Correlation in Life Risk Based Capital

Life Investment and Capital Adequacy Committee

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Guiding Principles for this review

Consistent measure of aggregate company risk

- A best estimate view of tail risk aggregation supports the regulatory objective to identify potentially weakly capitalized companies and provides consistent differentiation between companies with concentration or diversification of risks

Consistent with targeted statistical safety level of RBC

- Target a correlation approach that achieves a Company Action Level RBC that maintains the statistical safety level to which the individual risk factors within RBC are calibrated over a multiyear horizon
- Recognize that correlations may not be linear across all outcomes

Practical to implement

- Avoid false precision in both methodology and numerical values: maintain simple linear correlation approach with appropriate rounding of correlation factors

Recommendation

Linear correlation between major risk categories expressed as a correlation matrix:

No change to the structure of how existing risk factors are defined

	Credit C-1o, C-3b	Equity C-1cs, C-3c	Interest Rate C-3a	Insurance C-2a, C-2b	Business C-4a, C-4b
Credit	100%	50%	25%	0%	0%
Equity	50%	100%	50%	0%	0%
Interest Rate	25%	50%	100%	0%	0%
Insurance	0%	0%	0%	100%	0%
Business	0%	0%	0%	0%	100%

Nested correlation used to combine C risks that fall within each major risk category:

Credit	C-1o	C-3b
C-1o	100%	25%
C-3b	**25%**	100%

Insurance	Mortality C-2a	Longevity C-2b
Mortality C-2a	100%	-25%
Longevity C-2b	**-25%**	100%

Equity	C-1cs	C-3c
C-1cs	100%	100%
C-3c	**100%**	100%

Business	C-4a	C-4b
C-4a	100%	0%
C-4b	**0%**	100%

Data Sources and Limitations

Recommendations are informed by analysis of historical correlations among data used to proxy C-risks within LRBC

Risk	Proxy Data	Key Assumptions
Credit	**Primary** – Issuer weighted corporate bond default rates **Secondary** – NCREIF real estate index total returns	Correlation of data weighted by issuer used as a proxy for correlations for mix of insurer bond holdings
Equity	S&P 500 Total Return	Insurer equity holdings under C-1cs assumed to be correlated with other risks similarly to S&P 500 equity returns
Interest Rate	Total Return of Investment Grade Bond Fund FBNDX	Correlations in bond fund returns driven by rates and spreads are assumed to be a reasonable proxy for more the complex C-3 calculation Recommend the absolute value of correlations with interest rates since rate & spread movements could be in either direction and not practical to differentiate correlation between up rate and down rate binding scenarios given the current structure of the C-3 calculation
Insurance	United States population mortality rates by age and socioeconomic decile	Age weighting based on SOA Mortality Experience Studies for Individual Life Insurance and Individual Payout Annuity used to represent Mortality and Longevity risks
Business	Life and Annuity State Guaranty Association Assessments as a Percentage of Capacity; *data available 1988 to 2021*	Represents portion of C-4a whose factor is in part intended to cover potential exposure to guaranty fund assessments

Time Period – Core period of 1982 to 2019 to create a consistent period for all risks (except Business); longer time periods were also reviewed for individual pairs where available to check for consistency with core period

Calibration

The guiding principle for calibration is a linear correlation assumption that achieves an aggregate RBC amount that maintains the statistical safety level to which the individual risk factors were calibrated.

Our approach to achieving this calibration result considered three elements:

1. **Analysis of average risk correlation**
    - Numerous metrics were considered aimed at calibrating the average observed correlation between risks across different time horizons
    - A mathematical appendix demonstrates that for normally distributed risks that are linearly correlated, this average correlation achieves this calibration objective
2. **Confirmed that average correlation remains appropriate for non-normal market loss distributions**
    - Analysis was done to confirm that for market losses that are not normally distributed the average correlation remains an appropriate calibration target for the approximate level of statistical significance targeted by RBC
3. **Considered if there is evidence of non-linear correlations that are higher in unfavorable risk scenarios**
    - Cumulative 5 year risk losses were calculated and compared to the corresponding rolling 5 year correlations to identify risk pairs where higher correlations have been observed in years where losses were greater (e.g. tail events)

Summary Results & Rationale – Market Risks

The primary metric was the average annual correlation over the core 1982-2019 period

Numerous secondary metrics along with qualitative factors were also considered; more information on these additional considerations is included in the appendices

Risk Pair	Average Annual Correlation	Recommend	Reasonable Alternatives	Key Additional Insights from Secondary metrics
Credit - Equity	24% with bond default 9% with real estate	50%	25%, 75%	• Multi-year cumulative correlations more strongly supported 50% • Rolling 5 and 10 year distributions were most consistent with 25% or 0% • Data was consistent with nonlinearity with higher correlations in stress scenarios which could support 50% or 75% assumption
Interest Rate - Credit	18% with bond default 17% with real estate	25%	0%	• Rolling 5 and 10-yr distributions were consistent with both 0% and 25% while 50% was a much poorer fit
Interest Rate - Equity	43%	50%	75%	• Rolling 5-year distribution tail supported both 50% and 75% • Other metrics most consistent with 50%

Summary Results & Rationale – Insurance Risks

There was little quantitative evidence or qualitative considerations supporting a non-zero correlation for Insurance risk

Risk Pair	Average Annual Correlation	Recommend
Insurance – Credit	8% Life Mortality with Bond default -10% Life Mortality with Real Estate -6% Annuity Mortality with Bond default 8% Annuity Mortality with Real Estate	0%
Insurance – Equity	16% with Life Mortality -14% with Annuity Mortality	0%
Insurance – Interest Rate	4% with Life Mortality -1% with Annuity Mortality	0%

Correlations for mortality risk based on q(x) values while longevity risk represented by p(x) = 1 - q(x)

Results reflect total population mortality, though analysis done on the wealthiest population decile showed similar results

Summary Results & Rationale – Business Risk

The average annual correlations for business risk analysis used the available 1988-2021 period

The 1998-2021 results were also considered which exclude the wave of guaranty fund assessments in the early 1990's and also supported the recommendation

Risk Pair	Average Annual Correlation	Recommended
Business - Credit	-34% with bond default 29% with real estate	0%
Business - Equity	-28%	0%
Business – Interest Rate	-5%	0%
Business - Insurance	-46% with Life 48% with Annuity	0%

Current RBC includes a C-4b health administrative component within the correlation matrix with 0% correlation to the other risks, while C-4a is excluded from the correlation matrix and added to the total after covariance

- The limited historical data supports a 0% correlation assumption which is achieved by including Business Risk within the correlation matrix
- A theoretical argument for keeping Business Risk as additive outside of the correlation matrix is that guaranty assessments result from insurance company failures which would be caused by the realization of RBC risks in aggregate, therefore should be expected to have high correlation with the total RBC amount in times of stress
- Counterarguments include cases of insolvencies driven by underpricing or a lack of diversification rather than systemic risk events along with the lag between low RBC indicating financial difficulty and the ultimate guaranty fund assessment
- Recommend combining C-4a and C-4b to a single Business Risk value then treating all business risk consistently whether included within or additive to the correlation matrix

Nested Correlation Rationale

Rationale for nested correlations rely on descriptions of risks covered and judgment of reasonable correlations in the absence of data

Credit: Recommend 25% Correlation between C-1o and C-3b

- C-3b Health Credit Risk covers the risk that the company will pay capitation payments to health care providers but will not receive the agreed-upon services and will encounter unexpected expenses in arranging for alternative coverage
- It seems plausible that this risk would be independent from asset default risk covered in C-1o which would support a 0% correlation assumption
- It could also be possible that a weak economic environment that would lead to C-1o asset defaults could also be associated with increased incidence of failure of health care provider entities
- In the absence of data, we recommend the more conservative argument for a correlation of 25%.

Equity: Recommend 100% Correlation (additive) between C-1cs and C-3c

- Both C-1cs and C-3c capture market risk of equity assets and therefore the existing approach of combining the risks for covariance purposes is reasonable

Nested Correlation Rationale - Continued

Insurance: Recommend no change to existing -25% Correlation between C-2a and C-2b

- Correlation between C-2a mortality and C-2b longevity was recently reviewed when Longevity risk was added to LRBC; we are not recommending changes to the existing negative 25% correlation between C-2a and C-2b.

Business: Recommend 0% Correlation between C-4a and C-4b

- C-4a premium and liability components cover in part the risk of guaranty fund assessments following the failure of other insurers in addition to other risks not covered elsewhere in the RBC formula such as exposure to litigation
- C-4b health administrative expense component provides for the risk that actual expenses of administering certain types of health insurance will exceed the portion of the premium allocated to cover these expenses
- The lack of an expected relationship between these components supports a zero correlation assumption

Impacts – 2023 Aggregate Industry Mix

The recommendation would increase the effective required capital after covariance for Equity and Credit Risk and decrease the effective required capital for Insurance, Interest Rate and Business Risks

The net impact to a hypothetical company with a risk distribution equal to the 2023 aggregate industry mix would be an increase of 1.6% to RBC After Covariance

YE'23 Industry Mix	
C-0	15.5%
C-1cs	26.1%
C-1o	30.0%
C-2	14.5%
C-3a	7.3%
C-3b	0.0%
C-3c	1.1%
C-4a	5.3%
C-4b	0.3%
Total	**100.0%**

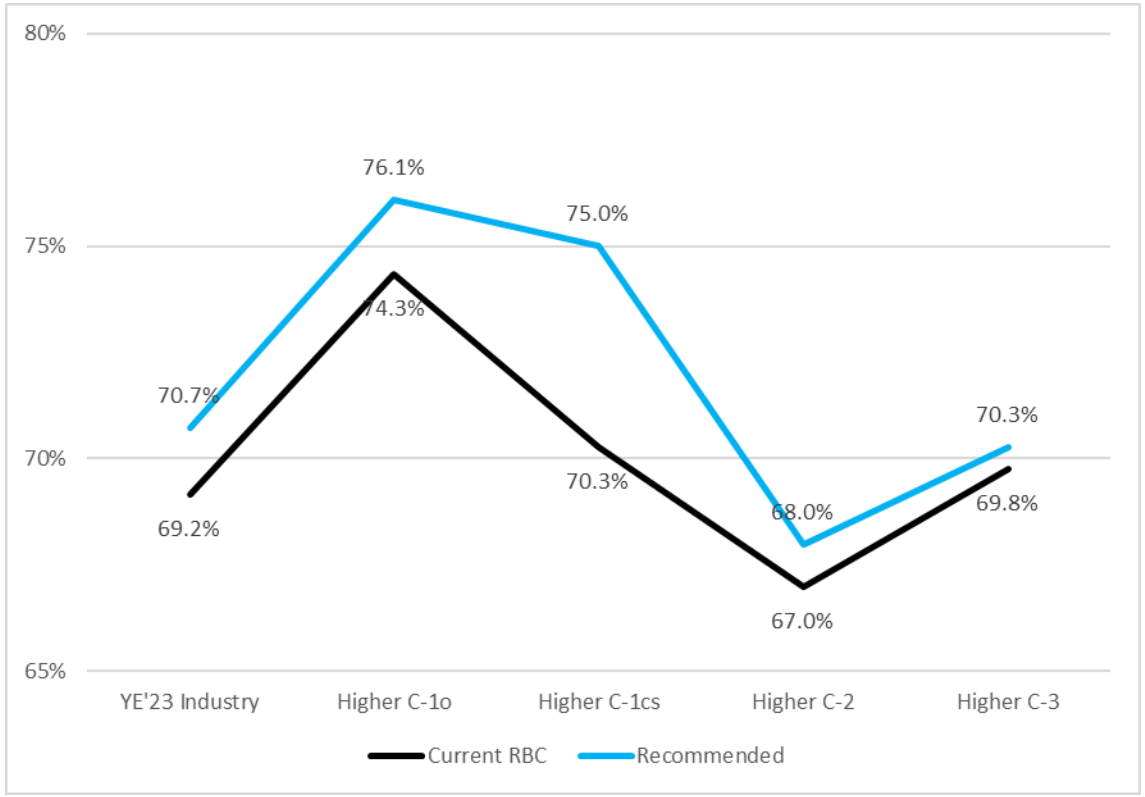
RBC After Covariance as a % of RBC Before Covariance

	Current RBC	Recommended	Change
Equity	56%	83%	27%
Credit	77%	82%	5%
Insurance	30%	26%	-4%
Interest Rate	77%	51%	-26%
Business	100%	10%	-90%
Total	**69.2%**	**70.7%**	**1.6%**

Impact shown for a hypothetical company with a distribution of risks equal to the reported 2023 aggregate industry RBC mix
This is not necessarily representative of the impact to average company RBC across the industry

Impact Sensitivities

Each of the sensitivities tested resulted in an increase to RBC after covariance
The impact is greatest for companies with higher concentration of C-1cs risk



Sensitivities increase the percentage of each risk noted by 50% relative to the 2023 Aggregate Industry baseline while all other risks are reduced proportionally

	YE'23 Industry	Higher C-1o	Higher C-1cs	Higher C-2	Higher C-3
C-0	15.5%	15.5%	15.5%	15.5%	15.5%
C-1cs	26.1%	18.9%	39.2%	23.4%	24.9%
C-1o	30.0%	45.0%	23.3%	26.9%	28.6%
C-2	14.5%	10.5%	11.2%	21.7%	13.8%
C-3a	7.3%	5.3%	5.6%	6.5%	10.9%
C-3b	0.0%	0.0%	0.0%	0.0%	0.0%
C-3c	1.1%	0.8%	0.8%	1.0%	1.0%
C-4a	5.3%	3.9%	4.1%	4.8%	5.1%
C-4b	0.3%	0.2%	0.2%	0.2%	0.2%

Questions?

For more information, please contact:

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Appendix

Overview of Secondary Metrics

Several metrics were used to inform the recommendation and improve consistency with core principles:

- Average annual correlation over core 1982-2019 period (primary metric)
- Average annual correlation over extended period where data is available for each risk pair
- Average correlation of cumulative multi-year risk outcomes (rolling 2-year, 5-year and 10-year periods) – recognizes the fact that the calibration of RBC factors considers losses over the risk cycle which is generally longer than one year
- Distribution of observed multi-year rolling correlations (5-year, 10-year):
    - Correlations observed from data over rolling 5 and 10-year periods
    - Observations rounded to nearest 10% and plotted as a histogram
    - Expected histogram distributions for 0%, 25%, 50% correlations developed through simulation
    - Goodness of fit (error sum of squares) evaluated to quantify best fit to data distribution
    - Considered error sum of squares for only values >=0 and >=50% to ensure appropriate right tail
    - Also provided graphical perspective on level of uncertainty from only 37 years of data

Calibration

Demonstration that within a linear correlation framework, the average correlation is appropriate for calculating target capital

- Let X1 and X2 denote individual risk random variables
- Y = X1 + X2 is the aggregate outcome resulting from the risks
- Assume for illustration that X1 and X2 are standard normally distributed with mean zero and variance 1
- It follows that Y is also normally distributed with variance = $\sigma_{X1}^2 + \sigma_{X2}^2 + 2\,\rho\,\sigma_{X1}\,\sigma_{X2} = 2 + 2\,\rho$ where ρ is the linear correlation between X1 and X2
- C1 and C2 are capital factors for risks X1 and X2
- Assume that C1 and C2 are calibrated to capture risk of X1 and X2 between 1 standard deviation and 95th percentile, so that C1 and C2 both equal ~0.645
- Assume that aggregate reserves cover aggregate risk of Y at approximately 1 standard deviation
- Assume the objective is to combine C1 and C2 with covariance to achieve an aggregate capital requirement C_A equal to the excess of the 95th percentile of Y over the 1 standard deviation covered by reserves
- The targeted C_A is achieved across all correlations by combining C1 and C2 using the average linear correlation ρ between X1 and X2

Risk correlation ρ	**0**	**25%**	**50%**	**75%**	**100%**
Y 95th	2.33	2.60	2.85	3.08	3.29
Y 1σ	1.41	1.58	1.73	1.87	2.00
Target Capital	0.91	1.02	1.12	1.21	1.29
Correlation that achieves Target	0%	25%	50%	75%	100%

Analysis was done to empirically validate this result using the observed loss distributions for equity, credit and interest rate risk as well as using loss distributions output by the published ESG

Tail Calibration

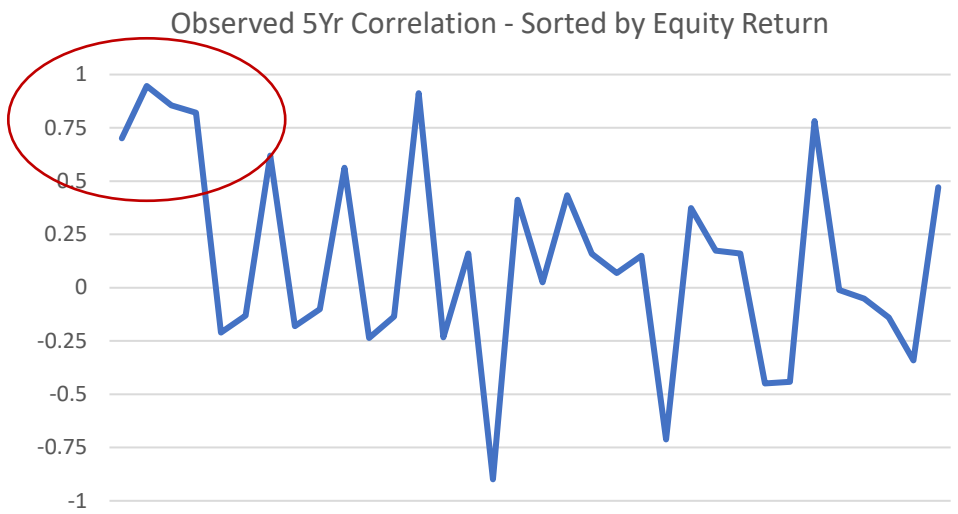
A key assumption in a linear correlation framework is that correlations are static across time

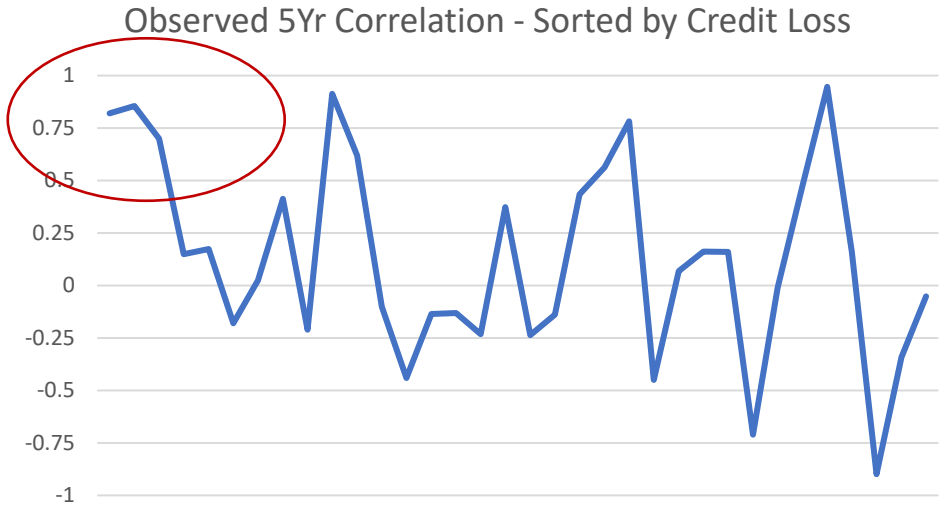
The calibration process also considered whether there was evidence to suggest that correlations may be higher in tail scenarios

The Credit – Equity risk pair showed the most evidence consistent with correlations increasing during times of stress, and this observation influenced the recommendation

The graphs below show observed rolling 5 year correlations between Equity and Credit data, each sorted with the worst outcomes for each risk on the left. In both cases the worst several risk outcomes were observed to also have higher observed correlations

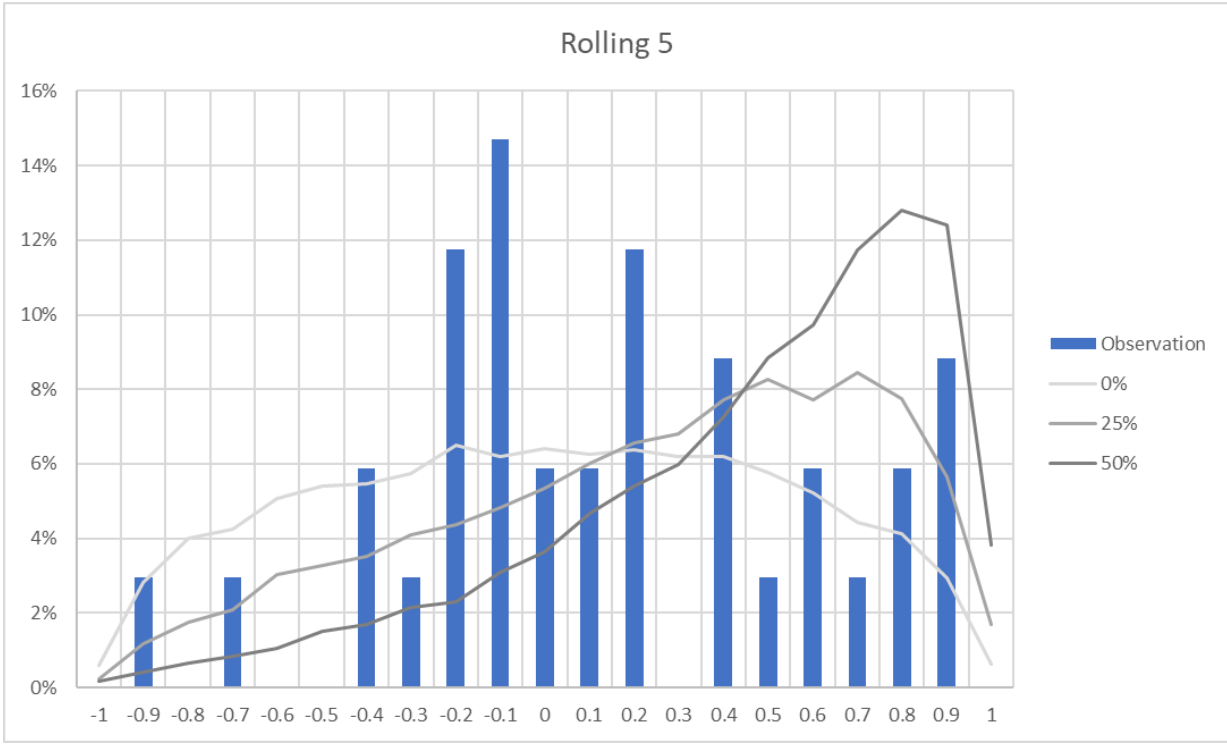
The small number of data points available in stress scenarios limits the credibility that should be assigned to this observation





Results Detail – Credit & Equity

Recommended:	50%
Average Annual Correlation – Core 1982-2019	24%
Average Annual Correlation – Extended 1972-2021	11%
Average Cumulative 2yr, 5yr, 10yr Correlations	46% 2-year 56% 5-year 53% 10-year
5-year Rolling Distribution best fit	**0% best fit** using all data (25% also good fit)
10-year Rolling Distribution best fit	**0% best fit** using all data (25% also good fit)
Tail Correlation in Worst 10% & 20% of 5Yr Credit Outcomes	63% in worst 4 rolling 5yr data points 36% in worst 7 rolling 5yr data points
Tail Correlation in Worst 10% & 20% of 5Yr Equity Outcomes	81% in worst 4 rolling 5yr data points 51% in worst 7 rolling 5yr data points

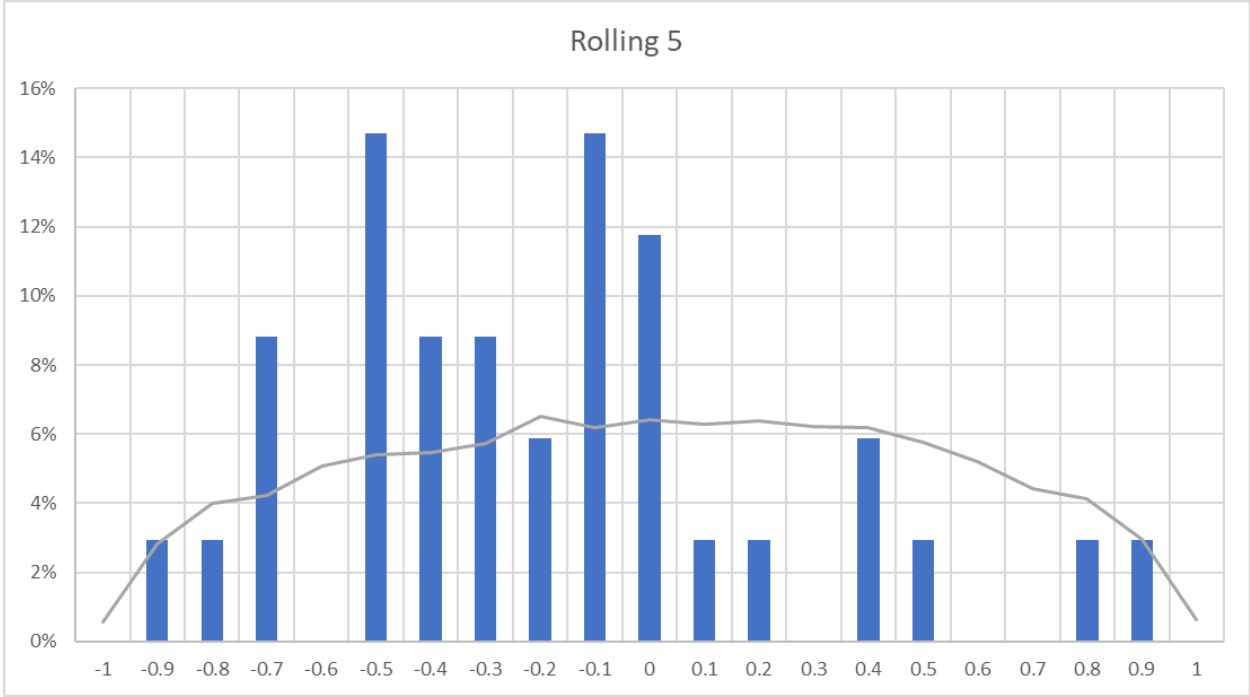


Qualitative Considerations

- Expect positive correlation given the nature of the risks
- Weak economic environment with company credit defaults to debt holders would also be expected to be unfavorable for equity holders
- There may be a time lag in the data between the risks which weakens the observed correlations
- The longer time period for calibration of risks within LRBC would support a lower correlation compared to 1 year capital frameworks

Results Detail – Credit & Interest Rate

Recommended:	25%
Average Annual Correlation – Core 1982-2019	18%
Average Annual Correlation – Extended 1972-2021	33%
Average Cumulative 2yr, 5yr, 10yr Correlations	31% 5-year 5% 10-year
5-year Rolling Distribution best fit	**25% best fit** using all data, taking the absolute value of -25% (0% also good fit)
10-year Rolling Distribution best fit	**25% best fit** using all data
Tail Correlation in Worst 10% & 20% of 5Yr Credit Outcomes	49% in worst 4 rolling 5yr data points 27% in worst 7 rolling 5yr data points
Tail Correlation in Worst 10% & 20% of 5Yr Rate Outcomes	3% in worst 4 rolling 5yr data points 9% in worst 7 rolling 5yr data points

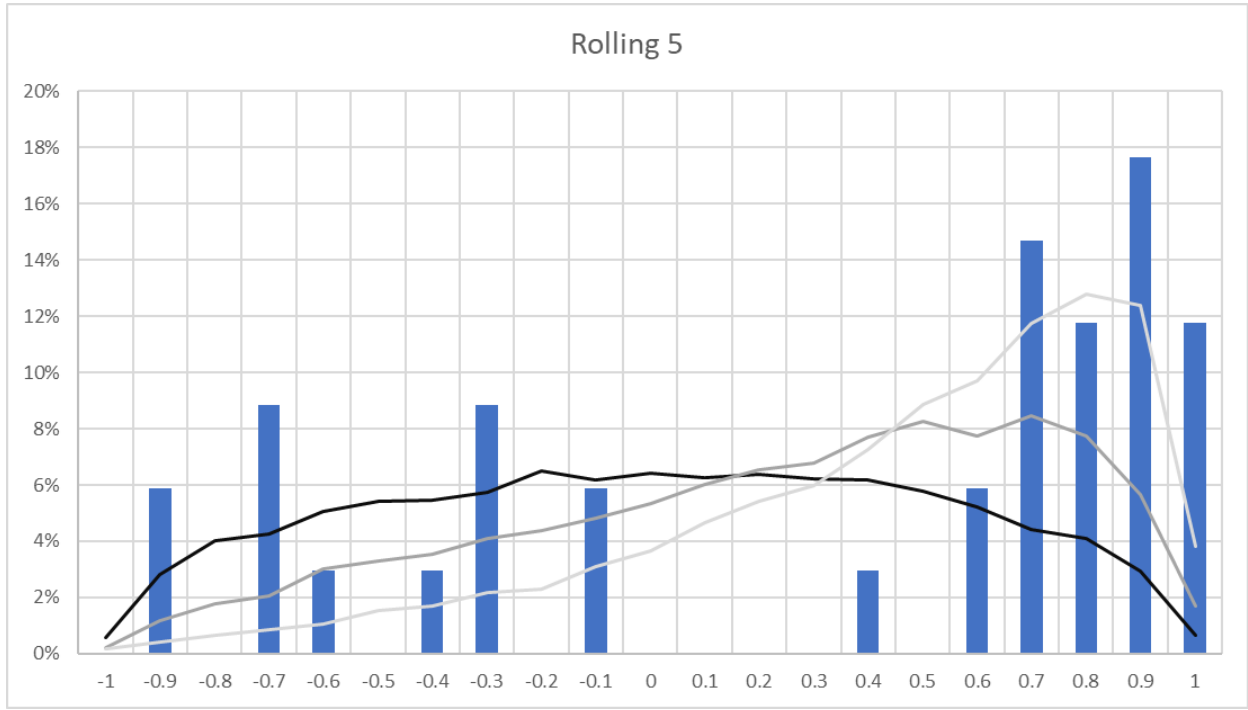


Qualitative Considerations

- Since interest rate losses could be driven by either increases or decreases in rates, we have considered the absolute value of all interest rate correlations in our results
- Correlations may differ in up rate vs down rate binding scenarios; the current structure of RBC does not easily allow for this differentiation
- The data used for interest rate risk captures both rate and spread movements; we might expect a positive relationship between credit defaults and increase in spreads

Results Detail – Equity & Interest Rate

Recommended:	50%
Average Annual Correlation – Core 1982-2019	43%
Average Annual Correlation – Extended 1972-2023	46%
Average Cumulative 2yr, 5yr, 10yr Correlations	12% 5-year 42% 10-year
5-year Rolling Distribution best fit	**75% best fit** using all data (50% also good fit)
10-year Rolling Distribution best fit	**50% best fit** using all data
Tail Correlation in Worst 10% & 20% of 5Yr Equity Outcomes	31% in worst 4 rolling 5yr data points 2% in worst 7 rolling 5yr data points
Tail Correlation in Worst 10% & 20% of 5Yr Rate Outcomes	91% in worst 4 rolling 5yr data points 68% in worst 7 rolling 5yr data points



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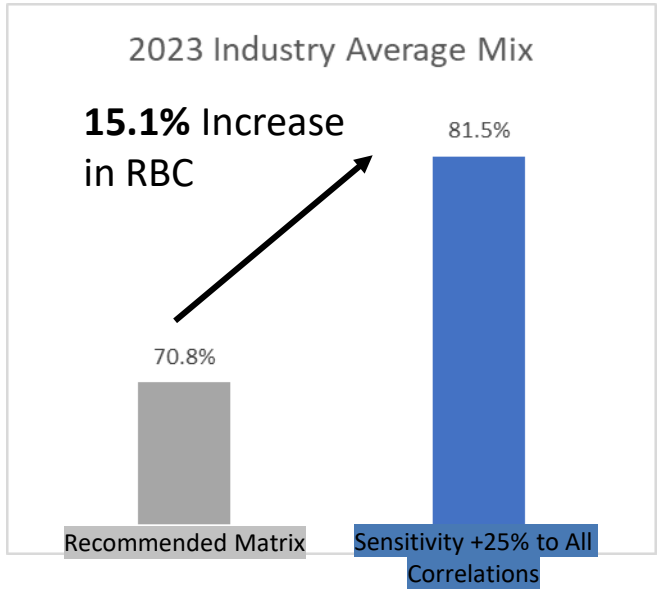
Conservatism in Calibration

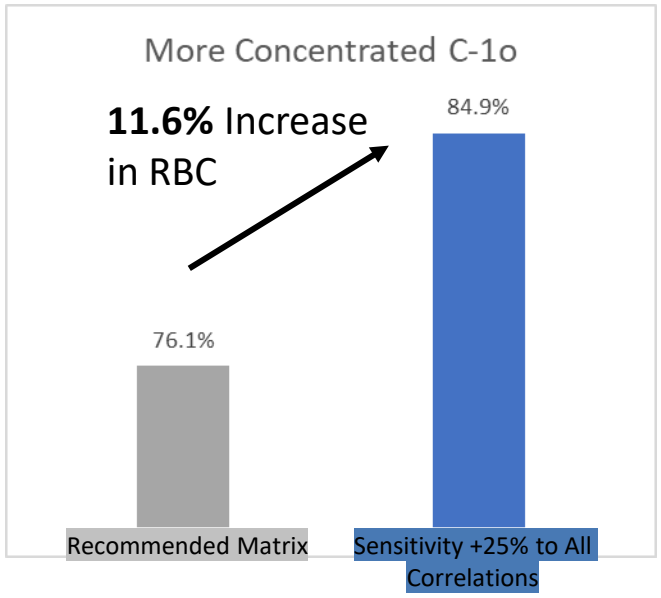
Higher correlation assumptions are 'conservative' in that they will increase aggregate RBC

However the impact would disproportionately impact diversified companies while having less impact on aggregate RBC for companies with relatively more concentrated risk exposures

This could weaken the effectiveness of RBC as a tool for identifying potentially weakly capitalized companies

Recommend best estimate correlations without explicit conservatism consistent with the objective of maintaining the statistical safety level to which risk factors were calibrated





Sensitivity shows the impact of increasing correlations between major risk categories 25% higher than the recommendation

Higher correlations increase RBC for both companies, but the impact less for companies with more concentrated risk exposures

The "More Concentrated C-1o" sensitivity increases C-1o risk by 50% while proportionally reducing all other C risks

Background

- The Life Risk Based Capital Working Group has reviewed and made updates to many areas of the LRBC formula in recent years to maintain the effectiveness of LRBC as a regulatory tool to identify potentially weakly capitalized insurers
- The calculation of each individual risk factor within LRBC has been reviewed and/or updated since the introduction of formula in the 1990s
- A holistic review of correlation of risks within the formula has not yet been undertaken
    - In 2001, the C1-cs component was created with separate covariance from C-1o
    - In 2021, C-2b longevity risk was introduced, including correlation with mortality C-2a
- Except for longevity and mortality risk, all correlations within LRBC are either 0% or 100%
- The scope of this analysis is initially focused on correlation between C-risks within LRBC; an extension of this effort could also consider correlation within individual C-risks (such as within C-1o)

Rationale for Review of Covariance Within LRBC

Due for regular maintenance review

- Every C-factor within LRBC has been individually reviewed in recent years; covariance between C-factors is due for a routine review to maintain the effectiveness of LRBC

Current approach is simplistic

- Except for C-2b longevity which was recently added, every correlation within LRBC is either 0% or 100%
- A more refined approach could be considered that improves effectiveness without adding undue complexity

Impact to effectiveness of LRBC could be material

- Changes to covariance could improve the effectiveness of RBC in differentiating between companies with concentration or diversification of risks

Current Life Risk Based Capital

RBC after Covariance =

$C0 + C4a + \text{Square Root of } [(C1o + C3a)^2 + (C\text{-}1cs + C\text{-}3c)^2 + (C2)^2 + (C3b)^2 + C4b)^2]$

Expressed as a correlation matrix, all correlations are either 0% or 100% except for the nested correlation within C-2 between mortality and longevity:

	C-1cs	C-1o	C-2	C-3a	C-3b	C-3c	C-4b
C-1cs	100%						
C-1o	0%	100%					
C-2	0%	0%	100%				
C-3a	0%	100%	0%	100%			
C-3b	0%	0%	0%	0%	100%		
C-3c	100%	0%	0%	0%	0%	100%	
C-4b	0%	0%	0%	0%	0%	0%	100%

Nested correlation for C-2:

	C-2 Mortality	C-2 Longevity
C-2 Mortality	100 %	
C-2 Longevity	-25%	100 %