Report [Sample rating report] from www.mortalityrating.com

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2. Summary statistics

Table 1 shows some summary statistics for this portfolio. It shows the number of records uploaded to mortalityrating.com, together with the number rejected and the number actually used in the rating report. Records can be rejected for a variety of reasons, including missing data (such as a missing date of birth) or invalid data (such as a date of birth after the date of pension commencement). Records with invalid postcodes are not rejected, however, and such cases are included in the report. A download file of cases with unrecognised postcodes is available in case you wish to correct them and re-rate the portfolio.

Table 1 also shows the average age of the lives behind each record, split by gender. These average ages are also shown weighted by amount. Ill-health lives are deemed to be those where the benefit started before age 50.

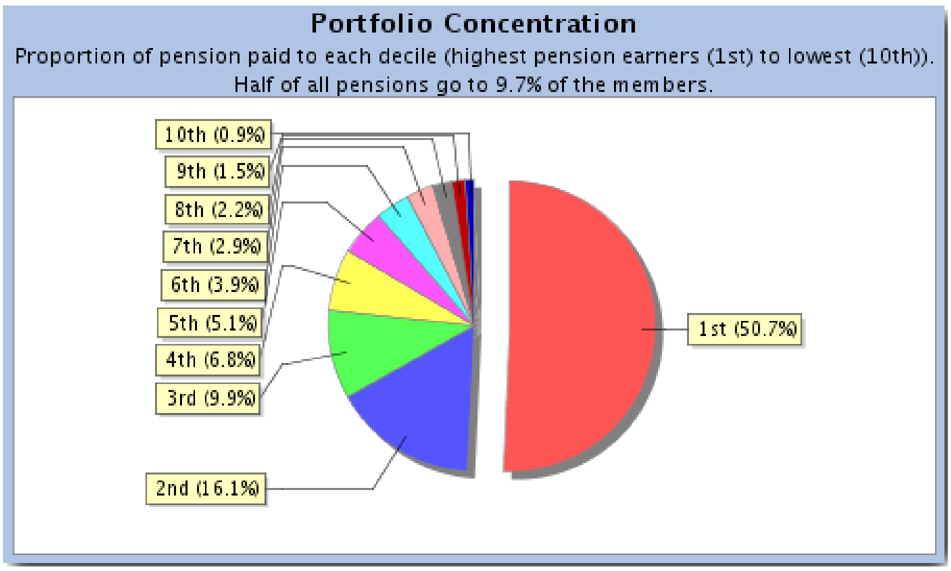
Table 1. Summary portfolio data:

Metric	Value
Records read	1502
Records rejected	0
Records with second life	0
Records used in rating	1502
Males	506
Females	996
Ill-health members	66
Male average age	75.48
Female average age	78.39
Amounts-weighted male average age	75.35
Amounts-weighted female average age	76.83
Pensions p.a. to males	£2874184.48
Pensions p.a. to females	£2237074.10
Pensions p.a. to ill-health members	£237861.02
Pensions p.a. to single lives	£5111258.58
Pensions p.a. to joint lives	£0.00

3. Concentration of liabilities

Liabilities within any given portfolio are rarely equal, and they usually differ widely in size. Typically, a large proportion of liabilities is concentrated on a relatively small number of lives. One measure of inequality in income distribution is the Gini Index. It ranges from 0% (perfect equality) to 100% (one person has all the income). The CIA World Fact Book gave the UK as a whole a value of 36.8% in 2005, whereas the figure for this portfolio is 62.11%. An alternative approach is to show the proportion of pensions for each decile of lives, as in Figure 1.

Figure 1. Concentration of amounts

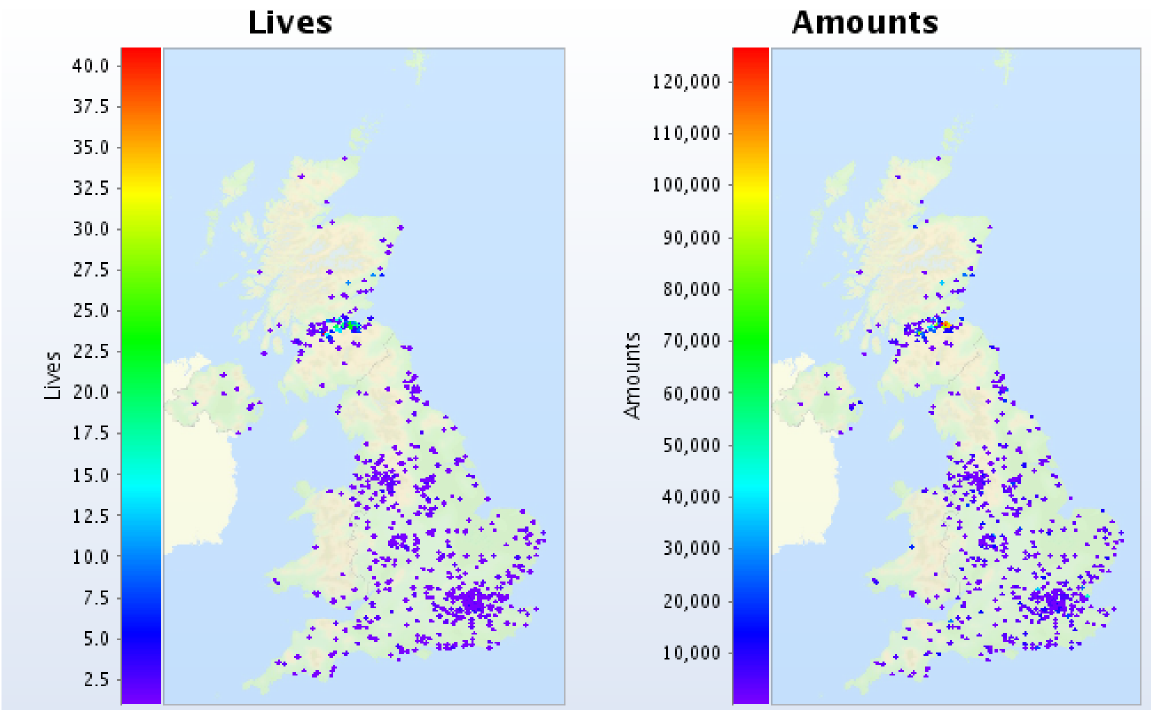


This concentration carries an extra risk, namely that the lives with the largest proportion of liabilities have a markedly different life expectancy than the ones with the smallest proportion. To assess the mortality risk of this portfolio, we therefore need to look at its socio-economic mix.

4. Geographic spread of liabilities

Figure 2 shows the geographic spread of lives and amounts for records with valid UK postcodes (data aggregated and plotted at postcode district level):

Figure 2. Geographical spread of liabilities by lives (left) and amounts (right)



5. Socio-economic group

People belonging to more upmarket socio-economic groups tend to live longer, as shown in Figure 3. Socio-economic differentials have proved very durable in the UK over the past thirty years, as tracked in the ONS Longitudinal Study. The Study is a complete set of census records for a sample of the population of England and Wales. The sample comprises people born on one of four selected dates of birth and was initiated at the time of the 1971 Census (and updated at the 1981, 1991 and 2001 Censuses and in routine event registrations). New study members enter through birth and immigration and existing members leave through death and emigration. The study represents a continuous sample of the population of England and Wales, rather than a sample taken at one time point only, and now includes records for over 950,000 people. More details can be found at http://www.celsius.lshtm.ac.uk.

Figure 3 shows that socio-economic differentials are important for rating any portfolio. This is all the more acute if the concentration of risk shown in Figure 1 is magnified if the group with the largest proportion of liabilities is also the group with markedly different life expectancy. It is therefore critical to assess the portfolio for socio-economic differentials.

However, the drawback of socio-economic group in Figure 3 is that it is determined by occupation. This is a semi-subjective categorisation, which is prone to misclassification or exaggeration. What is needed for underwriting social group is simple data that reliably predicts higher or lower mortality. One particularly helpful piece of data, the postcode, can be used to profile people for their life expectancy. We use postcode to map to one of seven life expectancy groups, and we call these *lifestyle groups* to distinguish them from the socio-economic groups in Figure 3. The lifestyle groups are defined by postcode, whereas the socio-economic groups are defined by occupation.

Figure 3. Male life expectancy at age 65 by socio-economic group

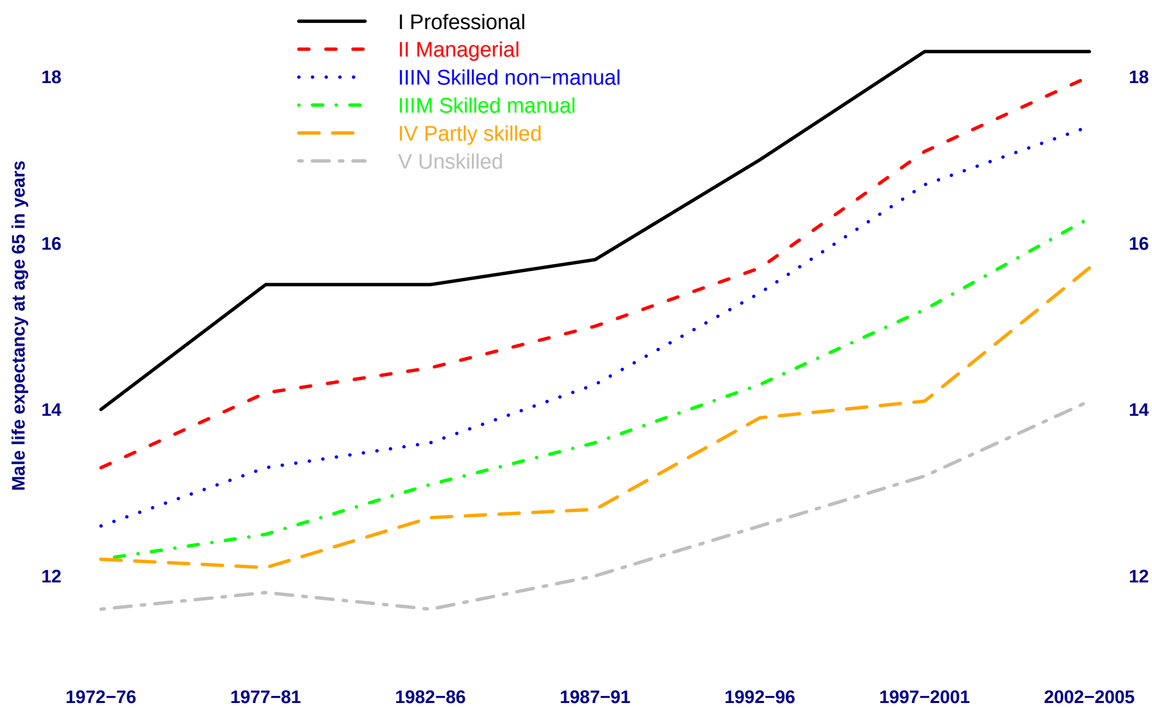


Table 2 shows the socio-economic mix of the portfolio weighted by pension. Note that £942758.24 of all pensions (18.44% of total) could not be profiled and were put in group 1. A further £1107794.16 (21.67% of total) were over £25000.00 and forcibly switched into group 1 from their profiled group.

Table 2. Summary lifestyle data *for first lives only*:

Group	Life expectancy at 65: males/females	Lives: (a) count	(b) % total	Amounts: (a) value	(b) % total
1	19.50/22.87	508	33.82%	£2646601.67	51.78%
2	18.67/22.16	444	29.56%	£1131201.17	22.13%
3	17.41/21.15	353	23.50%	£917916.49	17.96%
4	16.20/20.31	197	13.12%	£415539.25	8.13%

The values in Table 2 show the records assigned via postcode to the relevant lifestyle group. Assignment is not solely by postcode, however. If a pension exceeds £25000.00, then the postcode profile is overridden and the pension is assigned to the longest-lived lifestyle group. This is to trap cases where a postcode profile does not match the size of the pension, say if the postcode has been entered incorrectly. Finally, cases without a recognisable postcode — and where the pension is under £25000.00 — are assigned to group 1. Both the default group and the trigger value of £25000.00 are user-controlled, and the rating report can easily be re-run with different values.

To get a feel for the differentials amongst these lifestyle groups, Table 2 shows specimen life-expectancy figures for males and females at age 65. The broad spread of life expectancies is similar to that shown in Figure 3, despite the considerable differences in their calculation. The most obvious exception is social class

V in Figure 3, which covers people who are either casual labourers or unemployed. We do not have a rating group for these people, as they are only rarely holders of financial products.

6. Why use postcodes?

Walking down a street will usually give quite a good impression of the socio-economic status of the people who live there. Very broadly, a postcode covers a single street (or less) in the UK, so postcodes should be useful potential indicators of socio-economic status. As a result, actuaries in the United Kingdom are increasingly making use of so-called *geodemographic models* of mortality, primarily driven by the use of postcodes. The market for bulk annuities has long been driven by postcode for rating socio-economic group, and now annuity products marketed directly to individual consumers are priced using postcode (Legal and General, 2007, and Norwich Union, 2008).

A geodemographic model is one where a person's address or postcode is used to profile their socio-economic or lifestyle status. Such models have been used for mortality studies before, for example, McLoone (2000) published so-called *Carstairs Scores* for deprivation using Scottish Postcode Sectors from the 1991 Census. However, a key drawback of this approach lies in the use of the postcode sector, rather than the full postcode itself (a postcode sector would be the 'EH4 2' part of the full 'EH4 2AB' postcode). As noted in McLoone (2000), a postcode sector includes approximately three thousand households and is only a good predictor of socio-economic status where the postcode sector is relatively homogeneous.

mortalityrating.com derives groups from geodemographic types based on the full UK postcode. This has the advantage that the number of households covered by the same postcode is around fifteen on average, and the likelihood of the households being homogeneous with respect to socio-economic status is therefore greatly increased. Postcodes were introduced to the United Kingdom by the state-owned Royal Mail for the purpose of automating the sorting of mail. Postcodes have been widely adopted beyond their original mail-sorting purpose, including consumer profiling for marketing, and premium calculations for general insurance and bulk-annuity pricing. Socio-economic group is determined by occupation, so we will call our postcode-driven categories *lifestyle groups* to distinguish them.

7. Other summary information

Table 3 shows the size-band distribution of the portfolio weighted by pension size.

Table 3. Summary size-band data *for first lives only*:

Size-band	**Lives:**		**Amounts:**	
(lower to upper)	**(a) count**	**(b) % total**	**(a) value**	**(b) % total**
£0.00–550.00	247	16.44%	£95211.00	1.86%
£550.00–1500.00	509	33.89%	£497778.46	9.74%
£1500.00–6200.00	561	37.35%	£1698205.10	33.22%
£6200.00–999999999.00	185	12.32%	£2820064.02	55.17%

Table 4 shows the breakdown of the portfolio by presumed health status. Lives retiring before age 50 are presumed to be ill-health early retirals. Whether these lives are assumed to have higher mortality than those retiring at later ages depends on your choice of rating model.

Table 4. Summary health statuses *for first lives only*:

Health	**Lives:**		**Amounts:**	
status	**(a) count**	**(b) % total**	**(a) value**	**(b) % total**
Normal	1436	95.61%	£4873397.56	95.35%
Ill	66	4.39%	£237861.02	4.65%

One other important risk factor in U.K. longevity is year of birth, or birth *cohort*. This is a phenomenon whereby people born in the late 1920s and 1930s have noticeably longer life expectancies than previous generations. The current version of this report does not include cohort as a rating factor, but it is useful to tabulate the liability breakdown in order to decide what adjustments might need to be made to the figures elsewhere in this report. Table 5 shows the year-of-birth or cohort mix of the portfolio weighted by pension size.

Table 5. Summary cohort data *for first lives only*:

Years of birth	**Lives: (a) count**	**(b) % total**	**Amounts: (a) value**	**(b) % total**
up to 1919	152	10.12%	£391727.78	7.66%
1920-1929	540	35.95%	£1747625.10	34.19%
1930-1939	488	32.49%	£1427036.92	27.92%
1940-1949	280	18.64%	£1415501.60	27.69%
1950 onwards	42	2.80%	£129367.18	2.53%

If your liabilities are biased towards later years of birth, for example, you may want to put in extra margins for prudence in the figures in Table 6, for example.

8. Combined ratings of portfolio

The rating system behind this report uses fourteen mortality tables: there are seven lifestyle groups, with a separate table for males and females. However, actuaries often require to use so-called *standard tables* for their calculations. It is therefore necessary to express the profiling used in this report in terms of a standard actuarial table. Table 6 shows the various initial ratings for this portfolio.

These ratings use a system with an effective date in the middle of calendar year 2008. Thus, further deductions from these percentages are required to allow for the mortality improvements which have occurred since then. One approach is to use your chosen improvements basis to roll forward the given tables and percentages from the middle of 2008 to 2009-04-01. A further adjustment may be required to the figures in Table 6 in respect of the cohort effect if the portfolio is very old or very young.

Note that if you have other reliable information which would lead you to use different percentages than shown here, then you should adjust as necessary for prudence.

Table 6. Ratings: do not use without further adjustment

Table	**Table modification**	$1000 \times q_{65}$: **male/female**	**Disc. rate**	**Esc. rate**	**Ratings: male/female**
S1NA		10.39/7.17	5.00%	1.50%	78.03%/79.97%
S1NAlight		7.13/6.75	4.75%	1.75%	92.60%/83.34%
S1PA		11.24/7.94	4.50%	2.00%	78.41%/78.87%
S1PAheavy		18.33/9.18	4.25%	2.25%	62.00%/70.92%
PNA00Base		10.40/6.54	4.00%	2.50%	83.44%/83.06%

Reminder: mortalityrating.com should only be used to rate pensions in payment in the United Kingdom, and not deferred pensions or pensions outside the U.K. The use of mortalityrating.com for deferred pensions or pensions outside the U.K. is entirely at the user's own risk. Further adjustment for the cohort effect may be required for portfolios with particularly old or young pensioners, or for annuity portfolios experiencing anti-selection.

9. Methodology

The rating methodology used here is the so-called *equivalent-reserve method*, as described in the 2004 SIAS paper *Financial aspects of longevity risk* by S. J. Richards and G. L. Jones. This method uses the actual individual liability values, and effectively weights the calculation not just towards cases with the largest pension, but also to cases with the largest reserve value. For example, a sixty-year-old and an eighty-year-old might each have the same size of pension, but the weighting for the former is much larger because the reserve is bigger.

The procedure for calculating the percentages in Table 6 is as follows:

1. A postcode-driven socio-economic rating has been applied to the members, and a seven-level socio-economic mortality table used.
2. Liability cash flows were projected annually using the given pension.
3. Liability cash flows were discounted using the given discount rate, and assuming the given indexation rate.
4. The same process as steps 2 and 3 was followed, but using the given standard tables instead of the different socio-economic mortality tables.
5. The total reserves from steps 3 and 4 were equated using an equivalent-reserve calculation to get the percentage of the given standard table which gave the same reserves in step 3.

10. Caveats and exclusions

- Deferred benefits should be excluded from the calculations.
- Where a member was aged below the minimum age in the mortality table, the mortality rate for the minimum age is used.
- Where no postcode was available, or where the postcode could not be recognised, the member was assigned to the default category provided at run-time.
- No allowance was made for any geographic variations in mortality.
- No allowance was made for any temporary initial selection.
- No explicit allowance was made for the cohort effect.

11. Future mortality improvements

The assessments in Table 6 are for current rates of mortality only, whereas any reserve for pensions requires an assumption of future mortality improvements. Our current preferred method of setting a basis for mortality improvements for pensions in payment only is the CMI's P-spline methodology using age-cohort penalties, but age-year penalties are also possible. This free software is available from www.actuaries.org.uk, and has the following advantages:

1. It comes with a publicly available data set for past data,
2. It can fit a model to the past data and extrapolate trends for projection, and
3. It is possible to get percentile ranges for these projections, thus permitting the investigation of the uncertainty over future improvement trends.

If you have a large portfolio with several years' experience, another possibility is to use Longevitas to do projections. This has the advantage of there being no basis risk, i.e. you are using projections for the portfolio concerned and not projections derived from another population.

Note that we do not consider the short- or medium-cohort projections for future improvements to be adequate when valuing pensions in payment. We do not regard reserves calculated using these projections to be prudent.

12. Impact of stochastic variation

Mortality is a stochastic process, by which we mean that we cannot predict who will die when. Even if we knew exactly what the underlying mortality rates were, and even if investment returns were certain, the portfolio will still have variable cashflows resulting from random variation.

Table 7 shows the impact of stochastic variation for this portfolio. We simulate the entire portfolio in run-off, record-by-record, until the last person is dead. We then calculate the present value of the cashflows for each simulation of the portfolio. For pensions in payment, the extra capital is that required to be sure that there will be enough money to pay all benefits at the given probability level. The higher the required probability level, the more extra capital will be required. For small portfolios, high values of the extra capital can be a sign that the scheme should consider buying annuities or reinsuring.

Table 7. Impact of stochastic variation

Scenario	Discount rate p.a.	Escalation rate p.a.	Simulations	p-value	Extra capital
1	5.00%	1.50%	1000	99.50%	5.68%
2	4.75%	1.75%	1000	99.50%	5.85%
3	4.50%	2.00%	1000	99.50%	6.12%
4	4.25%	2.25%	1000	99.50%	6.25%
5	4.00%	2.50%	1000	99.50%	7.01%

13. Impact of heterogeneity

As Section 3 shows, not everyone has the same size of liability. This is one important driver of the extra capital in Table 7. Table 8 shows the equivalent figures assuming everyone has the same size of pension.

Table 8. Impact of heterogeneity

	Extra capital if pensions are:	
Scenario	(a) Actual	(b) Homogeneous
1	5.68%	2.88%
2	5.85%	2.80%
3	6.12%	3.06%
4	6.25%	3.11%
5	7.01%	3.33%

For small portfolios of pensions in payment, a large difference between columns (a) and (b) in Table 8 can suggest that reinsuring the benefits for the largest pensions can reduce the overall volatility and mortality risk.

14. Impact of trend variation

Mortality trends cannot be predicted with certainty, and we can explore the financial impact of mortality trends for this portfolio. In Table 9 we show the extra capital assuming improvement projections generated from a P-spline model for the mortality of males in England & Wales based on age-cohort penalties for ages 40–100. The same improvements for males are applied to females, ages under 40 assumed to have improvements of 40-year-olds and ages over 100 assumed to have improvements of 100-year-olds. In each case in Table 9 the baseline is a reserve assuming no future improvements, and the columns show the impact of various percentiles of the projections. For example, there is a 10% probability that the figures are at least as large as those in the 90th percentile column.

Table 9. Impact of trend variation

	Projection method	Discount rate p.a.	Esc. rate p.a.	Extra capital for given p-value: 1%	10%	50%	90%	99%
1	AC	5.00%	1.50%	6.93%	8.51%	10.44%	12.36%	13.88%
2	ACC	4.75%	1.75%	6.37%	7.78%	9.53%	11.28%	12.70%
3	APC	4.50%	2.00%	6.87%	8.77%	11.12%	13.46%	15.35%
4	AC	4.25%	2.25%	8.36%	10.36%	12.83%	15.25%	17.18%
5	ACC	4.00%	2.50%	7.81%	9.58%	11.78%	13.98%	15.76%

The details of the projection bases used are listed below:

- Method AC is a P-spline regression on population data from mortality.org using age-cohort penalties. Only data between ages 40 and 100 are used, with the reduction factors for age 40 being used for all ages below 40, and the factors for age 100 being used for all ages above 100.

- Method ACC is a P-spline regression on assured-lives data from the CMI using age-cohort penalties. Only data between ages 40 and 100 are used, with the reduction factors for age 40 being used for all ages below 40, and the factors for age 100 being used for all ages above 100. Note that the CMI data has very little exposure for females, so the male projections are used for both genders.

- Method APC is a P-spline regression on assured-lives data from the CMI using age-period penalties. Only data between ages 40 and 100 are used, with the reduction factors for age 40 being used for all ages below 40, and the factors for age 100 being used for all ages above 100. Note that the CMI data has very little exposure for females, so the male projections are used for both genders.

15. Combined impact of stochastic risk and trend variation

Here we illustrate the combined effect of the stochastic risk and trend risk. We assume that the central scenario is the 50th percentile from Section 12, and simulate both the trend and the stochastic scheme experience. Note that the figures in Table 10 assume a baseline where mortality trends follow the 50th percentile, whereas the figures in Table 9 assume a baseline of no improvements. The figures in the two tables are therefore not comparable.

Table 10. Combined impact of stochastic risk and trend variation

Scenario	Projection method	Discount rate p.a.	Escalation rate p.a.	Simulations	p-value	Extra capital
1	AC	5.00%	1.50%	1000	99.50%	6.63%
2	ACC	4.75%	1.75%	1000	99.50%	7.25%
3	APC	4.50%	2.00%	1000	99.50%	6.97%
4	AC	4.25%	2.25%	1000	99.50%	9.54%
5	ACC	4.00%	2.50%	1000	99.50%	8.26%

16. Mortality shocks and stress tests

Standards like QIS4 specify that reserves must be large enough to accommodate a 25% permanent reduction in mortality rates. In Table 11 we illustrate the extra capital required under various shock scenarios.

Table 11. Impact of mortality shocks

Scenario	Discount rate p.a.	Escalation rate p.a.	Shock	Extra capital
1	5.00%	1.50%	25.00%	9.89%
2	4.75%	1.75%	25.00%	10.25%
3	4.50%	2.00%	25.00%	10.62%
4	4.25%	2.25%	25.00%	11.02%
5	4.00%	2.50%	25.00%	11.43%

17. Other options

The analysis in this report is suitable for portfolios where the experience data is too small to be statistically credible for a bespoke analysis. By definition, it is taking a general model for mortality by age, gender and lifestyle and applying it to a specific portfolio. The results in this report can only be a good first assessment as to the risks in the portfolio itself.

For larger portfolios with credible experience data, it will usually be preferable to carry out a bespoke mortality analysis using a tool like Longevitas (www.longevitas.co.uk). Longevitas was used to create the rating model behind this report, and it can be used to analyse a wide variety of risk factors, including:

- Age
- Gender
- Lifestyle (via postcode)
- Region (via postcode)
- Ill-health status
- Benefit size
- Birth cohort
- Time trends
- Period effects
- Select period
- Marital status
- Duration

In each case, Longevitas is capable of modelling not just the effect of each rating factor, but also how it varies by age, duration or calendar time. To get more information on Longevitas's capabilities, view our web video at http://www.longevitas.co.uk

Stephen Richards Consulting Ltd
Report run: 2009-04-01
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Table 12. System environment

Description	Value
Version	v1.36 2009-02-04
Model	ExtendedFactors
Mortality law	Makeham-Perks
q_x interpolation	linear
Random-number generator	Knuth
Rating Description	Sample rating report
Registered User	LONGEVITAS
Original File	ratingtestdata.csv
Tracking	2 6964 26419
Effective Date	2009-04-01
Run Date	2009-04-01
Validation Rejects	0
Gini Coefficient	62.11
Liability Type	pension
Spouse Records Uploaded	0
Rating Includes Spouses	NO
Spouse Allocation Type	Adjust Benefit Proportion
Spouse Percentage Married	50
Spouse Female Age Difference (years)	-3
Spouse Benefit Percentage	67.7
Generate Cashflows	NO