Report to the National Association of Insurance Commissioners Property and Casualty Risk-Based Capital (E) Working Group

Property and Casualty Risk-Based Capital Premium and Loss Concentration Factors

Presented by the American Academy of Actuaries[1]
Property and Casualty Risk-Based Capital Committee

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Jeremy Smith, MAAA, FCAS, CERA
David Traugott, MAAA, FCAS
Jianhui Yu, MAAA, FCAS

Key Contributors: Allan Kaufman, Joseph Cofield
Additional Contributor: Smitesh Dave
NAIC support was provided by Eva Yeung

The analysis and conclusions in this Report reflect the opinions of the committee members and do not necessarily reflect the views of their employers or the actuarial organizations in which they are members.

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1. BACKGROUND

The American Academy of Actuaries Property and Casualty Risk-Based Capital Committee ("Committee" or "We") prepared this Report ("Report") at the request of the National Association of Insurance Commissioners' ("NAIC") Property and Casualty (P&C) Risk-Based Capital (RBC) Working Group ("NAIC Working Group" or "Working Group").

In this Report, we evaluate the indicated Loss Concentration Factor ("LCF") and Premium Concentration Factor ("PCF")—RBC Line 14 on pages PR017 and PR018, respectively.[2]

The LCF/PCFs have not been revised since the inception of the RBC Formula.

This is Report 3 in the series of reports described to the NAIC Working Group in May 2019:

- Report 1: Indicated risk factors (Line 4 in the RBC Formula pages PR017 and PR018). We refer to these as Line 4 Factors. This report was submitted to the Working Group in March 2021 and revised in April 2021 ("April 2021 Report"[3]).
- Report 2: Indicated Investment Income Adjustment (IIA) factors (Lines 7/8 in the RBC Formula) and updated indicated Line 4 Factors. This report was submitted to the Working Group in August 2023 ("August 2023 Report"[4]).
- Report 3: This Report on indicated LCFs and PCFs.

The analysis presented in this Report uses the same insurance industry data as Reports 1 and 2, i.e., data evaluated through December 31, 2017.[5]

[2] "PR017" and "PR018" refer to pages in the 2022 NAIC P&C RBC Formula forms, which insurers file annually on a confidential basis.

[3] American Academy of Actuaries Property and Casualty Risk-Based Capital Committee, "Report to the National Association of Insurance Commissioners Property and Casualty Risk-Based Capital (E) Working Group Update to Property and Casualty Risk-Based Capital Underwriting Factors Experience Through December 31, 2017," Presented March 2021 (Revised April 21, 2021).

[4] American Academy of Actuaries Property and Casualty Risk-Based Capital Committee, "Update to Property and Casualty Risk-Based Capital Underwriting Factors and Investment Income Adjustment Factors," Presented Aug. 31, 2023.

[5] Substantial work is involved in data preparation for the three analyses in the May 2019 letter to the NAIC. Therefore, we planned to produce the three reports with the same data. While the Reports have taken longer than we anticipated, adding additional data was not clearly beneficial as (a) processing additional data would have delayed this report, (b) the data includes 30 AYs, 1988-2017, so the effect of adding a small number of years, unless they identify new trends, is not likely to be material, and (c) any new trends from additional data through 2022, for example, would include the initial COVID effects on claim frequency and severity, but not the full cycle of COVID emergence in favorable and unfavorable impacts on loss ratio and reserve development. Furthermore, both this study and CAS Dependency and Calibration Working Party (DCWP) Report #14, which used data through 2010, support an increase in the MDC.

LCF/PCF in RBC Formula

RBC Terminology

Unless otherwise specified, references to the RBC Formula relate to the formula used for the year-end 2022 RBC Formula. "Indicated risk factors" are the indicated Line 4 premium and reserve risk factors presented in the Academy's August 2023 Report 2.[6]

The Authorized Control Level (ACL) capital is 50% of the Company Action Level (CAL) capital value calculated using the RBC Formula.[7] The factors we discuss herein are used to produce the CAL required capital value.

LCF/PCF

The LCF and PCF components of the RBC Formula reduce the Total Reserve RBC value on PR017 and the Net Written Premium RBC value on PR018 for multiline companies. For each company, the concentration is measured as the largest of the 19 RBC lines of business (LOBs) premiums or reserves, divided by the total premium or reserve.

- This ratio is 100% for monoline companies.
- The ratio is lower, though greater than zero, for diversified companies.

We refer to this method of measuring concentration as the Company Maximum Line Percentage of Business or "CoMaxLine%" approach, denoted as $\text{CoMaxLine\%}_{\text{premium}}$ and $\text{CoMaxLine\%}_{\text{reserve}}$, for premium and reserve risk, respectively.

The CoMaxLine% approach includes a parameter we call the Maximum Diversification Credit (MDC). The MDC is the notional maximum diversification credit for a company with a not achievable zero concentration ratio.[8]

[6] The NAIC decided that, except for a small number of LOBs lines affected by specific issues, the Line 4 Factors indicated in the August 2023 Report will be implemented partly in the 2024 RBC Formula and fully in the 2025 RBC Formula.

[7] If the company's Total Adjusted Capital is below the Company Action Level (CAL) value from the RBC Formula, then, according to the RBC Instructions, subject to state laws and regulations, "…the company [is required] to prepare and submit an RBC Plan to the commissioner of their state of domicile. The RBC Plan is to be submitted within 45 days. After review, the commissioner will notify the company if the plan is satisfactory." The value produced by the RBC Formula on PR032, Line 71, is the CAL value.

The Authorized Control Level (ACL) capital is 50% of the CAL value. "Authorized Control Level authorizes the commissioner to take whatever regulatory actions are considered necessary to protect the best interest of the policyholders and creditors of the insurer, which may include the actions necessary to cause the insurer to be placed under regulatory control (i.e., rehabilitation or liquidation)."

[8] 0% concentration is not achievable because the number of LOBs is finite, but premium or reserves equally spread among 19 LOBs would produce a concentration value of 1/19 or approximately 5%. With CoMaxLine% equal to 5%, the concentration factor would be 0.715 and the diversification credit would be 28.5%.

In the current RBC Formula, the MDC is 30%. The MDC is applied linearly based on CoMaxLine%[9] for each company as follows:

- $PCF_{COMPANY} = (1 - MDC) + (MDC * CoMaxLine\%_{premium})$, or
- $PCF_{COMPANY} = 0.7 + 0.3 * CoMaxLine\%_{premium}$

- $LCF_{COMPANY} = (1 - MDC) + (MDC * CoMaxLine\%_{reserves})$, or
- $LCF_{COMPANY} = 0.7 + 0.3 * CoMaxLine\%_{reserves}$

Thus, the diversification credit is 1.0 - PCF or 1.0 - LCF, for premium and reserves, respectively. A monoline company receives no diversification credit as the PCF and LCF equal 1.0.

The Total Net Reserve RBC (PR017) and the Net Written Premium RBC (PR018) are each calculated by summing the RBC amounts across all LOBs and multiplying by the LCF or PCF, on PR017 and PR018 Lines 13 and 14, respectively.

Origin of CoMaxLine% and 30% MDC

The CoMaxLine% approach was originally selected during the mid-1990s when the RBC Formula was developed. The CoMaxLine% formula with the 30% MDC was presented in a February 1993 Actuarial Advisory Committee report to the NAIC P/C Risk-Based Capital Working Group.[10,11]

It was adopted as part of the original RBC Formula and has not been revised since.

[9] For example, a company with 25% of its premium in its largest line would have PCF = 0.7 + 0.3 * 0.25 = 77.5% under the CoMaxLine% approach. It would receive a diversification credit equal to 1.0 – PCF = (1.0 – $CoMaxLine\%_{premium}$) * MDC = 75% of 30% = 22.5%. The credit is applied to the sum of the risk charges by LOB. In other words, the risk charges would be summed across all LOBs and then that sum would be multiplied by 0.775 (77.5% = 100% - 22.5%). A monoline company has a zero diversification credit and CoMaxLine% = 100%.

[10] "Report on Covariance Method for Property-Casualty Risk-Based Capital," pages 173-202.

We have not identified references to NAIC discussion of the 30% MDC in the Actuarial Advisory Committee report.

[11] Our calibration approach and the 1993 calibration approach are different. For example, our MDC calibration approach is based on 87.5th percentile outcomes (consistent with the Line 4 calibration). This differs from the 1993 MDC calibration approach which was based on standard deviations and correlations.

2. IMPACT OF REVISED LCF/PCF

Based on the Committee's work, described in detail in this report, the Committee believes:

- MDCs of 45% for premium and 65% for reserves are reasonable selections and are better supported by the data than the current 30% MDC.

  We refer to these as the indicated MDCs.

- There are alternative reasonable MDC selections that the NAIC might select, and we discuss some of them, below, in Section 3/ Alternative Indicated MDCs.

- With the indicated MDCs, the PCF and LCF formulas would be

  - $PCF_{COMPANY} = 0.55 + 0.45 * CoMaxLine\%_{premium}$
  - $LCF_{COMPANY} = 0.35 + 0.65 * CoMaxLine\%_{reserves}$

- While the CoMaxLine% approach is not perfect, considering the alternatives, the Committee believes it is a reasonable approximation, especially for more diversified companies.

Tables 2-1 through 2-5, below, show the effect on ACL reserve risk charges and premium risk charges of adopting MDCs of 45% for premium and 65% for reserves.

Table 2-1: Average RBC Value Change

Table 2-1 shows the change in RBC values assuming MDCs of 45% and 65%, in total and by Type of Company,[12] based on NAIC staff analysis using 2025 Line 4 risk factors and Line 7/8 IIA Factors.

[12] As described in the April 2021 Report 1 and August 2023 Report 2, each LOB is categorized by the NAIC P&C Working Group as typical of a particular Type of Company, e.g., B-PPA is typical of Personal Lines companies. For each company, the category with the largest amount of net written premium (NWP) + reserves determines the Type for that company. For example, a company with more of its premium in B-PPA, Homeowners A-HO and J-APD than in any of the other groups of LOBs is categorized as Personal Lines as opposed to Commercial Lines. Report 2, Appendix 8, pages 114-115, provides more details.

Table 2-1
Indicated Changes in RBC Values by Type of Company[13]

(1)	(2)	(3)	(4)	(5)	(6)
Row	Type of Company	ACL - $ Billions (2022)	% Change		
			Reserve Risk Charge	Premium Risk Charge	ACL
1	Commercial	84.4	-21.6%	-11.7%	-13.4%
2	Med Prof Liab	2.9	-8.0%	-3.4%	-1.9%
3	NOC	0.7	-6.5%	-3.1%	-2.2%
4	Personal	100.2	-18.2%	-9.2%	-2.1%
5	Reinsurance	9.5	-22.3%	-11.4%	-2.4%
6	Workers Comp	7.5	-10.0%	-4.5%	-5.7%
7	Total	205.3	-20.0%	-10.0%	-6.9%

From individual company RBC Filing data, summarized by NAIC staff and provided, in summary form, to this Committee.
Uses 2022 RBC Formula, but using 2025 Line 4 Factors and Line 7/8 IIA Factors. Compares ACL with 30% MDC to ACL with indicated MDCs.
Including only companies with RBC Filings in 2022 and 2022 non-zero net written premium plus loss reserves (NWP+Rsv>0).
NOC = "Not otherwise classified" Type of Company.[14]

Table 2-1 shows that the weighted average impacts are:

- Reserve risk is decreased by 20%.
- Premium risk is decreased by 10%.
- ACL is decreased by 6.9%.

The Table also shows:

- Reserve risk and premium risk reductions are largest for Commercial, Personal, and Reinsurance Types of Companies.
- However, the ACL reduction for Reinsurance and Personal companies is much smaller than for Commercial companies.

  This is because Reinsurance and Personal Types of Company have a greater share of RBC from risk categories other than reserve risk and premium risk, and the RBC values from those risks are not affected[15] by the change in diversification.

[13] Including only companies with 2022 RBC Filings and non-zero net written premium plus loss reserves.

[14] "NOC," standing for Not Otherwise Classified, means companies for which the portion of net written premium plus loss reserves is greatest for the sum of the following LOBs: G-SL, K-Fid/Sur, L-Other, M-Intl, or S-FG/MG. See glossary for LOB abbreviations definition.

[15] Although, in some cases, the R3-credit risk is affected by the relative values of reserve risk and reinsurance credit risk.

Table 2-2: Distribution of % Change in RBC Value

Table 2-2 shows the number of companies with various percentage changes in ACL value, comparing the ACL value using the current MDC to the ACL value using the indicated MDC.

Table 2-2
Distribution of Number of Companies by Change in ACL Values

(1)	(2)	(3)
% Changes in ACL	# Companies	% Companies
Less than -50%	0	0%
-35% to -50%	0	0%
-25% to -35%	46	3%
-15% to -25%	202	11%
-5% to -15%	500	28%
0% to -5%	676	37%
0%	393	22%
Greater than 0%	0	0%
Total	1,817	100%

Excluding companies with zero NWP+Rsv.

This table shows:

- No company sees an increase in ACL.
- 59% of companies see ACL decreases between 0% and 5%.
- 3% of companies see a decrease in ACL greater than 25%.

The individual company data shows that the largest decrease in ACL value is 29%.

Tables 2-3 through 2-5: ACL Changes by Size and Diversification

These tables show changes in:

- Reserve Risk (Table 2-3)
- Premium Risk (Table 2-4)
- ACL (Table 2-5)

We show five size bands, A-E, each with 20% of the companies. Underwriting (UW) Size in these Tables equals the sum of net written premium and net reserves.

We show six levels of diversification.[16]

- Level "0" refers to monoline companies.

[16] In Table 2-3 through 2-5, diversification by company is the weighted average of the premium diversification and the reserve diversification, calculated as the square root of the sum of (a) the square of premium diversification credit in dollars, plus (b) the square of the reserve diversification credit in dollars.

- Levels 1-5 refer to five levels of diversification, each with 20% of the non-monoline companies.

Table 2-3 – Reserves
% Change in Reserve Risk Value by UW Size and Diversification

Div/Size	A	B	C	D	E	All
0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1	-0.9%	-1.4%	-1.6%	-2.1%	-2.2%	-2.1%
2	-5.8%	-6.0%	-8.4%	-6.5%	-8.4%	-8.2%
3	-10.7%	-12.9%	-10.4%	-14.4%	-12.2%	-12.3%
4	-17.1%	-22.9%	-19.1%	-18.9%	-19.5%	-19.5%
5	-17.9%	-26.4%	-25.4%	-26.4%	-29.3%	-29.2%
All	-3.2%	-8.0%	-11.7%	-13.8%	-20.6%	-20.0%

Table 2-4 – Premium
% Change in Premium Risk Value by UW Size and Diversification

Div/Size	A	B	C	D	E	All
0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1	-0.1%	-0.7%	-0.9%	-1.2%	-1.2%	-1.1%
2	-3.0%	-3.3%	-4.1%	-3.4%	-4.0%	-3.9%
3	-6.5%	-5.9%	-6.9%	-7.1%	-8.1%	-8.0%
4	-8.9%	-8.3%	-9.0%	-9.7%	-11.0%	-10.9%
5	-11.1%	-12.2%	-13.2%	-13.2%	-13.9%	-13.8%
All	-1.4%	-3.2%	-6.1%	-7.3%	-10.4%	-10.0%

Table 2-5 – Total ACL
% Change in Unweighted ACL Value by UW Size and Diversification

Div/Size	A	B	C	D	E	All
0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1	-0.5%	-0.6%	-0.9%	-1.0%	-0.7%	-0.7%
2	-1.8%	-3.3%	-3.3%	-3.7%	-3.9%	-3.2%
3	-4.6%	-6.0%	-6.6%	-8.7%	-8.3%	-7.1%
4	-6.7%	-7.4%	-10.7%	-10.7%	-12.5%	-10.5%
5	-7.4%	-14.9%	-16.2%	-17.7%	-16.6%	-16.6%
All	-3.5%	-5.4%	-6.3%	-7.0%	-7.0%	-6.4%

Table 2-5 shows the unweighted average effect on ACL, as several very large companies have unusual values for RBC risks other than reserve risk and premium risk. As a result, the weighted averages distort patterns by size and diversification that apply to most companies.

Therefore, "All" in Table 2-5, 6.4%, differs from the average in Table 2-1, 6.9%, which is weighted by ACL value.

Tables 2-3 and 2-4 show average effect weighted by premium/reserves, within each cell, so "All" in Tables 2-3 and 2-4 agree with the average in Table 2-1.

These tables show the following:

- The effect of the change in MDC is zero for monoline companies (diversification band 0) and largest for companies with diversification level 5.
- The impact of the change in MDC is greater for reserve risk than for premium risk.
- In total, the row "All," larger companies tend to be more diversified, hence see greater ACL reductions.

Based on past practices, we note that the NAIC might provide additional analysis of MDC impact after evaluating this report; for example, the extent to which there are changes in the number of companies below the various RBC action levels or the distribution of companies with capital at specific multiples of CAL.

3. SUMMARY – APPROACH, KEY FINDINGS, AND SENSITIVITY TESTS

The CoMaxLine% approach assumes:

- The MDC, which determines the total diversification credit arising from the RBC Formula, is 30%, and
- Diversification credit by company is proportional to 1.0-CoMaxLine%.

In this Section, we summarize our analysis of these CoMaxLine% assumptions. For this summary and in the remainder of this report, we assume the reader has some knowledge of the methods used in Reports 1 and 2.

Approach & Findings

Data (Section 4)

Separately for premium and reserves:

1. We compile all-lines loss ratios (LRs) and reserve runoff ratios (RRRs) for each individual company (or each pool, for companies reporting on a pooled basis, for simplicity, referred to below as a "company," "company/year," or "data point") for each year 1988 to 2017.

   There are approximately 50,000 company/years of data across all years, for each of the premium and reserve data sets.

2. We assign each company to one of five size bands, referred to as A-E, with an equal number of companies in each size band.

   We also assign each company to one of six diversification bands, one monoline and 5 multi-line bands, referred to as 0-5, with an equal number of multi-line companies in each size band.

   Thus, there are 5x6=30 size/diversification cells.

Indicated Diversification Credit (Section 5-Part 1)

3. For each of the 30 size/diversification cells, we calculate the 87.5th percentile Accident Year Underwriting Loss % (AYUL%) and Reserve Runoff Ratios (RRRs) for companies in that cell. We refer to this as the **Observed Risk**.
4. For each of the 30 size/diversification cells, we also calculate the company average (each company counts once, regardless of size[17]) of premium and reserve RBC values (PR0018 and PR0017) before and after diversification, for companies in that cell.[18] We refer to this as the **Modeled Risk**, before or after diversification.

[17] This is consistent with the calibration of Line 4 Factors.

[18] The premium and reserve values in the Modeled Risk are based on the RBC formula with some simplifications: We do not include the IIA, the own-company adjustment, the loss-sensitive contract adjustment, or the growth risk charge. For premium risk, we used a simplified expense calculation. Section 7 describes these simplifications further.

5. The percentage difference between the Observed Risk and the Modeled Risk before diversification[19] is the indicated diversification credit for that cell.
6. For each cell, we calculate the MDC that would produce the indicated diversification credit for that cell, using the CoMaxLine% approach.

   By converting the indicated diversification credit by cell to an indicated MDC, we can compare the indicated MDC across diversification bands.

Overall Indicated MDC (Section 5-Part 1)

7. We calculate the weighted[20] average indicated MDC for the 9 cells: size bands C-E and diversification bands 3-5 that we refer to as cells C3-E5, or just C3-E5. These represent:
   a. 34% of premium company/years and 31% of reserve company/years,
   b. 84% of premium and 74% of reserves.
   c. 96% of the total premium diversification credit and 97% of the reserve diversification credit.[21]

   The resulting indicated MDCs are 45% for premium and 65% for reserves.

Finding 1:
Based on the above analysis, the committee believes that MDCs of 45% for premium and 65% for reserves are reasonable selections and are better supported by the data than the current 30% MDC. We refer to these as the indicated MDCs.

There are reasonable alternative MDC selections, some of which we discuss in the Alternative Indicated MDCs subsection below.

RBC Diversification Credit by Company (Section 5-Part 2 and Appendix 3)

8. We use regression through the origin to test the hypothesis that there is a linear relationship between CoMaxLine% and indicated diversification credit by level of diversification.
9. We reviewed the two 2019 Casualty Actuarial Society (CAS) Dependency and Calibration Working Party (DCWP) reports on alternative diversification formulas.[22]
   a. DCWP considered alternatives to CoMaxLine%, including:
      i. The Correlation Factor approach,

[19] Since the Observed Risk and the Modeled Risk are calibrated to the 87.5th percentile, runoff, safety level, we interpret the result as the 87.5th percentile, runoff, MDC.

[20] Weights are equal to the number of data points in each cell.

[21] Diversification credit measured as a percentage of Modeled Risk that does not reflect IIA, the own-company adjustment or the loss-sensitive contract adjustment.

[22] Report 13 - RBC LOB Diversification: Current RBC Approach vs. Correlation Matrix Approach, CAS E-Forum Winter 2019.

Report 14 - Calibration of LOB Diversification in Underwriting Risk Charges, CAS E-Forum Spring 2019

DCWP work was based on data through December 2010.

ii. The CoMaxLine% approach using LOB risk, rather than LOB premium/serves ("volume"),[23] and

iii. The Herfindahl-Hirschman Index (HHI),[24] rather than CoMaxLine%.

b. DCWP found that alternatives to CoMaxLine%:

i. Do not produce very different results, by company,

ii. Do not indicate greater accuracy, and

iii. Are not theoretically more appropriate in the context of the RBC Formula.[25]

10. The indicated MDCs using the approach outlined above are largely independent[26] of the method of measuring diversification by company.

Therefore, to that extent, the choice of diversification formulas largely affects only the allocation by company and has only a limited effect on the total diversification credit across all companies.

Finding 2:
While the linear relationship between diversification credit and CoMaxLine% is not exact, considering the alternatives, the Committee believes it is a reasonable approximation, especially for more diversified companies.

[23] CoMaxLine%-Risk approach applies the CoMaxLine% framework to LOB risk rather than LOB volume, when calculating the LCF and PCF for a company. For clarity, as needed, we refer to the current implementation as CoMaxLine%-Volume and the alternative as CoMaxLine%-Risk.

For this purpose, LOB reserve risk equals reserve value times reserve risk factor. LOB premium risk equals premium value times premium risk factor plus expenses minus 100%. The PCF and LCF are calculated using LOB-risk rather than LOB-volume. For premium risk, implementation of this method requires expense information by LOB.

[24] HHI equals the sum of the squares of the LOB shares of total. For example, if there is only one LOB, HHI is 1.0, as is the case for the CoMaxLine%. With two lines split 25% and 75% HHI is 0.25^2 plus 0.75^2 or 0.625 compared to the CoMaxLine% of 0.750, i.e., HHI shows more diversification. With three lines split 50%, 25% and 25% HHI is 0.50^2 plus 0.25^2 plus 0.25^2 or 0.375, more diversification than the CoMaxLine% of 0.5. With two lines split 50% and 50% HHI and the CoMaxLine% are both 0.5.

[25] Except that CoMaxLine%-risk may be more appropriate than CoMaxLine%-volume.

[26] The indicated diversification credit from Approach Step 6 depends on the diversification allocation method only to the extent that different methods would assign companies to different diversification bands.

The indicated MDC from Step 7 depends on the extent to which diversification credit varies linearly with the CoMaxLine% diversification metric for the larger/more diversified companies, C3-E5.

DCWP analysis indicates the different methods tend to assign companies to the same bands and produce relatively similar diversification credits, especially for the more diversified companies.

Therefore, we can view the total diversification credit implied by Step 7 as being largely independent of the diversification metric, CoMaxLine%, or otherwise.

Finding 3:
We recommend further research on alternatives to the current RBC diversification approach, particularly the method we refer to as CoMaxLine%-Risk, which measures diversification by risk by LOB rather than dollars of premium/reserve.

Alternative Indicated MDCs

Table 3-1 identifies several other MDC selections that the NAIC could reasonably adopt, based on alternative assumptions.

Table 3-1
Alternative Indicated MDCs

Item	Alternative Method	Indicated MDC	
		Premium	Reserve
1	Base indicated MDC	46%	66%
2	Use Size Adjusted Line 4 Factors	42%	56%
3	Using combined RBC and Annual Statement data to calibrate indicated MDCs	**56%**	59%
4	Using 6-cell averge D3.E5 (Largest)	**50%**	**80%**
5	Using 6-cell average C4.E5 (Most diversified)	**48%**	55%
6	Using 4-cell average D4.E5	**50%**	64%
7	Regression analysis	45%	58%
8	Early years only (1988-2002)	42%	58%
9	Recent years only (2003-2017)	**64%**	**85%**
Yellow= MDC lower than row 1			
Green = MDC higher than row 1			

We discuss these alternatives below and provide further details in Section 6: Sensitivity Analysis. We note that any of these alternatives implies an MDC higher than the current 30%.

Row 1: Base Indicated MDC

Row 1 presented the MDC indicated method outlined above and described in more detail in Section 5.

Row 2: Company-size ("Size Adjusted")

The indicated MDC is sensitive to the fact that company-size is not reflected in Line 4 Factors.

Larger companies exhibit both greater diversification and, independently, a lower indicated risk charge. Therefore, part of the apparent diversification effect can be attributed to size.

Notwithstanding that analysis, we do not "remove" the effect of size from the MDC calibration, as our goal is to produce an MDC reflecting the structure of the RBC Formula, which does not reflect variation in risk charge by company-size.

The NAIC could reasonably make a different choice in the treatment of company-size differences and MDCs.

Row 3: Use RBC Filing Data ("AS+RBC")

The base analysis uses Annual Statement (AS) data for both Two-Year LOBs and Ten-Year LOBs. However, RBC Filing data (RBC data) for Two-Year LOB data has certain advantages relative to AS data.[27]

Working with NAIC personnel, we attempted to match AS company/years with RBC company/years, replacing the AS LOB data point with a higher-maturity RBC data point. This match was only partially successful.[28]

Due to limited access to RBC source data, we rely on AS data for our base indications. The NAIC could reasonably make a different choice.

Rows 4-6: Selected Size/Diversification Cells

The indicated MDC uses 9 cells, C3-E5. There is a significant degree of variability in the indicated MDC from each of those cells, especially for the reserve. Using subsets of those 9 cells produces different indicated MDCs, again, especially for the reserve MDC.

In Section 6, we provide more details on the variation in the indicated MDC by size/diversification band.

Row 7: Regression Analysis

We use regression through the origin to test the hypothesis that there is a linear relationship between CoMaxLine% and indicated diversification credit by level of diversification. The slope of the regression curve represents an indicated MDC.

- For premium, the regression slope is very similar to the average of the 9 cells.
- For reserves, the regression slope is lower than the average of the 9 cells.

Row 8-9: Alternative Time Periods

The base analysis uses AYs 1988-2017 for premium and initial reserve years 1988-2016 for reserves (referred to as "2017 (2016)" below). That covers a range of inflation/interest and underwriting environments, which we believe is appropriate.

[27] In AS data, for Two-Year LOBs, the maximum maturity for LRs and for RRRs is two years, but it is ten years in RBC data. For Two-Year LOBs, the RBC data includes only companies that are subject to RBC, while the AS data includes all companies.

A disadvantage of RBC data is that it does not include Prior Year data for reserve development, while AS data does.

[28] RBC Filing data and AS data have claims at different valuation dates, for the same AY or initial reserve year. Therefore, the RBC Filing data and AS data may be assigned to pools differently, and will not "match." Also, companies in runoff will have reserve data in only the "prior" row of Schedule P. Prior row data is not reported in RBC Filings. Not all companies make RBC filings.

When there was no matching year, we used the AS values for Two-Year LOBs.

When we divide the experience into two equal periods--1988-2002 and 2003-2017 (2016)--the earlier period shows substantially lower MDCs, suggesting greater between-line dependencies than in the more recent period. This might be a statistical fluctuation due to variability in the indicated MDCs[29] and because the more recent data is less mature than the older data.

However, two other features that might contribute to this difference are lower catastrophe activity and higher inflation/interest rates in the earlier period. We discuss these issues further in Section 7.

Summary of Alternative Indicated MDCs

While there is a range of indicated MDCs, any of these alternatives indicates an MDC in excess of 30%, the current MDC.

Issues for Future Research

Interaction of Diversification Credit and IIA (Section 7 and Appendix 2)

The indicated diversification credit is **calibrated** based on LR and RRR data on a **nominal value** (NV) basis, not a present value (PV) basis. However,

- The diversification credit is **applied** to premium/reserve risk on RBC PR0017 and PR0018 Line 13 after application of the IIA, i.e., **PV basis**, and
- If the diversification credit (based on NV analysis) were applied to the risk charge before the IIA (i.e., NV basis), the effect of the diversification credit would be larger, and the RBC value would be smaller.

We discuss this further in Section 7/Additional Considerations and Appendix 2

We have not evaluated this issue sufficiently to recommend a change in the RBC Formula.

Effect of Changes in Interest Rate/Inflation Environment (Section 7)

Report 2 showed that there is an interaction between Line 4 risk factors and interest/inflation rates. To address that interaction, we evaluated indicated risk charges on a present value (PV) basis--Line 4 risk factors and Line 7/8 IIA Factors combined. We separated these into NV Line 4 Factors and IIA Factors, which, combined, produced the target PV risk charges.

In this Report, we calibrate the indicated MDC based on a comparison of NV Observed Risk and NV Modeled Risk. In doing this, we assume that the ratio of PV Observed Risk Value to PV Modeled Risk Value is comparable to the corresponding NV ratios.

We discuss this assumption further in Section 7.

[29] Looking across the 9 cells, C3-E5, variability is large. The values for early-year and later-year indicated MDCs are within one standard deviation of the all-year indicated MDC for reserve risk. See Table 5-2 A and B for values of the standard deviation.

Finding 4:
The treatment of the IIA/Diversification interaction and the effect of a fully PV analysis are matters for future research.

Other Areas of Future Research

There are other areas of future research that we identify in this Report. We list those in Finding 5, below.

Finding 5:
Other areas of future research for dependency analyses that we identify in this Report are the following:

Calibration net of cats covered by R-Cat
Resolving issues in combining RBC and AS data
Within the CoMaxLine% approach, or any alternative, test square, square root, or other relationships between diversification index and diversification credit, rather than the current linear relationship.

General Considerations:

Ratemaking versus Risk Theory (Appendix 3)

RBC calibration is often understood in the context of risk theory. However, there are limitations to that framework, as outlined below.

Individual Company Capital Model Calibration: Grounded in Risk Theory

In an individual company capital model (ICCM), each LOB has a company-specific risk distribution, reflecting its underwriting, claims, reinsurance, and other practices. These company-specific LOB risk distributions are aggregated using empirically-derived or expert judgment-based correlations.

RBC Calibration: Grounded in Risk Classification

Unlike the ICCM, the RBC Formula is calibrated from, and applies to, a heterogeneous population of insurers. The ICCM risk correlation assumptions do not apply.

Variation in Risk within LOB

Consider Company 1A (writing LOB A), Company 1B (writing LOB B), and Company 2 (writing LOBs A and B). Company 2 is more diversified than either Company 1A or Company 1B. Risk theory suggests that the risk charge for Company 2 should be lower than the sum of the risk charges for Company 1A plus Company 1B, depending on the degree of correlation between the LOBs.

However, that expectation assumes that the risk distributions for LOBs A and B in Companies 1A and 1B are the same as the risk distributions for LOBs A and B in Company 2, respectively.

That assumption is not routinely valid. See Appendix 3 for examples.

Risk Classification Provides a Better Conceptual Framework

Therefore, risk classification and manual ratemaking provide a better framework for reflecting diversification in RBC. Specifically, in the risk classification framework, calibrating dependency

means measuring the extent to which companies writing more LOBs have different indicated all-lines risk charges than companies writing fewer LOBs.[30]

In this Report, diversification calibration means:

- The total credit for diversification is estimated empirically as we present in Tables 5-2A and 5-2B. This measurement is analogous to calculating the statewide indicated rate levels in manual ratemaking.
- Diversification is a "risk characteristic" that can be used to allocate credits across degrees of diversification using a reasonable formula, e.g., CoMaxLine%, CoMaxLine%-Risk, and Correlation Factor. This is analogous to setting territorial rate differentials.
- Not all risk characteristics are used in a particular risk classification system, e.g., company-size is not used.
    - The RBC Formula does not consider risk characteristics like company-size, Type of Company, or variations in LOB sub-segments that are not in the Formula.
    - Instead, the calibration considers aggregates across those risk characteristics.
- The Formula is intended to be reasonable overall, but will not be "exact" for any particular insurer.

Calibration Safety Level (Section 7)

There is no explicit overall safety level target for the CAL level in the P&C RBC Formula. Nonetheless, we understand that the prevailing regulatory view is that the implicit safety level has produced satisfactory results.

The indicated MDCs presented in this report are larger than the MDC in the RBC Formula. This suggests that the current RBC Formula incorporates some conservatism in the underwriting risk elements, relative to the 87.5th percentile/runoff time horizon safety level. Thus, even though the Line 4 Factors are calibrated at the 87.5th percentile, the Line 4 Factors combined with the conservative MDCs produced a safety level higher than the 87.5th percentile.

To maintain a satisfactory overall safety level for CAL, adopting a significant change to any element of the RBC Formula should include an assessment, possibly on a judgment basis, of whether the resulting overall impact on the safety level is appropriate, and then to what extent a reduction (or increase) in one area might indicate a corresponding increase (or decrease) in another area to achieve the desired overall level.[31]

[30] More precisely, we measure diversification using CoMaxLine%, but that correlates to the number of LOBs written.

[31] Since the implementation of the RBC Formula there have been changes that have increased the implied safety level (e.g., RCAT set at the 1-in-100 safety level and the addition of the operational risk charge at 3% of RBC). There have also been changes that decreased the implied safety level (e.g., reduced fixed income risk charges for assets and reduced reinsurance credit risk charges).

Specifically, adopting the indicated MDC in the RBC Formula reduces the safety level for R4 and R5, and therefore CAL.

We do not measure the impact of adopting the indicated MDCs on R4, R5, or CAL safety levels, nor do we determine whether the total ACL is appropriate for regulatory purposes. That is beyond the scope of this Report.

4. DATA

For our analysis of the RBC diversification formula, we construct all-lines data points for each available company (pool)/year.[32,33] Each point represents either a premium or a reserve risk observation, i.e., a premium amount and LR or an initial reserve amount and RRR. Following the data treatment in Reports 1 and 2, we combine the data for multiple companies that pool their experience into a single "pooled" data point.

- For premium risk, the all-lines net earned premium (NEP) for each company-AY data point is the sum of the NEP across all LOBs in the risk dataset.

  For each company-AY, the all-lines loss ratio (LR) is the NEP-weighted average of LRs by LOB.

- For reserve risk, the all-lines initial reserve for each company-initial reserve date is the sum of the initial reserves across all LOBs in the reserve risk dataset.

  For each company-initial reserve date, the reserve risk is the all-lines average reserve runoff ratio (RRR) weighted by the initial reserves of each LOB.

There are approximately 50,000 all-lines data points each for premium risk and for reserve risk, totaling roughly 100,000 data points. We classify each data point by company-size and diversification as described below.

Company Size Bands

For each data point, i.e., each company/year, we measure size using either all-lines NEP (for premium risk) or all-lines initial reserve (for reserve risk). We assign each data point to one of five company-size bands, such that 20% of the data points fall into each. We label these company-size bands A (smallest) through E (largest).[34]

Company Diversification Bands

Separately for premium and reserves, for each company/year, we define the diversification index as 1.0-CoMaxLine%.[35] We assign each data point to one of six diversification bands:

[32] Our risk data includes AYs 1988-2017 and initial reserve years 1988-2016. from Annual Statements 1997-2017.

Unlike the data in Reports 1 and 2, our data for this analysis includes Minor Lines, and "new" LOBs, i.e., LOB-age<5. LOB data can be zero or negative, but we exclude data points with negative total premium or initial reserve. Following the RBC Formula, we calculate the CoMaxLine% using zero for negative LOB premium or reserves values.

[33] We assume the reader is familiar with the methods, data, and conclusions presented in the Committee's April 2021 and August 2023 Reports, to the extent that provides the basis for the risk data we use in this analysis.

[34] Band A includes companies with premium/reserves at percentiles greater than or equal to 0% and less than 20%. Band B includes companies with premium/reserves at percentiles greater than or equal to 20% and less than 40%. Similarly for bands C and D. Band E includes companies with premium/reserves at percentiles greater than or equal to 80%, including 100%, the" largest" data point.

[35] A company with 25% of its business in the largest line has a diversification index of 75% (100% - 25%). A monoline company, with 100% of business in the largest (and only) LOB has diversification index of 100% minus 100% or zero.

- Band "0" contains company/years with a zero diversification index, which are considered monoline companies.[36]
- Bands 1-5 are five levels of diversification, each with 20% of the remaining (non-monoline) companies.[37]

Number of All-Lines Data Points by Size and Diversification

Tables 4-1A and 4-1B, below, show the number of data points by company-size and diversification band, for premium risk and reserve risk, respectively.

Table 4-1A
Premium
Number of Data Points by Company Size/Diversification Band

Div	Size Band					
Band	A	B	C	D	E	Total
0	5,067	3,303	2,003	1,393	1,065	12,831
1	1,509	1,728	2,017	1,637	1,013	7,904
2	1,478	1,717	1,804	1,812	1,091	7,902
3	1,318	1,605	1,752	1,801	1,426	7,902
4	878	1,496	1,703	1,789	2,036	7,902
5	219	619	1,189	2,037	3,838	7,902
Total	10,469	10,468	10,468	10,469	10,469	52,343

Table 4-1B
Reserve
Number of Data Points by Company Size/Diversification Band

Div	Size Band					
Band	A	B	C	D	E	Total
0	5,337	3,216	2,520	1,562	1,083	13,718
1	961	1,623	1,809	1,891	1,102	7,386
2	1,201	1,568	1,556	1,530	1,526	7,381
3	1,284	1,568	1,540	1,485	1,507	7,384
4	1,035	1,327	1,471	1,749	1,802	7,384
5	313	822	1,231	1,910	3,108	7,384
Total	10,131	10,124	10,127	10,127	10,128	50,637

[36] For our purpose, monoline means only one LOB has a premium/reserve greater than zero. Thus, band zero includes companies where one or more LOBs have negative premium/reserves and but only one LOB has positive premium/reserves.

[37] We define diversification bands 1-5 in the same way as for size bands, as described in footnote 34.

In these tables, we observe:

- Roughly 13,000 premium and reserve data points are classified as monoline (Div=0), representing 25% of the premium and 27% of the reserve data points.[38] This reflects that data points are individual company/years or pool/years, but not company group/years.
- Monoline companies (Div Band 0) tend to be smaller.
- The most diversified companies, in the row Div Band=5, tend to be larger.
- Nonetheless, even the largest size (band E) includes companies across all diversification levels.
- Almost all size-diversification cells include more than 1,000 data points.

All-Lines Risk Data – Premium/Reserves – by Size and Diversification

Tables 4-2A and 4-2B, below, show NEP and initial reserves by company size/diversification. These tables highlight that both premium and reserve volumes are heavily concentrated in the largest and most diversified segments.

Size Band E

- Over 90% of the premium and reserve volume falls in size band E.
- Over 39%of the total NEP/reserves are in cell E5 (largest size/most diversified)

Size/Diversification Bands C3-E5

- For premium, cells C3-E5 include 34% of companies and 84% of premium.
- For reserves, cells C3-E5 include 31% of companies and 74% of initial reserves.

Table 4-2A
Premium Volume Data[39]
NEP ($millions) by Company Size/Diversification Band

Div	Size Band					
Band	A	B	C	D	E	Total
0	3,205	12,809	26,281	69,325	437,778	549,398
1	1,146	6,944	26,962	77,997	356,626	469,676
2	1,080	6,918	24,826	90,416	714,390	837,630
3	968	6,484	24,603	88,998	1,823,068	1,944,122
4	735	5,937	23,388	87,751	2,174,754	2,292,566
5	211	2,677	16,676	109,209	5,162,054	5,290,827
Total	7,345	41,769	142,736	523,698	10,668,670	11,384,217

[38] 12,831 of 52,343 data points for premium and 13,718 of 50,637 data points for reserves.

[39] This total excludes data points with zero all-lines premium. These totals treats negative premium by LOB as zero premium.

Table 4-2B[40]
Reserve Volume Data
Initial Reserve ($millions) by Company Size/Diversification Band

Div	Size Band					
Band	A	B	C	D	E	Total
0	1,375	8,293	25,860	68,771	1,263,400	1,367,699
1	369	4,535	19,594	86,164	604,874	715,535
2	457	4,122	17,284	71,169	1,469,595	1,562,626
3	473	4,177	17,139	67,627	1,502,865	1,592,280
4	392	3,467	16,424	78,303	3,049,031	3,147,617
5	140	2,308	13,847	93,964	5,559,384	5,669,643
Total	3,205	26,901	110,147	465,999	13,449,149	14,055,402

Dollars of Diversification Credit – by Size and Diversification

Table 4-3A (Premium) and 2-3B (Reserves), below, present the dollar value of diversification credits under the current RBC Formula with the current 30% MDC, before application of the IIA.[41] The data show:

- Companies in cells C3-E5 receive 96% of the total premium diversification credit and 97% of the reserve diversification credit,[42]
- Cell E5 alone accounts for more than 60% of the total diversification credit.[43]

Because the impact is so heavily concentrated in cells C3-E5, we focus on these 9 cells when estimating the indicated MDC.

Table 4-3A
Dollars ($millions) of Diversification Credit (Premium)
Total Premium Diversification Credit by Company Size/Diversification Band

Div	Size					
Band	A	B	C	D	E	Total
0	0	0	0	0	0	0
1	6	34	135	469	1,556	2,199
2	18	122	418	1,611	11,239	13,408
3	23	174	621	2,360	41,441	44,619
4	25	207	807	3,103	74,330	78,472
5	9	116	716	4,858	252,685	258,384
Total	81	652	2,696	12,402	381,251	397,082

[40] This total excludes data points with zero all-lines reserves. This total treat negative reserves by LOB as zero reserves.

[41] This is calculated as Modeled Risk before diversification minus Modeled Risk after diversification, where those values are defined in Section 5.

[42] 380,921/397,082 = 96% for premium and 748,817/773356 = 97% for reserves.

[43] 252,685/397,082 = 64% for premium and 477,306/773356 = 62% for reserves

Table 4-3B
Dollars ($millions) of Diversification Credit (Reserves)
Total Reserve Diversification Credit by Company Size/Diversification Band

Div	Size Band					
Band	A	B	C	D	E	Total
0	0	0	0	0	0	0
1	1	15	66	306	2,333	2,720
2	7	62	255	1,113	19,873	21,309
3	15	136	573	2,403	61,775	64,902
4	19	176	863	4,417	193,565	199,039
5	10	155	1,026	6,889	477,306	485,385
Total	51	544	2,782	15,128	754,851	773,356

5. ANALYSIS OF LCF/PCFS

In this Section, we evaluate the following key assumptions of the RBC diversification approach:

- The 30% MDC
- The assumption that diversification credit is proportional to CoMaxLine%

Part 1 -Indicated MDC

We calculate the indicated MDC for each size/diversification band using the observed and modeled risk ratios and CoMaxLine% values corresponding to those segments. We define these terms below.

Observed Risk Ratio (Diversified)

Premium

For premium risk, for each company/year, we define the Observed AY Underwriting Gain/Loss (Observed AYUL$ in dollars and Observed AYUL%, as a percentage of premium) as the all-lines average LR plus company expense ratio minus 100%.

The LR is the NEP-weighted average LR by LOB for each company/year. The expense ratio is the industry average expense ratio by LOB, weighted by the company/year net earned premium by LOB.

For each size/diversification band or combination of bands, the observed risk ratio is the 87.5th percentile Observed AYUL% across data points within each size/diversification band.[44]

Reserves

For reserves, for each size/diversification band or combination of bands, the observed risk ratio is the 87.5th percentile RRR across data points within each size/diversification band.

Calculation Notes

Note that for each company/year premium or reserve data point, the observed risk ratio inherently reflects diversification across the LOBs.

When calculating observed risk, within a particular size/diversification band, or a combination of bands, we assign each data point equal weight, regardless of premium or reserve volume.

Modeled Risk Ratio Before Diversification

We calculate the Modeled Premium Risk and Modeled Reserve Risk using the RBC Formula applied to the LOB premium and reserve values for each data point.

Premium:

For each company/year, we calculated the Modeled Risk as follows:

[44] The premium and reserve risk factors adopted by the NAIC (Line 4 of the RBC Formula) are based on the 87.5th percentile safety level for the RBC CAL. We calibrate the LCF/PCF to the same safety level. The diversification relationship might be different if the safety level were a different value, e.g., the 90th percentile. We have not calculated the MDC at the 90th percentile safety level.

- The all-lines average premium risk factor is the NEP-weighted average of the LOB-specific premium risk factors.
- The company expense ratio is the average industry expense ratio by LOB, weighted by the company/year net earned premium by LOB.
- The Modeled Risk before diversification is the all-lines average premium risk factor, plus the company expense ratio minus 100%.

The overall Modeled Risk before diversification, as a percentage of premium, is the unweighted average of the company/year Premium Modeled Risk values within each size/diversification band or combination of bands.

Reserve:

Similarly, for each company/year, the all-lines average reserve risk charge is the average of the LOB reserve risk factors weighted by the company/year initial reserve by LOB.

The overall all-lines reserve risk charge before diversification, as a percentage of reserves, is the unweighted average of the company/year Reserve Modeled Risk percentages within each size/diversification band or combination of bands.

Modeled Risk Calculation Simplifications

These modeled risk calculations reflect several simplifications relative to the full RBC Formula.

- First, we evaluate experience on an undiscounted (nominal value, or NV) basis rather than the present value (PV) basis used in Report 2, and, accordingly, we do not apply the investment income offset in the modeled risk calculation.[45]
- Second, we do not apply the own-company adjustment factor, the loss-sensitive contract adjustment factor, or the growth risk charge.[46]
- Third, for company expenses, we use the average of the industry average expense ratio (2017) by LOB, weighted by the company-specific premium by LOB, rather than the company's own all-lines expense ratio.[47]
- Also, we use NEP in place of NWP.

Calculation of MDC – "D5" Companies

Table 5-1, below, presents the calculation of the indicated MDC for companies in Size Band "D" (60th to 80th percentile of size) and Diversification Band "5" (80th to 100th percentile of multi-line diversification).

[45] We discuss the PV/NV treatment in more detail in Section 7.

[46] We have not tested the effect of these simplifications. That said, we note, however, that the effect of including growth risk charge would increase the Modeled Risk and therefore likely increase the indicated MDCs. The effect of the own-company adjustments could be to increase or decrease the Modeled MDCs. In Section 5 we discuss the interaction of the IIA and implementation of the diversification credit.

[47] In the Sensitivity Section, below, we discuss the effect of some of this assumption.

Table 5-1
Sample Calculation of Indicated MDC
Size Band D/Diversification Band 5

	(1)	(2)	(3)
#	Item	Premium	Reserves
1	Observed Risk - 87.5th Percentile	15.8%	25.9%
2	Modeled Risk - 87.5th Percentile before diversification credit	21.0%	38.0%
3	Indicated Diversification Credit[1.0-(1)/(2)]%	25.0%	32.0%
4	Average Diversification Credit(Current Formula)	21.0%	19.2%
5	Indicated Maximum Credit [(3)/(4)]*30%	36%	50%

We display rounded values, but we calculate with unrounded values. Therefore, calculations using the rounded values shown may not exactly reproduce the displayed rounded results.

This applies to all Tables and Exhibits in this Report.

These calculations are as follows:

- Row 1 is the observed risk ratio equal to the 87.5th percentile AYUL% and RRR.
- Row 2 is the modeled risk ratio, before diversification, from the RBC Formula.
- Row 3 is the indicated diversification credit calculated from rows 1 and 2 as shown in row 3.
- Row 4 is the average diversification credit for this size/diversification band produced by the current RBC Formula (which reflects the current 30% MDC).
- Row 5 is the indicated MDC, calculated as shown on row 5.

Because the modeled risk before diversification (row 2) exceeds the observed diversified risk (row 1), some diversification credit is warranted. Row 3 shows indicated diversification credits of 25.0% for premium and 32.0% for reserves. These represent the level of credit that reconciles modeled risk with the observed risk.

Row 4 represents the diversification credit, utilizing the current 30% MDC. Since row 3 exceeds row 4, the indicated MDC is higher than 30%.

Row 5 shows that the indicated MDCs are 36% and 50%, which are higher than the current 30%.

Accordingly, the diversification formulas indicated for this cell would become:

- PCF = 64% plus 36% * CoMaxLine%$_{premium}$
- LCF = 50% plus 50% * CoMaxLine%$_{reserve,}$

where 36% and 50% replace the 30% MDC in the current RBC Formula.

Calculation of MDC – 30 Segments

Tables 5-2A and 5-2B, below, extend the Table 5-1 framework to each of the 30 size/diversification segments and sub-totals.

Table 5-2A Premium
Indicated MDC by Size/Diversification (5x6 Analysis)

Divers Band Quintiles	Observed Risk (Part 1) Size Band Quintiles A	B	C	D	E	AllSize > 20%
0	70%	32%	26%	27%	39%	31%
1	67%	27%	29%	25%	28%	27%
2	48%	26%	22%	18%	18%	20%
3	52%	21%	18%	18%	16%	18%
4	45%	18%	16%	16%	14%	16%
5	83%	24%	15%	16%	14%	15%
All	62%	26%	22%	19%	18%	21%
All ex 0	57%	24%	21%	18%	16%	19%
	C3-E5 Unweighted	16.0%	Weighted	15.7%		

Divers Band Quintiles	Modeled Risk No Diversification (Part 2) Size Band Quintiles A	B	C	D	E	AllSize > 20%
-	31%	32%	36%	46%	63%	40%
1	25%	27%	29%	32%	35%	30%
2	21%	23%	22%	23%	23%	23%
3	19%	21%	20%	21%	22%	21%
4	22%	21%	21%	21%	22%	22%
5	22%	21%	21%	21%	22%	22%
All	26%	26%	25%	27%	28%	26%
All ex 0	22%	23%	23%	23%	24%	23%
	C3-E5 Unweighted	21.3%	Weighted	21.4%		

Divers Band Quintiles	Indicated Diversification Credit (Part 3) Size Band Quintiles A	B	C	D	E	AllSize > 20%
0	-128%	1%	28%	42%	38%	23%
1	-173%	2%	-1%	21%	22%	11%
2	-130%	-16%	1%	23%	23%	9%
3	-168%	1%	11%	14%	28%	15%
4	-109%	15%	23%	24%	37%	27%
5	-277%	-16%	26%	25%	37%	29%
All	-139%	0%	15%	29%	35%	22%
All ex 0	-160%	-2%	11%	24%	34%	20%
	C3-E5 Unweighted	25.0%	Weighted	26.5%		

(Part 3) = 1 - (Part 1)/(Part 2)

Divers Band Quintiles	Calculated Diversificaiton Credit (Part 4) Size Band Quintiles A	B	C	D	E	AllSize > 20%
0%	0%	0%	0%	0%	0%	0%
1	2%	2%	2%	2%	2%	2%
2	8%	8%	8%	8%	8%	8%
3	12%	12%	12%	13%	13%	13%
4	16%	16%	16%	16%	17%	16%
5	20%	21%	21%	21%	22%	21%
All	5%	7%	9%	11%	14%	10%
All ex 0	9%	10%	11%	12%	15%	12%
	C3-E5 Unweighted	16.6%	Weighted	17.2%		

(Part 4) = Diversification Credit Calculated (Current RBC)

Divers Band Quintiles	Indicated Max Diversification Credit (Part 5) Size Band Quintiles A	B	C	D	E	AllSize > 20%
0						
1	-2614%	26%	-17%	328%	348%	178%
2	-500%	-63%	2%	86%	87%	35%
3	-405%	3%	28%	33%	68%	35%
4	-206%	28%	42%	44%	67%	50%
5	-413%	-23%	38%	36%	52%	41%
All	-890%	0%	51%	80%	76%	66%
All ex 0	-528%	-5%	30%	58%	66%	48%
	C3-E5 Unweighted	45.1%	Weighted	45.9%		
	StdDev	13.5%	StdDev	12.9%		

(Part 5) = 0.30 * (Part 3)/(Part 4)

Notes: See Notes to Table 5-2B

Each table includes the following:

- Parts 1-5 in this Table are analogous to rows 1-5 in Table 5-1.
- Part 1 – Each cell is the 87.5th percentile AYUL% or RRR for all data points in that cell. We refer to this as Observed Risk
- Parts 2 and 4 – Each cell is the average of modeled risk (before diversification) and diversification credit, respectively, for all data points in the cell; each point counts equally.
- Parts 3 and 5 – Indicated Diversification Credit and Indicated MDC, calculated using the formulas shown in the Table at the bottom of each of those Parts.
- The label "C3-E5 unweighted" means the simple average of the 9 cells, C3 to E5.

- The label "C3-E5 weighted" means average of the values in the 9 cells, C3 to E5, weighted by the number of company/year data points per cell (see Tables 2-1A and 2-1B for the number of data points by cell).
- StdDev, at the bottom of Part 5, is the standard deviation for the 9 cells C3-E5.
    - Unweighted means each of the 9 cells is weighted equally.
    - Weighted means each of the 9 cells has a weight equal to the number of company/years in that cell.

Table 5-2B Reserves
Indicated MDC by Size/Diversification (5x6 Analysis)

Divers Band	Observed Risk (Part 1) Size Band Quintiles					
Quintiles	A	B	C	D	E	AllSize > 20%
0	58%	41%	28%	25%	18%	29%
1	50%	53%	24%	23%	15%	27%
2	53%	42%	28%	21%	13%	25%
3	57%	41%	31%	25%	18%	28%
4	49%	42%	33%	27%	25%	30%
5	75%	36%	30%	26%	25%	27%
All	56%	43%	28%	25%	21%	28%
All ex 0	54%	43%	29%	25%	21%	27%
	C3-E5 Unweighted	26.7%	Weighted	26.4%		

Divers Band	Modeled Risk No Diversification (Part 2) Size Band Quintiles					
Quintiles	A	B	C	D	E	AllSize > 20%
0	33%	35%	36%	37%	31%	35%
1	29%	29%	29%	30%	31%	29%
2	29%	31%	30%	32%	31%	31%
3	32%	33%	34%	36%	39%	36%
4	34%	35%	37%	38%	42%	38%
5	37%	36%	39%	38%	42%	40%
All	32%	33%	34%	35%	37%	35%
All ex 0	32%	32%	33%	35%	38%	35%
	C3-E5 Unweighted	38.3%	Weighted	38.7%		

Divers Band	Indicated Diversification Credit (Part 3) Size Band Quintiles					
Quintiles	A	B	C	D	E	AllSize > 20%
0	-75%	-16%	22%	34%	44%	17%
1	-74%	-83%	16%	24%	50%	7%
2	-81%	-37%	7%	34%	58%	20%
3	-75%	-24%	8%	31%	53%	22%
4	-42%	-17%	10%	31%	39%	22%
5	-100%	-1%	23%	32%	40%	32%
All	-73%	-28%	17%	30%	44%	21%
All ex 0	-71%	-33%	14%	29%	45%	21%
	C3-E5 Unweighted	29.8%	Weighted	31.2%		
(Part 3) = 1 - (Part 1)/(Part 2)						

Divers Band	Calculated Concentration Ratio (Part 4) Size Band Quintiles					
Quintiles	A	B	C	D	E	AllSize > 20%
0	0%	0%	0%	0%	0%	0%
1	1%	1%	1%	1%	1%	1%
2	5%	5%	5%	5%	5%	5%
3	10%	10%	10%	10%	10%	10%
4	14%	14%	14%	14%	14%	14%
5	18%	19%	19%	19%	20%	19%
All	4%	6%	7%	8%	11%	8%
All ex 0	8%	9%	9%	10%	12%	10%
	C3-E5 Unweighted	14.5%	Weighted	15.0%		
(Part 4) = 1 - Diversification Credit Calculated (Current RBC)						

Divers Band	Indicated Max Diversification Credit (Part 5) Size Band Quintiles					
Quintiles	A	B	C	D	E	AllSize > 20%
0						
1	-1739%	-2109%	394%	628%	1190%	174%
2	-491%	-229%	43%	215%	367%	124%
3	-232%	-73%	26%	96%	160%	67%
4	-91%	-36%	22%	64%	83%	45%
5	-165%	-2%	36%	50%	61%	50%
All	-554%	-145%	73%	107%	121%	78%
All ex 0	-256%	-117%	47%	88%	109%	64%
	C3-E5 Unweighted	66.5%	Weighted	66.3%		
	StdDev	40.5%	StdDev	37.5%		
(Part 5) = 0.30 * (Part 3)/(Part 4)						

Findings from Tables 5-2A and 5-2B

Table 5-3, below, is a copy of Part 5 of Tables 5-2A and 5-2B, which shows the indicated MDCs, by cell.

If the relationship between diversification credit and CoMaxLine% were perfectly linear, then the values in Table 5-3 would show no clear trend as you move across diversification bands. If there were also no random variation, all the values in Part 5 would be identical regardless of company-size and diversification band.

Also, with those assumptions, if the appropriate MDC were 30%, then all the indicated MDC values in Part 5 would be approximately 30%.

Instead, there is substantial variability in the indicated MDC among 30 size/diversification bands, which we discuss below.

Table 5-3
Indicated MDC by Size Diversification Band

Premium

Divers Band	Indicated Max Diversification Credit (Part 5) Size Band Quintiles					AllSize
Quintiles	A	B	C	D	E	> 20%
0						
1	-2614%	26%	-17%	328%	348%	178%
2	-500%	-63%	2%	86%	87%	35%
3	-405%	3%	28%	33%	68%	35%
4	-206%	28%	42%	44%	67%	50%
5	-413%	-23%	38%	36%	52%	41%
All	-890%	0%	51%	80%	76%	66%
All ex 0	-528%	-5%	30%	58%	66%	48%
	C3-E5 Unweighted	45.1%	Weighted	45.9%		
	StdDev	13.5%	StdDev	12.9%		

Reserves

Divers Band	Indicated Max Diversification Credit (Part 5) Size Band Quintiles					AllSize
Quintiles	A	B	C	D	E	> 20%
0						
1	-1739%	-2109%	394%	628%	1190%	174%
2	-491%	-229%	43%	215%	367%	124%
3	-232%	-73%	26%	96%	160%	67%
4	-91%	-36%	22%	64%	83%	45%
5	-165%	-2%	36%	50%	61%	50%
All	-554%	-145%	73%	107%	121%	78%
All ex 0	-256%	-117%	47%	88%	109%	64%
	C3-E5 Unweighted	66.5%	Weighted	66.3%		
	StdDev	40.5%	StdDev	37.5%		

Smaller companies (Size bands A and B)[48]

For these companies, the indicated MDCs are generally negative, implying a diversification surcharge, rather than credit.

We understand this to be because the indicated risk charge for small companies is higher than the Line 4 Factors in the RBC Formula.

In Appendix 1, we examine the relationship between company-size and Line 4 risk factors.

Low Diversification Bands – Diversification Bands 1-2)/Company Sizes C-E

For these companies, the indicated MDCs are generally high.

[48] As we noted, the Modeled Risk before Diversification is based on certain simplifications. In particular, it does not reflect the own-company adjustment or the growth risk adjustment. If Modeled Risk had included those elements of the RBC Formula the differences between companies by size and diversification might have been reduced. That adjustment was outside the scope of our work.

Low diversification, bands 1-2, means the company specializes in a small number of LOBs. The CAS Dependency and Calibration Working Party (DCWP) Report 8, *Differences in Premium Risk charge by Type of Company*,[49] showed that specialist companies[50] have lower than average Line 4 charges for their primary LOBs.

The favorable effect of "specialization" is not reflected in the RBC Line 4 Factors. Therefore, it appears in this analysis as an indicated increase in diversification credit as evidenced by a higher indicated MDC. An examination of the benefit of specialization is outside the scope of this project, and we do not use the experience of the low diversification bands in the indicated MDC.

Larger/more diversified companies – Cells C3-E5

Table 5-3, above, shows the range of values for these cells:

- Premium: Indicated MDCs range from 28% (C3) to 68% (E3); average >45%.
- Reserves: Indicated MDCs range from 22% (C3) to 160% (E3); average >65%.

It also shows the standard deviation across the 9 cells:

- For premium, the standard deviation is 12.9%, compared to the mean of 45.9%, a coefficient of variation of 30%.

  For reserves, the standard deviation is 37.5%, compared to the mean of 66.3%, a coefficient of variation of 57%.

Thus, there is notable variability within that range.

One factor contributing to variability is company-size. In Appendix 1, we calculate the indicated MDCs with risk factors that vary with company-size. The variability after that adjustment is reduced, as follows:

- For premium, the standard deviation is 6.1%, compared to the mean of 42.0%, a coefficient of variation of 15%.
- For reserves, the standard deviation is 25.2%, compared to the mean of 56.2%, a coefficient of variation of 45%.

MDC Indication

The variability, even after the size adjustment, suggests that there are many factors contributing to the differences between companies with increased diversification by LOB.

This makes the selection of the MDC less clear-cut than might be desirable.

[49] Casualty Actuarial Society E-Forum, Spring 2014 1 Risk-Based Capital (RBC) Premium Risk Charges—Differences in Premium Risk Charge by Type of Company.

[50] "Specialist" companies were defined as those with more than 50% of premium in business categories such as "personal," "medical professional," "workers compensation," "reinsurance," etc.

We base our final indicated MDC on the average value in cells C3–E5 (highlighted in yellow). While these nine cells account for only about 34% of premium and 31% of reserve data points, they cover:

- 84% of total premium
- 74% of total reserves
- 95% of total premium diversification credit
- 96% of total reserve diversification credit

Thus, these cells represent the companies with the bulk of policyholders and claims exposure, making them the most relevant for setting diversification parameters.

Most cells in the C3-E5 group imply an MDC higher than the current 30%.

Part 2 – Diversification Credit by Company – Regression Analysis

Tables 5-4 and 5-5, below, use regression through the origin to test the assumption that diversification is linear with respect to CoMaxLine%. This regression analysis also provides a further test of the indicated MDC.

In that regression:

- We use regression through the origin because a diversification formula should yield zero credit when there is zero diversification.
- We apply the regression to data from cells C3-E5, excluding company-sizes A and B and diversifications bands 0-2 for the reasons explained previously.

The regression data in Table 5-4 is as follows:

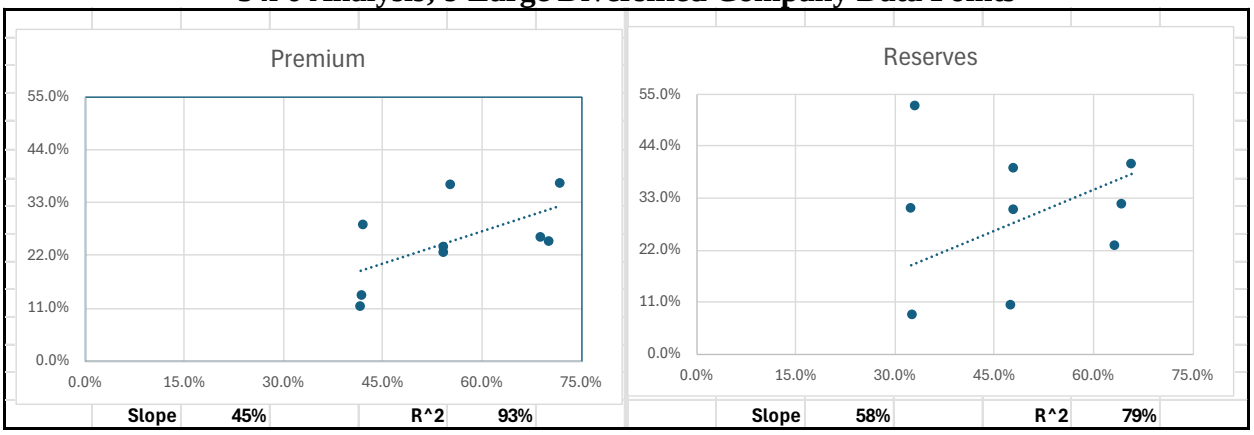
- Columns 1 & 4: Average diversification index for premium and reserve risk, respectively (from Table 5-2A/B, Part 4 divided by 30%).
- Columns 2 & 5: Indicated diversification credit (from Part 3 of Tables 5-2A and 5-2B).
- Columns 3 & 6: Fitted diversification credit, derived from the regression through the origin applied to the prior columns.

Table 5-4
Large Diversified Companies
Graphical Analysis of CoMaxLine% Element of Diversification Formula
5 x 6 Analysis; 9 Large Diversified Company Data Points

		Premium			Reserves		
		(1)	(2)	(3)	(4)	(5)	(6)
Size Band	Div Band	Average Div Index	Indicated Div Credit	Fitted Div Credit	Average Div Index	Indicated Div Credit	Fitted Div Credit
C	3	41.6%	11.5%	18.7%	32.5%	8.3%	18.9%
D	3	41.8%	13.8%	18.8%	32.4%	31.0%	18.8%
E	3	42.0%	28.5%	18.9%	32.9%	52.7%	19.1%
C	4	54.2%	22.6%	24.3%	47.5%	10.5%	27.5%
D	4	54.1%	23.9%	24.3%	47.9%	30.8%	27.8%
E	4	55.1%	36.9%	24.8%	47.7%	39.4%	27.7%
C	5	68.7%	25.9%	30.9%	63.2%	23.0%	36.6%
D	5	70.1%	25.0%	31.5%	64.1%	32.0%	37.2%
E	5	71.7%	37.2%	32.2%	65.7%	40.2%	38.1%

Table 5-5, below, shows Table 5-4 graphically.

Table 5-5
Large Diversified Companies
Graphical Analysis of CoMaxLine% Element of Diversification Formula
5 x 6 Analysis; 9 Large Diversified Company Data Points



In Table 5-5:

- The X-axis represents the average diversification index (Table 5-4 columns 1 and 4).
- The Y-axis represents the indicated diversification credit (Table 5-4 columns 2 and 5)
- The slope of the fitted line is 45% for premiums and 58% for reserves.

The regression "R-squared" values[51] are:

- 93% for premium, and
- 79% for reserves.

This regression analysis evaluates the assumption that diversification is proportional to the CoMaxLine% parameter. The "R-squared" metrics suggest that the proportionality assumption is reasonable, albeit with more variability for reserves than for premiums.

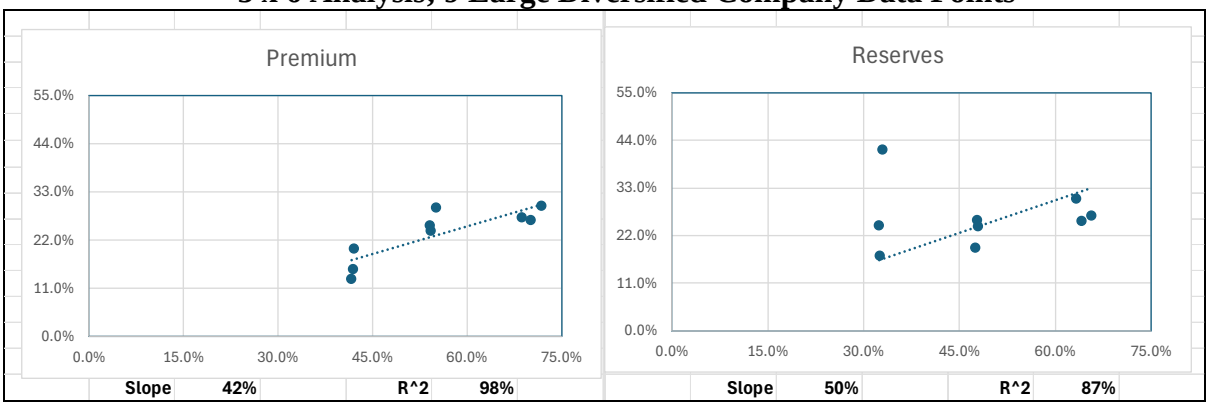
The slopes serve as alternative estimates of the premium and reserve indicated MDCs.

- The premium slope, 45% is essentially the same as the C3-E5 average in Table 5-2A.
- The reserve slope, 58% is not as close to the C3-E5 average, 66%, as the premium slope. In light of the higher variability in the reserve risk regression, our reserve MDC indication is based on the C3-E5 average in Table 5-2B.

Analysis after size adjustment

In Section 6/Sensitivity Analysis, and Appendix 1/Size-Adjusted Indicated MDC, we observe that company-size contributes to both the indicated MDC and the variation in indicated MDC by size/diversification cell. Table 5-6, a copy of Appendix 1-Exhibit A1-4, shows the size-adjusted equivalent of Table 5-5.

Table 5-6
(Copy of Appendix 1 – Exhibit A1-4)
Large Diversified Companies (with Size-Adjusted Risk Factors)
Graphical Analysis of CoMaxLine% Element of Diversification Formula
5 x 6 Analysis; 9 Large Diversified Company Data Points



[51]The R-squared statistic is calculated by Excel regression in Excel data pack. The Excel formula for R-squared for regression through the origin is different from the R-squared formula used for OLS regression. Regression through the Origin by Joseph G Eisenhauer.

Removing the company-size effect improves the quality of the regression. Table 5-6 shows the adjusted regression "R-squared" values:

- 98% for premium and
- 87% for reserves.

This improvement in regression results contributes to the Committee's view that using a linear relationship between CoMaxLine% and diversification credit is reasonable.[52]

[52] There is limited data (nine points) and high variability by size within diversification levels. Therefore, we have not tested the extent to which a non-linear relationship, such as a square or square root relationship between diversification level and diversification credit, might better match the experience.

6. SENSITIVITY ANALYSIS

Alternative Indicated MDCs and Sensitivity Tests

In this Section, we evaluate how changes in assumptions affect the indicated MDC.

Table 6-1, row 1, columns 7 and 8, shows the indicated MDCs that we develop in Section 5, 46% for premium risk and 66% for reserve risk. Rows 2-16, columns 7 and 8, show the indicated MDCs based on the alternative assumptions briefly listed in column 2.

We discuss each of the alternatives in the material following Table 6-1.

Table 6-1 – Alternatives and Sensitivity Analysis
Summary of Indicated Maximum Diversification Charges

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
						Indicated MDC	
Row #	Label	Size/Div Cells	Segments	Data-AS/RBC	Expense Data	Premium	Reserves
1	Base indicated MDC	Wtd C3.E5	5x6	AS only	Industry	46%	66%
1.1	Unweighted Indicated MDC	UnWtd C3.E5	5x6	AS only	Industry	45%	66%
2	Size Adjusted Line 4 Factors	Wtd C3.E5	5x6	AS only	Industry	42%	56%
3	AS + RBC	UnWtd E5.J10	10x11	AS+RBC	Industry	56%	59%
4	Sizes D & E/Div 3-5	Wtd D3.E5	5x6	AS only	Industry	50%	80%
4.1	Size C/Div 3-5	Wtd C3.C5	5x6	AS only	Industry	35%	28%
4.2	Size D/Div 3-5	Wtd D3.D5	5x6	AS only	Industry	38%	68%
4.3	Size E/Div 3-5	Wtd E3.E5	5x6	AS only	Industry	59%	90%
5	Div 4 & 5/Size C-E	Wtd C4.E5	5x6	AS only	Industry	48%	55%
5.1	Div 3/Size C-E	Wtd C3.E3	5x6	AS only	Industry	41%	93%
5.2	Div 4/Size C-E	Wtd C4.E4	5x6	AS only	Industry	52%	58%
5.3	Div 5/Size C-E	Wtd C5.E5	5x6	AS only	Industry	45%	53%
6	Div 4&5/Size D&E	Wtd C4.E5	5x6	AS only	Industry	50%	64%
7	Regression Slope	C3.E5	5x6	AS only	Industry	45%	58%
8	Yrs - 1988-2002	Wtd C3.E5	5x6	AS only	Industry	42%	58%
9	Yrs - 2003-2017 (2016)	Wtd C3.E5	5x6	AS only	Industry	64%	85%
10	Yrs - 1995-2017 (2016)	Wtd C3.E5	5x6	AS only	Industry	43%	67%
11	2022 Line 4 factors	Wtd C3.E5	5x6	AS only	Industry	58%	59%
12	110 Segments	UnWtd E5.J10	10x11	AS only	Industry	46%	67%
13	6 Segments	UnWtd Div 3-5; Size >A	5x6	AS only	Industry	42%	54%
14	1 Segment	Ex A/Ex 0	1x1	AS only	Industry	48%	64%
15	Co Expense	Wtd C3.E5	5x6	AS only	Co	46%	NA
16	DCWP 2010 data	UnWtd C3.E5	5x6	AS+RBC	Industry	54%	70%

AS+RBC = Annual Statement data for Ten-Year LOBs and RBC data for Two-Year LOBs, for company/years where RBC data is available.

Row 1.1 – Unweighted Average cells C3-E5

Row 1.1 shows the indicated MDC based on the unweighted average of cells C3-E5, i.e., weighting each cell equally. The differences compared to row 1 are small, 46% versus 45% for premium and 66.3% versus 66.5% for reserves.[53] We use row 1.1 as the base for certain alternatives that we calculated based on the unweighted average of cells C3-E5.

[53] Each of these rounds to 66% in Table 6-1.

Row 2 – Effect of Company-Size

There is an interaction between (a) company-size and (b) risk factors. This interaction affects the indicated MDC, as follows:

Variation in Indicated Risk Charges by Company-Size

First, Appendix 1-Exhibits A1-1A and A1-1B (Part 3), show that, for premium and reserves, respectively, the indicated LOB risk charges are lower for larger companies, even if they have the same level of diversification as smaller companies.

Company Size and Diversification

Second, larger companies tend to have higher levels of diversification, including within the C3-E5 range. For example, for premium, looking at Table 4-1A:

- The number of E3 companies/years (1,426 for premium) is less than the number of C3 or D3 companies/years (1,752 and 1,801 for premium).
- Conversely, the number of E5 company/years (3,838 for premium) is more than the number of C5 or D5 company/years (1,189 and 2,037 for premium).

For reserves, looking at Table 4-1B, the difference in the number of companies by size level for diversification band 3 is small, but for diversification band 5, the number of companies by size is skewed to large companies. For example, there are 3,108 E5 companies but only 1,231 C5 and 1,910 D5 companies.

Interdependency of Risk Charge by Size and Diversification by Size

Because larger companies independently exhibit both greater diversification and lower risk charges, part of the apparent diversification effect is attributable to size. To assess this impact, in Appendix 1, we adjust the modeled premium/reserve risk charges to reflect company-size. The resulting indicated MDCs, shown in row 2, are lower:

- 42% rather than 46%, for premium, and
- 56% rather than 65% for reserves.[54]

Appendix 1 Exhibits A1-2A and A1-2B show the supporting calculations.

Notwithstanding that analysis, we do not "remove" the effect of size from the MDC calibration, as our goal is to produce an MDC reflecting the structure of the RBC Formula, which does not reflect variation in risk charge by company-size.

Row 3 – Using RBC Filing Data ("RBC data")

In the base analysis, we use Annual Statement (AS) data for both Two-Year LOBs[55] and Ten-Year LOBs.

[54] The variation in risk charge by company-size, for size bands C-E is more significant for reserve risk than for premium risk. Hence the impact on MDC is greater for reserve risk than for premium risk.

[55] RBC Filing data and AS data have claims at different valuation dates, for the same AY or initial reserve year. Therefore, the RBC Filing data and AS data may be assigned to pools differently, and will not "match."

Also, companies in runoff will have reserve data in only the "prior" row of Schedule P, and will therefore not have premium or reserve data in the RBC Filings.

For the Line 4 analysis in Reports 1 and 2, we use RBC data for Two-Year LOBs because the RBC Two-Year LOB data has certain advantages relative to AS data.

- First, RBC data includes LRs and RRRs with maturity up to ten years, longer than the two-year maturity of AS data.
- Second, RBC data includes only companies and LOBs that are subject to RBC requirements. Certain health coverages in LOB L-Other are excluded (governed by Health RBC), and single state monoline financial guarantee companies, LOB S- FG/MG, are not included because they are not covered by RBC.

On the other hand, RBC data does not include the development of Prior Year reserves. This is less significant for the Two-Year LOBs than for the Ten-Year LOBs because the Two-Year LOBs are generally shorter-tailed business, with less prior year reserves.

Merging AS and RBC data is more complex in this dependency analysis than with the Line 4 analysis. The Line 4 analysis evaluates each LOB separately. The dependency analysis requires aggregation across Two-Year LOBs and Ten-Year LOBs to produce the all-line total company/year experience.

Working with NAIC personnel, we attempted to match the AS company/years with the RBC company/years, replacing AS Two-Year LOB data points with higher-maturity RBC data points for those LOBs. This match was only partially successful. When there was no matching year, we used the AS values for Two-Year LOBs.

Using the RBC data, to the extent available, increases the premium indicated MDC and reduces the reserve indicated MDC,[56] as shown in Table 6-2, below, extracted from Table 6-1.

Due to limited access to RBC source data, we rely on AS data for our base indications. The NAIC might reasonably make a different choice.

[56] Technically, the RBC+AS indicated MDCs are based on 110 size/diversification segments rather than 30 size/diversification segments and should be compared to the AS indicated MDCs based on 110 size/diversification segments. The AS-only 110 segment analysis produces indicated MDCs essentially the same as the 30 segment indicated MDC, so the display in Table 3-4 is not misleading.

Table 6-2
Effect of Using RBC data for Two-Year LOBs

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
						Indicated MDC	
Row #	Label	Size/Div Cells	Segments	Data-AS/RBC	Expense Data	Premium	Reserves
1	Base indicated MDC	Wtd C3.E5	5x6	AS only	Industry	46%	66%
3	AS + RBC	UnWtd E5.J10	10x11	AS+RBC	Industry	56%	59%

The RBC data was evaluated with 110 segments, rather than 30 segments, and an unweighted average of the 110-segment equivalent of 9-segment cells C3-E5.

Nonetheless, we compare the AS+RBC indicated MDC to row 1, because the indicated MDC with the unweighted average, row 12, is essentially the same as the indicated MDC.

Rows 4 through 6 – Size/Diversification Segments

The indicated MDC is based on the nine size/diversification cells C3-E5. Tables 6-3 and 6-4 (extracted from Table 6-1), below, show indicated MDCs for different size and diversification combinations within that overall range.

Table 6-3
By Size Level – Combined Diversification Levels
Focus by Size for Diversification 3-5 Combined

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
						Indicated MDC	
Row #	Label	Size/Div Cells	Segments	Data-AS/RBC	Expense Data	Premium	Reserves
1	Base indicated MDC	Wtd C3.E5	5x6	AS only	Industry	46%	66%
4	Sizes D & E/Div 3-5	Wtd D3.E5	5x6	AS only	Industry	50%	80%
4.1	Size C/Div 3-5	Wtd C3.C5	5x6	AS only	Industry	35%	28%
4.2	Size D/Div 3-5	Wtd D3.D5	5x6	AS only	Industry	38%	68%
4.3	Size E/Div 3-5	Wtd E3.E5	5x6	AS only	Industry	59%	90%

Indicated MDC by Company-Size (Diversification bands 3-5 combined)

Table 6-3, above, shows that indicated MDCs increase with size, as follows:

- For premium risk, the indicated MDCs are 35%, 38% and 59% for size bands C, D, and E, respectively, and 50% for D+E, which compares to the overall indicated MDC of 46%.
- For reserve risk the indicated MDCs are 28%, 68% and 90% for size bands C, D and E, respectively, and 80% for D+E, compared with an overall indicated MDC of 66%.

This is consistent with prior observations that, absent a company-size adjustment in risk factors, indicated MDCs will be larger for larger companies.

Indicated MDC by Diversification (Size bands C-E combined)

Table 6-4, below, shows that there is no consistent pattern in indicated MDCs as diversification increases:

- For premium risk, the indicated MDCs are 41%, 52%, and 45%, for diversification bands 3, 4, and 5, respectively, and 48% for diversification bands 4+5, relative to the overall indicated MDC of 46%.
- For reserve risk, the indicated MDCs are 93%, 58%, 53% for diversification bands 3, 4, and 5, respectively, and 55% for diversification bands 4 + 5, relative to the overall indicated MDC of 66%.

Table 6-4
By Diversification Level – Combined Size Levels
Focus by Diversification for Sizes C-E Combined

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
						Indicated MDC	
Row #	Label	Size/Div Cells	Segments	Data-AS/RBC	Expense Data	Premium	Reserves
1	Base indicated MDC	Wtd C3.E5	5x6	AS only	Industry	46%	66%
5	Div 4 & 5/Size C-E	Wtd C4.E5	5x6	AS only	Industry	48%	55%
5.1	Div 3/Size C-E	Wtd C3.E3	5x6	AS only	Industry	41%	93%
5.2	Div 4/Size C-E	Wtd C4.E4	5x6	AS only	Industry	52%	58%
5.3	Div 5/Size C-E	Wtd C5.E5	5x6	AS only	Industry	45%	53%
6	Div 4&5/Size D&E	Wtd C4.E5	5x6	AS only	Industry	50%	64%

Row 6 shows the effect of considering the weighted average of the four cells D4-E5. This 4-cell average indicates a somewhat higher MDC for premium and a slightly lower MDC for reserves.

Row 7 – Regression Analysis

We use regression through the origin to test the hypothesis that there is a linear relationship between CoMaxLine% and indicated diversification credit by level of diversification. The slope of the regression curve represents an indicated MDC. Exhibit 5-5 shows that:

- The regression slope for premium is 45%, which is very similar to the average of the 9 cells, 46%.
- The regression slope for reserves is 58%, which is lower than the average of the 9 cells, 66%.

Rows 8-10 – Years Included

The base analysis uses AYs 1988-2017 for premium and initial reserve years 1988-2016 for reserves. Table 6-5, below, from Table 6-1, shows the indicated MDCs based on alternative year ranges.

Table 6-5
Indicated MDC by Year-Range

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
						Indicated MDC	
Row #	Label	Size/Div Cells	Segments	Data-AS/RBC	Expense Data	Premium	Reserves
1	Base indicated MDC	Wtd C3.E5	5x6	AS only	Industry	46%	66%
	Early 15 Years vs. Recent 15/14 Years						
8	Yrs - 1988-2002	Wtd C3.E5	5x6	AS only	Industry	42%	58%
9	Yrs - 2003-2017 (2016)	Wtd C3.E5	5x6	AS only	Industry	63%	85%
	Most recent Lastest 22/21 years						
10	Yrs - 1995-2017 (2016)	Wtd C3.E5	5x6	AS only	Industry	43%	67%

Note: The indicated Line 4 Factors will vary for each year-range. Therefore, when examining MDC by year-range, we adjust the all-lines average modeled risk factors to reflect differences in indicated risk charges based on the selected year-range relative to the full dataset.

Rows 8 and 9 split the experience into two approximately equal periods—1988-2002 and 2003-2017 (2016 for reserve risk). The earlier period, from 1988 to 2002, exhibits substantially lower MDCs compared to the more recent period. We have not investigated the factors that cause that difference. This might be a statistical fluctuation due to variability in the indicated MDCs[57] and because the more recent data is less mature than the older data.

However, two other factors might contribute are that (a) the 2003-2017 period includes more catastrophe events than the 1988-2002 period,[58] and (b) there were higher inflation/interest rates in the 1988-2002 period than in the more recent period. We discuss these issues further in Section 7.

Row 10 presents the indicated MDC using a recent time frame, 1995-2017. The indicated MDCs are very similar to those in row 1.

Row 11 – 2022 Line 4 Factors

Row 11 shows the indicated MDC where the modeled risk ratios are based on the 2022 Line 4 risk factors rather than the indicated Line 4 Factors.

[57] Looking across the 9 cells, C3-E5, variability is large. The values for early-year and later-year indicated MDCs are within one standard deviation of the all-year indicated MDC for reserve risk. See Table 5-2 A and B for values of the standard deviation.

[58] For example, as we observed in Report 2, page 108, "Continental United States Hurricane Impacts/Landfalls, 1851-2022," the National Oceanic and Atmospheric Agency reports 1.3 hurricane landfalls per year in 1988-2003 and 1.8 hurricane landfalls per year in 2004-2017. NOAA and other sources show a similar relationship for tropical storm landfalls.

All else equal, if the average Line 4 Factors were higher than indicated by experience, then the indicated MDC would be higher than the otherwise indicated MDC, and vice versa.[59]

For premium risk, the average 2022 Line 4 Factor is higher than the indicated Line 4 Factor (0.950 versus 0.934).[60] Accordingly, the indicated MDC is higher when using the 2022 Line 4 Factors (58% using 2022 Line 4 versus 46% using the indicated).

For reserve risk, the average 2022 Line 4 Factor is lower than the indicated Line 4 Factor (0.365 versus 0.385). Accordingly, the indicated MDC is lower when using the indicated Line 4 Factors (59% using the 2022 Line 4 versus 66% using the indicated).[61]

Table 6-6
2022 Factors

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
						Indicated MDC	
Row #	Label	Size/Div Cells	Segments	Data-AS/RBC	Expense Data	Premium	Reserves
1	Base indicated MDC	Wtd C3.E5	5x6	AS only	Industry	46%	66%
11	2022 Line 4 factors	Wtd C3.E5	5x6	AS only	Industry	58%	59%

This highlights that MDCs should be calibrated with experience consistent with the experience used to calibrate Line 4 experience.

Rows 12-14 – Increasing/Decreasing the Number of Size/Diversification Segments.

The base analysis uses 30 size/diversification segments, 5 size bands (A-E) and 6 diversification bands (0-5). Rows 12-14 show the indicated MDC based on alternative segmentations, using more (110) or fewer (6 or 1) segments. The results are summarized below in Table 6-7 (excerpted from Table 6-1).

[59] The modelled risk in the calibration uses the Line 4 risk factors. If the modeled all-lines risk charge increases, the indicated diversification credit will increase to "offset" that. The increase in indicated diversification credit is reflected as an increase in indicated MDC.

[60] In the August 30, 2023, Report 2, Table 1.1A, page 7, we show that the 2022 and indicated average Line 4 Factors are 0.950 and 0.934, respectively, corresponding to risk charges, before IIA, of 22.0% and 20.4%, using industry all-lines average expense ratio of 27.0%.

[61] In the August 30, 2023, Report 2, Table 1.1B, page 8, we show that the 2022 and indicated average Line 4 Factors, before IIAs, are 0.365 and 0.385, respectively.

Table 6-7
Number of Size/Diversification Segments

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
						Indicated MDC	
Row #	Label	Size/Div Cells	Segments	Data-AS/RBC	Expense Data	Premium	Reserves
1.1	Unweighted Indicated I	UnWtd C3.E5	5x6	AS only	Industry	45%	66%
12	110 Segments	UnWtd E5.J10	10x11	AS only	Industry	46%	67%
13	6 Segments	UnWtd Div 3-5; Size >A	5x6	AS only	Industry	42%	54%
14	1 Segment	Ex A/Ex 0	1x1	AS only	Industry	48%	64%

Note: We compare rows 12-14 to row 1.1, rather than row 1, because we have the alternative segmented data on an unweighted basis only.

Row 12: 110 Segments

Row 12 shows the indicated MDC using a more detailed set of 110 cells: 10 size bands segments (A-J), each containing 10% of the companies/years, and 11 diversification bands (0-10), including one for monoline company/years and 10 for multi-line company/years, each containing 10% of the multiline companies.

Row 12 is the indicated MDC using the unweighted average of indicated MDCs for the six largest size bands (E through J) and the six most diversified diversification bands (bands 5 through 10), E5-J10, with each band equally weighted. Compared with the indicated MDC from the unweighted 30-segment average in row 2, the differences are small: 46% versus 45% for premium and 66% versus 67% for reserves.

Row 13: Six segments

Row 13 shows the MDC indicated using fewer segments, specifically one size band (including all companies larger than the smallest 20%) and six diversification bands (0-5), one band for monoline companies and 5 additional bands, each containing 20% of the multiline companies.

Row 13 is the indicated MDC based on the unweighted average of indicated MDCs for diversification bands 3-5, each in one size band, B-E combined.

This more aggregated approach results in lower MDCs, 42% versus 45% for premium and 54% versus 66% for reserves. This 6-segment design includes more smaller companies (Size B), one factor contributing to the lower indicated MDC.

Row 14: One segment

Row 14 shows the MDC indicated using a single broad segment: one size band (excluding the smallest 20%), and all multiline companies (i.e., excluding monoline companies). Compared to cells C3-E5 from the 30-segment approach, this segment includes:

- More smaller companies (Size B), which tends to reduce the MDC, and
- More specialized companies (diversification bands 1-2), which tend to increase the indicated MDC.

Compared to the unweighted 30-segment indicated MDC in row 2, this yields 48% versus 45% for premium and 59% versus 66% for reserves.

Row 15 – Company All-Line Expenses (Premium Risk Only)

Row 15 uses company-specific all-lines expense ratios[62] instead of industry LOB expense ratios weighted by each company's NEP by LOB (as in row 1). Using company-specific expenses aligns more closely with how the RBC Formula is applied.

Table 6-8
Indicated MDC with Industry versus Company-Specific Expenses

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
						Indicated MDC	
Row #	Label	Size/Div Cells	Segments	Data-AS/RBC	Expense Data	Premium	Reserves
1	Base indicated MDC	Wtd C3.E5	5x6	AS only	Industry	46%	66%
15	Co Expense	Wtd C3.E5	5x6	AS only	Co	46%	NA

Table 6-8 above shows that this simplification did not significantly affect the indicated MDC.

The comparison may understate the true effect of the expense simplification. For some company/years, we were unable to construct pooled company-specific expenses that matched the risk data. In those cases, we defaulted to 2017 industry expense ratio data, weighted by company/year LOB premium.

Row 16 – DCWP Analysis Using Data Through 2010.

Row 16 compares the indicated MDCs to the prior DCWP analysis based on data through 2010.[63]

Table 6-9
Comparison of Indicated MDC to Prior DCWP Analysis with 2010 Data

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
						Indicated MDC	
Row #	Label	Size/Div Cells	Segments	Data-AS/RBC	Expense Data	Premium	Reserves
1.1	Unweighted Indicated I	UnWtd C3.E5	5x6	AS only	Industry	45%	66%
16	DCWP 2010 data	UnWtd C3.E5	5x6	AS+RBC	Industry	54%	70%

Note: We compare row 16 to row 1.1, rather than row 1, because the DCWP data is provided on an unweighted basis only.

[62] From company-by-company Insurance Expense Exhibit data.

[63] Report 14 - Calibration of LOB Diversification in Underwriting Risk Charges.

Compared to this analysis, the DCWP analysis:

- Used fewer AYs/reserve years[64]
- Included less mature data for overlapping years
- Excluded LOBs categorized as minor lines, immature AYs/reserve years, and new LOBs that are included in this analysis
- Used a simpler pooling approach.

These data and methodological differences may explain part of the difference in indicated MDCs in this analysis compared to the DCWP analysis.

[64] Considering the years of experience alone, the current analysis using data from 1988-2010 indicated a premium MDC of 39% (versus 54% from the DCWP analysis) and a reserve MDC of 60% (versus 70% from the DCWP analysis).

7. ADDITIONAL CONSIDERATIONS

In addition to the quantitative analysis above, we note the following factors that we do not quantify in this Report:

1. Catastrophe experience and its effect on diversification
2. Apply IIA before or after the diversification credit
3. Effect of Changes in Interest/Inflation Rates
4. Alternative diversification metrics
5. Calibration safety levels

Catastrophe Experience (Premium Risk Only)

Catastrophe Treatment in RBC Formula

In the original RBC Formula, Net Written Premium on PR018 included both catastrophe and non-catastrophe risk. Beginning with year-end 2017 reporting, the RBC Formula introduced a new risk component, R_{CAT}, which covers the earthquake and hurricane components of the total premium risk. The catastrophe risk charge is calculated in RBC form PR027, and companies report their hurricane and earthquake loss experience data in their confidential RBC Filings in forms PR101, PR102, …, and PR122, one form for each LOB.

With the introduction of R_{CAT}, the otherwise applicable Line 4 risk factors in PR018 were reduced to exclude the portion of RBC attributable to those catastrophe risks. For simplicity, we will refer to the remaining premium risk element in PR018 as the non-catastrophe premium risk, although some catastrophe risks, such as wildfires, severe convective storms, and floods, remain in the non-catastrophe data.

Catastrophe Treatment in PCF Calibration

Our analysis of the PCF uses AS data that includes both catastrophe and non-catastrophe experience. Ideally, a diversification analysis would evaluate catastrophe and non-catastrophe experience separately. However, our ability to do so is limited in two respects.

- First, separate catastrophe experience has only been collected in RBC Filings for AYs since 2004[65]— i.e., for only 14 of the 30 years in our analysis.
- Second, the catastrophe experience is available only in confidential RBC Filings, and therefore accessible only to regulators, and not to this Committee, except in a summarized form.

The impact on the indicated MDC of separately considering catastrophe experience and non-catastrophe experience is uncertain. On one hand, catastrophe claims create a correlation between experience across catastrophe-exposed LOBs, which reduces the diversification apparent in our

[65] Accident Year 2004 catastrophe experience in the ten accident years provided in the 2013 RBC filings that contained catastrophe experience on an information basis only.

data and in the indicated MDC. On the other hand, catastrophes may reduce correlation between catastrophe exposed and non-catastrophe exposed LOBs and therefore may increase the diversification apparent in our data and in the indicated MDC.

Moreover, the impact of catastrophes on diversification across catastrophe-exposed LOBs and other LOBs depends on other variables. For example, there may be correlations across LOBs due to market pricing cycles related to catastrophes.

An evaluation of this issue is a matter for future research.

Apply PCF/LCF before or after IIA

The indicated diversification credit is **calibrated** based on LR and RRR data on a **nominal** value (NV) basis, not on a present value (PV) basis.

In the RBC Formula, the diversification credit is implemented through the PCF/LCF, which equals 1.0 – diversification credit. The PCF/LCF credit is **applied** to premium/reserve risk on RBC PR0017and PR0018 risk **after** the IIA discount, i.e., on a **PV basis**.

If the PCF/LCF credit were applied to the risk charge **before** the IIA, the effect of the diversification credit would be larger.

Table 7-1 Part A, below, shows the risk charge calculation with the current method.

Table 7-1A – IIA applied before PCF/LCF – Current Method

Part A -Diversification - Current Method				
Row	Item	Premium	Reserve	Notes
1	Line 4	0.934	0.385	Industry all-line-weighted average
2	IIA	0.927	0.872	Industry all-line-weighted average
3	Expense Ratio	0.270	NA	Industry all-line-weighted average
4	Diversification Credit	0.150	0.150	Industry all-line weighted average
5	PCF/LCF	0.850	0.850	1.0-(4)
6	Risk Charge Before IIA Before Div	0.204	0.385	Note 1
7	Risk Charge After IIA Before Div	0.136	0.208	Note 2
8	Risk Charge After IIA and After Div	0.115	0.177	(6)*(5)
9	Div Credit-% Rsv/Prem	0.020	0.031	(6)-(7)

Values in the Premium and Reserve columns are factors to apply to premium or reserves, respectively.

Note 1: Premium Risk row (5)=(1)+(3) -1.0; Reserve Risk: (5)=row 1.

Note 2: Premium Risk row (5)=(1)*(2)+(3)-1.0; Reserve Risk: (6)=(1.0+(1))*(2)-1.0.

We display rounded values, but we calculate with unrounded values. Therefore, calculations using the rounded values shown may not exactly reproduce the displayed rounded results.

This rounding feature applies to all Tables and Exhibits in this Report.

Table 7-1 Part B, below, shows the risk charge calculation with the alternative method.

Table 7-1B – IIA applied after Diversification – Alternative Method

Part B -Diversification - Apply Diversification Before IIA				
Row	Item	Premium	Reserve	Notes
1	Line 4	0.934	0.385	Industry all-line-weighted average
2	IIA	0.927	0.872	Industry all-line-weighted average
3	Expense Ratio	0.270	NA	Industry all-line-weighted average
4	Diversification Credit	0.150	0.150	Industry all-line weighted average
5	PCF/LCF	0.850	0.850	1.0-(4)
6	Risk Charge Before IIA Before Div	0.204	0.385	Note 1
7	Risk Charge Before IIA After Div	0.173	0.327	(4)*(5)
8	Risk Charge After IIA and After Div	0.107	0.157	Note 2
9	Div Credit as % Rsv/Prem	0.028	0.050	Part A Row 6 - (8)

Values in the Premium and Reserve columns are factors to apply to premium or reserves, respectively.

Note 1: Premium Risk row (5)=(1)+(3) -1.0; Reserve Risk: (5)=row 1.

Note 2: Premium Risk row (5)=(1)*(2)+(3)-1.0; Reserve Risk: (6)=(1.0+(1))*(2)-1.0.

Rows 1-6 in Part B are the same as in Part A. In row 7, we apply the PCF/LCF credit to the risk charge before applying the IIA (shown in row 6). This differs from Part A, the current method, where the PCF/LCF credit is applied after the IIA. Row 8 shows the risk charge after applying both the IIA and the diversification credit with the alternative method.

In row 9, we show the diversification credit as the difference between:

- The risk charge after IIA and before diversification – Part A row 6, and
- The risk charge after IIA and after diversification, alternative method – Part B row 8.

Table 7-1 Part C, below, compares parts A and B. It shows that with the alternative method, the diversification credit is significantly larger, e.g., 39% larger, for premium risk and 62% larger for reserve risk. As a result, the risk charge is 6.9% lower for premium risk and 10.9% lower for reserve risk, expressed as percentages of the risk charge.

Table 7-1C – Comparison IIA applied before or after Diversification

Part C- Change in RBC UW Risk Value - Alternative Methods				
Row	Item	Premium	Reserve	Notes
1	% Diversification Credit	39%	62%	Part B row 9 / Part A row 9
2	% Risk Charge	-6.9%	-10.9%	Part B row 8 / Part A row 8
3	% Reserve/Premium	-0.8%	-1.9%	Part B row 8 - Part A row 8

Appendix 2 analyzes the details that explain why the order of operations produces this difference.

Effect of Changes in Interest Rate/Inflation Environment

Report 2 showed that there is an interaction between Line 4 risk factors and interest rates. It evaluated the indicated risk factors on a present value (PV) basis, and in that way, it produced the indicated Line 4 and IIAs that consider this interaction.

In this Report, we calibrate the diversification credit using LR and RRRs on a nominal value (NV) basis, rather than a present value (PV) basis.

On one hand,

- The Modeled Risk calculation in the MDC calibration uses the Line 4 Factors, NV factors, reflecting the changes in interest/inflation rates over the 1988-2017 (2016) time period, and
- We observe that the indicated MDCs are lower in the earlier periods when interest/inflation rates are higher, and the indicated MDCs are higher in the current periods when interest/inflation rates are lower. The indicated MDC represents experience across both periods.[66]

From that perspective, there is reason to expect that the NV calculation of MDC is reasonable.

On the other hand,

- More complex relationships might exist between MDC and interest/inflation rates, and the current analysis might not reflect those relationships. An analysis of MDC on PV value could explore that possibility.
- The PV analysis would reduce the proportion of risk from long-tail LOBs, compared to shorter-tail LOBs, which might affect the indicated MDC.

We have not done a PV analysis for this Report, and it remains a matter for future research.

Diversification Metrics

In this report:

- We calculate the indicated MDC to produce a total LOB diversification credit that is consistent with the loss experience.
- We test the extent to which the CoMaxLine% allocation of diversification credit by company is consistent with loss experience.

[66] Specifically, the inflation and interest rates in the earlier 1988-2002 time period were higher than in the more recent years, 2003-2017 (2016). Higher interest rates produce higher LRs and higher RRRs, and therefore higher indicated risk charges. The indicated MDCs adjust for that by increasing the average Line 4 Factor in Modeled Risk in the earlier periods, compared to the overall average. The MDC reflects the difference in Observed Risk by size/diversification after removing this difference in overall risk level.

We did not test alternatives to the CoMaxLine% approach, because:

- Our calibration of the indicated MDC established the appropriate total level of LOB diversification credit in the RBC Formula, which is largely independent of the diversification formula.
- Based on our review of DCWP Reports 13 and 14,[67] we conclude that:
    - The company-by-company impact of alternative formulas is not generally large.
    - The potential additional accuracy of a revision is not large compared to the effect of the overall change indicated by this report.
    - The theoretical case for making a change is not compelling, especially in light of the two points above.

Appendix 3 presents our review of the DCWP findings.

Nonetheless, a review of the dependency formula is appropriate for the future.

Calibration Safety Level

There is no explicit overall safety level target for the CAL level in the P&C RBC Formula. Nonetheless, we understand that the prevailing regulatory view is that the implicit safety level has produced satisfactory results.

Impact on Safety Level-Revised MDC

Within the overall CAL, the Line 4 premium and reserve risk factors and the MDC are calibrated to a safety level of 87.5% with a runoff time horizon. This 87.5th percentile/runoff time frame safety level for premium and reserve risk is implicit in the original calibration[68] and has been retained for reasons including the regulatory view that the premium and reserve risk components and the overall effect of the RBC Formula are satisfactory.

The indicated MDCs presented in this report are larger than the MDC in the RBC Formula. This implies that the current RBC Formula incorporates some conservatism in the underwriting risk elements, relative to the 87.5th percentile safety level. Thus, even though the Line 4 Factors are calibrated at the 87.5th percentile, the Line 4 Factors combined with the conservative MDCs produced a safety level higher than the 87.5th percentile.

Adopting the indicated MDC in the RBC Formula reduces the safety level for R4 and R5, and therefore CAL.

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[67] DCWP Report 13 - RBC LOB Diversification: Current RBC Approach vs. Correlation Matrix Approach, DCWP Report 14 - Calibration of LOB Diversification in Underwriting Risk Charges

DCWP work was based on data through December 2010.

[68] American Academy of Actuaries, Property and Casualty Risk-Based Capital Underwriting Factors and Investment Income Adjustment Factors, Pages 57-58.

Impact on Safety Level-Past Formula Changes

Since the implementation of the RBC Formula, several changes have been made that increased the implied safety level (e.g., R_{CAT} set at the 1-in-100 safety level and the addition of the operational risk charge at 3% of RBC).

There have also been changes that have decreased it (e.g., reduced fixed income risk charges for assets and reduced reinsurance credit risk charges).

Each of these changes may make the RBC Formula more accurate in assessing a particular risk. However, any significant change to any element of the RBC Formula implies a potential change in the implied safety level.

Observation

Any change in the RBC Formula implies a judgment that the resulting overall impact on the CAL safety level is appropriate, and whether a reduction (or increase) in one area requires a corresponding increase (or decrease) in another area to achieve the desired overall level.

We do not measure the safety level impact of adopting the indicated MDCs on R4, R5, or CAL, nor do we determine whether the total ACL is appropriate for regulatory purposes. That is beyond the scope of this Report.

8. SUMMARY OF FINDINGS

The scope of this Report is to examine the CoMaxLine% approach as applied in the RBC Formula. In that context, the committee findings are:

Finding 1:
Based on the above analysis, the committee believes that MDCs of 45% for premium and 65% for reserves are reasonable selections and are better supported by the data than the current 30% MDC. We refer to these as the indicated MDCs.

There are reasonable alternative MDC selections, which we discuss in Section 3 and Section 6/Sensitivity Analysis.

Finding 2:
While the linear relationship between diversification credit and CoMaxLine% is not exact, considering the alternatives, the Committee believes it is a reasonable approximation, especially for more diversified companies.

Finding 3:
We recommend further research on alternatives to the current RBC diversification approach, particularly the method we refer to as CoMaxLine%-Risk, which measures diversification by risk by LOB rather than dollars of premium/reserve.

Finding 4:
The treatment of the IIA/Diversification interaction and the effect of a fully PV analysis are matters for future research.

Finding 5:
Other areas of future research for dependency analyses that we identify in this Report are the following:

Calibration net of cats covered by R-Cat
Resolving issues in combining RBC and AS data
Within the CoMaxLine% approach, or any alternative, test square, square root, or other relationships between diversification index and diversification credit, rather than the current linear relationship.

9. Appendix 1 – Size-adjusted Indicated MDC Calculations

In Section 6, Sensitivity Analysis, Table 6-1, row 2, we present the indicated MDCs that would result if the risk factors in Line 4 varied by company-size, specifically 42% and 56% for premium and reserve risk, respectively.

This Appendix presents the derivation of those results.

Variation in Risk by Company-size

In Exhibits A1-1A and A1-1B, below, we calculate adjustments to the all-lines premium and reserve risk factors that reflect company-size.

Part 1 of Appendix 1- Exhibit A1-1A, below, is a copy of Table 5-2A, Part 1.[69] It shows the 87.5th percentile AYUL for each size and diversification cell. We refer to this as the observed risk. The values in the column "All ex A" are the observed risk values for all company-sizes larger than A (i.e., company-sizes B-E), for each diversification level.[70]

Part 2 shows the ratio of each cell to the value in the column "labeled "All ex A," in the corresponding row. For example:

- The value 2.273 in the cell with diversification 0 and size A equals 0.700/0.308. The value 2.273 means that the observed risk for cell A/0 is 2.273 times larger than the observed risk for size cells B-E.
- The value 0.910 in the cell with diversification 5 and size E equals 0.139/0.153. The value 0.910 means that the observed risk for cell E5 is 0.910 times (9% less than) the observed risk for size cells B-E.

Looking across columns, in any row, these ratios generally decline (indicating lower risk) as company-size increases. This is consistent with our expectation that the risk level decreases with increasing company-size, while holding the diversification level constant.

Part 3 shows the unweighted average observed risk in Part 2 for diversification bands 3-5[71] (down each column), for each size level, A-E.

We use these ratios to create size-adjusted all-line average Line 4 Factors.

[69] Tables 5-2A and B show the values as rounded percentages. This table shows the values as three-decimal ratios.

[70] We exclude company-size A, which consists of the data points with the smallest 20th percentile of company-size because that corresponds, approximately, to the Line 4 calibration that excludes the smallest 15th percentile of LOB-size, for the reasons we discuss in Section 5.

[71] We use diversification 3-5 because, as we discussion in Section 5, those are the diversification bands we use in the MDC calibration.

Appendix 1 – Exhibit A1-1A
Premium Risk
(Corresponding to Table 5-2A-Part 1)

Part 1 - Observed AYUL (87.5th percentile)							
Div/Size	A	B	C	D	E	All	All ex A
0	0.700	0.316	0.259	0.270	0.388	0.400	0.308
1	0.675	0.269	0.294	0.255	0.277	0.312	0.271
2	0.477	0.264	0.215	0.178	0.177	0.236	0.204
3	0.521	0.212	0.181	0.178	0.160	0.213	0.181
4	0.450	0.182	0.165	0.163	0.139	0.175	0.157
5	0.833	0.243	0.154	0.158	0.139	0.159	0.153
All	0.623	0.259	0.216	0.189	0.179	0.251	0.206
All ex 0	0.565	0.235	0.205	0.179	0.156	0.213	0.187

Part 2 - Observed AYUL (87.5th percentile) / All ex A							
Div/Size	A	B	C	D	E	All	All ex A
0	2.273	1.027	0.841	0.877	1.259	1.299	1.000
1	2.490	0.992	1.086	0.939	1.023	1.152	1.000
2	2.333	1.290	1.053	0.870	0.863	1.156	1.000
3	2.883	1.172	1.000	0.987	0.887	1.180	1.000
4	2.857	1.155	1.045	1.037	0.884	1.112	1.000
5	5.453	1.591	1.007	1.032	0.910	1.041	1.000
All	3.031	1.262	1.050	0.920	0.870	1.218	1.000
All ex 0	3.022	1.257	1.096	0.957	0.835	1.136	1.000

Part 3 - Size Adjustment for Premium Risk					
SizeBand	A	B	C	D	E
Div 3-5	3.731	1.306	1.017	1.019	0.893

We apply the same method to reserve risk.

Appendix 1 – Exhibit A1-1B
Reserve Risk
(Corresponding to Table 5-2B-Part 1)

Part 1 - Observed Reserve Development (87.5th percentile)							
Div/Size	A	B	C	D	E	All	All ex A
0	0.582	0.411	0.278	0.245	0.177	0.371	0.291
1	0.500	0.529	0.241	0.227	0.154	0.298	0.274
2	0.531	0.422	0.281	0.208	0.128	0.277	0.247
3	0.566	0.412	0.312	0.246	0.185	0.310	0.278
4	0.490	0.415	0.329	0.266	0.254	0.323	0.301
5	0.750	0.362	0.297	0.259	0.251	0.280	0.269
All	0.561	0.428	0.282	0.245	0.209	0.315	0.277
All ex 0	0.542	0.432	0.285	0.245	0.212	0.298	0.274

Part 2 - Observed Reserve Development (87.5th percentile) / All ex A							
Div/Size	A	B	C	D	E	All	All ex A
0	2.001	1.412	0.957	0.843	0.608	1.275	1.000
1	1.822	1.929	0.879	0.826	0.563	1.087	1.000
2	2.144	1.704	1.134	0.842	0.517	1.119	1.000
3	2.034	1.483	1.123	0.886	0.663	1.113	1.000
4	1.628	1.378	1.093	0.881	0.843	1.071	1.000
5	2.791	1.347	1.106	0.963	0.934	1.042	1.000
All	2.024	1.544	1.019	0.885	0.755	1.138	1.000
All ex 0	1.977	1.576	1.041	0.895	0.773	1.087	1.000

Part 3 - Size Adjustment for Reserve Risk					
SizeBand	A	B	C	D	E
Div 3-5	2.151	1.402	1.107	0.910	0.813

Size-Adjusted Indicated MDC

Appendix 1, Exhibit A1-2A and A1-2B, below, corresponds to Tables 5-2A and 5-2B.

- Part 1 Observed Risk and Part 4 Calculated Diversification have values equal to those in Tables 5-2A and 5-2B, Parts 1 and 4.
- Part 2 Modeled Risk values equal the Part 2 values from Tables 5-2A and 5-2B times the size adjustment factors in Exhibit A1-1A and A1-1B Part 3.[72]
- Parts 3 and 5 are calculated with the formulas shown at the bottom of those sections.

[72] More precisely, for premium risk we multiply the Line 4 risk factor by the Part 3 value and combine that with the company expense ratio to produce the adjusted modeled risk. For reserve risk we multiply the Line 4 risk factor by the Part 3 value.

Appendix 1 – Exhibit A1-2A – Premium Risk
Size-adjusted
Indicated MDC by Size/Diversification (5x6 Analysis)
(Corresponding to Table 5-2A-Parts 1-5)

Divers Band Quintiles	Observed Risk (Part 1) Size Band Quintiles (adj B-E) A	B	C	D	E	AllSize > 20%
0	70%	32%	26%	27%	39%	31%
1	67%	27%	29%	25%	28%	27%
2	48%	26%	22%	18%	18%	20%
3	52%	21%	18%	18%	16%	18%
4	45%	18%	16%	16%	14%	16%
5	83%	24%	15%	16%	14%	15%
All	62%	26%	22%	19%	18%	21%
All ex 0	57%	24%	21%	18%	16%	19%
	C3-E5 Unweighted	16.0%	Weighted	15.7%		

Divers Band Quintiles	Modeled Risk No Diversification (Part 2) Size Band Quintiles (adj B-E) A	B	C	D	E	AllSize > 20%
0%	114%	42%	36%	47%	56%	40%
100%	92%	36%	30%	33%	32%	30%
200%	78%	30%	22%	23%	21%	23%
3	73%	28%	21%	21%	20%	21%
4	80%	28%	22%	22%	20%	22%
5	82%	27%	21%	21%	20%	22%
All	97%	34%	26%	27%	25%	26%
All ex 0	81%	30%	23%	24%	21%	23%
	C3-E5 Unweighted	20.8%	Weighted	20.7%		

Divers Band Quintiles	Indicated Diversification Credit (Part 3) Size Band Quintiles (adj B-E) A	B	C	D	E	AllSize > 20%
0	39%	25%	29%	43%	31%	23%
1	27%	25%	1%	23%	12%	11%
2	38%	11%	2%	24%	14%	9%
3	28%	25%	13%	15%	20%	15%
4	44%	35%	24%	25%	29%	27%
5	-1%	11%	27%	26%	30%	29%
All	36%	23%	16%	30%	28%	22%
All ex 0	30%	22%	12%	25%	26%	20%
	C3-E5 Unweighted	23.3%	Weighted	24.2%		

(Part 3) = 1 - (Part 1)/(Part 2)

Divers Band Quintiles	Calculated Diversification Credit (Part 4) Size Band Quintiles A	B	C	D	E	AllSize > 20%
0%	0%	0%	0%	0%	0%	0%
100%	2%	2%	2%	2%	2%	2%
2	8%	8%	8%	8%	8%	8%
3	12%	12%	12%	13%	13%	13%
4	16%	16%	16%	16%	17%	16%
5	20%	21%	21%	21%	22%	21%
All	5%	7%	9%	11%	14%	10%
All ex 0	9%	10%	11%	12%	15%	12%
	C3-E5 Unweighted	16.6%	Weighted	17.2%		

(Part 4) = 1 - Diversification Credit Calculated (Current RBC)

Divers Band Quintiles	Indicated Max Diversification Credit (Part 5) Size Band Quintiles A	B	C	D	E	AllSize > 20%
0						
1	405%	404%	12%	351%	197%	178%
2	148%	42%	9%	91%	53%	35%
3	68%	59%	31%	37%	47%	35%
4	83%	65%	44%	47%	53%	50%
5	-1%	16%	39%	38%	41%	41%
All	229%	100%	56%	84%	60%	66%
All ex 0	100%	65%	34%	61%	51%	48%
	C3-E5 Unweighted	42.0%	Weighted	42.0%		
	StdDev	6.3%	StdDev	6.1%		

(Part 5) = 0.30 * (Part 3)/(Part 4)

Appendix 1 – Exhibit A1-2B – Reserve Risk
Size-adjusted
Indicated MDC by Size/Diversification (5x6 Analysis)
(Corresponding to Table 5-2B-Parts 1-5)

Divers Band Quintiles	Observed Risk (Part 1) Size Band Quintiles (adj B-E) A	B	C	D	E	AllSize > 20%
0	58%	41%	28%	25%	18%	29%
1	50%	53%	24%	23%	15%	27%
2	53%	42%	28%	21%	13%	25%
3	57%	41%	31%	25%	18%	28%
4	49%	42%	33%	27%	25%	30%
5	75%	36%	30%	26%	25%	27%
All	56%	43%	28%	25%	21%	28%
All ex 0	54%	43%	29%	25%	21%	27%
	C3-E5 Unweighted	26.7%	Weighted	26.4%		

Divers Band Quintiles	Modeled Risk No Diversification (Part 2) Size Band Quintiles (adj B-E) A	B	C	D	E	AllSize > 20%
0%	71%	50%	39%	34%	26%	40%
100%	62%	41%	32%	27%	25%	30%
200%	63%	43%	33%	29%	25%	23%
3	70%	47%	38%	33%	32%	21%
4	74%	50%	41%	35%	34%	22%
5	81%	50%	43%	35%	34%	22%
All	70%	47%	37%	32%	30%	26%
All ex 0	68%	45%	37%	32%	31%	23%
	C3-E5 Unweighted	35.9%	Weighted	35.5%		

Divers Band Quintiles	Indicated Diversification Credit (Part 3) Size Band Quintiles (adj B-E) A	B	C	D	E	AllSize > 20%
0	19%	17%	29%	27%	31%	27%
1	19%	-31%	24%	17%	39%	10%
2	16%	3%	16%	28%	49%	-10%
3	19%	12%	17%	24%	42%	-31%
4	34%	17%	19%	24%	26%	-40%
5	7%	28%	30%	25%	26%	-25%
All	20%	9%	25%	23%	31%	-5%
All ex 0	20%	5%	22%	23%	32%	-17%
	C3-E5 Unweighted	26.0%	Weighted	25.9%		

(Part 3) = 1 - (Part 1)/(Part 2)

Divers Band Quintiles	Calculated Concentration Ratio (Part 4) Size Band Quintiles A	B	C	D	E	AllSize > 20%
0%	0%	0%	0%	0%	0%	0%
100%	1%	1%	1%	1%	1%	1%
200%	5%	5%	5%	5%	5%	5%
3	10%	10%	10%	10%	10%	10%
4	14%	14%	14%	14%	14%	14%
5	18%	19%	19%	19%	20%	19%
All	4%	6%	7%	8%	11%	8%
All ex 0	8%	9%	9%	10%	12%	10%
	C3-E5 Unweighted	14.5%	Weighted	15.0%		

(Part 4) = 1 - Diversification Credit Calculated (Current RBC)

Divers Band Quintiles	Indicated Max Diversification Credit (Part 5) Size Band Quintiles A	B	C	D	E	AllSize > 20%
0						
1	452%	-776%	598%	434%	919%	248%
2	98%	17%	100%	174%	307%	-62%
3	57%	36%	53%	75%	127%	-97%
4	72%	35%	40%	50%	53%	-83%
5	11%	45%	48%	39%	40%	-39%
All	151%	45%	108%	82%	86%	-19%
All ex 0	74%	18%	74%	67%	78%	-52%
	C3-E5 Unweighted	58.5%	Weighted	56.2%		
	StdDev	26.4%	StdDev	25.2%		

(Part 5) = 0.30 * (Part 3)/(Part 4)

Appendix 1- Exhibit A1-3, below, shows the size-adjusted indicated MDCs from Exhibit A1-2A and 2B, and compares them to the unadjusted results in Table 5-2A and 5-2B.

Appendix 1 – Exhibit A1-3
Indicated MDCs

Size Adjustment = NO	Premium	Reserves
C3-E5 Wtd Average	45.9%	66.3%
C3-E5 Standard Deviation	12.9%	37.5%
Size Adjustment = YES	**Premium**	**Reserves**
C3-E5 Wtd Average	42.0%	56.2%
C3-E5 Standard Deviation	6.1%	25.2%

The size-adjustment reduces the indicated MDCs, and it also decreases variability among the C3—E5 MDC indications, as measured by the standard deviation. It also narrows the difference between the premium risk indicated MDC and the reserve risk indicated MDC.

The size-adjusted indications still suggest MDCs larger than the current 30%.

Regression Analysis

In Appendix 1, Exhibits A1-4 and A1-5 below, we repeat the regression analysis from Section 5, applied to size-adjusted risk data in Exhibit A1-2A and 2B.

Appendix 1 – Exhibit A1-4
Large Diversified Companies (with Size-Adjusted Risk Factors)
Graphical Analysis of CoMaxLine% Element of Diversification Formula
5 x 6 Analysis; 9 Large Diversified Company Data Points
(Corresponding to Table 5-4, no size adjustment)

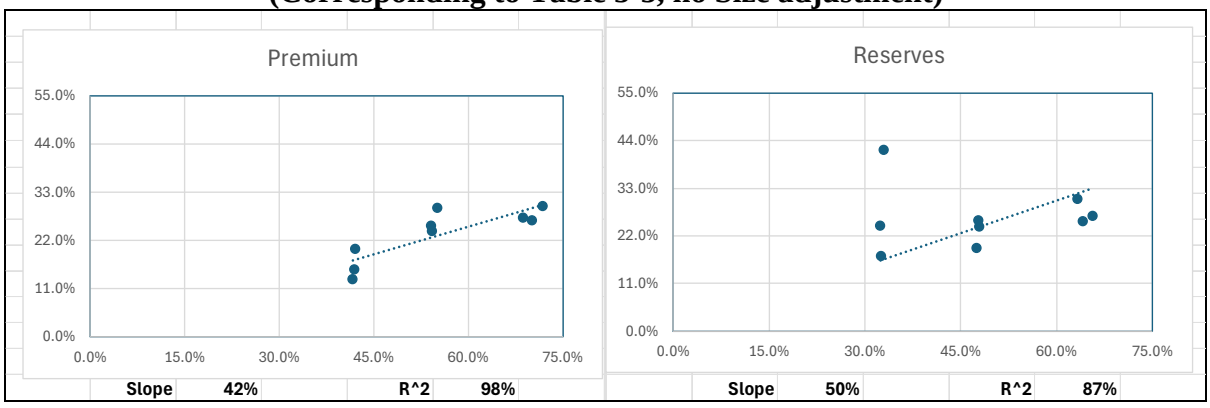
		Premium			Reserves		
		(1)	(2)	(3)	(4)	(5)	(6)
Size Band	Div Band	Average Div Level	Indicated Divers	Fitted Divers	Average Div Level	Indicated Divers	Fitted Divers
C	3	41.6%	13.0%	17.5%	32.5%	17.2%	16.4%
D	3	41.8%	15.4%	17.6%	32.4%	24.2%	16.3%
E	3	42.0%	19.9%	17.6%	32.9%	41.8%	16.5%
C	4	54.2%	23.9%	22.8%	47.5%	19.1%	23.9%
D	4	54.1%	25.3%	22.7%	47.9%	23.9%	24.1%
E	4	55.1%	29.4%	23.1%	47.7%	25.5%	24.0%
C	5	68.7%	27.1%	28.9%	63.2%	30.5%	31.8%
D	5	70.1%	26.4%	29.4%	64.1%	25.3%	32.2%
E	5	71.7%	29.7%	30.1%	65.7%	26.5%	26.5%

The regression data in Exhibit A1-4 is as follows:

- Columns 1 & 4: Average diversification index for premium and reserve risk, respectively (from Exhibits A1-2A and A1-2B, Part 4 divided by 30%).

- Columns 2 & 5: Indicated diversification credit (from Exhibit A1-2A/B, Part 3).
- Columns 3 & 6: Fitted diversification credit, derived from the regression through the origin applied to the prior columns.

Appendix 1 – Exhibit A1-5
Large Diversified Companies (with Size Adjustment)
Graphical Analysis of CoMaxLine% Element of Diversification Formula
5 x 6 Analysis; 9 Large Diversified Company Data Points
(Corresponding to Table 5-5, no Size adjustment)



In Appendix 1 – Exhibit A1-5

- The X-axis represents the average diversification index (Appendix 1-Exhibit A1-4 columns 1 and 4).
- The Y-axis represents the indicated diversification credit (Appendix 1-Exhibit A1-4 columns 2 and 5)
- The slope of the fitted line is 42% for premium risk and 50% for reserve risk.

The regression "R-squared" values[73] are:

- 98% for premium and
- 87% for reserves.
- These indicate a 'better fit' than with the data before size-adjustment.

The slopes serve as alternate estimates of the size-adjusted indicted MDCs shown in Exhibit A1-3, above.

- The premium slope, 42%, is the same as the slope from the C3-E5 cell average, 42%.
- The reserve slope of 50% is not as close to the C3-E5 cell average, 56%.

[73]See footnote 51.

Appendix 2 – Diversification and IIAs

In Section 7, we showed that the risk value depends on the order in which we apply diversification credit and IIA. In this Appendix, we explain how the operation of the IIA produces that effect.

The IIA can be viewed in three parts:

- Part 1 - The investment income credit on the premium less expense[74] /initial carried reserves,
- Part 2 - The investment income credit on the premium/reserve risk charge, and
- Part 3 - The reduction in investment income credit related to the diversification credit.

Part 1 is the investment income on loss reserves and on the expense portion of the premium, before considering risk charges. Parts 2 and 3 are the elements of investment income on the risk charge.

In the current RBC Formula, the investment income adjustment on the diversification credit, Part 3, is, in effect, the average of the investment income credits on parts 1 and 2, as follows:

Assume, for example, for reserves, that the IIA is 0.872 (a 12.8% discount) and the risk charge is 0.385. Then, the first two parts of the investment income credit would be:

- Part 1 – 12.8% of reserves (or premium less expense), and
- Part 2 – 12.8% of the risk charge, 0.385 times reserves 4.9%.

Therefore,

- Part 1 and Part 2 investment income credit combined is 12.8% of the total reserves plus 12.8% of the reserve risk charge.
- That equals 46.0% of the risk charge before IIA (12.8% + 4.9%)/0.385.
- The total investment income credit, 46% of risk charge, is ‘large’ compared to 12.8% because Part 1 of the investment income credit is large compared to the risk charge.

[74] The loss portion of premium, i.e., premium less expenses

Thus, the diversification credit is applied to the risk charge after the 46% reduction for the investment income credit, and therefore, the diversification credit is implicitly reduced by 46%.

The alternative treatment is to reduce the diversification credit by the marginal investment income attributable to the diversification credit alone, i.e., 12.8%, rather than 46%. Using the 12.8% investment income adjustment increases the diversification credit and reduces the risk charge for multi-line companies.

The section below provides a detailed comparison of the alternatives.

Exhibit A2-1/Part A – Current Method – Apply IIA before Diversification Credit

Exhibit A2-1 uses sample values for the Line 4 Factor, the IIA Factor, and the diversification credit to show the investment income treatment under the current and alternative calculations in detail.

Part A, rows 1-4, shows the values for RBC Formula inputs.

Rows 5-7 use the current RBC Formula to calculate risk charges:
(a) Row 5: before IIA and Diversification,
(b) Row 6: after IIA, before diversification, and then
(c) Row 7: after IIA and diversification.

Row 8 displays the diversification credit as a percentage of premium/reserve, calculated as row 6 minus row 7.

Appendix 2 – Exhibit A2-1 – Part A – Current Method
(Values are % of Premium or Reserves)

Part A -Diversification - Current Method				
Row	Item	Premium	Reserve	Notes
1	Line 4	0.934	0.385	Industry all-line-weighted average
2	IIA	0.927	0.872	Industry all-line-weighted average
3	Expense Ratio	0.270	NA	Industry all-line-weighted average
4	Diversification Credit	0.150	0.150	Industry all-line weighted average
5	Risk Charge-Before IIA Before Div	0.204	0.385	Note 1
6	Risk Charge-After IIA Before Div	0.136	0.208	Note 2
7	Risk Charge-After IIA and After Div	0.115	0.177	(6)*(1.0-(4))
8	Div Credit-% Rsv/Prem	0.020	0.031	(6)-(7)

Note 1: Premium Risk row (5)=(1)+(3) -1.0; Reserve Risk: (5)=row 1.

Note 2: Premium Risk row (5)=(1)*(2)+(3)-1.0; Reserve Risk: (6)=(1.0+(1))*(2)-1.0.

We display rounded values, but we calculate with unrounded values. Therefore, calculations using the rounded values shown may not exactly reproduce the displayed rounded results.

This applies to all Tables and Exhibits in this Report.

Exhibit A2-1/Part B – Current Method – Apply IIA Before Diversification Credit

In Part B, we rearrange Part A to explicitly show the interaction between the IIA and diversification credit.

Appendix 2 – Exhibit A2-1 – Part B – Current Method-Details of IIA
(Values are % of Premium or Reserves)

Part B -Diversification - Re-Arrange -Current Method				
Row	**Item**	**Premium**	**Reserve**	**Notes**
9	Risk Charge-Before IIA or Div	0.204	0.385	(5)
10	IIA Credit Before Div	0.068	0.177	(5)-(6)
11	Div credit before IIA	0.031	0.058	(4)*(9)
12	IIA credit on Div	0.010	0.027	**(4)*(10)**
13	Div credit after IIA	0.020	0.031	(11)-(12)
14	Risk charge-after IIA and Div credits	0.115	0.177	(9)-(10)-(13)

Relative to $100 of reserves, this shows:

Row 9-Reserve risk before IIA or diversification credit is $38.50, row 5.

Row 10-Investment income credit is $17.70 ($38.50 – $20.70, row 5 – row 6).

Row 11-Diversification credit before investment income is $5.80 (15% of $38.50).

Row 12-Investment income credit on diversification credit is 2.70 (15% of 17.70).

$17.70 is based on Part 1 and Part 2 investment income, so this calculation is equivalent to applying the average investment income credit to the diversification portion of the risk charge.

Row 13-Diversification credit net of investment income is $3.10 ($5.80 – $2.70).

Row 14-Risk Charge after IIA and diversification credit is **$17.70**
($38.50 – $17.70 – $3.10).

Exhibit A2-1/Part C – Alternative Method – Apply Diversification Credit Before IIA

Part C shows the alternative treatment of investment income offset:

Appendix 2 – Exhibit A2-1 – Part C – Alternative Method
(Values are % of Premium or Reserves)

Part C -Diversification - Alternative Method				
Row	**Item**	**Premium**	**Reserve**	**Notes**
15	Risk Charge-Before IIA or Div	0.204	0.385	(5) or (9)
16	IIA Credit Before Div	0.068	0.177	(10) or (5)-(6)
17	Div credit before IIA	0.031	0.058	(11) or (4)*(9)
18	IIA credit on Div	0.002	0.007	**(1-(2)*(17)**
19	Div credit after IIA	0.028	0.050	(17)-(18)
20	Risk charge-after IIA and Div credits	0.107	0.157	(15)-(16)-(19)

Relative to $100 of reserves, this shows:

Row 15-Reserve risk before IIA or diversification credit is $38.50, row 1.
Row 16-Investment income credit is $17.70 (38.50 – 20.70, row 5 – row 6).
Row 17-Diversification credit before investment income is $5.80 (15% of 38.5).
Row 18-Investment income credit on diversification credit is $0.70 (0.128 * $5.8, where 0.128 =1.0 -0.872).
Row 19-Diversification credit net of investment income is $5.10 (5.80 – 0.70)
(5.00 shown on row 19 is calculated from values before rounding.)
Row 20-Risk Charge after IIA and diversification credit is **$15.70** (38.50 – 17.70 – $5.10).

The difference between the methods is presented in the two bold lines, rows 12 and 18.

Row 12, the current method: The diversification credit is reduced by the average investment income effect on the risk charge, yielding an investment income credit of **$2.70**.

Row 18, the alternative method: The diversification credit is reduced by the marginal investment income loss on the diversification credit, which is **$0.70** = (1.0 - 0.872) * $5.80.

- The **$2.00** difference per $100 reserve, $2.70 - $0.70, is a reduction of over 10% of the $17.70 risk charge under the current method.

Exhibit A2-1/Part D – Comparison of the Effect of the Alternative Method

Part D of Exhibit A2-1, below, shows the difference in the methods as percentages of the diversification credit, the risk charge, and the reserve/premium volume.

- Row 21 shows that diversification credit is much larger with the alternative method, 39% larger for premium and 62% larger for reserves.
- Row 22 shows that the effect of the larger diversification credits on the risk charges is a decrease of 6.9% for premium risk and 10.9% for reserve risk.

- Row 23 expresses those effects as a percentage of reserves or premium, a decrease of 0.8% of premium and 1.9% for reserves.

Appendix 2 – Exhibit A2-1 – Part D – Effect of Alternative Method

Part D- Change in RBC UW Risk Value - Alternative Methods				
Row	Item	Premium	Reserve	Notes
21	% Diversification Credit	39%	62%	(19)/(13)
22	% Risk Charge	-6.9%	-10.9%	(20)/(14)-1.0
23	% Reserve/Premium	-0.8%	-1.9%	(20)-(14)

Effect of Alternative Method – Varying Line 4, IIA, and Diversification Credits

Part D, above, illustrates the impact on a specific set of risk factors and diversification levels. The effect of the alternative method depends on the level of diversification, the IIA Factor, and the Line 4 Factor. Exhibits A2-2A and 2B below show further examples for premium risk and reserve risk, respectively.

1. Vary Diversification Credit –with Fixed Line 4 and IIA-Reserve Risk

The first section in Exhibits A2-2A and A2-2B, "Div Credit," illustrates the extent to which the alternative method reduces the risk charge at different levels of diversification credit, for fixed Line 4 and IIA Factors.

The example uses typical Line 4 and IIA Factors, e.g., 0.385 and 0.872 for reserves. We observe that:

- For reserve risk, the impact on the diversification is an increase of 62% regardless of the diversification level.
- Even though the impact on the diversification credit is constant as a percentage of the diversification credit, the impact increases with diversification as a percentage of risk or reserve level. At a high level of diversification, e.g., 25%, the risk charge decreases by 21% with the alternative method.

2. Vary Line 4 Factor - with Fixed IIA and Diversification Credit-Reserve Risk

The "Line 4" section of Exhibit A2-2A illustrates the extent to which the risk charge changes with varied Line 4 Factors and constant IIA and diversification credit:

- The impact is constant as a percentage of premium/reserves, regardless of the Line 4 Factor, 1.1% in this example, for premium.
- The impact is lower with higher Line 4 Factors as a percentage of diversification credit and risk charge.

3. Vary IIA - with Fixed Line 4 and Diversification Credit-Reserve Risk

The "IIA" section of the Exhibit shows that lower IIAs, equivalent to higher investment income, means that the alternative method will have a greater impact, given fixed L4 and diversification credit.

Appendix 2 – Exhibit A2-2A – Premium Risk Impact

Test Variable	Inputs			Impact		
	Line 4	IIA	Div. Credit	% Div Credit	% Risk	% Premium
Div Credit	0.934	0.927	0%	NA	0%	0.0%
	0.934	0.927	5%	39%	-2%	-0.3%
	0.934	0.927	10%	39%	-4%	-0.5%
	0.934	0.927	15%	39%	-7%	-0.8%
	0.934	0.927	25%	39%	-13%	-1.3%
Line 4	0.900	0.900	0.15	91%	-16%	-1.1%
	0.950	0.900	0.15	58%	-10%	-1.1%
	1.000	0.900	0.15	43%	-8%	-1.1%
	1.100	0.900	0.15	28%	-5%	-1.1%
	1.200	0.900	0.15	21%	-4%	-1.1%
IIA	0.934	0.975	0.15	10%	-2%	-0.3%
	0.934	0.872	0.15	111%	-20%	-1.4%

Exhibit A2-2B shows similar examples for reserve risk.

Appendix 2 – Exhibit A2-2B – Reserve Risk Impact

Test Variable	Inputs			Impact		
	Line 4	IIA	Div. Credit	% Div Credit	% Risk	% Reserve
Div Credit	0.385	0.872	0%	NA	0%	0.0%
	0.385	0.872	5%	62%	-3%	-0.6%
	0.385	0.872	10%	62%	-7%	-1.3%
	0.385	0.872	15%	62%	-11%	-1.9%
	0.385	0.872	25%	62%	-21%	-3.2%
Line 4	0.385	0.800	0.15	185%	-33%	-3.0%
	0.400	0.800	0.15	167%	-29%	-3.0%
	0.500	0.800	0.15	100%	-18%	-3.0%
	0.700	0.800	0.15	56%	-10%	-3.0%
	0.900	0.800	0.15	38%	-7%	-3.0%
IIA	0.385	0.950	0.15	16%	-3%	-0.7%
	0.385	0.800	0.15	185%	-33%	-3.0%

Appendix 3 – Alternatives to the CoMaxLine% Approach

In this report, we evaluate the MDC based on the existing CoMaxLine% approach. As part of that work, we reviewed the two 2019 Casualty Actuarial Society (CAS) Dependency and Calibration Working Party (DCWP) reports on alternative diversification formulas.[75]

This Appendix presents our review of the DCWP work.

DCWP evaluated three questions:

1. Meaningful differences – To what extent do different formulas impact the indicated diversification credit by company?

2. Improved accuracy – To what extent is the CoMaxLine% approach a better or worse predictor of indicated diversification credit effects than other formulas?

3. Theoretical considerations – What are the theoretical considerations in selecting among the diversification formulas?

In the next four subsections, we identify the alternative formulas that DCWP considered and discuss DCWP's analysis of those three questions.

Alternative Formulas

Looking at the treatment of diversification in regulatory capital formulas outside the RBC framework, the UK Individual Capital Adequacy Standard[76] (UK ICAS) can be thought of as the simplest. The UK ICAS required capital is called the Enhanced Capital Requirement (ECR).[77] Under the ECR, there is no premium or reserve risk diversification adjustment. Instead, LOB risk factors were selected to represent the LOB risk when combined with a typical LOB distribution.[78]

The CoMaxLine% approach can be viewed as one step more complex than the UK ICAS in that it recognizes different levels of diversification.

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[75]Report 13 - RBC LOB Diversification: Current RBC Approach vs. Correlation Matrix Approach, https://www.casact.org/sites/default/files/2021-02/01_cas-working-party_dependency.pdf, CAS E-Forum Winter 2019

Report 14 - Calibration of LOB Diversification in Underwriting Risk Charges, https://www.casact.org/pubs/forum/19spforum/01_DCWP_Rpt14.pdf, CAS E-Forum Spring 2019

DCWP work was based on data through December 2010.

There were no company-size adjustments in the DCWP work.

[76] Implemented in the UK in the early 2000's before Solvency II.

[77] "Enhanced" because it increase the capital required compared to the EU "Solvency I" regime.

[78] ECR is discussed in https://www.casact.org/sites/default/files/presentation/affiliates_cae_1205_indiv-capital-assessments.pdf, and

https://www.abi.org.uk/globalassets/sitecore/files/documents/consultation-papers/2003/11/cp190.pdf, and

Models, Assessment and Regulation, Arne Sandström, 2006, Taylor & Francis Group, LLC, p 161-164, (no active link)

Correlation Factor Method

Individual company capital models (called 'internal models' in Solvency II) often combine risk charges by LOB using correlation.[79] factors between each pair of LOBs. The Solvency II Standard Formula[80] uses this pairwise Correlation Factor approach.[81]

The Correlation Factor approach, if applied to the RBC Formula, would require 171 parameters, as there are 19 LOBs. By contrast, the CoMaxLine% approach in RBC is simpler--perhaps overly so--and perhaps somewhat ad hoc.

CoMaxLine%-Risk Method

One difference between the CoMaxLine% approach and the Correlation Factor approach is that the degree of diversification in the Correlation Factor approach is based on risk by LOB. In contrast, the degree of diversification in the CoMaxLine% approach is based on volume (premium or reserve amount) by LOB.

Therefore, another alternative to the CoMaxLine% approach is the CoMaxLine%-Risk approach, which applies the CoMaxLine% framework to LOB risk rather than LOB volume, when calculating the LCF and PCF for a company.[82] For clarity, as needed, we refer to the current implementation as CoMaxLine%-Volume and the alternative as CoMaxLine%-Risk.

HHI Method

Finally, the Herfindahl-Hirschman Index (HHI), widely used by economists to measure concentration, considers the relative proportions of all LOBs—not just the largest.[83] HHI is more

[79] We use the term correlation factor approach to describe a factor method or copula method for computing total risk by combining several individual risks. In using the term, we do not intend to imply that the assumptions related to linear correlation are appropriate.

[80] The "Standard Formula" in Solvency II regime is analogous to RBC in that it is a formula that applies to all companies.

[81] Solvency II uses a CoMaxLine% approach to reflect geographic diversification.
DCWP Report 3, CAS E-Forum 2012. "Solvency II Standard Formula and NAIC Risk-Based Capital (RBC)"
https://www.casact.org/sites/default/files/database/forum_12fforumpt2_rbc-dcwprpt3.pdf

[82] For this purpose, LOB reserve risk equals reserve value times reserve risk factor. LOB premium risk equals premium value times premium risk factor plus expenses minus 100%. The PCF and LCF are calculated using LOB-risk rather than LOB-volume. For premium risk, implementation of this method requires expense information by LOB.

[83] HHI equals the sum of the squares of the LOB shares of total. For example, if there is only one LOB, HHI is 1.0, as is the case for the CoMaxLine%. With two lines split 25% and 75% HHI is 0.25^2 plus 0.75^2 or 0.625 compared to the CoMaxLine% of 0.750, i.e., HHI shows more diversification. With three lines split 50%, 25% and 25% HHI is 0.50^2 plus 0.25^2 plus 0.25^2 or 0.375, more diversification than the CoMaxLine% of 0.5. With two lines split 50% and 50% HHI and the CoMaxLine% are both 0.5.

complex than the CoMaxLine% because it reflects diversification across the 2nd, 3rd, 4th, etc., largest LOBs.[84]

Alternatives Considered by DCWP

Thus, the DCWP Reports considered the following alternatives to the CoMaxLine%-Volume approach:

- the Correlation Factor approach,
- the CoMaxLine%-Risk approach, and
- the HHI approaches: HHI-Volume and HHI-Risk.

Meaningful Differences?

For each company filing a 2010 Annual Statement, DCWP calculated the all-lines premium and reserve risk values, using the 2010 RBC Formula, for each company and for each of the five diversification approaches.[85] From these, DCWP computed the combined RBC UW Risk Value for each company.[86]

In the following discussion, we categorize changes in UW Risk Values as:

- Small (<5%)
- Other (≥5% and ≤ 10%)
- Moderate (10-25%)
- Large (>25%)

In comparing any two methods, we select the parameters so that the industry total diversification is the same for both methods.[87]

In our discussion, we focus on the differences we call Small, Moderate and Large.

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[84] The HHI is sometimes applied to only the n-th largest segments, e.g., the degree of diversification among the top ten LOBs. The HHI index applied to the single largest segment would be very similar to the CoMaxLine%. HHI can be written as p_1^2+p_2^2+p_3^2…+p_n^2. The truncated HHI limited to one element would be p_1^2. CoMaxLine% is p_1. HHI is always less than or equal to CoMaxLine%.

While HHI can CoMaxLine% may distribute the diversification credit differently among companies, the total diversification credit depends on MDC-HHI and MDC-CoMaxLine%. Those can be selected to achieve the same total diversification credit.

[85] DCWP Report 13 Appendix 1 describes how DCWP approximated the RBC UW Risk Value using public data.

[86] The RBC UW Risk Value for this purpose equals the square root of (a) the reserve risk value squared plus (b) the premium risk value squared. The reserve risk does not include the portion of reinsurance credit risk that is included in R4.

[87] Using the same total diversification for all methods is appropriate because the indicated total diversification is the ratio of modeled risk value before diversification compared to observed risk value. Those two are the same regardless of the diversification model, to the extent that different methods produce similar size/diversification bands, as the DCWP works showed in plausible. This is the indicated diversification we show in Box 3 of Tables 5-2A and B of this Report.

CoMaxLine% versus Correlation Factor

Applying the correlation approach requires a set of pairwise correlation factors. Calibrating those factors based on experience is a major undertaking, perhaps beyond the limits of available data.

In 2010, Solvency II Standard Formula addressed this problem in calibrating Correlation Factors as follows:[88]

- There were 12 LOBs and, therefore, 66 correlation factors.
- Each of the 66 correlation factors was selected to be either 0.25 or 0.50, based on expert judgment on whether each pair was more or less correlated.

The objective of DCWP work was to compare the CoMaxLine% to the Correlation Factor approach, as applied in a standard formula such as RBC. Therefore, regardless of the limitations of the Solvency II correlation factor calibration, DCWP followed that approach and constructed a set of pairwise correlation factors,[89] selecting values of 25% or 50% for most of the 171 LOB-pairs.

Appendix 3-Exhibit A3-1, below, shows the difference in diversification credit and UW RBC Values identified by DCWP.[90] We discuss the main differences below.

% Change in Diversification Credit (A. Div Credit Impact)

- There are large changes in diversification credit for 48% of companies, but those are concentrated in the least diversified bands.[91] For example, 81% of companies in the least diversified 20% showed large changes, but only 6% of the most diversified 20% did.

% Change in RBC UW Risk Value (B. RBC UW Risk Impact)

- Since companies receiving the large changes in diversification credit had low diversification credit levels, the overall effect on RBC UW Risk Value is small.
    - No companies experienced large changes in RBC UW Risk Value.
    - Only 10% experienced moderate changes—mostly companies in the 40th to 80th percentile diversification bands.

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[88] The Solvency II approach to selecting is described in Groupe Consultatif Actuariel Europeen, Diversification, Technical paper, 31 October 2005, pg. 11, and shown in "Advice for Band 2 Implementing Measures on Solvency II: SCR Standard Formula Article 111(d) Correlations," (former Consultation Paper 74), January 2010, pp 39-44, pg. 26.

[89] DCWP modified select pairwise correlations for LOBS possibly highly correlated: 100% between claims-made and occurrence medical malpractice and between general liability, special liability, and products liability; and 75% between special property and homeowners, between private passenger automobile liability and automobile physical damage and between commercial automobile liability and automobile physical damage.

See DCWP Report 13, Appendix 1 for further details on the construction of the DCWP Correlation Matrix.

[90] In comparing CoMaxLine%-Volume to the Correlation Factor method, DCWP used a CoMaxLine%-Volume MDC of 39.1% to produce the same total diversification credit as produced by the selected correlation factors.

[91] The fact that larger differences arise for companies with low diversification is important.

For example, if the diversification credit is 1% of risk, and if the differences between the two methods are 100%, the impact on risk is only 1%.

On the other hand, if the diversification credit is 10% of risk, and if the difference between the two methods is 100% the impact on risk is 10%, 10 times larger.

- Only 3% of the most diversified 20% had changes in the moderate category.
- Across all companies, 69% had changes below 5%.

Appendix 3 – Exhibit A3-1
CoMaxLine%-Volume versus Correlation
% of Multi-Line Companies with Large, Moderate, or Small change in Diversification Credit or UW Risk RBC Value

% Change		A. Div Credit Impact				B. RBC UW Risk Impact				
		All Div band	Least Div 0-20%	Most Div 80-100%		All Div band	Least Div 0-20%	Div 20%-40%	Div 40%-80%	Most Div 80-100%
>25%	Large	48%	81%	6%		0%	0%	0%	0%	0%
>10%	Moderate	71%	90%	28%		10%	2%	6%	20%	3%
<5%	Small	14%	3%	34%		69%	96%	59%	57%	78%

Yellow highlight on the values noted in the discussion above.

CoMaxLine%-Risk versus Correlation Factor[92]

One of the differences between CoMaxLine%-volume and Correlation is the use of premium by LOB versus risk by LOB. To test the extent to which that difference affected the comparison of CoMaxLine% to correlation, DCWP repeated the analysis for CoMaxLine%-Risk versus the Correlation Factor method. Appendix 3-Exhibit A3-2, below, shows the results.

The values in Exhibit A3-2 are lower than the corresponding values in Exhibit A3-1, indicating the CoMaxLine%-Risk is a step "towards" the Correlation Factor method.

Appendix 3 – Exhibit A3-2
CoMaxLine%-Risk versus Correlation
% of Multi-Line Companies with Large, Moderate, or Small change in Diversification Credit or UW Risk RBC Value

% Change		A. Div Credit Impact				B. RBC UW Risk Impact				
		All Div band	Least Div 0-20%	Most Div 80-100%		All Div band	Least Div 0-20%	Div 20%-40%	Div 40%-80%	Most Div 80-100%
>25%	Large	42%	74%	2%		0%	0%	0%	1%	0%
>10%	Moderate	65%	84%	21%		7%	0%	4%	15%	2%
<5%	Small	21%	4%	51%		76%	98%	67%	65%	84%

Yellow highlight on the values noted in the discussion above.

CoMaxLine%-Volume versus HHI-Volume[93]

DCWP found only small differences in RBC UW Risk Value between CoMaxLine%-Volume and HHI-Volume. For more than 97% of companies, the effect is less than 5%. The effect is below 10% for all companies.

[92] In comparing CoMaxLine%-Risk to correlation factor, DCWP used a CoMaxLine%-Risk MDC of 44.4% to produce the same total diversification credit as produced by the selected correlation factors.

[93] In comparing the CoMaxLine% approach to the HHI approach, DCWP used a CoMaxLine% MDC of 37.7% to produce the same total diversification credit as the HHI approach with MDC of 30%.

Accuracy

Subject to random variation, a perfect diversification model would result in a uniform indicated total diversification credit,[94] across the 9 cells (C3-E5) in Table 5-3.[95]

To measure accuracy, DCWP calculated the standard deviation and the absolute difference ("absolute error") in MDC values across the 9 cells, around the average for those 9 cells, for each of four methods. Appendix 3-Exhibit A3-2, below, shows these absolute error results.

For premium risk, CoMaxLine%-Risk has the lowest error. For reserve risk, the Correlation Factor approach has the lowest error. The differences in error measures between the "best" and worst" methods are as follows:

- 0.7% of premium between the best and worst approaches for premium risk,
  (0.9% CoMaxLine%-Risk best versus 1.6% Correlation Factor worst)
- 1.0% of reserves between the best and worst approaches for reserve risk.
  (1.9% for Correlation Factor, the best, versus 2.9% for CoMaxLine%-Volume, the worst)

Appendix 3 – Exhibit A3-3[96]
Absolute Error as a Percentage of Reserves or Premium (C3-E5)

Dependency Method	Premium	Reserves
CoMaxLine%-Volume	1.1%	2.9%
Correlation	1.6%	1.9%
HHI-volume	1.1%	2.1%
CoMaxLine%-Risk	0.9%	2.3%

Yellow highlight for the smallest absolute error among these methods.

These differences are approximately 5% of premium and reserve risk,[97] which is not large considering that:

- The errors represent a reallocation of the overall diversification credit rather than a change in the overall diversification level; and
- The effect is smaller than the impact of adopting the indicated MDCs, which would reduce premium risk values by 10% and reserve risk values by 20%.

Theoretical Considerations – Correlation Factor Approach

The Correlation Factor approach is commonly applied in individual company economic capital models. However, the underlying assumptions do not translate well to standard formulas such as the RBC Formula, as we explain below.

[94] Represented as a constant indicated MDC for CoMaxLine% approaches. Represented as a constant indicated change in the average level in the Correlation Factor approach.

[95] Table 5-3 is a copy of Part 5 of Tables A5-2A and A5-2B.

[96] DCWP Report 14, Table 4-2. Highlight added for emphasis.

[97] Average indicated risk charges, after IIA, before diversification and before growth risk or loss-sensitive contracts is 13.5% for premium and 20.2% for reserves (from Report 2, Table 1-1).

Individual Company Capital Model Calibration: Grounded in Risk Theory

In an individual company capital model (ICCM), each LOB has a company-specific risk distribution, reflecting its underwriting, claims, reinsurance, and other practices. To produce the all-lines risk distribution, these company-specific LOB risk distributions are aggregated using empirically-derived or expert judgment-based correlations.

RBC Calibration: Grounded in Risk Classification

Unlike the ICCM, the RBC Formula is calibrated from, and applies to, a heterogeneous population of insurers. The ICCM risk correlation assumptions do not apply.

Variation in Risk within LOB

Consider Company 1A (writing LOB A), Company 1B (writing LOB B), and Company 2 (writing LOBs A and B). Company 2 is more diversified than either Company 1A or Company 1B. Risk theory suggests that the risk charge for Company 2 should be lower than the sum of the risk charges for Company 1A plus Company 1B, depending on the degree of correlation between the LOBs.

However, that expectation assumes that the risk distributions for LOBs A and B in Companies 1A and 1B are the same as the risk distributions for LOBs A and B in Company 2, respectively.

That assumption is not routinely valid.

Variation in Risk within LOB by Type of Company

Specifically, DCWP[98] examined premium risk distributions by type of company and found variation in risk distributions for any given LOB by Type of Company.[99] For example:

- Personal Lines specialists[100] had "lower" risk[101] for PPA or HO than did more diversified insurers writing the same LOBs.

  Therefore, an insurer writing multiple LOBs may have a diversification benefit, but that benefit may be offset by the higher LOB risks (for the same LOBs) for the non-specialized (diversified) insurer compared to the "specialist."[102]

[98] Report 8 - Risk-Based Capital (RBC) Premium Risk Charges—Differences in Premium Risk Charge by Type of Company.

[99] Type of Company is defined in footnote 12.

[100] A company is a Personal Lines specialist if more than 50% of written premium is in the HO, PPA and Auto Physical Damage LOBs.

[101] We use the phrase 'lower/higher risk to mean that the 87.5th percentile LR or RRR is lower/higher for one distribution compared to another. (Note: Note that higher or lower risk does not mean higher or lower profitability.)

[102] The higher risk distribution for companies writing multiple LOBs can have various causes. These possible causes include: (a) a benefit from specialization; (b) 'specialists' write a different type of business within a single LOBs, e.g., personal use automobiles in a specialist Personal Lines writing and vehicles used for business in a multiline insurer; and (c) possible higher policy limits and higher reinsurance retention in a diversified insurer than in a specialist insurer.

- Reinsurers often have diversified portfolios. This includes the proportional business that is reported in the LOBs based on the underlying ceded business and the non-proportional business reported in LOBs N, O, or P.[103]

  However, the reinsurer's proportional business is 'riskier' than 'average' business in those LOBs. Hence, some of the diversification benefit is offset by the higher-than-average risk level of that additional business.

Thus, the effect of 'risk theory' diversification, while real, can be offset by the higher LOB-specific risk levels of that additional business.

Variation in Risk within LOB – A general feature of UW Risk

These are two high-level examples that can be identified from Annual Statement data. The issue is deeper, in that within each of the publicly reported LOBs, there are many UW sub-segments. A company that appears "diversified" between LOBs may be diversified into sub-segments that have higher or lower than average risk. Thus, companies that look 'diversified' may or may not warrant a credit for that diversification, depending on the areas of focus within their LOBs.

Risk Classification Provides a Better Conceptual Framework

We explained above that, given the risk distribution for average LOB A business and the risk distribution for average LOB B business, we cannot necessarily use a correlation approach to calculate the risk distribution for a company writing LOBs A and B.

Therefore, framing the analysis as a risk theory question is problematic. As an alternative, we frame the analysis in the context of risk classification and manual ratemaking.

Specifically, in the risk classification framework, calibrating dependency means measuring the extent to which companies writing more LOBs[104] have different indicated risk charges than companies writing fewer LOBs, after considering the risk by LOB (Line 4 Factors) and other factors considered in the RBC Formula.

In this Report, diversification calibration means:

- The total credit for diversification is empirically measured using the methods we show in Tables 5-2A and 5-2B. This measurement is analogous to calculating the statewide indicated rate levels in manual ratemaking.
- Diversification is a "risk characteristic" that can be used to classify companies by diversification level and then allocate diversification credits across companies using approaches such as CoMaxLine%, CoMaxLine%-Risk, and Correlation Factor. This is analogous to setting territorial boundaries and rate differentials.
- Not all risk characteristics are used in a particular risk classification system.

[103] In Schedule P, reinsurers are expected to allocate premiums, losses, and reserves for proportional business to LOBs based on the underlying LOB ceded by the primary insurer, LOBs other than N, O or P. LOBs N, O and P are used if the business cannot be allocated that way, i.e., for non-proportional business.

[104] More precisely, we measure diversification using CoMaxLine%, but that correlates to the number of LOBs written.

- The RBC Formula does not consider risk characteristics like company-size, Type of Company, or variations in LOB sub-segments of the Schedule P LOBs that are used in the RBC Formula.
- Instead, the calibration considers aggregates across the risk characteristics not included in the risk classification system, i.e., the RBC Formula.

- The Formula is intended to be reasonable enough overall, but will not be "exact" for any particular insurer.

Data Adequacy and Proportionality Considerations

Finally, as a practical matter, there will not be enough data for a data-driven calibration of the 87.5^{th} percentile level for every one of the 171 correlation factors (for 19 LOBs), separately for premium risk and reserve risk.

Moreover, 171 parameters is a disproportionate number of parameters compared to the number of parameters used for other aspects of the RBC Formula.

DCWP Conclusions

Based on the DCWP analysis of the impact of alternative formulas, the relative accuracy of the formulas, and the theoretical considerations, DCWP concluded:

- The CoMaxLine%-Risk approach may be better than the CoMaxLine% approach.
- Neither the Correlation Factor approach nor the HHI approach represents the data significantly better than the CoMaxLine% approach, for both reserve risk and premium risk.

Given the prior DCWP findings and this Committee's analysis of current data, this Committee prioritized the MDC calibration over further analysis of alternatives to the CoMaxLine% approach.

4. GLOSSARY

Glossary – Part 1

Term	Definition/Description
10x11 size/diversification bands	Company data reflecting 10 size deciles and 11 diversification (monoline plus 10 multiline) deciles
1x1 size/diversification band	Aggregate company data for size bands B through E and multiline diversification bands 1 through 5 (excluding monoline)
1x6 size/diversification bands	Aggregate company data for size bands B through E and each diversification band (monoline plus 5 multiline)
5x6 size/diversification bands	Company data reflecting 5 size quintiles and 6 diversification (monoline plus 5 multiline) quintiles
ACL	Authorized Control Level required capital from the RBC Formula: 50% of CAL.
AYUL	Accident Year Underwriting Loss, in dollars
AYUL%	Accident Year Underwriting Loss as a percentage of premium
CAL	Company Action Level: required capital value from the RBC Formula.
CoMaxLine%-Risk	Method of Measuring LOB Concentration reflecting Volume of Premium Risk or Reserve Risk Charges
CoMaxLine%	Company Maximum Line Percentage of Business
CoMaxLine% Approach	Method of Measuring LOB Concentration reflecting the Company's Maximum Line Percentage of Business
CoMaxLine%-Volume	Method of Measuring LOB Concentration reflecting Volume of Premiums or Reserves
Committee	American Academy of Actuaries Property and Casualty Risk-Based Capital Committee
Concentration Ratio or concentration index	LOB Concentration used in determining the company diversification grouping
Correlation Factor	Measure of “pairwise” LOB correlation (100% if two LOBs are fully correlated with each other)
Correlation Matrix	Matrix of all “pairwise” LOB correlations used to determine aggregate risk in Solvency II
DCWP or CAS DCWP	Casualty Actuarial Society (CAS) Dependency and Calibration Working Party
Diversification Credit	One minus Premium Concentration Factor or Loss Concentration Factor (for premiums and reserves, respectively)
Diversification index	One minus Concentration Ratio
Expense Ratio	2017 industry net expenses divided by net earned premium, from the 2017 Insurance Expense Exhibit, by LOB.
HHI	Herfindal-Hirschman Index of concentration reflecting relative volumes of all LOB Premiums or Reserves
HHI-Risk	Method of Measuring LOB Concentration reflecting Relative Volumes of all LOB Premium or Reserve Risk Charges

Term	Definition/Description
HHI-Volume	Method of Measuring LOB Concentration reflecting Relative Volumes of all LOB Premiums or Reserves
IIA	Investment Income Adjustment; Also referred to as Line 7/8.
Initial reserve	The reserve at the selected valuation date.
Initial Reserve Year	The year ending at the selected valuation date. This is usually the year of the least mature AY in the reserve, i.e., the initial reserve year for the reserves as of December 31, 1995, is 1995.
LCF	Loss Concentration Factor is measured as the largest of 19 RBC LOB reserves divided by total reserves.
Line 4 Factor	Risk factor, line in RBC Formula PR017, PR018.
Line 7/8 Factor	IIA, row in RBC Formula, PR017 (Line 8) and PR018 (Line 7).
LOB	Line of Business
LR	Loss Ratio, loss and all loss adjustment expenses divided by earned premium, net of reinsurance.
MDC	Maximum Diversification Credit included in the RBC Formula (currently 30%)
NOC	"NOC," standing for Not Otherwise Classified, means companies for which the portion of net written premium plus loss reserves is greatest for the sum of the following LOBs: G-SL, K-Fid/Sur, L-Other, M-Intl, or S-FG/MG. See definitions in Part 2 of this Glossary.
PCF	The Premium Concentration Factor is measured as the largest of 19 RBC LOB premiums divided by total premiums.
PR017	Page of the P&C RBC Formula that contains the main calculations for the reserve risk component of R4 UW Risk—Reserves.
PR018	Page of the P&C RBC Formula that contains the main calculations for the premium risk component of R5 UW Risk—Net Written Premium.
Premium IIA	Investment Income Adjustment for premium risk. Line 7 on page PR018.
Premium risk charge	Premium risk charge for LOBs generally.
Premium risk charge $_{LOB}$	Our analysis uses the simplified formula: Premium Risk Factor $_{LOB}$ * IIA $_{LOB}$ + Industry Average Expense Ratio $_{LOB}$ - 100%
Premium risk factor	Line 4 in RBC Formula PR018
R0	Part of the RBC Formula for Affiliated Insurance Companies and Misc. Other Amounts.
R2	Part of the RBC Formula for Equity Assets.
R4 or R4- UW Risk—Reserves	Part of the RBC Formula for UW Risk—Reserves RBC mainly using page PR017.
R5 or R5 - UW Risk—Net Written Premium	Part of the RBC Formula for UW Risk—Net Written Premium RBC, mainly using page PR018.
RBC	Risk-Based Capital

Term	Definition/Description
RBC Formula	Risk-Based Capital Formula promulgated by the NAIC for use in solvency monitoring of company Annual Statements.
R_{CAT}	Part of the RBC Formula that accounts for earthquake and hurricane premium risk.[105]
Reserve IIA	Investment Income Adjustment for reserve risk. Line 8 on page PR017.
Reserve Risk Charge	Reserve risk charge for LOBs generally.
Reserve Risk Charge $_{LOB}$	Our analysis uses the simplified formula: (1.0 + Reserve Risk Factor $_{LOB}$) * IIA $_{LOB}$ - 100%
Reserve Risk Factor	Line 4 in RBC Formula PR017
RRR	Reserve Runoff Ratio
TAC	Total Adjusted Capital as defined in the RBC Formula.
Ten-Year LOBs	LOBs for which Schedule P contains information on the most recent 10 AYs.
Two-Year LOBs	LOBs for which Schedule P (prior to 2024 AS) contains information on the most recent 2 AYs.
Working Group or NAIC Working Group	National Association of Insurance Commissioners' Property and Casualty Risk-Based Capital Working Group

[105] The NAIC P&C RBC Committee Catastrophe Risk (E) Subgroup annually publishes a catastrophe event list on its website to guide companies as to which events from the most recent 10 years should be included in their catastrophe experience disclosed in PR101, PR102, etc. These events include US and non-US earthquakes, hurricanes, and tropical storms, consistent with the perils modeled for R_{CAT} (August 2017 CIPR Newsletter).

Glossary Part 2 – LOB descriptions

(1)	(2)	(3)	(4)
Schedule P LOB Name	**RBC LOB Name (PR017 and PR018)**	**Schedule P Letter Code**	**Short Label**
Homeowners & Farmowners	H/F	A	HO
Private Passenger Auto Liability	PPA	B	PPA
Commercial Auto Liability	CA	C	CA
Workers' Compensation	WC	D	WC
Commercial Multiple Peril	CMP	E	CMP
Medical Professional Liability (Occurrence)	MPL OCCURRENCE	F1	MPL-O
Medical Professional Liability (Claims Made)	MPL CLMS MADE	F2	MPL-C
Special Liability (Note 1)	SL	G	SL
Other Liability: Claims Made and Other Liability: Occurrence	OL	H	OL
Special Property (Note 2)	SPECIAL PROPERTY	I	SP
Auto Physical Damage	AUTO PHYSICAL DAMAGE	J	APD
Fidelity & Surety	FIDELITY/SURETY	K	Fid/Sur
Other (Inc Credit, Accident & Health) (Note 3)	OTHER (INCLUDE CREDIT, A&H)	L	Other
International (Note 4)	INTL	M	Intl
Reinsurance: Nonproportional Assumed Financial and Reinsurance: Nonproportional Assumed Property	REIN PROPERTY & FINANCIAL LINES	N	Re-Prop
Reinsurance: Nonproportional Assumed Liability	REIN LIABILITY	O	Re-Liab
Product Liability: Claims Made and Product Liability: Occurrence	PL	R	PL
Financial & Mortgage Guaranty	FINANCIAL/MORTGAGE GUARANTY	S	FG/MG
Warranty	WARRANTY	T	Wrnty

The 19 RBC LOBs are a subset of the 22 Schedule P LOBs, which are a subset of the 45 Statutory Page 14 LOBs, plus write-in LOBs in the "Underwriting and Investment Exhibit Part 1 Premium Earned" section of the Annual Statement.

Note 1: Special Liability consists of Statutory Page 14 LOBs: Ocean Marine, Aircraft (all perils), and Boiler and Machinery (Statutory Page 14 LOBs 8, 22, and 27).

Note 2: Special Property consists of Statutory Page 14 LOBs: Fire, Allied Lines, Inland Marine, Earthquake, and Burglary and Theft (Statutory Page 14 LOBs 1, 2, 9,12, and 26).

Note 3: Other (Inc Credit, Accident & Health) consists of Statutory Page 14 LOBs: Group A&H, Credit A&H (group and individual), Other A&H, and Credit (Statutory Page 14 LOBs 13, 14, 15, and 28)

Note 4: LOB International consists of non-US business that cannot be identified by Statutory Page 14 LOB in the 2017 Annual Statement.