and that the practical difficulties of having a plausible calibration would be high.

Other risk pairs

3.1404 The above discussion gives a framework for the methods of analysis CEIOPS has performed to arrive at and justify its correlation coefficients. Similar analysis has been performed on many other risk pairs, in order to arrive at the correlation matrix for market risk shown in this final advice.

Interest rate up shocks

3.1405 It may be argued that for some pairs of risks, the correlation between interest rates up and various risks would differ from those with interest rates down and the same risks. For example we may experience a positive correlation between a fall in interest rates and a fall in equities, but a rise in interest rates may be negatively correlated, or uncorrelated with a fall in equities.

3.1406 For two risks, namely equity, and spread, we have observed very few historical data points where interest rates have risen substantially, and the other risk has fallen. This is partly a function of prevailing economic policy over the period of analysis; central banks tend to cut interest rates when other assets are shocked. Given this observation CEIOPS considers two sided stresses appropriate, with the interest rate up shock being set to zero.

3.1407 For property risk against interest rate up risk, there is some evidence for a negative correlation between property fall and interest rate rise, however there is little data where there are 'extreme' property falls, together with 'extreme' interest rate rises; there is also an economic argument for a positive correlation. Taking this into account CEIOPS considers the correlation should be set to zero.

4. Minimum Capital Requirement[130]

Background

4.1 The MCR approach tested in QIS4 combined a linear formula with a cap of 50% and a floor of 20% of the SCR. Overall, this approach was found workable in QIS4. The Level 1 text sets out an MCR calculation method similar to QIS4, yet with a narrower corridor (25% to 45% of the SCR).

4.2 The calibration of the linear component of the MCR in QIS4 was regarded as satisfactory for non-life business, whereas it was also concluded that the calibration of the linear formula for life business would need

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[130] This section follows CEIOPS-DOC-69/10

improvement.[131] The subject of this paper is the refinement of the QIS4 calibration, as well as its adjustment to post-QIS4 changes of the MCR and the SCR.

4.3 This section builds on the the definitions and notations used in CEIOPS' advice on the calculation of the MCR (CEIOPS-DOC-47/09)[132].

4.4 The Level 1 text requires that the MCR linear formula is calibrated to a 85% Value-at-Risk confidence level over a one-year time horizon. It is not expected, however, that a simple linear formula will accurately reflect a prescribed level of confidence. Therefore, instead of an independent modelling of the 85% VaR confidence level, CEIOPS calibrated the MCR linear formula relative to the SCR standard formula. The life linear formula was fitted to a benchmark percentage (35%) of the SCR standard formula; whereas the non-life calibration was built on the standard deviation parameters used in the premium and reserve risk submodule of the SCR standard formula.

4.5 Admittedly, the relationship between the 85% and 99.5% confidence levels can not be described by a fixed percentage across all probability distributions. CEIOPS however considers that the 35% ratio – which corresponds to the middle of the 25%–45% corridor – is broadly consistent with the range of distribution assumptions used in the SCR standard formula.

4.6 From this approach it follows that the calibration of the MCR linear formula is closely linked to the calibration of the SCR standard formula. This also means that when there is a significant change in the calibration of the SCR standard formula, the MCR linear formula should also be recalibrated.

4.7 Accordingly, the change of the level of the linear formula in this advice relative to QIS4 largely mirror the impact of CEIOPS' revised proposals for SCR standard formula calibrations.

4.8 The calibration exercise described in this paper has been carried out on the basis of QIS4 data, taking into account the proposed changes in the calibration of the SCR standard formula. CEIOPS suggests that the calibration of the MCR should be further revised after the results of the new calibration of the SCR standard formula become available following QIS5.

4.9 It is also noted that, from the 20%–50% corridor used in QIS4, the Level 1 text narrowed down the corridor to between 25% and 45% of the SCR. Therefore it is expected that, despite calibration refinements, a larger

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[131] CEIOPS provided background for the QIS4 MCR linear formula calibration in *CEIOPS–DOC–02/2008: QIS4 Background Document – Calibration of SCR, MCR and proxies* (1 April 2008).

[132] CEIOPS-DOC-47/09 (October 2009), see http://www.ceiops.eu//content/view/17/21/.

percentage of linear formula results will fall outside the corridor than was observed in QIS4.

Reflecting the impact of SCR standard formula changes

4.10 For the purpose of adjusting the calibration of the MCR to the revised SCR standard formula, a single-factor adjustment technique was used. That is, CEIOPS estimated a single factor reflecting the average change in the overall SCR standard formula.

4.11 The SCR adjustment factors were informed by an impact assessment study, carried out by CEIOPS with the aim of delivering an estimate of the overall impact of proposed calibration changes relative to QIS4.

4.12 Separate SCR adjustment factors were estimated in respect of the life and for non-life components of the MCR linear formula. The non-life adjustment factor was set at 1.45, reflecting the estimated SCR impact for the undertakings affected (non-life, composite, reinsurance and captive). The life adjustment factor, reflecting the estimated SCR impact for life and composite undertakings, was set at 1.5.

4.13 Both of the above factors are rounded and are of an approximate nature. Given the simplified treatments used in the calculation, the results are regarded as a preliminary indication. QIS5 will allow a far more accurate assessment of the impact, on the basis of undertaking-by-undertaking data.

4.1 Non-life linear formula

4.14 Following CEIOPS' advice in CEIOPS-DOC-47/09 on the calculation of the MCR, similarly to the QIS4 approach, the non-life linear formula is expressed as a function of net technical provisions and net written premiums according to the segmentation defined below. The linear formula charge for each line of business is the higher of a fixed percentage of technical provisions and a fixed percentage of written premiums. The non-life linear formula is the sum of charges over all lines of business.

Index	Segment
Volume measure: technical provisions & written premiums	
A.1	Motor vehicle liability
A.2	Motor, other classes
A.3	Marine, aviation, transport
A.4	Fire and property
A.5	Third-party liability
A.6	Credit and suretyship
A.7	Legal expenses
A.8	Assistance

Index	Segment
Volume measure: technical provisions & written premiums	
A.9	Miscellaneous
A.10	NP reinsurance – property
A.11	NP reinsurance – casualty
A.12	NP reinsurance – MAT
A.13	Accident
A.14	Sickness
A.15	Workers compensation

4.15 Following the results of QIS4, CEIOPS concluded that the QIS4 calibration approach was broadly satisfactory for non-life undertakings. CEIOPS therefore retains its general approach to the calibration of the non-life linear formula, whereby the factors were derived from the SCR standard formula premium and reserve risk parameters.

4.16 The suggested linear formula factors are derived from the SCR premium and reserve risk standard deviations as follows:

- technical provision factor: $\alpha_{lob} = K \cdot \rho_{85\%}\left(\sigma_{res,lob}\right)$
- written premium factor : $\beta_{lob} = K \cdot \rho_{85\%}\left(\sigma_{prem,lob}\right)$

where the steps of the process, and the meaning of the $\rho(\sigma)$ function and the adjustment factor K are explained below:

4.17 Step 1 – Determine the 85% VaR factor corresponding to the premium and reserve risk standard deviations: Following the lognormal assumptions of the SCR premium and reserve risk module, this is done by applying the $\rho(\sigma)$ function similar to that used in the SCR standard formula (see CEIOPS-DOC-41/09 on the non-life underwriting risk), but reflecting a 85% quantile instead of 99.5%:

$$\rho_{85\%}(\sigma) = \frac{\exp\left(N_{0.85} \cdot \sqrt{\log\left(\sigma^2 + 1\right)}\right)}{\sqrt{\sigma^2 + 1}} - 1$$

where $N_{0.85}$ is the 85% quantile of the standard normal distribution. (An indicative value of the $\rho_{85\%}(\sigma)$ to $\rho_{99.5\%}(\sigma)$ ratio is 0.35, varying slightly according to line of business.)

4.18 For reserve risk, the net standard deviations by line of business are directly available from CEIOPS' advice on the calibration of the non-life and health underwritng risk modules. For premium risk, the net parameters are derived from the gross parameters by using undertaking-specific adjustment factors (the NCR/GCR ratio in each line of business). It is assumed that, for the purpose of this paper, the overall effect of the gross-to-net adjustments can be reflected by adjustment factors equal to 100%.

4.19 Step 2 – Apply an adjustment factor to reflect risks other than premium and reserve risk: In the first step, only premium and reserve risk has been explicitly reflected. To implicitly reflect all other risks in the SCR (non-life CAT risk, market risk, operational risk, counterparty default risk etc.) an adjustment factor K is applied.

4.20 On the basis of the QIS4 calibrations of the SCR standard formula, the correct choice of the adjustment factor would have been 1.18. This means that a 1.18 factor would scale up the $\rho_{85\%}$ factors such that the weighted average of the linear formula to SCR ratio for property and casualty undertakings is equal to 35%, where the SCR is calculated by the QIS4 standard formula.

4.21 Based on an assessment of the impact of SCR calibration changes it is estimated that, after the calibration changes suggested by CEIOPS, the overall increase in the SCR premium and reserve risk sub-modules (both under life and health underwriting risk) could be reflected by a factor of 1.45[133], whereas the overall SCR increase for the undertakings affected is estimated by a factor of 1.45. This leads to an adjustment factor of $K = 1.18 \cdot 1.45/1.45 = 1.18$.

4.22 The results of the above steps are the following (in step 2, the factors are rounded):

Factor	**Segment**	**SCR standard deviation** ($\sigma_{res,lob}$)	**Step 1** $\rho_{85\%}(\sigma)$	**Step 2** $K \cdot \rho_{85\%}(\sigma)$
		Volume measure: technical provisions		
$\alpha_{A.1}$	Motor vehicle liability	9.5%	9.8%	12%
$\alpha_{A.2}$	Motor, other classes	12.5%	12.9%	15%
$\alpha_{A.3}$	Marine, aviation, transport	17.5%	17.9%	21%
$\alpha_{A.4}$	Fire and property	12.0%	12.4%	15%
$\alpha_{A.5}$	Third-party liability	16.0%	16.4%	19%
$\alpha_{A.6}$	Credit and suretyship	25.0%	25.2%	30%
$\alpha_{A.7}$	Legal expenses	9.0%	9.3%	11%
$\alpha_{A.8}$	Assistance	12.5%	12.9%	15%
$\alpha_{A.9}$	Miscellaneous	.20.0%	20.4%	24%
$\alpha_{A.10}$	NP reinsurance – property	25.5%	25.7%	30%
$\alpha_{A.11}$	NP reinsurance – casualty	25.0%	25.2%	30%

[133] A precise change factor cannot be provided because of the different aggregation structures, especially in health, and also because of the different impact on categories of undertakings (life, non-life, composite, reinsurer, captive). The estimated factor assumes a 40% increase for non-life premium and reserve risk, a 75% increase for non-SLT health premium and reserve risk, and a 85%–15% weighting between the two risk types in QIS4. These figures are consistent with the SCR impact assessment results, but include rounding and simplifications.

$\alpha_{A.12}$	NP reinsurance – MAT	25.0%	25.2%	30%
$\alpha_{A.13}$	Accident	17.5%	17.9%	21%
$\alpha_{A.14}$	Sickness	12.5%	12.9%	15%
$\alpha_{A.15}$	Workers compensation	12.0%	12.4%	15%

Factor	**Segment**	**SCR standard deviation** ($\sigma_{prem,lob}$)	**Step 1** $\rho_{85\%}(\sigma)$	**Step 2** $K \cdot \rho_{85\%}(\sigma)$
Volume measure: written premiums				
$\beta_{A.1}$	Motor vehicle liability	11.5%	11.9%	14%
$\beta_{A.2}$	Motor, other classes	8.5%	8.8%	10%
$\beta_{A.3}$	Marine, aviation, transport	23.0%	23.3%	27%
$\beta_{A.4}$	Fire and property	15.0%	15.4%	18%
$\beta_{A.5}$	Third-party liability	17.0%	17.4%	21%
$\beta_{A.6}$	Credit and suretyship	28.0%	28.0%	33%
$\beta_{A.7}$	Legal expenses	8.0%	8.3%	10%
$\beta_{A.8}$	Assistance	5.0%	5.2%	6%
$\beta_{A.9}$	Miscellaneous	15.5%	15.9%	19%
$\beta_{A.10}$	NP reinsurance – property	20.0%	20.4%	24%
$\beta_{A.11}$	NP reinsurance – casualty	18.5%	18.9%	22%
$\beta_{A.12}$	NP reinsurance – MAT	16.5%	16.9%	20%
$\beta_{A.13}$	Accident	12.5%	12.9%	15%
$\beta_{A.14}$	Sickness	9.5%	9.8%	12%
$\beta_{A.15}$	Workers compensation	5.5%	5.7%	7%

4.23 The results of Step 2 reflect the factors suggested by CEIOPS. The MCR factors have been derived based on the factors calibrated for the SCR standard formula. Therefore in case a different calibration is adopted in the SCR standard formula, the calibration of the MCR linear formula factors should be adjusted accordingly, following the procedure described above.

4.2 Life linear formula

Linear fitting techniques

4.24 Following CEIOPS' advice in advice in CEIOPS-DOC-47/09 on the calculation of the MCR, the life linear formula is expressed as a function of the volume measures listed below. The formula specified in CEIOPS' advice is a linear combination of the variables, with the exception of the application of the with-profit floor, which sets a minimum value for the capital charge for participating contracts.

Index	Segment
Volume measure: technical provisions	
C.1.1	participating contracts, guaranteed benefits
C.1.2	participating contracts, discretionary benefits
C.2.1	unit-linked contracts without guarantees
C.2.2	unit-linked contracts with guarantees
C.3	non-participating contracts
Volume measure: capital-at-risk	
C.4	total capital-at-risk

4.25 It is noted that, in its draft advice in CP55 CEIOPS had suggested more granular capital-at-risk factors (with three segments depending on the outstanding term of contract, factors C.4.1 to C.4.3). Following stakeholder feedback on CP55, capital-at-risk is now treated as a single segment. However, a large part of the calibration work had been completed before this change; therefore some of the following explanations refer to multiple capital-at-risk factors.

4.26 To derive the calibration of the life linear formula factors, CEIOPS applied least-squares linear regression techniques to the data collected in QIS4, using 35% of the SCR standard formula as a proxy for the target confidence level (85% VaR).

4.27 The linear properties of these techniques allowed to carry out a linear fitting exercise without collecting individual undertaking data in a central database. This was possible because the coefficient matrices of the resulting linear equation systems are additive across populations of undertakings. Therefore it was sufficient to collect the relevant coefficient matrices for each country market instead of centralising individual undertaking data.

4.28 In light of the QIS4 results, it was expected that applying linear fitting techniques to the problem of life MCR calibration would face significant difficulties, including the following ones:

- possible significant non-linearity in the target function,
- possible material effect of hidden variables, e.g. market risk of assets and deferred taxes,
- lack of consistent interpretation or comparability of part of the data, especially with regard to future discretionary benefits.

4.29 Aware of these difficulties, CEIOPS tested several variants of least-squares linear regression techniques on QIS4 data in two iterations, and compared their results against each other and against expert judgement. The factors resulting from linear fitting tests were treated with extreme caution. It was recognised that linear regression alone, without expert judgement, was unlikely to lead to a satisfactory calibration.

4.30 Linear fitting was attempted both on an *absolute distance* and on a *relative distance* basis. The absolute vs. relative distance approaches seek to minimize, respectively, the following square distance functions:

$$\sum D_{absolute} = \sum_i \left(\sum_j \alpha_j V_{ij} - Z_i \right)^2$$

$$\sum D_{relative} = \sum_i \left(\frac{\sum_j \alpha_j V_{ij} - Z_i}{Z_i} \right)^2$$

Where:

- i is the running index for undertakings;
- j is the running index for volume measures;
- a_j is the linear formula factor for volume measure j;
- V_{ij} is volume measure j for undertaking i; and
- Z_i is the target function for undertaking i.

4.31 Regarding the choice of the target function, *net* and *gross* fitting approaches were both tested. By net and gross we refer to the adjustment of the SCR standard formula for the risk absorbing effect of future profit sharing.

4.32 In the net approach, the target function was 35% of the SCR of each undertaking, that is,

$Z = 0.35 \cdot SCR$,

$D_{absolute} = \left(\sum_j \alpha_j V_j - Z \right)^2$,

$D_{relative} = \left(\frac{\sum_j \alpha_j V_j - Z}{Z} \right)^2$.

4.33 In the gross approach, linear fitting was applied separately for the gross SCR *(BSCR + SCR_{Op})* and for the adjustment term for future profit sharing *(Adj_{FDB})*, with

$Z^{gross} = 0.35 \cdot \left(BSCR + SCR_{OpRisk} \right)$,

$Z^{FDB} = -0.35 \cdot Adj_{FDB}$,

$$D_{absolute}^{gross} = \left(\sum_j \alpha_j V_j - Z^{gross} \right)^2$$

$$D_{absolute}^{FDB} = \left(\alpha_{C.1.2} \cdot V_{C.1.2} - Z^{FDB} \right)^2$$, and

$$D_{relative}^{gross} = \left(\frac{\sum_j \alpha_j V_j - Z^{gross}}{Z^{gross}} \right)^2$$

$$D_{relative}^{FDB} = \left(\frac{\alpha_{C.1.2} \cdot V_{C.1.2} - Z^{FDB}}{Z^{FDB}} \right)^2 .$$

Note that in this approach $\alpha_{C.1.2}$ (the factor for technical provisions for discretionary benefits) is finally derived as the sum of a positive and a negative fitted factor (resulting from the Z^{gross} target and the Z^{FDB} target, respectively).

4.34 For the target function of the life side of composite undertakings, a proxy "life SCR" was disaggregated from the overall SCR result. This was calculated by decomposing the market risk and counterparty default risk modules, as well as the adjustment for deferred taxes according to the ratio of the life technical provisions to the total technical provisions, and by recalculating the operational risk charge from the life side volume measures.

4.35 The more unknown parameters are included in the fitting test or are calibrated at the same time, the less reliable the result becomes. Therefore the number of fitted factors was reduced to five in the first iteration, and to just two in the second one:

- In the 5-factor fitting, the $\alpha_{C.2.2}/\alpha_{C.2.1}$, $\alpha_{C.4.2}/\alpha_{C.4.1}$ and $\alpha_{C.4.3}/\alpha_{C.4.1}$ ratios were fixed identically to QIS4, i.e. only one independent factor was left for unit-linked technical provisions and capital-at-risk each[134].

- In the 2-factor fitting, all factors except $\alpha_{C.1.1}$ and $\alpha_{C.1.2}$ (the factors for technical provisions for guaranteed and discretionary benefits in respect of participating contracts) were fixed. The setting of the fixed factors was identical to the respective QIS4 parameters; however a set of increased capital-at-risk factors (1.5 times higher than in QIS4) was also tested in parallel to inform expert judgement.

- Furthermore, only when fitting for the gross target in the gross approach, no disctinction was made between the guaranteed and

[134] Please note that the decision to move to a single capital-at-risk factor in the linear formula design was made afterwards.

discretionary part of technical provisions (a single factor was fitted for both).

Linear fitting results

4.36 The first iteration of the exercise took into account QIS4 data of 334 life and 225 composite undertakings in 29 countries. The second iteration included QIS4 data of 340 life and 225 composite undertakings in 29 countries. (Some undertakings whose data were thought to be grossly unreliable were excluded by national QIS analysts.)

4.37 Generally, the relative distance approaches failed to yield meaningful factors (most of the fitted factors were very close to zero). In the relative distance approach, small and large undertakings influence the outcome by an equal weight, however, this approach apparently introduced such a level of noise to the target function that masked any possible linear trend.

4.38 In the absolute distance approaches, in the 5-factor fitting exercise the raw fitted factors were the following:

	Segment	**QIS4**	**5-factor fitting, net approach**	**5-factor fitting, gross approach**
life and composite undertakings				
$a_{C.1.1}$	participating/guaranteed	3.5%	2.0%	4.8%
$a_{C.1.2}$	participating/discretionary	–9%	–0.7%	–8.5%
$a_{C.2.1}$	unit-linked w/o guarantees	0.5%	0.5%	-0.1%
$a_{C.3}$	non-participating	1%–3.5%	2.6%	3.0%
$a_{C.4.1}$	capital-at-risk, >5 years	0.125%	0.03%	0.28%

4.39 These results illustrate the limitations of the linear fitting technique. Apart from the differences between the results of the net and gross approaches, country-by-country results also showed significant variations. There were examples of the fitted factors falling outside the acceptable range (e.g. a result falling below zero where a positive factor was expected).

4.40 Furthermore, it appeared that the outcome was heavily driven by the first two factors (relating to participating contracts). CEIOPS therefore focused its efforts to find the most appropriate factors $a_{C.1.1}$ and $a_{C.1.2}$, hoping that reducing the number of factors would lead to more reliable results. Even for these two factors, the net and the gross approaches yielded markedly different overall results:

- Net fitting results (absolute distance basis):

	5-factor fitting	**2-factor fitting, QIS4 CaR factors**	**2-factor fitting, high CaR factors**
		life undertakings	
$a_{C.1.1}$	2.9%	2.6%	2.4%
$a_{C.1.2}$	0.7%	-0.2%	-0.4%
		composite undertakings	
$a_{C.1.1}$	1.0%	1.4%	1.3%
$a_{C.1.2}$	-1.4%	-1.4%	-1.3%
		life and composite undertakings	
$a_{C.1.1}$	2.0%	1.7%	1.5%
$a_{C.1.2}$	-0.7%	-0.4%	-0.4%

- Gross fitting results (absolute distance basis):

	5-factor fitting	**2-factor fitting, QIS4 CaR factors**	**2-factor fitting, high CaR factors**
		life undertakings	
$a_{C.1.1}$	7.9%	7.4%	7.2%
$a_{C.1.2}$	-10.8%	-11.6%	-11.7%
		composite undertakings	
$a_{C.1.1}$	3.0%	3.3%	3.2%
$a_{C.1.2}$	–6.2%	–5.8%	–5.9%
		life and composite undertakings	
$a_{C.1.1}$	4.8%	4.9%	4.8%
$a_{C.1.2}$	–8.5%	–8.5%	–8.6%

4.41 Combined with further analysis of data, these results indicated that the gross SCR had a stronger linear relationship with the volume measures than the net SCR. The analysis also indicated that in the net approach, both factors are more sensitive to the non-linear effects and random distortions in the QIS4 data regarding discretionary benefits and SCR adjustments. For these reasons, the results of the gross fitting approach was selected as the starting point for the choice of the linear formula factors.

4.42 It is noted that, despite the effort put into finding the correct linear factors, a major improvement in the overall quantitative effect relative to QIS4 cannot be expected. In QIS4, the linear formula result was inside the 25%–45% SCR band for 154 out of 558 life and composite undertakings (28% of the results). Since QIS4, CEIOPS back-tested a range of alternative calibration proposals on the QIS4 datasets. In addition to testing the results of the above linear fitting approaches, independent expert adjustments of the QIS4 factors were also tested. None of the tested alternatives did materially increase the proportion of the results falling within the 25%–45% corridor. Restricting the majority of the life linear formula results to the corridor between 25% and 45% of the SCR would require a strong linear relationship between the volume measures and the (net) SCR, while the analysis of the data indicates that such a strong linear relationship is not present.

Choice of factors

4.43 Following the above analysis, the choice of the life linear formula factors was derived in the following three steps:

4.44 Step 1 – Set initial calibration to reflect the results of the gross fitting approach: Following the gross fitting results, $a_{C.1.1}$ and $a_{C.1.2}$ were set to 4.8% and –8.5% respectively. For the remaining factors, the QIS4 calibration was retained, adjusted for changes in the segmentation (these QIS4 factors had been informed by expert judgement during the preparation for QIS4, reflecting a ranking of the risks of the respective segments):

- for the $a_{C.2.1}$ and $a_{C.2.2}$ factor in respect of unit-linked contracts, the QIS4 factors were retained;
- for the $a_{C.3}$ factor in respect of non-participating contracts, a 2.8% value was chosen, which was between the gross and net fitted factors, and also fell in between the QIS4 factors of the former sub-segments;
- for the $a_{C.4}$ factor in respect of capital-at-risk, a 0.095% factor was chosen, leading to the same aggregate risk charge as the former more granular factors in QIS4.
- The with-profit floor parameter was also left unchanged at 1.5%. This parameter resulted too from expert judgement, however the net fitting results indicate that the choice of this parameter was in the correct range (we note that the with-profit floor parameter has been included to keep the with-profit charge in a reasonable range for those countries where, due to the specificities of the profit sharing regime, the gross approach does not work well).

4.45 Step 2 – Remove bias from the weighted average: Next, the weighted averages of the linear formula to SCR ratio (weighted by the SCR) were calculated for each country, and the weighted average of the country weighted averages was calculated (where countries were weighted according to the number of relevant undertakings in the QIS4 sample). The initial calibration was then adjusted by a factor of 0.85 to adjust the weighted average of country averages to the 35% target.

4.46 Step 3 – Adjust for changes in SCR calibration: A single-factor adjustment was applied to the calibration in order to take into account to overall change in the level of the SCR standard formula following the proposed new calibrations (the resulting factors were also rounded). The setting of the adjustment factor (1.5) took into account the assessment of the impact of SCR calibration changes.

4.47 The results of the above steps are the following:

Factor	**Segment**	**QIS4**	**Step 1**	**Step 2**	**Step 3**
Volume measure: technical provisions					
WP_floor	participating/guaranteed	1.5%	1.5%	1.3%	1.9%
$a_{C.1.1}$	participating/guaranteed	3.5%	4.8%	4.1%	6.1%
$a_{C.1.2}$	participating/discretionary	–9%	–8.5%	-7.2%	-11%
$a_{C.2.1}$	unit-linked without guarantees	0.5%	0.5%	0.4%	0.6%
$a_{C.2.2}$	unit-linked with guarantees	1.75%	1.75%	1.5%	2.2%
$a_{C.3}$	non-participating	1%–3.5%	2.8%	2.4%	3.5%
Volume measure: capital-at-risk					
$a_{C.4}$	total capital at risk	0.05% – 0.125%	0.095%	0.081%	0,1%

4.48 The results of Step 3 reflect the factors suggested by CEIOPS. The MCR factors have been derived based on the factors calibrated for the SCR standard formula. Therefore in case a different calibration is adopted in the SCR standard formula, the calibration of the MCR linear formula factors should be adjusted accordingly, following the procedure described above.