# P&C Risk-Based Capital — Calibration of Investment Income Offset

Report 15 of the CAS Risk-Based Capital (RBC) Research Working Parties
Issued by the RBC Dependencies and Calibration Working Party (DCWP)

**Abstract:** In this paper we describe a method of calibrating the Investment Income Offset element of the RBC Formula. Our key calibration decisions are the following:
1. We select the Present Value Approach rather than the Nominal Value Approach
2. We convert the current combination of interest rate safety margins and UW risk safety targets to an equivalent UW risk safety target with no interest rate safety margin.
In our calibration, for simplicity, we apply a single interest rate approach to all LOBs. In an actual calibration interest rates might vary by LOB, for example, longer duration interest rates for LOBs with longer payment patterns.
This is one of several papers being issued by the Risk-Based Capital (RBC) Dependencies and Calibration Working Party.
**Keywords:** Risk-Based Capital, Capital Requirements, Analyzing/Quantifying Risks

## 1. INTRODUCTON & TERMINOLOGY

The NAIC Property & Casualty RBC Formula ("RBC Formula") has six main risk categories, $R_0 - R_5$. Underwriting (UW) risk is represented in $R_4$ and $R_5$, reserve risk and premium risk, respectively. Appendix 1 describes all the elements of $R_4$ and $R_5$.[1]

The purpose of this report is to develop an approach to calibrating the Adjustment for Investment Income ("Investment Income Offset," "IIO," IIO_R for reserves, and IIO_P, for premium) element of $R_4$ and $R_5$, in response to changing interest rates.

<u>Terminology and Simplifications</u>

For our analysis we use the terms Premium Risk Factor (PRF), Reserve Risk Factor (RRF), Company UW Expense Ratio (CER), IIO_P and IIO_R which we define in our discussion of below.

<u>Reserve Risk Charge – $R_4$</u>

For each of the 19 RBC Lines of Business (LOB),[2] reserve risk $R_4$ is determined using an "Industry Loss and Expense RBC %" in RBC Formula, Form PR016, Line 4, a value

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[1] For a detailed description of the operation of the RBC Formula, Odomirok, et al, Chapter 19, Risk Based Capital https://www.casact.org/library/studynotes/Odomirok-etal_Financial-Reportingv4.pdf
For an older description of the formula and its original basis, see Feldblum, Sholom, NAIC Property/Casualty Insurance Company Risk-Based Capital Requirements, Proceedings of the Casualty Actuarial Society, 1996. For the actual formula, see NAIC, Risk-Based Capital Forecasting & Instructions, Property Casualty, 2010.

[2] The 19 RBC LOBs are the 22 Schedule P LOBs, with occurrence and claims made LOBs for other liability and products liability on a combined basis and non-proportional property and non-proportional financial on a combined basis, leaving a net of 19 LOBs.

applicable to all companies. We refer to this as the Reserve Risk Factor (RRF). The RRF is applied to the loss and loss adjustment expense reserve in the latest annual statement. For each company, we use a simplified version of the Reserve Risk Charge (RRC) by LOB defined as follows:[3,4]

$$RRC_{LOB,COMPANY} = \{(\text{Initial Reserve}_{LOB,COMPANY}) * [(1.0 + RRF_{LOB}) * IIO\_R_{LOB} - 1.0]\}$$

$$RRC\%_{LOB,COMPANY} = RRC / \text{Initial Reserve}_{LOB,COMPANY}$$

<u>Premium Risk Charge – $R_5$</u>

Similarly, for each RBC LOB, premium risk $R_5$ is determined using an "Industry RBC Loss and Expense Ratio", in RBC Formula, Form PR017, line 4, a value applicable to all companies. We refer to this as the premium risk factor (PRF). The PRF is applied to net written premium (NWP) for the most recent year in the latest annual statement. For each company, we define a simplified version of the Premium Risk Charge (PRC) by LOB as follows:[5]

$$PRC_{LOB,COMPANY} = \{\text{Net Earned Premium}_{LOB,COMPANY} * [PRF_{LOB} * IIO\_P_{LOB} + CER_{LOB,Industry\ Avg} - 100\%]\}$$

$$PRC\%_{LOB,COMPANY} = PRC / (\text{Net Earned Premium}_{LOB,COMPANY})$$

<u>Factors in 2010 RBC Formula</u>

Appendix 1/Exhibit 3 shows the PRF, RRF, IIO_P, and IIO_R values, by LOB, in the 2010 RBC Formula.

<u>Investment Income Offsets</u>

The stated purpose of the IIO element of the RBC Formula is to reflect the investment income that can be expected to be earned on assets corresponding to the unpaid claim reserves (reserve risk) and on assets arising from premium collected for new policies (premium risk) over the period that the related premium and reserve obligations are settled. In Statutory Accounting, this investment income is available to offset adverse reserve development or adverse underwriting results.[6] Mathematically, the IIOs are the premium and reserve discount

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[3] As if the own-company adjustment is 1.0, the loss sensitive contract adjustment is zero and there is no growth risk charge.

Also, for our analysis we use the company loss and defense and cost containment expense (DCCE) reserve rather than the reserve for loss and all loss adjustment expense.

We do not include the portion of $R_3$- Reinsurance Credit Risk that is included in $R_4$ in the RBC Formula.

[4] These simplifications are the way that the LOB risk factors have been calibrated in American Academy of Actuaries reports dealing with the calibration of UW risk factors.

[5] The simplifications in footnote 3 apply. In addition, for premium risk, the RBC Formula uses the all-lines CER by company. For our analysis, we use the industry average expense by LOB instead. Also, we use net earned premium (NEP) rather than net written premium (NWP).

[6] Feldblum, 1996, page 329 says, *Statutory accounting requires that loss reserves be reported at undiscounted values. The "implicit interest margin," or the difference between the discounted value of the reserves and the undiscounted value of the reserves, serves as an*

factors by LOB.

The effect of the IIO on the total RBC UW Risk Values in the 2010 RBC Formula is significant. In total, across all companies, the effect of the IIO is to reduce the premium risk charge by 34%, to reduce the reserve risk charge by 47%, and to reduce the total RBC UW Risk Values by 44%.[7,8] Thus, calibration of the IIO is significant for the RBC Formula results.

<u>Current Calibration of IIOs</u>

The IIOs in the 2010 RBC Formula were calibrated using claim payment patterns by LOB and an interest rate of 5%. The NAIC periodically adjusts the IIOs for more recent payment pattern data, but it has not changed the 5% interest rates assumption since the RBC Formula was developed in the early-1990s.

Table 1, below, shows interest rates for the period 1962-2013. From a calibration perspective, the notable features of this table include the following:

- The current interest rates are well below the interest rates in the 1990's when the IIO's were calibrated and when the NAIC selected the 5% interest rate, and
- The trend in interest rates since 1981 has been downward

In this paper we present an approach to updating the IIO calibration to reflect the change in interest rates over time.

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*implicit "cushion" for solvency. Not taking this implicit "cushion" into account would double-count the required capital: an explicit capital requirement held as surplus and an implicit capital cushion held as reserves.*

[7] For premium, the RBC risk value decreases from an average of 26.3% of premium, before the IIO adjustment, to 17.3% of premium after the IIO adjustment. For reserves, the RBC risk value decreases from an average of 36.9% of reserves, before the IIO adjustment, to 19.7% of reserves, after the IIO adjustment. See Appendix 1/Exhibit 3.

[8] These averages are based on 2010 industry total LOB net earned premium and net loss and loss expense reserve amounts, 2010 industry average expenses, with no adjustment for concentration/diversification, own-company adjustment, growth charge and loss sensitive adjustments. This calculation assumes the effect of the later three adjustments is proportional across LOBs and between premium risk and reserve risk. Combined premium and reserve UW risk value is based on premium and reserve risk values and the square root rule of the RBC Formula.

**Table 1**
**Annual Interest Rates by Year- 1962-2013**
**US Treasury Bonds / Durations of 3 years, 5 years and 10 years[9]**
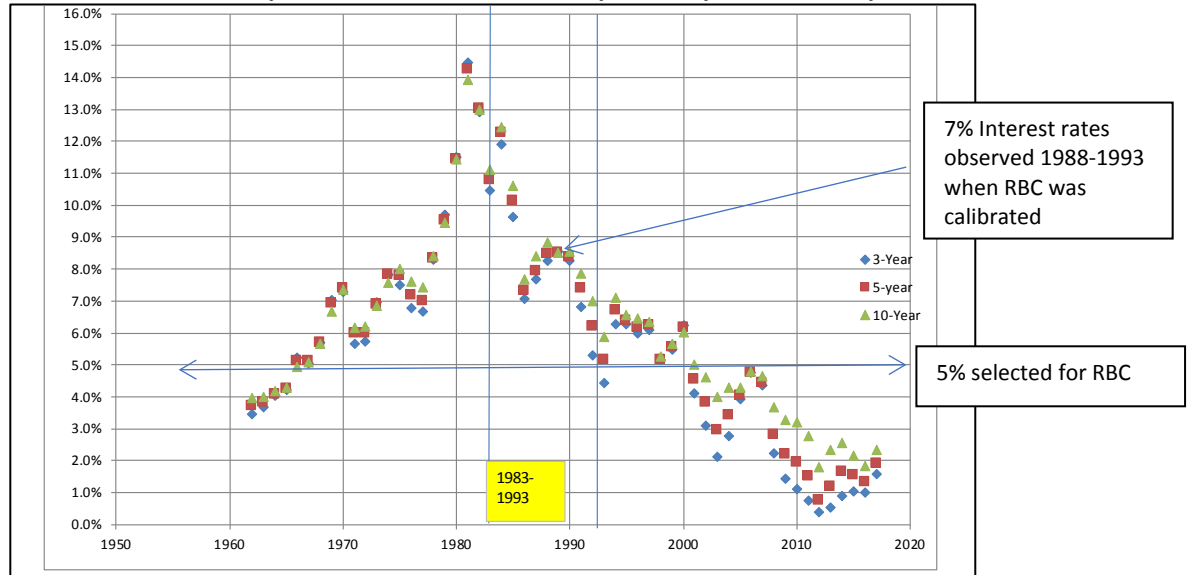


See data in Table 2, Section 2.2.2 below.

## 1.1    Assumed Reader Background and Disclaimer

This paper assumes the reader is generally familiar with the RBC Formula.

References to "we" and "our" mean the principal authors of this paper.

The "working party" and "DCWP" refer to the CAS RBC Dependencies and Calibration Working Party.

The analysis and opinions expressed in this report are solely those of the principal authors, and are not those of the authors' employers, the Casualty Actuarial Society, or the American Academy of Actuaries.

Nether the authors nor DCWP make recommendations to the NAIC or any other body. This material is for the information of CAS members, policy makers, actuaries and others who might make recommendations regarding the RBC formula.  In particular, we expect that the material will be used by the American Academy of Actuaries.

This paper is one of a series of articles prepared under the direction of the DCWP.

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[9] Federal Reserve website: http://www.federalreserve.gov/releases/h15/data.htm
Market yield on U.S. Treasury securities at 3-year, 5-year and 10-year constant maturity, annual rate by day, averaged over each year.

## 2. CALIBRATION APPROACH

### 2.1 Calibration Alternatives

A key aspect in the current calibration method is described in the 1993 Report on Reserve and Underwriting Risk Factors by the American Academy of Actuaries Property/Casualty Risk-Based Capital Task Force, page 17, as follows:

> *The current factors are based on nominal reserve development and nominal loss ratios. Separately, credit for the time value of money is given using a constant 5% interest rate. This approach overlooks the correlation between the level of interest rates and industry underwriting experience. Intuitively, it makes sense that during periods of high interest rates loss ratios will be higher, because market conditions force the companies to set their prices in anticipation of investment income. Since high interest rates often occur during high inflation periods, it also makes sense that reserve development will be worse during periods of high interest rates. Interest experience over the last ten years generally supports both of those hypotheses.[10]*

The 1993 American Academy of Actuaries Task Force proposed that premium and reserve risk factors be calibrated from discounted loss and loss adjustment expense ratios (LRs) and discounted reserve runoff experience. We refer to this as the Present Value Approach (PVA), in contrast the Nominal Value Approach (NVA) used in the calibration of the IIO and underwriting risk factors in the current[11] RBC Formula.

Thus, a key decision in the calibration is to determine whether to apply the NVA or the PVA.[12] In Section 2.2, below, we describe the data we use to test the NVA and PVA approaches. In Section 2.3 we test the NVA and PVA.

### 2.2 Data

To examine the two calibration approaches, we use claim payment patterns, interest rates, and risk data that we describe in the sub-sections below.

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[10] American Academy of Actuaries Property/Casualty Risk-Based Capital Task Force, Report on Reserve and Underwriting Risk Factors, May 1993, https://www.casact.org/pubs/forum/93sforum/93sf105.pdf

[11] As of the 2018 RBC Formula.0

[12] Still another approach to addressing investment income potential is to report reserves on a discounted basis, increasing reported capital rather than as an offset to risk. Solvency II uses the discounted reserve approach. Statutory Accounting and RBC do not use the discounted reserve approach.

The NVA and the discounted reserve approach are similar in treating risk levels and interest rates as independent variables. The PVA differs from both, in treating interest rates risk levels as being as related.

### 2.2.1 Payment Patterns

The NAIC uses the 1986 IRS payment pattern methodology in its IIO updates, the last[13] of which was completed in 2010 using 2007 data. We use the same IRS methodology, but we apply it using 2010 data. In Appendix 2, we show the resulting payment patterns, we show examples of how we use the patterns to determine IIOs, and we compare the IIOs at 5% interest with our indicated payment patterns to the current IIOs. Appendix 2/Exhibit 3 shows that our all-lines average LOB IIO's at a 5% interest rate are very similar to the IIO's in the 2010 RBC Formula. Hence, our updated payment patterns are very similar to the payment patterns underlying the IIOs in the current[14] RBC Formula.

There are more refined methods of calculating payment patterns, but we did not apply those in our work. Analysis of possible refinements is a matter of future research.

### 2.2.2 Selecting Interest Rates

To calculate discounted LRs the American Academy of Actuaries 1993 Report used 5-year duration US Treasury interest rates, less 2%,[15] for the year in which premium was earned. To calculate discounted reserve runoff values, the in the 1993 Academy RBC Task Force used interest rates for each accident year (AY) component of reserves for reserve risk equal to the interest rate in that AY LR.[16]

We consider using the interest rates selected in the following ways:

Duration

- 3-year, 5-year and 10-year duration US Treasury interest rates[17]

  Time Period
- The average interest rate[18] during the year that the premium was earned and the year of the initial reserve date, e.g., the 1989 average interest rate for 1989 AY LRs and for 1989 initial reserve dates (we refer to this period as "earned year" or "current year"),
- The average interest rate during the year prior to the year the premium was earned year, and the year prior to the initial reserve date e.g., 1988 for 1989 LRs and 1989 initial reserve dates (we refer to this as "prior year"). From the premium perspective,

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[13] Last update as of 2018.

[14] As of the 2018 RBC Formula.0

[15] The interest rate in the years that were considered in that 1993 analysis ranged from 7% to 14%. In recent years, interest rates are lower. Since 2008, interest rates for some durations in some years have been less than 2%. Subtracting 2% would produce a negative interest rate, which, while possibly appropriate, should be noted.

[16] https://www.casact.org/pubs/forum/93sforum/93sf105.pdf, page 17-18.

[17] From daily per annum interest rates at constant maturity.

[18] Arithmetic average of daily per annum rates for current year, prior year and December interest rates.

premium earned in 1989 would have been written partially in 1988 and rate decisions would have been made in 1988 or prior, and

- For reserve risk, in addition to current year and prior year interest rates, we considered the interest rate for the month of December of the initial reserve year, e.g., average for December 1989 for initial reserve year 1989.

Table 2, below, shows the US treasury interest rates at durations of 3-years, 5-years and 10-years, average by calendar year or by month of December within the calendar year. Table 1 is a graphical display of values from Table 2, columns 2-4.

**Table 2**
**Annual Interest Rates by Duration[19]**

| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|
| | Calendar Year Average | | | Average for Month of Dec. | | |
| Year | Duration | | | Duration | | |
| | 3 Year | 5 Year | 10 Year | 3 Year | 5 Year | 10 Year |
| 1978 | 8.3% | 8.3% | 8.4% | 9.3% | 9.1% | 9.0% |
| 1979 | 9.7% | 9.5% | 9.4% | 10.7% | 10.4% | 10.4% |
| 1980 | 11.5% | 11.4% | 11.4% | 13.6% | 13.2% | 12.8% |
| 1981 | 14.5% | 14.2% | 13.9% | 13.7% | 13.6% | 13.7% |
| 1982 | 12.9% | 13.0% | 13.0% | 9.9% | 10.2% | 10.5% |
| 1983 | 10.4% | 10.8% | 11.1% | 11.1% | 11.5% | 11.8% |
| 1984 | 11.9% | 12.3% | 12.5% | 10.6% | 11.1% | 11.5% |
| 1985 | 9.6% | 10.1% | 10.6% | 8.4% | 8.7% | 9.3% |
| 1986 | 7.1% | 7.3% | 7.7% | 6.4% | 6.7% | 7.1% |
| 1987 | 7.7% | 7.9% | 8.4% | 8.1% | 8.5% | 9.0% |
| 1988 | 8.3% | 8.5% | 8.8% | 9.1% | 9.1% | 9.1% |
| 1989 | 8.6% | 8.5% | 8.5% | 7.8% | 7.7% | 7.8% |
| 1990 | 8.3% | 8.4% | 8.6% | 7.5% | 7.7% | 8.1% |
| 1991 | 6.8% | 7.4% | 7.9% | 5.4% | 6.2% | 7.1% |
| 1992 | 5.3% | 6.2% | 7.0% | 5.2% | 6.1% | 6.8% |
| 1993 | 4.4% | 5.1% | 5.9% | 4.5% | 5.1% | 5.8% |
| 1994 | 6.3% | 6.7% | 7.1% | 7.7% | 7.8% | 7.8% |
| 1995 | 6.3% | 6.4% | 6.6% | 5.4% | 5.5% | 5.7% |
| 1996 | 6.0% | 6.2% | 6.4% | 5.9% | 6.1% | 6.3% |
| 1997 | 6.1% | 6.2% | 6.4% | 5.7% | 5.8% | 5.8% |
| 1998 | 5.1% | 5.2% | 5.3% | 4.5% | 4.5% | 4.6% |
| 1999 | 5.5% | 5.6% | 5.6% | 6.1% | 6.2% | 6.3% |
| 2000 | 6.2% | 6.2% | 6.0% | 5.3% | 5.2% | 5.2% |
| 2001 | 4.1% | 4.6% | 5.0% | 3.6% | 4.4% | 5.1% |
| 2002 | 3.1% | 3.8% | 4.6% | 2.2% | 3.0% | 4.0% |
| 2003 | 2.1% | 3.0% | 4.0% | 2.4% | 3.3% | 4.3% |
| 2004 | 2.8% | 3.4% | 4.3% | 3.2% | 3.6% | 4.2% |
| 2005 | 3.9% | 4.0% | 4.3% | 4.4% | 4.4% | 4.5% |
| 2006 | 4.8% | 4.7% | 4.8% | 4.6% | 4.5% | 4.6% |
| 2007 | 4.3% | 4.4% | 4.6% | 3.1% | 3.5% | 4.1% |
| 2008 | 2.2% | 2.8% | 3.7% | 1.1% | 1.5% | 2.4% |
| 2009 | 1.4% | 2.2% | 3.3% | 1.4% | 2.3% | 3.6% |
| 2010 | 1.1% | 1.9% | 3.2% | 1.0% | 1.9% | 3.3% |
| 2011 | 0.7% | 1.5% | 2.8% | 0.4% | 0.9% | 2.0% |
| 2012 | 0.4% | 0.8% | 1.8% | 0.4% | 0.7% | 1.7% |
| 2013 | 0.5% | 1.2% | 2.4% | 0.7% | 1.6% | 2.9% |
| 2014 | 0.9% | 1.6% | 2.5% | 1.1% | 1.6% | 2.2% |
| 2015 | 1.0% | 1.5% | 2.1% | 1.3% | 1.7% | 2.2% |
| 2016 | 1.0% | 1.3% | 1.8% | 1.5% | 2.0% | 2.5% |
| 2017 | 1.6% | 1.9% | 2.3% | 2.0% | 2.2% | 2.4% |

Market yield on U.S. Treasury securities at 3-year, 5-year and 10-year constant maturity, per annum rate by day, arithmetic average of daily rates per over each year for columns 2-4 and month of December for columns 5-7.

<u>Selecting Duration and Time Period for Our Calibration</u>

We use 3-year US Treasury interest rates by year by year in the PVA/NVA analysis in

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[19] Federal Reserve website: http://www.federalreserve.gov/releases/h15/data.htm

Section 3. For LRs we use the interest rates for the year that proceeded the year that the premium was earned. For the reserve runoff values, we use the interest rates for the year-ending 12 months before the initial reserve date. That is, for example, we used 1988 average interest rates to discount AY 1989 LRs and December 31, 1989 reserve runoff values. We refer to those interest rates as the "actual" interest rates by year.

In Appendix 3 we test the effect of alternative interest rates. Based on the material in Appendix 3, we believe that using the 3-year duration/prior-year average interest rates is reasonable overall, for purposes of this Report, although other choices would also be reasonable. Further research, as part of an actual calibration, could assess of the extent to which the selected interest rates should vary by LOB and/or vary between premium risk and reserve risk. The research could also examine the effect of using 1993 American Academy of Actuaries approach of discounting the reserve using separate interest rates for each AY component of the initial reserve amount.

### 2.2.3   Risk Data

We describe our risk data in DCWP Reports 6[20] and 7,[21] and we summarize the characteristics of that data below.

Our premium risk data consists of net earned premium (NEP) and LRs for AYs 1988-2010, net of reinsurance, at the latest available maturity from Schedule P, Part 1, in the 1997-2010 Annual Statements, by LOB and by company for individual companies and DWCP-defined group pools, as indicated.[22] Each LOB data point is the NEP and LR for a single AY and LOB for a single company or pool (LOB-Company-AY).

Similarly, the reserve risk data consists of the Initial Reserve amount (Initial Reserve[23]) reserve runoff ratios (RRRs) for initial reserve dates 1988-2009. The RRR for each initial reserve date is the ratio of (a) movement in incurred loss and defense and cost containment

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[20] http://www.casact.org/pubs/forum/13fforum/01-Report-6-RBC.pdf

[21] http://www.casact.org/pubs/forum/14wforum/Report-7-RBC.pdf

[22] The Risk Data points are filtered as we describe in DCWP Report 6 (on PRFs) and Report 7 (on RRFs). In brief, the main filters are that we exclude anomalous values; treat pool company data on a combined basis (DCWP-defined group pools); exclude Minor Lines data points (see Glossary); exclude the smallest LOBs data points, defined as those in smallest 15th percentile of LOB-size, by AY; exclude companies with less than 5 AYs of NEP; use values at the latest available maturity; and include companies regardless of whether they filed a 2010 Annual Statement (Survivorship Adjustment).

Those filters are largely the same as the filters used in the 2016 American Academy of Actuaries calibration report 2016 Update to Property and Casualty Risk-Based Capital Underwriting Factors http://www.actuary.org/files/publications/PC_RBC_UWFactors_10282016.pdf

[23] Reserve for loss and defense and containment expenses, but not including adjusting and other expenses.

expense (DCCE) from the initial reserve date to the most mature valuation date available, to (b) the Initial Reserve for loss and DCCE. The ratios in that RRR calculation are net of reinsurance, from Schedule P, Parts 2 and 3, in the 1997-2010 Annual Statements, by LOB and by company for individual companies and DWCP-defined group pools, as indicated.[24] Each LOB data point is the Initial Reserve amount and RRR from a single initial reserve date and LOB for a single company or pool (LOB-Company-Initial Reserve Date).

As we describe in DCWP Reports 6 and 7, using that data, the indicated PRFs by LOB are the 87.5th percentile value of LRs by LOB. The indicated RRFs by LOB are the 87.5th percentile of RRRs. We calculate all-year indicated risk factors using data from all years combined. We calculate year-by-year indicated risk factors using the risk data separately for each AY or reserve runoff year.

From indicated PRFs and RRFs we determine indicated PRC%s and RRC%s percentages, by LOB. The indicated PRC% equals the indicated PRF plus industry expense ratios, by LOB minus, 100%. The indicated RRC% equals the indicated RRF.

### 2.2.4  Discounted Risk Data

Using the payment patterns developed as described in 2.2.1, the 3-year US treasury interest rates, and alternative interest rates for sensitivity testing, we construct discount factors for LRs and RRRs, by LOB, by year. Appendix 2/Exhibits 1 to 2 show how we determine the discount factors for LRs and RRRs, respectively, using the NAIC 5% interest rate and using interest rates for sample years.

The discounted $LR_{COMPANY, LOB, YEAR}$ equal the $LR_{COMPANY, LOB, YEAR}$ multiplied by the discount factor. The discounted $RRR_{COMPANY, LOB, YEAR}$ equals $(1+RRR_{COMPANY, LOB, YEAR})$ multiplied by discount factor – 1.0. The indicated discounted $PRF_{LOB}$ and $RRF_{LOB}$ are the 87.5th percentile value of discounted $LR_{COMPANY, LOB, YEAR}$ or discounted $RRR_{COMPANY, LOB, YEAR}$.

From discounted PRFs and RRFs we determine indicated discounted premium risk charge

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[24] The Risk Data points are filtered as we describe in DCWP Report 6 (on PRFs) and Report 7 (on RRFs). In brief, the main filters are that we exclude anomalous values; treat pool company data on a combined basis (DCWP-defined group pools); exclude Minor Lines data points (see Glossary); exclude the smallest LOBs data points, defined as those in smallest 15th percentile of LOB-size, by AY; exclude companies with less than 5 AYs of NEP; use values at the latest available maturity; and include companies regardless of whether they filed a 2010 Annual Statement (Survivorship Adjustment).

The runoff ratio includes movement related to "all prior year" element of Schedule P.

Those filters are largely the same as the filters used in the 2016 American Academy of Actuaries calibration report *2016 Update to Property and Casualty Risk-Based Capital Underwriting Factors* http://www.actuary.org/files/publications/PC_RBC_UWFactors_10282016.pdf

percentages (PRC%) and indicated discounted reserve risk charge (RRC%) percentages. Discounted RRC% equals the discounted RRF as a percentage of reserves. Discounted PRC% equals the discounted PRF as a percentage of premium, plus industry expenses by LOB, minus 100%.

### 2.2.5   Important Caution Regarding Data Adequacy

Our interest rate data and our risk data include a single long period of declining interest rates. Therefore, any observed relationship between risk and interest rates may be due to long term trends in factors other than interest rates. We address the implication of this caution later in our analysis.

## 3.   INDICATED RISK CHARGE VARIATION WITH INTEREST RATES

NVA and PVA imply different relationships between risk charges and interest rates, as follows:

- The NVA is more applicable for calibration if indicated undiscounted risk charges, year-by-year, are independent of the interest rates.

  If this were the case, NVA indicated risk charges would vary only randomly when interest rates change.

- The PVA is more applicable for calibration if indicated risk charges vary with interest rates, higher when interest rates are higher and lower when interest rates are lower; such that indicated present value risk charges, year-by-year, are independent of interest rates.

  If this were the case, PVA indicated risk charges would vary only randomly when interest rates change.

Based on this understanding, we test which approach is better represented by the data. We first examine the private passenger automobile liability (PPA) and workers compensation (WC) LOBs, as examples. We then examine the extent to which the patterns from those two LOBs apply to other LOBs.

### 3.1 PPA and WC Examples

For PPA, Table 3 shows the actual interest rate by year, column 2, and the indicated nominal and discounted PRFs (column 3 and 4), corresponding PRC%s (column 5 and 6), the indicated nominal and discounted RRFs (column 7 and 8). and the corresponding RRC%

values (also columns 7 and 8).

**Table 3**
**PPA – Indicated Nominal and Discounted Risk Factors and Risk Charges by Year**

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|
| Year | Interest Rate | PRF | | PRC% | | RRF=RRC% | |
| | | Nominal | Discounted | Nominal | Discounted | Nominal | Discounted |
| 1988 | 7.7% | 1.048 | 0.933 | 30.1% | 18.5% | 24.6% | 11.5% |
| 1989 | 8.3% | 1.074 | 0.948 | 32.6% | 20.0% | 26.0% | 11.9% |
| 1990 | 8.6% | 1.069 | 0.939 | 32.1% | 19.2% | 23.9% | 9.6% |
| 1991 | 8.3% | 0.971 | 0.857 | 22.3% | 10.9% | 15.4% | 2.5% |
| 1992 | 6.8% | 0.968 | 0.871 | 22.0% | 12.4% | 13.7% | 2.9% |
| 1993 | 5.3% | 0.958 | 0.882 | 21.0% | 13.4% | 11.6% | 3.1% |
| 1994 | 4.4% | 0.942 | 0.878 | 19.4% | 13.0% | 13.3% | 6.0% |
| 1995 | 6.3% | 0.948 | 0.860 | 20.0% | 11.3% | 17.5% | 7.1% |
| 1996 | 6.3% | 0.929 | 0.844 | 18.2% | 9.6% | 19.6% | 9.1% |
| 1997 | 6.0% | 0.930 | 0.847 | 18.2% | 9.9% | 19.5% | 9.4% |
| 1998 | 6.1% | 0.897 | 0.816 | 15.0% | 6.8% | 14.0% | 4.2% |
| 1999 | 5.1% | 1.009 | 0.931 | 26.1% | 18.3% | 22.6% | 13.5% |
| 2000 | 5.5% | 1.103 | 1.013 | 35.6% | 26.5% | 33.5% | 23.0% |
| 2001 | 6.2% | 1.067 | 0.969 | 31.9% | 22.1% | 32.1% | 20.6% |
| 2002 | 4.1% | 1.035 | 0.970 | 28.7% | 22.2% | 23.3% | 16.0% |
| 2003 | 3.1% | 0.904 | 0.860 | 15.6% | 11.2% | 18.7% | 13.2% |
| 2004 | 2.1% | 0.855 | 0.827 | 10.8% | 7.9% | 8.8% | 5.3% |
| 2005 | 2.8% | 0.850 | 0.812 | 10.2% | 6.5% | 10.9% | 6.3% |
| 2006 | 3.9% | 0.858 | 0.806 | 11.1% | 5.9% | 13.9% | 7.4% |
| 2007 | 4.8% | 0.914 | 0.848 | 16.6% | 10.0% | 9.4% | 1.9% |
| 2008 | 4.3% | 0.931 | 0.869 | 18.3% | 12.1% | 11.2% | 4.1% |
| 2009 | 2.2% | 0.978 | 0.944 | 23.1% | 19.6% | 11.9% | 8.1% |
| 2010 | 1.4% | 0.973 | 0.950 | 22.5% | 20.2% | NA | NA |

Column 2 interest rate = 3-year US Treasury constant maturity interest rates average for year prior to year shown. For example, 1988 year shows 7.7% is interest rate. This is interest rate average for 1987 applicable to AY 1988 and initial reserve date 1988.
Appendix 1/Exhibit 3 shows the of nominal and discounted PRC, PRC% and RRC% with 2010 risk factors.

We show the Table 3 information graphically in Tables 4A and 4B, arrayed by interest rate rather than year, for premium risk and reserve risk, respectively. In each of Tables 4A and 4B the horizontal axis represents the annual interest rates; the vertical axis represents the year-by-year indicated PRC%/RRC%; and, each diamond-shaped point on the chart shows the indicated PRC%/RRC% compared to its annual interest rate, for premium risk and reserve risk respectively.

The graph on the left shows how undiscounted, i.e., NVA indicated risk charges vary with interest rates. The graph on the right shows how indicated discounted, i.e., PVA, indicated risk charges vary with interest rates.
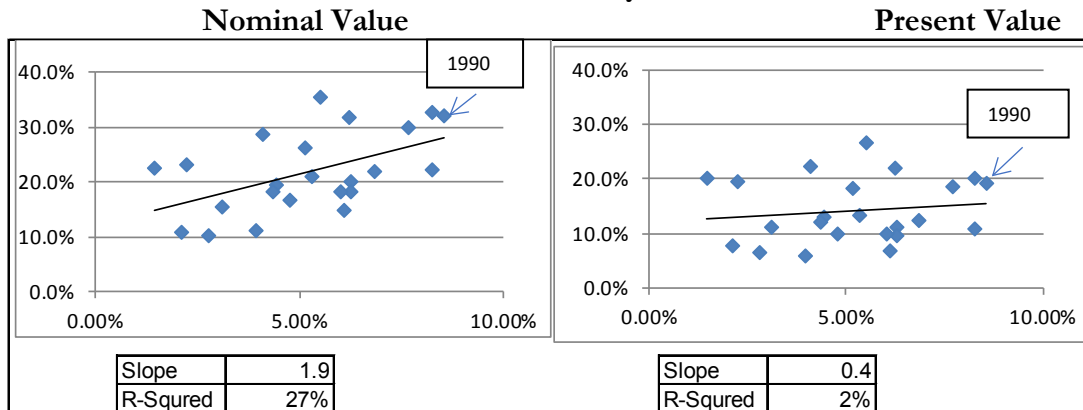
For example, as marked on Table 4A, for AY 1990 the interest rate we use is 8.6%.[25] The

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[25] Reminder, for 1990 we use the average interest rate for 1989 (the year prior to 1990) for 3-year duration US Treasury securities.

indicated PRC% with 1990 data is 32.1% on an NVA basis and 19.2% on a PVA basis. Thus, the NVA graph, on the left, includes the data point x=8.66% and y=32.1%, (8.6%, 32.1%) in coordinate notation. The present value graph, on the right, includes the data point x=8.6% and y=19.2%, (8.6%, 19.2%), in coordinate notation.

In the NVA indicated risk charge exhibit on the left of each Table, the line slopes upward showing that indicated PRC%s and RRC%s (Tables 4A and 4B, respectively) tend to increase as interest rates increases. In the discounted value indicated risk charge exhibit on the right side of each graph, the slope and R-squared values are much lower than for the NVA indicated PRC%s/RRC%s.

**Table 4A - - PPA- Premium Risk**
**Indicated PRC%s by interest rate**



| | Nominal Value | | Present Value | |
|---|---|---|---|---|
| Slope | 1.9 | | Slope | 0.4 |
| R-Squred | 27% | | R-Squred | 2% |

**Table 4B - PPA-Reserve Risk**
**Indicated RRC%s by interest rate**



| | Nominal | | Present Value | |
|---|---|---|---|---|
| Slope | 1.8 | | Slope | 0.2 |
| R-Squred | 24% | | R-Squred | 0% |
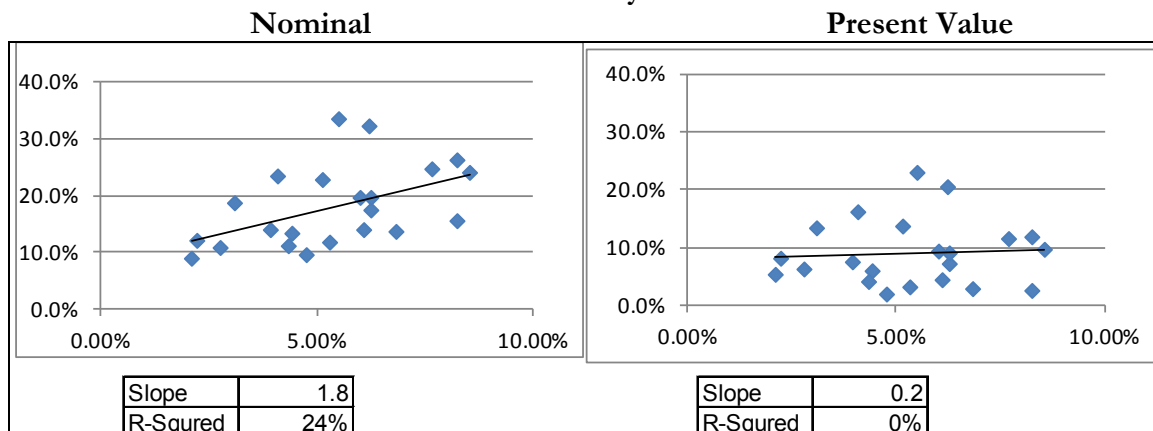
Tables 5A and 5B, below, show the same information for the workers compensation LOB. The workers compensation patterns are similar to the PPA patterns.

**Table 5A - Workers Compensation- Premium Risk**
**Indicated PRC%s by interest rate**

| Nominal | Present Value |
|---------|---------------|



| Slope | 3.0 |
|-------|-----|
| R-Squred | 17% |

| Slope | -0.2 |
|-------|------|
| R-Squred | 0% |
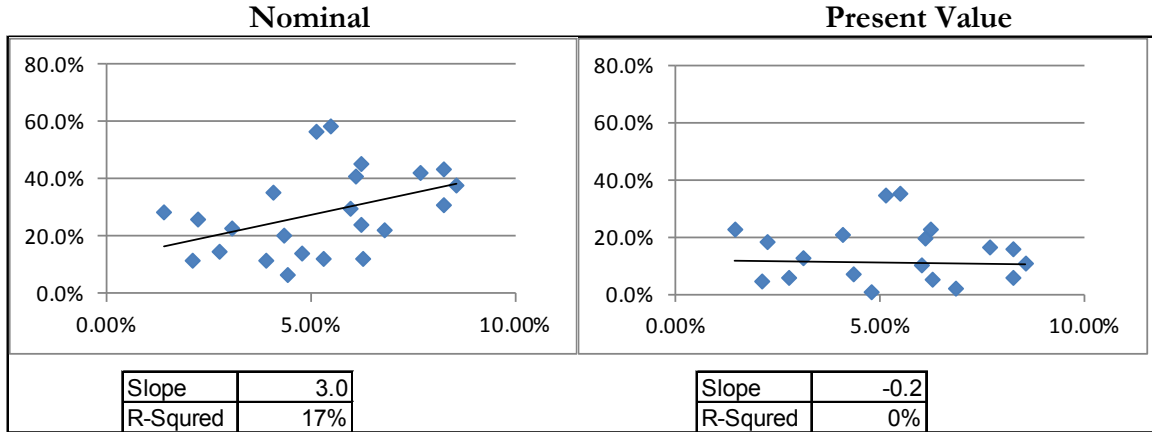
**Table 5B - Workers Compensation – Reserve Risk**
**Indicated RRC%s by interest rate**

| Nominal | Present Value |
|---------|---------------|



| Slope | 4.2 |
|-------|-----|
| R-Squred | 21% |

| Slope | -0.3 |
|-------|------|
| R-Squred | 0% |
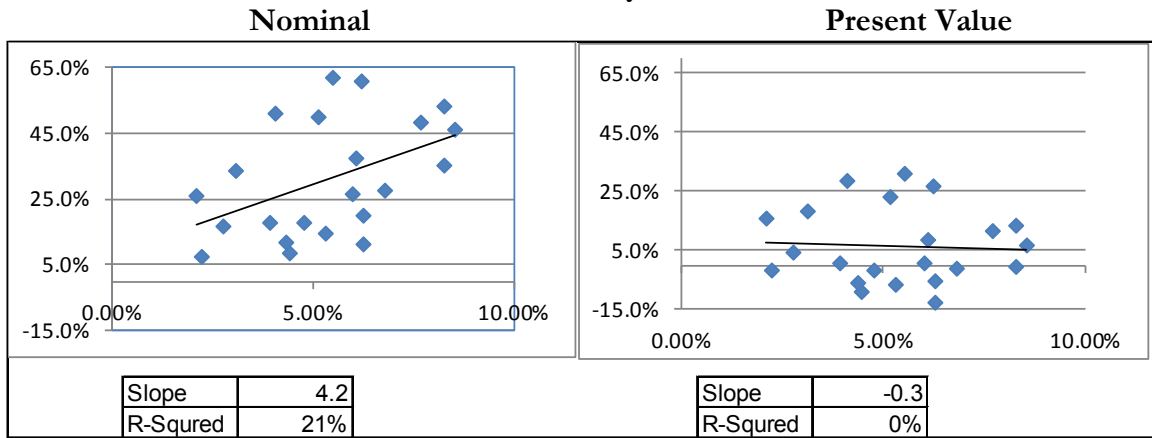
Thus, for PPA and WC, the data is more consistent with PVA than with NVA.

The upward slope in the NVA indications is an important consideration when calibrating risk factors for a low interest rate environment, as is currently the case. An NVA calibration based in multiple years of data would be satisfactory when the current interest rate is close to the interest rate typical during the risk data experience period, in our case 1988-2010. The indication would not be correct for a year when interest rates were higher than typical in the experience period. In that case the NVA indications, based on a 'typical' interest rate would be too low. For a year when interest rates were lower than typical in the experience period, the NVA indications, based on typical interest rates, would be too high.

### 3.2 Line-by-Line by Results

Tables 6A and 6B, below, for premium and reserves, respectively, show that the patterns

demonstrated above for PPA and WC apply to most LOBs. Columns (1) and (4) show the slope of NVA and PVA indicated risk charges. Columns (2) and (5) show the R-squared value for the regression of risk charge compared to interest rates, respectively. Columns (3) and (6) show the slope compared to the standard error of the slope, a measure of the statistical significance of the slope, respectively.

On the NVA basis, the slope is upward for nearly all LOBs. On the PVA basis the slope is more randomly up or down. Thus, the data overall, is more consistent with PVA than with NVA.

## Table 6
## Summary of Relationship of Indicated PRC% to interest rate
### Table 6A-Premium

| Lines of Business | Nominal | | | Discounted | | | 2010 |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | NEP % |
| | Slope | R-Sqr | Slope/ Std Err | Slope | R-Sqr | Slope/ Std Err | |
| A- Homeowners/Farmowners | 0.0 | 0% | 0.0 | (0.7) | 3% | (0.8) | 15% |
| B- Private Passenger Auto | 1.9 | 27% | 2.8 | 0.4 | 2% | 0.7 | 23% |
| C- Commercial Auto | 3.1 | 25% | 2.7 | 1.0 | 4% | 0.9 | 4% |
| D - Workers Compensation | 3.0 | 17% | 2.1 | (0.2) | 0% | (0.2) | 8% |
| E - Commercial Multi-Peril | 1.3 | 5% | 1.1 | (0.2) | 0% | (0.2) | 7% |
| F1 - Med Prof Liab-Occ | 1.9 | 1% | 0.6 | (3.7) | 9% | (1.5) | 1% |
| F2 - Med Prof Liab-CM | 2.0 | 2% | 0.7 | (1.1) | 1% | (0.5) | 2% |
| G - Special Liability | 4.6 | 32% | 3.1 | 2.5 | 15% | 1.9 | 1% |
| H - Other Liability | 1.3 | 3% | 0.7 | (1.8) | 8% | (1.3) | 9% |
| I - Special Property | 0.4 | 1% | 0.4 | (0.4) | 1% | (0.5) | 8% |
| J - Auto Physical Damage | 0.4 | 1% | 0.6 | 0.0 | 0% | 0.0 | 16% |
| K - Fidelity/Surety | (2.0) | 8% | (1.4) | (2.8) | 18% | (2.2) | 1% |
| L - Other | (0.6) | 3% | (0.8) | (1.5) | 15% | (1.9) | 2% |
| M - International | 8.1 | 7% | 1.3 | 5.0 | 3% | 0.9 | 0% |
| N&P - Reinsurance-Prop/Fin | 6.0 | 7% | 1.3 | 3.1 | 2% | 0.7 | 2% |
| O - Reinsurance-Liabiity | 6.0 | 12% | 1.7 | 1.0 | 1% | 0.4 | 1% |
| R - Products Liability | 1.9 | 1% | 0.5 | (2.1) | 2% | (0.7) | 1% |
| S - Financial/Mort Guarantee | NA | NA | NA | NA | NA | NA | NA |
| T - Warranty | NA | NA | NA | NA | NA | NA | NA |
| | | | | | | | |
| **Wtd Avg** | 1.36 | 10% | 1.25 | (0.22) | 3% | (0.16) | 1.00 |

### Table 6B-Reserves

| Lines of Business | Nominal | | | Discounted | | | % 2010 |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | Rsv |
| | Slope | R-Sqr | Slope/ Std Err | Slope | R-Sqr | Slope/ Std Err | |
| A- Homeowners/Farmowners | (0.0) | 0% | (0.0) | (1.4) | 13% | (1.7) | 4% |
| B- Private Passenger Auto | 1.8 | 24% | 2.5 | 0.2 | 0% | 0.2 | 17% |
| C- Commercial Auto | 1.7 | 11% | 1.6 | (0.5) | 1% | (0.5) | 4% |
| D - Workers Compensation | 4.2 | 21% | 2.3 | (0.3) | 0% | (0.2) | 21% |
| E - Commercial Multi-Peril | 6.2 | 33% | 3.1 | 2.7 | 11% | 1.5 | 7% |
| F1 - Med Prof Liab-Occ | (2.6) | 6% | (1.2) | (5.2) | 26% | (2.7) | 2% |
| F2 - Med Prof Liab-CM | (0.3) | 0% | (0.2) | (2.3) | 14% | (1.8) | 3% |
| G - Special Liability | 7.2 | 30% | 2.9 | 4.0 | 14% | 1.8 | 1% |
| H - Other Liability | 5.1 | 20% | 2.2 | 0.7 | 1% | 0.3 | 24% |
| I - Special Property | 0.7 | 2% | 0.7 | (0.1) | 0% | (0.1) | 2% |
| J - Auto Physical Damage | 1.6 | 4% | 0.9 | 1.0 | 2% | 0.6 | 1% |
| K - Fidelity/Surety | 2.8 | 2% | 0.6 | 1.0 | 0% | 0.2 | 1% |
| L - Other | 3.4 | 9% | 1.4 | 2.5 | 6% | 1.1 | 1% |
| M - International | 9.4 | 26% | 2.2 | 6.3 | 17% | 1.7 | 0% |
| N&P - Reinsurance-Prop/Fin | 10.7 | 44% | 4.0 | 7.2 | 31% | 3.0 | 1% |
| O - Reinsurance-Liabiity | 6.6 | 10% | 1.5 | 0.7 | 0% | 0.2 | 7% |
| R - Products Liability | 8.4 | 16% | 1.9 | 2.8 | 3% | 0.8 | 3% |
| S - Financial/Mort Guarantee | NA | NA | NA | NA | NA | NA | NA |
| T - Warranty | NA | NA | NA | NA | NA | NA | NA |
| | | | | | | | |
| **Wtd Avg** | 3.86 | 18% | 1.98 | 0.37 | 3% | 0.09 | 100.00% |

### Table 6C – Premium Plus Reserves

| Wtd Average | 2.78 | 15% | 1.67 | 0.11 | 3% | (0.01) |
|---|---|---|---|---|---|---|

LOBs S and T show NA and are not included in the averages as there is insufficient year-by-year data.

Because essentially no companies have an industry distribution by LOB, the weighted average is a summary, but does not represent a typical company.

### 3.3 Analysis and Summary – NVA or PVA

<u>Considerations Favoring NVA</u>

From a statistical perspective, the data for slope, R-squared and slope/standard error statistics, by LOB, and on average, from Table 6A and 6B, are not, by themselves, strong statistical proof that the interest rate is a significant explanatory variable.

Also, our data consists of a single long period of declining interest rates. Therefore, the pattern we observe may be due to factors other than interest rates that affected risk during the past 30 years. For example, if, during that period, there were improved company business controls on pricing and reserving and/or improved regulatory oversight, those improvements might have produced effects that would appear in the statistical tests as being related to interest rates.

Moreover, the effects we observe may be due to the downward trend in interest rates, rather than the absolute level of the interest rates.

<u>Considerations Favoring PVA</u>

However, patterns for some LOBs are notable. The R-squared value is over 15% for many of the larger LOBs, suggesting that the interest rate alone explains as much as 15% of the variability from year to year. Average value for slope/standard error of 2.0 at levels of statistical significance for one-tail (slopes greater than zero) hypothesis testing, for some LOBs. Moreover, the upward slopes for nominal risk charges are much greater than the slopes for discounted risk charges, consistently across LOBs.

Thus, most of the statistical evidence is more consistent with PVA rather than NVA.

Also, as explained in the 1993 American Academy of Actuaries Report, it is not surprising that the risk factors vary with interest rates. For premium risk, the relationship between interest rates and the 87.5$^{th}$ percentile LR might reflect the extent that pricing reflects investment earning potential. The relationship might reflect that rate adequacy is harder to achieve in high inflation rate environments that often occur in high interest rate environments. Similarly, for reserve risk, the relationship between interest rates and 87.5$^{th}$ percentile runoff ratios might reflect several factors. For example, it might reflect difficulties in reserve estimates in higher inflation environment that typically arise in higher interest rate environments; and it might reflect that reserve adequacy could follow the premium adequacy, in that reserves for the least mature AYs are often based on LRs.

<u>Our Calibration</u>

For our calibration we use the PVA for the following reasons:

- The PVA perspective is a plausible interpretation of risk experience.
- The statistics are more consistent with PVA than with NVA.
- Even if improvements in business controls and regulatory oversight were the drivers for the apparent relationship between interest rates and; risk, reflecting the business controls and regulatory oversight using change in interest rates as proxies is more accurate than ignoring the business and regulatory changes, as would be the case by using the NVA.
- As we show in the next section, NVA indications are for larger increases in risk charges than are PVA indications. Therefore, implementing indications on the PVA would be a step towards implementing the NVA, if the latter were, ultimately, proved more appropriate.

  Implementing and Updating Risk Factors with PVA

Calibration based on the PVA has the following implications with respect to the RBC Formula and future risk factor updates:

- Formula Impact of PVA - With the PVA, separate IIOs and risk factors are not required. A single risk factor could be used to represent the combined effect. However, in implementing the RBC Formula, the existing IIO structure could be retained, by splitting the indicated discounted risk factor into an IIO component and an undiscounted risk factors component, by LOB.
- Calibration Implications of PVA - Regardless of how the PVA were implemented, risk factors and payment patterns in the RBC Formula should be reviewed periodically. However, with PVA there is be no need to review the interest rate component of the formula, as the interest rates are reflected in the discounted risk data used in the calibration.

## 4. SELECTING THE TARGET SAFETY LEVEL

When the NAIC selected a 5% interest rate for the RBC Formula, the actual interest rate was higher than 5%. For example, interest rates averaged 7%[26] for the period 1988-1993. As a result, the safety margin effectively included in the UW risk charge in the original RBC Formula had two components:

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[26] The basis for the 5% selection is not documented.  The average interest rate for 1988-1993 was 6.9% and 7.3% for 3-year and 5-year duration US treasury securities, respectively. In the period 1980-1996 interest rates averaged over 9%, for all bond durations from 1 year to 10 years. (See Table 2)

- One component is the selection of the PRF/RRF safety level. We call that the UW margin, i.e., the 87.5th percentile, as we discussed in Reports 6 and 7 and in American Academy of Actuaries risk factor calibration reports, most recently in 2016.[27]
- The second component arises from the selection of the interest rate for the IIO, i.e., 5% selected versus 7% observed at the time.

In selecting interest rates for IIO calibrations, for either the NVA and the PVA, there are three regulatory choices for UW risk safety margins and interest rate safety margins:

| Option | UW Risk Safety Margin | Interest Rate Safety Margin[28] |
|---|---|---|
| 1 | 87.5th percentile | No interest rate safety margin |
| 2 | 87.5th percentile | Interest rate safety margin>0 |
| 3 | Greater than 87.5th percentile | No interest rate safety margin |

Among these options, Option 1 produces the lowest risk charges and the lowest target safety level. The target safety level would be lower than the safety level achieved by the original RBC calibration, with respect to UW and interest rate combined. On the other hand, there is no documentation to demonstrate that the interest rate difference was intended as a 'safety margin.' Perhaps the 5% was intended as a long-term value,[29] around which safety levels might vary from year to year. If so, the implicit safety effect may not have been intended, and, arguably, there is no reason to continue it.

Options 2 and 3 could be designed to produce equal overall safety levels[30] if we select the UW risk safety level in Option 3 to offset the interest rate risk margin in Option 2. Option 3 is less complex, in that it has fewer discretionary safety level parameters, i.e., an underwriting safety level rather than both an underwriting safety level and an interest rate safety margin. Also, Option 3 is more transparent in that safety levels are generally[31] described in terms of percentiles of outcomes, not as interest rate safety margins or a mixture of percentiles of outcomes and interest rate safety margins.

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[27] AAA 2016 report
http://www.actuary.org/files/publications/PC_RBC_UWFactors_10282016.pdf
[28] If there is an interest rate safety margin, its effect applies to both the NVA and PVA. In the NVA, the interest rate safety margin is reflected in the IIO value. In the PVA, the interest rate safety margin in reflected in the discount factors applied to calibration risk data.
[29] A current assessment of a long-term interest rate might be lower than the 5% selected about 25 years ago.
[30] Although the change in safety level would vary between LOBs.
[31] For example, in individual company capital models, in solvency II and regulatory capital formulas following solvency II.

## 4.1    Effect of Alternative Target Safety Levels-Options 1, 2 and 3

In Tables 7A and 7B, below, we compare PVA indicated risk charges by LOB, based on options 1, 2 and 3, with various interest rate safety margins and UW safety levels, for premium risk and reserve, respectively.

- We consider interest rates margins of 0%, 1%, 1.5% and 2%.[32] 2% being our estimate of the implicit interest rate safety margin when the underwriting risk factors and IIOs were first calibrated.
- We consider underwriting safety levels of 87.5%, 89% and 90%.

Tables 7A and 7B show the following:

- Regarding Option 1: Column 2 shows the indicated risk charges by LOB with an underwriting safety margin of 87.5% and actual interest rates by year with zero interest rate safety margin using the PVA.
- Regarding Option 2: Columns 3-5 show the indicated risk charges by LOB with an underwriting safety margin of 87.5% and actual interest rates by year minus interest rate safety margins of 1%, 1.5% and 2%, respectively, using the PVA.
- Regarding Option 3: Columns 6-9 show the indicated risk charges by LOB with zero interest rate safety margin with underwriting safety margins of 87.5% to 90%, as shown, using the PVA.

We observe the following:

- Column 2 values, "current years" rate less 0%," have the same values as the 87.5[th] percentile results in column 6, i.e., a 16.5% premium risk charge, as column 2 and column 6 are the same calculation.
- Columns 3 to 5 show that the indicated PRC%s and RRC%s (for example, the all-lines values of 18.6%, 18.9%, and 19.8% for premium risk) increase as we reduce the annual interest rate by increasing the interest rate safety margins from 1%, to 1.5% to 2% and UW safety margin of 87.5%.
- Columns 6 to 9 show that the indicated PRC%s and RRC%s (for example, the all-lines values of 16.5%, 17.3%, 19.0% and 20.7% for premium risk) increase as we increase the safety level from 87.5%, 88%, 89% and 90%, with zero interest rate safety margins.
- For all lines combined, the indicated PRC% and RRC% with interest rate safety

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[32] US Treasury rates since 2008 have often been lower than these safety margin. As such, the interest rate used in the present value calculation would sometimes be a negative number. That is not necessarily incorrect, but it is worth noting.

margins of 1.5% or 2% (the circled values in columns 4 and 5), are close to at the indicated PRC% and RRC% with 89%-90% safety level (the circled values in column 8 and 9).

Thus, the PVA calibration with a safety level of 89%-90% can be viewed as producing the same overall the target safety level in the original NAIC calibration considering both the UW margin and the interest rate safety margin.[33]

**Table 7 Re-Calibration of UW Risk Charges**
**Indicated Risk Charges at Various Safety Level Combinations**
**Table 7A – Premium**

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|
| | PV Indicated at 87.5th %-ile 3 Yr/Current Year Rates Less: | | | | PV Indicated at 3 Yr/Current Year Rates: At %-ile | | | |
| **Lines of Business** | 0% | 1% | 1.5% | 2% | 87.5% | 88.0% | 89.0% | 90.0% |
| A- Homeowners/Farmowners | 22.1% | 23.3% | 23.4% | 23.9% | 22.1% | 22.7% | 24.2% | 26.0% |
| B- Private Passenger Auto | 15.3% | 17.0% | 17.3% | 18.0% | 15.3% | 15.8% | 16.8% | 17.8% |
| C- Commercial Auto | 20.1% | 22.4% | 23.1% | 24.2% | 20.1% | 20.6% | 22.1% | 23.9% |
| D - Workers Compensation | 14.1% | 18.1% | 18.5% | 20.2% | 14.1% | 14.6% | 16.2% | 17.9% |
| E - Commercial Multi-Peril | 15.6% | 17.6% | 18.0% | 18.8% | 15.6% | 16.2% | 17.5% | 19.3% |
| F1 - Med Malp - Occ | 46.7% | 55.9% | 56.6% | 60.1% | 46.7% | 48.6% | 51.4% | 53.9% |
| F2 - Med Malp - CM | 27.6% | 32.7% | 33.2% | 35.1% | 27.6% | 28.7% | 31.0% | 33.2% |
| G - Special Liability | 21.6% | 24.0% | 24.2% | 25.1% | 21.6% | 22.2% | 24.3% | 27.3% |
| H - Other Liability | 14.3% | 18.3% | 19.3% | 21.2% | 14.3% | 15.2% | 17.5% | 20.0% |
| I - Special Property | 11.0% | 12.2% | 12.1% | 12.5% | 11.0% | 11.9% | 13.4% | 15.2% |
| J - Auto Physical Damage | 6.5% | 7.1% | 7.2% | 7.4% | 6.5% | 7.0% | 8.1% | 9.3% |
| K - Fidelity/Surety | 6.1% | 7.5% | 7.8% | 8.4% | 6.1% | 7.0% | 8.8% | 11.6% |
| L - Other | 24.2% | 25.4% | 25.6% | 26.1% | 24.2% | 24.7% | 26.3% | 27.7% |
| M - International | 18.0% | 21.6% | 20.5% | 21.4% | 18.0% | 18.8% | 20.2% | 21.7% |
| N&P - Reinsurance Prop/Fin | 36.2% | 39.5% | 40.0% | 41.3% | 36.2% | 37.1% | 39.7% | 43.4% |
| O - Reinsurance - Liabiity | 23.2% | 29.9% | 30.4% | 32.9% | 23.2% | 25.0% | 27.3% | 31.2% |
| R - Products Liability | 26.8% | 32.4% | 34.5% | 37.3% | 26.8% | 27.9% | 29.2% | 32.4% |
| S - Financial/Mort Guarantee | 60.0% | 63.0% | 64.8% | 66.5% | 60.0% | 68.3% | 83.5% | 88.1% |
| T - Warranty | 73.4% | 73.3% | 74.7% | 75.2% | 73.4% | 73.7% | 74.4% | 75.0% |
| | | | | | | | | |
| Average | 16.5% | 18.6% | 18.9% | 19.8% | 16.5% | 17.3% | 19.0% | 20.7% |

Note: Because essentially no companies have an industry distribution by LOB, the weighted average is a summary, but does not represent a typical company.

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[33] As the weighted average indicated risk factor is not necessarily the risk factor for the typical company, in an actual calibration this 'equivalence' test might be applied by type of company to examine whether there are types of company that are affected in an unexpected way.

**Table 7B – Reserve**

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|
| | PV Indicated at 87.5th %-ile 3 Yr/Current Year Rates Less: | | | | PV Indicated at 3 Yr/Current Year Rates: At %-ile | | | |
| **Lines of Business** | 0% | 1% | 1.5% | 2% | 87.5% | 88.0% | 89.0% | 90.0% |
| A- Homeowners/Farmowners | 13.9% | 15.3% | 16.0% | 16.8% | 13.9% | 15.1% | 17.1% | 19.2% |
| B- Private Passenger Auto | 9.1% | 10.7% | 11.5% | 12.4% | 9.1% | 9.8% | 11.5% | 12.9% |
| C- Commercial Auto | 22.5% | 24.6% | 25.7% | 26.8% | 22.5% | 23.4% | 25.6% | 29.1% |
| D - Workers Compensation | 8.3% | 12.3% | 14.4% | 16.5% | 8.3% | 9.2% | 11.0% | 13.8% |
| E - Commercial Multi-Peril | 30.6% | 33.4% | 34.9% | 36.4% | 30.6% | 31.9% | 34.6% | 37.8% |
| F1 - Med Malp - Occ | 11.6% | 14.8% | 16.4% | 18.1% | 11.6% | 13.5% | 17.3% | 20.2% |
| F2 - Med Malp - CM | -1.5% | 0.9% | 2.1% | 3.4% | -1.5% | -0.7% | 0.5% | 3.6% |
| G - Special Liability | 25.4% | 27.9% | 29.1% | 30.4% | 25.4% | 28.3% | 35.6% | 40.7% |
| H - Other Liability | 29.6% | 33.4% | 35.3% | 37.4% | 29.6% | 31.3% | 34.7% | 39.4% |
| I - Special Property | 24.1% | 24.9% | 25.3% | 25.8% | 24.1% | 25.7% | 29.6% | 32.9% |
| J - Auto Physical Damage | 9.7% | 10.3% | 10.5% | 10.8% | 9.7% | 11.8% | 15.2% | 18.9% |
| K - Fidelity/Surety | 39.0% | 40.8% | 41.7% | 42.6% | 39.0% | 41.7% | 50.2% | 56.3% |
| L - Other | 22.2% | 23.1% | 23.5% | 24.0% | 22.2% | 23.2% | 28.5% | 31.6% |
| M - International | 23.4% | 25.4% | 26.5% | 27.5% | 23.4% | 24.7% | 28.3% | 32.3% |
| N&P - Reinsurance Prop/Fin | 27.4% | 30.0% | 31.4% | 32.7% | 27.4% | 28.5% | 31.1% | 32.8% |
| O - Reinsurance - Liabiity | 33.4% | 38.7% | 41.7% | 44.6% | 33.4% | 35.8% | 40.4% | 43.2% |
| R - Products Liability | 52.9% | 57.8% | 60.2% | 62.8% | 52.9% | 55.2% | 58.1% | 64.6% |
| S - Financial/Mort Guarantee | -10.6% | -9.4% | -8.8% | -8.2% | -10.6% | -9.3% | -6.8% | -4.3% |
| T - Warranty | -16.8% | -16.4% | -16.2% | -15.9% | -16.8% | -16.5% | -16.0% | -15.5% |
| | | | | | | | | |
| Average | 18.3% | 21.3% | 22.8% | 24.5% | 18.3% | 19.6% | 22.3% | 25.5% |

Note: Because essentially no companies have an industry distribution by LOB, the weighted average is a summary, but does not represent a typical company.

## 4.2 Impact on RBC of alternative approaches to IIO calibration – Summary

Table 8, below, compares PVA indications for all lines combined from Table 7A and 7B, with 2010 factors and two NVA indications.

Rows 1-3 shows the combined premium and reserve risk factors using the 2010 RBC Formula values and two NVA indications, as follows:

Row 1: 2010 risk factors and IIOs

Row 2: Indicated risk factors and IIOs at 5% interest rate

Row 3: Indicated risk factors and IIOs at 0% interest rate

Rows 4-7 show risk charges based on PVA with UW safety margins of 87.5% to 90 %, and interest rate interest rates selected with interest rate margins of 0% or 2%.[34]

In each row, column 6 shows the total premium and reserve risk charge as a percentage of premium, derived from columns 4 and 5, premium risk and reserve risk, respectively. In each row, column 9 shows the change in total risk charge compared to the 'starting point' in row 1, 2010 risk factors and IIOs. Row 1, column 9 is 0.0% because that is the base for these

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[34] Table 8 Row 4-7 values are from Table 7A and 7B, columns 2, 5, 8 and 9, respectively.

comparisons. Row 2, column 9 equals -0.5% (1.319/1.320-1.0 as a percentage), is small, on average across LOBs, showing that using the new risk data and our selected payment patterns does not produce much overall change in risk charges.

Row 3, column 9, shows the result of an NVA calculation with a zero percent interest rate, based, say, on 2% interest rate and a 2% safety margin. Those assumptions imply an 85.8% increase from current risk charges. The row 3 assumptions are consistent with the original calibration of the RBC Formula, but, for the reasons described above, we do not believe that the NVA provides an appropriate measure of risk. The NVA indications will be too high when interest rates are low, as is currently the case, and too low when interest rates are high.

**Table 8**
**Impact of Changing Interest Rates on All-Line Average Indicated PRC%s and RRC%s Before Diversification**

| Row | Option | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Calibration Approach | | | Average Risk Charges | | | % Increase in RBC over Current | | |
| | | NAV/PVA | UW % | Interest Rate Safety Margin | PRC% | RRC% | Total% | PRC% | RRC% | Total% |
| | | A. Before Considering Changing Interest Rates | | | | | | | | |
| 1 | a | 2010 Factors | 87.5th | 5% IIO | 17.3% | 19.7% | 32.0% | 0.0% | 0.0% | 0.0% |
| 2 | b | NVA indicated | 87.5th | 5% IIO | 17.1% | 19.7% | 31.9% | -1.4% | -0.2% | -0.5% |
| | | B. After Considering Changing Interest Rates | | | | | | | | |
| 3 | c | NVA indicated | 87.5th | 0% IIO | 23.1% | 40.1% | 59.5% | 33.5% | 103.5% | 85.8% |
| 4 | 1 | PVA Indicated | 87.5th | 0% safety margin | 16.5% | 18.3% | 30.0% | -4.4% | -7.2% | -6.4% |
| 5 | 2 | PVA Indicated | 87.5th | 2% safety margin | 19.8% | 24.5% | 38.9% | 14.4% | 24.3% | 21.5% |
| 6 | 3 | PVA Indicated | 89th | 0% safety margin | 19.0% | 22.3% | 36.0% | 9.6% | 13.3% | 12.2% |
| 7 | 3 | PVA Indicated | 90th | 0% safety margin | 20.7% | 25.5% | 40.6% | 19.4% | 29.5% | 26.6% |

For each row, column 7= (1.0+ col 4) divided by (1.0+ column 74for row 1) – 1.0 as a percentage. Similarly, for columns 8 and 9, based on columns 5 and 6, respectively.

Total% in column (6) equals the square root of (column 4)$^2$ +(1.37 x column 5)$^2$, assuming reserves = 1.37 * premium based on 2010 industry totals.

Because essentially no companies have an industry distribution by LOB, the weighted average is a summary, but does not represent a typical company.

Column 9, Rows 4-7 show PVA calculations that produce changes in UW risk charges as follows:

- Row 4: A 6.4% decrease, using the PVA, with no interest rate safety margin.
- Row 5: 21.5% increase based on the PVA, an interest rate safety margin of 2% and an UW safety margin of 87.5%.
- Row 6:  12.2% increase based on the PVA, actual interest rates and an UW margin of 89%; and
- Row 7: 26.6% increase based on the PVA, actual interest rates and an UW margin of 90%.

Depending on regulatory selection of safety levels, the indicated increase to reflect current

interest rates, using the option 3 method of expressing safety margins, is an increase of 12.2% to 26.6%.

## 5. FUTURE RESEARCH

For simplicity in our PVA calibration, for each AY, we use a single interest for all LOBs, and we for each initial reserve date we use a single interest rate for all LOBs. We used the same "prior year/3-year duration interest rate" approach for both premium risk and reserve risk. Further research, could assess of the extent to which the selected interest rates should vary by LOB and/or vary between premium risk and reserve risk. The research could also examine the effect of using the 1993 American Academy of Actuaries approach of discounting the reserve using separate interest rates for each AY component of the Initial Reserve amount.

In our work, we used the IRS payment pattern methodology. Analysis of more refined methods would be useful.

The interest rate history includes years with a wide range of interest rates, which is helpful for our analysis. However, the risk data is from 1988 to 2010, a portion of a single period of falling interest rates. That means there is less certainty that our results would apply than if our calibration were based on multiple periods of rising/falling interest rates. An analysis of experience from earlier time periods, when interest rates were rising would be useful in testing the extent to which our calibration has been affected by the interest environment we used. In particular, it could re-test the NVA and PVA assumptions in a wider range of interest rate environments.

# 6. GLOSSARY

| Term | Interpretation |
|------|----------------|
| AY | Accident year |
| Data point | Each PRF data point is the LR for an AY, LOB and a single company or pool at the latest available maturity within the database.<br>Each RRF data point is the RRR for an initial reserve date, LOB and a single company or pool, at the latest available maturity. |
| DCCE | Defense and cost containment expenses<br>DCCE is called "Allocated Loss Adjustment Expenses" in older Annual Statements. In our analysis we treat DCCE and ALAE as equivalent. |
| DCWP | Dependency and Calibration Working Party |
| Formula<br>RBC Formula | The 2010 RBC Formula |
| IIO, IIO_P, IIO_R | Investment Income Offset, called Adjustment for Investment Income in the RBC Formula.<br>IIO_P for premium risk. IIO_R for reserve risk. |
| Initial Reserve | The loss and loss adjustment expense reserve amount, net of reinsurance, for the current and all prior AYs evaluated at the initial reserve date. |
| Initial Reserve Date | December 31$^{st}$ for the year specified (i.e., December 31, 2008 is the initial reserve date for the 2008 net loss reserve which includes AY's 2008 and prior) |
| LOB<br>RBC LOB | RBC uses 19 LOBs from the Annual Statement Schedule P. Schedule P shows 22 LOBs. RBC calculations treat occurrence and claims made LOBs for other liability (H1 and H2) and products liability (R1 and R2) on a combined basis and treats non-proportional property and non-proportional financial (N and O) on a combined basis, leaving a net of 19 LOBs. |
| LR | Ratio of net loss and all loss adjustment expense to net earned premium by AY |
| Minor lines | LOB whose data points are excluded due to LOB-size versus total company size |
| NAIC | National Association of Insurance Commissioners |
| PRC | Premium Risk Charge |
| PRC% | Premium Risk Charge as a percentage of premium |
| PRF | Premium Risk Factor |
| RBC | Risk-Based Capital |
| RBC Formula or Formula | The 2010 NAIC Property-Casualty RBC Formula |

| Term | Interpretation |
|---|---|
| RBC UW Risk Value | The Company Action Level amount calculated for the UW risk components of the RBC Formula for a company or group of companies. |
| RBC Value | The Company Action Level amount calculated from the RBC Formula for a company or group of companies. |
| Reserves or Loss Reserves | Case, bulk and IBNR loss and DCCE reserves net of reinsurance, as shown in Schedule P – Part 2 and 3, in our analysis. In the RBC Formula the Reserves include Adjusting and Other Expense. |
| RRC | Reserve Risk Charge |
| RRC% | Reserve Risk Charge as a percentage of initial reserve amount |
| RRF | Reserve Risk Factor |
| RRR Reserve Runoff Ratio Runoff ratio | The ratio of (a) incurred movement from the initial reserve date to the latest available evaluation date, for all constituent AYs combined, including "all prior year" reserve development to (b) the Initial Reserve. |
| UW | Underwriting |
| UW risk | Underwriting risk – the combination of premium risk and reserve risk. |

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## APPENDICES

## Appendix 1 - UW Risk — RBC Components $R_4$ & $R_5$

This Appendix describes the calculation of $R_4$ and $R_5$ risk values and the simplifications we use in our IIO analysis. The NAIC 2010 RBC Forecasting & Instructions publication and Odomirok, et al, 2014, provide further details on the RBC calculations.

$R_4$ – Reserves

The RBC charge for reserve risk, $R_4$, measures the susceptibility of loss reserves to adverse development.[35,36]

We describe, the calculation of the $R_4$ risk charge amount as follows: For each of 19 RBC LOBs,[37] we multiply the net carried loss and loss adjustment expense (LAE) reserve by the industry-RRF adjusted for the difference between company and industry experience; we reduce that result to recognize future investment income; and, we reduce it further with credits for the presence of loss-sensitive business[38] within a company's portfolio. We calculate the sum of the reserve risk RBC by LOB; we reduce that total to reflect diversification across the 19 LOBs; and we increase that value by the growth charge, if applicable. The result is further increased by a portion of the $R_3$-Reinsurance Credit Risk charge.

For each RBC LOB, Appendix 1/Exhibit 1 below shows the key items used in the calculation of $R_4$:

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[35] Feldblum, Sholom, "NAIC Property/Casualty Risk-Based Capital Requirements," Proceedings of the Casualty Actuarial Society, 1996, www.casact.org/pubs/proceed/proceed96/96297.pdf, page 324

[36] The reserve risk charge does not, measure the adequacy of reported reserves for the company. The assessment of reserve adequacy is addressed outside the RBC framework through measures including financial examinations, regulatory examinations, and the Statement of Actuarial Opinion provided by each individual company's appointed actuary.

[37] RBC UW risk values are determined using data in the Annual Statement Schedule P, which shows 22 LOBs. RBC calculations treat occurrence and claims made LOBs for other liability and products liability on a combined basis and treat non-proportional property and non-proportional financial on a combined basis, leaving a net of 19 LOBs.

[38] Loss sensitive business in that for which additional income can be collected by the insurer if experience is worse than bands specified in the contract. Detailed definitions are contained in the NAIC Annual Statement Instructions for Schedule P Part 7. Also, it is described in Feldblum, 1996 pages 344-349.

**Appendix 1/Exhibit 1**
**Components of Reserve Risk (R$_4$)**
**Line references are to RBC Form PR0016 in the 2010 RBC Formula**

| Item | Risk Element By LOB: | Description |
|---|---|---|
| 1 | Net Unpaid Loss and Loss Adjustment Expense (Lines 6 and 7) | The risk charge varies with the volume of the company's carried reserve, net of reinsurance, gross of all interest discount other than workers compensation tabular discount on indemnity claims. |
| 2 | Reserve Risk Factor (RRF) "Industry Loss and Expense RBC %", (Line 4) | A factor applied to all companies, selected by NAIC to represent the reserve risk at the desired safety level. |
| 3 | Factor to adjust for company reserve development experience that is better or worse than the industry (own-company adjustment), (Lines 1-3) | Compares the company reserve development over the most recent nine years with the reserve development for the average company.[39] |
| 4 | Adjustment for Investment Income, (also called Investment Income Offset for reserves, or IIO_R), (Line 8) | A factor applied to all companies, selected by the NAIC to represent the potential for investment income to offset adverse loss development. Based on 5% per annum investment return. |
| 5 | Adjustment for loss sensitive business (Lines 10, 11) | Reduces the risk charge if unfavorable experience can be offset by increases in income on loss sensitive business. |
|  | **For all LOBs combined:** |  |
| 6 | Loss Concentration Factor (LCF), (Line 14) | A discount for the extent to which company has a diversified distribution of reserves by line. |
| 7 | Growth charge (RBC Form PR0015) | For companies with premium growth in excess of 10% per year over the past three years. |
| 8 | Portion of reinsurance credit risk from R$_3$ (RBC Form PR0011) | 50% of R$_3$-reinsurance credit risk, if R$_3$-reinsurance credit risk is lower than the otherwise determined reserve risk.[40] Zero otherwise. |

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[39] Annually the NAIC determines the reserve development factor to be used by each company eligible to apply the own-company adjustment. The reserve development for the average company is the unweighted average reserve development of those companies, using the prior year's data.

[40] The 50% 'transfer' from credit risk to reserve risk applies only if the reserve risk without the Reinsurance Credit Risk component is larger than 50% of the reinsurance credit risk plus credit risk other than reinsurance credit risk, as is most often the case. Otherwise the entire R$_3$-Reinsurance Credit Risk charge is added to the R$_3$-Other Credit Risk charge.

In formula terms, the calculation is as follows:

$$R_4 = \{\sum [\text{Over all RBC LOBs}] (\text{Initial Reserve}_{\text{LOB,COMPANY}})* [((1.0+\text{RRF}_{\text{LOB}}*(3)_{\text{LOB,COMPANY}}) *\text{IIO\_R}_{\text{LOB}} -1.0)- (5)_{\text{LOB,COMPANY LOB}}]\}*\text{LCF}_{\text{Company}}*(7)+0.5*(8),$$

where items (3), (5) and (7) are defined in Appendix 1/Exhibit 1.

As we describe in Section 1, in this paper we make certain simplifications. We treat the own-company adjustment (Appendix 1/Exhibit 1 Line 3) as 1.0. We treat the reduction for loss sensitive business (Appendix 1/Exhibit 1 Line 5) and the growth charge (Appendix 1/Exhibit 1 Line 7) and as 0%. We do not include any of =the $R_3$-Reinsurance Credit Risk Charge (Appendix 1/Exhibit 1 Line 8). We use the reserve for loss and DCCE and rather than the reserve for loss and all loss adjustment expense. We do not use the LCF (Appendix 1/Exhibit 1 Line 6) because are analyzing risk charges by LOB.

We refer to the simplified portion of $R_4$ as $\text{RRC}_{\text{LOB}}$, defined as follows:

$$\text{RRC}_{\text{LOB,COMPANY}}=\{(\text{Initial Reserve}_{\text{LOB,COMPANY}})*[((1.0+\text{RRF}_{\text{LOB}})*\text{IIO\_R}_{\text{LOB}}-1.0)]\}$$

$$\text{RRC\%}_{\text{LOB,COMPANY}} = \text{RRR}_{\text{LOB,COMPANY}}/ \text{Initial Reserve}_{\text{LOB,COMPANY}}$$

### $R_5$ – Premium

The RBC charge for premium risk, $R_5$, measures the potential that the company's future business will be unprofitable. Because the volume of business that will be written during the year is unknown, the volume of the most recent calendar year is used as a proxy for future premium writings.[41]

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[41] Feldblum, "Risk Based Capital Requirements," 1996, pages 334-335.

We describe, the calculation of the $R_5$ risk charge amount as follows: For each of 19 RBC LOBs,[42] we multiply the NWP by the industry-PRF adjusted for the difference between company and industry experience; we reduce that result to recognize future investment income; and, we reduce it further with credits for the presence of loss-sensitive business[43] within a company's portfolio. The LOB $_{risk}$ charge is that result, plus the company all-lines operating expense ratio, less 100%. We calculate the sum of the reserve risk RBC by LOB; we reduce that total to reflect diversification across the 19 LOBs; and we increase that value by the growth charge, if applicable.

For each LOB, Appendix 1/Exhibit 2 below shows the key items used in the calculation of $R_5$.

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[42] RBC UW risk values are determined using data in the Annual Statement Schedule P, which shows 22 LOBs. RBC calculations treat occurrence and claims made LOBs for other liability and products liability on a combined basis and treats non-proportional property and non-proportional financial on a combined basis, leaving a net of 19 LOBs.

[43] Loss sensitive business in that for which additional income can be collected by the insurer if experience is worse than bands specified in the contract. Detailed definitions are contained in the NAIC Annual Statement Instructions for Schedule P Part 7. Also, it is described in Feldblum, 1996 pages 344-349.

**Appendix 1/Exhibit 2**
**Components of Premium Risk (R₅)**
**Line references are to RBC Form PR0016 in the 2010 RBC Formula**

| Item | Risk Element By LOB: | Description |
|---|---|---|
| 1 | Net written premium (NWP) (Line 8) | The risk charge varies with the volume of the company's net written premium in the latest year. |
| 2 | Premium Risk Factor (PRF) "Industry RBC Loss and Expense Ratio" (Line 4) | A factor applied to all companies, selected by NAIC to represent the premium risk at the desired safety level. |
| 3 | Factor to adjust for company LR experience that is better or worse than the industry (own-company adjustment), (Lines 1-3) | Compares the company LR over the most recent ten years with the LR for the average company.[44] |
| 4 | Company Expense Ratio (CER) | Other UW expenses for all LOBs combined. |
| 5 | Adjustment for Investment Income, (also called Investment Income Offset, or IIO_P) (Line 7) | A factor applied to all companies, selected by NAIC to represent the potential for investment income to offset unfavorable LRs. Based on 5% per annum investment return. |
| 6 | Adjustment for loss sensitive business (Lines 10 and 11) | Reduces the risk charge if unfavorable experience can be offset by increases in income on loss sensitive business. |
| | **For all LOBs combined:** | |
| 7 | Premium Concentration Factor (PCF), (Line 14) | A discount for the extent to which company has a diversified distribution of premium by line. |
| 8 | Growth charge (PR00015) | For companies with premium growth in excess of 10% per year over the past three years. |

In formula terms, the calculation is as follows:

$$R_5 = \{\sum \text{[Over all RBC LOBs]} (NWP_{LOB, COMPANY})*[PRF_{LOB}*(3)_{LOB,COMPANY}*IIO\_P_{LOB} + CER_{COMPANY} -100\%-(6)]\}*PCF_{LOB}*(8)_{LOB,COMPANY}$$

Where items (3), (6) and (8) are defined in Appendix 1/Exhibit 2.

As we describe in Section 1, in this paper we make certain simplifications. We treat the

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[44] Annually the NAIC determines the LR for each company eligible to apply the own-company adjustment. The LR for the average company is the unweighted average LR of those companies, using the prior year's data.

own-company adjustment (Appendix 1/Exhibit 1 Line 3) as 1.0. We treat the reduction for loss sensitive business (Appendix 1/Exhibit 1 Line 5) and the growth charge (Appendix 1/Exhibit 1 Line 7) and as 0%. We do not use the PCF (Appendix 1/Exhibit 2 Line 7) because are analyzing risk charges by LOB. We also use NEP rather than NWP.

We refer to the simplified portion of $R_5$ by LOB as the $PRC_{LOB}$, defined as follows:

$PRC_{LOB, COMPANY} = \{(NEP_{LOB,COMPANY}) * [(PRF_{LOB} * IIO\_P_{LOB} + CER_{Industry, LOB} - 100\%)]\}$

$PRC\%_{LOB, COMPANY} = PRC_{LOB, COMPANY} / NEP$

Appendix 1/Exhibit 3, below, shows the PRF, RRF, IIO_P, IIO_R. RC%s, PRC%s and RRC% values using the 2010 RBC Formula with our simplifications

**Appendix 1/Exhibit 3**
**2010 RBC Formula UW Risk Parameters**

| Line of Business | 2010 RBC Factors | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Premium | | | | | Reserves | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | PRF | IIO_P | 2010 Avg Co Exp | PRC% before IIO | PRC% (Discounted) | RRF/ RRC% before IIO | IIO_R | RRC% (Discounted) |
| A- Homeowners/Farmowners | 0.937 | 0.954 | 30.10% | 23.8% | 19.5% | 0.201 | 0.938 | 12.7% |
| B- Private Passenger Auto | 0.969 | 0.925 | 25.20% | 22.1% | 14.8% | 0.192 | 0.928 | 10.6% |
| C- Commercial Auto | 0.988 | 0.890 | 30.80% | 29.6% | 18.7% | 0.230 | 0.911 | 12.1% |
| D - Workers Compensation | 1.033 | 0.839 | 26.80% | 30.1% | 13.5% | 0.324 | 0.830 | 9.9% |
| E - Commercial Multi-Peril | 0.921 | 0.896 | 35.50% | 27.6% | 18.0% | 0.465 | 0.876 | 28.3% |
| F1 - Med Malp - Occ | 1.822 | 0.767 | 28.00% | 110.2% | 67.7% | 0.431 | 0.865 | 23.8% |
| F2 - Med Malp - CM | 1.092 | 0.827 | 28.00% | 37.2% | 18.3% | 0.306 | 0.883 | 15.3% |
| G - Special Liability | 0.904 | 0.898 | 34.40% | 24.8% | 15.6% | 0.257 | 0.890 | 11.9% |
| H - Other Liability | 1.042 | 0.816 | 30.30% | 34.5% | 15.3% | 0.511 | 0.852 | 28.7% |
| I - Special Property | 0.941 | 0.949 | 32.60% | 26.7% | 21.9% | 0.191 | 0.966 | 15.1% |
| J - Auto Physical Damage | 0.843 | 0.971 | 25.20% | 9.5% | 7.1% | 0.112 | 0.976 | 8.5% |
| K - Fidelity/Surety | 0.883 | 0.904 | 45.40% | 33.7% | 25.2% | 0.325 | 0.940 | 24.6% |
| L - Other | 0.893 | 0.947 | 35.80% | 25.1% | 20.4% | 0.172 | 0.967 | 13.3% |
| M - International | 1.169 | 0.905 | 40.00% | 56.9% | 45.8% | 0.327 | 0.874 | 16.0% |
| N&P - Reinsurance Prop/Fin | 1.349 | 0.893 | 24.70% | 59.6% | 45.2% | 0.286 | 0.901 | 15.9% |
| O - Reinsurance - Liabiity | 1.507 | 0.777 | 24.70% | 75.4% | 41.8% | 0.769 | 0.838 | 48.2% |
| R - Products Liability | 1.214 | 0.774 | 31.10% | 52.5% | 25.1% | 0.643 | 0.841 | 38.2% |
| S - Financial/Mort Guarantee | 1.482 | 0.884 | 28.50% | 76.7% | 59.5% | 0.200 | 0.926 | 11.1% |
| T - Warranty | 0.883 | 0.904 | 35.90% | 24.2% | 15.7% | 0.325 | 0.940 | 24.6% |
| Weighted Avg | 0.976 | 0.912 | 28.75% | 26.3% | 17.3% | 0.369 | 0.919 | 19.7% |
| Average effect of IIO | | | | | -34% | | | -47% |

(4)  -PRC% before IIO = (1)+(3)-100%

(5) – PRC% Discounted = (1)*(2)+(3)-100%

(8) – RRC% Discounted = (1+(6))*(7)-100%

# Appendix 2 – Calculating IIOs with Selected Interest Rates

The IIOs are premium and reserve discount factors by LOB, which are calculated with payment patterns and interest rates. In this Appendix we show our payment patterns, we illustrate how we calculate the IIOs, and we compare our indicated IIOs to the IIOs in the

2010 RBC Formula.

<u>Payment Patterns and Discount Factors – LRs used in PRF Calculation</u>

We develop AY payment patterns using a methodology like the 1986 IRS approach, as was done in the current calibration approach.[45,46] Specifically, for each LOB, we calculate the AY payment pattern as follows:

- Use the 2010 industry total Schedule P Part 1, for each AY, to determine the ratio of (a) cumulative loss and LAE paid through December 31, 2010 to (b) ultimate loss and LAE, evaluated at December 31, 2010.

  We use these ratios as the cumulative payment percentage for the paid development age of each component the AY.

- Determine the difference between those cumulative payment ratios.

  We use these differences as the incremental AY payment percentages.

- Next, consistent with past RBC payment pattern calibrations, we extend the payment patterns for LOBs with payment patterns that appear longer than 10 years (for 10-year lines) or longer than 2 years (for 2-year LOBs).

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[45] NAIC RBC 2010 Formula, page 20 says:

*Line 08 (for reserves) – Adjustment for Investment Income - This discount factor assumes a 5 percent interest rate. For lines of business other than workers compensation and the excess reinsurance lines, the payment pattern is determined using an IRS type methodology applies to industry-wide Schedule P data by line of business; otherwise a curve has been fit to the data to estimate the average payout over time. The discount factor for workers' compensation is adjusted to reflect the tabular portion of the reserves that is already discounted. The factors are provided by the NAIC and are shown on the Underwriting RBC Summary by line of business. The 2010 Formula provides similar explanation for premium risk, Line 07.*

[46] There are more precise ways to measure payment patterns, but we did not apply those in our work. We believe using the "IRS-type" methodology is sufficient for the analysis described in this Paper. Use of more refined methods is a matter for future research.

Appendix 2/Exhibit 1 shows the resulting payment patterns by LOB and illustrates the calculation of the LR discount factors.

<u>Payment Patterns and Discount Factors – Loss Reserves used in RRF Calculation</u>

For each LOB, we calculate the loss reserve payment pattern as follows:

- From the 2010 industry total Schedule P Part 1, we determine the percentage of the total reserve attributable to each AY component, evaluated at December 31, 2010.
- For each accident year component, we calculate the expected payments in future calendar years, using the appropriate 'tail' portion of the selected AY payment pattern.
- We assume payments are made in the middle of each calendar year.
- We calculate the discounted value for each AY component of the reserve.
- We calculate the total of the discounted AY portions of the total reserve.
- The discount factor is the ratio of the discounted total reserve to the undiscounted total reserve.

We show the AY discount factors at interest rates of 5% (current rate for IIOs), 8.3% (the 3-year duration US Treasure rate for 1988 that we use for AY 1989) and 1.4% (the 3-year duration US Treasure rate for 2009 that we use for AY 2010).

Appendix 2/Exhibit 2 illustrates the calculation of the reserve date discount factors.

Appendix 2/Exhibit 3 compares (a) the 2010 IIOs, based on 5% per annum interest rates to (b) the IIOs we calculate using our selected payment patterns with a 5% per annum interest rate. Our new IIOs differ somewhat from the current IIOs, as the payment patterns are not identical, but are close for most lines and close overall.

**Appendix 2/Exhibit 1**
**Selected Payment Patterns and Discount Factor at Various Annual Interest Rate**

| Year | A | B | C | D | E | F1 | F2 | G | H | I |
|------|------|------|------|------|------|------|------|------|------|------|
| 0 | 70.7% | 43.0% | 25.7% | 23.4% | 42.2% | 1.2% | 6.5% | 36.6% | 9.4% | 55.9% |
| 1 | 22.0% | 29.0% | 22.6% | 22.4% | 21.3% | 3.1% | 16.9% | 25.0% | 15.7% | 33.8% |
| 2 | 3.7% | 12.8% | 19.6% | 12.6% | 12.6% | 7.7% | 18.9% | 13.4% | 15.2% | 10.2% |
| 3 | 1.3% | 7.5% | 14.2% | 7.6% | 4.7% | 13.5% | 14.7% | 8.7% | 13.8% | |
| 4 | 1.0% | 3.9% | 8.4% | 5.4% | 5.9% | 17.2% | 14.4% | 6.6% | 12.2% | |
| 5 | 0.1% | 1.7% | 4.2% | 5.4% | 5.8% | 14.7% | 11.0% | 4.5% | 9.1% | |
| 6 | 0.6% | 0.8% | 2.4% | 2.4% | 2.0% | 11.9% | 4.3% | 0.2% | 5.7% | |
| 7 | 0.3% | 0.4% | 1.2% | 2.3% | 0.4% | 13.5% | 4.6% | 1.4% | 4.6% | |
| 8 | 0.1% | 0.2% | 0.4% | 2.6% | 0.9% | 4.2% | 3.6% | 0.6% | 3.0% | |
| 9 | 0.1% | 0.2% | 0.2% | 2.6% | 1.4% | 4.8% | 2.6% | -1.6% | 0.5% | |
| 10 | 0.2% | 0.4% | 1.1% | 2.6% | 2.7% | 8.3% | 2.5% | 4.7% | 5.5% | |
| 11 | | | | 2.6% | | | | | 2.8% | |
| 12 | | | | 2.6% | | | | | 1.4% | |
| 13 | | | | 2.6% | | | | | 0.7% | |
| 14 | | | | 2.6% | | | | | 0.3% | |
| 15 | | | | | | | | | 0.2% | |
| PV factors by LOB @ sample interest rates | | | | | | | | | | |
| @ 5% | 0.955 | 0.924 | 0.890 | 0.837 | 0.902 | 0.760 | 0.830 | 0.902 | 0.814 | 0.951 |
| @8.3% | 0.929 | 0.882 | 0.830 | 0.760 | 0.850 | 0.645 | 0.743 | 0.849 | 0.724 | 0.922 |
| @1.4% | 0.986 | 0.977 | 0.966 | 0.946 | 0.969 | 0.922 | 0.946 | 0.969 | 0.940 | 0.985 |

| Year | J | K | L | M | O | N&P | R | S | T |
|------|------|------|------|------|------|------|------|------|------|
| 0 | 90.3% | 22.9% | 54.7% | 14.7% | 3.5% | 19.5% | 6.7% | 6.2% | 85.4% |
| 1 | 9.5% | 32.9% | 29.6% | 48.6% | 19.7% | 38.1% | 10.1% | 33.5% | 14.1% |
| 2 | 0.3% | 22.1% | 15.7% | 17.9% | 20.5% | 14.2% | 14.8% | 20.1% | 0.5% |
| 3 | | 11.0% | | 0.0% | -4.8% | 6.5% | 8.3% | 20.1% | |
| 4 | | 11.0% | | 8.0% | 9.1% | 7.8% | 13.3% | 20.1% | |
| 5 | | | | 4.9% | 32.0% | 8.0% | 8.8% | | |
| 6 | | | | 1.1% | -3.5% | 1.8% | 6.8% | | |
| 7 | | | | 3.1% | 1.7% | 1.3% | 6.8% | | |
| 8 | | | | 1.6% | 1.9% | -0.1% | 4.6% | | |
| 9 | | | | | -0.2% | -0.1% | 4.4% | | |
| 10 | | | | | 4.3% | 1.5% | 7.9% | | |
| 11 | | | | | 3.9% | 0.8% | 3.9% | | |
| 12 | | | | | 3.5% | 0.4% | 2.0% | | |
| 13 | | | | | 3.1% | 0.2% | 1.0% | | |
| 14 | | | | | 2.8% | 0.1% | 0.5% | | |
| 15 | | | | | 2.5% | 0.0% | 0.2% | | |
| PV factors by LOB @ sample interest rates | | | | | | | | | |
| @ 5% | 0.971 | 0.907 | 0.948 | 0.896 | 0.782 | 0.887 | 0.777 | 0.881 | 0.969 |
| @8.3% | 0.954 | 0.854 | 0.917 | 0.839 | 0.682 | 0.827 | 0.673 | 0.815 | 0.950 |
| @1.4% | 0.992 | 0.972 | 0.984 | 0.968 | 0.927 | 0.965 | 0.927 | 0.963 | 0.991 |

Notes on the following page.

**Appendix 2/Exhibit 1- Notes**
**Selected Payment Patterns and Discount Factor at 5% Annual Interest Rate**
**Notes**

- For most 10-year LOBs we use the 10-year AY payment pattern derived in that fashion from Schedule P Part 1.

- For workers compensation, other liability, non-proportional reinsurance (property and lability) and product liability we extend the payment pattern to 15 years assuming uniform payment or exponentially decaying payments, by year for years 10-15.

- For the 2-year LOBs we use payment patterns of 3 years or 5 years.

- For lines H and R, other liability and products liability, we use the combined H1 (occurrence) and H2 (claims made) and the combined R1 (occurrence) and R2 (claims made), respectively.

  For LOB O the data method has some time periods with negative incremental payments. We found that the results are not particularly sensitive to that feature of the payment pattern, and we did not over-ride those negative values.

**Appendix 2/Exhibit 2**
**Sample Calculation of Reserve Discount Factor**
**5% Annual Interest Rate**
**HO/FO LOB=A**

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Row # | Year | Pattern Pattern | Discount Factor @5% | Reserve for Year at the maturity (month): | | | | | | | | | |
| 1 | Remaining Reserve: | | | 14,274,039 | 3,346,587 | 1,853,884 | 860,646 | 454,076 | 459,418 | 213,429 | 112,488 | 75,384 | 65,191 |
| 2 | Maturity (yrs): | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 3.1 | 1 | 70.7% | | | | | | | | | | | |
| 3.2 | 2 | 22.0% | 0.976 | 10,704,251 | 1,667,502 | 647,943 | 368,767 | 48,706 | 214,013 | 90,855 | 33,075 | 17,260 | 65,191 |
| 3.3 | 3 | 3.7% | 0.929 | 1,778,717 | 586,850 | 516,718 | 52,761 | 188,836 | 104,467 | 36,040 | 18,182 | 58,124 | |
| 3.4 | 4 | 1.3% | 0.885 | 625,990 | 467,998 | 73,929 | 204,557 | 92,177 | 41,440 | 19,813 | 61,231 | | |
| 3.5 | 5 | 1.0% | 0.843 | 499,211 | 66,958 | 286,625 | 99,851 | 36,565 | 22,781 | 66,721 | | | |
| 3.6 | 6 | 0.1% | 0.803 | 71,424 | 259,600 | 139,911 | 39,609 | 20,101 | 76,717 | | | | |
| 3.7 | 7 | 0.6% | 0.765 | 276,914 | 126,719 | 55,500 | 21,775 | 67,692 | | | | | |
| 3.8 | 8 | 0.3% | 0.728 | 135,171 | 50,267 | 30,511 | 73,327 | | | | | | |
| 3.9 | 9 | 0.1% | 0.694 | 53,619 | 27,634 | 102,747 | | | | | | | |
| 3.10 | 10 | 0.1% | 0.661 | 29,477 | 93,059 | | | | | | | | |
| 3.11 | 11 | 0.2% | 0.629 | 99,265 | | | | | | | | | |
| | | | | | | | | | | | | | |
| 4 | Total | 100.0% | | 13,561,046 | 3,066,016 | 1,667,899 | 776,011 | 403,357 | 423,430 | 195,947 | 103,377 | 70,866 | 63,620 |
| | | | | | | | | | | | | | |
| 5 | Total Undiscounted | | 21,715,142 | | | | | | | | | | |
| 6 | Total Discounted | | 20,331,569 | | | | | | | | | | |
| 7 | Discount Factor | | 0.936 | | | | | | | | | | |

Notes on following page

## Appendix 2/Exhibit 2 - NOTES
## Sample Calculation of Reserve Discount Factor

Column 1-4:

| |
|---|
| **Column 1**: Row # |
| **Column 2**: Year in which reserve will be paid, where 1= first year; 2= next year, etc. |
| **Column 3**: Percentage of AY claims that would be paid, calendar year-by-calendar year |
| **Column 4**: Discount factor for payments in 0.5 years, in 1.5 years, etc., measured from the present, using 5% per annum interest rate. |

Columns 5-14 – There is one column for each maturity year. Each row is as follows:

| |
|---|
| **Row 1**: The AY components of the 2010 HO reserve at December 2010, e.g., AY 2010 unpaid at 2010 is age 1, $14.3 million, … AY 2000 unpaid at 2010 is age 10, $65 thousand. |
| **Row 2**: The number of years of payment already made for the AY component in Row 1. |
| **Rows 3.1-3.11** for Maturity Years 1 – 11 show the expected future payments for each of the AY components on row 1, by future year of payment, based on the payment pattern shown in column 2, which was derived as described in Appendix 2/Exhibit 1. We calculate the values in rows 3.1 to 3.11, using column 3.<br><br>For example, in column 14 the entire amount unpaid at 2010 of from claims arising in AY 2000 (age 10) will be paid in the subsequent year; hence, the value in row 3.2 equals the value in row 1.<br><br>For example, in column 13, the amount unpaid at 2010 from claims arising in AY 2001 (age 9) will paid in the remaining two years. The payment pattern in row 4, column 3.10 and 3.11, shows that 0.2% of the full AY payments (0.2037% before rounding) are expected to be paid in year 11 and 0.1% of the full AY payments (0.0605% before rounding) are expected to be paid in year 10. The total is 0.2542% of the full accident year, 23% (.0605/.2542) in year 1 and 77% (.2037/.2542) in year 2, producing $17k and $58k shown. |
| **Row 4**: The sum of the row 3 values times the column 4 discount factors for all years. |
| **Row 5**: The total undiscounted, i.e., the sum of the payments in calendar years 2011 and beyond, equals the sum of values in row 2. |
| **Row 6**: The total discounted, i.e., the sum of the discounted payments in calendar years 2011 and beyond, the sum of values in row 4. |
| **Row 7**: The reserve discount factor, 0.936, is the ratio of row 6, the total of discounted future payments, to row 5, the total of undiscounted future payments. |

**Appendix 2/Exhibit 3**
**2010 RBC IIO's vs. Calculated IIOs at 5% annual interest rate**

| Lines of Business | Premium | | Reserves | |
|---|---|---|---|---|
| | 2010 IIO_P | Indicated IIO_P | 2010 IIO_R | Indicated IIO_R |
| A- Homeowners/Farmowners | 0.954 | 0.955 | 0.938 | 0.936 |
| B- Private Passenger Auto | 0.925 | 0.924 | 0.928 | 0.928 |
| C- Commercial Auto | 0.890 | 0.890 | 0.911 | 0.913 |
| D - Workers Compensation | 0.839 | 0.837 | 0.830 | 0.822 |
| E - Commercial Multi-Peril | 0.896 | 0.902 | 0.876 | 0.888 |
| F1 - Med Malp - Occ | 0.767 | 0.760 | 0.865 | 0.862 |
| F2 - Med Malp - CM | 0.827 | 0.830 | 0.883 | 0.883 |
| G - Special Liability | 0.898 | 0.902 | 0.890 | 0.895 |
| H - Other Liability | 0.816 | 0.814 | 0.852 | 0.856 |
| I - Special Property | 0.949 | 0.951 | 0.966 | 0.967 |
| J - Auto Physical Damage | 0.971 | 0.971 | 0.976 | 0.975 |
| K - Fidelity/Surety | 0.904 | 0.907 | 0.940 | 0.935 |
| L - Other | 0.947 | 0.948 | 0.967 | 0.964 |
| M - International | 0.905 | 0.896 | 0.874 | 0.922 |
| N&P - Reinsurance Prop/Fin | 0.893 | 0.887 | 0.901 | 0.899 |
| O - Reinsurance - Liabiity | 0.777 | 0.782 | 0.838 | 0.817 |
| P - Products Liability | 0.774 | 0.777 | 0.841 | 0.840 |
| S - Financial/Mort Guarantee | 0.884 | 0.881 | 0.926 | 0.941 |
| T - Warranty | 0.904 | 0.969 | 0.940 | 0.980 |
| Total | 0.912 | 0.913 | 0.878 | 0.877 |

Calibration IIO's use the payment patterns by LOB from Exhibit 1, applied to LRs and reserves as described in Appendix 2/Exhibits 1 and 2.

## Appendix 3 – Selection of Interest Rates

Our calibration in Section 3 uses the interest rates from US Treasury securities with 3-year durations. We also analyze the effect of using interest rates based on 5-year and 10-year duration interest rates.

Also, we consider the various ways to attribute interest rates to LRs and RRRs by year. Our calibration in Section 3 uses the average interest rate for the year that proceeded the year that the premium was earned and for LRs and the year-ending 12 months prior initial reserve date for RRRs. That is, for example, we use 1988 average interest rates to discount the AY 1989 LRs and the December 31, 1989 RRR.

We consider two alternatives. We analyze data with LRs and RRRs discounted based on the interest rate in the year the year earned, i.e., using 1988 average interest rates for AY 1988 LRs and December 31, 1988 RRRs. Also, we analyze data with RRRs discounted based on average December interest rates, i.e., average interest rate for December 1988 for the 1988 RRR.

<u>PVA vs. NVA Indicated Risk Charges with Alternative Interest Rate Selections</u>

The values in Appendix 3/Exhibits 1A and 1B, below, are comparable to the total rows of Tables 6A and 6B, for premium and reserve risk, respectively, with various alternative interest rate approaches. This exhibit shows the PVA and NVA statistics for the weighted average of all LOBs. The first row of these exhibits, "3Year/Prior Year," is the interest rate we use in Section 3. The values in that row equal the weighted average lines from Exhibits 6A and 6B. The values in the other rows represent the comparable weighted average values based on the alternative interest rate selections, as described in the Interest Rate column.

Consistent with our observations regarding the 3-year interest rates we used in Section 3, we observe that for all interest rates selections the PVA shows lower values for the slope, R-squared values and ratios of slope to standard error. This indicates that that the variation of risk with interest rate is more random with PVA than NVA, regardless of the interest rate selection.

**Appendix 3/Exhibit 1A - Premium**
**Indicated PRC% vs. Interest Rate Graph – Slope, R-squared and Slope/Standard Error**
**PVA vs. NVA**
**All-Lines Weighted Averages**

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|
| **Interest Rate** | | **Slope** | | **R-sqr** | | **Slope/std err** | |
| | | NVA | PVA | NVA | PVA | NVA | PVA |
| 3Year | Prior Year | 1.36 | (0.22) | 10% | 2.7% | 1.25 | (0.16) |
| 3Year | Current Yr | 0.87 | (0.70) | 8% | 5.0% | 0.78 | (0.69) |
| 5Year | Prior Year | 1.33 | (0.22) | 9% | 2.8% | 1.12 | (0.14) |
| 5Year | Current Yr | 0.93 | (0.61) | 8% | 4.2% | 0.78 | (0.53) |
| 10Year | Prior Year | 1.15 | (0.35) | 8% | 3.3% | 0.88 | (0.22) |
| 10Year | Current Yr | 0.90 | (0.59) | 8% | 4.3% | 0.71 | (0.41) |

**Appendix 3/Exhibit 1B - Reserves**
**Indicated RRC% vs. Interest Rate Graph – Slope, R-squared and Slope/Standard Error**
**PVA vs. NVA**
**All-Lines Weighted Averages**

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|
| **Interest Rate** | | **Slope** | | **R-sqr** | | **Slope/std err** | |
| | | **NVA** | **PVA** | **NVA** | **PVA** | **NVA** | **PVA** |
| 3Year | Avg Dec | 3.04 | (0.40) | 13% | 4.5% | 1.60 | (0.44) |
| 3Year | Prior Year | 3.86 | 0.37 | 18% | 3.3% | 1.98 | 0.09 |
| 3Year | Current Yr | 3.38 | (0.09) | 16% | 3.4% | 1.78 | (0.20) |
| 5Year | Avg Dec | 3.48 | 0.04 | 14% | 3.9% | 1.66 | (0.18) |
| 5Year | Prior Year | 4.01 | 0.56 | 17% | 3.6% | 1.85 | 0.16 |
| 5Year | Current Yr | 3.76 | 0.29 | 16% | 3.4% | 1.79 | 0.01 |
| 10Year | Avg Dec | 3.94 | 0.47 | 14% | 3.8% | 1.64 | 0.04 |
| 10Year | Prior Year | 3.87 | 0.48 | 14% | 3.6% | 1.57 | 0.07 |
| 10Year | Current Yr | 3.99 | 0.53 | 15% | 3.6% | 1.66 | 0.11 |

Selecting Interest Rate Approach

In Appendix 3/Exhibits 1A and 1B, above, the values shaded green are the lowest (most consistent with PVA assumptions) among the interest rates selections. The values shaded yellow are the second lowest (second most consistent with PVA assumptions) among the interest rates selections.

The 3-year duration, prior year average, interest is the most often "green" selection. Hence, our selection of that rate for Section 3. In implementation, both 3-year and 5- year duration are reasonable choices, and the choice might vary by LOB and between reserves and premium.

Appendix 3/Exhibit 2 shows the indicated PRC% and RRC%, by LOB, for each of the alternative interest rates. On average, across LOBs, differences in all line average indicated risk charges due to interest rate duration and time period is less significant for premium (PRC%) than for reserves (RRC%).

- PRC% - The difference in PRC% between 3, 5 and 10-year duration interest rates is approximately a 50 basis points[47] (comparing columns 2, 4 and 6 for current year average or columns 3, 5 and 7 for prior year average, in premium section of Appendix 3/Exhibit 2), respectively.

  RRC% - The difference for RRC% is more than 100 basis points[48] (comparing columns 2, 5 and 8 for current year, 3, 6 and 9 for prior year, or 4, 7 and 10 for "December, from reserve section of Appendix 3/Exhibit 2), respectively.

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[47] 50 basis points is about 2% of the risk charge, using the 90th percentile indicated premium risk charge with 'actual' interest rates

[48] 100 basis points is about 4% of the risk charge, using the 90th percentile indicated reserve risk with 'actual' interest rates

- PRC% - The difference in PRC% between current year average and prior year average is 50 basis points (comparing columns 2 and 3 for 3-year duration, columns 4 and 5 for 5-year duration or columns 6 and 7 for 10-year duration), respectively.
- RRC% - The difference in RRC% between current year average and prior year average is over 100 basis points (comparing columns 2 and 3 for 3-year duration, columns 5 and 6 for 5-year duration or columns 8 and 9 for 10-year duration interest rates), respectively.

**Appendix 3/Exhibit 2**
**Indicated PRC% and RRC% - PVA – Various Bases for Interest Rate Selection**
**87.5th Percentile UW Safety Level/Zero Risk Margin**

| PRC% - Present Value Model - Various Bases for Interest Rate Selection | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| **Lines of Business** | With 5% IIO | Current Year | Prior Year | Current Year | Prior Year | Current Year | Prior Year | % 2010 NEP |
| | | 3Yr | 3Yr | 5Yr | 5Yr | 10YR | 10YR | |
| A- Homeowners/Farmowners | 22.3% | 22.1% | 22.5% | 21.9% | 22.2% | 21.5% | 21.7% | 15% |
| B- Private Passenger Auto | 15.8% | 15.3% | 15.6% | 14.9% | 15.1% | 14.4% | 14.6% | 23% |
| C- Commercial Auto | 20.9% | 20.1% | 20.4% | 19.4% | 19.7% | 18.9% | 19.1% | 4% |
| D - Workers Compensation | 14.5% | 14.1% | 15.2% | 13.0% | 14.0% | 11.8% | 12.6% | 7% |
| E - Commercial Multi-Peril | 16.1% | 15.6% | 16.1% | 15.2% | 15.5% | 14.5% | 14.8% | 7% |
| F1 - Med Prof Liab-Occ | 44.9% | 46.7% | 49.4% | 45.2% | 47.5% | 43.2% | 45.7% | 1% |
| F2 - Med Prof Liab-CM | 28.0% | 27.6% | 29.0% | 26.7% | 27.8% | 25.4% | 25.9% | 2% |
| G - Special Liability | 22.5% | 21.6% | 22.1% | 20.7% | 21.6% | 20.0% | 21.1% | 1% |
| H - Other Liability | 14.5% | 14.3% | 15.0% | 12.8% | 13.7% | 11.5% | 12.2% | 9% |
| I - Special Property | 11.3% | 11.0% | 11.4% | 10.9% | 11.1% | 10.5% | 10.7% | 7% |
| J - Auto Physical Damage | 6.6% | 6.5% | 6.6% | 6.4% | 6.5% | 6.3% | 6.4% | 16% |
| K - Fidelity/Surety | 6.3% | 6.1% | 6.3% | 5.7% | 5.7% | 5.3% | 5.3% | 1% |
| L - Other | 24.5% | 24.2% | 24.4% | 24.0% | 24.2% | 23.8% | 23.9% | 2% |
| M - International | 16.9% | 18.0% | 19.9% | 17.3% | 18.7% | 16.7% | 17.5% | 0% |
| N&P - Reinsurance-Prop/Fin | 39.0% | 36.2% | 37.0% | 35.0% | 36.5% | 34.6% | 34.8% | 1% |
| O - Reinsurance-Liabiity | 27.7% | 23.2% | 25.3% | 22.6% | 23.9% | 22.1% | 21.8% | 1% |
| R - Products Liability | 23.5% | 26.8% | 27.9% | 24.5% | 26.1% | 21.5% | 23.2% | 1% |
| S - Financial/Mort Guarantee | 67.2% | 60.0% | 59.7% | 59.0% | 59.5% | 57.5% | 59.0% | 2% |
| T - Warranty | 71.5% | 73.4% | 72.4% | 72.9% | 72.3% | 72.1% | 72.1% | 0% |
| | | | | | | | | |
| Weighted Average | 17.1% | 16.5% | 17.0% | 16.0% | 16.4% | 15.4% | 15.8% | 100% |

| RRC% - Present Value Model - Various Bases for Interest Rate Selection | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| **Lines of Business** | With 5% IIO | Current Year | Prior Year | Dec Avg | Current Year | Prior Year | Dec Avg | Current Year | Prior Year | Dec Avg | % 2010 Rsv |
| | | 3Yr | 3Yr | 3Yr | 5Yr | 5Yr | 5Yr | 10Yr | 10Yr | 10Yr | |
| A- Homeowners/Farmowner | 14.3% | 14.7% | 13.9% | 14.4% | 14.2% | 13.5% | 13.8% | 13.5% | 13.0% | 13.3% | 4% |
| B- Private Passenger Auto | 9.5% | 10.0% | 9.1% | 9.6% | 9.5% | 8.6% | 9.1% | 8.9% | 8.1% | 8.6% | 16% |
| C- Commercial Auto | 23.5% | 24.3% | 22.5% | 23.0% | 23.5% | 22.0% | 22.4% | 22.4% | 21.4% | 21.8% | 4% |
| D - Workers Compensation | 9.6% | 11.8% | 8.3% | 10.1% | 9.9% | 6.8% | 8.2% | 7.8% | 5.4% | 6.7% | 20% |
| E - Commercial Multi-Peril | 32.3% | 32.2% | 30.6% | 31.4% | 31.5% | 29.7% | 30.5% | 30.1% | 28.7% | 29.6% | 6% |
| F1 - Med Prof Liab-Occ | 13.4% | 14.5% | 11.6% | 13.4% | 13.6% | 10.5% | 12.7% | 11.7% | 9.7% | 10.8% | 2% |
| F2 - Med Prof Liab-CM | -2.3% | 0.2% | -1.5% | -1.3% | -0.8% | -2.6% | -2.0% | -2.3% | -3.7% | -3.1% | 3% |
| G - Special Liability | 30.3% | 27.4% | 25.4% | 26.3% | 26.5% | 25.0% | 25.3% | 23.9% | 24.2% | 24.5% | 1% |
| H - Other Liability | 30.3% | 31.3% | 29.6% | 30.0% | 30.2% | 28.4% | 29.0% | 28.6% | 27.3% | 27.5% | 22% |
| I - Special Property | 24.4% | 24.6% | 24.1% | 24.5% | 24.4% | 24.0% | 24.2% | 24.2% | 23.9% | 23.9% | 2% |
| J - Auto Physical Damage | 10.3% | 10.2% | 9.7% | 10.0% | 10.0% | 9.7% | 9.9% | 9.8% | 9.6% | 9.6% | 1% |
| K - Fidelity/Surety | 40.2% | 41.3% | 39.0% | 40.3% | 40.9% | 38.1% | 39.9% | 40.2% | 37.8% | 39.5% | 1% |
| L - Other | 22.2% | 22.8% | 22.2% | 23.0% | 22.5% | 22.1% | 22.5% | 22.4% | 22.1% | 21.9% | 1% |
| M - International | 29.2% | 25.6% | 23.4% | 25.5% | 24.7% | 22.2% | 23.9% | 23.1% | 21.6% | 22.4% | 0% |
| N&P - Reinsurance-Prop/Fin | 27.8% | 27.4% | 27.4% | 26.8% | 27.0% | 26.2% | 26.4% | 26.3% | 25.6% | 26.2% | 1% |
| O - Reinsurance-Liabiity | 34.6% | 35.7% | 33.4% | 35.6% | 34.2% | 31.5% | 33.4% | 32.2% | 30.3% | 31.0% | 6% |
| R - Products Liability | 56.5% | 55.0% | 52.9% | 51.8% | 52.5% | 50.6% | 52.1% | 49.9% | 48.2% | 50.7% | 3% |
| S - Financial/Mort Guarantee | -1.2% | -11.1% | -10.6% | -11.2% | -11.1% | -10.8% | -11.3% | -11.3% | -11.2% | -11.5% | 5% |
| T - Warranty | 4.0% | -15.6% | -16.8% | -16.1% | -15.8% | -16.8% | -16.3% | -16.1% | -16.9% | -16.6% | 0% |
| | | | | | | | | | | | |
| Weighted Average | 19.7% | 20.1% | 18.3% | 19.0% | 19.0% | 17.2% | 18.0% | 17.6% | 16.3% | 16.9% | 100% |

Note: Because essentially no companies have an industry distribution by LOB, the weighted average is a summary, but does not represent a typical company.