Longevity Risk Task Force Update (LRTF) – Correlation Recommendation August 2019

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Introduction

- The objective of the Longevity Risk Task Force (LRTF) work is to develop a proposed method to incorporate longevity risk into the NAIC's Life Risk-Based Capital formula (LRBC).
- Earlier this year, the LRTF shared its preliminary proposal for Longevity C-2 factors applied to base statutory reserves.
- That proposal included the recommendation that new C-2 longevity factors be implemented concurrently with a correlation adjustment within C-2.
- This document discusses the recommendation and rationale for the correlation between C-2 mortality and C-2 longevity.

Summary

- **We recommend a correlation of -33% between longevity and mortality C-2.**
  - This is consistent with the overall 95th percentile objective across a wide range of company sizes while being simple to implement within the existing Life RBC framework.
- A key premise in the development of Longevity Risk factors was to target a 95th percentile outcome for longevity risk. The key premise of our work on correlation was the extension of this to now achieve a 95th percentile outcome for the combined C-2 risk from longevity and mortality.
- This recommendation considers the differences in age and other population characteristics between life insurance and annuity policyholders and their resulting impact on correlations.
- It also considers the differing correlations among the components of longevity & mortality risk.
  - Mortality trend risk has historically shown high negative correlation between mortality and longevity
  - Non-trend risk components (volatility, level risk) are less related and assumed to be independent (0% correlation)
- Other regulatory capital frameworks include negative correlation between longevity and mortality risk, including Bermuda BSCR (-50%), Canada LICAT (-25%) and European Solvency II (-25%). (See Appendix page 25)
- From our standpoint, the practical implications of this approach are consistent with the objectives of the Life RBC framework.

Background

Correlation describes the strength and direction of the linear statistical relationship between two random variables (e.g. gain/loss on longevity and mortality), measured from +100% to -100%

Direction

- Positive correlation indicates that high outcomes of 1 variable are more likely to occur together with high outcomes of the 2nd variable
- Negative correlation indicates the opposite—that high outcomes of 1 variable are more likely to occur together with low outcomes of the 2nd variable

Background

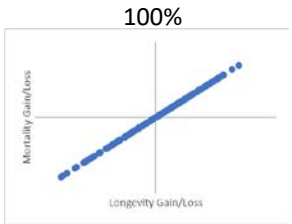
Correlation describes the strength and direction of the linear statistical relationship between two random variables (e.g. gain/loss on longevity and mortality), measured from +100% to -100%

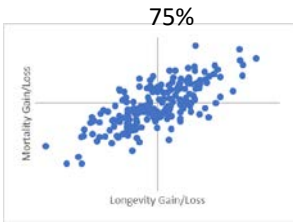
Strength

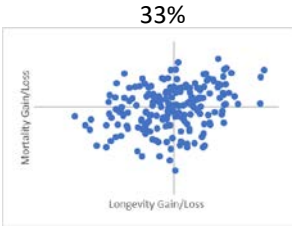
- Correlation values of 100% or -100% indicate perfect certainty of the relationship – a high outcome for 1 variable will ***always*** occur with an equally high (+100%) or low (-100%) outcome for the 2nd variable
- Correlations closer to zero indicate greater statistical variability around the relationship
- Correlation of zero (i.e., independence) indicates that there is no relationship between the variables

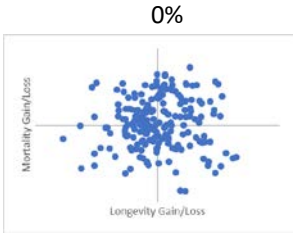
Background

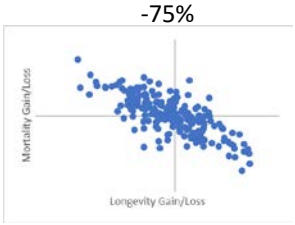
Correlation describes the strength and direction of the linear statistical relationship between two random variables (e.g. gain/loss on longevity and mortality), measured from +100% to -100%

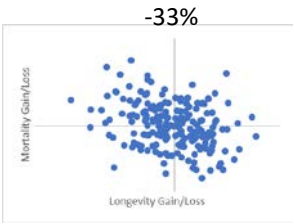












Correlation in Life RBC

All components of the existing LRBC formula include some level of assumed correlation.

- Some components have correlation of 100% and are added together in the existing LRBC formula
  - For example, C-1 and C-3
- Some components have correlation of 0% (independent) where total risk equals the square root of the sum of squares of the individual risk components
  - For example C-2 with the total of C-1 and C-3
- In general, the total risk under any correlation between risk components C_X and C_Y with correlation ρ_{XY} follows the formula: SQRT($C_X^2 + C_Y^2 + 2\ \rho_{XY}\ C_X\ C_Y$)

When added to LRBC, Longevity risk will also implicitly or explicitly reflect some assumption for correlation with other risk components.

- We recommend a correlation factor of **-33%** within C-2 to reflect the relationship between mortality and longevity risk:
- C-2 = SQRT(C-2a^2 + C-2b^2 + 2*(**-0.33**) * C-2a * C-2b)
  - Where C-2a is mortality and morbidity risk and C-2b is longevity risk

Key Assumptions

1. The calibration target for RBC C-2 remains at 95th percentile for the combined impact of longevity and mortality risk.
   - This was the statistical level targeted for longevity risk on a stand-alone basis, and the analysis on covariance targets the same level for the combination of longevity and mortality risk.
2. Normal Distribution of loss amounts resulting from longevity and mortality risk.
   - The liability side of a typical insurance company tends to have many more policies than the asset side has issuers, and the cyclical volatility of equity returns and asset defaults is not as generally evident on the liability side. The Law of Large Numbers helps to make mortality risk more normally distributed than asset-side risks.
3. Process Correlation between mortality and longevity is constant over time.
   - Process Correlation is the underlying correlation between risks while Observed Correlation is the resulting correlation from a limited sample of historical observations.
   - The distribution of observed correlations over different time periods using Social Security Administration historical data is consistent with this assumption of constant process correlation.
4. Trend Risk is independent (0% correlation) of Non-Trend Risk (Level, Volatility, and Catastrophe risks), and Non-Trend Risks are independent (0% correlation) of each other
   - Catastrophe risk for mortality is likely negatively correlated with longevity risk; the independence assumption greatly simplifies the analysis without significantly impacting results.

Key Assumptions (Cont.)

5. -65% Correlation of Trend Risk Component between Longevity and Mortality:
   - Correlation would start at -100% correlation if insuring the same individuals against both risks
   - Observed correlation of -80% between age distributions of life and annuity policies using historical SSA data (most complete available source of relevant data, detail on Appendix page 23)
   - Additional 15% haircut assumption to reflect population basis risk beyond age difference between life insurance and annuity populations. We believe this haircut should be smaller than the (20%) haircut from age distribution because insured populations are more socioeconomically similar to each other than to the general population.
   - -65% resulting trend correlation assumption.
   - Sensitivity tests also included under -55% and -75%; as a benchmark SSA analysis using non-overlapping over/under age 65 populations showed historical correlation of -64%. (Appendix page 24)

Correlation of Risk Components

- Correlation differs between the trend and non-trend components of longevity/mortality risk.
- Our approach considered the different correlation of these components and their relative contribution to overall longevity/mortality risk in determining the appropriate overall risk correlation.

Mortality Risk Component	Longevity Risk Component	Risk Component Correlation Assumption
Trend Risk	Trend Risk	-65%
Trend Risk	Non-Trend Risk (Level/Basis, Volatility)	0%
Non-Trend Risk (Level/Basis, Volatility, Catastrophe)	Trend Risk	0%
Non-Trend Risk (Level/Basis, Volatility, Catastrophe)	Non-Trend Risk (Level/Basis, Volatility)	0%

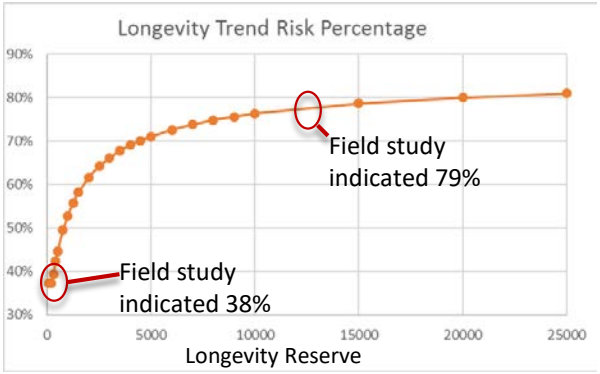
Composition of Trend vs. Non-Trend Risk

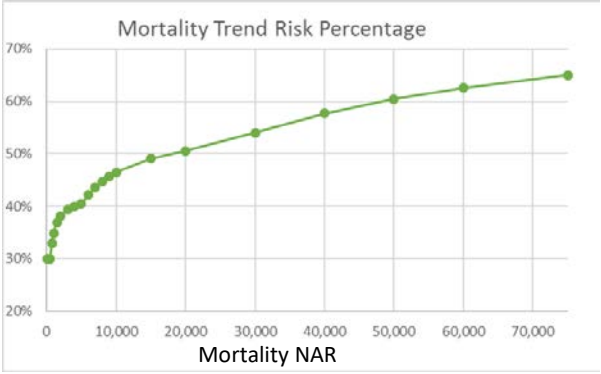
We separated the mortality and longevity C-2 risk into Trend and Non-Trend components to understand the impact on aggregate risk correlation.

- Trend risk is a constant percentage of exposure at all exposure levels, while non-trend risk decreases on a percentage basis as exposure increases.
  - This effect is the reason for the decreasing C-2 factor at higher exposure levels for both mortality and longevity.
  - C-2 for mortality and longevity at each exposure indicated by the factors was decomposed into a Trend and Non-Trend component such that: $(C\text{-}2)^2 = (\text{Trend})^2 + (\text{Non-Trend})^2$
  - For example at $1B of exposure, C-2b of $9.25m separated into $6.9m of Trend and $6.16m of Non-Trend risk.
- We used a constant Longevity Trend risk factor of 0.69% in determining the composition of Longevity risk between Trend and Non-Trend components.
  - This composition aligns to Longevity Field Study results which showed that trend risk was 79% of total risk under the 1% level stress ($12.5B exposure), and 38% of total risk under the 6% level stress ($250m exposure).
  - This amount is just below the lowest proposed C-2 factor of 0.70%, indicating that at the highest exposure levels most of the incremental risk is from Trend.
- We assumed a constant Mortality Trend risk factor of 0.59% for Individual Mortality risk.
  - As for Longevity, this is 0.01% lower than the marginal C-2 for the largest exposure band (0.60%) for Individual Mortality C-2.

Longevity Trend vs Non-Trend Risk

- Since volatility risk declines with size for both mortality and longevity, trend risk is the smaller component at low exposure levels but dominates at larger exposure levels
- The mortality trend risk assumption indicates that trend risk is a slightly smaller percentage for mortality than for longevity
- These results overall seem reasonable based on preliminary analysis by the C-2 Mortality Working Group, but should be reviewed once their work is complete.





Total Risk Correlation Calculation

Total correlation of longevity and mortality risk was calculated as:

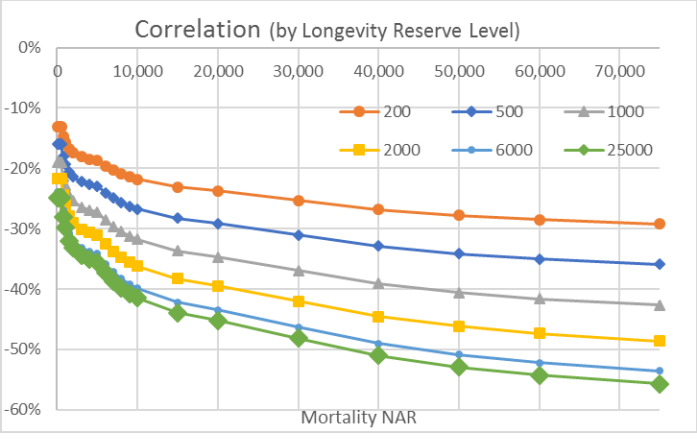
$$\rho = \rho_T \lambda_L \lambda_M$$

- Where ρ_T is the trend risk correlation assumption -65%, and
- Trend weight parameters λ_L & λ_M are calculated as Trend / C-2 for Longevity and Mortality respectively
- These formulas were developed analytically and validated through simulation

Total Risk Correlation Results

The chart below shows the resulting correlations for different combinations of Mortality NAR (x-axis) and Longevity Reserve (data series)

Total risk correlations vary by size, and range from -15% for the smallest exposures to less than -50% for the largest exposures



Sensitivities using -55% and -75% Trend Risk Correlation included in the appendix Pg24
A sample range of exposure sizes was tested above, however we do not have the benefit of information on the distribution of actual company exposures

Correlation Impact on 95th Percentile

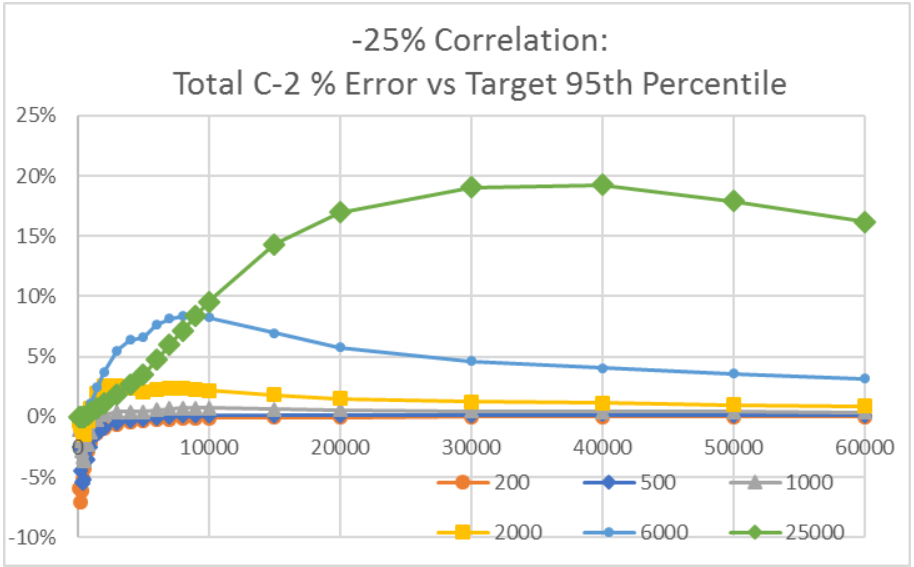
Sensitivities on the following slides address the practical implications of using a simple fixed correlation assumption even though the analysis indicates aggregate correlation varies with exposure size

- Total C-2 (mortality C-2a and longevity C-2b) is calculated using a fixed correlation and compared to the 95th percentile outcome calculated using the exposure specific correlations
- Overall a fixed -33% correlation provides the most balanced fit across all exposure sizes tested

Correlation Impact on 95th Percentile: -25%

With a fixed -25% correlation:

C-2 for low exposure amounts are close to the 95th percentile, but C-2 for large exposure amounts are up to 20% too high.



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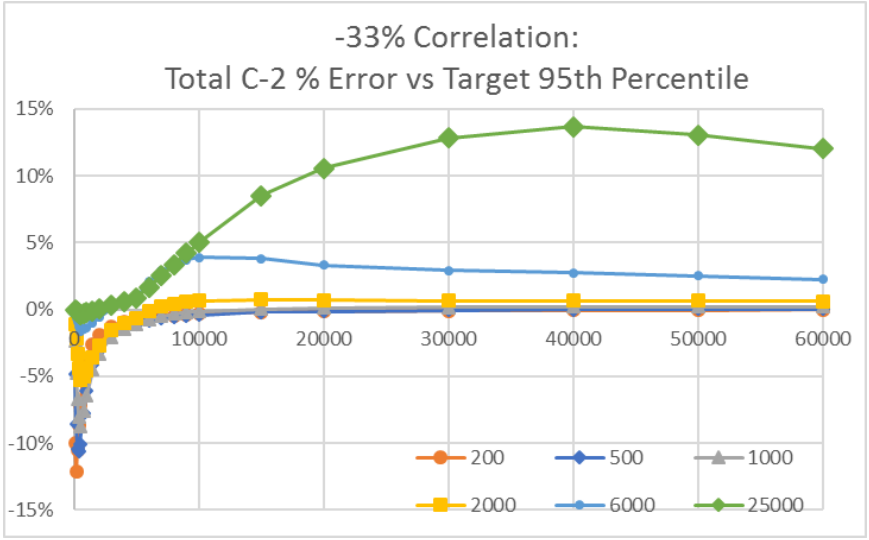
Correlation Impact on 95th Percentile: -33%

With a fixed -33% correlation:

C-2 for the largest exposure amounts are up to 14% too high while C-2 for the smallest exposures are up to 12% too low.

This provides the closest overall fit to the targeted correlation.



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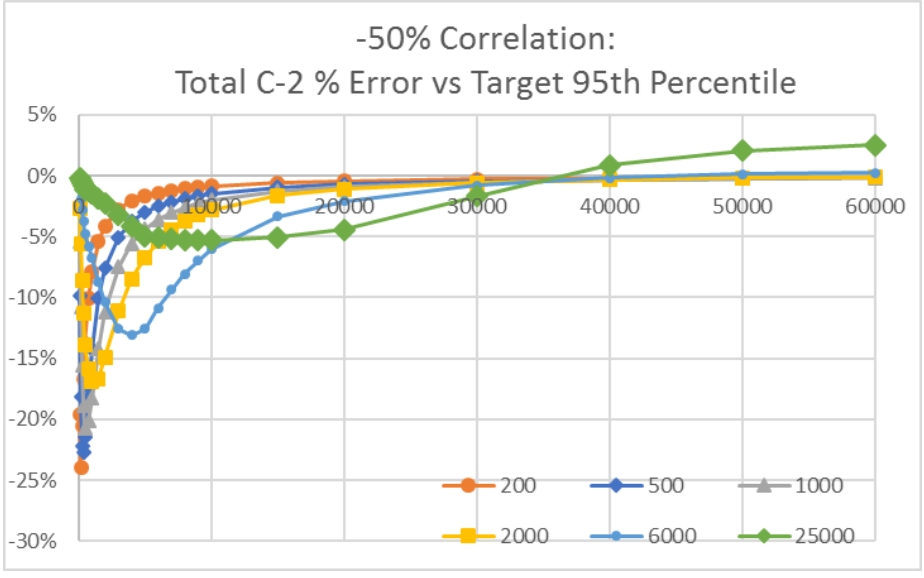
Correlation Impact on 95th Percentile: -50%

With a fixed -50% correlation:

C-2 for high exposure amounts are close to the 95th percentile, but C-2 for small exposure amounts are up to 25% too low.



Implementation Alternatives

We considered a number of implementation alternatives and the proposed -33% correlation is a simple approach that achieves reasonable accuracy across the spectrum of company sizes

Alternative		Advantages	Drawbacks
Fixed Correlation	-25%	Aligns to 95th % for smaller companies	Overstates C-2 by almost 20% for largest companies
	Proposed -33%	Achieves total C-2 within +/- 14% of 95th percentile for all sizes tested	Overstates C-2 for largest companies; understates for smallest companies
	-50%	Aligns to 95th % for largest companies	Understates C-2 by up to 25% for smallest companies
Variable Correlation	Cliff factor, e.g.: -25% if C-2 < X -50% if C-2 >= X	Achieves total C-2 within +/- 8% of 95th percentile for all size companies	More complicated Discontinuity in RBC for companies near threshold
	Continuous Function of C-2	Closest alignment to calculated 95th %	Most complicated to implement, but could be done

Hypothetical Company RBC Impacts

- **Introduction of "C-2b" longevity risk factor is effective in identifying companies with concentrated exposure to longevity risk, and has appropriately smaller impact on companies with balanced risk exposures.**
- RBC impacts to companies with concentrated longevity risk exposure can be material (examples on next slide) and achieve the RBC purpose as a tool to identify potentially weakly capitalized insurers.
- The impact on companies with balanced risk exposures is much lower and recognizing the offsets between longevity and mortality in an economic way within RBC encourages sound risk management practices.
  - An overly conservative approach to correlation would have little impact on companies with concentrated risk exposures and would result in a statistical safety level that is not targeted at 95% in a consistent way across companies.
- A negative correlation does result in a lower total C-2 for companies with low longevity exposure, however the magnitude of these reductions is quite small and is consistent with the 95th percentile target.

Hypothetical Company RBC Impacts

	Baseline	Concentrated Longevity			Balanced Longevity			Low Longevity Exposure		
C2a Mortality/Other Insurance Risk		25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1
C2b Longevity Insurance Risk	n/a	75.4	75.4	75.4	25.1	25.1	25.1	5.0	5.0	5.0
Longevity - Mortality Correlation	n/a	-25%	-33%	-50%	-25%	-33%	-50%	-25%	-33%	-50%
Calculated CAL RBC	101.8	129.3	127.8	124.4	104.0	103.3	101.8	101.6	101.4	101.1
Total Adjusted Capital	526.6	526.6	526.6	526.6	526.6	526.6	526.6	526.6	526.6	526.6
Calculated CAL RBC Ratio	**517%**	**407%**	**412%**	**423%**	**506%**	**510%**	**517%**	**518%**	**519%**	**521%**
Change in RBC Ratio vs Baseline	-	*-110%*	*-105%*	*-94%*	*-11%*	*-7%*	*0%*	*1%*	*2%*	*4%*

Illustration shown using distribution of non-Longevity RBC amounts from aggregate 2017 Life RBC

We do not have access to actual impacts for any particular company which may differ from examples shown

Sample impacts shown for companies with Concentrated Longevity exposure (C-2b 3x greater than C-2a), Balanced Longevity exposure (C-2b equal to C-2a), and Low Longevity exposure (C-2a 5x greater than C-2b)

Expanded sensitivities shown in the appendix page 28

Appendix

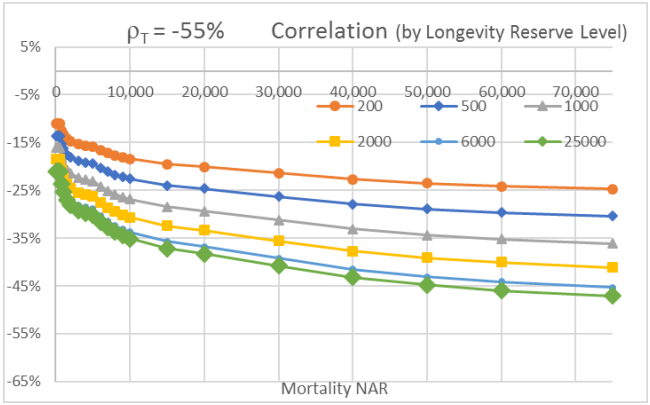
Historical Mortality Trend Correlation Analysis

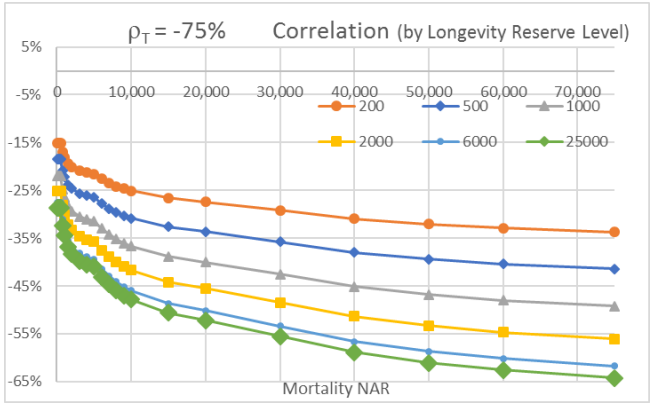
- We have used SSA historical data (1946 – 2013) to estimate the correlation in mortality trend risk among cohorts of different ages representative of life insurance vs annuity populations.
  - Population data was the best available source of data to compare mortality improvement rates over long time periods
  - We have applied an additional adjustment to our mortality trend correlation assumption to reflect potential impacts from life vs annuity population differences beyond age distribution
- Baseline results reflect the age distribution for life and annuity business based on SOA mortality studies. A sensitivity is also included showing completely non-overlapping age distributions (over/under age 65).
- Historical correlations shown using annual mortality improvement as well as correlation of 2-year improvements.
  - Longer time periods were not considered because the limited quantity of historical data would result in high standard error in correlation estimates, though the assumption that correlations are stable over time also indicates that annual correlations are consistent with correlation measured over longer time periods.
- Analysis suggests that the correlation of trend risk reflecting the age differences between annuity and life policyholders is in the range of -80%.

	SOA Study Age Distribution		**Non-overlapping Ages**	
	Historical Correlation	Standard Error	Historical Correlation	Standard Error
Annual	-81%	7%	-64%	9%
Biennial	-76%	11%	-54%	15%

Total Risk Correlation - Sensitivities

- There was judgment in selecting -65% as the trend correlation assumption
- A range of -55% to -75% was considered reasonable for this assumption
- This assumption impacts correlation at large exposures more than small exposures





Other Jurisdictions

- Bermuda BSCR applies a -50% correlation between longevity and mortality risks
- Canada's LICAT and Europe's Solvency II apply a correlation factor of -25% and acknowledge significant judgment was applied
- BSCR
  - BMA "believe that an appropriate selection of tail correlations matrixes strikes an adequate balance between tractability, robustness and risk sensitivity."
- LICAT
  - "Analysis" indicated a negative correlation between risks; a description of the analysis is not provided
  - Notes that longevity risk is primarily associated with older ages than life mortality risks
  - Framework also includes -75% correlation between mortality risk for "life supported" and "death supported" products
- Solvency II
  - Mortality/Longevity insured differences, including likely age differences, could limit the potential for risk offsets
  - Systemic changes in mortality would likely impact risks evenly, providing offsets

Importance of Correlation

- In our view it is necessary to consider correlation between longevity and mortality concurrent with the implementation of a C-2 Longevity factor and that it would not be appropriate to adopt a proposed Longevity C-2 factor without also reflecting correlation with mortality risk.
- In order to achieve a 95th percentile level across multiple risks it is necessary to consider the likelihood that risks occur together.
- If the longevity factor were adopted and applied additively to existing mortality C-2 this would represent an implicit 100% correlation between longevity and mortality risks.
- A 100% correlation would express the view that a stress 95th percentile longevity outcome where annuitants are living longer than expected would with 100% certainty occur concurrent with a stress 95th percentile mortality outcome where insureds are dying sooner than expected.
- We do not find this to be a plausible view of how longevity and mortality risk are related, and this would result in a total RBC C-2 amount materially in excess of a 95th percentile outcome.

Impact of Excluding Correlation

- From a practical perspective, using an implicit 100% correlation would result in a total C-2 amount that does not represent a consistent level of statistical safety across companies.
  - C-2 for companies with concentrated exposure to longevity or mortality would be close to 95th percentile
  - C-2 for companies with balanced exposure to longevity and mortality would be materially in excess of 95th percentile
- This inconsistency may reduce the value of RBC as a tool to identify potentially weakly capitalized companies.
- Examples on the next slide illustrate the RBC ratio impact of introducing the C-2b longevity risk factors under a range of longevity-mortality correlation assumptions:
  - 100%; (high longevity always occurs together with high mortality)
  - 0%; (independence between longevity and mortality)
  - Negative correlations of -25%, -33%, -50% and -75%

Hypothetical Company RBC Impacts – Impact of Excluding Correlation

	Baseline	**Concentrated** Longevity Exposure Company Example					
C2a Mortality/Other Insurance Risk		25.1	25.1	25.1	25.1	25.1	25.1
C2b Longevity Insurance Risk	n/a	75.4	75.4	75.4	75.4	75.4	75.4
Longevity - Mortality Correlation	n/a	100%	0%	-25%	-33%	-50%	-75%
Calculated CAL RBC	101.8	150.7	133.9	129.3	127.8	124.4	119.3
Total Adjusted Capital	526.6	526.6	526.6	526.6	526.6	526.6	526.6
Calculated CAL RBC Ratio	**517%**	**349%**	**393%**	**407%**	**412%**	**423%**	**441%**
Change in RBC Ratio vs Baseline	-	*-168%*	*-124%*	*-110%*	*-105%*	*-94%*	*-76%*

	Baseline	**Balanced** Longevity Exposure Company Example					
C2a Mortality/Other Insurance Risk		25.1	25.1	25.1	25.1	25.1	25.1
C2b Longevity Insurance Risk	n/a	25.1	25.1	25.1	25.1	25.1	25.1
Longevity - Mortality Correlation	n/a	100%	0%	-25%	-33%	-50%	-75%
Calculated CAL RBC	101.8	113.9	106.1	104.0	103.3	101.8	99.6
Total Adjusted Capital	526.6	526.6	526.6	526.6	526.6	526.6	526.6
Calculated CAL RBC Ratio	**517%**	**462%**	**496%**	**506%**	**510%**	**517%**	**529%**
Change in RBC Ratio vs Baseline	-	*-55%*	*-21%*	*-11%*	*-7%*	*0%*	*11%*

	Baseline	**Low** Longevity Exposure Company Example					
C2a Mortality/Other Insurance Risk		25.1	25.1	25.1	25.1	25.1	25.1
C2b Longevity Insurance Risk	n/a	5.0	5.0	5.0	5.0	5.0	5.0
Longevity - Mortality Correlation	n/a	100%	0%	-25%	-33%	-50%	-75%
Calculated CAL RBC	101.8	103.7	102.0	101.6	101.4	101.1	100.7
Total Adjusted Capital	526.6	526.6	526.6	526.6	526.6	526.6	526.6
Calculated CAL RBC Ratio	**517%**	**508%**	**516%**	**518%**	**519%**	**521%**	**523%**
Change in RBC Ratio vs Baseline	-	*-9%*	*-1%*	*1%*	*2%*	*4%*	*6%*

Shown on page 14

Questions

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