Economic Capital Modeling – Theory v. Practice

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Economic Capital Modeling – Theory v. Practice

Presentation Overview

- Intended for P&C actuaries.
- Emphasis on practical approaches.
- Assumes loss/exposure data is (reasonably) correct.
- Common thread will be capital modeling and the forward time horizon does not exceed 1 year.

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Tabula Rasa Exercise

What is the project?

Who is the pupil?

What is the goal?

- Measure risk v Manage risk v Moving risk
- 3 C's (Credible/Consistent/Comprehendible)
  - Book Value Relativities
  - Directional Leverage Deltas
  - Inflection Points Under Alternative Risk Structures

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Financial Mathematics & Modeling Mantras

Credibility is the prime directive.

- Bigger book is better than smaller.
- More diversity is better than less.
- More years of historical data is better than fewer.
- More alignment is better than less.
- More simulation trials in the tail does not necessarily improve predictive inferences

Financial Mathematics & Modeling Mantras

Capital Charges are a function of Surplus Impairment.

CV measures are useful & analogous to Sharpe Ratios.

All DRM projects are dripping with parameter risk.

Physics envy exists (i.e., process risk…is what it is).

There is no “loss pick” & “everyone is Bayesian”.

Standard of Care Hierarchy

1. Deal junkies
2. Investment managers
3. Executives and lead underwriters
4. Board of Directors
5. Third party reviewers
   - Auditors
   - Regulators
   - Rating Agencies

P&C Insurance Company Key Risk Variables

1. Premium Risk (*aka* U/W Risk)
2. Reserving Risk (*e.g.*, Prior Years Effects)
3. Interest Rate Risk
4. Investment Risk - Bonds
5. Investment Risk - Stocks/Equities
6. Credit Risk – Bonds
7. Credit Risks – Reinsurance Recoveries

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Underwriting Risk

- Frequency & Severity PDF's
  - Best Fit does not always yield Best Selection
- Reinsurance Structural Needs/Tradeoffs
  - Do not model Fac Treaty by Risk/other tradeoff
- Good Industry Benchmarks Available
- Embrace Bayesian Philosophy

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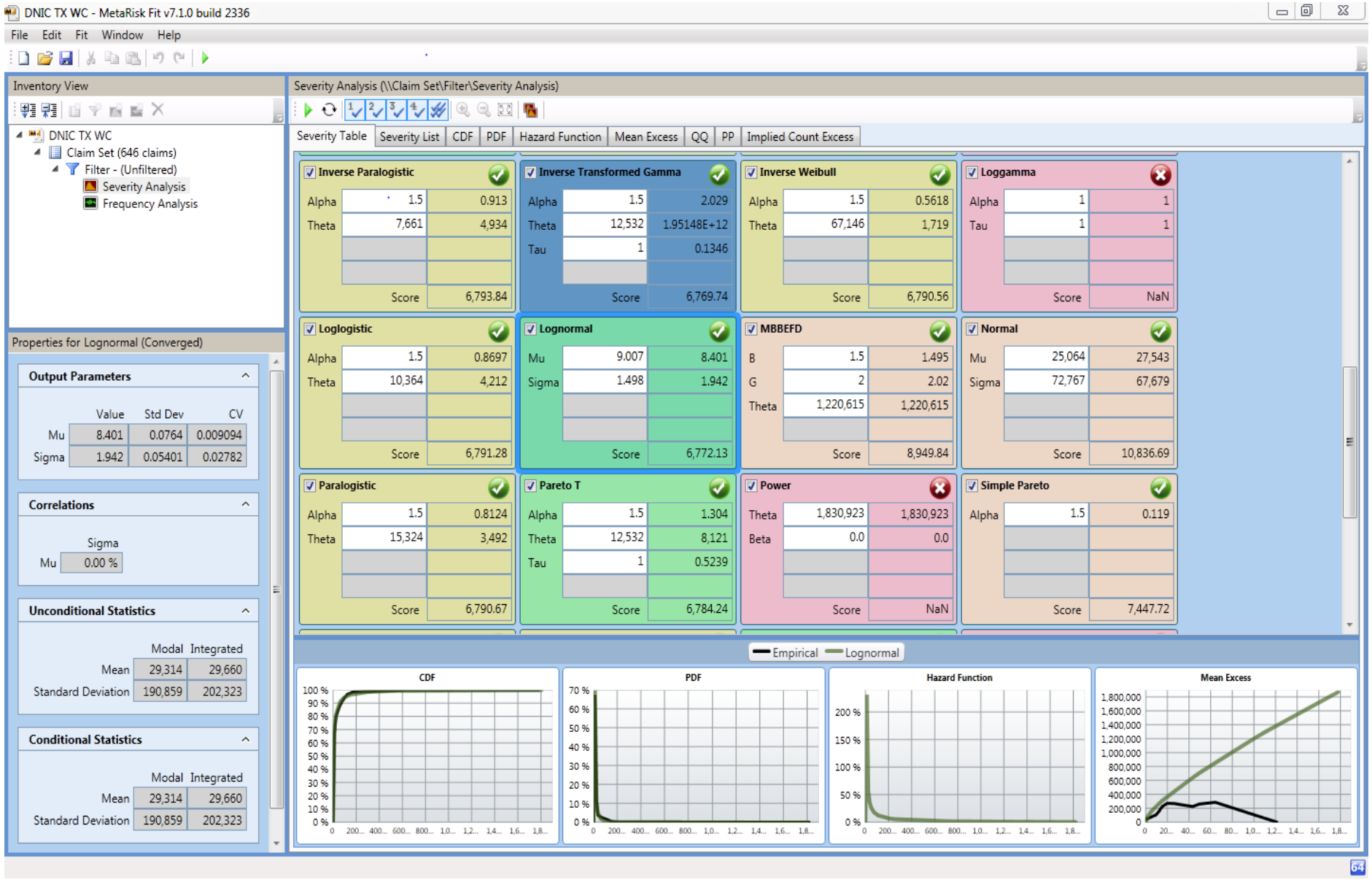
Underwriting Risk – Curve Fitting Example



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P&C Industry (U.S.) Aggregate U/W Risk Benchmarks

Coefficient of Variation of Gross Loss Ratio
Accident Years 1992 - 2010

ALL RISK	
Private Passenger Auto	14%
Auto Physical Damage	16%
Commercial Auto	24%
Workers Compensation	27%
Warranty	29%
Medical PL - Occurrence	33%
Commercial Multi Peril	34%
Other Liability - Occurrence	37%
Special Liability	40%
Other Liability - Claims Made	41%
Medical PL - Claims Made	42%
Products Liability - Occurrence	47%
Homeowners	48%
Other	53%
Reinsurance - Liability	67%
Fidelity & Surety	69%
International	70%
Reinsurance - Property	85%
Reinsurance - Financial	94%
Products Liability - Claims Made	101%

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P&C Industry (U.S.) Aggregate U/W Risk Benchmarks

US Market Risk Parameters
Coefficient of Variation of Gross Loss Ratio (1992 - 2010)

All Risk		No Underwriting Cycle Risk		Δ
Private Passenger Auto	14%	Private Passenger Auto	13%	1%
Auto Physical Damage	16%	Auto Physical Damage	15%	1%
Commercial Auto	24%	Commercial Auto	18%	6%
Workers Compensation	27%	Workers Compensation	18%	9%
Warranty	29%	Warranty	31%	-2%
Medical PL - Occurrence	33%	Medical PL - Occurrence	32%	1%
Commercial Multi Peril	34%	Commercial Multi Peril	27%	7%
Other Liability - Occurrence	37%	Other Liability - Occurrence	25%	12%
Special Liability	40%	Special Liability	30%	10%
Other Liability - Claims Made	41%	Other Liability - Claims Made	27%	14%
Medical PL - Claims Made	42%	Medical PL - Claims Made	30%	12%
Products Liability - Occurrence	47%	Products Liability - Occurrence	33%	14%
Homeowners	48%	Homeowners	41%	7%
Other	53%	Other	50%	3%
Reinsurance - Liability	67%	Reinsurance - Liability	45%	22%
Fidelity & Surety	69%	Fidelity & Surety	53%	16%
International	70%	International	55%	15%
Reinsurance - Property	85%	Reinsurance - Property	55%	30%
Reinsurance - Financial	94%	Reinsurance - Financial	59%	35%
Products Liability - Claims Made	101%	Products Liability - Claims Made	48%	53%

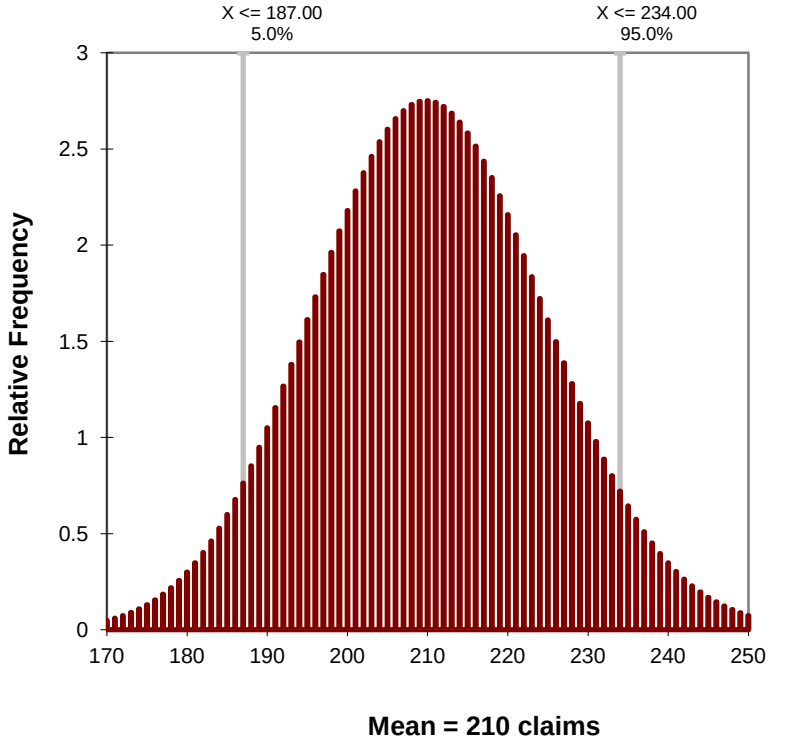
Economic Capital Modeling Constraints

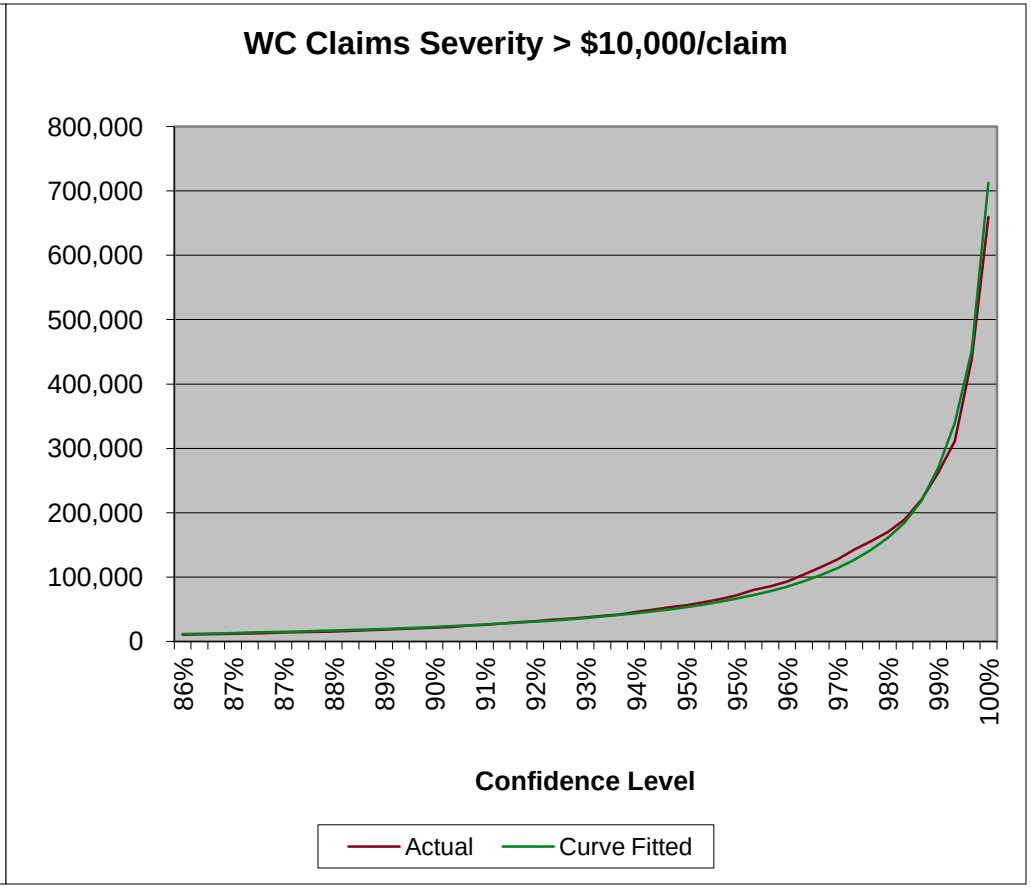
- 1 year forward time horizon
- 1:200 stress level events

Underwriting Risk (Example)

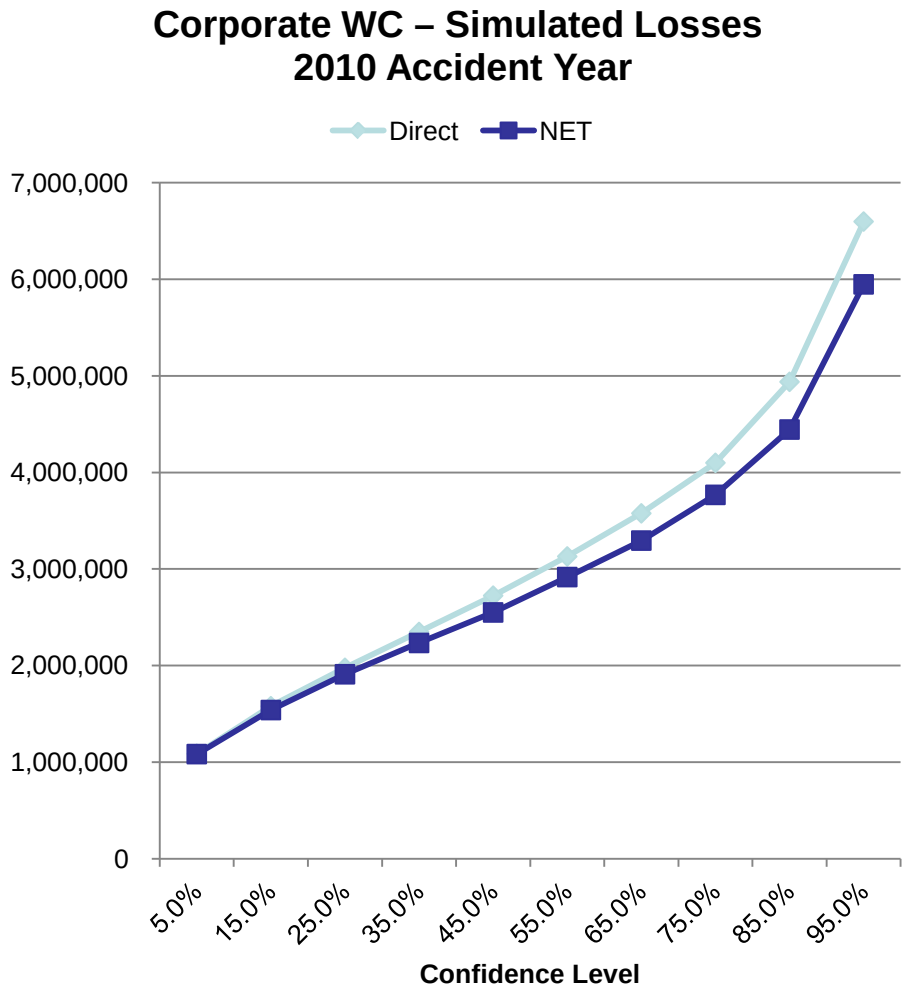
- Frequency
- Severity
- Aggregate claims distribution
- Stochastic (i.e., Monte Carlo) simulated outcomes
- Stress level thresholds
- Economic capital contribution

Underwriting Risk – Example (Corp WC-Only)
Stochastic Simulation (aka Monte Carlo)





Underwriting Risk – Example (Corp WC-Only)



Monte Carlo	Direct	Net
Mean	**3,246,900**	**2,997,000**
5.0%	1,087,400	1,083,600
15.0%	1,579,700	1,539,700
25.0%	1,977,300	1,910,400
35.0%	2,348,000	2,234,400
45.0%	2,724,200	2,550,200
55.0%	3,130,200	2,916,600
65.0%	3,576,500	3,294,400
75.0%	4,099,400	3,767,600
85.0%	4,938,000	4,444,200
95.0%	6,597,700	5,947,300
98.0%	7,849,600	6,935,200
99.0%	9,154,800	7,973,800
99.5%	9,750,400	**8,800,000**

Underwriting Risk – Example (Corp WC-Only)

	Net
99.5th Percentile Losses	8,800,000
Expected Earned Premium	(3,500,000)
Required Risk Capital	5,300,000

Economic Capital Modeling Results (U/W Risk variable only)

- Stochastic Simulation of each LOB variable at 1:200 stress

• Work Comp - Corp	$ 5.3 MM
• Work Comp - Retail	2.1 MM
• Gen Liab. - Corp & Retail	1.6 MM
• Auto Liab. - Corp & Retail	1.0 MM
• Auto PD - Corp & Retail	0.5 MM
• Retail Property	2.0 MM
• Sum	$12.5 MM

Required Economic Capital => $ 8.5 MM*

*does not equal the sum of the parts due to portfolio effects (i.e. diversification credit)

Economic Capital Modeling – Theory v. Practice

Reserving Risk

- Traditional Methods if for GAAP Balance Sheet
- Stochastic Methods if for Capital Modeling
- GLM Methods if Pro Forma Planning
- ALL Methods if for M&A
- Good Industry Benchmarks Available
- Embrace Bayesian Philosophy

P&C Industry (U.S.) Reserve Risk Benchmarks; CV of ULT Development of a Single Accident Year

U.S. Industy Aggregate - AY's (1980 - 2002)
NET of Reinsurance

Statistic = actual final reserve / initial reserve

Line of Business	Mean	CV
Private Passenger Auto	0.95	7%
Homeowners	0.99	9%
Commercial Auto Liability	1.06	12%
Commercial Multi-Peril	1.07	12%
Workers Compensation	1.06	17%
Products Liability	1.14	25%
General Liability	1.12	27%
Medical Professional Liability	1.03	29%

Interest Rate Risk

- ESG approach v. Modular approach
- Practical Actuarial Alternatives

Typical model of interest rate dynamics in the form:

$$\Delta r_t = k(b - r_t)\Delta t + \sigma r_t^{\gamma} \Delta Z_t$$

$\gamma = 0$;Vasicek model where changes are normally distributed

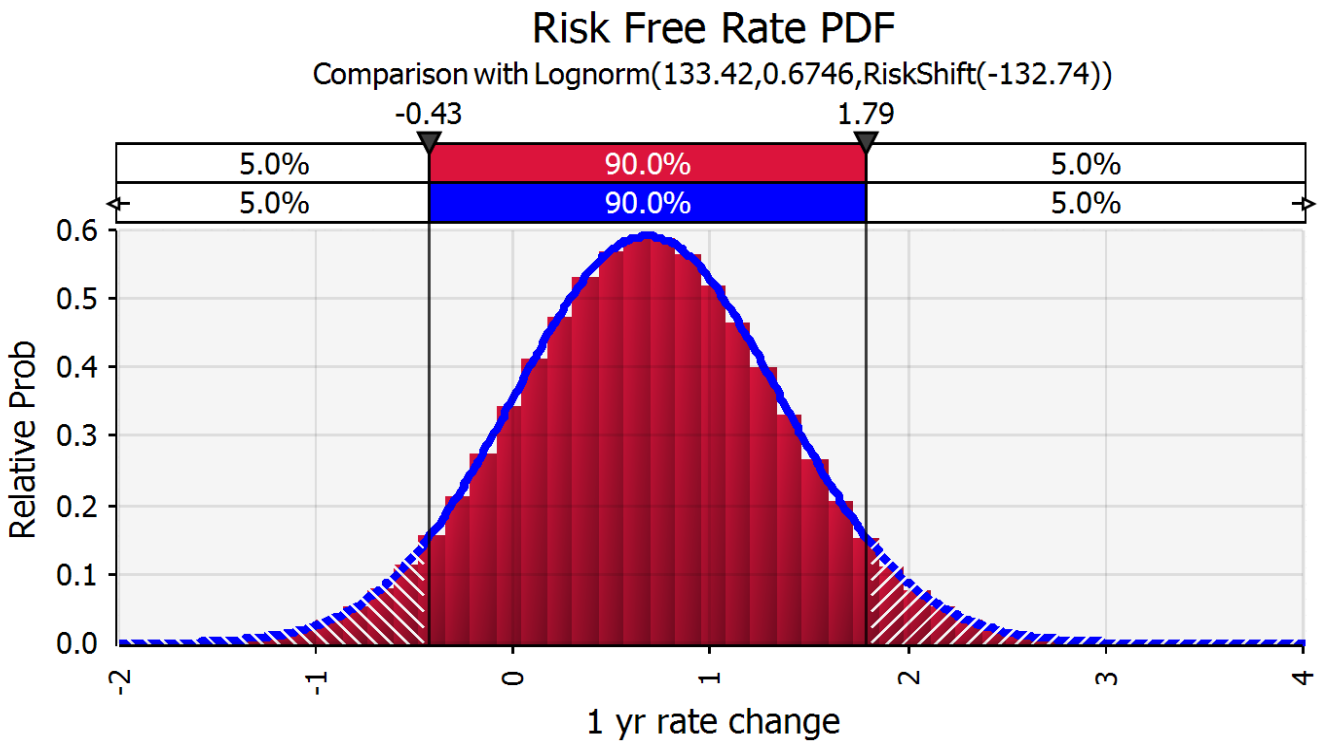
$\gamma = 1$; RiskMetrics model which yields lognormal distribution

$\gamma = 0.5$; Cox, Ingersoll, Ross model

Interest Rate Risk

Practical Actuarial Alternatives (continued)

- Based upon historical empirical market statistics
- Sourced from Life/Pension colleagues



Interest Rate Risk – Summary of Results

Generic Insurance Co. Ltd - Fixed Income Portfolio Sensitivities

Rate Change	Market Value	Market Value Change	Market Value % Change	Effective Duration	Effective Convexity
300	202,843	(32,157)	-13.7%	4.56	0.20
250	207,934	(27,066)	-11.5%	4.61	0.18
200	213,226	(21,774)	-9.3%	4.63	0.14
150	218,695	(16,305)	-6.9%	4.63	0.05
100	224,189	(10,811)	-4.6%	4.60	-0.04
50	229,657	(5,343)	-2.3%	4.55	-0.10
0	235,000	-	0.0%	4.75	-0.14
-50	240,141	5,141	2.2%	4.38	-0.11
-100	245,131	10,131	4.3%	4.31	-0.06
-150	249,969	14,969	6.4%	4.25	0.02
-200	254,833	19,833	8.4%	4.22	0.10
-250	259,848	24,848	10.6%	4.23	0.13
-300	265,040	30,040	12.8%	4.26	0.14

Investment Risk - Bonds

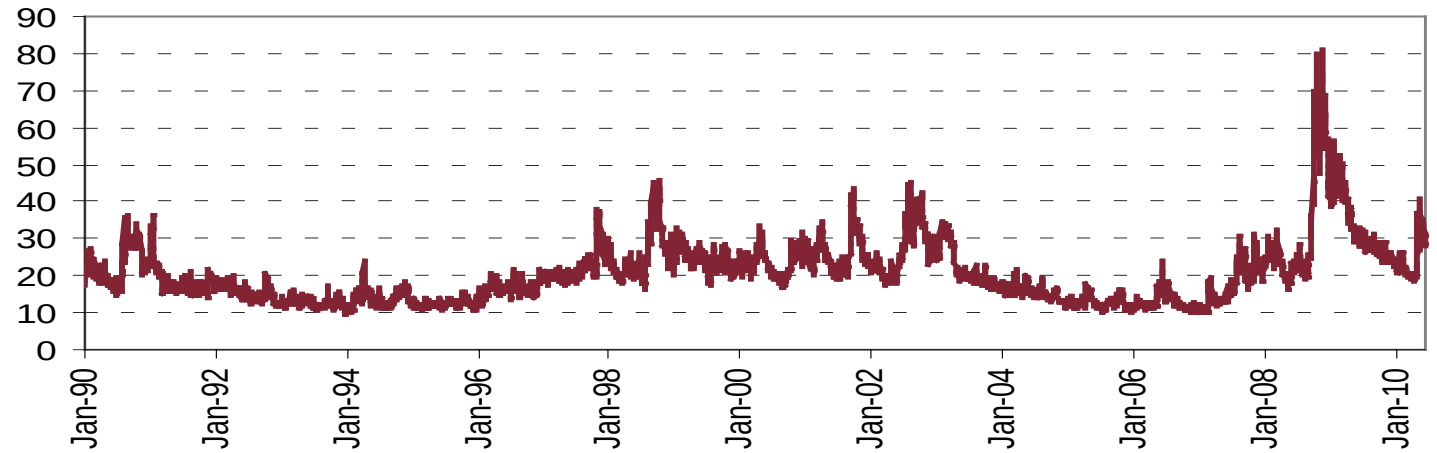
Equates to Interest Rate Risk

Increased Credibility due to Severity certainty

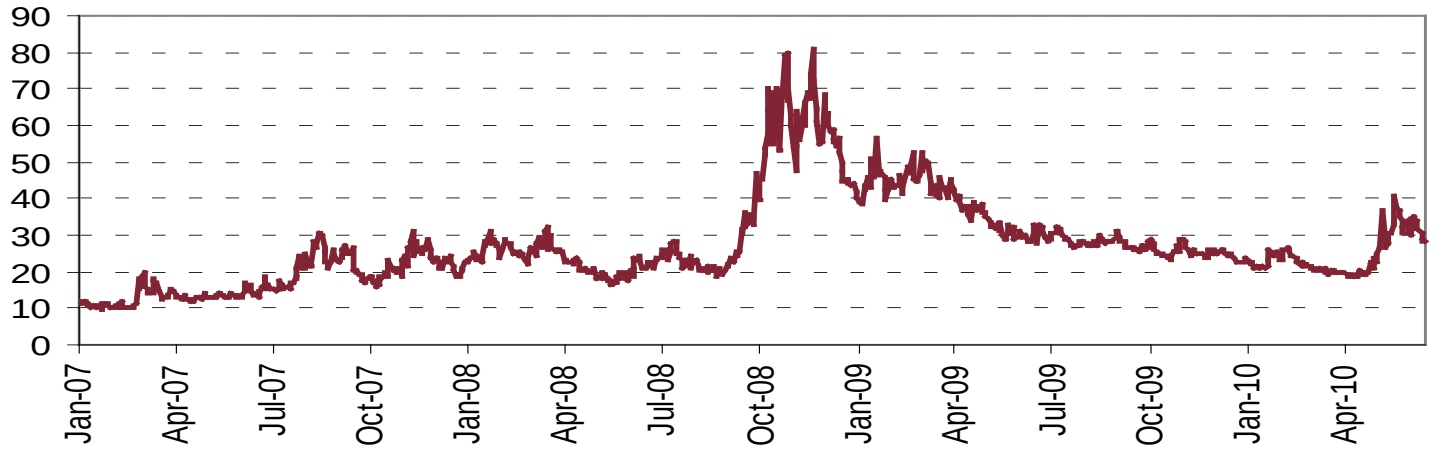
Investment Risk – Stocks/Equities

Practical actuarial approach uses McNichols/Rizzo method with CV = VIX

1990-June 2010



2007-June 2010



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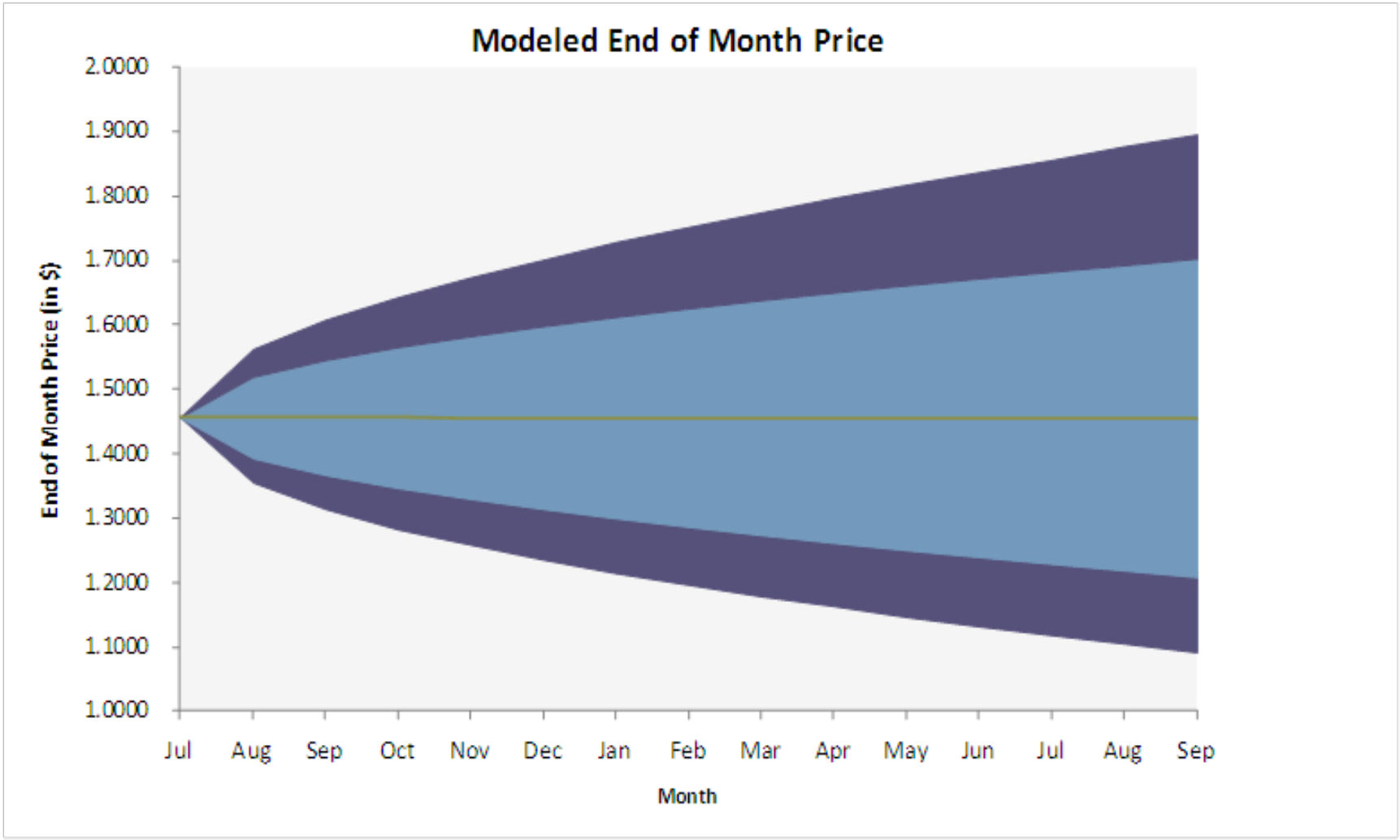
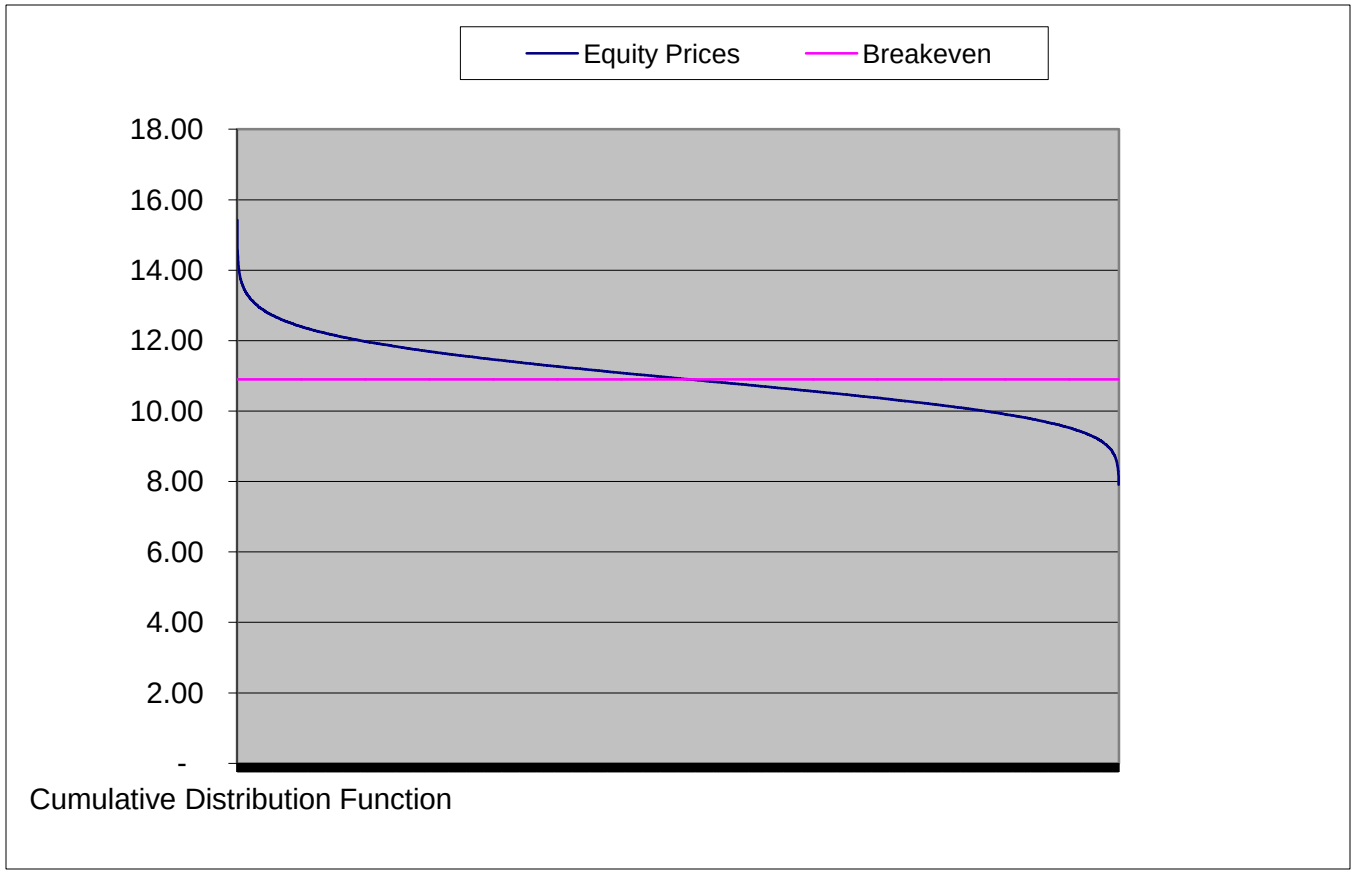
Stochastic Modeling of Market Prices



Generic Insurance Co. Ltd, 1 year Stock Return Projection



Credit Risk - Bonds

- Liquidity(“L”) & Contagion(“C”) Exposure
- Rating agency transitions matrices
- Other time accelerative approaches
- Recognize L&C induce leptokurtosis
- Copula inference below 95th (Newtonian Physics)
- 95th to 99th, L or C (Special Relativity Physics)
- Beyond 99th, L and C (Quantum Physics)
- Conclusion: Mimic ESG or BCAR to keep pace

Credit Risk – Reinsurance Recoverable

- Not a material concern in general (due to the lower financial leverage of Insurers v. Banks).
- Property Cat and Commercial Excess effects.
- Copula considerations (where in the CDF does the credibility need to be the highest).
- Conclusion: Mimic BCAR to keep pace.

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Dependence & Correlation Structures

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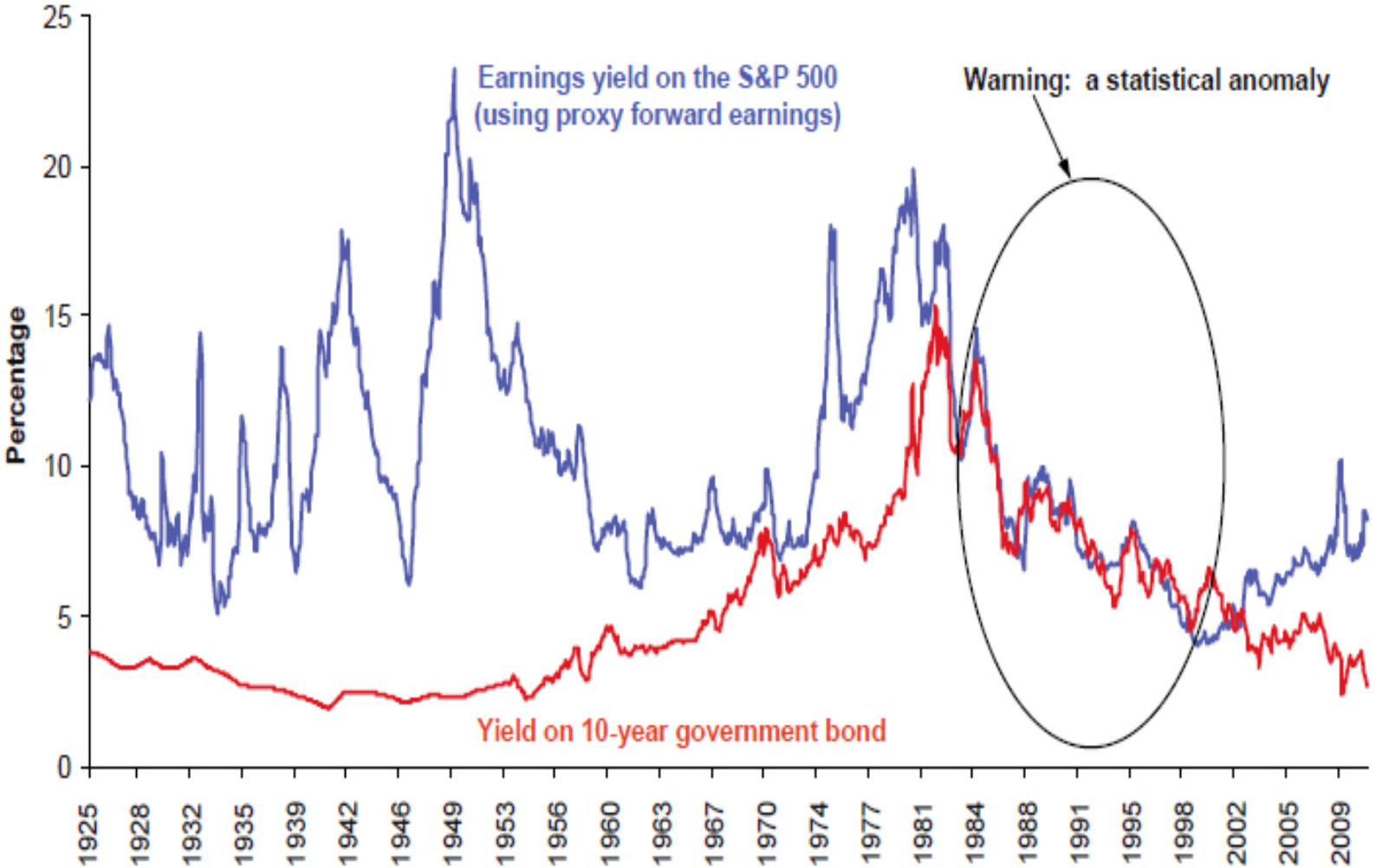
A Corollary to the Dilbert Principle

- *Economic Capital Modeling – Theory v. Practice*

Correlation Does Not Imply Causation



Underwriting Dependence

Correlation between Lines

Change entries in matrix by changing blue selections.

US	Line 2								
Line1	Homeowners	Personal Auto Liability	Commercial Multi Peril	Commercial Auto	Workers Comp	Other Liability Occ	Medical Malpractice CM	Other Liability CM	Products Liability Occ
Homeowners									
Personal Auto Liability	6%								
Commercial Multi Peril	20%	24%							
Commercial Auto	5%	27%	51%						
Workers Comp	-9%	31%	45%	64%					
Other Liability Occ	-2%	31%	49%	69%	65%				
Medical Malpractice CM	-11%	21%	57%	71%	76%	80%			
Other Liability CM	-4%	34%	43%	45%	60%	59%	74%		
Products Liability Occ	11%	24%	41%	74%	65%	66%	80%	31%	

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Correlation Structure – "amongst and in between"

Selected

CovMatrix for Iman - Conover Copula - Adequacy

	Total UW	Resv Risk	Reins Rec	Credit Risk	Int Rate Risk	Stock Risk	Inv Income
Total UW	1.00	0.40	0.25	0.15	0.15	0.10	0.15
Resv Risk	0.40	1.00	0.40	0.40	0.25	0.25	0.25
Reins Rec	0.25	0.40	1.00	0.25	0.25	0.25	0.25
Credit Risk	0.15	0.40	0.25	1.00	0.50	0.25	0.5
Int Rate Risk	0.15	0.25	0.25	0.50	1.00	0.30	0.75
Stock Risk	0.10	0.25	0.25	0.25	0.30	1.00	0.3
Inv Income	0.15	0.25	0.25	0.50	0.75	0.30	1

High

CovMatrix for Iman - Conover Copula - Adequacy

	Total UW	Resv Risk	Reins Rec	Credit Risk	Int Rate Risk	Stock Risk	Inv Income
Total UW	1.00	0.50	0.50	0.40	0.40	0.35	0.4
Resv Risk	0.50	1.00	0.65	0.65	0.50	0.50	0.5
Reins Rec	0.50	0.65	1.00	0.50	0.50	0.50	0.5
Credit Risk	0.40	0.65	0.50	1.00	0.75	0.50	0.75
Int Rate Risk	0.40	0.50	0.50	0.75	1.00	0.55	0.75
Stock Risk	0.35	0.50	0.50	0.50	0.55	1.00	0.55
Inv Income	0.4	0.5	0.5	0.75	0.75	0.55	1

- Correlation Assumptions are extremely difficult to parameterize
- Correlation not constant... Risks tend to become more correlated in extreme events
- Requires ability to test sensitivity to alternative correlation assumptions

Dependence & Correlation Structures
Modular Method Boundaries

Show Dependent Results (r = 1)

Then Show Independent Results (r = 0)

Dependence & Correlation Structures

Modular Method Risk Adjustment Simplified

Fully Dependent (Minimal ROC)

Fully Independent (Excess ROC)

Then take the Geometric Mean

Cap @D^0.5 x Cap @I^0.5 = Risk Adjusted

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Fundamental Guidelines

True Capital Requirement? Optimum Leverage?

TVar v Var

1 year forward only (Sugihara & May paper)

Manage for risk and not for risk charges

KEEP YOUR BALANCE SHEET CURRENT!

Show deterministic at 98th and 99th to help visualize

Fundamental Guidelines

Make the pupil understand the difference between:

Process Risk (the estimator of the range)

versus

Parameter Risk (the range of the estimator)

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Fundamental Guidelines

If you have determined an inflection point.

"Speak up" and get it to be known;

- Reserve Risks exceeds Premium Risks
- More Stock Mutual Funds then Stocks
- More Derivatives Volume than Issuance

XL Capital: Claims Made v Occurrence Profile

Note to Self: Average Home Prices can decrease!

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Suggested Reading Non-CAS

Recipe for Disaster: The Formula That Killed Wall Street, Felix Salmon, Wired Magazine, February 23, 2009.

Warning: Physics Envy May Be Hazardous To Your Wealth!, Lo & Mueller, MIT physics journal, March 19, 2010.

Chaos: Making a New Science, James Gleick, Viking Press, 1987.

The (Mis)Behavior of Markets: A Fractal View of Risk, Ruin, and Reward, Mandelbrot & Hudson, Basic Books, 2004.

Nonlinear forecasting as a way of distinguishing chaos from measurement error in time series, Sugihara & May, Nature Magazine, Vol. 344, April 1990.

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Suggested Reading CAS

Actuarial Geometry, Stephen Mildenhall, CAS, March, 2006.

An Examination of Credibility Concepts, Stephen Philbrick, CAS, February, 1980.

Stochastic GBM Methods for Modeling Market Prices, McNichols & Rizzo, CAS, August, 2012.