CAS RBC Research Working Parties:

Underwriting Risk Working Party (URWP) Dependency and Calibration Working Party (DCWP)

Allan Kaufman
Dan Murphy
Christina Zhou

Working Party Members listed on last pages and in eForum 2012 Winter Vol 1

Working Party Charge

- Two working parties now operating as one
- Providing support to Academy RBC committee
- 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.

Working Party Publications To Date

DCWP Report:

www.casact.org/pubs/forum/12wforum/DCWP_Report.pdf

URWP Report:

www.casact.org/pubs/forum/12wforum/RBC_URWP_Report.pdf

Why?

There is recent 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.
- A good study of the standard formula provides data and analytical techniques contributing to individual company risk assessment methodologies.
- Each standard formula (RBC, ICAS, Solvency II) has drawn ideas from its predecessors. We plan to expand on that chain of developments.

Agenda

- URWP/DCWP charge and structure (Allan)
- URWP Findings (Dan)
- URWP– Current Activities (Allan)
- DCWP Findings (Allan)
- DCWP - Current Activities (Allan, Christina)
- Future Directions including Q&A

Q&A Throughout

CAS RBC
Underwriting Risk WP
2011 Findings

RBC Underwriting Risk is Comprised of Premium Risk and Reserve Risk

Premium Risk is the easier of the two!

- In general terms, the amount of a company's premium risk charge is a factor times premium:

$$RBC\ Premium\ Risk\ Charge = NWP \cdot PremiumRiskLoadFactor$$

- In general terms, the factor is based on industry-wide Loss and LAE ratios

$$PremiumRiskLoadFactor = Loss\&LAE\ Ratio_{87.5\%} \cdot DiscountFactor + UW\ Expense\ Ratio - 1$$

- Premium Risk Charge provides capital for the potential that actual loss and adjustment expense on policies written last year may ultimately be higher than anticipated in the pricing

Calculation of Industry-Wide Loss & LAE Ratio$_{87.5\%\text{-ile}}$

- Generally, based on Loss and LAE ratios found in Part 1 of Schedule P (by RBC line of business)
- Gather all the company data together
- Calculate the empirical 87-½ percentile
- Problem: Empirical percentiles at high risk levels are notoriously volatile

	Schedule P Part 1 (col 31)			
	Net Loss and Loss Expense Percentage			
	Co. A	Co. B	Co. C	…
Prior	XXX	XXX	XXX	
2002	85.4	43.8	228.4	
2003	87.9	35.3	202.2	
2004	90.4	33.3	157.4	
2005	78.3	32.5	164.7	
2006	82.1	39.9	117.9	
2007	79.4	50.4	100.0	
2008	78.9	54.9	95.6	
2009	122.2	92.8	55.9	
2010	95.0	70.3	395.0	
2011	116.7	72.3	113.8	
	=PERCENTILE(D6:F15,0.875)			
			160.1	

Reserve Risk Calibration: Inherently More Complicated

- In general terms, the amount of a company's reserve risk charge is a factor times booked reserves:

$$\begin{aligned} &\mathit{RBC\ Reserve\ Risk\ Charge} \\ &\quad = \mathit{Carried\ Net\ Reserves} \cdot \mathit{ReserveRiskLoadFactor} \end{aligned}$$

- In general terms, the *Reserve Risk Load Factor* is based on industry-wide ratios of Loss and DCC development

$$\begin{aligned} &\text{"}\mathit{ReserveRunoffRatio}\text{"} \\ &= \frac{\mathit{development\ amount\ of\ net\ reserves\ after\ the\ statement\ date}}{\mathit{net\ reserves\ as\ of\ the\ statement\ date}} \end{aligned}$$

$$\begin{aligned} &\mathit{ReserveRiskLoadFactor} \\ &\quad = (1 + \mathit{Reserve\ Runoff\ Ratio}_{87.5\%}) \cdot \mathit{DiscountFactor} - 1 \end{aligned}$$

- Reserve Risk Charge provides capital for the potential that the actual unpaid loss and DCC may ultimately be higher than anticipated by management's carried reserve

Calculation of Industry-Wide Reserve Runoff Ratio$_{87.5\text{-}\%ile}$

Co. A	Schedule P Part 2														
	Incurred Net Loss & DCC										DEVELOPMENT		For RBC		
	1	2	3	4	5	6	7	8	9	10	One Year	Two Year	3 Yr	...	9 Yr
Prior															
2002															
2003	XXX														XXX
2004	XXX	XXX													XXX
2005	XXX	XXX	XXX												XXX
2006	XXX	XXX	XXX	XXX											XXX
2007	XXX	XXX	XXX	XXX	XXX									XXX	XXX
2008	XXX	XXX	XXX	XXX	XXX	XXX								XXX	XXX
2009	XXX	XXX	XXX	XXX	XXX	XXX	XXX						XXX	XXX	XXX
2010	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX				XXX	XXX	XXX	XXX
2011	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX		XXX	XXX	XXX	XXX	XXX
										12. Totals	10	20	30		90
										Reserves as of previous year ends	100	100	100	...	100
										Co. A Reserve Runoff Ratio	10.0%	20.0%	30.0%	...	90.0%
										Co. B Reserve Runoff Ratio	-35.5%	-44.5%	-32.0%	...	-20.3%
										Co. C Reserve Runoff Ratio	47.3%	2.4%	19.1%	...	-10.5%
										...					
												PERCENTILE(L19:P21,0.875) =			0.408

- Generally, based on Loss and LAE amounts found in Part 2 of Schedule P
- Gather all the company data together and calculate the empirical 87.5%-ile
- Problem: Empirical percentiles at high risk levels are notoriously volatile
  - The smaller the data set, the greater the volatility

Volatility Exacerbated by Limited Data: "Filtering"

- For reserve risk a company is eliminated if it has
  - Negative incurred, paid, or reserve Loss & DCC in any accident year as of any statement date
  - Fewer than ten accident years with non-zero loss data as of some evaluation date
- For premium risk a company is eliminated if it has
  - Average AY earned premium less than $500,000
  - Any AY loss ratio ≤ 0%
  - Less than eight AYs with net earned premium greater than 20% of its average earned premium for all accident years
  - Fewer than ten years of earned premium
- In most lines of business filtering eliminates more than 50% of available industry data
  - See Exhibit 1 next slide

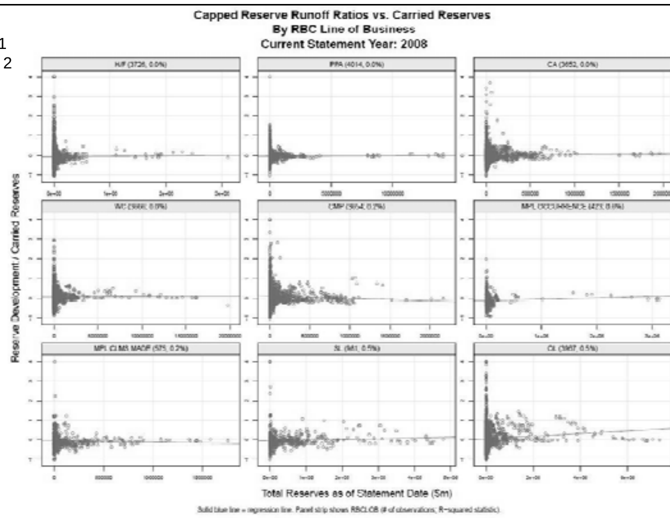
Exhibit 1: Current Company Filtering More companies are eliminated than dollars

Percentage of Industry Data Utilized						
Line	Line Letter	Reserve Dollars	Reserve Companies	Premium Dollars	Premium Companies
(1) H/F	A	81.7%	39.0%	95.7%	57.0%
(2) PPA	B	85.1%	42.5%	95.6%	57.0%
(3) CA	C	80.6%	40.2%	90.5%	53.7%
(4) WC	D	82.5%	41.4%	91.1%	54.9%
(5) CMP	E	71.0%	40.3%	93.0%	56.7%
(6) MM Occurrence	F1	43.0%	10.7%	74.0%	20.3%
(7) MM CM	F2	59.2%	14.2%	71.9%	21.3%
(8) SL	G	64.5%	18.7%	83.3%	31.2%
(9) OL	H	64.4%	27.7%	89.8%	43.5%
(11) Spec Prop	I	29.9%	26.9%	89.0%	51.8%
(12) Auto Phys Damage	J	31.3%*	12.8%*	95.8%	56.9%
(10) Fidelity & Surety	K	29.8%	8.6%	88.9%	31.2%
(13) Other	L	25.7%	10.5%	68.7%	22.6%
(15) International	M	20.5%	1.4%	28.9%	1.9%
(16) Reins Property & Financial	N&P	34.3%	7.7%	63.3%	20.9%
(17) Reinsurance Liab	O	15.9%	4.4%	49.9%	13.8%
(18) Products Liability	R	48.4%	19.7%	75.1%	31.0%
(14) Fin & Mort	S	**	**	**	**
(19) Warranty	T	**	**	**	**
Average		67.1%	31.7%	91.3%	51.6%

- RBC calibration tends to be dominated by the results of larger companies

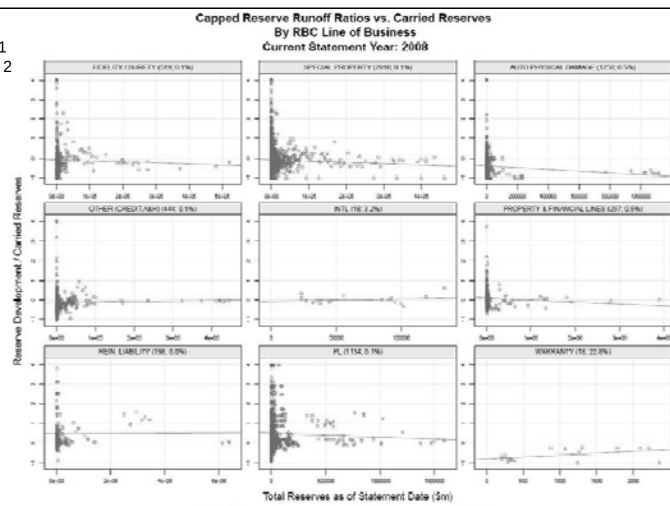
Reserve Runoff Ratio Volatility Varies by Size of Booked Reserve

Exhibit B.1
Page 1 of 2



Reserve Runoff Ratio Volatility Varies by Size of Booked Reserve (cont.): Some lines have very thin data

Exhibit B.1
Page 2 of 2



Alternatives Investigated

- Alternative filtering
  - "Dial back" on the filtering parameters so as to keep a selected percent of the industry
- Curve fitting
  - Normal
  - Lognormal
- Investment income rates other than 5%
- One-year horizon for reserve risk charges

CAS RBC
Underwriting Risk
Current Research

WARNING:
The following slides describe preliminary work which may change materially when research is complete.

Ongoing Research

- Use different data sources
  - More years
  - Company-specific data
- Use stochastic methods on data triangles as an alternative to percentiles of carried loss ratios/reserve runoff ratios
  - Paid
  - Incurred
- Application of solvency II calibration models to percentiles of carried loss ratios and runoff ratios
- Cannot rule out possibility that this research will suggest an alternative to the current RBC "formula"
- Dependency structure

Research Status
Data

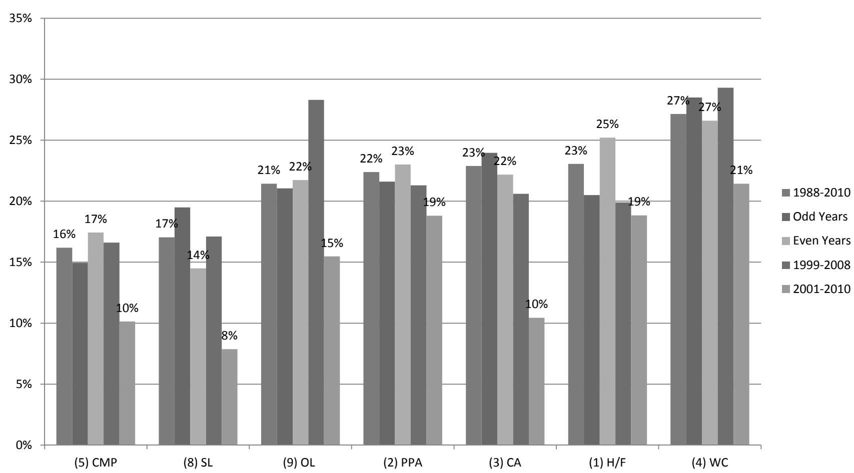
- 23 accident years of loss ratios and 23 years of reserve date runoff ratios, developed by year up to 10 years
- By company (3700 companies in total across all lines and years)
- Summarization into groups and pooled entities (as needed)
- Capable of isolating sub-types of company (e.g. non-standard auto)

Research Status
Time Period, Filtering and Size

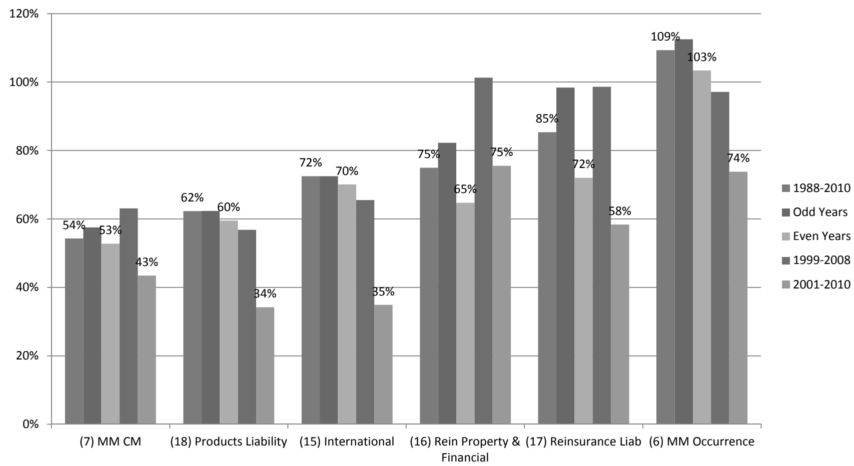
- Risk Charge indications vary (too much) from one annual statement to the next*
- Risk charges vary based on the filter
- Risk charges vary based on company size

[*Based on "current filter" including only companies with data in all years.]

Premium Risk
Time Period Effect-Lower Risk LOBs



Premium Risk
Time Period Effect-Higher Risk LOBs



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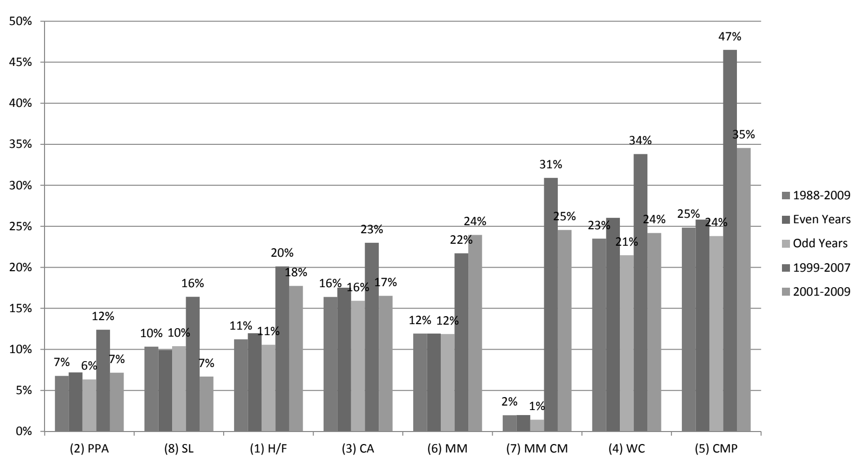
Reserve Risk
Time Period Effect-Lower Risk LOBs



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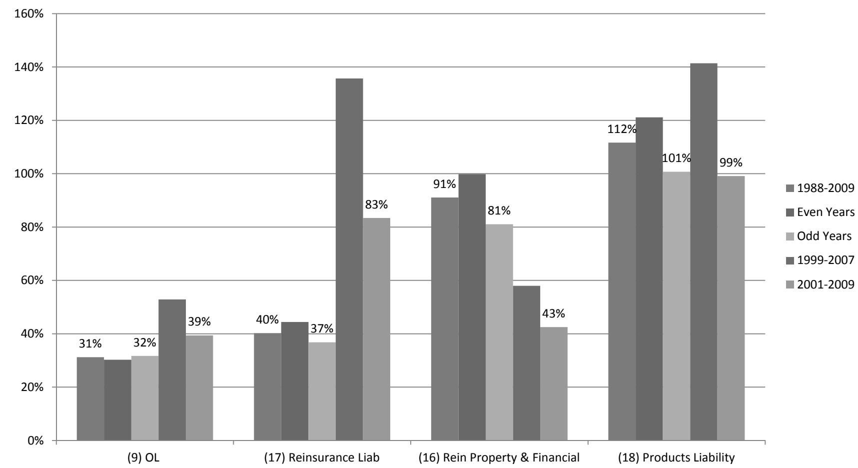
Reserve Risk
Time Period Effect-Higher Risk LOBs



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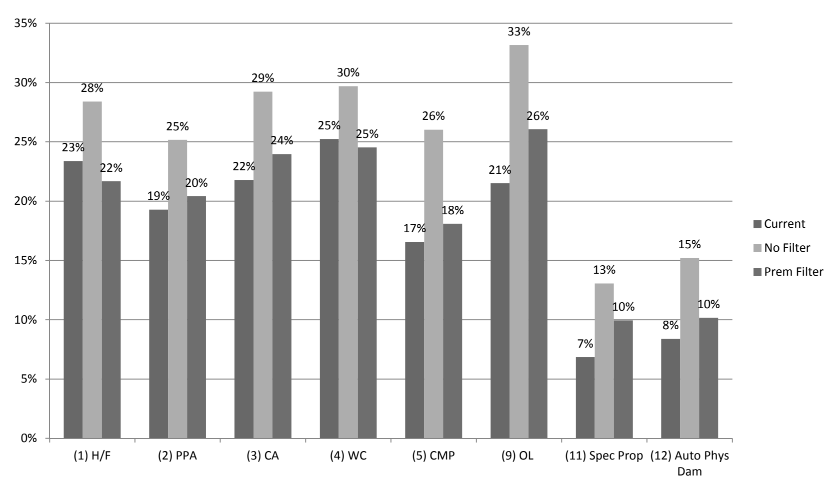
Premium Risk
Filter Effect – Lower Risk LOBs



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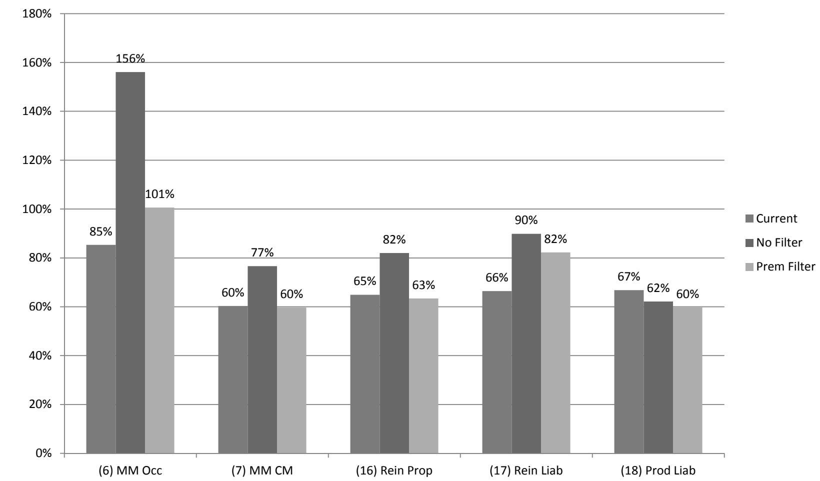
Premium Risk
Filter Effect– Higher Risk LOBs



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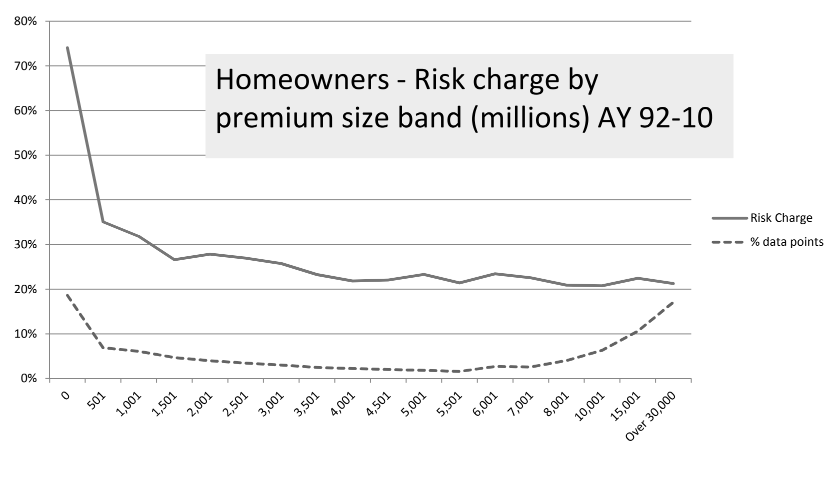
Premium Risk
Charge Varies with LOB Size



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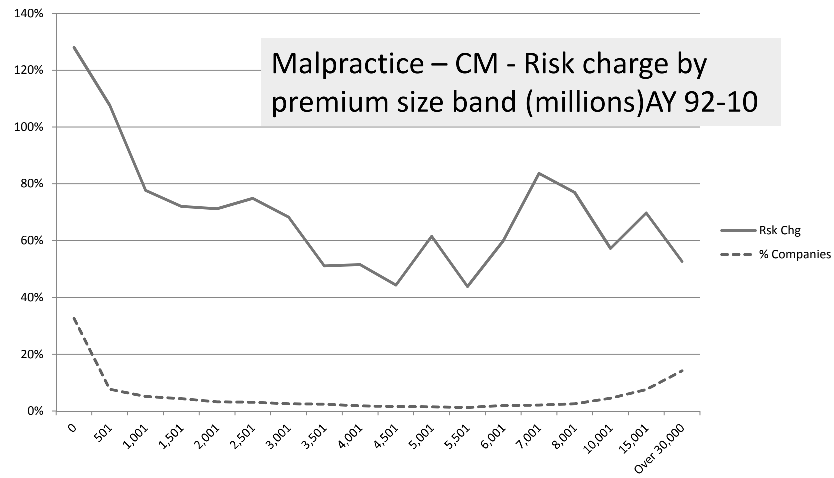
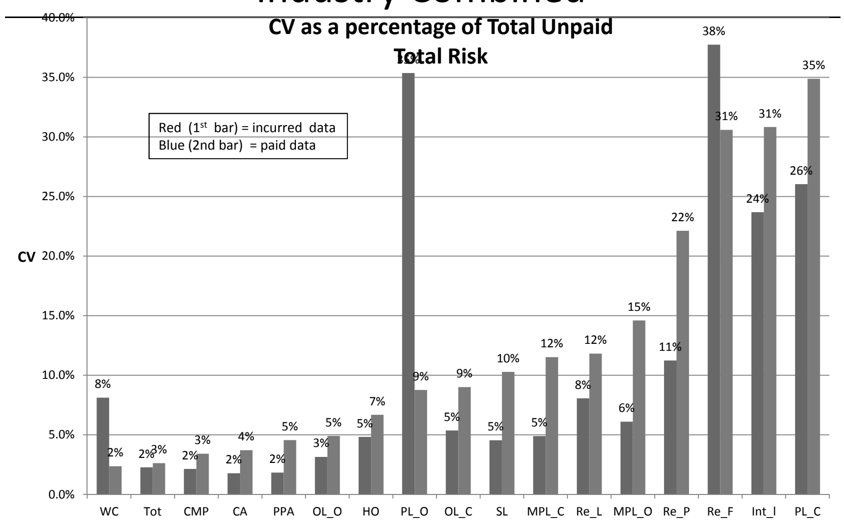
Premium Risk
Charge Varies with LOB Size



Reserve Risk Based on Data Triangles
Industry Combined

- Risk can be assessed based on variability in data triangles
- This can done with an analytical method like Mack or a stochastic modeling method
- Applying Mack-like method to industry total data (less risk than for any individual company) gives results on following slide
- Plan is apply analytical and stochastic methods to companies of various sizes

Reserve Risk Based on Data Triangles Industry Combined



Dependency

For a standard formula there are two methods of reflecting dependency:

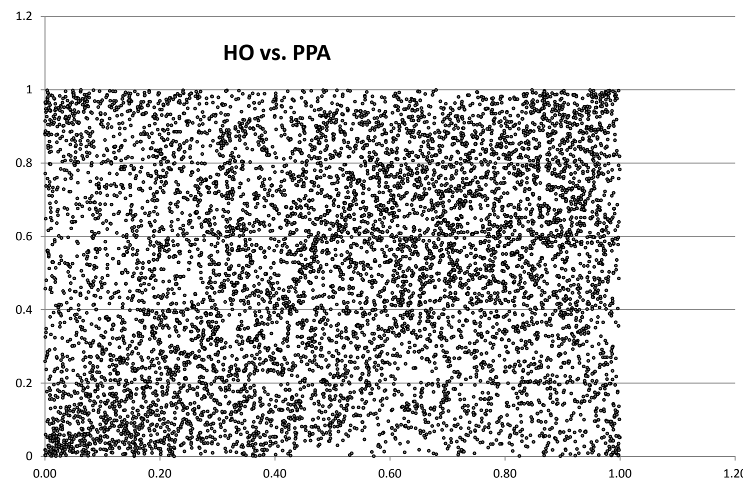
1. Weighting factors (that look like a covariance matrix) combining component risk charges
2. Scenario sets* measuring the effect of risks singly in combinations, e.g., cats, adverse loss ratios, or interest rate changes

*In practice a single or small number of scenarios. In theory, large sets of scenarios to reflect a whole stochastic set of possibilities.

Dependency
DCWP/URWP Research Directions

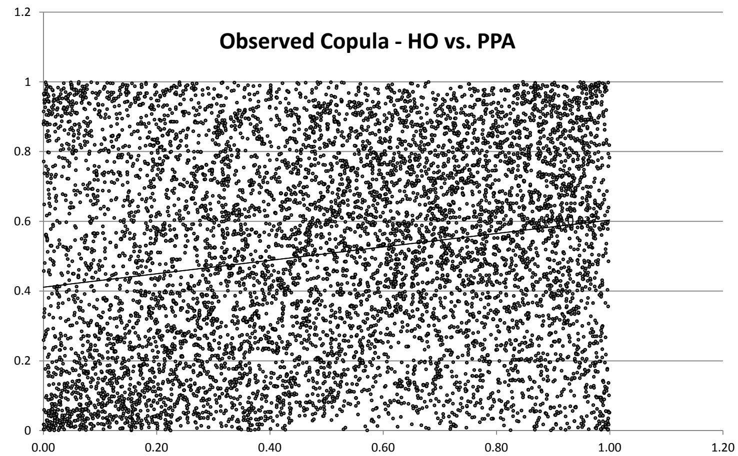
- Analyze LOB-pairs (by AY and company) for patterns in percentile relationships of reserve development or loss ratios
- Common shock models, reflecting company size
- Stochastic modeling reflecting specific common drivers like inflation

Observed Percentile Pairs
"Empirical Copula"

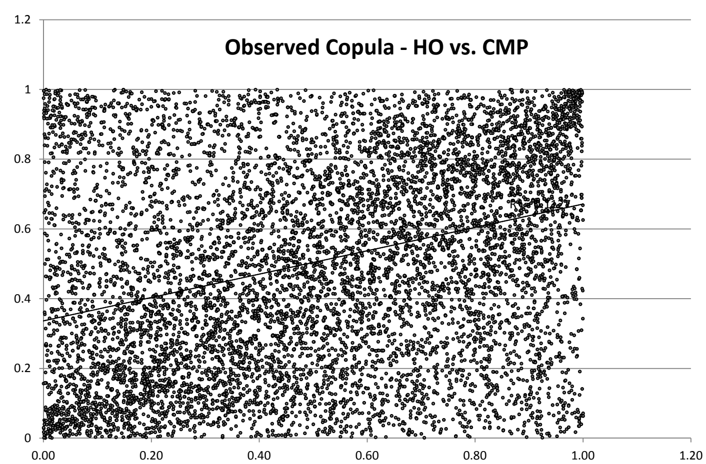


Observed Percentile Pairs

Linear Regression does not reflect the pattern well



Observed Percentile Pairs



CAS RBC
Dependency and Calibration WP
2011 Findings and Next Steps

Summary of DCWP Findings

A. Overall adequacy declining
B. Charges too low/high by type of company
C. Safety standard not specified
D. Dependency is not properly reflected
E. Use of simplifications could be reduced
F. Many factors not reviewed or updated since inception

Details in Appendix I

DCWP Ongoing Research

1. Learning from insolvencies
2. Interesting ideas from Solvency II
3. Effect of changes in RBC structure – in total and by type of company
4. Risk Metrics

WARNING:
The following slides describe preliminary work which may change materially when research is complete.

Insolvency History

1996-2010 Impairments*

- 397 impaired companies
- 3,287 unimpaired companies

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

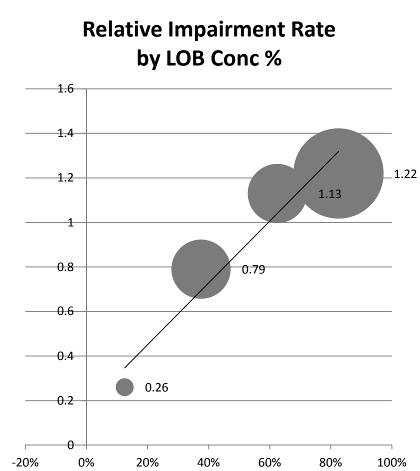
- *This count may not be complete. Our main objective is to review risk characteristics of insolvencies. For that purpose a representative sample is sufficient.

Characteristics of Impaired Companies

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

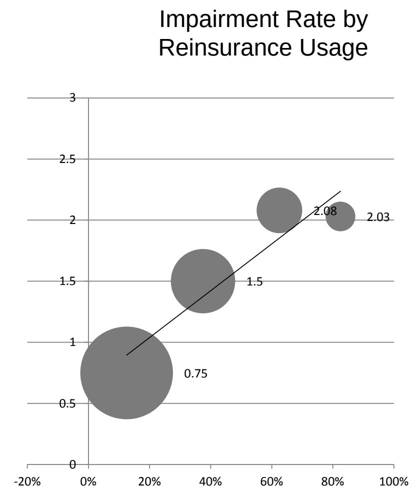
Insolvency by "LOB Concentration"

- 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



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



Review of Insolvencies - Caveats

- Two prior slides show the most “well-behaved” of risk characteristic patterns.
- Analysis is <u>univariate</u>, but size, concentration, reinsurance usage, etc. are likely to be highly correlated variables.
- Carried capital also varies with risk characteristics and observed impairment rate will depend on capital adequacy, obscuring or aggravating observed mortality patterns.

Solvency II

- Source of interesting ideas including:
  - LOB and premium/reserve covariance
  - Geographic diversification/concentration risk
  - Relationship of company size to risk
  - Asset risk – market value
  - Covariance across risk categories
  - Reinsurance credit risk (counterparty risk)

Risk Based Capital
Dependency and Calibration Working Party

Comparison of SII vs. RBC
- Reinsurance Counterparty Risk

SII Segregates Counterparty Risk into Type 1 and Type 2

- Solvency II (SII) standard formula requires separate charges for two types of Counterparty Default Risk:
  - Type 1 exposures may not be diversified and the counterparties are likely to be rated (reinsurance arrangements, derivatives, other risk mitigation contracts, etc).
  - Type 2 exposures usually are diversified and the counterparties are likely to be unrated (receivables from intermediaries, policyholder debtors, etc).
- For Type 1 exposures, Solvency Capital Requirement (SCR) under Solvency II standard formula is 3 times the standard deviation of the loss distribution if the standard deviation is less than 5% of total Loss Given Default (LGD), the usual case; otherwise 5 times the standard deviation and capped at total LGD.

Capital Charges Vary by Counterparty Ratings

- The variations are determined based on a function of LGD and Probability of Default (PD)
  - LGD usually is 50% of sum of receivables plus risk mitigation effects minus collaterals , but would be 90% of such if the collaterals are over 60% of the counterparty asset.
  - PD varies with ratings of counterparties or their solvency ratios if not rated.

    The risk charge is based on probability of default in stressed conditions, i.e. higher than the average PD.

Rating	PD
AAA	0.002%
AA	0.01%
A	0.05%
BBB	0.24%
BB	1.20%
B	6.04%
CCC or Lower	30.41%

Solvency Ratio	PD
>200%	0.025%
>175%	0.05%
>150%	0.1%
>125%	0.2%
>100%	0.5%
>90%	1%
>80%	2%
<=80%	10%

Examples – Solvency 2 vs. RBC Charge for Reinsurance Counterparty Risk

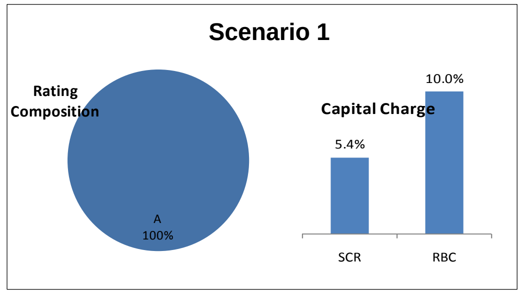
- Graphs opposite illustrate SII vs. RBC Charge for the same rating allocation .
- Assume total net recoverable of 10,000 , no collateral.
- Scenario 1:

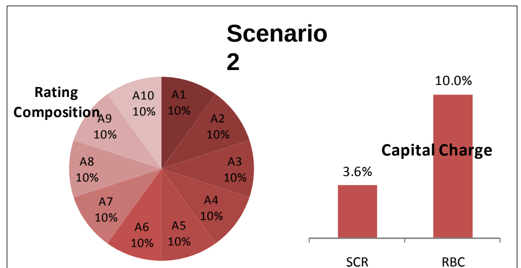
  All from one A-rated insurer with risk mitigation effect (RM) of 60% of recoverables.

  Results: SCR 5.4 % (as % of recoverables), RBC 10% .
- Scenario 2:

  Same, but 10% from each of 10 A-rated insurers.

  Results: SCR 3.6%, RBC 10%.





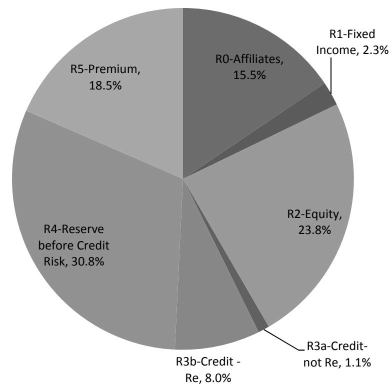
Risk Charge Components

- What actually matters
  - In total
  - By type of company

RBC Components

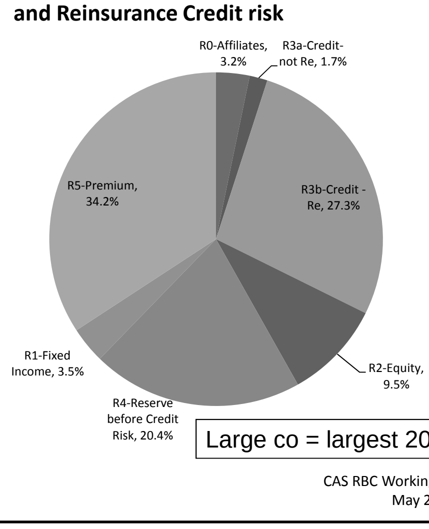
- RBC components - before covariance and before R3 (reinsurance) combined with R4 (reserve)
- Largest component is reserve risk –R5
- Second largest of R2- Equity.

  Over 25% of equity risk arises from equity concentration risk component
- Third largest risk is R4 – premium. Is that reasonable? Is that because cat risk is not sufficiently reflected?

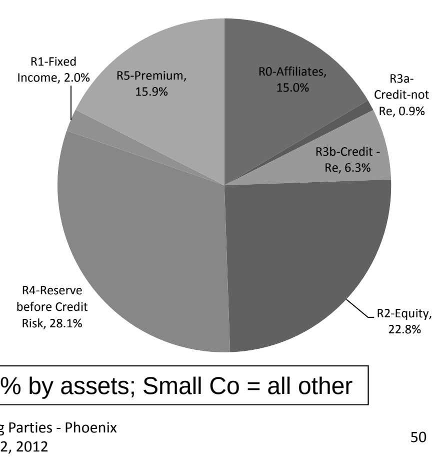


RBC Components by Size of Company

Small Cos -Largest risks are Premium and Reinsurance Credit risk



Large Cos– largest risks are reserves and equity; R0 is material



Large co = largest 20% by assets; Small Co = all other

Effect of Changes in RBC

- Reduction of Reinsurance Credit Risk Charge from 10% to 2%:
  - 5% RBC reduction for all companies
  - 4% RBC reduction for largest quintile of companies
  - 12% to 25% RBC reduction for lower four quintiles of companies by size.

- *Effect on R3-R5 components only

Risk Metrics

- What is the 'best' risk metric
  - VaR
  - Tvar or EPD
  - Other?

Risk Metrics

- 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 value to losses in the tail.
- Shape of consumer value is not highly sensitive to selection VaR trigger

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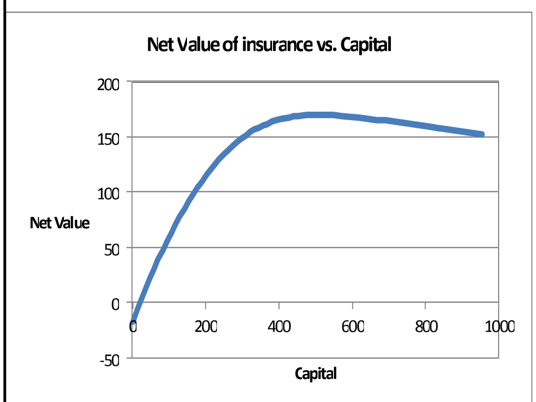
Risk Metrics
Consumer Benefit vs. Capital



Consumer benefit, "net value", varies +/-10% while required capital varies by factor of over 1.5.

Caveats:

Work still under development.

Parameters to assess optimization still illustrative.

Actual parameterization will be problematic.

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Other Possible Research Areas

- UW risk
- Reserve Risk
- Premium Risk
- Reinsurance and Related Credit Risk
- Asset Risk
- Other Formula Elements
- Multivariate Regression Analysis

Possible Further Research Areas

UW Risk

- Gross and net risk charges separately
- Segmenting companies –
  - standard/non-standard auto;
  - highly capitalized/others
- Further analysis of UW cycle
- Filtering for minor lines as well as small lines

Possible Further Research Areas
Reserve Risk

- Other ways to express reserve risk, e.g., % premium (e.g., does the old "Schedule P" returns as a component of capital charge?)
- Reserve risk by AY rather than reserve date

Possible Further Research Areas
Premium Risk

- Catastrophe risk (being handled by NAIC?)
- Measure risk from company/LOB/AY combined ratios rather than loss ratios

Possible Further Research Areas

Reinsurance & Related Credit Risk

- Evaluate loss given default as base for credit risk
- Reflect credit quality of reinsurers including codependency among reinsurers
- RBC to models (rather than factors) to measure effect of reinsurance risk reduction by company (a use of own-company modeling beyond catastrophe models)

Possible Further Research Areas

Asset Risk Areas

- Should R0 be treated as reduction to available capital rather than a risk charge (affects ratio interpretation)
- Review R1 and R2 risk charges, including concentration risk and market risk

Possible Further Research Areas

Other Elements of the Formula

- Alternatives to 50-50 rule
- Growth risk
- Loss sensitive contracts

Possible Further Research Areas

Regression Analysis

- Using multivariate regression to Look more deeply at issues like:
  - Insolvency characteristics
  - Risk charges by type of company (e.g., risk characteristics considered in insolvency review)

Questions?

Comments/Suggestions for the Working Party?

Disclaimer

- The analysis and opinions described here are solely those of the working party members and not those of their employers or the CAS.

DCWP Members (2011)

Jess Broussard Robert Butsic Joe Cofield Shiwen Jiang Allan Kaufman (Chair) Ed Marchena James McNichols Glenn Meyers David Rosenzweig	David Ruhm Ji Yao Christina Zhou CAS Staff: Karen Sonnet David Core Also Attending Regularly Dan Murphy

URWP Members (2011)

Emmanuel Bardis Robert Butsic Pablo Castets Nicole Elliott Brian Fannin Sholom Feldblum	Kendra Felisky Timothy Gault Shira Jacobson James Kahn Allan Kaufman Alex Krutov	Giuseppe (Franco) LePera Thomas Loy Daniel Murphy (Chair) G. Chris Nyce Andrew Staudt Jennifer Wu Linda Zhang

APPENDIX I
DCWP OBSERVATIONS – DETAIL LIST

Appendix I
DCWP Observations – Detail List

A. Overall adequacy of the RBC level has declined

- 1. The investment income offset in premium and reserve underwriting factors is based on 5% per annum discount in expected cash flows when current interest rates are significantly lower.
- 2. Catastrophe potential is not sufficiently reflected.

B. Charges are relatively too low or too high for certain types of companies:

- 3. Premium and reserve underwriting factors by line of business are not properly calibrated to the risk by line of business.
- 4. Company-specific catastrophe risk is not reflected (related to point 2 above).
- 5. Concentration by state or region (property, liability, workers compensation) is not considered
- 6. Company size is not considered.

C. Safety level standards are not specified.

- 7. There is no calibration standard to coordinate the selection of charges by risk or among the different types of risks.

D. Dependencies among risks is not properly reflected:

- 8. RBC treats premium and reserve risk as independent
- 9. RBC treats assets and underwriting risks as independent

E. RBC contains simplifications not properly reflective total risk or differences by company

- 10. The "70% rule"
- 11. The ten percent ceded reinsurance credit risk charge reflects a variety of considerations.

RBC might better reflect risk by company if it allowed greater complexity.

F. There are charges that have not been updated in 20 years with indeterminate effects on the safety level implied by the RBC results.

- 12. Asset charges have not been reviewed since the early 1990s notwithstanding the current understanding that extreme events may have more effect than previously expected.