Institute
and Faculty
of Actuaries

IFoA Longevity Risk Taxonomy

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2 Executive Summary

2.1 Introduction

This section provides a summary of the document and covers the following aspects:

- Need for a Reference Longevity Risk Taxonomy
- Qualities Desired
- IFoA Longevity Risk Taxonomy
- Consultation
- Further Development

This document has been commissioned and published by the Mortality and Morbidity Research Steering Committee on behalf of the IFoA. This final version of the paper has been published following consultation which closed on 31 March 2021.

2.2 Need for a Reference Longevity Risk Taxonomy

Actuaries in their responsibilities for the management of Longevity Risk and typically, under various risk frameworks such as Solvency II, split Longevity risk into different risk components to measure and manage the longevity risk exposed to. These risk components comprise what is commonly referred to as a Longevity Risk Taxonomy.

It would be expected that risk taxonomies used by different companies will vary to account for differences in the risk exposure and views of the organisation providing the longevity protection but often the same word is used to describe different components or different words to describe the same component. This can lead to misunderstanding of what and where sources of Longevity Risk are being accounted for and lead to inaccurate comparisons of risk quanta.

A reference taxonomy would create a common parlance for communication, benchmarking and validation, much in the same way the CMI Mortality Projections model does for mortality improvements assumptions, and this paper outlines such a reference taxonomy produced by the IFoA.

2.3 Qualities Desired

In constructing a taxonomy the aim has been to achieve the following qualities:

- The taxonomy should be applicable to both "economic" and "one year" assessments of risk – so relevant for all uses of risk taxonomies
- It should differentiate between the systemic population risk (to which all providers are exposed albeit to different extents) and the specific portfolio risk (to which individual providers may have materially different exposures)
- It should be applicable to all forms of longevity exposure and longevity risk management approaches

2.4 IFoA Longevity Risk Taxonomy

The proposed IFoA Longevity Risk Taxonomy contains 10 risk components split between those affecting the population and those affecting the specific portfolio. A summary description of these can be found in Table 1 with more detailed descriptions in section 7. A description of these in the context of "one year" assessment of risk is provided in section 8.

Table 1 – IFoA Longevity Risk Taxonomy

	Risk Component	Definition	Example
Population Risks	Event Risk	Risk of future longevity events occurring at times or with effects not consistent with the assumptions	Reduction in smoker propensity since the 1970s
	Population Modelling Risk	Risk that modelling choices or interpretations made regarding the ***reference population*** are incorrect (or change) ***without the data or information changing***	Recognition of the cohort effect
	Population Mis-estimation Risk	The risk that the ***reference population assumption*** mis-estimate the correct level of the population mortality rates	Overestimation of mortality improvement in the late 00s (realised following the 2011 census)
	Population Volatility Risk	Risk of short-term deviations in reference population mortality improvements from the underlying level of mortality improvement owing to systemic effects	Poor performance of 2015 flu vaccine
Portfolio Risks	Heterogeneity Risk	The risk that lives with materially different longevity profiles are considered homogenous within a classification group	Lack of behavioural or mental well-being information when determining assumptions
	Classification Risk	The risk that lives are misallocated to a classification group within the mortality basis and utilise assumptions that are not appropriate	Inaccuracy of assumed impairment level based upon individual medical information
	Basis Risk	The risk that the assumptions derived are not relevant to the lives in the portfolio (including geared impact on the portfolio exposure to future longevity events)	Uncertainty in relevance of the slowdown in population mortality improvements since 2011
	Portfolio Modelling Risk	Risk that modelling choices or interpretations made regarding the ***portfolio*** are incorrect (or change) ***without the data or information changing***	Uncertainty in the shape and duration of anti-selection effects
	Portfolio Mis-estimation Risk	The risk that ***portfolio adjustment assumptions*** derived from external evidence and/or empirical experience mis-estimate the correct level of the assumption	Limited credibility of experience at older ages
	Portfolio Volatility Risk	The risk that even if the classification and the assumptions are correct the specific mortality and morbidity events that occur cause the pattern of future cashflows to change	The number of actual deaths that occur over a period may differ from the expected number of deaths though random variation

3 Background

3.1 Introduction

This section provides the context for the development of the framework outlined in this document and covers the following elements:

- Overview of the Longevity Risk Priority
- Overview of the Longevity Risk Workstream
- Challenges to be addressed in delivering this priority

3.2 Overview of Longevity Risk Priority

The MRSC has defined 6 priority areas of focus[1] one of which is Longevity Risk Management, which is still in its infancy and there are a number of aspects that could be improved such as:

- **Common terminology with respect to the components of longevity risk** – often the same word is used to describe different components or different words to describe the same component. For example, many publications use "event" and "model" risk somewhat interchangeably. A reference taxonomy would create a common parlance for communication, benchmarking and validation.
- **Development of an approach for comparing longevity risk exposure** – it is currently very challenging to compare the quantum of risk to validate that an estimate is "reasonable" relative to the specific risk exposure.
- **Identification of alternative ways to manage longevity risk and the cost-benefit of these alternatives** - the current cost of longevity risk is significant and as such products providing longevity protection are expensive for consumers. Arguably a material proportion of the risk results from the methodologies used by actuaries above and beyond the intrinsic risk affecting the lives – for example, the reliance on information captured at the point of sale across the full duration of the liability. In addition, the frameworks operated under often impede an economic assessment and management of the risk. There are potentially alternative ways of managing the risk which may lead to reduced levels of risk, greater security for the recipients of longevity protection and reduced capital requirements.

3.3 Overview of the Longevity Risk Workstream

A workstream has been set up as part of the Mortality and Longevity Member Interest Group to explore the aspects described in section 3.2. The workstream has been supported by Kishore Ananda, Steven Baxter, Sacha Dhamani, Tim Gordon and Alison Yelland.

The intent is to publish a series of papers on Longevity Risk Management covering:

- **Taxonomy** – Creation of an industry standard definition of the risk components comprising longevity
- **Comparison of Exposure** – Development of a method for comparing longevity risk exposure
- **Risk Management** – Identification of new ways to reduce longevity risk

[1] Further details can be found at https://www.actuaries.org.uk/learn-and-develop/research-and-knowledge/mortality-research-hub/mortality-research-steering-committee-priority-research-areas

- **Risk Variations** – Expansion of the consideration of the different risks affecting different types of annuitants – standard, impaired and deferred annuitants

This document outlines the taxonomy element of Longevity risk. The steps to deliver all the intended work in this workstream are described further in section 11.

3.4 Challenges to be Addressed

The objectives to be achieved by the IFoA Taxonomy are:

- The creation of a reference terminology for Longevity Risk Components capable of describing the risk exposure of all forms of provider
- To enable practitioners to be able to discuss longevity risk in a common language
- To enable the comparison of approaches to longevity risk modelling for the purpose of benchmarking and validation

It is important to note that the intention is not to:

- Create a taxonomy that should be adopted by all providers as the structure of their internal Longevity Risk model Whilst the taxonomy may be useful for any provider developing an internal model from scratch the existence of this taxonomy should not be viewed as necessitating any change to existing internal models because:
    - The exposure to risk will differ such that taxonomies will vary from company to company to ensure the risk model is sensitive to the specific risks of the provider
    - Individual providers will have different views on longevity risk and their risk taxonomies should be consistent with these views
    - Alternative risk modelling approaches may be taken based upon views of longevity risk and so lead to different levels of granularity in the risk taxonomy
- This paper is not intended to cover risk modelling approaches, calibration methods or quantification of risk except in general terms where helpful to explain the taxonomy
- The consideration of how best to manage longevity risk is not covered in this document but rather will be the subject of a later paper

4 Economic and Regulatory Environment

4.1 Introduction

This section provides a brief overview of the regulatory and economic environment within which the individual annuity and Longevity Risk Transfer (LRT) market operates and covers the following elements:

- Market Overview
- Solvency II
- Economic environment and need for Enterprise Risk Management (ERM)

4.2 Market Overview

Preliminary data published by the OECD indicates that pension funds are held in excess of $32trn in the OECD area in 2019 with the United States, United Kingdom, Australia, Netherlands, Canada, Japan and Switzerland holding over 90% of all pension fund assets in the OECD area[2].

In the United Kingdom, as with many countries, there has been a shift from the traditional Defined Benefit (DB) pension funds towards Defined Contribution (DC) pension funds which has increased the extent to which individuals bear the risk (including longevity risk) associated with pension provision. The subsequent need for individuals to better manage these risks has driven the demand for individual annuity policies offered by insurers.

In 2014 the introduction of "Pensions Freedom in the UK has led to a decline in the volume of individual annuity policy purchases in recent years but market activity continues at pace with c.69,500 pension plans accessed and subsequently used to purchase an individual annuity in the year 2019/20. The individual annuity market therefore represents a material accrual of longevity risk on insurer balance sheets. This longevity risk exposure faced by insurers is further increased via sales of other insurance products offering long term guaranteed benefits but to a lesser degree.

In the case of DB pension funds, aggregate liabilities are estimated at approximately £1.9trn as of October 2020[3]. This again, represents a significant longevity risk exposure and has led to increasing activity in the LRT market over the last decade as pension funds look to transfer their longevity risk to insurers via the use of buy-in policies, buy-out policies and longevity swap transactions.

Since June 2009, liabilities worth in excess of £140bn have been transferred to insurers via buy-in or buy-out policies and longevity swap transactions covering liabilities worth in excess of £90bn have also been completed. The activity in the United Kingdom is has increased with bulk annuity market volumes exceeding £40bn in 2019 and the pension scheme longevity swap market exceeding £7bn in the same year. LRT activity is also on the rise in the United States, Canada and the Netherlands but has not yet reached the levels observed in the United Kingdom.

4.3 Solvency II

Many actuaries working to support insurer and reinsurer entities with exposure to the individual annuity market and the LRT market find themselves operating under Solvency II

[2] https://www.oecd.org/pensions/Pension-Funds-in-Figures-2020.pdf
[3] https://www.ppf.co.uk/ppf-7800-index

or a similar/equivalent regime. The aim of the Solvency II regime is to introduce a harmonised, sound and robust prudential framework for insurance firms within the EU. The implementation of Solvency II is built around three pillars:

1. Quantitative requirements
2. Governance and risk management requirements
3. Disclosure and transparency requirements

Under Pillar 1, insurers are required to calculate a Solvency Capital Requirement (SCR) using either the prescribed Standard formula or a regulator approved Internal Model. The SCR is a risk-based capital measure calibrated such that the insurer can meet its obligations over a 12 month period with a probability of at least 99.5%. In relation to longevity risk, the Standard formula adopts a scenario based stress i.e. 20% reduction to best estimate mortality rates at all ages. Many larger insurers and reinsurers, which dominate the LRT market, opt to develop an Internal Model. There is no exact regulatory definition and Solvency II gives insurers a large degree of flexibility in developing an Internal Model that is appropriate to the relevant entity. The absence of a prescribed model and/or prescriptive framework introduces variation in both the longevity risk taxonomy and modelling approach used.

The availability of a consistent longevity risk taxonomy and framework could potentially assist in both the development of an appropriate Internal Model (e.g. ensuring the main risk components have been correctly identified and captured without gaps or double-counting) and facilitate the effective supervision of insurers under Pillar 2 (e.g. allow for the consistent communication and benchmarking of Internal Models across entities by the regulator).

4.4 Economic Environment and ERM

Enterprise risk management (ERM) is an approach to risk management that takes into account the correlations and dependencies of risks across all the activities of the relevant entity. As one would expect, there are many similarities with the Solvency II regime which also requires insurance entities to put in place effective risk management systems.

A key tenet of ERM is the language used to communicate risk within organisations and risk taxonomies are encouraged, for example

"One of the ways in which communication can be made efficient is by ensuring that people understand what each other mean – something that is not a given in the world of risk, where definitions are frequently poorly understood, open to interpretation, or extremely broad. That is, a company should strive to establish a common language for risk.

One important part of this effort should be to establish a taxonomy of risk – a common structure for describing the categories and subcategories of risk, as well as the tools, metrics and strategies for risk management. A taxonomy is not only useful in talking about risks, but allows them to be broken down into manageable components that can be aggregated for exposure management and reporting purposes. This is not a one-off process; it should be iterative and reflect the dynamic and changing nature of the business." Lam (2003)

Taxonomies exist for major risks throughout organisations, and within insurers will cover market risks, insurance risks and operational risks. These will often be built within a hierarchical structure – for instance Chapman (2006) describes a multi-level approach of:

- Class (e.g. Financial)
- Elements (e.g. Credit)
- Attributes (e.g. default, exposure, recovery, counterparty)

Whilst insurance risks are well recognised as a class of risk, further tiers of the hierarchy can vary between firms. Considering longevity (and its counterpart mortality) risk as one of the elements of insurance risk, the IFoA taxonomy seeks to provide a common language for the lower tiers. Within this framework we use the phrase “risk components” rather than attributes for the next tier (as attributes of longevity has alternative meanings).

Larger insurance and reinsurance entities with longevity risk exposures in multiple regulatory regimes are likely to benefit from the use of a consistent longevity risk taxonomy and framework as this supports the implementation of the wider ERM framework e.g. ensuring longevity risk components are aggregated consistently across entity group structures where transactions are written by multiple subsidiaries.

5 Definition of Terms

5.1 Introduction

This section defines specific terms used in this document and covers the following elements:

- Longevity Risk
- Risk Component
- View of Risk

5.2 Longevity Risk

Longevity risk is the uncertainty in future life span leading to a different outcome to that expected / budgeted for.

Conceptually longevity risk can be best understood in the form of a multi-state model comprising two forms of transition:

- **Morbidity Risk;** the uncertainty and volatility of transition from the current morbidity state to other morbidity states over time each with differing rates of transition to death
- **Mortality Risk;** the uncertainty and volatility of transition from the specific morbidity state at any point in time to death

Whilst this may be a more conceptually correct approach, and one that leads to better management of the risk, most providers utilise a two state model (Alive, Dead) for best estimate assumptions and the morbidity element is subsumed into the expected variation in mortality. For ease and consistency the framework outlined in this document will follow the same approach. However, certain components of the framework can be seen to capture the morbidity element of longevity risk such as Classification risk.

5.3 Risk Component

A "Risk Component" is a specific element of the longevity risk taxonomy that partitions longevity risk to create distinct groupings of risk that distinguishes between fundamental differences in the risk such as:

- **Sources of the risk** – for example, whether the risk arises from a real world event or limitations in the actuarial method employed
- **Lives affected by the risk** – for example, whether it affects the population or just the portfolio

It is desirable for these to be orthogonal groupings of risk (i.e. statistically independent) so far as is practical to limit the challenges in identifying and aggregating the risks.

5.4 Views of Risk

Two views of risk are referred to in this document:

- **Economic** - where the longevity risk is considered from the current position with respect to the uncertainty in how experience will emerge over the full duration of the liabilities differently than that assumed. This way is also referred to as "run off" or "time 0[4]". This is how the risk would naturally be considered from a business management perspective under ERM frameworks.

[4] Noting that practitioners do define these views differently in practice.

- **One Year** - where the longevity risk is considered over a specific time period during which any assumption change may resulting in balance sheet movments. In this way the longevity risk arises more from changes in expectations rather than actual experience diverging from assumptions. This is how the risk is considered under many regulatory regimes, including Solvency II.

6 Construction Approach

6.1 Introduction

This section outlines the approach taken to constructing the framework and covers the following elements:

- Generic Longevity Basis
- Risk Distinctions
- Economic and One Year Views of Risk

6.2 Generic Longevity Basis

In considering the appropriate risk components it is helpful to describe a “generic” best estimate approach to enable definition of the sources of risk. Whilst there are any number of ways to construct a longevity basis the proposed generic best estimate structure is to:

- Utilise a reference population, that provides historical and projected mortality rates, to serve as a foundation for setting portfolio appropriate assumptions
- Adjust the reference population mortality rates so that they are appropriate to the specific lives within the portfolio

6.2.1 Reference Population Mortality Rates

Under this approach it is assumed that there is an underlying “mortality curve” that serves as a foundation for the mortality assumed for each specific life. This “curve” will be based upon a reference population that can be almost any group of lives - national populations, industry experience, historical portfolio experience, etc. The critical point is that the actuary has judged this to be a suitable starting point to base assumptions upon. These assumptions include both the historical mortality rates (for experience analysis) and future mortality rates (for valuation).

Example approaches which could be used are:

- **Single Reference Population Approach**: The same reference population underpins both the baseline longevity assumption (historical mortality rates) and the projection to create future mortality rates. For example, this could be the E&W population life tables alongside ONS or CMI mortality projections model.
- **Two Reference Population Approach:** A different reference population is used for the baseline to the roll forward / projection of that baseline. For example the baseline may be set using CMI tables (which use industry experience as the reference population) and projected using the CMI projections model (which uses England & Wales as the reference population)[5].
- **Reference Population = Portfolio**: In some cases the portfolio may be chosen as the reference population for directly fitting both historical mortality rates and projections. In this case the distinction made in this taxonomy between population risks and portfolio risks still serves as a useful framework, with the population risks being the general

[5] Noting that the use of two reference populations for this purpose creates an risk of misalignment that would need to be accounted for in measurement of the risk

external factors affecting all lives and the portfolio risks the specific factors affecting the lives in addition to the population risk[6] .

6.2.2 Portfolio Adjustment

Having established a suitable set of reference population mortality rates there needs to be adjustments to these mortality rates for the basis to be appropriate for the portfolio or the specific lives within the portfolio (if the former is not believed to be appropriate). Historically for valuation, this meant a flat percentage of the base table (split by gender) but over the last 20 years there has been a move to increased classification of lives (e.g. by annuity amount and postcode) and more complexity in the assumption structure (variation of the adjustment by age for example). These portfolio adjustments may also vary by calendar year – and affect both historical and future periods.

As a general method the application of portfolio adjustments can be considered to comprise of two steps:

- The classification of lives into suitable categories of longevity risk (noting that this classification may be discrete (e.g. gender) or continuous (e.g. level of impairment)[7]
- The assignment of assumptions based upon the classification of the life

Whilst this distinction in its purest form would lend itself to a multi-state model that is not what is being used in the generic approach. In the more common two-state model the morbidity or state transition behaviour is implicitly captured in the projected mortality rates.

6.3 Risk Distinctions

The following distinctions in risks are to be drawn out through the creation of the risk taxonomy

- Population-Portfolio
- Uncertainty-Volatility
- Real World-Actuarial Interpretation

6.3.1 Population-Portfolio

The structure of the generic longevity basis lends itself to a distinction between population and portfolio risks and this is believed to be advantageous in allowing the risk taxonomy to be more accessible to non-experts and increasing the comparability of element of the risk taxonomy between holders of longevity risk.

It should be clearly noted that the use of a Population-Portfolio distinction is not merely a re-labelling of the traditional “Base-Trend” approach i.e. “base” is not synonymous with “portfolio” nor “trend” with “population”.

For example, the uncertainty in the level of population mortality would traditionally be considered under “Base” whereas under this framework it would be captured under “Population”. Conversely, the uncertainty in the level of mortality improvement for the

[6] In the case where the portfolio is used as the reference population the risk components described in this document may need some further consideration to ensure that risks are not being double counted as there are risk components within each classification that now potentially overlap. A choice would need to be made whether to combine the population and portfolio variants or ensure a clear line of demarcation is made.

[7] Examples of the approach to classification of risk can be found in Madrigal et al (2011) and Richards et al (2013)

portfolio relative to the reference population would traditionally be captured under "Trend" whereas under this framework it would be captured under "Portfolio".

6.3.2 Uncertainty-Volatility

Longevity risk can be considered to be the result of two possibilities:

- The risk of getting the average wrong,
- The risk of getting the average right, but being unlucky.

As such it is a mixture of uncertainty and volatility. The latter might be considered as a stochastic process (and hence susceptible to models of that form) but the former is intrinsically harder to model.

The reason for this is that uncertainty largely relates to the possibility of the future not merely being a continuation of the past – the potential for "black swan" events renders any assumption that this is the case suspect. So the form of the risk may change in the future and the relevance of past data to parameterize a model is questionable. In addition, past levels of risk variation may not be a relevant measure of future variation, and hence back testing provides limited validation of any particular modelling approach.

Over the short term, volatility tends to dominate a risk exposure but in the long term uncertainty is the key driver. As a result longevity is more of an uncertainty risk than a volatility risk.

6.3.3 Real World-Actuarial Interpretation

It is often underappreciated what quantum of risks arise from uncertainty in what will happen in the real world and from uncertainty in the actuarial methods employed.

In setting longevity assumptions there are a great many interpretations and judgments made with respect to the modelling and parameterisation. This paper seeks to define a risk taxonomy which differentiates the risk arising from limitations (by necessity or by design) in the actuarial method from those arising from real world events.

6.4 Economic and One Year Views of Risk

In constructing the taxonomy the approach is to start with an economic view of longevity risk focusing on the sources of risk as they affect the portfolio across the full duration of the liabilities. In this way the taxonomy is appropriate for the way the risk is considered and managed in practice.

Solvency II and its requirement for a one year Value at Risk (VaR) assessment of risk led to a tendency to directly create one year views of risk. The associated risk taxonomies observed in the industry have taken different approaches such as focusing on the source of risk (as the IFoA framework does) or being predicated on the one year process of assumptions management (e.g. Kingdom [2019]).

These, and others used, represent conceptually different approaches and so can produce quite different risk taxonomies – but legitimately and appropriate to the purpose and views of the specific organisation. However, it is believed that starting with an economic view represents a more general and versatile approach. Having created an "economic" view consideration is then given to how this view varies under a one year time horizon which is covered in section 8.

7 IFoA Longevity Risk Taxonomy

7.1 Introduction

This section describes the components of the IFoA Longevity Risk taxonomy and covers:

- Population Risk Components;
  - Event Risk
  - Population Modelling Risk
  - Population Mis-estimation Risk
  - Population Volatility Risk
- Portfolio Risk components;
  - Heterogeneity Risk
  - Classification Risk
  - Basis Risk
  - Portfolio Mis-estimation Risk
  - Portfolio Modelling Risk
  - Portfolio Volatility Risk

The application of these definitions in a one year framework is discussed in Section 7.

7.2 Event Risk

7.2.1 Definition

Risk of future longevity events occurring at times or with effects not consistent with the assumptions.

7.2.2 Examples

This risk arises from events that impact the reference population and are not consistent with the assumptions made in the best estimate. Being derived from past data and expert judgments, the best estimate mortality improvements will allow for a future events scenario (for example smoking continues to decline) but there is the risk that events are different to those expected. The main categories of these events are:

- Medical Breakthroughs
- New diseases or existing diseases become resistant to current treatments
- Lifestyle Changes
- Government policies and spending
- Technological changes
- Climate or environmental changes

For each of these there will be a scenario that is consistent with the best estimate and changes in the external environment can cause a departure from this.

7.2.3 Shape/Nature of the Risk

This is a risk driven by real world events. These events can occur infrequently but with large impacts or gradually with uncertain total impacts. The impact of such events in the past may be difficult to quantify and separate from the impacts of each other.

Moreover, there are challenges in differentiating event risk other risk components in practice. For example, it will be assumed that a number of new events which cause changes in longevity will occur (as past driver of longevity improvements cannot generally be repeated). However it is difficult to assess whether a particular new event occurring is consistent with the plausible range of new events already assumed to occur, or is a genuinely a new development which will increase life expectancy beyond the plausible range from projecting past data.

7.3 Population Modelling Risk

7.3.1 Definition

Risk that interpretations made regarding the reference population are incorrect or change without the data or information changing.

7.3.2 Examples

This risk arises from the assumptions made in fitting a model to the reference population.

This may arise from the choices made in regards to the currently available models or from discovery or publication of a new model or research that is used to inform expert judgments. This can also arise from interpretations of the research and in judgements on what level of granularity to apply these judgements at.

The following are examples where assumptions or interpretations could change:

- Assumptions on mortality variation by gender
- Assumptions and models used to generate older age mortality where data is sparse
- Assumptions made on the maximum life span
- Structure of variation between subsets in the population (e.g. difference socio-economic groups)

In fitting models many decisions will have been taken where alternatives could be more appropriate such as:

- data period chosen
- model chosen
- fitting techniques chosen
- number of factors included in fitting
- model constraints applied to ensure unique solutions
- parameters set by expert judgement

7.3.3 Shape/Nature of the Risk

This risk is driven by the actuarial assumption setting process. In longevity there are relatively few observations to use to fit models and so it is difficult to judge the best model from past fit. Alternatives may be published that lead to a change in the modelling or further investigations may lead to alternative models appearing more suitable. This risk is made up of many small decisions that overlap.

7.4 Population Mis-estimation Risk

7.4.1 Definition

The risk that the reference population assumptions mis-estimate the correct level of the population mortality rates.

7.4.2 Examples

This risk arises because the model chosen can only estimate the underlying mortality rates.

This estimation could be limited because

- Insufficient credibility of reference population experience
- Data errors in the reference population experience
- Uncertainty of estimated parameters due to volatility in historical experience

7.4.3 Shape/Nature of the Risk

This risk will be related to the amount of data available but this is also related to modelling risk because a more complex model will require a larger amount of data to estimate the parameters to the same level of confidence. The level of mis-estimation risk should reduce over time as the reliance on modelling choices and interpretations of events increasingly determines the level of the assumption.

7.5 Population Volatility Risk

7.5.1 Definition

Risk of short term deviations in population mortality improvements from the underlying level of mortality improvement owing to systemic effects.

7.5.2 Examples

This risk is driven by events that impact the whole population (albeit to potentially differing extents), for example

- Seasonal mortality variation (such as harsh winters and poor performance of flu vaccines)
- Short term fiscal policy effects – such as austerity

7.5.3 Shape/Nature of the Risk

This risk is asymmetrical with more significant “upside” events more likely than “downside” events.

7.6 Heterogeneity Risk

7.6.1 Definition

The risk that lives with materially different longevity profiles are considered homogenous within a classification group.

When calibrating assumptions using portfolio experience, or other sources, the classification may group lives of materially different longevity profiles such that the calibrated assumption is an average for the group that is not sufficiently accurate for the sub-groups of lives within the classification – who will exhibit higher or lower mortality than assumed.

Whilst to some extent the “losses” on the lower mortality lives will be offset by the “gains” on the higher mortality lives there is the potential for more significant financial effects if there is significant variation in mix of lives between the “experience” portfolio and the “liability” portfolio.

7.6.2 Examples

The following examples are highlighted to enable understanding of this risk component:

- The lack of socio-economic, medical, behavioural or well-being information for the lives in the portfolio can limit the ability to identify material differences in mortality experience
- The use of data captured at point of sale to identify the variation in mortality at longer durations – as the relevance of this data decreases over time as:
  - It may no longer be accurate
  - Be a less relevant predictor of mortality variation at older ages
- Small premium (or benefit amount) policies may contain a mixed group of lives such that the observed mortality experience will not be representative of all the lives within that group

7.6.3 Shape/Nature of the Risk

Heterogeneity risk will emerge as:

- Deterioration of the A/E over time as the proportion of lower mortality lives increases
- Recognition of the heterogeneity within the classification through the addition of new risk factor data to partition the experience analysis

The emergence of the former behaviour will lead to investigation that causes the latter behaviour – therefore the risk will emerge as "jumps" in the estimated liability in specific years.

7.7 Classification Risk

7.7.1 Definition

The risk that lives are misallocated to a classification group within the mortality basis and utilise assumptions that are not appropriate.

When valuing liabilities most longevity bases will classify lives into sub-groups within the portfolio to recognise the different longevity profiles within the portfolio and reduce the level of heterogeneity risk. Some classifications are very reliable, such as gender, where there is minimal risk of the life being allocated to the "wrong" classification but for others, such as socio-economic class based upon postcode, there is a material risk that they are.

As a result it is possible that a life is allocated to a "high" mortality classification but would be more appropriately allocated to a "low" mortality classification.

Classification risk differs from heterogeneity risk in that heterogeneity risk is concerned about *"within group"* risk i.e. an individual has been assigned to the correct group for their assumption, but that group has considerable variability within it. For example where lives are grouped by pension band there can be considerable heterogeneity amongst the small pensions, whilst the open-ended nature of the top group can lead to very diverse lives. In contrast classification risk relates to the *misallocation* of a life to the wrong group. This can happen when it is difficult to classify an individual (for example determining the dominant impairment for lives with multiple morbidities) or when the information used to allocate an individual has grown "stale".

7.7.2 Examples

The following examples are highlighted to enable understanding of this risk component:

- Assumption of static postcode profiles (which postcodes map to which longevity profile) so failing to take into account movements in longevity profile in the future relative to the past

- Misallocation of lives to a particular medical condition when multiple medical conditions are present
- Inaccuracy of assumed impairment level based upon individual information such as medical details

7.7.3 Shape/Nature of the Risk

Classification Risk will emerge as:

- Deviation of the A/E over time but could be in either direction depending on whether the misallocation is systemically optimistic or prudent
- Recognition of the weaknesses in the classification rules through the improvement of the existing rules

The emergence of the former behaviour will lead to investigation that causes the latter behaviour – therefore the risk will emerge as "jumps" in the estimated liability in specific years.

The information used to classify the lives is likely to be a mixture of current information and information not updated since some past time point (such as the point of sale). As the time since capture increases, the reliability of the information decays.

As a result the risk increases over time.

7.8 Basis Risk

7.8.1 Definition

The risk that the assumptions derived are not relevant to the lives in the portfolio.

There are two primary forms of basis risk that can present where:

- Assumptions are derived from a group of lives that are not members of the portfolio and assumed to be relevant to the portfolio
- Assumptions are derived from past experience of the portfolio and assumed to be relevant to the future experience of the portfolio

In the former case – this can either be where the experience is assumed to be directly relevant to the portfolio or where it is adjusted to be relevant to the portfolio, in which case it is the uncertainty in the adjustment where the risk presents.

In the latter case, the past experience shows the observed mortality cohorts for specific age-period combinations. This may be assumed to be relevant to cohorts in later age-period combinations. This may not prove to be the case as there may be unknown differences between the cohorts that cause the mortality experience to be different.

7.8.2 Examples

The following examples are highlighted to enable understanding of this risk component:

- The assumption of relevance of population mortality improvement to a specific portfolio of lives (with or without adjustment) proving to be inaccurate
- As the impaired annuity market increased in size d the assumed relevance of historical experience for non-underwritten portfolios proving not to be the case

- For a defined benefit pension scheme if there are a material changes in employee profile, resulting from a significant change in business profile, this may result in the historical experience no longer being relevant to the likely future experience

7.8.3 Shape/Nature of the Risk

Given the varied nature of how basis risk can arise the nature of this risk will be specific to the individual portfolio and risk management approaches employed.

7.9 Portfolio Modelling Risk

7.9.1 Definition

Risk that interpretations made regarding the portfolio are incorrect or change without the data or information changing.

When creating longevity assumptions there are number of aspects where the assumptions will not be determined by data – either portfolio or non-portfolio experience. Specific cases of this include:

- Where there is no or limited data or information available to base an assumption upon
- Where there are multiple ways to interpret the observed data and information and conceptual reasoning is required to form a conclusion
- Where there is a non-unique solution to the model used and non-data constraints are required to produce an assumptions

7.9.2 Examples

The following examples are highlighted to enable understanding of this risk component:

- The attribution of mortality variation to the "correct" risk factors and corresponding time series (policy/commencement/calendar year, exposure/commencement age)
- The potential for factors that are correlated causing the mortality variation to be attributed to the wrong factor – for example, education and wealth
- The assumed behaviour of selection effects in terms of the duration of the effect
- Uncertainty in the variation in older age mortality within the portfolio from population

7.9.3 Shape/Nature of the Risk

Given the varied way mortality can be assumed to behave under different longevity bases the nature of this risk will be specific to the longevity basis used.

7.10 Portfolio Mis-estimation Risk

7.10.1 Definition

The risk that portfolio adjustment assumptions derived from external evidence and/or empirical experience mis-estimate the correct level of the assumption.

Assumptions that are derived quantitatively from either portfolio or non-portfolio data are unlikely to be statistically certain. Rather, they will be based upon a finite number of observations and as such the estimated parameters may not be accurate – with the uncertainty dependent upon the credibility of the observed experience.

In addition, the specific sample of observations may be biased in some way – either pertaining to the specific lives being observed or in the data capturing process.

It should be noted that the potential for mis-estimation of population mortality rates is captured under the Population Risk Components – rather this risk component concerns the potential mis-estimation of the adjustments of these mortality rates to be appropriate for the lives within the portfolio.

7.10.2 Examples

The following examples are highlighted to enable understanding of this risk component:

- Uncertainty in the calibration of an adjustment to account for the effect of selection within the portfolio based upon observed portfolio experience
- Uncertainty in medical studies assessing the effect of being diagnosed with Diabetes on mortality rates
- Historical changes in the granularity of the risk factor data captured

7.10.3 Shape/Nature of the Risk

Where the mis-estimation risk pertains to portfolio experience, as the likely relevance of the past experience reduces the mis-estimation risk reduces as it "morphs" into a basis risk. Therefore, the level of mis-estimation risk should reduce over time.

With respect to non-portfolio calibrated assumptions the shape will depend on the assumptions being calibrated and the specific issues affecting the non-portfolio experience.

7.11 Portfolio Volatility Risk

7.11.1 Definition

The risk that even if the classification and the assumptions are correct the specific mortality and morbidity events that occur within the portfolio cause the pattern of future cashflows to change.

7.11.2 Examples

The following examples are highlighted to enable understanding of this risk component:

- The number of actual deaths that occur over a period may differ from the expected number of deaths though random variation
- The average liability of deaths that occur over a period may differ from that expected
- Over a period there may be changes in "life information" such as marital status or u/w information which is not consistent the expectations made at outset.

7.11.3 Shape/Nature of the Risk

The level of volatility risk increases over time as the portfolio reduces in size and the average mortality rate increases – this is true even of larger portfolios.

8 One Year View

8.1 Introduction

The purpose of this framework is to create a reference definition of articulation of the risk components that comprise Longevity risk and to provide a mechanism for benchmarking the quantum of risk for different entities using the framework.

The Risk Components outlined in section 6 achieves a reference definition under the economic view. However, the purpose for which longevity risk is being described is often with respect to the one year view. This section outlines how the one year view relates to the economic view of risk and covers the following elements:

- What are the differences between the economic and one year views of risk
- Allowing for the impact of "experience" within the one year view
- Multi-year accumulation of experience

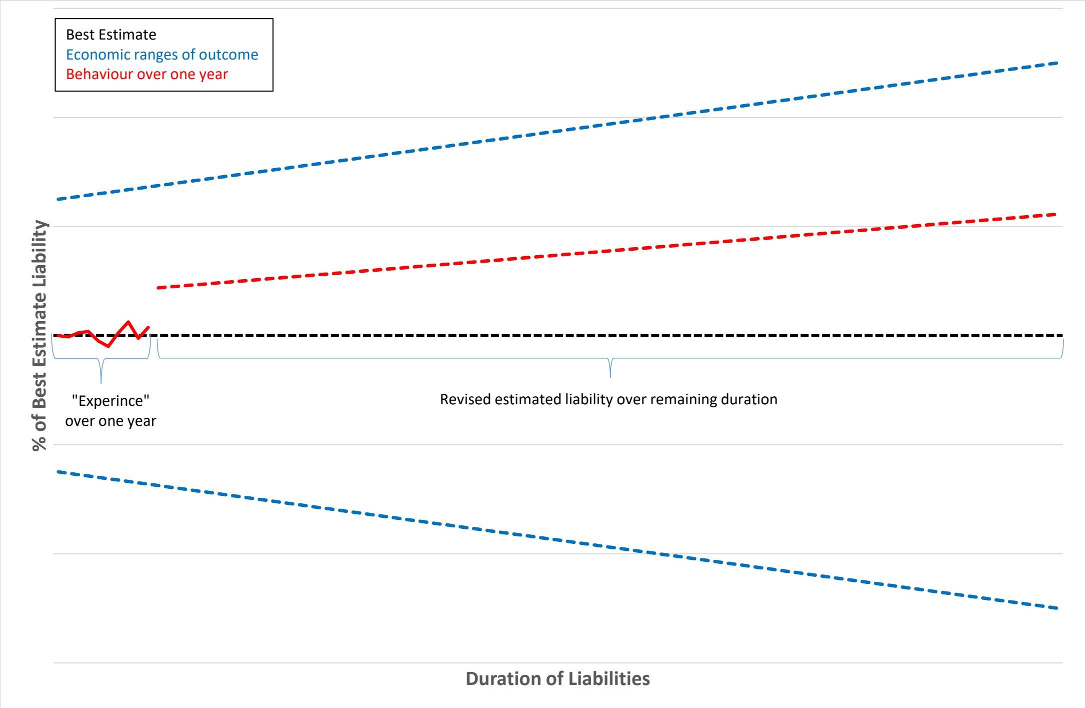
8.2 Differences between the economic and one year views of risk

The primary differences between the economic and one year views of risk are:

- The **quantum** of risk – the economic view considers the full potential variation in outcome (actual benefits paid to policyholders) over the total duration of liabilities and the one year view only considers the potential variation in cashflow and balance sheet outcome over a one year period. The key difference between the one year and economic view is that rather than considering how much the assumptions *might be wrong*, the one year view focusses on how much they *might change* over a one year period. The latter will generally exhibit a lower quantum of risk
- The **period** of risk assessment – the economic view is a point in time consideration of risk; specifically the uncertainty in the ultimate cost of liabilities relative to the current best estimate assessment. The one year view comprises two elements:
    - The risk resulting from the emergence of "experience" over one year
    - The risk resulting from the potential for assumptions to change at the end of the one year period

These differences are shown pictorially in Figure 1 and discussed further in section 8.3.

Figure 1 – Comparison of Economic and one year views of risk



8.3 Impact of Emerging Experience Over One Year

It is tempting to think of Longevity Risk having limited risk over a one-year timeframe given the limited changes that are likely to be seen in survivorship of the portfolio relative to expectations in just one year. It can be helpful to consider how "experience" over the year can manifest as this helps to align the risk taxonomy with the one year approach.

Over the next year the "experience" will feed through to a change in outgo during the year and the number/demography of the policyholders who constitute the year end liabilities. It also has the potential to result in a change in assumptions through the use of this data in the assumptions setting process. There may also be broader information that has come to light during the year which can change the judgements made in the assumptions setting process. In this way the one year view is comparable to the economic view in that the current best estimate takes into account all existing historical information and in one years' time this assumption might change in light of the emerging "experience" (in the broadest sense of including broader new information) over the period. Therefore, the risk components considered under the economic view also directly relate to the uncertainty in the assumption in one year's time. This is considered further by splitting the types of "experience" into three categories.

8.3.1 "Data" Experience

There is "experience" that directly effects the obligations of the insurer (i.e. its liabilities) without (necessarily) needing an assumption change i.e. it can simply be "volatility" consistent with the assumption. Specifically, this arises from changes in the portfolio composition resulting from the volatility in the specific lives surviving and the transitory information pertaining to those lives (such as marital status).

This has an impact on the assets of the provider through variation in actual obligations paid out and the assessment of the liabilities at the end of the year owing to changes in the portfolio composition.

This is an example of ***portfolio volatility risk***.

8.3.2 "A/E" Experience

This is the form of "experience" thought of as experience in a longevity context being the emergence of observed experience relative to expectations – in other words the "A/E". Note that meaning here is that the A/E would be considered for both the reference population and the portfolio – and that the "E" would be the actual assumptions of mortality and not some other benchmark such as a life office mortality table.

The A/E does not directly affect the liabilities (unless allowed to mechanistically update assumptions without interpretation) but rather is a piece of information that is used to assess whether the existing assumptions need to be revised. For many practitioners, the updated A/E would not mechanistically be used to update assumptions but rather any deviation from 100% would be explored to understand the underlying cause and considered as to whether the observed A/E is evidence that an assumption change is required.

However, in both cases this can impact the assumptions used to assess the liabilities and would lead to a specific risk manifestation under the one year framework. How it is categorised within the taxonomy depends on the assumptions setting process and so highlights why different firms could see different splits of risk exposure within the IFoA taxonomy:

- If the "A/E" experience is embedded mechanistically into assumptions then it can be seen as portfolio ***mis-estimation risk*** (for the excess of the change in the "A" compared to the change in the "E") and ***population mis-estimation risk*** (for the "E").
- If the "A/E experience" is subject to scrutiny then it is a manifestation of ***portfolio modelling risk*** and ***population modelling risk*** and both the allocation and the impact would depend on the process for that scrutiny, including the possibility for "water-shed" moments where the accumulation of deviations is interpreted as requiring a change in view.

8.3.3 "New Information" Experience

The third form of "experience" is the emergence of "new information" other than observed experience that can influence the assumptions by causing revisions to the interpretation of past observed experience and future expected experience. As per the assessment of the A/E, the assumptions at the end of the one year period incorporate an additional year of information but the uncertainty in those assumptions is behaviourally the same as at time 0 and hence the economic risk components are unchanged in behaviour (but again the modelling of the risk components may change to include the two elements of existing and emerging information)

8.4 Risk Components over one year

The discussion in 7.3 can be reversed to provide in Table 2 a description of the emergence of experience for each Risk Component and the forms of identification of experience that emerge for each.

Table 2 – Risk Components over One Year

<table>
<tr><th colspan="2">Risk Component</th><th>Emergence of Experience</th><th>Form(s) of identification over one year (section 7.3)</th><th>Comments</th></tr>
<tr><td rowspan="4">Population Risk</td><td>Event Risk</td><td>The emergence of experience that is contrary to existing assumptions will take one of the following forms:
• Occurrence of an event not expected under the current assumptions or non-occurrence of an event expected under the current assumptions
• Difference in the impact of an event currently occurring relative to the expectation under current assumptions
• Change in the assessment of likelihood or impact of future events owing to emerging new information
Whilst the event risk event may be observable in either population or portfolio experience the underlying cause and evidence of an event would not be drawn from population mortality experience.</td><td>New Information</td><td>Given the external nature of this risk component there is limited difference between the economic and one year views other than the reduction in the timescales over which the risk can occur.</td></tr>
<tr><td>Modelling Risk</td><td>The emergence of experience that is contrary to existing assumptions will take one of the following forms:
• Revised internal analysis of existing population experience
• External publication of analysis pertaining to population experience
• Observed population experience differing from that assumed</td><td>New Information, A/E (depending on the approach taken to recognising population experience)</td><td rowspan="3">Whilst New Information will be directly attributable to the crystallisation of modelling risk any deviation in A/E from expectations will require consideration to determine which aspect of the assumptions would need to be revised (if any)</td></tr>
<tr><td>Mis-estimation Risk</td><td rowspan="2">The observed population experience over a one year period may not be in line with existing assumptions. The experience will be assessed as to whether it is in line with the true level of mortality (and leads to a revised estimation of the mortality rates) or is the result of systemic volatility (which will require interpretation as to how it should be accounted for)</td><td>A/E (depending on the approach taken to recognising population experience)</td></tr>
<tr><td>Volatility Risk</td><td>A/E</td></tr>
</table>

<table>
<tr><th colspan="2">Risk Component</th><th>Emergence of Experience</th><th>Form(s) of identification over one year (section 7.3)</th><th>Comments</th></tr>
<tr><td rowspan="4">Portfolio Risk</td><td>Heterogeneity Risk</td><td>The risk will present as a deterioration of A/E in some of the groups currently used to set assumptions resulting from the emergence of survivorship bias.
However, heterogeneity can also be revealed by the use of additional data to distinguish lives within a classification further and reveal differences in their historical mortality experience.</td><td>New Information, A/E</td><td rowspan="4">New information or changes in the data will directly determine which risk component is emerging differently from assumptions.

The A/E experience will not be so clear and will require interpretation to determine which aspect of the assumptions would need to be revised or whether any deviation in A/E would be accepted as natural volatility.</td></tr>
<tr><td>Classification Risk</td><td>Whilst it is possible that A/E experience will evidence a classification risk it is more likely that a material change will result from revised analysis (both internal and external) that suggests the current classification rules need to be revised.</td><td>New Information</td></tr>
<tr><td>Basis Risk</td><td>The risk will present as a deviation in the A/E (either increasing or decreasing) as the assumed relevance[8] of the source experience proves not to be correct.
New analysis may be carried out or found externally (including external “news” such as drug breakthroughs) that suggests a change in the assumed relevance is required.</td><td>A/E, New Information</td></tr>
<tr><td>Mis-estimation Risk</td><td>The observed portfolio experience over a one year period may not be in line with existing assumptions leading to consideration of the portfolio experience derived assumptions.
Additional analysis regarding the non-portfolio source of assumptions may suggest changes to these assumptions are required.</td><td>A/E, New Information</td></tr>
</table>

[8] The assumed relevance could either be where the experience is used directly or with an adjustment to take account for the differences between the source and portfolio lives. In the latter case, it is the adjustment that may be found to require revision.

Risk Component		Emergence of Experience	Form(s) of identification over one year (section 7.3)	Comments
	Modelling Risk	The emergence of experience that is contrary to existing assumptions will take one of the following forms: • Revised internal analysis of existing portfolio experience • External publication of analysis pertaining to the lives within the portfolio • Observed portfolio experience differing from that assumed (e.g. in shape)	New Information, A/E	
	Volatility Risk	The observed portfolio experience over a one year may not be in line with assumptions and determined to be the result of volatility rather than inaccuracies in the assumptions. In addition, the portfolio composition may change to be inconsistent with expectations.	A/E, Data	

8.5 Effect of One Year Period vs Economic Risk

Under the economic view the source of the divergent experience can be identified at time 0 and then feeds through to the modelling of subsequent cashflows and so economic risks. In contrast the use of a one year period requires a consideration of the way in which emerging evidence interacts with the assumptions setting process. Consequently there may be some changes required to the modelling approach to capture this interaction. It can also lead to a different attribution of the risk between the risk components under the two views.

As such the risk taxonomy presented in section 6 provides a reference framework under both approaches since it covers all the all the sources of volatility and uncertainty within longevity risk that should be considered in the one year view but there will be differences in the following aspects:

- The quantum of the risk components will vary depending on the time horizon; and
- The modelling of the risk components will vary depending on the time horizon to align with the emergence of the risk over that time horizon – but this should not necessarily affect the definition of the risks

A consequence of the above is that the specific risk components that might be chosen for a specific provider may differ as some risk components may be immaterial given the nature of the exposure and risk management approach– but as a general framework this is not something that needs to be captured.

The IFoA taxonomy as an economic framework for risk does not include a "Catastrophe Risk" although other previously published frameworks for one year value at risk include it (see section 8). In this regard there are further issues relating to the multi-year accumulation of evidence that potentially affect the taxonomy. These are considered in section 8.6.

8.6 Accumulation of Evidence and "Catastrophe Risk"

The economic view is ultimately a series of "one year" experiences which can deviate from the assumed experience. This can suggest that a simple conversion between the economic view and the one year view based on the duration of the liabilities should be possible[9]. However, most simple conversions rely on strong statistical assumptions regarding the nature of the run-off process (e.g. independence of consecutive one year events) and ignore the potential for the multi-year accumulation leading to the "catastrophic year" of an assumptions "catch-up". This tends to increase the quantum of risk compared to a simplistic conversion, albeit generally still less than the same percentile of the economic risk.

8.6.1 Multi-Year Accumulation of Evidence

It is often the case that it takes a number of years for sufficient evidence to accumulate to justify a significant assumption change. For example, if a new theory is proposed that challenges the current conceptual understanding of longevity then it is unlikely to be accepted immediately. Rather there is likely to be a multi-year accumulation of evidence to enable acceptance of the new view of longevity. This is appropriate to ensure assumptions are managed appropriately but can cause bias in the assessment of risk in that:

- The best estimate assumption is typically drawn from a reasonable range based upon the available evidence and as the strength of evidence changes the choice of assumption within the reasonable range can change (even if the reasonable range itself hasn't changed)
- The emergence of risk will be "lumpy" and the potential for changes in a specific year can be greater than might otherwise be assumed.

8.6.2 Potential for a Catastrophic Year

When considering the risks over a one year period the level of risk should be ***plausible*** and ***realistic***

To help explain why it can be helpful to consider the probabilities of certain events happening. For example (assuming independence of Risk Components):

- For the 10 Risk Components identified in the IFoA taxonomy there is almost a 5% chance that at least one will exhibit a 1-in-200 event in any given year
- The number of years required for the probability at least one of the Risk Components to have experiences a 1-in-200 event to exceed 50% is only 14 years

However, there is also is the possibility of events occurring that are outside the plausible view of what is possible over a one year period – or a plausible event occurring with an impact that was previously believed to be implausible. This need not be an accumulation effect, instead being a "catastrophic year" in terms of "experience". This leads to an additional source of risk over and above what might be factored in to a plausible and realistic calibration.

The allowance for a "catastrophic" assumption change can then be contextualised by historical major changes (recast to allow for current longevity conditions) alongside an attribution as to whether they were "tail events" under a specific Risk Component, a multi-

[9] For example if the duration of the liabilities is τ then the one year 1-in-200 tail risk percentile is equivalent to the tail risk percentile under run-off might be α such that $0.995^{\tau} = 1 - \alpha$. This is an approach that was common under ICA but is no longer common practice given the issues with the approach highlighted in Richard et al (2014)

year accumulation or an interpretation change which would have previously be deemed implausible.

8.6.3 Incorporation in the risk taxonomy

In resolving the issue of allowing for these multi-year and catastrophic year "step" changes two possible approaches are considered:

- **Expand the calibration:** Ensure that the calibration of the individual Risk Components presented in section 6 accounts for the larger risk possibility. This is likely to particularly impact event risk and modelling risk
- **Add a Risk Component:** Include an additional Risk Component, termed Catastrophe Risk, that captures the additional risk possibility and allows the individual risk component calibrations to satisfy the plausibility requirement

If the latter approach is followed, then the additional risk component can be defined as Catastrophe Risk shown in Table 3.

Table 3 – Catastrophe Risk

Risk Component	Description	Examples
Catastrophe Risk	The risk that an external event occurs or internal interpretation change occurs that is viewed as implausible under the existing conceptual understanding of longevity or is based on a multi-year accumulation of evidence	Almost by definition plausible examples cannot exist but the longer term effects of COVID19 pandemic arguably fall into this category

8.6.4 Comparing the approaches to incorporation

Embedding an allowance within the calibration of the existing Risk Components has the challenges of:

- **Usage** – the output of the specific risk component models need to be usable in that they need to be reconcilable to the views and understanding of senior management – and hence the output needs to be plausible and realistic. If this is not the case then it is challenging for economic business decisions to be based upon the risk model
- **Practical** – the calibrations of the risk models based upon historical data and/or expert judgement are necessarily constrained to the plausible and will require adjustment to fully account for the full quantum of risk. It is challenging to justify the use of existing information as sufficient to account for the required level of risk
- **Dynamic** – the specific risk calibrations will need to be dynamic to account for the multi-year accumulation of evidence to necessitate a change in interpretation – is such an event more or less likely relative to normal expectations in the current year? This will cause the level of risk to change in the judgement of the longevity practitioners which will be highly subjective and open to challenge

If an additional Risk Component of Catastrophe Risk is added, then the challenges are:

- **Boundaries between risk components** – as the source of the risk events remains as described under the economic view the boundary between the Catastrophe Risk and these other risk components is not definitive – and thus it is challenging to ensure there is not under or over accounting for the level of risk. In addition the transparency of the risk coverage to non-experts will be harder to communicate

- **Calibration of Catastrophe Risk** – Calibration of the implausible and allowance for the multi-year accumulation will be naturally subjective and dynamic and be challenging for non-experts to validate against "real world" understanding of longevity

9 Comparison with Existing Frameworks

9.1 Introduction

This section compares the proposed IFoA framework with existing frameworks previously published and specifically considers the following frameworks:

- IAA (2004)
- Sweeting (2007)
- Richards et al. (2014)
- Dhamani (2015)
- Kingdom (2019)

9.2 Summary of Frameworks

Table 4 summarises the five frameworks being compared.

Table 4 – Summary of Frameworks

Framework	Specificity to longevity risk and value-at-risk	Risk Categorisation
IAA International Actuarial Association (2004)	Considers longevity risk within a wider framework for insurer solvency assessment	• **Level** (uncertainty of current average mortality) • **Trend** (uncertainty of future average mortality) • **Volatility** (future stochastic mortality variation) • **Catastrophe** (the risk of mortality being significantly different from the average because of a concentration of risk).
Sweeting (2007)	Uses the IAA framework, although distinguishes between • uncertainty (the risk of getting the average wrong), and • volatility (getting the average right, but being 'unlucky')	(Same as IAA)
Richards et al (2014)	Distinguishes between diversifiable and non-diversifiable risk Suggests assessing value-at-risk (VaR) by re-calibrating models to their stochastically generated futures	• **Model** (specifically that the projection model is wrong) • **Basis** (difference between reference population and specific portfolio) • **Trend** (interpreted here as trend volatility) • **Volatility** (interpreted here as volatility in the next years' experience) • **Idiosyncratic** (random individual variation) • **Mis-estimation** (uncertainty over the portfolio's actual underlying mortality rates)

<table>
<tr><th>Framework</th><th>Specificity to longevity risk and value-at-risk</th><th>Risk Categorisation</th></tr>
<tr><td>Dhamani
(2015)</td><td>Comprehensive framework for longevity risk placing components on two axes:
• uncertainty (model/parameter risk) v volatility (random future variation)
• systemic (reference population) risk v specific (portfolio) risk</td><td>• Trend Uncertainty (uncertainty in mortality improvement)
• Trend Volatility (volatility in mortality improvement)
• Catastrophe (risk of “shocks” to the level of population mortality)
• Basis (e.g.. setting mortality by reference to experience of different individuals)
• Underwriting (systematic error in use of individual information)
• Mis-estimation (aka parameter risk)
• Statistical Volatility (random individual variation)</td></tr>
<tr><td>Kingdom
(2019)</td><td>Longevity risk within a specifically value-at-risk context with emphasis on
• the VaR-setting process in its entirety
• recognising that purely statistical methods do not suffice for all risks
• avoiding simplistic conversion of run-off distributions into VaR</td><td>• One-year cashflow (random individual variation)
• New information
– Data (arising from updated data)
– Information discovery (discovery of previously available public information)
– Event (expansion in information universe)
• New model
– Model innovation
– Model discovery
• Model selection
– Model choice (change in chosen model)
– Data choice (change in data selection)
• Model calibration (variable model calibration)</td></tr>
</table>

9.2.1 Common Themes

The following are the common themes in these frameworks

- Distinguishing between
  - uncertainty, i.e. model and parameter risk and
  - volatility, i.e. future random variation,. ‘being unlucky’.
- Recognition of catastrophe risk
- From Richards et al onwards, an understanding of the importance of
  - model and parameter risk
  - the basis risk inherent in actuarial mortality modelling whereby population used to calibrate may differ from the portfolio at hand
- Recognition in Richards et al and Kingdom that VaR models need to account for new information emerging over the VaR interval

9.3 Comparison with IFoA Framework

Table 5 highlights the similarities and differences between the existing frameworks discussed above and the framework presented in this paper – the exception being the Kingdom Framework which is discussed further in section 9.3.1.

The key to the symbols used is as follows:

- + The categories in the IFoA and existing frameworks are the same
- ● The IFoA category is a subset, i.e. more granular than the existing framework category
- ◑ The categories in the IFoA and existing frameworks overlap
- ○ The IFoA category is a superset, i.e. more general than the existing framework category
- ■ The existing framework does not have a category corresponding to the IFoA framework

Table 5 – Comparison with IFoA Framework

		IFoA Framework									
		Population				Portfolio					
Framework	**Risk category within existing framework**	**Event**	**Modelling**	**Mis-estimation**	**Volatility**	**Heterogeneity**	**Classification**	**Basis**	**Mis-estimation**	**Modelling**	**Volatility**
IAA	*Level*			■		●	●	●	●	●	
	Trend	●	●	■	◑						
	Volatility			■	◑						◑
	Catastrophe	○		■							
Richards et al	*Model*		◑			■				◑	
	Basis					■	●	●			
	Trend			○		■					
	Volatility				+	■					
	Idiosyncratic					■					+
	Mis-estimation			◑		■			◑		
Dhamani	*Trend Uncertainty*	○	●								
	Trend Volatility			●	●						
	Catastrophe	○									
	Basis					●	◑	●		●	
	Underwriting						○				
	Mis-estimation								●		
	Statistical Volatility										+

What this comparison highlights is the potential for terms to be used in different ways encompassing larger or smaller groups of risk and the risk of miscommunication when comparing specific risk taxonomies and models.

In terms of the IFoA framework it can be seen that the proposed framework is attempting to achieve a more granular classification of longevity risk with clearer distinction and division between the sources of the risk.

9.3.1 Kingdom Framework

The Kingdom framework has not been included in the table above as it is conceptually quite different from the other frameworks. Rather than focusing on the sources of risk it focuses on the assumptions process and defines risk components according to where in that process they would emerge. As a result there does not appear to be a natural alignment with the other frameworks.

This provides an example of how different approaches can be taken when forming a risk taxonomy that lead to quite different but reasonable definitions of longevity risk. However, it highlights a challenge to be overcome when reconciling different longevity risk taxonomies – which requires a more granular level of risk sub-components below that which has been created in the IFoA framework.

As described in section 3.3 following the development of this framework a method to enable comparison of different longevity risk exposure will be produced. That work will include the creation of the sub-components that will allow the reconciliation of alternative conceptual approaches such as the Kingdom framework with the IFoA framework.

10 Different Portfolio Risk Profiles

10.1 Introduction

This section provides some examples of how the portfolio risks will vary for different types of provider to help explain the difference between the Portfolio Risk components.

10.2 Population Risk

The intention of the Population-Portfolio risk distinction is that the level of population risk should be fairly universal with limited differences between providers (assuming no weaknesses in their approach to managing population risk).

However, population risk events can have different effects upon different providers – for example, a "cure" for Alzheimer's and Dementia will have a disproportionate impact upon an annuity provider who has written annuities exclusively to lives diagnosed with Alzheimer's and Dementia. Under this framework this risk possibility is a form of basis risk – whereby the appropriateness of the reference population (and/or adjustment to that reference population) is reduced. The potential for this form of event should be captured in the model for basis risk.

As a result when comparing different forms of provider the consideration of Population Risk is not required.

10.3 Distinctions between provider

To distinguish between different providers the following example areas of difference are used:

- Assumptions Approach[10]:
  1. Aggregate – distinction between males and females but no other risk factors used
  2. Life Specific[11] – gender, postcode, health and a larger number of other risk factors used
- Portfolio Composition:
  - A. 100% Internal vesting – all pre-retirement lives vest at retirement with no external lives
  - B. 100% External vesting – all lives sourced from the external market with no internal vesting lives
- "Size" of the Portfolio:
  - i. Small with no historical experience
  - ii. Large with a long history of experience

10.4 Example Companies

Intuitively it should be seen that the most risky combination is 1Bi and the least risky is 2Aii – a company using aggregate assumption based upon minimal experience writing external vesting business subject to anti-selection risk owing to the existence of the underwritten market will be most at risk of the assumptions not being appropriate for lives written To

[10] It should be noted that the difference in granularity also includes the variation in the effect of different risk factors by age, calendar year, policy year, etc.

[11] Where a specific mortality curve is assumed for each individual in the portfolio based upon their individual longevity profile

elucidate the variation further four example but fictitious[12] "insurance companies" are envisaged:

- Company W – An aggregate approach proposition with lives sourced solely from the external market with a small portfolio and limited historical experience (1Bi)
- Company X – A life specific proposition with lives sourced solely from the external market with a small portfolio and limited historical experience (2Bi)
- Company Y – An aggregate approach used to value a large portfolio of lives solely sourced from a pre-vesting proposition with overly generous GAO[13] terms with a long history of experience (1Aii)
- Company Z - A life specific approach used to value a large portfolio of lives solely sourced from a pre-vesting proposition with overly generous GAO terms with a long history of experience (2Aii)

Note. A Defined Benefit scheme would be most similar to Companies Y or Z – with variations in size affecting the mix of risks.

10.5 Comparison of Company

The ranking in risk for each component is shown in the table below (1 = most risky, 4 = least risky). These are considered as undiversified risks for this purpose – the interaction with each other and with population risk is likely to vary significantly.

Risk Component	Companies				Rationale
	W	X	Y	Z	
Heterogeneity	1	3	2	4	The granularity of the classification of lives (minimally in the case of aggregate and significantly in the case of medically underwritten) is the key driver of the level of heterogeneity. A second order aspect is the source of the lives where an external vesting source would increase the level of heterogeneity.
Classification Risk	3	1	4	2	Classification risk behaves inversely to heterogeneity risk – with the history of experience leading to a lower overall risk profile as a second order effect
Basis Risk	2	1	4	3	The consistency in source of lives is the primary driver of the risk such that past experience is more relevant to future experience. As a second order effect the relevance of non-portfolio experience to a highly classified (or concentrated) portfolio causes an increase as there is a greater risk of non-relevance of mortality improvement assumptions based upon the reference population (or a need for uncertain adjustments for the portfolio overall or sub groups within the portfolio)
Mis-estimation	2	1	4	3	The volume of the experience is the key driver of the risk with the number of parameters providing a second order effect – the greater the number of parameters and complexity of model the greater the risk of mis-estimation
Modelling Risk	1	2	3	4	The consistency in source of lives is the primary driver of the risk such that past experience is more relevant to future experience. As a second order effect , as the level of

[12] Any resemblance to any real insurance company is completely coincidental and unintentional
[13] The effect of Guaranteed Annuity Options is to limit the level of selection risk with fewer lives able to find better terms in the external market.

					classification reduces the risk of misinterpreting how the diverse longevity drivers will affect the increasingly heterogeneous lives increases
Volatility Risk	2	1	4	3	Volatility is greatest for smaller portfolios with the variation in liability for individual lives acting as second order effect

11 Next Steps

11.1 Introduction

This section provides an overview of the next steps, at the time of publication, that are intended to complete the Longevity Risk work covering the following elements:

- Comparison of Exposure
- Management of Longevity Risk
- Variations in Longevity Risk
- Volunteer Engagement

11.2 Comparison of Exposure

It is currently very challenging to compare the quantum of risk to validate that the estimate is "correct" relative to the specific risk exposure. Whilst the creation of reference taxonomy provides a conceptual benchmark for longevity risk more is needed to enable a comparison of the quantum of longevity risk under different longevity risk models.

Therefore, the next step is to create a methodology that will enable the mapping of different longevity risk taxonomies to the IFoA taxonomy – and hence enable a like for like comparison of longevity risk quantum.

To achieve this it is expected that a more granular set of sub-components will be required and a methodology for accounting for the implicit diversification that is assumed when using different taxonomies.

11.3 Management of Longevity Risk

The current cost of longevity risk is significant and as such products providing longevity protection are expensive for consumers. Arguably a significant proportion of the risk results from the methodologies used by actuaries above and beyond the intrinsic risk affecting the lives. There are potentially alternative ways of managing the risk may lead to reduced levels of risk, greater security for the recipients of longevity protection and reduced capital requirements.

Using the Longevity Risk Taxonomy each risk component will be explored to identify whether the risk is unavoidable or whether there are underutilised or new techniques that can be used to manage and reduce the level of risk exposure.

11.4 Variations in Longevity Risk

There is considerable variation in the longevity risk of different type of "annuitant" ranging from deferred lives to lives in care homes.

This variation will be explored using the taxonomy to identify the relative difference in risk components in these lives and the level of diversification in risk between these lives.

11.5 Volunteer Engagement

Additional volunteers would be welcome to support the developments outlined above; if this would be of interest to you please contact a member of the MRSC, the Mortality and Longevity MIG or the IFoA (via research@actuaries.org.uk).

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