CAS RBC Dependency and Calibration Working Party (DCWP)

November 5, 2013
(Draft October 24, 2013)

Presenting today:
Allan Kaufman, Chair
Ashley Reller, work-stream leader

DCWP Members listed on last pages

Hello

This slide package contains highlights from all of the current DCWP work streams as follows:

- Risk Charges – improvement to current calibration method (ICM) for Premium and Reserves
- Risk Charge by Type of Company
- Dependency and Diversification Credit
- Risk Charges - Solvency II calibration
- Regression Analysis of Solvency Risk Factors
- Reserve Risk Charge - Company Basis Model vs. RBC
- Consumer Value Risk Metric
- Impact Analysis
- Premium Risk Charge based on Combined Ratio

The November 7, 2013 presentation will focus on the first three of these and answer audience questions about any of the other work streams.

This October 24 draft will be updated with final by October 28, 2013

Agenda

- DCWP charge and structure
- Areas of Research - Key Methods and Findings
  - Risk Charges – improvement to current calibration method (ICM)
  - Risk Charge by Type of Company
  - Dependency and Diversification Credit
- Future Directions

- Q&A Throughout

Disclaimer

- These slides describe work of multiple CAS RBC DCWP work streams.
- The analysis is solely the responsibility of the work stream participants, DCWP members and not that of their employers, the CAS or the American Academy of Actuaries.
- The presentation assumes the audience has a working knowledge of how the RBC formula works.

Current Work - Preliminary

WARNING:

Some of the following slides describe preliminary work which may change materially as research progresses.

Results are published in EForum when finalized.

Working Party Charge

- Research on how to handle calibration and dependencies in NAIC P&C RBC formula including:
  - Premium and reserve risk
  - Risk dependency and calibration
  - Within or beyond the constraints of the current NAIC RBC formula or current parameter calibration procedures.
- Providing support to Academy RBC committee

Why?

NAIC interest, and:

- A "standard formula" (like RBC) is a component of any regulatory capital structure, whether or not there are internal models or ORSA components.
- Each standard formula (RBC, ICAS, Solvency II) has drawn ideas from its predecessors. We plan to expand on that chain of developments.
- A good study of the standard formula provides data and analytical techniques contributing to individual company risk assessment methodologies.

DCWP Publications To Date

Overview of Dependencies and Calibration in the RBC Formula (Report 1)
www.casact.org/pubs/forum/12wforum/DCWP_Report.pdf

2011 Research – Short Term Project (Report 2)
www.casact.org/pubs/forum/12wforum/RBC_URWP_Report.pdf

Solvency II Standard Formula and NAIC RBC (Report 3)
http://www.casact.org/pubs/forum/12fforumpt2/RBC-DCWPRpt3.pdf

A Review of Historical Insurance Company Impairments (Report 4)
http://www.casact.org/pubs/forum/12fforumpt2/RBC-DCWPRpt4.pdf

An Economic Basis for P/C Insurance RBC Measures (Report 5)
http://www.casact.org/pubs/forum/13sumforum/01RBC-econ-report.pdf

DCWP Publications Pending

- Premium Risk Charges – Improvements to Current Calibration Method (Report 6)
- Reserve Risk Charges – Improvements to Current Calibration Method (Report 7)

DCWP Reports in Preparation

- Differences in Premium Risk Factors by Type of Company
- Application of Solvency II Calibration Method to RBC Premium and Risk Factors
- Regression analysis of risk factors associated with insurance company impairments
- Reserve Risk Factors – Individual Company Basis vs. NAIC RBC Basis
- Dependency and Credit for Diversification in NAIC RBC Formula
- Risk Metric – Time Horizon Analysis (extension of Report 5)
- Impact Analysis – Assessment of effect of changes in RBC Formula by type of company
- RBC Premium Risk Factor Calibration based on Combined Ratio Rather than Loss Ratio

DCWP – The People

- Many people contributed to this work (and are still contributing)
- The list of all committee members and the members who are leading or working on specific work streams follows:

RBC Research Working Party Members (2013)

Emmanuel Bardis	Allan Kaufman (Chair)	Ashley Reller
Jess Broussard	Terry Kuruvilla	David Rosenzweig
Robert Butsic	Apundeep Singh Lamba	Andrew Staudt
Pablo Castets	Giuseppe (Franco) LePera	Timothy Sweetser
Joe Cofield	Zhe Robin Li	Anna Marie Wetterhus
Jose Couret	Lily (Manjuan) Liang	Jennifer Wu
Brian Fannin	Thomas Loy	Jianwei Xie
Sholom Feldblum	Glenn Meyers	Linda Zhang
Dennis Franciskovich	Daniel Murphy	Christina Zhou
Dean Guo	Douglas Nation	
Shira Jacobson	G. Chris Nyce	CAS Staff:
Shiwen Jiang	Jeffrey Pflugger	Karen Sonnet
	Yi Pu	David Core

Work Stream Leaders

Work Stream	Leader	Team
Chair – Allan Kaufman		
Overview Reports 1 and 2	Rept-1 A. Kaufman Rept-2 D. Murphy	Committee members as listed on those reports
3. Solvency II Formula and RBC	Joe Cofield	Christina Zhou
4. Insolvency Risk Factors-Univariate	Ed Marchena	
5. Risk Metric	Bob Butsic	Sholom Feldblum, Glen Meyers
6. Premium Risk Factors	Jennifer Wu, Dennis Franciskovich	Karen Adams, Franco LePera, Daniel Murphy, Tim Sweetser
7. Reserve Risk Factors	Jennifer Wu	Karen Adams, Dennis Franciskovich, Franco LePera, Daniel Murphy, Tim Sweetser

Work Stream Leaders

Work Stream	Leader	Team
8. Risk Charge by Type of Company	Ashley Reller	
9. Solvency II Calibration	Jeff Pflugger, Tim Sweetser	Glen Meyers
10. Insolvency risk Factors- Regression	Jose Couret	
11. Rsv Risk Charge - Individual Co Model vs. RBC	Manolis Bardis	Christian Citarella, Glen Meyers, Linda Zhang, Damon Chom
12. Dependency	Apundeep Lamba	Shiwen Jiang, Glen Meyers, Dan Murphy, Damon Chom
13. Impact Analysis	Ron Wilkinson	Ji Yao, Damon Chom, Dean Guo,
14. Combined Ratio	Douglas Nation	

Themes in Today's Discussion

- Dabblers, specialists and the rest of the companies
- Diversification vs. Specialization
- Enough data and enough time periods

Underwriting Risk Charge Calibration

UW Risk Charges Application in RBC Formula

- UW RBC charges are factors applied to premium or reserves by line of business (LOB).
  - Premium Risk Factors – PRFs
  - Reserve Risk Factors - RRFs
- Selected factors are adjusted for investment income, own-company experience, loss sensitive contracts and (for premium risk) own company expenses.
- Diversification Reflected through "70% Rule"

UW Risk Charges – Calibration Metric

- Indicated factors (CCM) equal the 87.5%-ile of loss ratio distribution observed from all companies (after filtering) by LOB.
- 87.5%-percentile - a 'practical' decision by Academy in 2007 calibration.

Data

- 14 Annual Statements (1997-2010)
- 24 accident years of loss ratios and 23 years of reserve date runoff ratios, developed by year up to 10 years
- By company (3700 companies in total across all lines and years)
- Summarization into groups and pooled entities (as needed)
- Capable of isolating sub-types of company (e.g. personal lines, reinsurers

Data Structure - PRFs

Schedule P Part 1
Net Loss and Loss Expense Percentage

	Co A	Co B	Co C
1988	0.222	0.656	0.387
1989	0.771	0.602	1.023
1990	0.506	1.052	0.746
1991	0.393	0.899	0.259
1992	0.526	1.161	0.784
1993	0.797	0.993	0.356
1994	1.021	0.814	0.231
1995	0.203	0.254	1.081
1996	0.656	0.639	0.583
1997	0.969	0.671	1.066
1998	0.887	0.957	0.244
1999	0.299	0.618	0.500
2000	0.540	0.960	1.195
2001	0.751	0.759	0.840
2002	1.082	0.644	0.403
2003	0.486	0.317	0.842
2004	1.158	0.726	0.545
2005	0.297	1.174	0.976
2006	0.934	0.622	1.060
2007	0.756	0.481	0.838
2008	0.301	0.393	0.711
2009	1.073	1.007	0.418
2010	0.396	0.477	0.539

Collect premium and loss and LAE ratios by company and year

20,000 data points for PPA and 4,500 of medical malpractice occurrence

Calculate the 87.5Th percentile within each line of business

Data Structure - RRFs

Statement	Initial Date	Initial Ins'd	Latest Ins'd	Runoff Ratio
2010	2010	10,282	10,249	0%
2010	2009	10,338	9,556	-8%
2010	2008	10,363	9,622	-7%
2010	2007	10,569	10,285	-3%
2010	2006	10,975	11,391	4%
2010	2005	10,609	10,473	-1%
2010	2004	10,435	9,965	-5%
2010	2003	10,903	10,488	-4%
2010	2002	10,895	10,058	-6%
2010	2001	10,350	10,710	3%
2010	PRIOR	10,034	10,119	1%
2009	2009	10,152	9,262	-9%
2009	PRIOR	10,436	9,821	-6%
2008	1998	10,392	9,717	-6%
2008	PRIOR	10,381	10,522	1%
2007	1998	10,037	9,106	-9%
2007	PRIOR	10,406	9,977	-4%
2006	1998	10,151	9,211	-9%
2006	PRIOR	10,487	10,327	-2%
2005	1998	10,256	10,342	1%
2005	PRIOR	10,390	10,484	1%
2004	1998	10,961	11,793	8%
2004	PRIOR	10,610	10,956	3%
2003	1998	10,738	10,971	2%
2003	PRIOR	10,068	10,177	1%
2002	1998	10,118	10,155	0%
2002	PRIOR	10,734	9,916	-8%
2001	1998	10,447	9,968	-5%
2001	PRIOR	10,191	10,549	4%
2000	1998	10,432	11,068	6%
2000	PRIOR	10,080	10,998	9%
1999	1998	10,618	10,494	-1%
1999	PRIOR	10,545	10,943	4%
1998	1988	10,871	10,382	-4%
1998	PRIOR	10,170	9,538	-6%
1997	1988	10,889	11,409	4%
1997	PRIOR	10,441	10,099	-3%

Collect incurred and paid amounts by company and AY year – initial and most mature

Calculate initial reserve and reserve runoff for each "Initial Reserve Date" and each latest maturity

20,000 data points for PPA and 6,000 for medical malpractice occurrence

Calculate the 87.5Th percentile of reserve runoff ratios within each line of business

Data Features
Pooling, Size and Minor Lines

- Pooling adjustment
  - Generally (and appropriately) increases risk charge
- Size – all companies over threshold size by line
  - Reduce risk charge vs. all companies;
  - Differs from $500k threshold in CCM
- "Minor lines" (under 5% of all-line premium by company)
  - "Standard lines" – little effect
  - "Specialty lines" – reduces risk charge

PRFs –
Effect of Pooling, Size, Minor Lines

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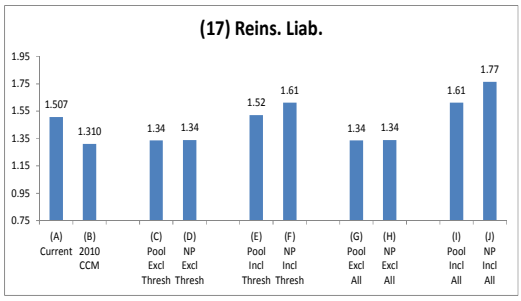
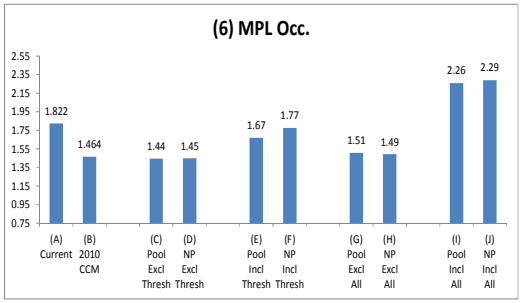
Effect of Pooling, Size, Minor Lines



PRFs – Effect of Pooling, Size, Minor Lines



Dealing with Size

- Indicated Risk Charges Vary with Size
- At least two ways to address that:
  - Risk charge above a selected threshold
    - CCM -- $500k in each line; applied by company not by accident year
    - Baseline - $100k-$1m, varying by line, to eliminate high implied risk charge from smallest companies without eliminating too many data points
  - Risk Charge for median sized company

Premium Risk by LOB Size

A. Homeowners/Farmowners

Size Percentile	Premium From (000)	Premium To (000)	Data Points	87.5th Percentile Loss Ratio	Risk Charge- by size	Risk Charge Cumulative
15%	0	730	1,429	1.287	53%	23%
25%	730	1,483	951	1.023	27%	**20%**
35%	1,483	2,758	951	0.985	23%	19%
45%	2,758	5,022	952	0.964	21%	18%
55%	5,022	8,866	952	0.941	**18%**	18%
65%	8,866	16,382	952	0.914	16%	18%
75%	16,382	31,572	951	0.959	20%	19%
85%	31,572	61,546	952	0.940	18%	18%
95%	61,546	252,884	952	0.929	17%	18%
To top 100	252,884	1,536,884	377	0.951	19%	19%
100%	1,536,884	10,820,092	98	0.912	15%	15%
	10,820,092					

Premium Risk by LOB Size

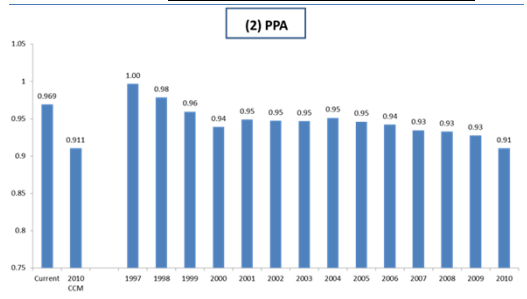
B. Private Passenger

Size Percentile	Premium From (000)	Premium To (000)	Data Points	87.5th Percentile Loss Ratio	Risk Charge- by size	Risk Charge Cumulative
15%	0	1,596	1,304	1.243	43%	18%
25%	1,596	3,634	869	1.019	20%	**15%**
35%	3,634	6,667	868	1.003	19%	15%
45%	6,667	11,219	869	1.013	20%	14%
55%	11,219	16,368	869	0.971	**16%**	14%
65%	16,368	28,352	869	0.971	16%	13%
75%	28,352	54,053	869	0.962	15%	12%
85%	54,053	130,201	868	0.959	14%	11%
95%	130,201	580,234	869	0.920	11%	9%
To top 100	580,234	4,072,500	336	0.895	8%	8%
100%	4,072,500	18,406,826	98	0.893	8%	8%
	18,406,826					

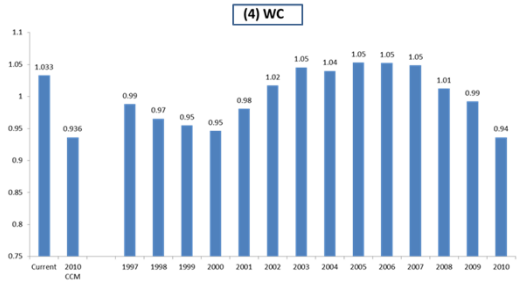
Dealing With Time - CCM

- Current Calibration Method – 10 Years from one Annual Statement
- PRF and RRF vary from statement year to statement year

CCM Premium Risk Factor by Annual Statement Year - PPA



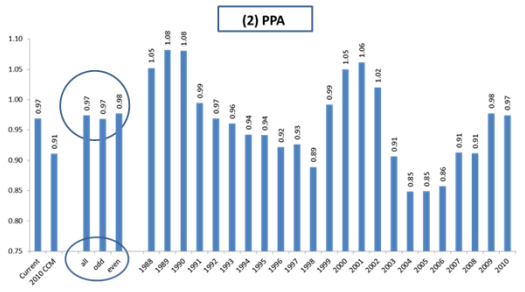
CCM Premium Risk Factor by Annual Statement Year - WC



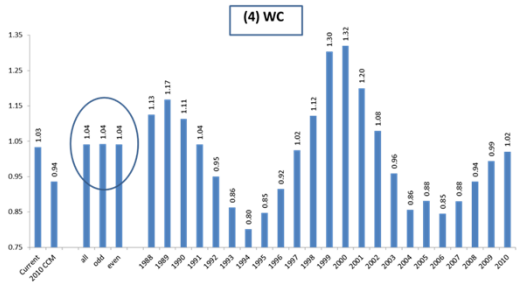
Dealing with Time Risk Charge by AY

- Risk Charges by AY show:
  - Effect of UW cycles
  - Effect of catastrophes
  - Even year/Odd year test of stability
- PRF and RRF by AY show how CCM variation is driven by variations among accident years
- Even/Odd test 24 AYs appears to be reasonably stable
- Also test every 4th year for stability.

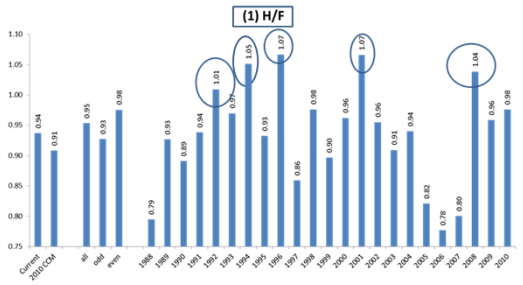
Risk Charge by Accident Year



Risk Charge by Accident Year



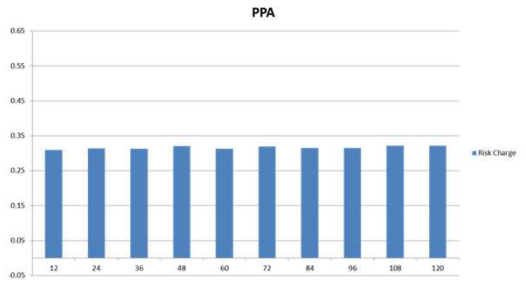
Risk Charge by Accident Year



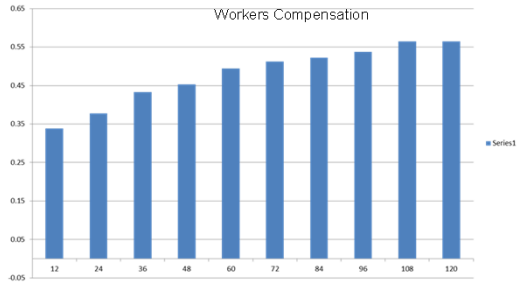
Variation in Risk by Maturity

- Data points from AYs 2010, 2009 are respectively 1 year developed, 2 years developed, etc.
- Use AY 1997-2001 to test differences in risk charges between data at 1 year, 2 year, … 10 year developed.
- Minor effect for some line – PPA, HO
- Significant for others – WC, Med Mal, Reins-Liab
- Adjustment for maturity seems appropriate
- Possible approach – exclude immature accident years.

Risk Charge by Maturity



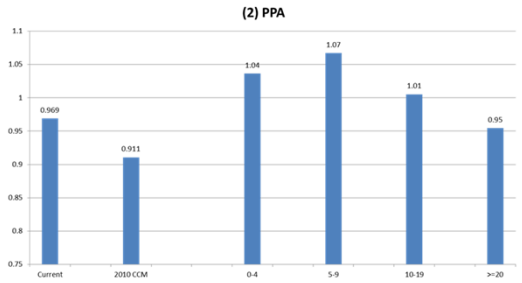
Risk Charge by Maturity



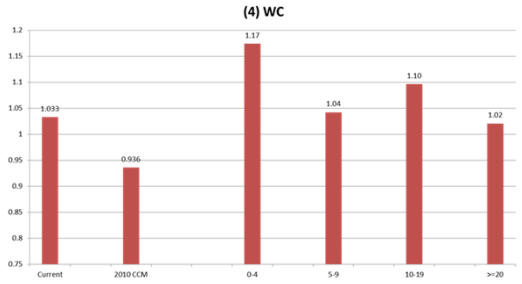
Mature Companies = Lower risk Variation in PRF by "Years of NEP>0"

- Baseline excludes data points from companies with less than five years of non-zero net earned premium (NEP)
- Often, but not universally, indicated risk charge declines for business with longer history
- For long tail lines, the effect of "development maturity" may be confounding the effect "longer history", making 'older age' look less important than it is.

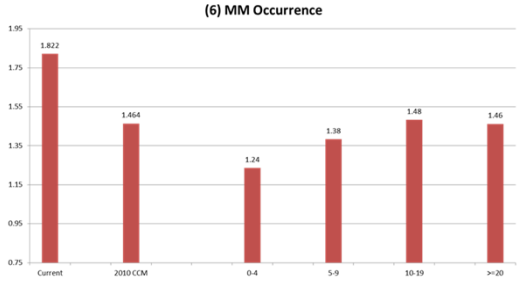
Risk Charge by Years of NEP



Risk Charge by Years of NEP



Risk Charge by Years of NEP



Risk Charge - Baseline

- Risk metric – 87%-ile over all companies all years (as in CCM)
- Minimum years of experience - 5
- Data adjusted for pooled Schedule P experience
- Data filtered to isolate effect of minor lines
- "Threshold" treatment of size
- No maturity adjustment

Baseline is not a recommendation, but a practical approach to dealing with the large number of alternatives

Risk Charge by Type of Company

Approach

- Assign each data point to a "business focus"
- We use SNL areas of business focus
- Areas of business focus include reinsurance, personal lines, medical professional, commercial, workers compensation….
- Note: Companies write multiple LOBs outside of their 'business focus'

Approach

- Use ICM baseline database to determine 87.5th percentile loss ratio (PRF)
  - by LOB
  - separately for companies within each 'business focus"
- Data considerations:
  - Pools assigned Business Focus based on majority of number of companies in DCWP -defined pool
  - Business Focus is based on current mix of business; Historic mix (24 years) may be different.

Findings

- Minor Line filter mitigates differences by type of company
  - PRF differences by type of company are smaller after minor line filter than before minor line filter
- Type of company differences remains

Observations - Business Focus = Reinsurance

- We'll refer to Reinsurers as 'specialists'
- Specialist PRFs are lower than non-specialist PRFs in specializing lines [Lines N&P and O]; [Next slide: [Are Col 3 & 6 <0]
- Difference between specialists and non specialists is smaller with minor line filter than without minor line filter. [Is |Col 6| < |Col 3|?]
- For non-specializing LOBs, Specialist PRFs are not always higher or lower than non-Specialist PRFs. [Col 6 > or < 0]

Prof Reinsurers

Exhibit 3.1: PRFs - All Reinsurers

Reins vs. Non-Reinsurer
Larger difference before minor line filter

		(1)	(2)	(3)	(4)	(5)	(6)
		Including Minor Lines			Excluding Minor Lines		
Line of Business (LOB)		Specialists	Non-Specialists	Difference	Specialists	Non-Specialists	Difference
A	Homeowners/Farmowners	0.908	0.966	-0.057	0.874	0.956	-0.082
B	Priv. Passenger Auto Liability	1.079	0.982	0.097	0.998	0.973	0.025
C	Commercial Auto Liability	1.122	0.984	0.139	0.979	0.982	-0.003
D	Workers' Compensation	1.202	1.053	0.149	1.067	1.04	0.027
E	Commercial Multiperil	1.041	0.922	0.118	1.002	0.881	0.122
F1	Medical Mal – Occurrence	1.599	1.667	-0.068	N/A	1.458	N/A
F2	Medical Mal - Claims made	1.308	1.2	0.108	0.946*	1.147*	(0.201)*
H	Other Liability	1.194	1.011	0.183	1.07	1.016	0.053
J	Auto Physical Damage	0.925	0.862	0.064	0.806	0.842	-0.036
N&P	Reinsurance A & C	1.331	1.621	-0.291	1.288	1.303	-0.015
O	Reinsurance B	1.329	1.652	-0.323	1.306	1.343	-0.037

Observations - Business Focus = Personal Lines

- We'll refer to Personal Lines Companies as 'specialists'
- Specialist PRFs are lower than non-specialist PRFs in specializing lines [Lines A & B]; [Are Col 3 & 6 <0]
- Difference between specialists and non specialists is (slightly) smaller with minor line filter than without minor line filter. [Is |Col 6| < |Col 3|?]
- For non-specializing LOBs, Specialist PRFs are lower than non-Specialist PRFs. [Col 6 > or < 0]

Personal Lines

Exhibit 3.2: PRFs - Personal Lines

		(1)	(2)	(3)	(4)	(5)	(6)
		Including Minor Lines			Excluding Minor Lines		
Line of Business (LOB)		Specialists	Non-Specialists	Difference	Specialists	Non-Specialists	Difference
A	Homeowners/Farmowners	0.954	0.981	-0.027	0.952	0.958	-0.006
B	Priv. Passenger Auto Liability	0.949	1.045	-0.096	0.947	1.028	-0.08
C	Commercial Auto Liability	0.9	1.023	-0.122	0.904	0.998	-0.095
D	Workers' Compensation	0.965	1.085	-0.121	0.944	1.06	-0.116
E	Commercial Multiperil	0.857	0.965	-0.108	0.814	0.917	-0.104
G	Special Liability	0.931	1.014	-0.083	1.201	0.943	0.258
H	Other Liability	0.902	1.054	-0.151	0.865	1.033	-0.168
J	Auto Physical Damage	0.846	0.884	-0.038	0.844	0.839	0.005
N&P	Reinsurance A & C	1.553	1.523	0.031	1.2	1.302	-0.102

*Asterisks identify PRFs that were computed with fewer than 100 data points, and thus may be unreliable.

Observations - Business Focus = Commercial Lines

- We'll refer to Commercial Lines Companies as 'specialists'
- Commercial Lines is all lines except Personal and Reinsurance.
- Specialist PRFs are not generally lower than non-specialist PRFs in specializing lines [Lines A & B]; [Are Col 3 & 6 <0]
- Difference between specialists and non specialists is not particularly smaller with minor line filter than without minor line filter. [Is |Col 6| < |Col 3|?]
- It may be that this category is too diverse to reflect significant patterns related to specialization.

Commercial Lines Companies

Exhibit 3.3: PRFs - Commercial Lines

Line of Business (LOB)		Including Minor Lines			Excluding Minor Lines		
		Specialists	Non-Specialists	Difference	Specialists	Non-Specialists	Difference
A	Homeowners/Farmowners	0.973	0.963	0.01	0.918	0.957	-0.039
B	Priv. Passenger Auto Liability	1.015	0.98	0.035	0.993	0.972	0.02
C	Commercial Auto Liability	1.029	0.98	0.05	0.997	0.979	0.018
D	Workers' Compensation	1.083	1.052	0.031	1.059	1.037	0.022
E	Commercial Multiperil	1.012	0.917	0.094	0.911	0.878	0.033
G	Special Liability	0.97	1.019	-0.05	0.848	0.976	-0.128
H	Other Liability	0.996	1.026	-0.03	0.974	1.039	-0.065
I	Special Property	0.843	0.834	0.008	0.804	0.82	-0.016
J	Auto Physical Damage	0.876	0.863	0.013	0.816	0.844	-0.028
K	Fidelity & Surety	0.848	0.811	0.036	0.732	0.6	0.132
L	Other	0.943	1.007	-0.065	0.897	0.956	-0.059
O	Reinsurance B	1.59	1.504	0.085	1.462	1.319	0.143
R	Products Liability	1.22	1.267	-0.048	1.134	1.277	-0.143

Dependency and Diversification Credit

Dependency and Diversification Credit

WARNING:

Results in this work stream are subject to several more rounds of peer review.

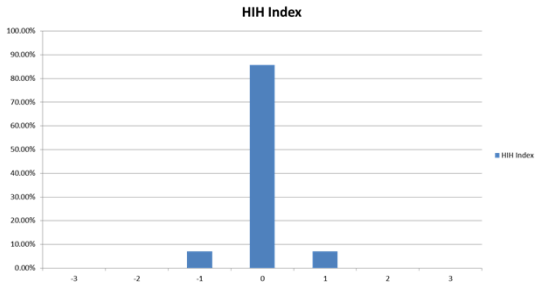
Dependency Areas of Discussion

1. Measures of diversification
2. LOB pairwise correlations
3. Indicated multi-line diversification credit

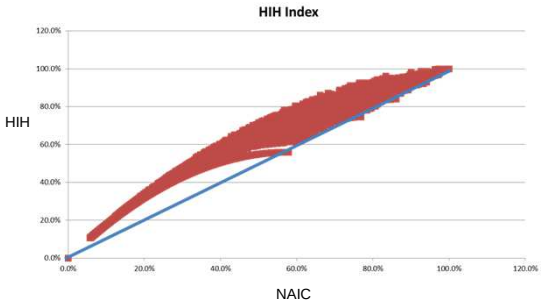
Alternative Measures of Diversification

- RBC Diversification measure:
  - NAIC max line - Max Line (Premium)/All line premium
- Alternative diversification measures
  - NAIC max risk – Max Line (Risk Charge)/All line Risk Charge
  - HIH index – Sum of squares of percentages by LOB
  - Covariance Matrix
- Company diversification rankings similar, regardless of diversification measure

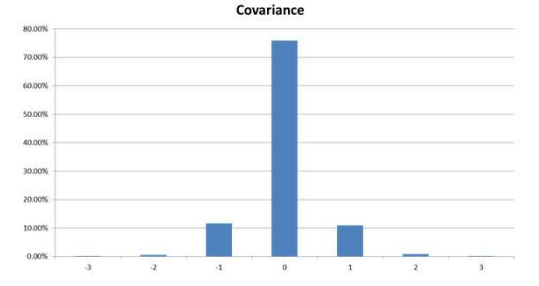
Diversification Measure
HIH vs. NAIC – Quintile Buckets



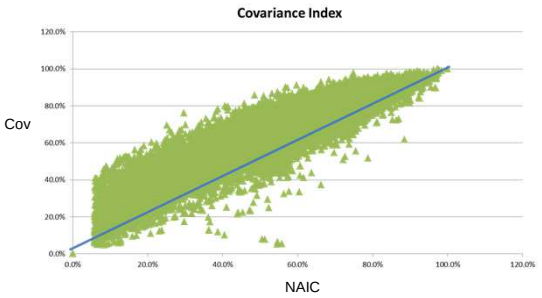
Diversification Measure
HIH vs. NAIC – Scatter Plot



Diversification Measure
Cov. vs. NAIC – Quintile Buckets



Diversification Measure Covariance vs. NAIC – Scatter Plot



LOB Pairwise Correlations

- Pairwise correlation varies widely by LOB-size

  Anticipated Observations
- Pairwise correlation might be expected to be low for small LOB-size, due to random effects predominating
- Pairwise correlating might be expected to be higher for larger LOB-size, as 'true' correlation over-rides random effects.

  Actual Observations
- Actual relationship is more U-shaped by size rather than increasing correlation with size.

  Hypothesis
- Premium correlation may predominate at small LOB-size.

Pairwise Correlation –Risk Charges PPA and HO

	"Observed" Risk Charge					"Modeled" PPA+ HO Risk Charge based on		
(1)	(2)	(3)	(4)	(5)		(6)	(7)	(8)
Size Band	PPA	HO	PPA+HO	Implied Correlation		70% rule	Indepen-dent	100% dependent
15%	29%	30%	24%	31%		26%	21%	30%
25%	22%	34%	21%	23%		24%	19%	27%
35%	25%	22%	16%	-9%		20%	17%	24%
45%	17%	21%	14%	8%		16%	13%	19%
55%	15%	22%	13%	1%		16%	13%	19%
65%	12%	22%	12%	-2%		15%	13%	17%
75%	15%	20%	10%	-29%		15%	12%	17%
85%	11%	21%	10%	-5%		13%	11%	15%
95%	11%	17%	10%	3%		12%	10%	14%
100%	10%	14%	9%	23%		10%	8%	12%
largest 100	11%	12%	8%	-16%		10%	8%	11%
All	17%	23%	14%	-3%		17%	14%	20%

LOB Pairwise Correlations Conclusions

- Similar patterns observed for other common LOB pairs.
- Dependency between lines is size-sensitive.
- In addition to mixing premium dependency with loss dependency, there may be other size-related PH variations within a LOB.
- The "independent" model bests matches observed data most closely, for these LOBs.
- Aggregate multiline model based on pairwise correlations appears to be problematic.

All- Lines Dependency Approach

All Lines Dependency Approach

- Rather than line-by-line, consider all lines relationships.
- Divide companies by size (5 bands) and diversification ranking (6 bands, including one band for monoline = 0 diversification)
- Calculate 87.5th percentile PRF for all lines combined within each diversification/size cell.
- If no diversification effect, PRFs constant down columns.
- Decrease in PRF down a column is measure of diversification benefit.

All Lines Dependency- Findings

- Rather than a simple pattern we find three regions.
- Benefit for diversification increases down column for smaller sizes.
- Benefit for diversification from diversification band 0 to 1 and 2 for larger companies.
- Little apparent benefit of diversification for larger three size bands beyond diversification band 2.

Indicated Risk Charge By Size & Degree of Diversification

All Lines: 87.5th Percentile Risk Charge

	Premium Size Band				
Div Band	A	B	C	D	E
0	45%	25%	24%	26%	35%
1	47%	20%	26%	22%	41%
2	49%	20%	17%	18%	18%
3	37%	21%	18%	20%	18%
4	43%	15%	19%	19%	18%
5	66%	20%	16%	16%	16%

All Line Dependency- Findings

- Finding is consistent with financial economics work that says specialization benefits often offset statistical diversification benefits.
- Liebenberg, Andre P. and David W. Sommer, Effects of Corporate Diversification: Evidence From the property–liability insurance industry, Journal of Risk and Insurance, 2008, Vol. 75, No. 4, 893-919
- As risk measure is 87.5th percentile, diversification across lines must come without any increase in loss ratio in order to produce a benefit.
- That is stronger test than lower variability around (a possibly higher) mean across multiple LOBs

Dependency
Actual vs. Model

- RBC 'model' of diversification effect is 70% rule.
- We can compare (1) observed multi-line risk charge to (2) 'current model', i.e., multiline risk charges implied by NAIC (current) risk charges and 70% rule.
- We can observed to other "models"
  - RBC model with parameter other than 70%, e.g., 50% or 25%;
  - Covariance rule with selected pairwise correlation factors, selected for 87.5th percentile
  - RBC model with indicated underwriting factors, varying by size (how much apparent diversification is due to lower risk charge with size.)
  - RBC model with indicated underwriting factors, varying by size, and adjusted for UW cycle (how much correlation is caused by cycle).

Dependency
Actual vs. Model

- Those models might useful, but the "shape" of diversification effect is inconsistent with any of the models.

Areas of Possible Future Research

Possible Further Research Areas Premium Risk

- PRF and RRF variation with growth/shrinkage
- PRF and RRF variation with reinsurance usage
- Adjusting for maturity effect
- Effect of tabular discount on WC RRF and PRF
- 50/50 rule
- Use of premium as base for reserve risk for immature years (the old "Schedule P reserve" as capital charge rather than balance sheet adjustment)
- Dependency between premium risk and reserve risk – by LOB and in total
- Risk charge on premium gross of reinsurance and implications for R3 risk
- R3 – changes in net risk charge due to ceded reinsurance
- Further analysis of UW cycle impact on calibration and risk charge targets
- Reconsider Investment Income Offset (5% p.a., currently) in light of current investment returns and use of historical loss ratios in calibration.
- Alternative risk metrics
- R0-R3
- Loss sensitive contracts
- Trend test

Questions?

Comments/Suggestions for the Working Party?

Glossary

Item	Definition
AY	Accident Year
CCM	Current Calibration Method
ICM	Improved Calibration Method
PRF	Premium Risk Factor
RRF	Reserve Risk Factor

Solvency II Calibration

Calibration of the Premium and Reserve Risk Factors in the Standard Formula of Solvency II, Report of the Joint Working Group on Non-Life and Health NSLT Calibration, *12 December 2011*

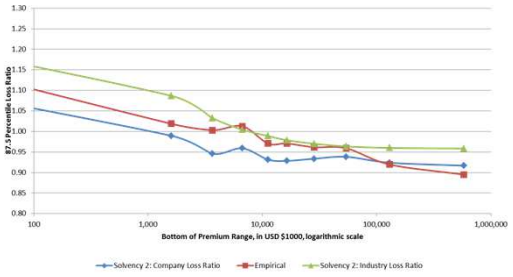
Solvency II Loss Ratio Model

- Random loss ratios driven by compound poison process
- Variance related to size (premium).
- Parameters vary over time.
- The expected value of the random process is the expected loss ratio.
- The variance of the process is a quadratic function of size and size-squared. Linear size-term implies variance goes to zero. Quadratic size-term implies variance goes to constant value.
- Error function is normal or lognormal.

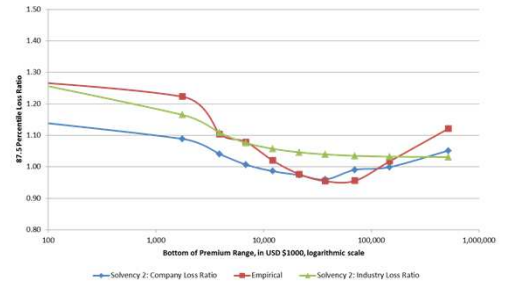
Solvency II Loss Ratio Model

- Loss ratio and variance parameters can be industry-wide values or company specific values.
- Data is more sparse for company specific parameters, but fit is better.
- We consider both industry and company loss ratio parameters.
- Use only industry variability parameter.
- Normal and Lognormal error functions produce similar results. Neither is a very good fit to small or large LOB-sizes.

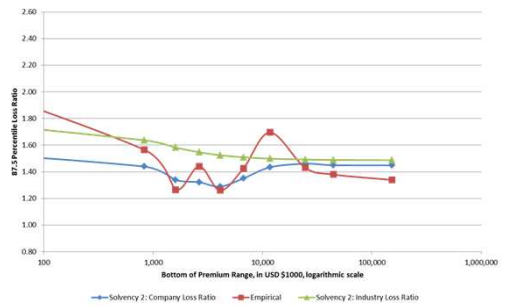
PRF – Solvency 2 and ICM – PPA



PRF – Solvency 2 and ICM – WC



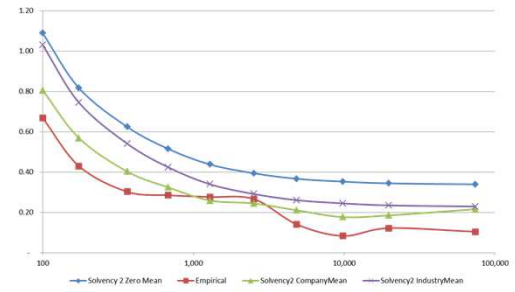
PRF – Solvency 2 and ICM - MPL



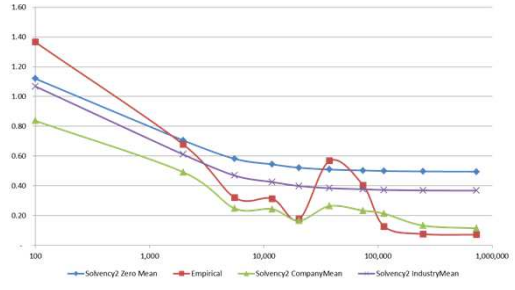
Solvency II Reserve Runoff Variability Model

- Same model
- Size = initial reserve
- Comments regarding premium apply equally to reserve runoff.
- Consider expected runoff =
  - Industry average,
  - Company specific, or
  - Zero

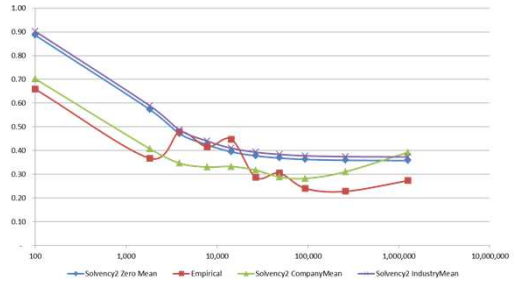
RRF – Solvency 2 and CCM - PPA



RRF – Solvency 2 and CCM – MPL Occ



RRF – Solvency 2 and CCM – WC



Regression Analysis of Risk Factors

Insolvency History

1996-2010 Impairments*

- 397 impaired companies
- 3,287 unimpaired companies

- 10.8% impairment over 14 years
- 0.8% impairment rate per year

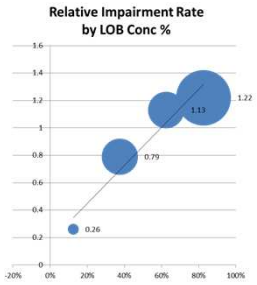
- *This count may not be complete. Our main objective is to review risk characteristics of insolvencies. For that purpose a representative sample is sufficient.

Characteristics of Impaired/Unimpaired Companies

- Risk Characteristics
  - Premium Size
  - State Concentration
  - LOB Concentration
  - Reinsurance Usage
  - Main geographic region
- Evaluate Relative "Mortality" Rate by risk characteristic (univariate basis only)

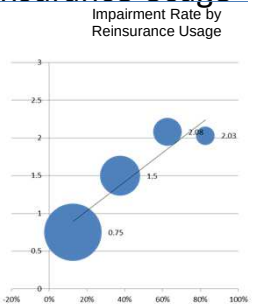
Univariate Analysis Insolvency by "LOB Concentration"

- Increasing impairment to the right as LOB concentration % increases.
- Bubble size represents the number impaired companies (data set). 202 companies in the largest bubble; 8 companies in smallest bubble.
- The range of insolvency rates is a factor of 5.0



Univariate Analysis Insolvency by Reinsurance Usage

- Increasing impairment rate to the right as reinsurance usage (ceded % of gross WP) increases
- Bubble size represents the number impaired companies (data set). 214 companies in the largest bubble; 22 companies in smallest bubble.
- The range of insolvency rates is a factor of 3



Regression Analysis Model Outline

The two-year impairment probability for the i^{th} company, p_i , is assumed to be a logistic function of n predictive variables

($\mathbf{X}_n$): $\text{Logit}(p_i)=B0+ B1\ X_{1i} + B2\ X_{2i} +\ldots+ Bj\ X_{ni}$,

where, $\text{Logit}(p_i)=\ln(p_i /(1- p_i))$.

The explanatory variables can be either continuous or categorical.

Regression Analysis Impairment Data

Impairment Lag	Annual Statement Year														
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
NA	3269	3269	3269	3269	3269	3269	3269	3269	3269	3269	3269	3269	3269	3269	3269
-1	13	11	13	37	43	40	31	16	10	14	5	12	15	16	17
-2	11	13	37	43	40	31	16	10	14	5	12	15	16	17	0
-3	13	37	43	40	31	16	10	14	5	12	15	16	17	0	0
-4	37	43	40	31	16	10	14	5	12	15	16	17	0	0	0
-5	43	40	31	16	10	14	5	12	15	16	17	0	0	0	0
-6	40	31	16	10	14	5	12	15	16	17	0	0	0	0	0
-7	31	16	10	14	5	12	15	16	17	0	0	0	0	0	0
-8	16	10	14	5	12	15	16	17	0	0	0	0	0	0	0
-9	10	14	5	12	15	16	17	0	0	0	0	0	0	0	0
-10	14	5	12	15	16	17	0	0	0	0	0	0	0	0	0
-11	5	12	15	16	17	0	0	0	0	0	0	0	0	0	0
-12	12	15	16	17	0	0	0	0	0	0	0	0	0	0	0
-13	15	16	17	0	0	0	0	0	0	0	0	0	0	0	0
-14	16	17	0	0	0	0	0	0	0	0	0	0	0	0	0
-15	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Count	3572	3549	3538	3525	3488	3445	3405	3374	3358	3348	3334	3329	3317	3302	3286
Impaired	34	24	50	80	83	71	47	26	24	19	17	27	31	33	17
Survive	3,538	3,525	3,488	3,445	3,405	3,374	3,358	3,348	3,334	3,329	3,317	3,302	3,286	3,269	3,269
Imp. Ratio	1.0%	0.7%	1.4%	2.3%	2.4%	2.1%	1.4%	0.8%	0.7%	0.6%	0.5%	0.8%	0.9%	1.0%	0.5%

Year 2000, for example:

1. 3488 companies are observed.
2. 83 will become impaired in 2000 and 2001 (we use a 2-year forecast window); 43 in 2000 and 40 in 2001.
3. For year 2001, there are 3445 companies, 3488 less the 43 impaired in 2000, but including the 40 that will become impaired in 2001.

Regression Analysis Control Variables

Control Variables:

- Underwriting Cycle – Industry Combined Ratio*
- Size – Invested Assets
- Capital – Surplus Ratio

*Combined Ratio (CR) 2 years after selected time.

Use CR to control for the fact that impairments relate UW cycle, and allow the regression to identify company-specific features that affect impairment probability.

Regression Analysis Significant Company Risk Factors

Company Risk Factors

- Reinsurance recoverable (on paid loss) portion of assets (higher is bad)
- Ceded Reinsurance (complicated pattern)
- LOB Risks - WC or Financial LOB concentration (perhaps a feature specific to 1996-2010 analysis period*)
- *(Another features that may be specific to the time period is that Medical Professional Liability shows lower than average risk in the 1996-2010 period.)

Regression Analysis of Impairment Risk Factors

Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept		1	-8.1920	0.9522	-10.0582	-6.3258	74.02	<.0001
CededRng_j	0-30%	1	0.2924	0.1991	-0.0979	0.6827	2.16	0.1420
CededRng_j	30-40%	1	0.9510	0.2245	0.5111	1.3909	17.95	<.0001
CededRng_j	40-70%	1	0.5982	0.2125	0.1817	1.0148	7.92	0.0049
CededRng_j	70-80%	1	0.7149	0.2819	0.1624	1.2674	6.43	0.0112
CededRng_j	80-90%	1	0.9019	0.2761	0.3608	1.4430	10.67	0.0011
CededRng_j	90-100%	0	0.0000	0.0000	0.0000	0.0000	.	.
MC_j		1	0.8525	0.1461	0.5662	1.1389	34.05	<.0001
Flines_j		1	1.0662	0.1730	0.7272	1.4053	37.98	<.0001
Max_CR		1	0.0758	0.0085	0.0591	0.0925	79.07	<.0001
BondsMinusReRec_j		1	-1.4603	0.1480	-1.7504	-1.1701	97.31	<.0001
InAssets_j		1	-0.1910	0.0203	-0.2307	-0.1513	88.80	<.0001
SurplusRatio_j		1	-5.4030	0.2898	-5.9770	-4.8410	348.31	<.0001
Scale		0	1.0000	0.0000	1.0000	1.0000		

Reins

LOBs

Reins

Control Factors

Company-Specific Reserve Risk Charge vs. RBC Reserve Risk Charge

Company-Specific Reserve Risk vs. RBC Reserve Risk Charge

WARNING:

Results in this work stream are particularly immature.

Reserve Risk Based on Data Triangles vs. ICM Calibration - 1

- Risk can be assessed based on variability in data triangles
- This can done with an analytical method like Mack or a stochastic modeling method:
  - Mack,
  - Correlated Chain Ladder (Meyers)
  - Stochastic loss development factors – chain ladder or BF (Feldblum)
- Compare these to ICM, by company size

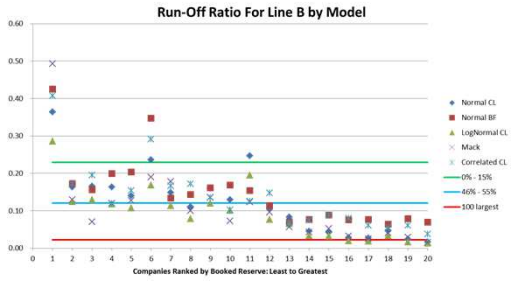
Reserve Risk Based on Data Triangles vs. ICM Calibration -2

- Selected sample of companies:
  - Covered all size ranges
  - Loss triangles well-behaved so reserving models can be applied;
  - 23 years of data; no unusual growth; reinsurance typical for size and line.
  - Selecting “well behaved” company data sets biases results

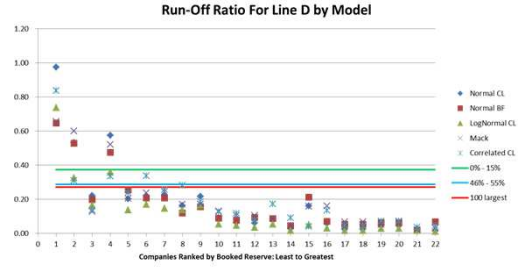
Reserve Risk Based on Data Triangles vs. ICM Calibration - 3

- Individual company parameters
  - Vary among methods
  - ICM results usually within the range of individual company methods.

Company Model vs CCM -PPA



Company Model vs CCM -WC



Consumer Value Risk Metric

Risk Metric Alternatives

- CCM and ICM use risk metric – 87%-ile over all companies all years ('current'),

  Alternatives (not tested) include:

  higher VaR,

  within years,

  within companies,

  TVar or other risk metric

  Alternative treatments of UW cycle

  "Consumer Value" measure

Consumer Value Parameters

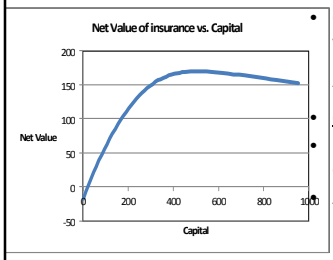
Rather than 'arbitrary' VaR or Tvar selections, "Consumer Value" parameters are:

- Cost of Capital
- Consumer Utility Function (what is certainty equivalent of losses of various size)
- Distribution of insurer's potential total losses

"Consumer Value Risk Metric"

- Optimize "consumer" value considering:
  - Benefit of lower default risk from capital increase
  - Cost of higher premium from capital increase
- Optimized risk metric is VaR of loss distribution transformed to give higher probability weight to losses in the tail.
- Shape of consumer value is not highly sensitive to capital near the optimum level

Risk Metrics
Consumer Benefit vs. Capital



- Consumer benefit, "net value", varies +/-10% while required capital varies by factor of over 1.5.
- Caveats:
- Parameters to assess optimization still illustrative.
- Actual parameterization will be problematic.

See More at:

An Economic Basis for P/C Insurance RBC Measures (Report 5)
http://www.casact.org/pubs/forum/13sumforum/01RBC-econ-report.pdf

Impact Analysis

Impact Analysis

- Apply current and indicated PRF and RRF to all companies with sufficient data.
- Using certain approximations:
  - NAIC provided R0, R1, R2 and R3
  - DCWP -calculated R4 and R5
  - No growth charge; No own-company adjustment for 2Year LOBs
- Determine effect: in total and by types of company (various categories)
- Determine distribution of % effects

Impact

- Work in Progress

Calibration based on Combined Ratio

Calibration based on Combined Ratio -1

- We considered whether higher loss ratios might be correlated with lower expense ratios.
- If so, premium risk factors calibrated based on loss ratio, to which expense ratios were added, might over-state risk charges.

Calibration based on Combined Ratio -2

- We prepared risk charge calculations based on combined ratios rather than loss ratios.
- Risk charges on that basis were higher than risk charges based on loss ratios with expenses added.
- Therefore concern regarding overstatement was not consistent with the data.
- Since expenses by company are in the formula, systematic understatement not likely either.

Calibration based on Combined Ratio -3

- Combined ratios within size band were more variable than loss ratios on the same basis.
- This is a further indication that individual company treatment of expenses, as in the current RBC formula, seems appropriate.

DCWP Members:

RBC Research Working Party Members (2013)

Emmanuel Bardis	Allan Kaufman (Chair)	Ashley Reller
Jess Broussard	Terry Kuruvilla	David Rosenzweig
Robert Butsic	Apundeep Singh Lamba	Andrew Staudt
Pablo Castets	Giuseppe (Franco) LePera	Timothy Sweetser
Joe Cofield	Zhe Robin Li	Anna Marie Wetterhus
Jose Couret	Lily (Manjuan) Liang	Jennifer Wu
Brian Fannin	Thomas Loy	Jianwei Xie
Sholom Feldblum	Glenn Meyers	Linda Zhang
Dennis Franciskovich	Daniel Murphy	Christina Zhou
Dean Guo	Douglas Nation	
Shira Jacobson	G. Chris Nyce	CAS Staff:
Shiwen Jiang	Jeffrey Pflugger	Karen Sonnet
	Yi Pu	David Core

RBC Research Working Party 'Retired' Members (2011-2012)

Karen Adams Damon Chom Orla Donnelly Chris Dougherty Nicole Eliot Kendra Felisky	Timothy Gault Jed Nathaniel Isaman James Kahn Alex Krutov Ed Marchena	Mark McCluskey Daniel Murphy James McNichols David Ruhm Ji Yao

Work Stream Leaders

Work Stream	Leader	Team
Chair – Allan Kaufman		
Overview Reports 1 and 2		Committee members as listed on those reports
3. Solvency II Formula and RBC	Joe Cofield	Christina Zhou
4. Insolvency Risk Factors-Univariate	Ed Marchena	
5. Risk Metric	Bob Butsic	Sholom Feldblum, Glen Meyers
6. Premium Risk Factors	Jennifer Wu, Dennis Franciskovich	Karen Adams, Franco LePera, Daniel Murphy, Tim Sweetser
7. Reserve Risk Factors	Jennifer Wu	Karen Adams, Dennis Franciskovich, Franco LePera, Daniel Murphy, Tim Sweetser

Work Stream Leaders

Work Stream	Leader	Team
Risk Charge by Type of Company	Ashley Reller	
Solvency II Calibration	Jeff Pflugger, Tim Sweetser	Glen Meyers
Insolvency risk Factors- Regression	Jose Couret	
Rsv Risk Charge - Individual Co Risk Charge vs. RBC	Manolis Bardis	Christian Citarella, Glen Meyers, Linda Zhang, Damon Chom
Dependency	Apundeep Lamba	Shiwen Jiang, Glen Meyers, Dan Murphy, Damon Chom
Impact Analysis	Ron Wilkinson	Ji Yao, Damon Chom, Dean Guo,
Combined Ratio	Douglas Nation	