Thank you for joining us – the webinar will start shortly
Your panel

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Agenda

1. Introduction
2. Standard tables
3. Factor based models
4. Experience analysis & credibility theory

Today we’ll use the language of pension plans, - techniques apply to any group of lives
1 Introduction
Jargon buster

**Longevity**
How long you are expected to live

**Survival rates** $p_x$ - the probability a person aged $x$ will survive the next year

$$p_x = (1 - q_x)$$

**Longevity risk** - the risk of people living longer than expected

**Mortality**
When you are expected to die

**Mortality rates** $q_x$ - the probability a person aged $x$ will die within the next year

**Mortality risk** - the risk of people dying sooner than expected
Life Expectancy
The expectation of the number of years a person will live. Expressed as either
• “years left” (20 years Life Expectancy for a 65 year old); or
• “total years” (Total Life Expectancy of 85 for a 65 year old)

Period Life Expectancy
Life expectancy based on mortality rates for one particular period – no allowance for any future changes in mortality rates

Cohort Life Expectancy
Life expectancy of a person born in a certain year (cohort) allowing for expected future changes (usually improvements/reductions) in mortality rates.
Two steps to calculate life expectancy

Baseline
- Snapshot of current state of longevity
- Objective measure
- Based on past experience

Future trends
How longevity will change in the future
- More subjective measure
- Recent experience a good starting point, but how and when will it change?
What does a baseline assumption look like

<table>
<thead>
<tr>
<th>Age ($x$)</th>
<th>$q_x$</th>
</tr>
</thead>
<tbody>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>57</td>
<td>0.724%</td>
</tr>
<tr>
<td>58</td>
<td>0.767%</td>
</tr>
<tr>
<td>59</td>
<td>0.808%</td>
</tr>
<tr>
<td>60</td>
<td>0.845%</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>89</td>
<td>14.079%</td>
</tr>
<tr>
<td>90</td>
<td>15.694%</td>
</tr>
<tr>
<td>91</td>
<td>17.391%</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>120</td>
<td>100%</td>
</tr>
</tbody>
</table>
Different approaches

“Top Down” approach

“Bottom Up” approach

Collect large amounts of data from similar pension plans

Average out experience and apply to your plan

Your assumption

Combine assumptions for the individuals within your plan

Calculate longevity for different individuals based on their characteristics
2 Standard tables
What are standard tables?

- Mortality base tables published by national agencies or actuarial bodies
- Constructed using a large portfolio, based on the expectation that they will be widely used across the industry.
- Separate tables are published for common risk classes
- "Top down" approach

Collect large amounts of data from similar pension plans

Average out experience and apply to your plan

Your assumption
Using standard tables

When they are useful

• Plan-specific characteristics are “similar” to composite data in standard tables
• Small plan/limited experience - not sufficiently credible

Limitations

• May not accurately reflect plan-specific characteristics
• Limited risk factors available for investigation
• Assessing sub-populations for risk transfer purposes

Reference population is rarely exactly appropriate to an individual plan’s needs, so standard tables are often adjusted by applying an age rating or scaling factor.
Data collection and segmentation

- **Age**
- **Gender**
- **Collar Type**
  - Blue/White
- **Sector Type**
  - Public/Private
- **Pensioner Type**
  - Pensioner/Survivor
- **Retirement-Health**
  - Normal/ILL-Health
- **Pension Amount**
Data collection and segmentation

Experience data is collected from a variety of pension plans, actuarial consulting firms and/or annuity providers.

Data is summarized and segmented into risk factors with a standard table being produced for each subgroup.
Selecting the study period

**Longer period**
- Increases data volume
- Smooths out year over year volatility

**Shorter period**
- More appropriate picture of current rates of mortality
- Better separation between baseline mortality rates and trend
Calculating $q_x$

$q_x$ The mortality rate for age $x$ - calculated as the number of deaths for exact age $x$ divided by exposure for exact age $x$.

**Deaths** Number of people who died receiving a pension

**Exposure** Measures the number of people receiving a pension who are “at risk” of dying
Lives-weighted vs amounts-weighted qx

**Lives-weighted or Headcount** $q_x$

\[
\frac{\text{Total Deaths}}{\text{Total Lives Exposed to Risk}}
\]

Equal weight for each life

**Amounts-weighted** $q_x$

\[
\frac{\text{Total Pension Amounts for Deceased Lives}}{\text{Total Pension Amounts for Exposed Lives}}
\]

Weighted by pension amount

Amounts-weighted qx's are lighter than lives-weighted qx's hence they are more appropriate for valuing pension plan liabilities.
Graduating tables

Graduation is the mathematical process of ironing out bumps in observed mortality rates at individual ages to produce rates that progress smoothly between ages.
Graduating tables

Crude Mortality Rates (Lives-Weighted) for CPM Males Private Sector

Transform to log scale so that rates are broadly linear with age

Illustration of Graduation of CPM Male Private sector (Lives-weighted), Logarithmic Scale

1. Smooth rates over age range with reliable data
2. Extend rates at lower and higher ages
### Examples of different standard tables

<table>
<thead>
<tr>
<th>Published by</th>
<th>Table Name</th>
<th>Underlying population</th>
<th>Risk Factors</th>
<th>Mortality Experience</th>
<th>Effective Date/Base Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous Mortality Investigation (CMI)</td>
<td>“S3” Series</td>
<td>Self-administered pension schemes (SAPS)</td>
<td>Gender Pensioner Type Retirement Type Pension Bands</td>
<td>2009-2016</td>
<td>1 January 2013</td>
</tr>
<tr>
<td>Canadian Institute of Actuaries (CIA)</td>
<td>CPM2014</td>
<td>Canadian registered pension plans</td>
<td>Gender Sector Type Pension Size Adjustment Factors</td>
<td>1999-2008</td>
<td>1 January 2014</td>
</tr>
<tr>
<td>Society of Actuaries (SOA)</td>
<td>Pri-2012</td>
<td>US private-sector retirement plans</td>
<td>Gender Pensioner Type Collar Type Top/Bottom Benefit Quartile</td>
<td>2009-2014</td>
<td>1 January 2012</td>
</tr>
<tr>
<td></td>
<td>Pub-2010</td>
<td>US public-sector retirement plans</td>
<td>Gender Pensioner Type Retirement Type Employment Type Above/Below Median Income</td>
<td>2008-2013</td>
<td>1 July 2010</td>
</tr>
</tbody>
</table>

"Weighted mid-point of the standard table" or date the mortality rates are said to be applied
3  Factor based models
Factor based models

- ‘Bottom up’ approach
- Consider factors which influence longevity
- Which should be modelled?
- Construct model to reflect those factors
- Allocate individuals based on their characteristics
- Overall assumption based on aggregating across individuals

Your assumption

Combine assumptions for the individuals within your plan

Calculate longevity for different individuals based on their characteristics
What affects how long people live?

- Age
- Gender
- Affluence
- Lifestyle
- Health
- Occupation
- Location
- Smoker?
- Married?
- Genetics
Data collection

- Age
- Gender
- Pension / salary
- Postcode / ZIP code
- Disability / ill health?
- Manual / Non-manual
- Location
- Smoker?
- Pension form
- Genetics
Should we split the data?

Factor

Split
- Split data into groups
- Model groups independently
- Reflects fundamental differences between groups

Don’t split
- Allow for interactions
- Model simultaneously
- Maximises data used to inform model
Splitting the data

Reasons to split the data (stratify):

1. **Differences in shape**  
   (e.g. normal versus ill health)

2. **Difference in meaning**  
   (e.g. pension amount for pensioners versus dependants)

3. **Different age ranges**  
   (e.g. dependants older than pensioners)

Source: Crude mortality rates with 95% confidence intervals, 2015-2017 Club Vita (UK) data
Assigning variables

**Which** factors to use?
- How much ‘extra’ does each additional factor add?
- Does it justify extra complexity?

How to **assign** variables?
- Number of ‘buckets’ to use
- Thresholds for each bucket

Simplicity  Predictiveness
Grouping ZIP/postcodes

- Postal code is a proxy for lifestyle etc
- Residents in similar areas have similar characteristics
- Areas can be categorised by typical residents
- Similar areas exist in different parts of a country
- People with similar characteristics have similar longevity
- Postal code can be assigned to small number of groupings

- See our ‘Zooming in on ZIP codes’ paper for more details

https://www.clubvita.us/collaborative-research/zooming-in-on-zipcodes-whitepaper
Fitting the model

• Consider interaction of two factors

• Standard table approach:
  – each combination treated separately
  – very small ‘buckets’

• Factors based models:
  – allows for interactions between factors
  – maximises data used to inform fit
Fitting the model

Chance of dying over next year

Transformed onto a “log” or “logistic” scale so broadly linear with age

Fit curves to across different combinations of affluence, postal code, occupation etc... simultaneously

Maximises the predictive power of the data
Checking fitted rates

• Important to validate generated rates
• Consider ‘goodness of fit’ to underlying data
  ‒ Range of statistical, actuarial and validation tests applied
• Check internal consistency
  ‒ Expect to increase with age
  ‒ Curves in ‘right’ order
  ‒ Less granular curves within extremes of more granular curves
Using factor based models

When they are useful

- Reflect diversified nature of pension plan
- Better fit at individual level than ‘average’
- Allow for changing demographics over time
- Smaller plans can benefit for wider ‘pool’ of experience data

Limitations

- Dependent on data held by administrators
- Plan/Industry specific characteristics may not be fully reflected
4  Experience analysis & credibility theory
Overview

What: Comparison of actual deaths within plan to that expected under an assumption.

When used: To confirm appropriateness of proposed assumption. To adjust proposed assumption for known plan effect.

Limitations: Generational stability assumption. Seeking the perfect answer / false confidence.
Explaining the jargon

Actual deaths experienced over the time period

Expected deaths experienced over the time period

“A over E ratio”

More deaths than expected
Assumption *overstates* life expectancy

 Fewer deaths than expected
Assumption *understates* life expectancy
“Lives” or “amounts”

Lives
Number of people dying

Amounts
Amount of pension ceasing
The “A over E” chart

**Overall amounts based A/E**

*Plan XYZ vs VitaCurves factor based model*

1. Point represents A/E
2. Want to see A/E close to 100%
3. “Whiskers” represent how certain we are about the point
Getting the age shape right

Actual compared to expected deaths on an amounts basis

More deaths than expected (assumption of too long a life)

Fewer deaths than expected (assumption of too short a life)
Adjusting baseline to get A/E close to 1

**Scaling**

120% * rates in table

**Age rating / Step**

Treat everyone is if

3 years older
Capturing diversity

Actual compared to expected deaths on an amounts basis
(by benefit amount band)

More deaths than expected
(assumption of too long a life)

Fewer deaths than expected
(assumption of too short a life)
Limitation: “Generational stability”

Mortality experience of the pension plan
(total pension amount ceasing over a 5 year investigation period)

Experience analyses focus on where most pensioner deaths occur.
For this plan this is a generation of blue collar workers

Liabilities of the pension plan

Many plans will have majority of liabilities relating to younger lives
For this plan this is primarily white collar workers

1. Ensure assumption underpinning experience analyses is able to pick up these differences
2. Smaller adjustments preferable (more likely to apply across generations)
Applying credibility theory

- Mechanism for deciding how much belief to have in plan experience:
  \[
  \text{weight} = 100\% \quad \text{or} \quad \text{weight} = 0\%
  \]
  - weight = 100% entirely relies on experience analysis
  - weight = 0% entirely relies on unadjusted tables

  \[
  \text{weight} \times \text{Plan experience} + (1 - \text{weight}) \times \text{Unadjusted table}
  \]

- Value of weight determined by a formula reflecting statistical confidence in unadjusted tables or experience analysis
- Never exactly 100% (“entirely self-credible”)
- Guide only: Lots of considerations including can you rationalise, data weaknesses etc…

Session 201 will explore issues in more detail
Thank you