REVIEW OF LIFE MORTALITY RISK-BASED CAPITAL (RBC)

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Discussion Topics

- Purpose, Scope, and Approach
- Products Modeled
- Comparison to Original Work
- Risk Distribution Development
- Status and Next Steps

C-2 Life Mortality RBC Work Group

Work Group Purpose:

The C-2 Work Group was formed in 2017 to review the current National Association of Insurance Commissioners (NAIC) C-2 RBC requirement for life insurance. The group is reviewing assumptions and methodology and will recommend revisions, as appropriate, which may include structure and factor updates.

In-Scope	Out-of-Scope

▪ Life Insurance
  ▪ Individual & Industrial Life
  ▪ Group & Credit Life
	▪ Accident & Health Insurance
	▪ Annuities*
	*The group is working with the Longevity Risk Task Force (LRTF) to reflect potential correlation between mortality and longevity risks in aggregate C-2

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Overall Approach

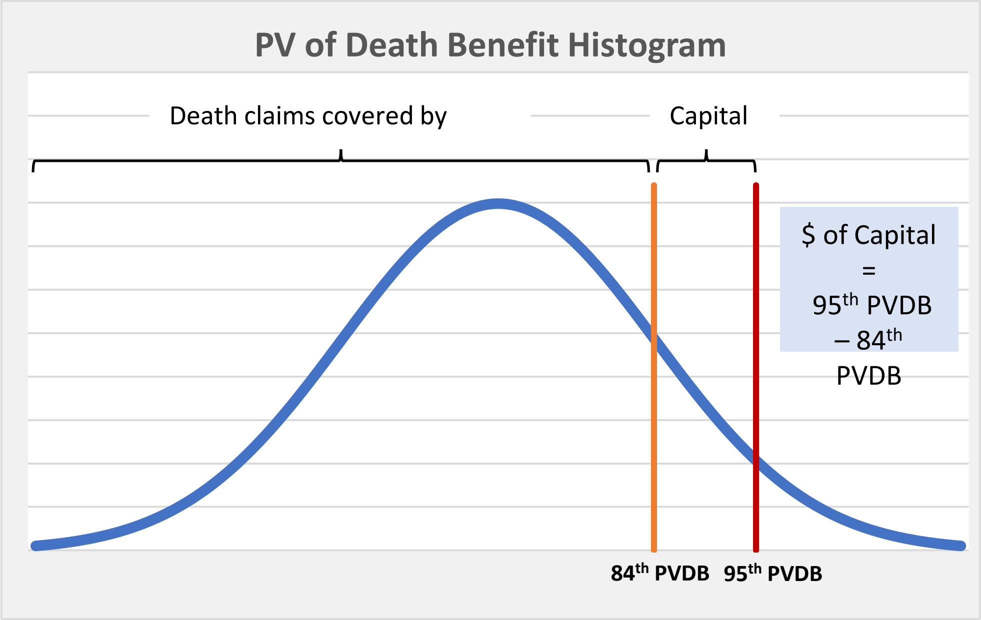
- RBC is a regulator tool to identify potentially weakly capitalized companies
- C-2 requirements cover mortality risk in excess of the mortality risk covered by statutory reserves
- C-2 requirements include mortality risks arising from:
  - Volatility Risk—natural statistical deviations in experienced mortality
  - Level Risk—error in base mortality assumption
  - Trend Risk—adverse mortality trend
  - Catastrophe Risk—large temporary mortality increase from a severe event
- Evaluate mortality risk and quantify capital requirement using Monte Carlo simulation
- Express capital requirement using a factor-based approach (e.g., factor applied to Net Amount at Risk (NAR))

Monte Carlo Simulation for Capital Quantification

Life Insurance Block

Stochastic Mortality Model

$q = f(Level, Trend, Cat, Vol)$



A distribution of death claims is developed through Monte Carlo simulation in which random draws/processes determine scenario deaths/benefits

Products Modeled

- Same products as original work:
  - Term
  - Permanent Whole Life
  - Universal Life
  - Group Life
    - Original work reduced the projection period as a group life proxy; we're currently exploring Group Life methodology
- Products are differentiated by:
  - Inforce distribution (gender, age, face amounts, risk class, issue year, etc.)
  - Lapse rates
  - Mortality (Term only, increased post-level period mortality)
- The model projects deaths, death benefits, and lapses. Refined product details such as secondary guarantees, reserve growth, cash value growth, and premium/cost of insurance (COI) are not explicitly modelled.

Method and Assumption Comparison

Item	Original Work	Current Review- Preliminary
General Method	Monte-Carlo Model—PV of Death Benefits	Monte-Carlo Model—PV of Death Benefits
Capital Quantification	PV[95th]—105%*PV[Expected] ▪ 105% represents assumed margin available to offset losses in excess of expected	PV[95th]—PV[84th] ▪ Capital based on requirement over reserves (assumed 95th percentile statistical safety level)
Projection Period	5 years (3 years for Group) ▪ Assumed exposure past 5 years could be offset through management actions (raise premium, etc.)	Period consistent with length of material risk exposure
Discount rate	6% after tax	5% pretax (3.95% after tax)
Base Mortality	88% of 1975–1980 Male Basic Table ▪ 15Y Select & Ultimate Structure ▪ Male/Female not explicitly modelled ▪ Underwriting adjustments applied based on generation	2017 Unloaded CSO ▪ 25Y Select & Ultimate structure ▪ Gender distinct—Male/Female ▪ 5 underwriting classes (3 nonsmoker/2 smoker)
Base Improvement	Unknown source ▪ 1.00%	2017 Improvement Scale for AG-38 ▪ Varies by gender and age

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Risk Distribution Development

- Work has focused on developing risk distributions around key risk components:
  - Volatility Risk
  - Trend Risk
  - Level Risk
  - Catastrophe Risk
- Distributions used for stochastic mortality projection in Monte Carlo simulation:

$$\boldsymbol{q_{s,t}^{stoch}} = f(q_t^{base}, Lev, Trend, Cat, Vol)$$

Stochastic Mortality

$$q_{s,t}^{stoch} = q_t^{base} * (1 + LR_s) * e^{TR_{s,t}} + Cat_{s,t}$$

Where:

LR_s = Level Risk random variable for scenario s $\sim N(0, \sigma_L)$

$TR_{s,t}$ = Trend Risk random variable for scenario s, projection period t

$TR_{s,t} = \sum_0^t [MI^{base} + D_{s,i}]$ where $D_{s,i} \sim N(0, \sigma)$

$Cat_{s,t}$ = Catastrophe Risk random variable for scenario s, projection period t

Deaths = Binom.Inv[N, $q_{s,t}^{stoch}$, z] ← Volatility Risk

Where:

N = Number of Policies

z = standard normal draw

Volatility Risk

- Volatility risk reflects natural statistical deviations in experience
  - When flipping an unbiased coin five times, you can end up with five heads
- For mortality, this is natural statistical differences from expected deaths and can be represented by a binomial distribution
  - Prob[Deaths = n] = $\binom{Policies}{n} * q^n * (1-q)^{Policies-n}$
- Volatility risk reduces with increased exposure/trials (i.e., less dispersion around 50% heads in 500 trials than in five trials)
- Volatility risk is less for larger blocks than smaller blocks; this is the basis for the current factor structure (i.e., C2 factors decrease as NAR increases)

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Level Risk

- Level Risk is the risk of incorrect base mortality assumptions
- Level Risk parameters are developed from two components
  1) Statistical Sampling Volatility—assumes mortality rates are set with experience studies, credibility of estimates dependent on study size (# policies and years)
  2) Natural Mortality Volatility—historical data suggests natural volatility exists
     - Insured age-weighted regression on social security data implied annual volatility of 2.2%
     - Scales down with number of years in mortality study: $\sigma_{Natural} = 2.2\%/\sqrt{Study\ Years}$
- Independence assumed: $\sigma_L = \sqrt{\sigma^2_{Stat\ Samp.} + \sigma^2_{Natural}}$
- Consistent with Longevity Risk Task Force level risk

Trend Risk

- Trend Risk is the risk that future mortality improvement is different than assumed
- Historically, both mortality improvement (MI) and MI volatility have differed by historical period, gender, and age, among others. While average MI over long periods tends to stabilize, period to period MI can be quite different
  - Male age 45 MI may differ greatly from Female age 45 or Male age 75
- We've pursued an improvement distribution that captures these characteristics while balancing the desire for simplicity

Trend Risk—Stochastic MI Deviation

- Deviation in mortality improvement will be modeled across male/female and young/middle/old ages as ***correlated normally distributed random variables***
  - MI deviation generated for ***each cohort*** in ***each year*** of ***each scenario***
  - Allows for large differences year-to-year consistent with historical data

MI Deviation	Male	Female
Young (<45)	$D_{Y,M}$	$D_{Y,F}$
Middle(45-79)	$D_{M,M}$	$D_{M,F}$
Old(80+)	$D_{O,M}$	$D_{O,F}$

$$[D_{Y,M}, D_{M,M}, \ldots, D_{O,F}] \sim N(\mu, \Sigma)$$

Where:

- μ = zero vector = [0, 0, …, 0]
- ∑ = covariance matrix calibrated with social security data 1950+

Model MI(scen s, period t): $MI^{s,t}_{Male\,55} = MI_{Male\,55} + D^{s,t}_{M,M}$

Catastrophe Risk

- Catastrophe risk is the risk of a temporary increase in mortality
- Created two discrete distributions
  1) Pandemic distribution—calibrated from multiple sources and historical observations
  2) Terrorism distribution—calibrated from September 11 life insurance claims

Pandemic Dist.—Annual		
Prob	CDF	Dths/1K
0.50%	0.50%	1.5
0.50%	1.00%	0.7
0.50%	1.50%	0.55
0.50%	2.00%	0.35
0.50%	2.50%	0.2
0.50%	3.00%	0.1
0.50%	3.50%	0.05
96.500%	100.00%	0

Terrorism Dist.—Annual		
Prob	CDF	Dths/1K
5.00%	5.00%	0.05
95.00%	100.00%	0.00

Risk Distribution Approach Comparison

Risk	Original Work	Current Review- Preliminary
Volatility	Binomial(Policies, q)	Binomial(Policies, q)
Level	Implicit from Discrete Scenarios: ▪ 7 *Competitive Pressures* scenarios – risk of overoptimistic pricing assumptions ▪ 15 AIDS scenarios – early 90's estimates of the impact of AIDS on insured mortality (could fit in level, trend, or catastrophe)	LR~N(0, σ_{Lev}); $\sigma_{Lev} = \sqrt{\sigma_{Stat\ Samp.}{}^2 + \sigma_{Natural}{}^2}$ ▪ Two independent components: • Statistical sampling/credibility volatility ($\sigma_{Stat\ Samp.}$) • Natural mortality volatility ($\sigma_{Natural}$) ▪ Continuous normal distribution
Trend	Discrete Distribution ▪ 7 scenarios adjust mortality improvement assumption	$[D_1, D_2, \ldots, D_6] \sim N(\mu, \Sigma)$ ▪ 6 gender/age group improvement deviation variables (D_n) ▪ Correlated normally distributed random variables
Catastrophe	Discrete Distribution ▪ Pandemic	2 Discrete Distributions ▪ Pandemic – calibrated from multiple sources ▪ Terrorism – 5% probability of additional 0.05 / 1K

Status and Next Steps

- Status
  - Developed preliminary model and approximately replicated original 1993 factors
  - Developed preliminary distributions and assumptions for each risk component
  - Developed preliminary lapse assumptions by product
- Next steps
  - Continue model assumption development (e.g., mix-of-business, lapse rates, reinsurance)
  - Define group life approach
  - Finalize model development and testing
  - Coordinate with the Academy's Longevity Risk Task Force, as appropriate
  - Recommend factors, targeting late-2019 preliminary factors

Questions?

Additional Questions, contact:

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Appendix

Level Risk—Statistical Sampling Volatility

- Statistical Sampling Volatility is dependent on:
  - Number of policies in experience study
  - Number of years in experience study
  - Mortality rate

$$\sigma_{Stat\ Samp} = \sqrt{\frac{q(1-q)}{Policies * Study\ Years}} \Big/ q$$

Study Years	5

Stat Samp σ	q per 1K			
Policies	0.5	1.0	3.0	5.0
10,000	**20.0%**	**14.1%**	**8.2%**	**6.3%**
100,000	**6.3%**	**4.5%**	**2.6%**	**2.0%**
500,000	**2.8%**	**2.0%**	**1.2%**	**0.9%**
1,000,000	**2.0%**	**1.4%**	**0.8%**	**0.6%**

- $\sigma_{Stat\ Samp}$ decreases with policy count increase
- $\sigma_{Stat\ Samp}$ decreases with q increase
  - $\sigma_{Stat\ Samp}$ is a relative measure, absolute level risk *increases* with q increase

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Level Risk—Natural Mortality Volatility

- Mortality rates are volatile and change from year to year, even with fully credible data
- This volatility is assumed to be 2.2% annually
  - Regression analysis of Social Security data since 1950 produced a 2.2% standard deviation
  - Average life insurance age weights were used
- This risk scales down with the number of study years
  - $\sigma_{True\ Mort} = 2.2\% / \sqrt{Study\ Years}$

Level Risk: Aggregate (Statistical Sampling + Natural Volatility)

- Level risk components are assumed to be independent
  - Aggregate level risk volatility: $\sigma_L = \sqrt{\sigma^2_{Stat\ Samp.} + \sigma^2_{Natural}}$
- Level Risk random variable is set by scenario and applied to all projection years
  - $q_{scen\ s} = q * (1 + LR_{scen\ s}); LR_{scen\ s} \sim N(\mu = 0, \sigma_L)$
- Addresses the risks of setting mortality assumptions and provides for risk differentiation due to study size and mortality rate

Study Years	5
$\sigma_{Natural}$	2.2%

Aggregate Level σ	q per 1K			
Policies	0.5	1.0	3.0	5.0
10,000	**20.0%**	**14.2%**	**8.2%**	**6.4%**
100,000	**6.4%**	**4.6%**	**2.8%**	**2.2%**
500,000	**3.0%**	**2.2%**	**1.5%**	**1.3%**
1,000,000	**2.2%**	**1.7%**	**1.3%**	**1.2%**

Trend Risk—MI Covariance Calibration

- Σ is calibrated with Social Security data since 1950
  - Improvement volatility varies by historical period and has been decreasing
  - 1950 is felt to balance the high volatility of older periods with more recent reductions.

Historical Period since 1950

Mort Improvement Standard Deviation		
Males	Young	**2.9%**
	Middle	**1.5%**
	Old	**2.2%**
Females	Young	**2.3%**
	Middle	**1.4%**
	Old	**2.4%**

Mort Improvement Correlation		Males			Females		
		Young	Middle	Old	Young	Middle	Old
Males	Young	1.00					
	Middle	0.42	1.00				
	Old	0.24	0.80	1.00			
Females	Young	0.73	0.45	0.34	1.00		
	Middle	0.38	0.79	0.79	0.59	1.00	
	Old	0.17	0.68	0.91	0.34	0.81	1.00