Combined Annex for the Consultation on the future development of the pension protection levy

This document combines five separate annexes:

Please note that these annexes contain a significant amount of technical material, which explains the theory behind the proposed new levy formula, and may not be accessible to all.

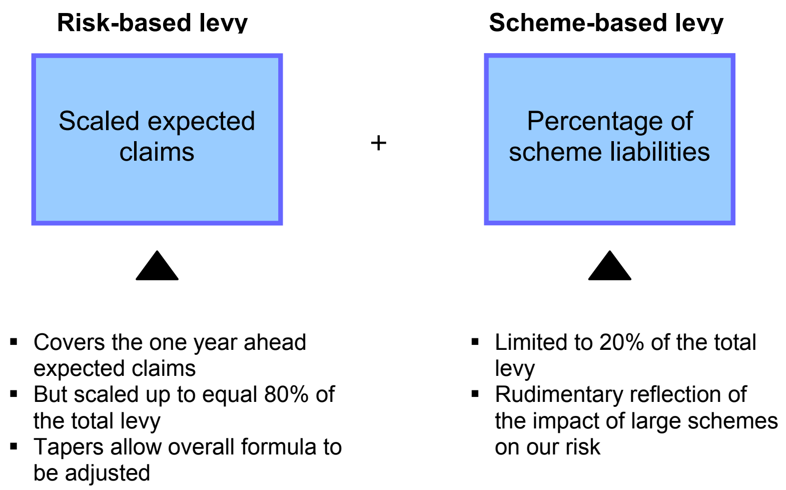
Annex A

Impact analysis

1. Overview

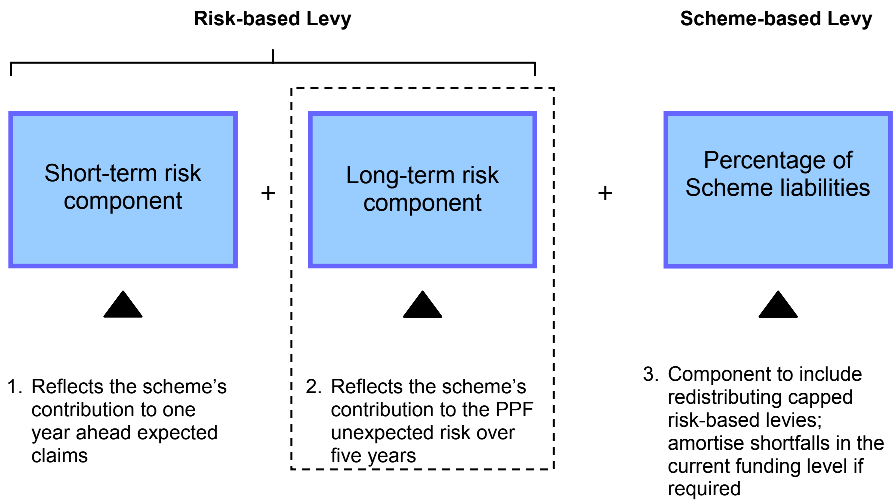
The current formula (as depicted in Figure 1) consists of two components. The first component is a risk-based levy that incorporates a short term insolvency probability (P) and scheme short-term underfunding risk (U). The second component is a scheme-based levy which is a fixed percentage of the scheme liabilities.

Figure 1: Current levy formula



The proposed formula will add a second component to the risk-based levy which covers schemes' contribution to the PPF unexpected risk. The scheme-based levy could be used to distribute the capped risk-based levies and to repair any deficit. The proposed formula is shown in Figure 2.

Figure 2: Proposed levy formula with second risk-based component



2. Description of the data set

The data set used in the comparison is that used for the 2008/09 levy scaling factor calculation and includes schemes' liabilities, assets, and asset allocations as well as the contingent assets recognised by the PPF.

Figure 3 shows the distribution of scheme funding levels. Under the current formula, any scheme with more than 140 per cent funding is not charged a risk-based levy.

Figure 3: Distribution of schemes by funding level

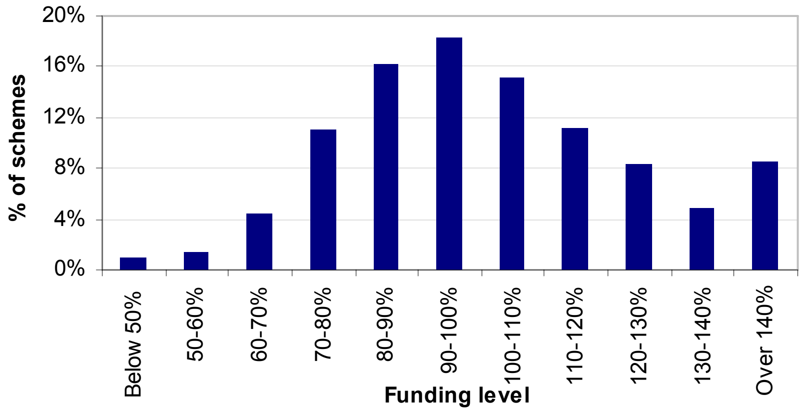
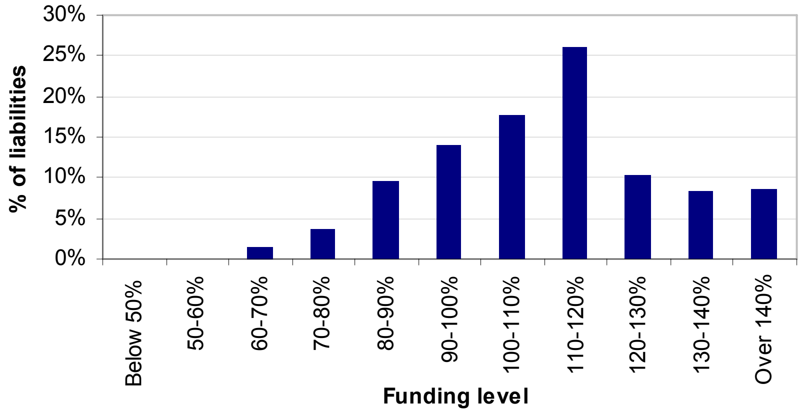


Figure 4: Distribution of scheme liabilities by funding level



The following figures show the distribution of schemes and scheme liabilities by credit rating and insolvency groups. There is a significant concentration of schemes in the top insolvency groups used in Purple 2007,[1] however, there is no such concentration in the better credit rating groups. In terms of liabilities, it seems that larger schemes have better insolvency probabilities, as well as better credit ratings.

[1] http://www.pensionprotectionfund.org.uk/purple_book_ii_2007_final_version.pdf

Figure 5: Distribution of schemes by credit rating

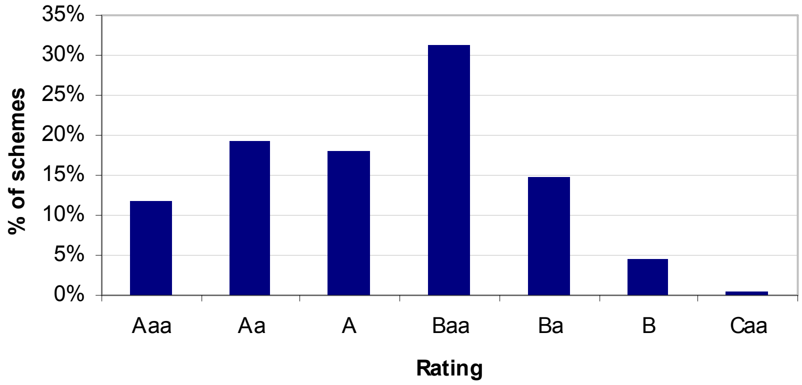


Figure 6: Distribution of scheme liabilities by credit rating

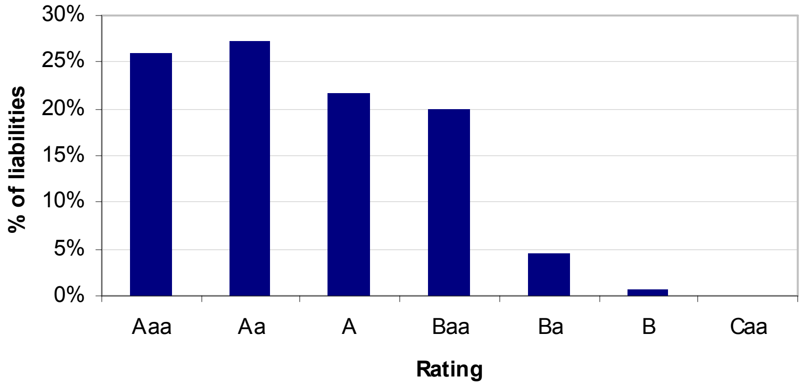


Figure 7: Distribution of schemes by insolvency group (Purple 2007)

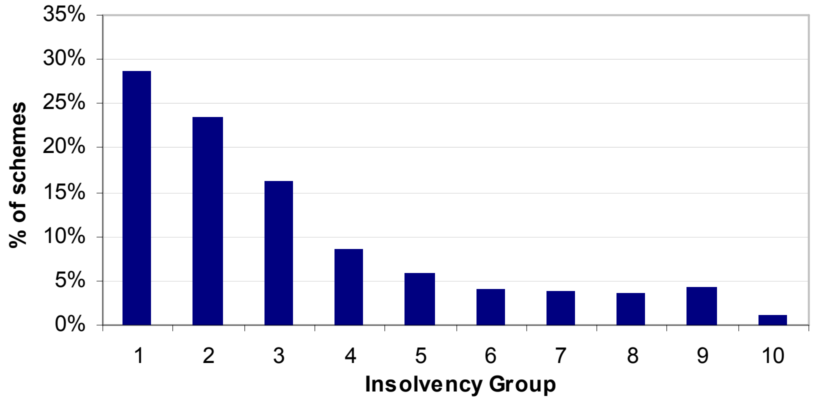
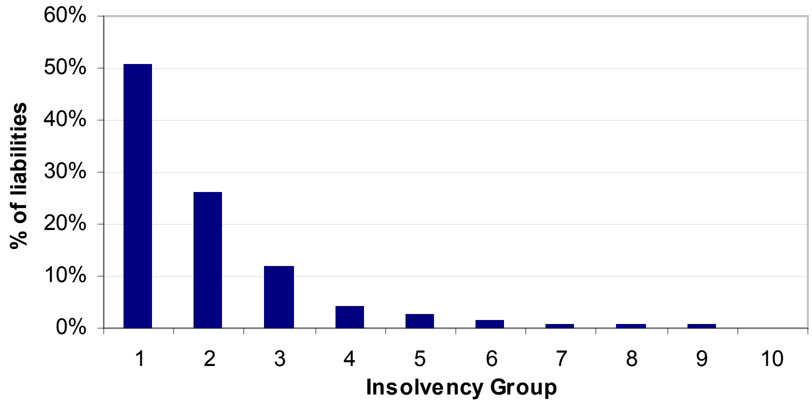


Figure 8: Distribution of scheme liabilities by insolvency group (Purple 2007)



The individual probabilities of insolvency (p) are provided by Dun & Bradstreet.

Table 1 shows the mappings used to relate the p to an insolvency group from Purple 2007. Table 2 shows the mappings used to relate the p to the credit rating system used by the PPF's Long-term Risk Model (LTRM).

Table 1: Insolvency group and range for p

Insolvency Group	p
1	0 – 0.074%
2	0.074 – 0.1804%
3	0.1804 – 0.3033%
4	0.3033 – 0.4286%
5	0.4286 – 0.5548%
6	0.5548 – 0.7241%
7	0.7241 – 0.9609%
8	0.9609 – 1.3044%
9	1.3044 – 3.521%
10	Greater than 3.521%

Table 2: Credit rating and range for p

Credit rating	Minimum D&B insolvency probability	Maximum D&B insolvency probability
Aaa		0.03%
Aa	0.03%	0.08%
A	0.08%	0.17%
Baa	0.17%	0.5%
Ba	0.5%	1.4%
B	1.4%	6.4%
Caa	6.4%	19%
Ca	19%	

3. Proposed formula including second risk-based component

3.1. Overview

Figure 9 shows a possible formula which includes the second risk-based component relating to schemes' contribution to the PPF unexpected risk, either without or with inclusion of an investment risk measure. The scheme-specific investment risk is calculated based on the data collected on each scheme's asset mix and liability profile. It should be noted that obtaining additional information in relation to scheme investment strategy (for example the results of internal models on investment risk) would likely change the distributional impact.

Figure 9: Proposed formula without investment risk

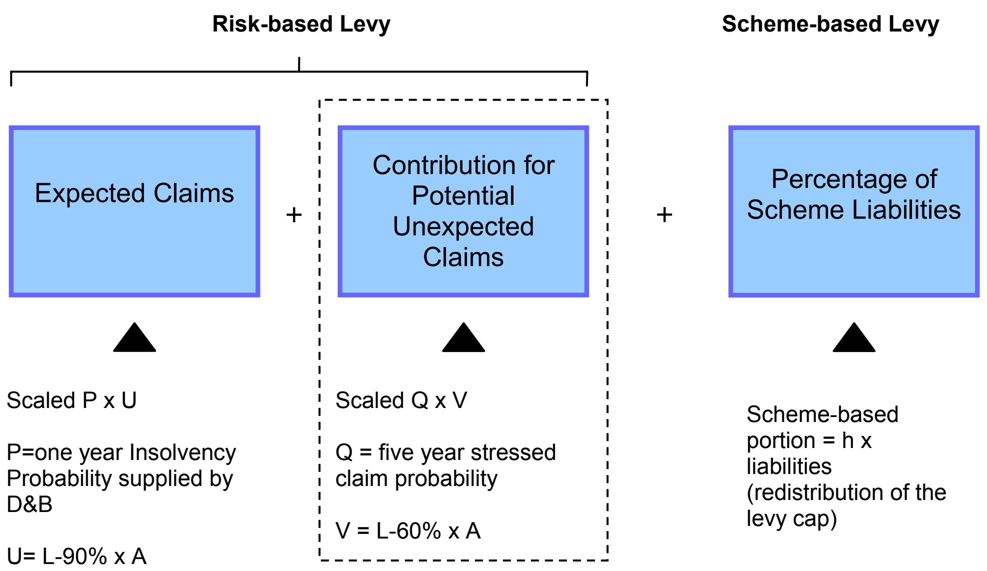
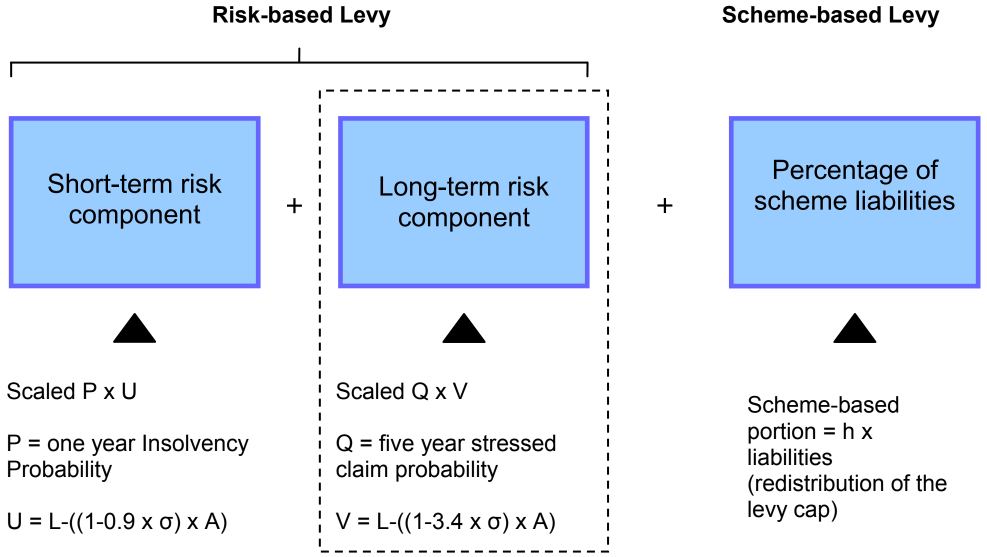


Figure 10: Proposed formula - with investment risk



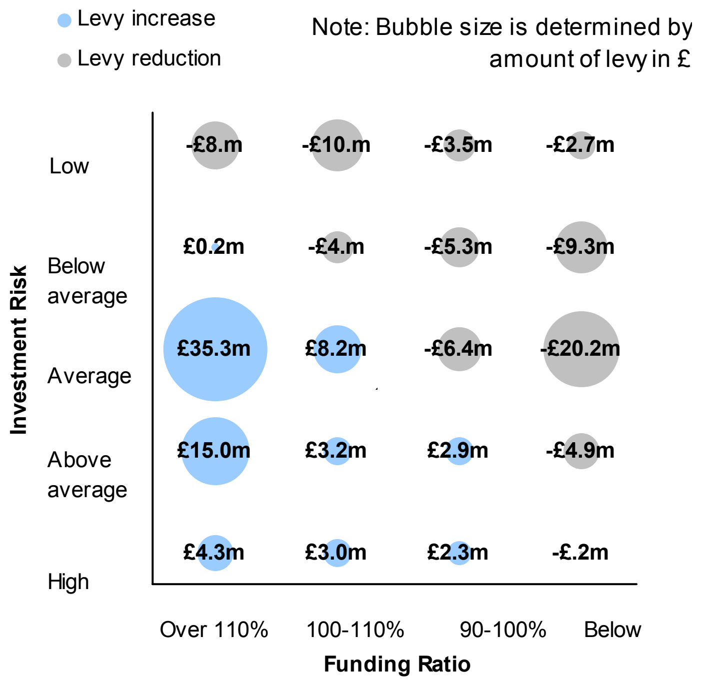
Note that U and V have a minimum value of 0. Sigma (σ) is the investment risk measure (see the Glossary in the main document for definitions).

3.2. Impact assessment

Figure E in Chapter 6 of the main document shows that, in general, schemes with high short-term risk (i.e. those with lower funding and/or greater insolvency scores) gain from the introduction of the new formula taking account of investment risk. Comparing the change in levy relative to the liabilities of the scheme it is noticeable that, for those that lose out, changes are on average small in relation to the size of the scheme (measured by liabilities). Furthermore, the improvement is significant for those who gain. Underfunded schemes with weak employers are likely to be constrained in their ability to make deficit reduction contributions, so a lower levy may help improve funding as well as being fairer.

Another group of schemes that tend to gain are those that have a relatively low investment risk. Figure 11 charts changes in the levy for schemes with different levels of investment risk and funding ratio. It shows that schemes with higher investment risk generally pay more, but that this increase is small compared to liabilities.

Figure 11: Increase/Decrease in levies by investment risk and funding ratio



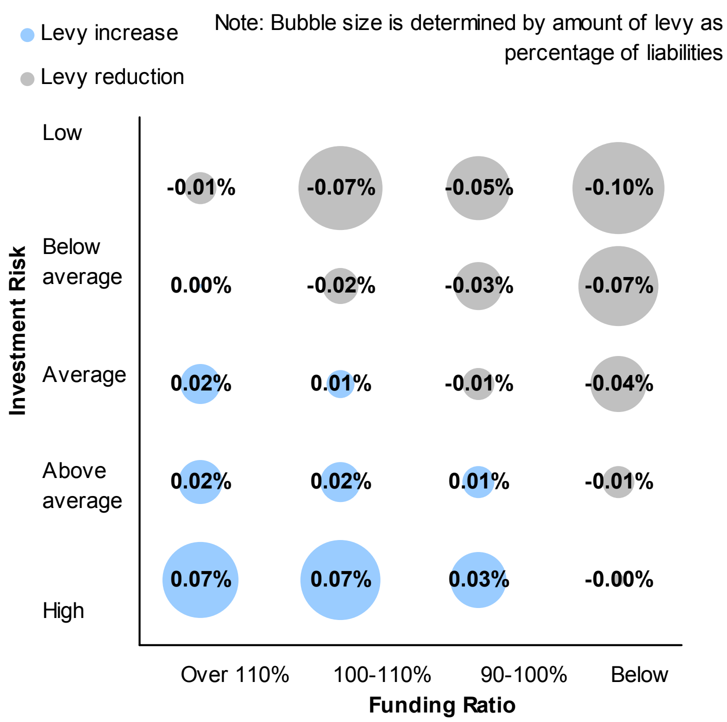


Figure 12 shows the distribution of changes in schemes' levies. Forty-one per cent of schemes will pay a levy under the proposed formula within 25 per cent of their current levy. 50 per cent of schemes will show a reduction in their levy, while 17 per cent will show an increase of up to 25 per cent compared with their current levy. 24 per cent of schemes will see a decrease in their levy of less than 25 per cent. Nine per cent of schemes will experience a levy decrease of more than 50 percent. Eleven per cent of schemes will experience a levy increase greater than 100 per cent, and around 6 per cent will have their levy increase by more than 200 per cent. However, it should be noted that these schemes paid very small levies in the past, benefiting from the focus on short-term risk. Hence the absolute increase in the levy for these schemes is small.

Figure 12: Distribution of increases in levy under the proposed new formula

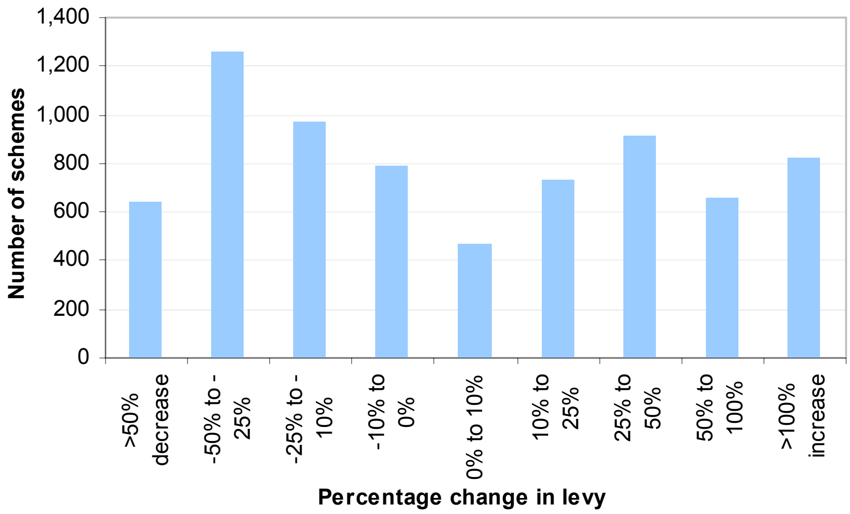


Figure 13 shows the distribution of the levy as a percentage of liabilities. Under the proposed formula there will be a narrower spread of levies expressed as a percentage of liabilities; fewer schemes paying between 0 per cent and 0.04 per cent of liabilities as well as fewer schemes paying more than 0.50 per cent of liabilities. Under the current formula, 15 per cent of schemes pay a levy greater than 0.5 per cent of their liabilities. The proposed formula reduces this to 10 per cent. Thus there will be more schemes (70 per cent compared with 52 per cent under the current formula) paying a levy that is between 0.04 per cent and 0.50 per cent of liabilities.

Figure 13: Distribution of levy as a percentage of liabilities under current and proposed formulae

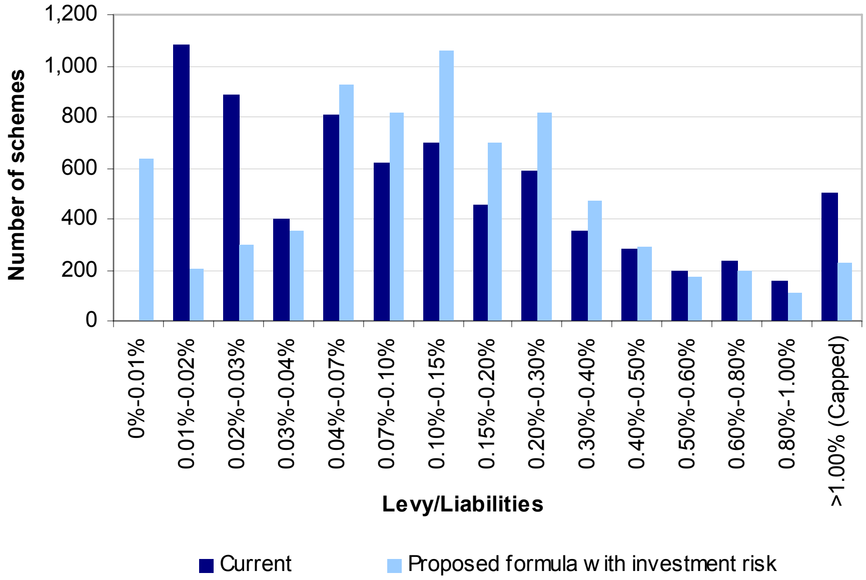
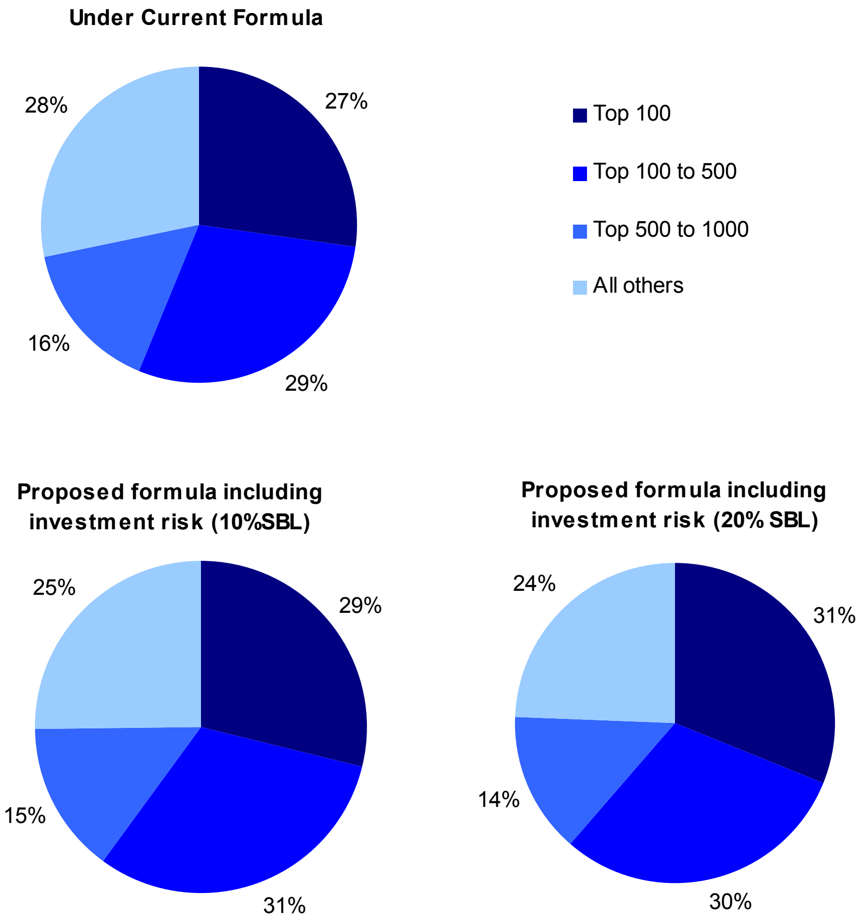


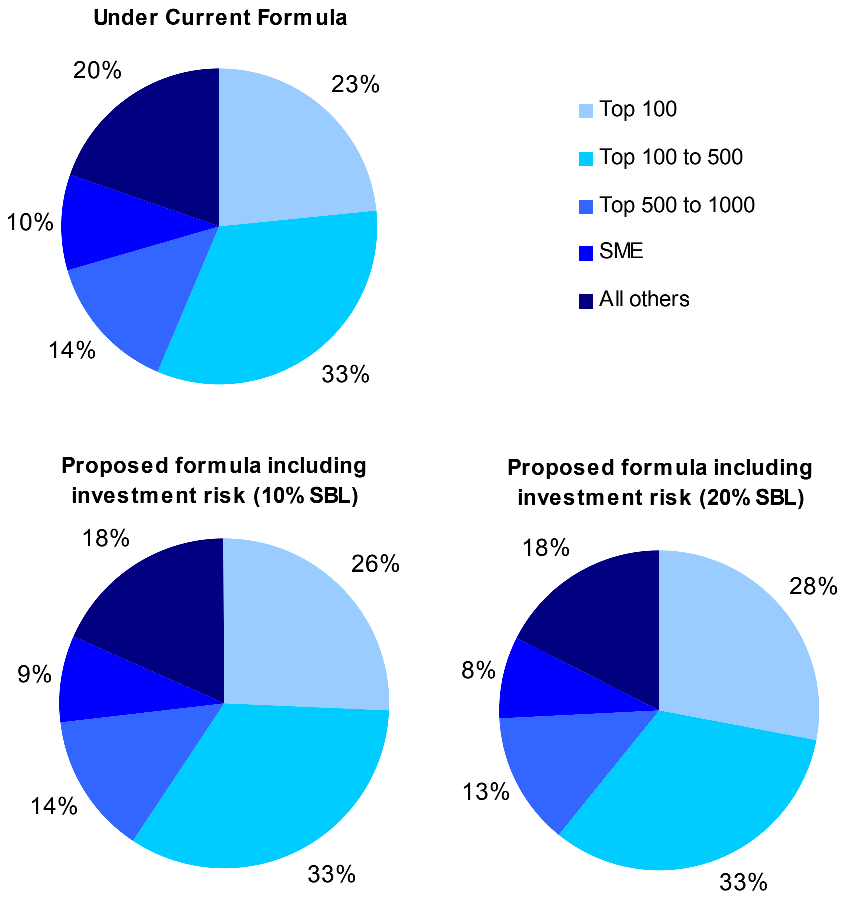
Figure 14a shows the distribution of the levy by ranked scheme size, measured by liabilities. It can be seen that the distribution of levy by scheme size remains fairly similar under the proposed formula albeit with a slight rise in the proportion of the levy charged to the largest schemes.

Figure 14a: The distribution of levy by scheme size (measured by liabilities)



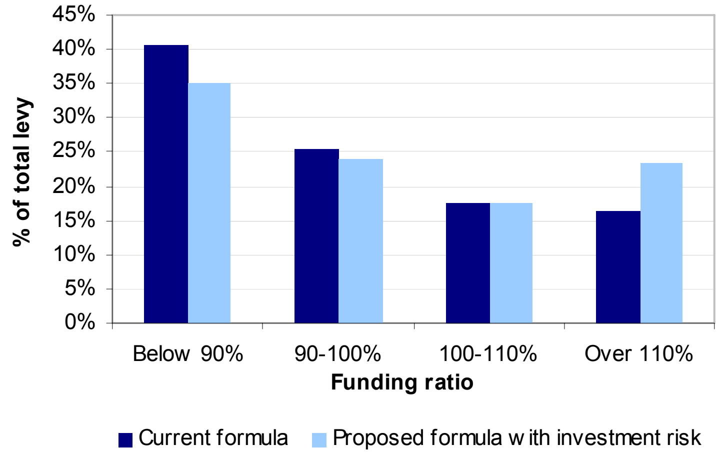
We can also measure scheme size in relation to number of members (Figure 14b). This shows a similar pattern, and provides a guide to the impact on small and medium sized enterprises (SMEs). It will be seen that there is a reduction of 10 per cent in the share of the levy paid by schemes with 300 or less members (a group which will be broadly similar to SME's though it will include some small schemes run by larger businesses).

Figure 14b: The distribution of levy by scheme size (measured by scheme members)



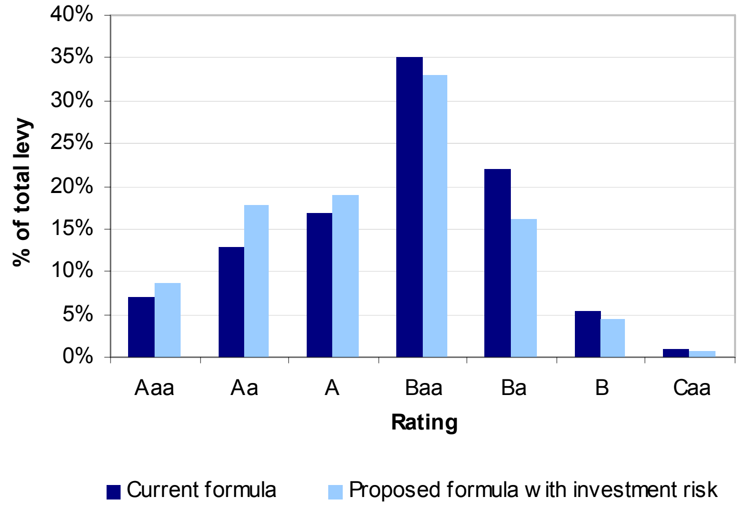
As Figure 15 shows, the distribution of levy by funding level shows limited change under the proposed formula, although a decline in levy paid by the least well funded schemes and an increase for the better funded are evident.

Figure 15: Distribution of levy by funding level under proposed new formula



The proposed levy formula will redistribute the levy to scheme sponsors with higher credit ratings, as seen in Figure 16. This reflects the fact that the current formula favours these schemes through its focus on short-term risk. Many of the better rated sponsors' schemes make significant contributions to the PPF's tail risk.

Figure 16: Distribution of levy by credit rating



The following figures show the distribution of the investment risk factor by schemes (number of schemes and percentage of scheme liabilities). As can be seen, a large number of schemes have an investment risk factor between 8 and 14 per cent.

Figure 17: Distribution of scheme investment risk (% of schemes)

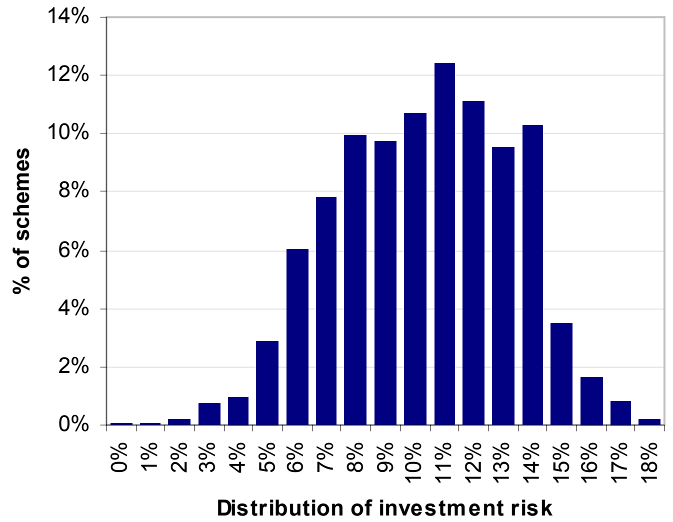
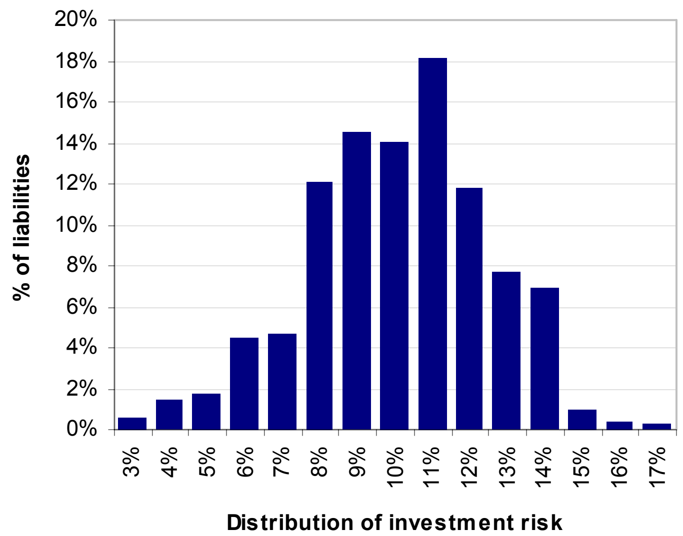


Figure 18: Distribution of scheme investment risk (% of scheme liabilities)



The figures below show how the levy paid by schemes with different insolvency probabilities (here represented by three example credit ratings) will vary depending on their funding level. They assume the scheme has average investment risk.

It can be seen that a scheme whose employer has a higher insolvency probability always pays more as a proportion of liabilities than a similarly funded scheme with a stronger employer. It can also be seen that the new formula has fewer points of dramatic change in levy (Figure 21) and that the rate of reduction in levy is slower at levels of funding below the current start of the levy taper (121 per cent). These factors can be expected to help levy stability since the less sensitive the levy collected is to changes in funding, the less the need to adjust the new levy using scaling factors.

Figure 19: Levy as proportion of liabilities for Aa rated company

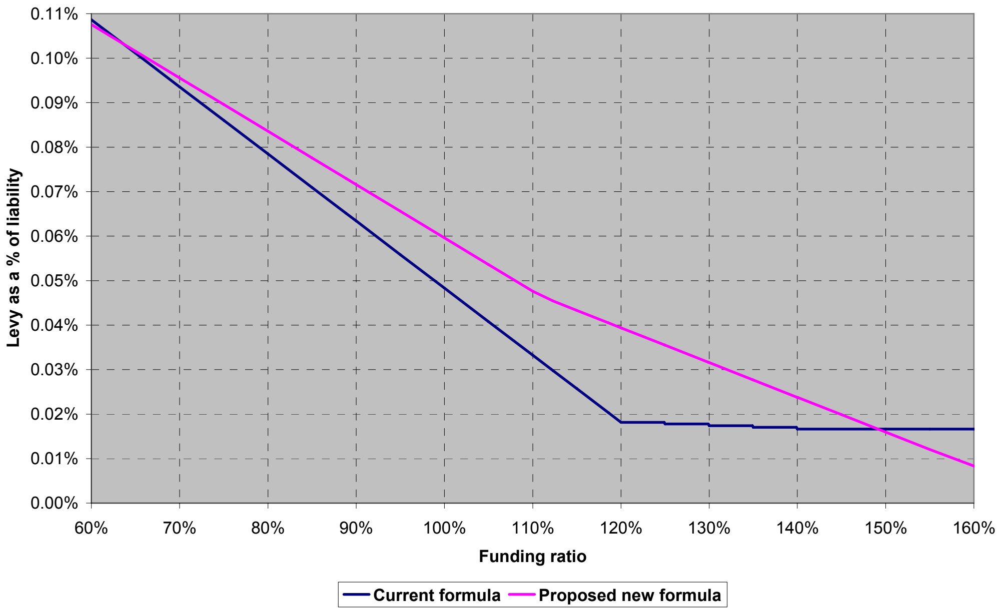


Figure 20: Levy as proportion of liabilities for Baa rated company

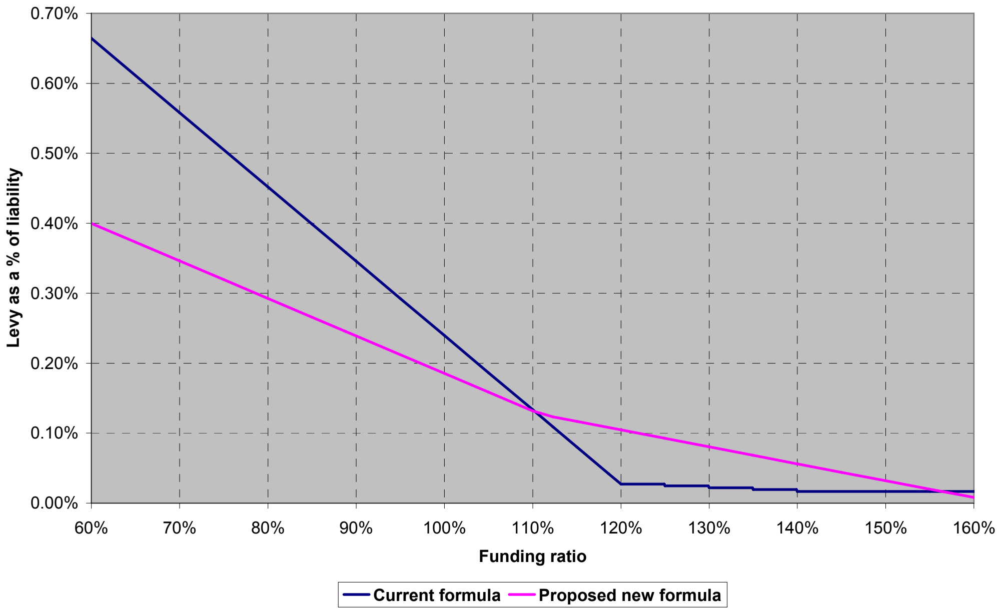
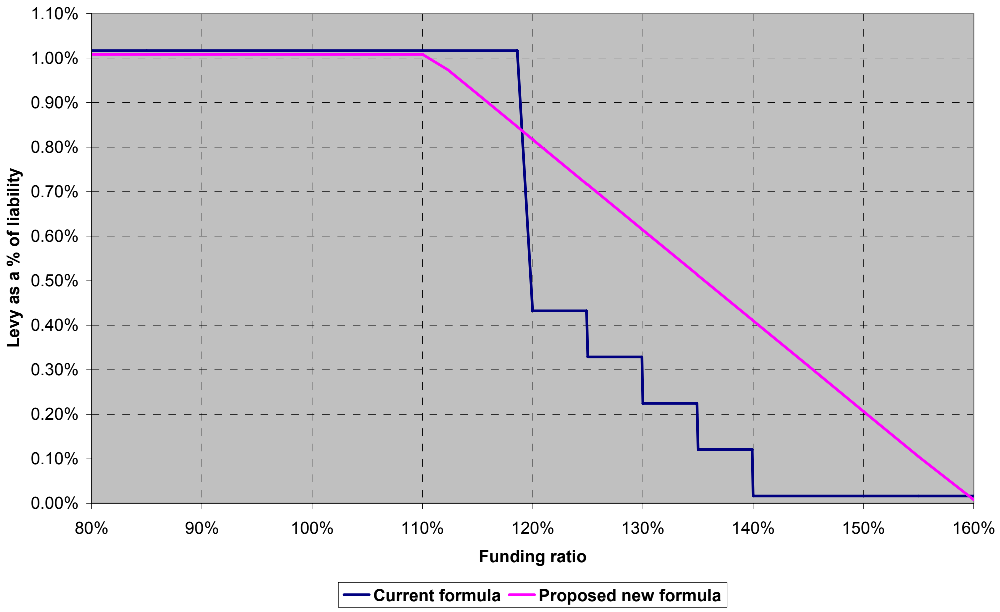


Figure 21: Levy as proportion of liabilities for Caa rated company



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Annex B

Derivation of the simple levy formula

1. Components of the simple levy formula

A simple levy formula[2] should be able to calculate a levy which is close to a scheme's share of the combined risk measure while still adhering to the PPF's principles of fairness, proportionality and simplicity.

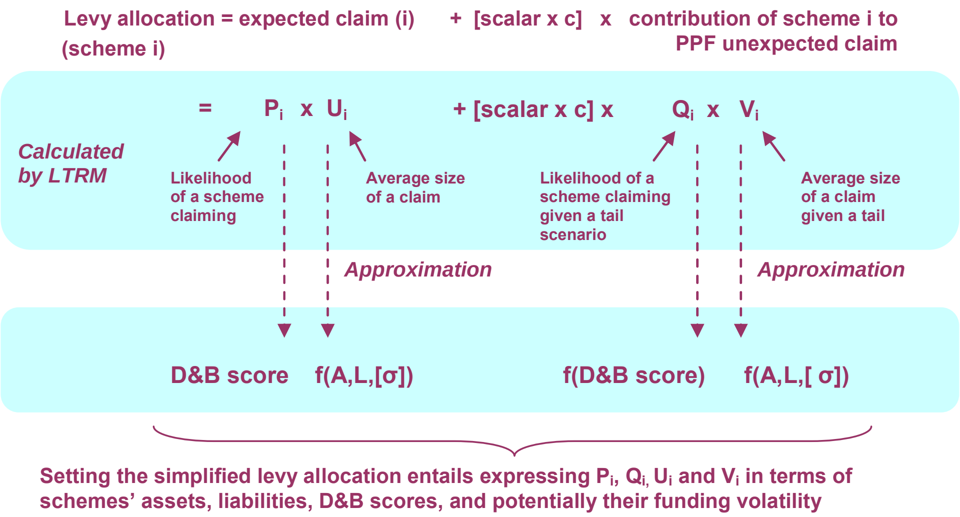
The current formula uses a one-year insolvency probability, underfunding risk and a single scaling factor. As explained in the main consultation document, the new levy formula should reflect both short-term expected risk and long-term unexpected risk. This formula would be fairer to individual schemes.

As discussed in Annex E, the combined risk measure approach provides a scheme's fair allocation of the levy. However, in practice it cannot be used to set an individual scheme's levy because:

- The calculation method is not simple
- The combined risk measure is an output of the long-term risk model (LTRM), which is rather complex and not easily accessible to levy payers; and
- Schemes would therefore not be able to easily predict the amount of their levy bill.

A simple formula can be used to approximate the fair allocation from the LTRM using objective and measurable scheme-level data. The data and methods of approximation are described below.

Figure 1: Method for approximating the fair allocation



[2] The simple levy formula is used to calculate schemes' levy bills. For information on the more complex theoretical levy formula, based on the long-term risk model, please see page 17 of *The Future Development of the Pension Protection Levy*, August 2007, http://www.pensionprotectionfund.org.uk/levy_consultation_aug_07.pdf

A scheme's one year insolvency probability (P) is based on the Dun & Bradstreet failure scores and associated probabilities of insolvency (p) of its sponsoring employer(s). The measurement of the scheme's one year underfunding risk (U) is a function its assets, liabilities and, the scheme's investment risk (σ), based on the volatility of its funding level. The product of P and U will be the scheme's expected claim.

The long-term risk component of the formula is approximated using the probability of insolvency (Q) and underfunding risk (V) over five years in adverse economic scenarios. Similarly to U, V is a function of the scheme's funding level and potentially the investment risk of the scheme.

In order to determine a scheme's new simple levy formula, a number of options have been considered. The options have ranged from including additional factors into the regression discussed in Chapter 2 to the inclusion of a size component to the formula, as well as the use of non-linear regressions. These options, while possibly providing a better fit, were deemed as being unsuitable as they were too complex and unintuitive.

2. Determining the parameters for the simple levy formula

The parameters described in this annex and in the main body of this consultation document are indicative, based on data to 2008. Final parameters for 2011/12 would be set in the levy determination for 2011/12 in autumn 2010.

2.1. Regression for a simple formula without investment risk

Two new possible options of a simple levy formula have been derived using the methodology described in this document. This section will describe the methodology used to estimate the formula that does not acknowledge scheme-specific investment risk.

Regressions are used to find simple explanatory factors to model outputs from the LTRM. The outputs are P, Q, U and V. P is the average frequency with which a scheme defaults (i.e. the sponsoring employer becomes insolvent and the scheme is underfunded) over a one year time horizon. U is the measure of the PPF average loss in one year by the scheme in all scenarios. Q is the number of times that a scheme defaults over five years in the adverse economic scenarios calculated by the LTRM, with V the measure of the PPF loss in those scenarios.

The explanatory variables used are the assets and liabilities of the schemes and the scheme investment risk. The assets and liabilities are inputs into the LTRM and the funding level volatility provides a measure of investment risk.

2.1.1. Parameters for the simple formula without investment risk

Table 1 illustrates the data set that is used for the regressions. The first regression conducted was on the estimated expected loss over one year given a scheme default, U_i. The two columns that are shaded in Table 1 show a sample of how the LTRM output used in the regression may appear.

Table 1: Example of data used in regression to determine U

Scheme No.	Short-term exposure (U_i)	Long-term tail exposure (V_i)	Assets (A_i)	Liabilities (L_i)	U_i / L_i	V_i / L_i	A_i / L_i
1	20	40	100	95	21%	42%	105%
2	40	60	220	200	20%	30%	110%
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
7000	500	1500	1000	1600	31%	94%	63%

We conducted the approximations for the simple formula using regressions and the formula in Equation 1. The additional term ε_i is an error term, which is the distance between the estimated point on the regression line and the actual scheme's position on the scatter plot.

Equation 1: Regression on U_i without investment risk

$$\frac{U_i}{L_i} = \alpha_0 + \alpha_1 \left(\frac{A_i}{L_i} \right) + \varepsilon_i$$

The results of the above regression formula are shown below in Table 2. The funding level coefficient corresponds to α_1 while the constant is α_0.

Table 2: Results of U without investment risk[3]

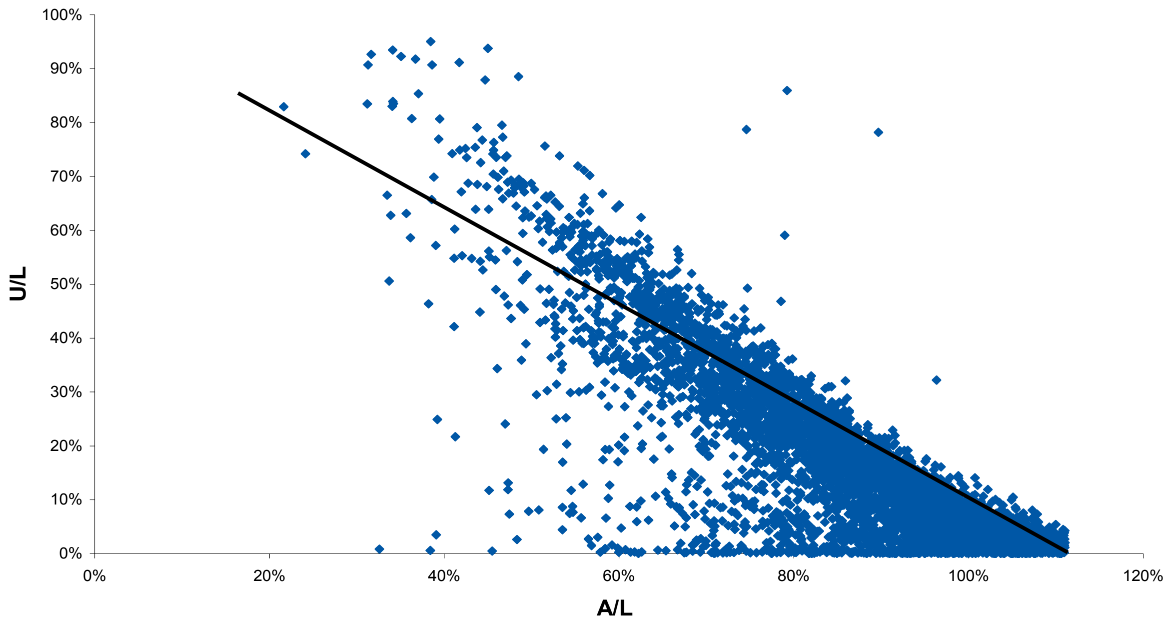
Short term exposure	Constant (α_0)	Funding level (α_1)
Linear Coefficients	1	-0.91[4]
R-squared	0.67	
F-stat	10,330	5,161 (DoF)[5]
T-stat	125.7	-101.64

[3] An iterative process has been used to truncate the sample. The adjustment is required to reflect the cap whereby schemes can make a positive claim on the PPF if they are underfunded, but can not make a negative claim on the PPF if they are overfunded. This adjustment is achieved through an iterative process whereby the regression is run and based on its results the sample is cropped. The regression is re-run on the truncated sample and the process repeated. The coefficients are shown after this iterative adjustment.

[4] Rounded in the formula below as 0.9

[5] (DoF) stands for Degrees of Freedom

Figure 2: Scatter plot for U regression[6]



From this formula, it is possible to arrive at a formula that fits well with the Board's principles of simplicity. Multiplying liabilities through the formula results in Equation 2.

Equation 2: Simplified formula for U_i without investment risk

$$\hat{U}_i = \alpha_0 \times L_i + \alpha_1 \times A_i + \varepsilon_i$$

With the coefficients calculated, the final equation to produce an estimate of each scheme's underfunding is shown in Equation 3.

Equation 3: Estimation of U_i

$$\hat{U}_i = L_i - 0.9 \times A_i$$

As with the U parameter, Table 3 is illustrative of the data set that is used to determine the V parameters. This regression was conducted using the estimated tail exposure of the PPF, V. The estimated tail exposure of scheme *i* is calculated by looking at those LTRM scenarios around the 97.5th percentile[7] in which scheme *i* makes a claim and calculating the average size of that claim. The regression was performed on data from the two shaded columns in Table 3.

6 Visually, it is difficult to see the true density of the distribution of the data, which is highly concentrated.
7 In fact, we take 12,500 scenarios from the 94th to the 99th percentile as described in Annex D.

Table 3: Example of data used in regression to determine V

Scheme No.	Short term exposure (U_i)	Long-term tail exposure (V_i)	Assets (A_i)	Liabilities (L_i)	U_i /L_i	V_i /L_i	A_i /L_i
1	20	40	100	95	21%	42%	105%
2	40	60	220	200	20%	30%	110%
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
7000	500	1500	1000	1600	31%	94%	63%

Equation 4 shows the formula that was used to calculate the original parameters for V. Note the similarity to Equation 1.

Equation 4: Regression on V_i without investment risk

$$\frac{V_i}{L_i} = \beta_0 + \beta_1\left(\frac{A_i}{L_i}\right) + \varepsilon_i$$

The results of the above regression formula are below in Table 4 and have similar meaning to the results from Table 2.

Table 4: Results of V without investment risk[8]

Long-term tail exposure	Constant ($ß_0$)	Funding Level ($ß_1$)
Linear Coefficients	1	-0.64[9]
R-squared	0.40	
F-stat	4,201	6,617 (DoF)[10]
T-stat	105.42	-64.81

The results of this regression result in the formula for our approximation of long-term risk shown in Equation 5 below.

Equation 5: Estimation of V_i

$$\hat{V}_i = L_i - 0.6 \times A_i$$

2.1.2. Parameters from regression without investment risk

After all simplifications are made, the resulting equations are shown in Equation 6.

[8] In the raw regression results, the coefficient for $ß_0$ does not equal one for a number of reasons, including for example interest rate risk. The impact of this is taken into account in Q rather than the underfunding level (V). The results in Table 4 are shown after making this adjustment.
[9] Rounded in the formula as 0.6
[10] (DoF) stands for Degrees of Freedom.

Equation 6: Proposed levy parameters, without investment risk

$$U_i = \max\left[0, L_i - (0.9 \times A_i)\right]$$
$$V_i = \max\left[0, L_i - (0.6 \times A_i)\right]$$

2.2. Regression for the simple formula with investment risk

Once the investment risk measure, σ (see Annex D), has been calculated for each scheme, we are in a position to estimate the expected and unexpected loss parameters. As in the case without investment risk, the dataset for this estimation is drawn from the LTRM (Table 5) and consists of the previous variables augmented this time by the data on each scheme's investment volatility.

Table 5: Example of data used in regression to determine U – with investment risk

Scheme No.	Short term exposure (U_i)	Long-term exposure (V_i)	σ_i	Assets (A_i)	Liabilities (L_i)	U_i / L_i	V_i / L_i	$(A_i/L_i) \times \sigma_i$	A_i / L_i
1	20	40	7%	100	95	21%	42%	7%	105%
2	40	60	10%	220	200	20%	30%	11%	110%
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
7000	500	1500	13%	1000	1600	31%	94%	8%	63%

We conduct the approximations for the simple formula with investment risk using regressions and the formula in Equation 7 (and similarly for V_i).

Equation 7: Regression with investment risk

$$\frac{U_i}{L_i} = \alpha_0 + \alpha_1\left(\frac{A_i}{L_i}\right) + \alpha_2\left(\frac{A_i}{L_i}\right)\sigma_i + \varepsilon_i$$

The results of the above regression formula are shown below in Table 6 (for U_i) and Table 7 (for V_i).

Table 6: Results of U with investment risk[11]

Short term exposure	Constant (α_0)	Funding level (α_1)	Investment Risk (α_2)
Linear Coefficients	1	-1	0.85[12]
R-squared	0.68		
F-stat	5,457	5160 (DoF)[13]	
T-stat	126.79	-78.46	13.97

Table 7 : Results of V with investment risk

Long-term tail exposure	Constant ($ß_0$)	Funding Level ($ß_1$)	Investment Risk ($ß_2$)
Linear Coefficients	1	-1	3.38[14]
R-squared	0.64		
F-stat	10,330	5161 (DoF)[15]	
T-stat	139.90	-99.68	61.11

The resulting parameters are illustrated below in Equation 8.

Equation 8: Proposed levy parameters, with investment risk

$$U_i = \max\left[0, L_i - \left(1 - 0.9 \times \sigma_i\right) \times A_i\right]$$
$$V_i = \max\left[0, L_i - \left(1 - 3.4 \times \sigma_i\right) \times A_i\right]$$

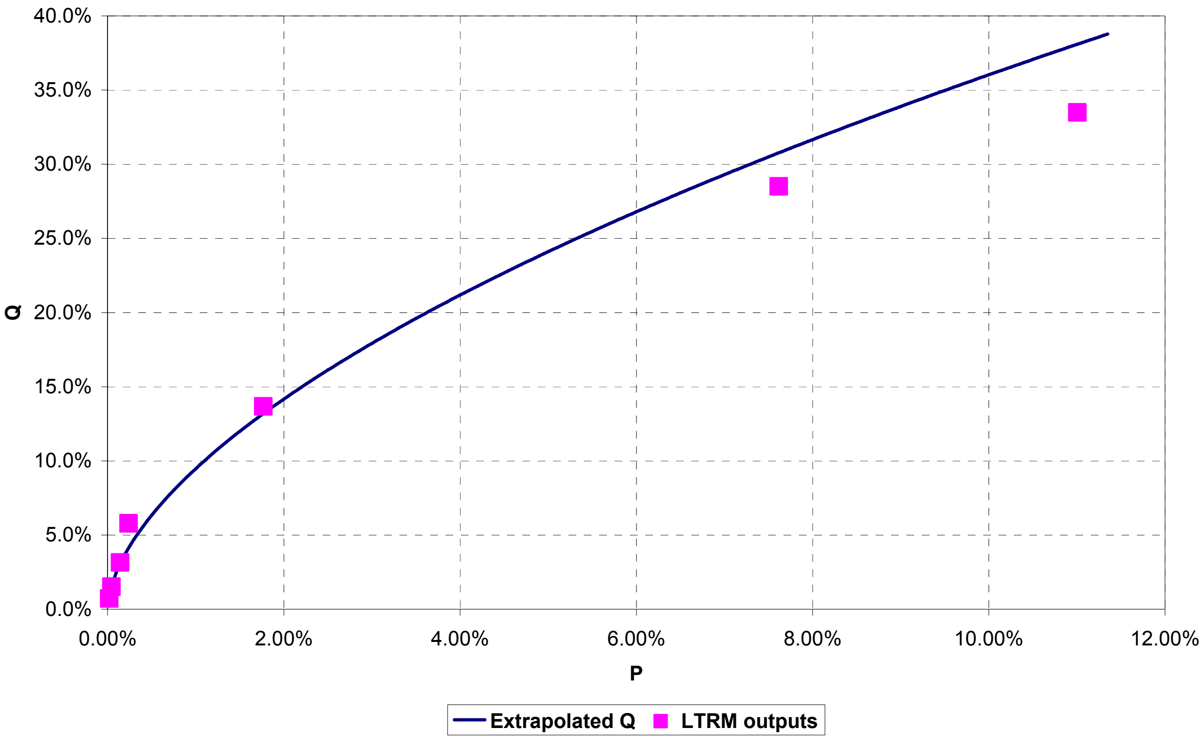
2.3. Calculation of P and Q

In order to calculate a scheme's levy, we also need a simple approximation of the likelihood of claiming, both in the short-term (P) and in adverse economic scenarios over five years (Q). P_i, the one year insolvency probability, is supplied by the insolvency ratings provider. To develop a simple approximation of $Q_{i,}$ the five year probability of insolvency in adverse economic scenarios, for each scheme, we again use the LTRM output. Taking the set of scenarios which determine the PPF's long-term risk (approximated by the 94th to 99th percentile) we look at the proportion of those scenarios in which scheme i makes a claim on the PPF. Our aim is to derive a simple relationship between a scheme's P_i and its Q_i. We therefore bracket schemes into P_i groupings (i.e. schemes with the same short-term default probability) and calculate the

[11] As with the previous regressions, the sample was adjusted to reflect the impact of the cap of 0 on claims
[12] Rounded in the formula as 0.9
[13] (DoF) stands for Degrees of Freedom
[14] Rounded in the formula as 3.4
[15] (DoF) stands for Degrees of Freedom

average Q_i for that bracket. This enables us to calculate a translation from a scheme's P_i to its Q_i. Q is only calculated for a limited number of rating categories, making it necessary to extrapolate for all insolvency scores. This is demonstrated in Figure 3.

Figure 3: Estimate of P to Q relationship[16]



One way to understand P and Q is to think of insolvency probability P_i as a typical mortality rate and then liken Q_i to the same mortality rate, conditional to the fact that there is a stressed mortality scenario (for example a war). In the war, the mortality rate of young and old age groups would be fairly stable, while that of the age group fighting the war or of inhabitants in the region most affected by the war will go up depending on its severity. Such groups would have higher estimates of Q_i as would a specific company that is most likely to go insolvent when the PPF is having the worst claims experiences.

[16] The reason why the LTRM output points related to the higher insolvency probabilities look further apart from the fitted curve is an optical effect owing to the scale. If the graph were on a logarithmic scale, this effect would not be present.

Table 8 lists the values of Q corresponding to each D&B UK insolvency probability. Q would be calculated by the PPF.

Table 8: Example of extrapolated results by D&B insolvency probability for each failure score

Failure Score	Insolvency Probability **(P)**	Cumulative Five-Year Insolvency Probability **(Q)**	Multiple **(Q/P)**	**Failure Score**	Insolvency Probability **(P)**	Cumulative Five-Year Insolvency Probability **(Q)**	Multiple **(Q/P)**	**Failure Score**	Insolvency Probability **(P)**	Cumulative Five-Year Insolvency Probability **(Q)**	Multiple (Q/P)
100	0.01%	0.70%	65	**66**	0.52%	6.40%	12	**32**	1.93%	13.80%	7
99	0.03%	1.20%	41	**65**	0.54%	6.60%	12	**31**	2.02%	14.10%	7
98	0.05%	1.70%	33	**64**	0.56%	6.70%	12	**30**	2.09%	14.40%	7
97	0.07%	2.00%	29	**63**	0.58%	6.90%	12	**29**	2.13%	14.60%	7
96	0.08%	2.20%	27	**62**	0.60%	7.00%	12	**28**	2.16%	14.70%	7
95	0.09%	2.30%	26	**61**	0.63%	7.20%	11	**27**	2.23%	15.00%	7
94	0.10%	2.50%	25	**60**	0.65%	7.30%	11	**26**	2.30%	15.20%	7
93	0.11%	2.60%	24	**59**	0.67%	7.50%	11	**25**	2.37%	15.50%	7
92	0.12%	2.80%	23	**58**	0.70%	7.60%	11	**24**	2.50%	16.00%	6
91	0.13%	2.90%	22	**57**	0.73%	7.80%	11	**23**	2.52%	16.00%	6
90	0.15%	3.10%	21	**56**	0.76%	8.00%	11	**22**	2.54%	16.10%	6
89	0.17%	3.40%	20	**55**	0.79%	8.20%	10	**21**	2.57%	16.20%	6
88	0.18%	3.50%	19	**54**	0.82%	8.40%	10	**20**	2.69%	16.90%	6
87	0.20%	3.70%	18	**53**	0.86%	8.60%	10	**19**	2.84%	17.20%	6
86	0.21%	3.80%	18	**52**	0.90%	8.80%	10	**18**	2.90%	17.40%	6
85	0.23%	4.00%	17	**51**	0.94%	9.10%	10	**17**	2.97%	17.70%	6
84	0.24%	4.10%	17	**50**	0.98%	9.30%	9	**16**	3.09%	18.10%	6
83	0.25%	4.20%	17	**49**	1.02%	9.50%	9	**15**	3.26%	18.60%	6
82	0.27%	4.40%	16	**48**	1.08%	9.80%	9	**14**	3.46%	19.30%	6
81	0.28%	4.50%	16	**47**	1.12%	10.00%	9	**13**	3.64%	19.90%	5
80	0.30%	4.70%	16	**46**	1.17%	10.30%	9	**12**	3.81%	20.40%	5
79	0.31%	4.80%	15	**45**	1.22%	10.50%	9	**11**	4.11%	21.30%	5
78	0.32%	4.90%	15	**44**	1.26%	10.70%	9	**10**	4.40%	22.20%	5
77	0.34%	5.00%	15	**43**	1.32%	11.00%	8	**9**	4.67%	23.00%	5
76	0.35%	5.10%	15	**42**	1.38%	11.30%	8	**8**	5.01%	23.90%	5
75	0.37%	5.30%	14	**41**	1.42%	11.50%	8	**7**	5.35%	24.90%	5
74	0.39%	5.40%	14	**40**	1.47%	11.80%	8	**6**	5.89%	26.30%	4
73	0.40%	5.50%	14	**39**	1.53%	12.00%	8	**5**	6.63%	28.10%	4
72	0.41%	5.60%	14	**38**	1.59%	12.30%	8	**4**	7.74%	30.80%	4
71	0.43%	5.80%	13	**37**	1.67%	12.70%	8	**3**	9.71%	35.10%	4
70	0.44%	5.80%	13	**36**	1.72%	12.90%	7	**2**	13.79%	43.00%	3
69	0.46%	6.00%	13	**35**	1.76%	13.00%	7	**1**	29.26%	66.60%	2
68	0.48%	6.10%	13	**34**	1.82%	13.30%	7				
67	0.50%	6.30%	13	**33**	1.87%	13.50%	7				

3. Sensitivity of parameters to changes in the economic environment

In order to test the robustness and stability of the new levy formula, the LTRM has been used to simulate the position of the PPF in various states of the economy. Shocks were applied to the level of equity markets, interest rates and to credit markets. The resulting levy equations that would come out under each scenario are similar, if not identical to the base case estimation. The proposed formula that doesn't use scheme-specific investment risk is more stable than the one that does.

Table 9, Table 10, and Table 11 show the impact of an equity market shift, interest rate changes and credit changes on the regression parameters. The results show that the formulae are very stable in all three cases. Limitations in the LTRM meant that we were unable to calculate results for a downgrade in credit ratings.

Table 9: Impact of equity market shift on regression parameters

Base case	Equity up 20%	Equity down 20%
Results without scheme-specific investment risk		
$\hat{U}_i = \max[0, L_i - (0.9\times A_i)]$ $\hat{V}_i = \max[0, L_i - (0.6\times A_i)]$	$\hat{U}_i = \max[0, L_i - 0.9\times A_i]$ $\hat{V}_i = \max[0, L_i - 0.6\times A_i]$	$\hat{U}_i = \max[0, L_i - 0.9\times A_i]$ $\hat{V}_i = \max[0, L_i - 0.7\times A_i]$
Results with scheme-specific investment risk		
$\hat{U}_i = \max[0, L_i - (1-0.9\times\sigma_i)\times A_i]$ $\hat{V}_i = \max[0, L_i - (1-3.4\times\sigma_i)\times A_i]$	$\hat{U}_i = \max[0, L_i - (1-1.1\times\sigma_i)\times A_i]$ $\hat{V}_i = \max[0, L_i - (1-3.3\times\sigma_i)\times A_i]$	$\hat{U}_i = \max[0, L_i - (1-0.7\times\sigma_i)\times A_i]$ $\hat{V}_i = \max[0, L_i - (1-3.4\times\sigma_i)\times A_i]$

Table 10: Impact of interest rate change on regression parameters

Base case	Interest rates up 100bps	Interest rates down 100bps
Results without scheme-specific investment risk		
$\hat{U}_i = \max[0, L_i - (0.9\times A_i)]$ $\hat{V}_i = \max[0, L_i - (0.6\times A_i)]$	$\hat{U}_i = \max[0, L_i - A_i]$ $\hat{V}_i = \max[0, L_i - 0.6\times A_i]$	$\hat{U}_i = \max[0, L_i - 1.1\times A_i]$ $\hat{V}_i = \max[0, L_i - 0.7\times A_i]$
Results with scheme-specific investment risk		
$\hat{U}_i = \max[0, L_i - (1-0.9\times\sigma_i)\times A_i]$ $\hat{V}_i = \max[0, L_i - (1-3.4\times\sigma_i)\times A_i]$	$\hat{U}_i = \max[0, L_i - (1-1.1\times\sigma_i)\times A_i$ $V_i = \max[0, L_i - (1-3.3\times\sigma_i)\times A_i$	$\hat{U}_i = \max[0, L_i - (1-0.7\times\sigma_i)\times A_i]$ $\hat{V}_i = \max[0, L_i - (1-3.2\times\sigma_i)\times A_i]$

Table 11: Impact of credit change on regression parameters

Base case	1 notch upgrade
Results without scheme-specific investment risk	
$\hat{U}_i = \max\left[0, L_i - (0.9 \times A_i)\right]$ $\hat{V}_i = \max\left[0, L_i - (0.6 \times A_i)\right]$	$\hat{U}_i = \max\left[0, L_i - 0.9 \times A_i\right]$ $\hat{V}_i = \max\left[0, L_i - 0.7 \times A_i\right]$
Results with scheme-specific investment risk	
$\hat{U}_i = \max\left[0, L_i - \left(1 - 0.9 \times \sigma_i\right) \times A_i\right]$ $\hat{V}_i = \max\left[0, L_i - \left(1 - 3.4 \times \sigma_i\right) \times A_i\right]$	$\hat{U}_i = \max\left[0, L_i - \left(1 - 0.9 \times \sigma_i\right) \times A_i\right]$ $\hat{V}_i = \max\left[0, L_i - \left(1 - 3.1 \times \sigma_i\right) \times A_i\right]$

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Annex C

Investment risk factor

1. Calculation of the investment risk factor (σ)

Schemes' investment risk, based on the volatility of funding level, is calculated using the information provided by schemes on their asset and liability mix. The variance-covariance matrix for asset classes is calculated using Barrie & Hibbert's economic scenario generator (ESG).[17] The final variance-covariance matrix arrived at is presented in Table 1.

Table 1: Asset variance-covariance matrix (Σ)

	UK Equity	Non-UK equity	Property	Conventional bonds	Inflation-linked bonds	Cash
UK Equity	4.2%	2.3%	0.6%	0.4%	0.5%	0.0%
Non-UK equity	2.3%	4.0%	0.2%	0.3%	0.5%	0.0%
Property	0.6%	0.2%	2.3%	0.2%	0.2%	0.0%
Conventional bonds	0.4%	0.3%	0.2%	0.4%	0.1%	0.0%
Inflation linked bonds	0.5%	0.5%	0.2%	0.1%	0.6%	0.0%
Cash	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

The equation that results in the final scheme-specific investment risk factor is shown in Equation 1.

Equation 1: Scheme investment risk calculation

$$\sigma_i = \sqrt{(A_i - L_i)^T \Sigma (A_i - L_i)}$$

In Equation 1, A_i is a 6 x 1 matrix of asset allocations, L_i is a 6 x 1 matrix of asset allocation that approximates scheme liabilities, and Σ is the 6 x 6 asset variance-covariance matrix displayed in Table 1. Equation 1 results in scheme-specific investment risk within the range of zero to 20 per cent. A scheme investing heavily in equities presents more investment risk, and hence will receive a higher sigma, than one largely invested in bonds. The vast majority of schemes (74 percent) have sigma values between 8 and 14 percent. A worked example of the investment risk calculation is given in the next section.

[17] We assume that fixed income has an average duration of ten years and liabilities an average duration of twenty years. These are based on estimates of the average asset/liability profile.

2. Proxy asset mix for the liability

Results of the calculation of the sensitivities to nominal and real interest rates of active members', deferred members' and pensioners' liabilities on a sample of over 5,000 pension schemes are shown in Table 2 below.

Table 2: Sensitivity to real and nominal interest rates of s179 liabilities

		5th percentile	Median	95th percentile
Sensitivity to nominal rates	Active	7.1	9.1	11.1
	Deferred	6.6	8.6	10.9
	Pensioners	4.1	7.0	9.9
	Long-term bond portfolio		8.0	
Sensitivity to real rates	Active	8.0	15.9	22.9
	Deferred	8.0	15.9	21.9
	Pensioners[18]	0.0	0.0	0.0
	Long-term inflation linked bond portfolio		15.0	

We derived from these results the following proxy assets for the three liability categories:

Table 3: Conversion of pensioner split to asset allocation

	Long-term conventional bonds	Long-term inflation linked bonds	Cash
Active	+100%	+100%	-100%
Deferred	+100%	+100%	-100%
Pensioners	+100%	0%	0%

For example, a scheme for which the liability is made up of 30 per cent active members' liability, 20 per cent deferred liability and 50 per cent pensioners' liability will have a proxy asset mix of 100 per cent in long-term bonds, 50 per cent in long-term inflation linked bonds and -50 per cent in cash.

Although sensitivities of active members or deferred pensioners' liabilities are widely dispersed, we propose to make a standard assumption for the proxy asset mix because we have no information on the duration of schemes' bond portfolios and using scheme-specific liability durations would not improve accuracy significantly.

[18] Pensioners' liabilities are not sensitive to real interest rates because PPF compensation is non-indexed to inflation for pre-1997 service and the indexation is capped at 2.5 per cent for post-1997 service.

Calculating scheme investment risk: a worked example

Take the example of a scheme with an asset and liability allocation as shown in the table below. The liability mix is derived from 30% active members' liability, 20% deferred liability and 50% pensioners' liability.

Table A: Example net asset position for all asset classes

	Asset (A_i)	Liability (L_i)	$A_i - L_i$
UK Equity	30%	0%	30%
Non-UK equity	30%	0%	30%
Property	0%	0%	0%
Conventional bonds	30%	100%	-70%
Inflation linked bonds	10%	50%	-40%
Cash	0%	-50%	50%

The equation for funding volatility is:

$$\sigma_i = \sqrt{(A_i - L_i)^T \Sigma (A_i - L_i)}$$

Where A_i–L_i is a matrix of net positions in the six asset classes with six rows and one column (6 x 1) taken from Table A. Σ is the 6 x 6 variance-covariance matrix for asset classes, and $(Ai\text{-}Li)^T$ is the transpose (flipped sideways version) of A_i–L_i. For the sake of clarity, rename to $(A_i\text{-}L_i)^T$ as X. With values for our example inserted into the A_i-L_i and X matrices, the above equation can be represented as:

$$\sigma^2 = \underbrace{\begin{vmatrix} 0.3 & 0.3 & 0 & -0.7 & -0.4 & 0.5 \end{vmatrix}}_{X} \underbrace{\begin{vmatrix} 4.2\% & 2.3\% & 0.6\% & 0.4\% & 0.5\% & 0.0\% \\ 2.3\% & 4.0\% & 0.2\% & 0.3\% & 0.5\% & 0.0\% \\ 0.6\% & 0.2\% & 2.3\% & 0.2\% & 0.2\% & 0.0\% \\ 0.4\% & 0.3\% & 0.2\% & 0.4\% & 0.1\% & 0.0\% \\ 0.5\% & 0.5\% & 0.2\% & 0.1\% & 0.6\% & 0.0\% \\ 0.0\% & 0.0\% & 0.0\% & 0.0\% & 0.0\% & 0.0\% \end{vmatrix}}_{\Sigma} \underbrace{\begin{vmatrix} 0.3 \\ 0.3 \\ 0 \\ -0.7 \\ -0.4 \\ 0.5 \end{vmatrix}}_{Ai - Li}$$

The matrix multiplication required to obtain σ^2 can be performed in two stages. The first stage is to multiply X and Σ together to get a single matrix. X has one row and six columns (1 x 6) and Σ is 6 x 6. Multiplied together they produce a 1 x 6 matrix. For convenience, label this Y. To get the first (left-hand side) element of Q, multiply each element of X with the corresponding element of the first column of Σ (travelling from left to right in X and from top to bottom in Σ). Sum the products:

Y_1 = 0.3 x 4.2% + 0.3 x 2.3% + 0 x 0.6% + (-0.7 x 0.4%) + (-0.4 x 0.5%) + 0.5 x 0% = 1.47%

To get the second (from the left) element of Q, we perform the same process but multiplying each element of X with each element of the second column of Σ:

Y_2 = 0.3 x 2.3 + 0.3 x 4 + 0 x 0.2 + (-0.7 x 0.3) + (-0.4 x 0.5) + 0.5 x 0 = 1.48%

Repeating this procedure for the third to sixth columns of Σ gives the four remaining elements of Q. Since Q is the product of X and Σ, it can replace them in the equation for σ^2:

$$\sigma^2 = \underbrace{\begin{vmatrix} 1.47\% & 1.48\% & 0.02\% & -0.11\% & -0.01\% & 0.0\% \end{vmatrix}}_{Y} \underbrace{\begin{vmatrix} 0.3 \\ 0.3 \\ 0 \\ -0.7 \\ -0.4 \\ 0.5 \end{vmatrix}}_{A_i - L_i}$$

The second stage requires the multiplication of each element of Q with its corresponding element of A_i-L_i and the summation of the products. In this instance, the result will be a single number rather than a matrix:

σ^2 =1.47% x 0.3 + 1.48% x 0.3 + 0.02% x 0 - (0.11% x 0.7) - (0.01% x 0.4) + 0 x 0.5 = 0.97%

The investment risk of the example scheme in this case is:

σ = $\sqrt{0.00966}$ = **9.82%**

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Annex D

Setting the combined risk measure

It contains the following sections:

1. The combined risk measure

The combined risk measure (also called the economic levy) provides a ‘market price’ for the risks the PPF incurs and consists of a price for expected losses and the risk of unexpected losses.

Combining expected and unexpected claims into a single measure requires a choice to be made about the weighting given to the possibility of an adverse outcome.

Combined risk measure = Expected claims + weighting x Unexpected claims[19]

The distribution information in the long-term risk model provides the basis for producing both the expected claim over a period and a single measure of unexpected claims, i.e. the risk of claims being worse than the expected (average) claim. This is, in effect, the worst case that the Board will plan for and is similar in principle to the economic capital figure that a financial institution aiming to be fully-funded would calculate.

The economic levy provides a measure to inform the PPF Board’s view of the appropriate level of the total levy (quantum). It can be used to test the fairness of practical approaches to charging the levy and also as a basis for assessing whether the quantum charged is higher or lower than the value of the risk weighting. However, there are a number of reasons why the combined risk measure may not be used directly for charging the levy to schemes:

- It will vary over time reflecting the variability in short and long-term risk; however, the PPF Board may want to smooth the profile of the levy;
- It is entirely forward looking and takes no account of PPF’s funding position. It would therefore not provide a basis for amortising a deficit;
- A levy formula should aim for simplicity and consistency, whereas the measurement of risk through the combined risk measure needs to prioritise accuracy. For example, the long-term risk model uses data on insolvency from multiple sources (e.g. D&B scores and credit ratings) to achieve the most accurate representation of insolvency risks in calculating the contribution of each scheme to the combined risk measure. For distributing the levy fairly it is better to use a consistent measure for all schemes, a view supported by a large majority of those responding to last year’s consultation.

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19 **Expected claim**: The average claim across all scenarios (sometimes referred to as the ‘pure premium’)
Unexpected Claim: The amount the claim in the worst scenario (the adverse claim) exceeds the expected claim.
Weighting: A figure that determines how much is taken into account of the potential impact of unexpected claims for all schemes. (A weighting is needed because the sum of all unexpected risks would be the extreme claim of ca. £8 billion).

- Using the combined risk measure directly would be a questionable approach because it depends upon a weighting for unexpected claims derived from a comparison with commercial costs of capital. The PPF does not have a capital base and hence the comparison with commercial costs of capital is potentially inappropriate.

The following section describes our calibration of the key parameters in the combined risk measure.

2. Parameters of the combined risk measure

There are a number of choices that need to be considered when setting the economic levy:

- the time period over which to measure expected claims
- the time period over which to measure unexpected claims
- the confidence level used in calculating the unexpected claims, and
- the weighting applied to the unexpected claims (i.e. the 'unit cost of this risk).

These are discussed in more detail below.

2.1. Time period for expected claims

In principle, one could set the levy based on annualised expected claims over a one year time horizon or over a longer or shorter horizon with no impact on the combined risk measure.

Given that the levy is adjusted on an annual basis the Board feels that a one year time horizon is most appropriate. If expected claims were set on a longer-term horizon (e.g. five years) then for consistency the PPF would need to hold the expected loss element of the economic levy fixed for that period. This is clearly not desirable.

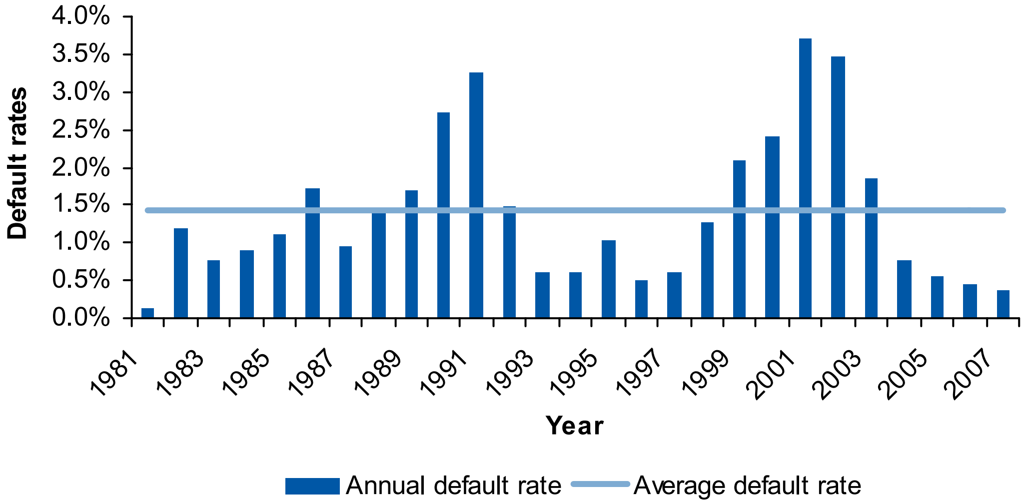
2.2. Time period for unexpected claims

The next consideration is the time period over which the unexpected losses should be assessed. Conversely to expected losses, the time period used has an impact on the results.

Therefore we look back at the length of previous downturns to act as a guide on the appropriate time period over which to measure unexpected claims.

Figure 1 shows global bond defaults since 1981. This can be used as a proxy for the level of company insolvencies. The data show that the longest consecutive period of higher than average defaults has been five years.

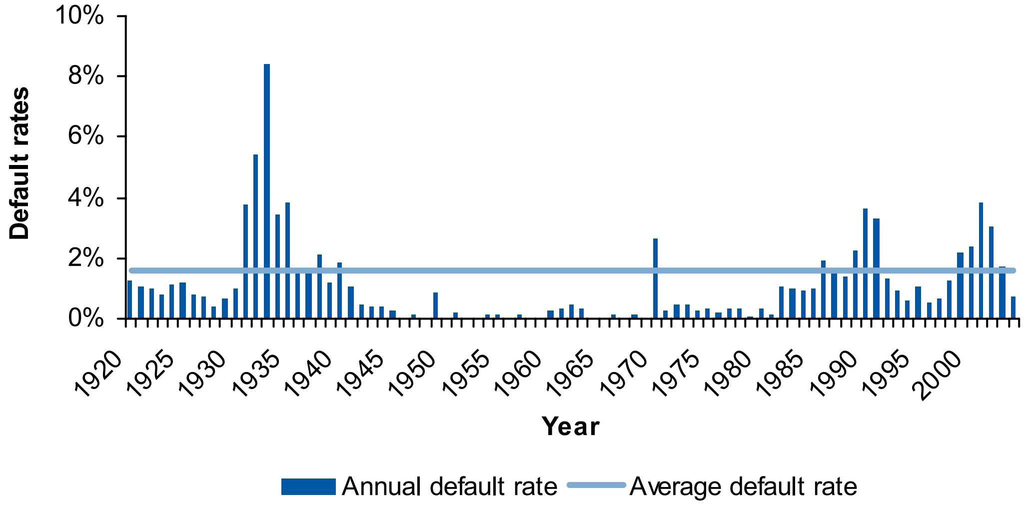
Figure 1: S&P rated global bond defaults – 1981 to 2007



Source: Standard and Poors

Analysis over longer periods, and using different default providers, leaves this conclusion unchanged. Figure 2 shows Moody's global bond defaults since 1920 and the analysis shows similar patterns.

Figure 2: Moody's rated global bond defaults – 1920 to 2004

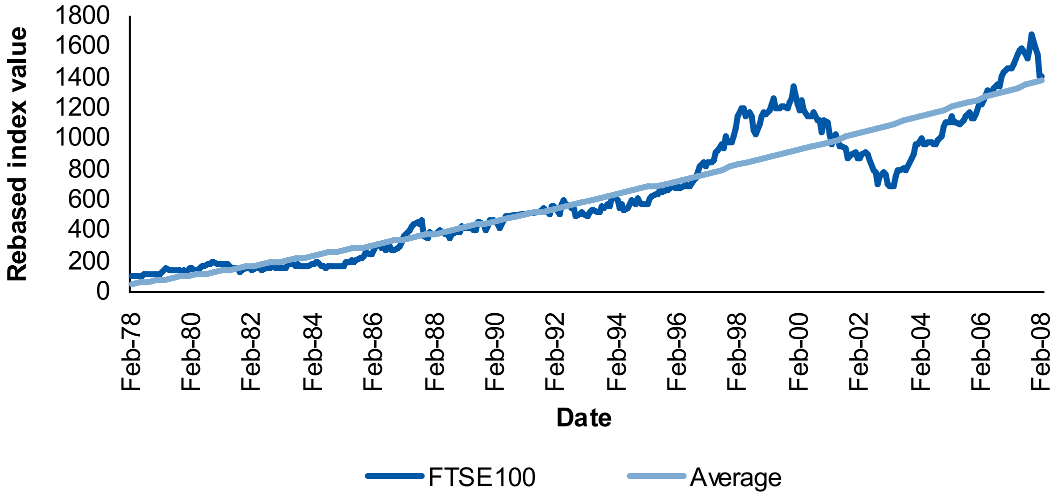


Source: Moody's

The other major risk that the PPF is exposed to is lower than average equity returns. This increases the level of underfunding of the pension schemes.

Figure 3 shows the level of the UK FTSE 100 equity market over the past 30 years compared with the trend over the same time period.

Figure 3: UK equity market levels – past 30 years



Source: Bloomberg

Over the last 30 years, the longest periods during which equity levels were persistently below the trend were from September 1992 to September 1996 and June 2001 to April 2006 – both periods less than five years.

The analysis suggests that using a five year period to assess unexpected losses is an appropriate time horizon to take in likely downturns.

2.3. Confidence level for unexpected claims

There is a range of options for the confidence level that the Board could choose for assessing its risk. The Board has chosen to use a measure of unexpected claims at the 97.5th percentile of the distribution, which is broadly analogous to the test a financial institution would use for the minimum economic capital it maintains (the 99.5th percentile over one year). Each describes a 'one-in-200-year' event. The great majority of financial institutions, of course, operate with economic capital at well above this minimum level.

2.4. Choosing the model scenarios representing the extreme claim

We want to calculate how much each scheme contributes to the PPF's unexpected claim. The Marginal Contribution Approach (MCA) is the most common way of doing this. Conceptually it works as follows: if we adjusted each scheme's individual risk exposure by a small amount, one at a time, the MCA calculates by how much the PPF's total risk exposure would change. The allocation of capital to any scheme is that scheme's stand-alone unexpected claim multiplied by the proportional impact on the PPF's total capital requirement of this small change in the individual risk exposure. In other words, the MCA allocates capital in a way which reflects the contribution that scheme makes to the PPF's need to hold capital:

- For some schemes (generally large ones with a large amount of systematic risk exposure) their presence significantly increases the PPF's total risk;

- For others (generally smaller ones whose risks diversify away) their presence has only a relatively limited impact on the PPF's total capital need

MCA is one of the most common ways in which financial institutions allocate capital.

Unfortunately it is not practical to directly use the MCA to calculate how much each scheme contributes to the PPF's need for capital: this would be computationally difficult and the time to run the model and produce the required output would be prohibitive as there are over 7,600 schemes.

We can, however, look at schemes' contributions to the PPF's unexpected claims by looking at their claims in the scenarios at or around the tail of the PPF's overall claims distribution (i.e. the scenarios that give risk to the unexpected losses). It is possible to find an approach to allocating capital using this information which is a reasonable approximation to the MCA approach.

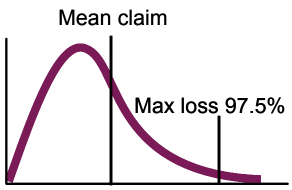
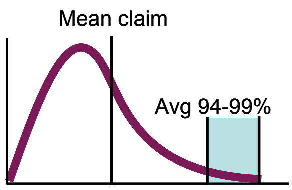
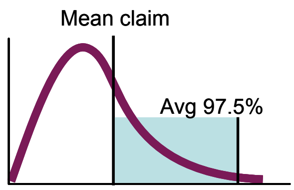
The three options we consider to assign scheme-level unexpected claims are as follows (and illustrated in Table 1):

- **Option 1:** Taking the single scenario which determines the 97.5th percentile of the PPF's claims distribution, calculate the claims of each of the pension schemes in that scenario. The sum of these claims (less the PPF's mean claims) determine the PPF's unexpected claims. Therefore we can estimate each scheme's contribution to the PPF's capital requirement as that scheme's claims in the scenario in question. Our potential concern with this approach is that we might expect it to be rather volatile, being based on a single scenario, and so to suffer from significant sample effects.

- **Option 2:** As for option 1 except that instead of using a single scenario we take a range of scenarios spread around the 97.5th percentile. This is designed to reduce the level of volatility driven by the use of a single scenario.

- **Option 3:** As for option 1 except that instead of using a single scenario we take a range of scenarios between the mean and the 97.5th percentile.

Table 1: Options to allocate unexpected claims

	Option 1: **97.5 percentile**	**Option 2:** **97.5 percentile is range average**	**Option 3: Average of range up to 97.5 percentile**
			
Description	▪ Use the scenario corresponding to the 97.5th percentile	▪ Use a range with the average of the range equal to the 97.5th percentile	▪ Use a range up to the 97.5th percentile
Pros	▪ Represents each scheme's actual contribution to calculated Economic Capital	▪ More stable than Option 1 ▪ Good approximation of the risks driving capital at the 97.5% tail	▪ Large number of simulations allows stable measure of scheme risk
Cons	▪ Unstable – allocation will be highly dependent on the specific scenarios used ▪ Does not fairly reflect each scheme's contribution to overall tail risk	▪ Range is arbitrarily selected ▪ May be influenced by extreme tail events beyond the capitalisation target	▪ Assigns capital to schemes whose inclusion has little impact on capital needs

Our ingoing expectation is that Option 2 should provide the best approximation to the marginal contribution approach. This is because it calculates unexpected claims based on those scenarios which drive the PPF's need to hold capital while avoiding the sampling effects of Option 1. Unfortunately we cannot test this empirically using the LTRM (due to the run-time limitations mentioned above). Instead a simpler spreadsheet model was built to conduct an empirical test of the three options above and compare them with the theoretical approaches. The model is simpler than the LTRM in that it simulates only five pension schemes and conducts only 1,000 stochastic simulations, removing the run-time limitations.

The model was used to calculate the MCA explicitly and also Options 1, 2 and 3. Analysis of the model results suggests that Option 2 is the best fit to the MCA since it has the lowest average deviation. This simple test therefore validates our preference for Option 2, and this is our recommended approach to the allocation of economic capital to individual schemes. By running a large number of samples the PPF will be able to average the results from these samples with the average of scenarios drawn very close to the 97.5 point on the distribution.

2.5. Weighting for unexpected claims

Finally, in order to construct a combined risk measure one needs to attribute a weighting to the unexpected claims. An appropriate basis for the weighting is to adopt an approach similar to that of a commercial business, using a unit cost of capital measure (this is employed in many cases even where a business is only estimating risk rather than calculating prices). The use of unit cost of capital reflects the fact that the PPF is exposed to unexpected risk while it has limited capital available to it and so would need to pass the cost to surviving schemes.

The cost of capital (in excess of the risk-free rate) is usually calculated as the sum of the following:

- an allowance for frictional costs, and
- a systematic-risk premium reflecting an investment's beta (i.e. the degree to which its returns are correlated with the wider investment market).

The frictional costs are generally associated with the capital being invested through a structure (normally a company) rather than investors taking on the risks directly themselves. The frictional costs include the cost of double taxation (where income on the risk-free rate is taxed within the company and in the hands of the investor) and agency costs of management.

The PPF does not pay tax and we do not include an agency cost of management as the PPF's customers are its capital providers. Our working assumption is therefore that the frictional costs within the cost of capital are zero.

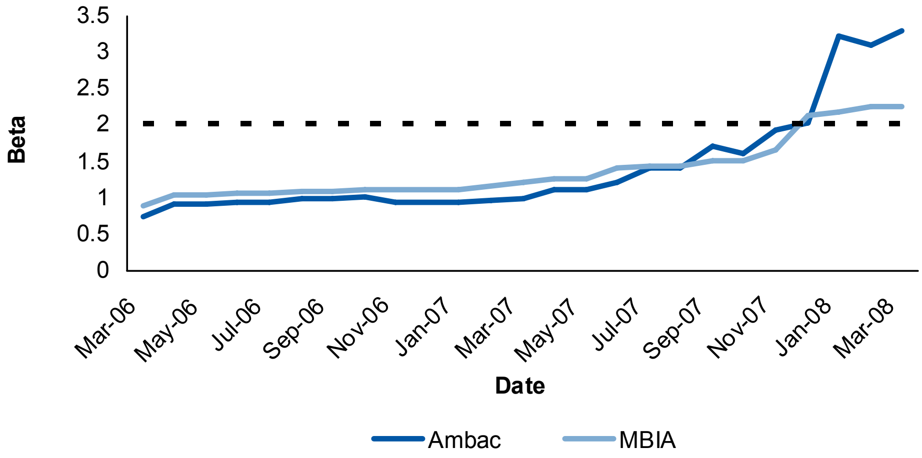
Systematic risk reflects the extent to which the company's fortunes are aligned with the rest of the investible market. For example, investors in a company which is only exposed to earthquake risk, and therefore is not correlated with the market, would not necessarily demand a premium for this risk, which diversifies away well. However, investors in an asset management company, whose profits and sales depend heavily on the stock market, would demand a premium for this risk.

Systemic risk is usually calculated by multiplying a stock's beta by an estimate for the market risk premium.

The beta for the PPF can be considered to be a weighted average of the betas for the two major components of the PPF risk, market risk and credit risk. The beta for the market risk can be measured using the LTRM through regression of the PPF deficit with modelled equity returns. This beta has been calculated by the PPF to be approximately two.

To calculate the beta for the credit risk, we look at the beta of monoline credit insurers. As Figure 4 shows this has increased dramatically as the credit crunch has persisted/deepened. It is hard to know what level the beta will return to when credit markets return to a more normal level. Our working assumption is that credit insurers will continue to be seen as more risky then in the past, but not to the current extent. Therefore on balance we feel a beta of two is appropriate.

Figure 4: Betas for sample of monoline credit insurers



Source: Datastream

Given that the combined PPF beta should be a weighted average of the betas for the individual components, the combined PPF beta emerges as two.

The market risk premium (MRP) can be calculated using a variety of methods with a correspondingly wide range of results (MRPs as high as 11 per cent and as low as 1 per cent have been estimated by various academic studies). We have used the MRP which is incorporated into the Barrie & Hibbert model used for the LTRM: we calculate the MRP as the (arithmetic) mean equity return in excess of the risk-free rate. This method yields a MRP of 4.5 per cent. This estimate is in line with most practitioners' view of the MRP and has the advantage of being consistent with the PPF's modelling in other areas.[20]

The overall cost of capital for the PPF is therefore the systematic-risk premium times the beta. The cost of capital (which is used as the weight for the unexpected claims in the economic levy) is therefore:

Equation 1: PPF cost of capital

Cost of capital = beta x systematic risk premium

= 2 x 4.5%

= 9%

[20] When estimating the systematic-risk premium, the arithmetic average and not the geometric mean should be used. See McCulloch, B, Geometric Return and Portfolio Analysis, New Zealand Treasury Working Paper 03/28, December 2003 for further details.

3. Summary

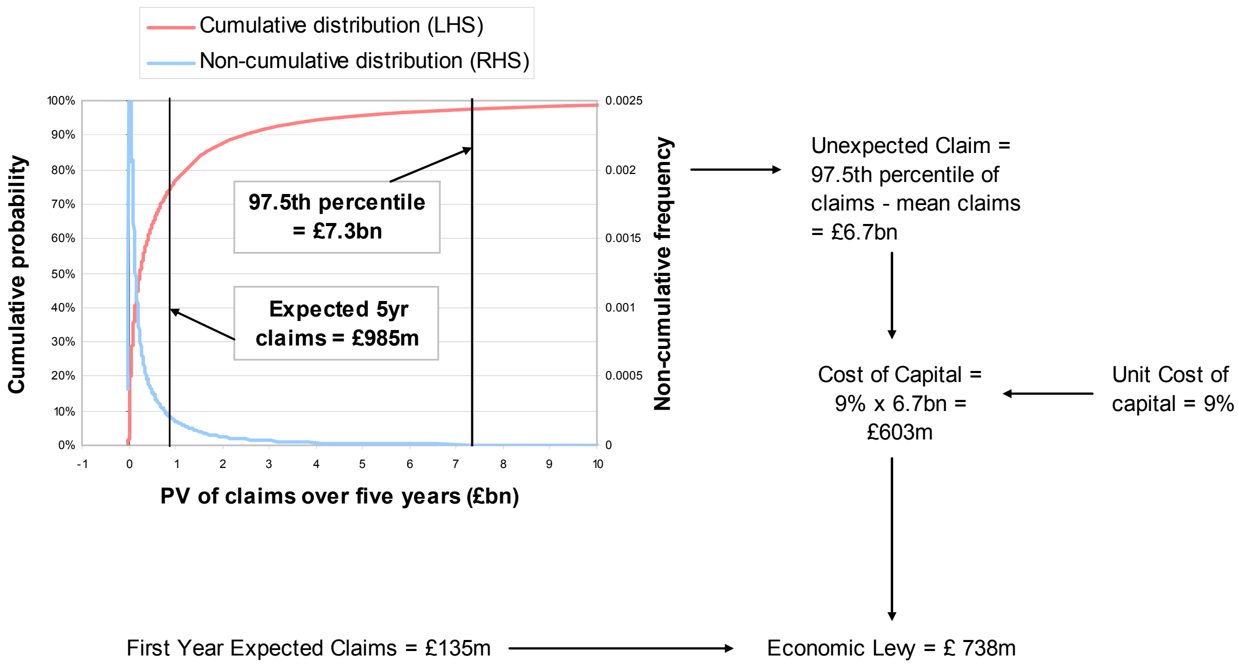
The economic levy can be calculated as follows:

Equation 2: Combined risk measure calculation

Combined risk measure = one-year expected claims + 9% × five-year unexpected claims (97.5th percentile)

The above calculation can be represented diagrammatically as can be seen in Figure 5.

Figure 5: Diagrammatic representation of the economic levy calculation



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Annex E

Estimating the impact of including investment risk in the levy formula on investment strategies of pension schemes

Annex E contains the following:

1. Background

There have been large shifts in pension fund asset allocation since the early-1990s. The equity share has fallen from 80 per cent in 1993 to 62 per cent in 2007 while the bond share has risen from 10 per cent to 24 per cent over the same period[21]. There is also evidence of the increased use of derivatives with bond like characteristics. The switch to non-return-seeking (matching) assets has reflected factors such as growing scheme maturity, the development of the corporate bond market, and attempts to better match pension fund assets and liabilities.

The proposal to take account of investment risk in the levy formula might, in principle, be expected to provide schemes with an incentive to reduce the level of risk in their portfolio to lower their levy, for example by diversification, or through replacing risk assets such as equities with matching assets – bonds or interest rate / inflation swaps. On the other hand, reducing the proportion of risk assets would reduce returns to the scheme by significantly more than the levy saved.

This analysis seeks to assess the extent to which it would be rational for schemes to de-risk in response to the proposed levy. It cannot assess the probability of a disproportionate reaction, though this might be reduced by seeking to be transparent about the potential impact.

2. Summary of the analysis

To work out an estimate of the impact, we assumed that all trustees behaved rationally and were faced with a simple trade-off between the volatility of their scheme's funding level and the potential out-performance of their assets over their liabilities. This out-performance potential comes from the risk premium of return-seeking assets such as equities. At the same time return-seeking assets do not match liabilities and produce volatility in the scheme's funding level.

We also assumed that the investment strategy pursued by schemes before the levy with an investment risk factor was an optimal strategy, i.e. an asset allocation that strikes the right balance between risk and return from the schemes' trustees' point of view. This assumption enables us to infer pension schemes' trustees' preferences between risk and return.

We then calculated new optimal asset mixes after taking into account the impact of the levy on the return of the schemes' assets. Our findings are that the inclusion of an investment risk factor in the levy:

- Has little effect on a scheme's investment strategy when its sponsor is strong (i.e. investment grade or with an insolvency probability smaller than 0.4 per cent)

[21] Based on the ONS's MQ5 survey which includes local authorities and some DC schemes and so is an imperfect representation of our universe.

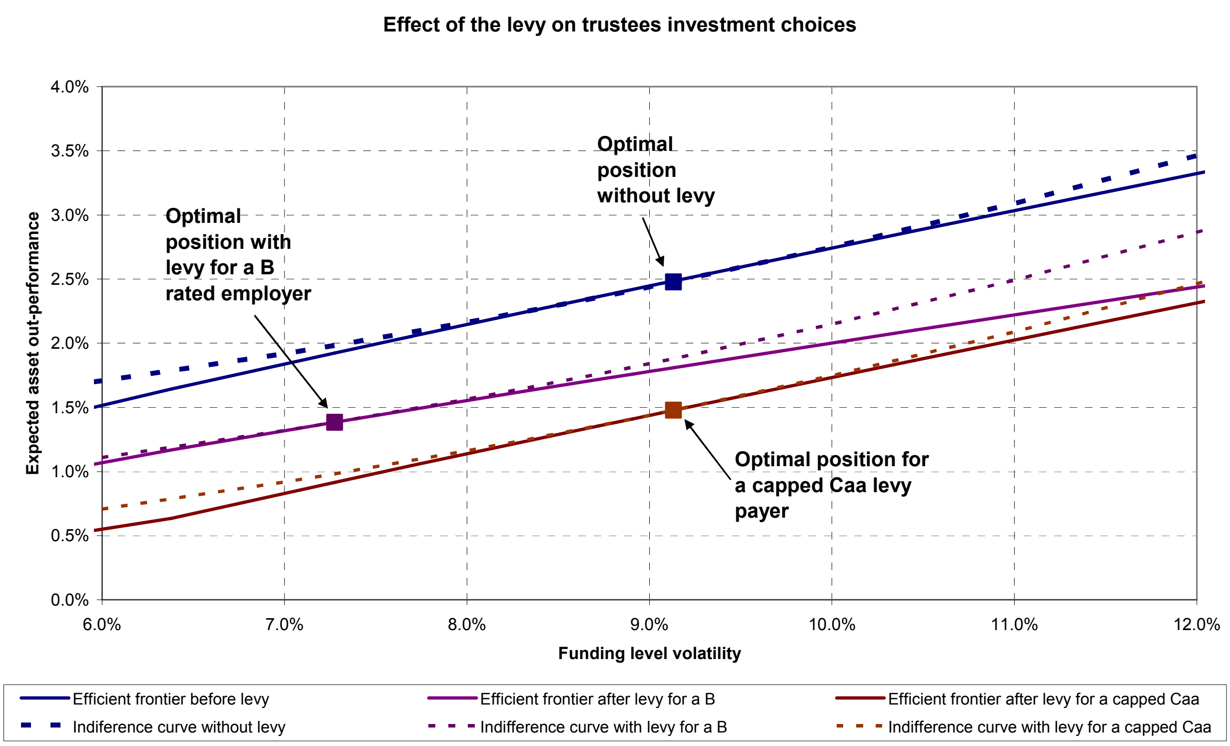
because in this case the risk-based levy is small relative to the potential asset out-performance;
- Has a more significant impact when the sponsoring employer is weak (of the speculative-grade category);
- Ceases to have any impact at all on the investment strategy once the levy is capped, because a capped levy is insensitive to the investment strategy and only depends on the size of liabilities.

Most large schemes fall into the first category – implying a limited overall impact.

Figure 1, below, shows how the levy affects pension schemes' efficient frontier when an investment risk factor is introduced in the formula. It shows that for a scheme sponsored by a weak employer, it significantly reduces the marginal increase of return per unit of risk taken i.e. the slope of the efficient frontier. As a result everything remaining unchanged, a lower risk strategy is chosen after taking into account the effect of the levy. We have chosen to represent efficient frontiers only for schemes sponsored by weak employers because the efficient frontier barely changes when the employer is strong i.e. when the levy is small compared to investment out-performance.

It also shows that when the levy is capped the efficient frontier is shifted without any change in its slope. As a result, capped levy payers will make the same investment choice before and after taking into account the levy.

Figure 1: Effect of the levy with an investment factor on trustees' investment choices



The table below shows how asset allocation of a fully-funded scheme may vary from a 60 per cent to 40 per cent split between return-seeking[22] and liability-matching assets following the introduction of investment risk in the risk-based levy.

Rating of the sponsoring employer	Percentage in return-seeking assets	Reduction in return seeking assets
Aa	59.1%	0.9%
A	58.4%	1.6%
Baa	57.0%	3.0%
Ba	54.1%	5.9%
B	46.3%	3.7%
Caa (levy is capped)	60.0%	0.0%

Applying this model to all schemes in the scheme return data base leads to a potential shift of the allocation in equities (both UK and non-UK) from 57.4 per cent to 56.2 per cent of assets. This represents a £10 billion to £11 billion transfer from equities to matching assets.

In this analysis no account was made of transaction costs associated with any change in the asset allocation, or of institutional reluctance to alter investment strategy particularly in respect of alternative investments. Therefore we think this estimate is an upper-limit to the impact of introducing an investment risk factor in the levy formula. Furthermore, this movement in investments if it occurred would be spread across a period of time. Pension funds, particularly those who have weaker sponsors (and who will be disproportionately small), are unlikely to all alter investment strategy immediately or implement any change rapidly. A range of £5-10 billion is a reasonable planning assumption over 3 years.

A reduction in equity holdings in this range would represent between less than 0.5 per cent and 1 per cent of UK companies' market capitalisation, and (even assuming all shares sold are UK shares) we consider such a shift would have a negligible impact on equity markets, particularly when spread over a number of years.

The impact on other markets would depend on the route used by schemes to de-risk. In practice, a mix of approaches is likely to be adopted including purchases of UK conventional gilts, UK index linked bonds, overseas government and corporate bonds, together with derivatives that mimic those assets – interest rate or inflation swaps and potentially investment in other asset classes such as property, hedge funds, private equity, infrastructure and commodities. If there were a straight shift from UK equities to "gilts and fixed interest" then the gilt and fixed income share in total assets would rise by around 0.5 per cent a year over a three year period, or 0.25 per cent a year over five years. This compares with an average rise in the gilt and fixed income share of around 1 per cent a year over the last 14 years.

[22] The return-seeking (or non-matching) assets portfolio is assumed to be comprised of 50% UK equity, 40% non-UK equity, 5% property and 5% cash.

In practice it is to be expected that there would be a mix of approaches adopted, implying a limited impact on financial markets.

3. Conclusion

Results of this analysis suggest that the introduction of investment risk as a risk factor in the risk-based levy formula would not affect schemes' investment strategies to a significant extent.

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