Why is Economic Capital Modeling so Difficult?

Stephen J. Mildenhall

November 1, 2016

Agenda

Section 1	What are the goals of ECM?
Section 2	How are we doing?
Section 3	Insurer risk modeling spectrum
Section 4	What we believe that ain't so
Section 5	What would improve ECM?

Section 1: What are the goals of ECM?

Why perform ECM?

ECM is the nerve center of insurance management

Enables **capital management** and **capital strategy**

- Effective capital management: How much? What form: equity, debt, reinsurance, on-/off-balance sheet, other?

- Enshrines and operationalizes **risk appetite** & risk-return tradeoff
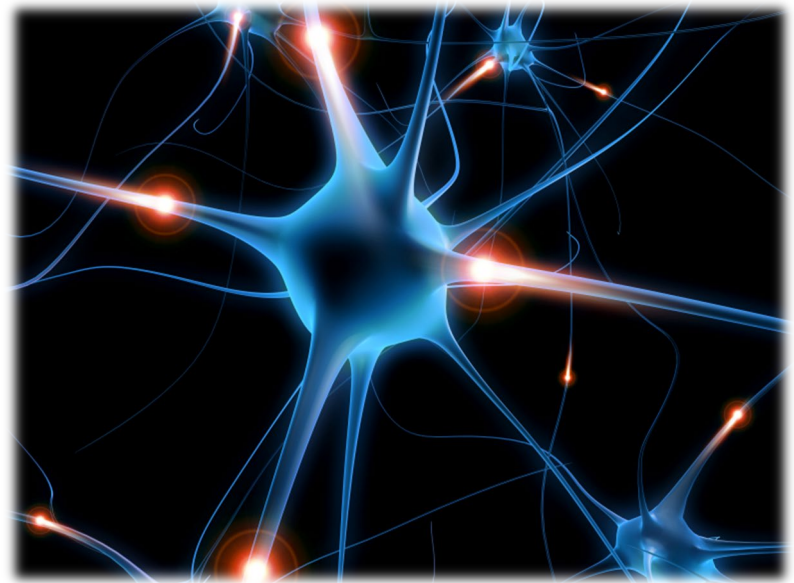
Communicate firm's risk position to stakeholders

- Monitor actual risk levels

Fair and **equitable** management of shared capital resources
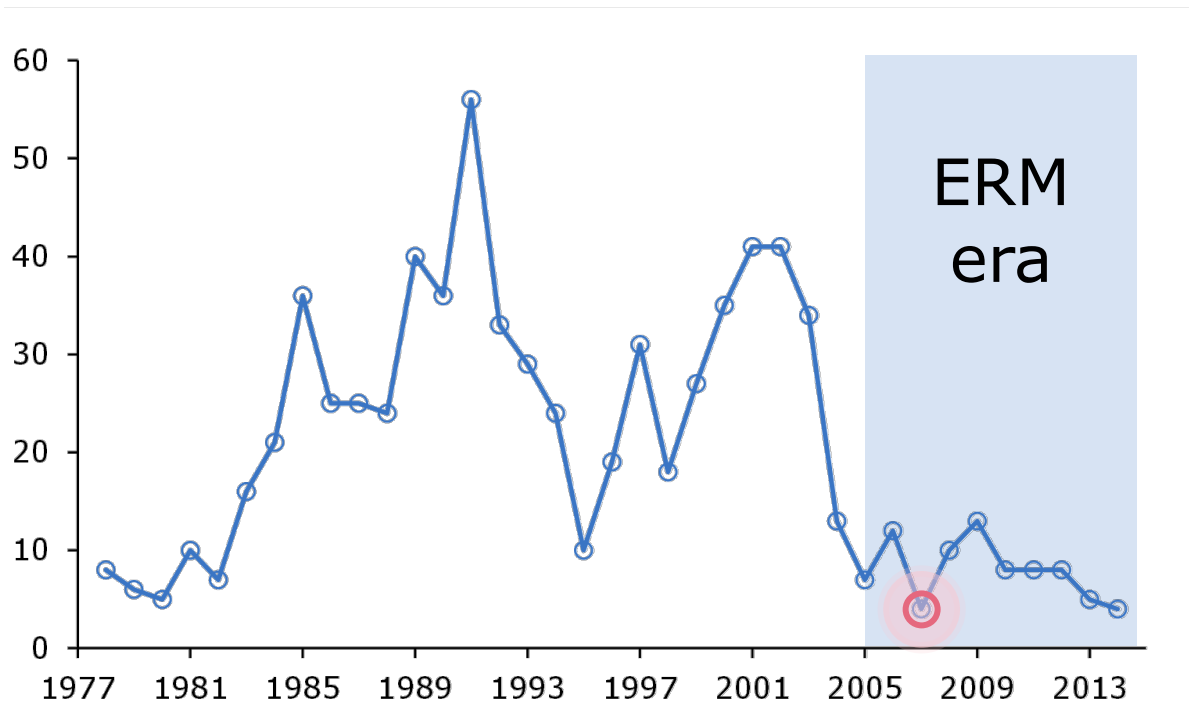
- Benchmark pricing, executive comp

- Portfolio optimization

ECM is **dynamic** and is a **process**
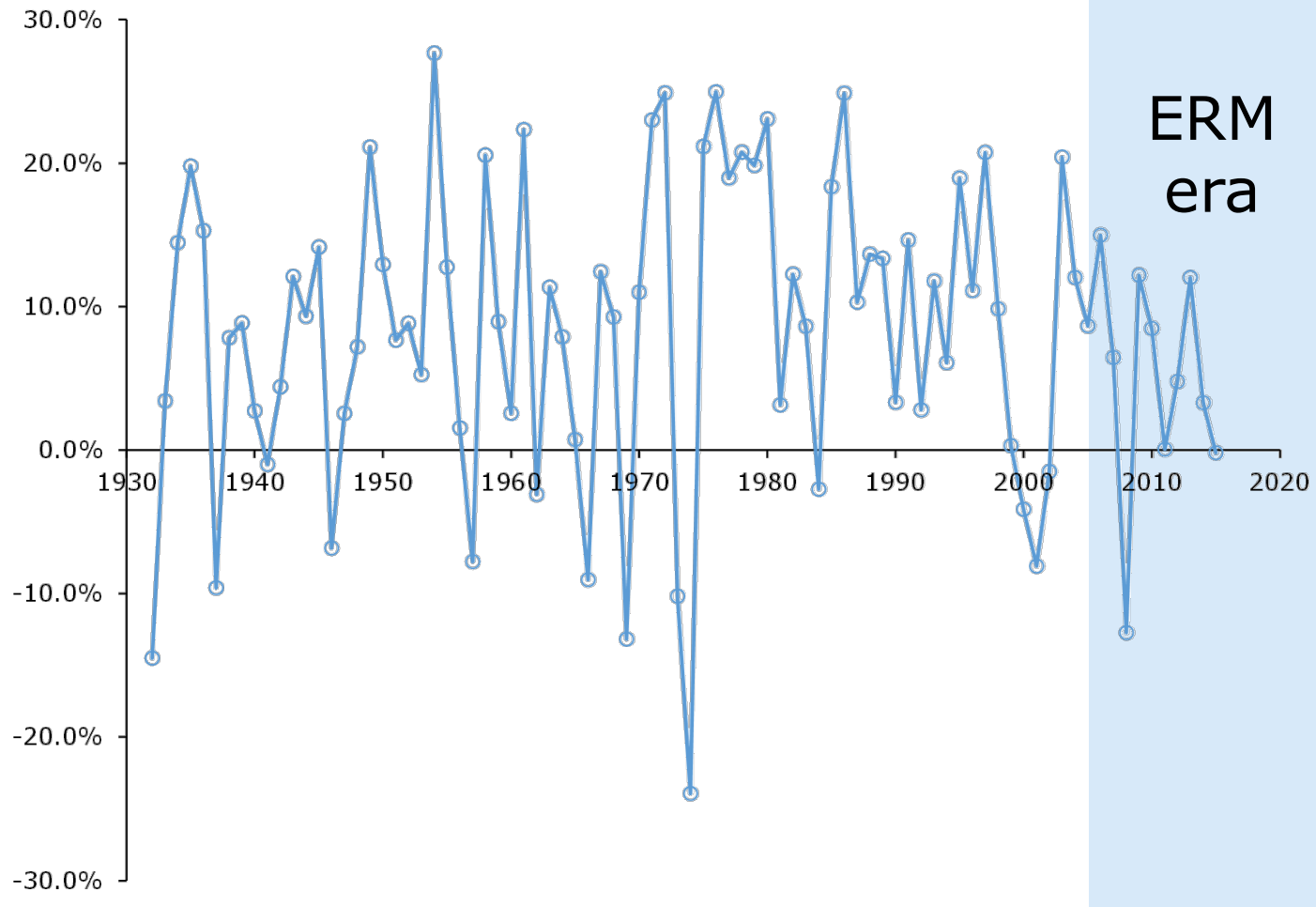
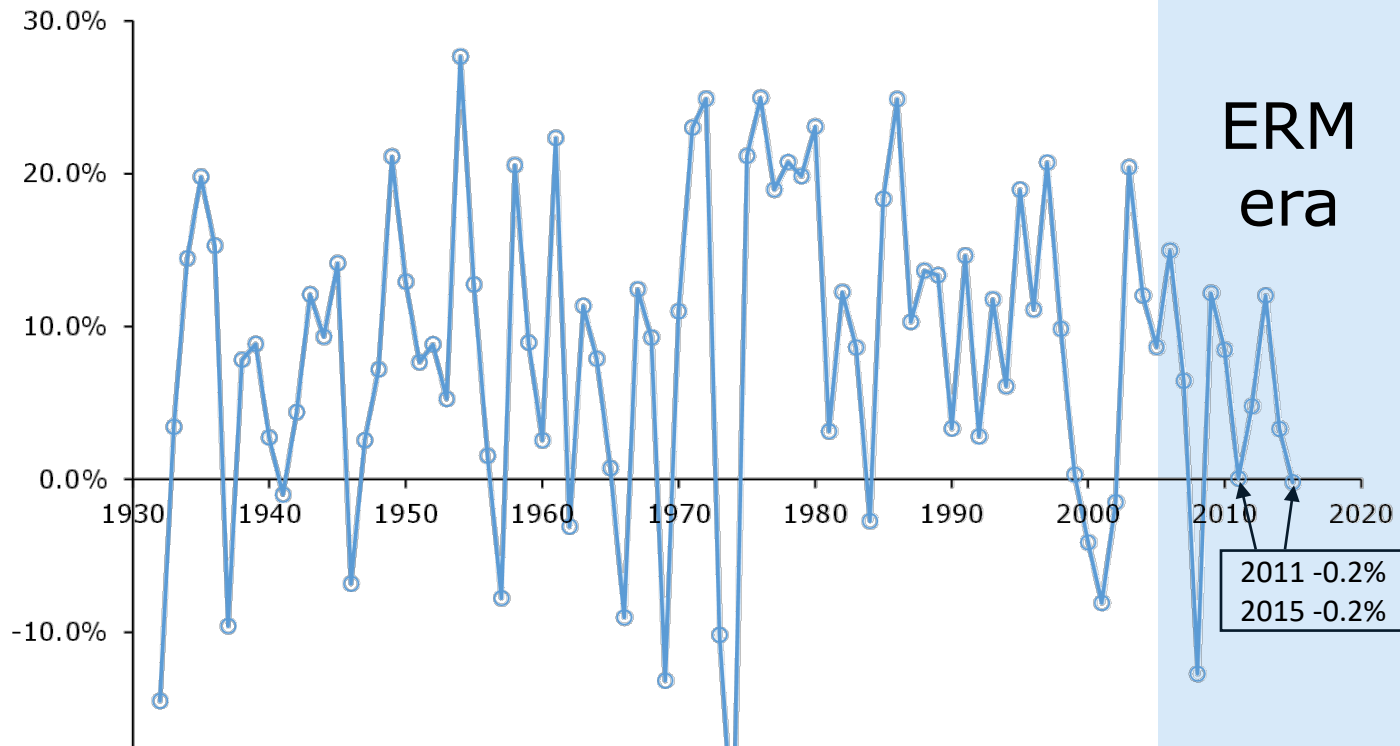# Section 2: How are we doing?

Historical insurer impairment rates

- Focus on ERM began circa 2005
- S&P began rating company ERM efforts
- Lots of confounding variables…

A.M. Best designates an insurer as a Financially Impaired Company (FIC) upon the **first official public regulatory action taken by an insurance department**. Such state actions include **involuntary liquidation** because of insolvency, as well as other regulatory processes and procedures such as **supervision, rehabilitation, receivership, conservator-ship, a cease-and-desist order, suspension, license revocation, administrative order** and any other action that **restricts a company's freedom to conduct its insurance business as normal**. Companies that enter voluntary dissolution and are not under financial duress at that time are not counted as financially impaired.

Source: Best's impairment rate and rating transition study -- 1977-2014 (2015)

Annual change in statutory surplus since 1931

Source: AM Best Aggregates and Averages and SNL

Annual change in statutory surplus since 1931

ERM era

2011 -0.2%
2015 -0.2%

Period	Years	Surplus Drops	Frequency	Avg Drop	Average Change	Std Deviation Change	Sharpe Ratio
1932-1974	43	10	1/4	-10%	7%	10%	75%
1975-2015	41	7	1/6	-4%	9%	11%	79%
1932-present	84	17	1/5	-8%	8%	10%	77%
2005-2015	11	3	1/4	-4%	5%	8%	69%

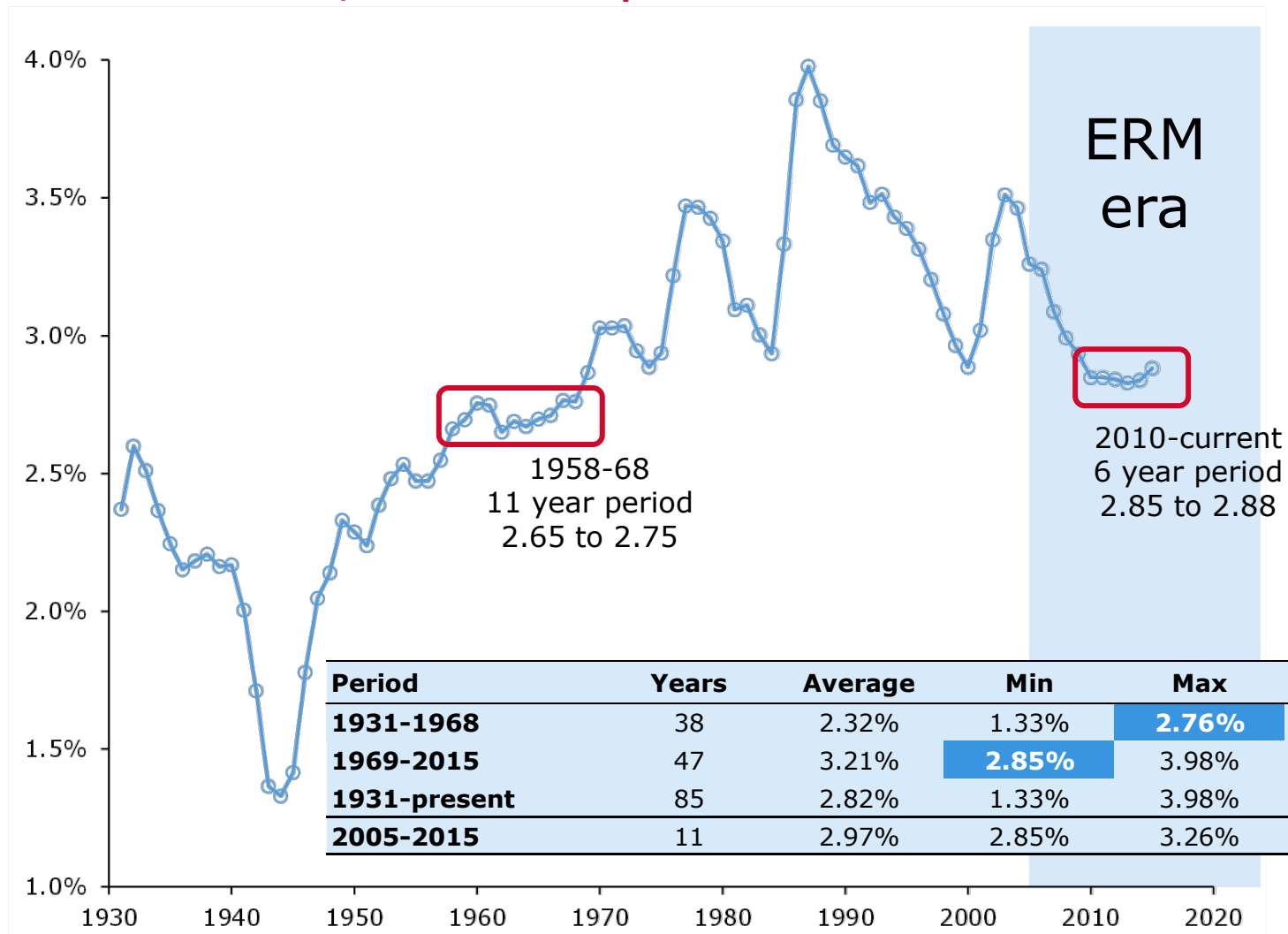Source: AM Best Aggregates and Averages and SNL

ERM is not about risk avoidance

It's about prudent risk management:
we get paid to take risk, not to avoid it

We cannot exclude our way to prosperity,
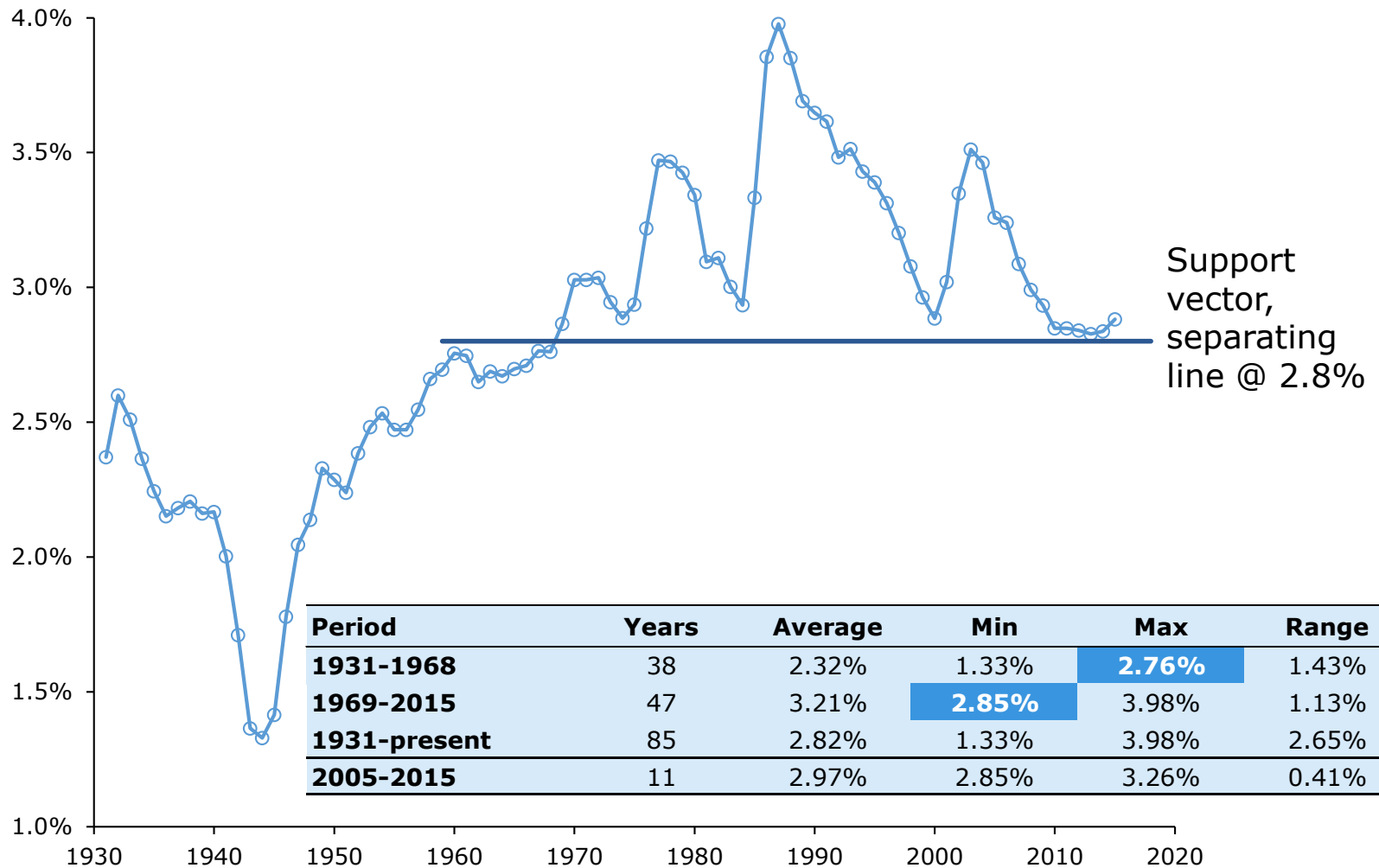and we cannot sub-limit our way to relevance.

Mike McGavick, CEO XL Catlin (2012)

Increasing relevance?
Premium to GDP, 1931 to present

ERM era

1958-68
11 year period
2.65 to 2.75

2010-current
6 year period
2.85 to 2.88

Period	Years	Average	Min	Max	Range
1931-1968	38	2.32%	1.33%	**2.76%**	1.43%
1969-2015	47	3.21%	**2.85%**	3.98%	1.13%
1931-present	85	2.82%	1.33%	3.98%	2.65%
2005-2015	11	2.97%	2.85%	3.26%	0.41%

Source: A. M. Best Aggregates and Averages, SNL, FRED GDP

Premium to GDP, 1931 to present

Support vector, separating line @ 2.8%

| Period	Years	Average	Min	Max	Range
1931-1968	38	2.32%	1.33%	**2.76%**	1.43%
1969-2015	47	3.21%	**2.85%**	3.98%	1.13%
1931-present	85	2.82%	1.33%	3.98%	2.65%
2005-2015	11	2.97%	2.85%	3.26%	0.41%

Source: A. M. Best Aggregates and Averages, SNL, FRED GDP

Premium to GDP, 1931 to present: 1968 watershed?

MAURICE R. GREENBERG

THE AIG STORY

LAWRENCE A. CUNNINGHAM

The forces driving the expanding E&O market...as lawyers representing plaintiffs developed **new theories of legal liability** and judgments were rendered, people **demanded new insurance coverage**—and insurance companies developed it. As plaintiffs' lawyers grew increasingly aggressive, insurance policies, in tandem, became more creative...A pattern emerged: **if a big lawsuit arose**, posing a new legal theory and resulting in a big money judgment, **underwriters** at American Home, National Union, or New Hampshire **would develop insurance to cover it**.
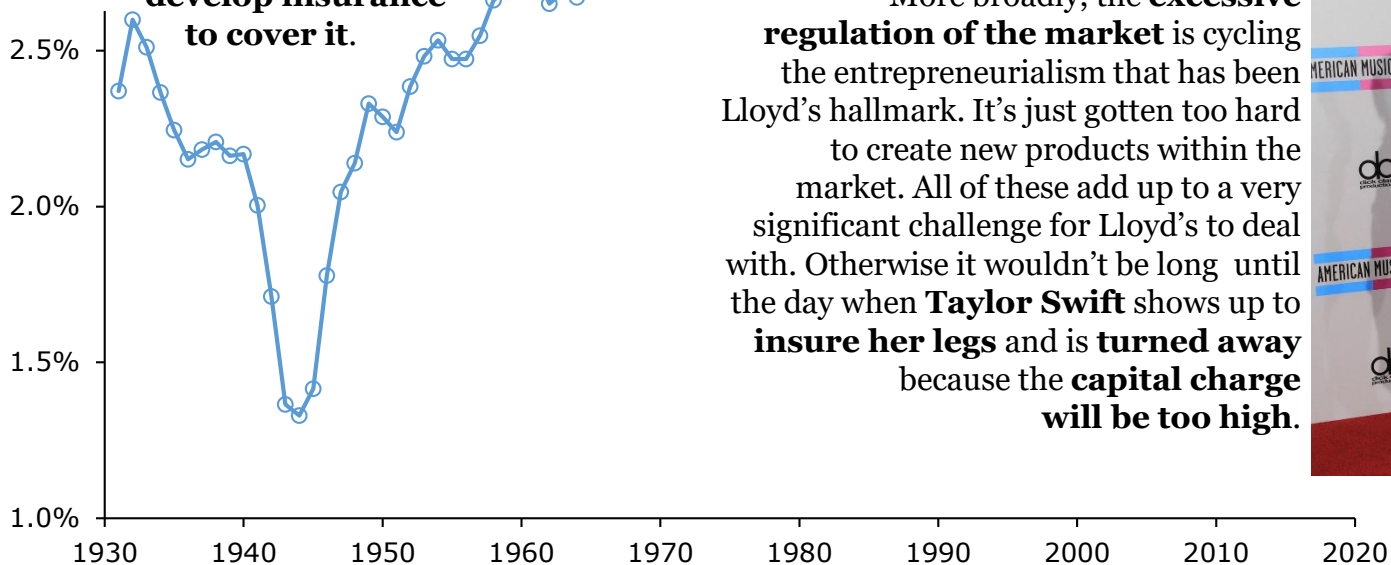
More broadly, the **excessive regulation of the market** is cycling the entrepreneurialism that has been Lloyd's hallmark. It's just gotten too hard to create new products within the market. All of these add up to a very significant challenge for Lloyd's to deal with. Otherwise it wouldn't be long until the day when **Taylor Swift** shows up to **insure her legs** and is **turned away** because the **capital charge will be too high**.
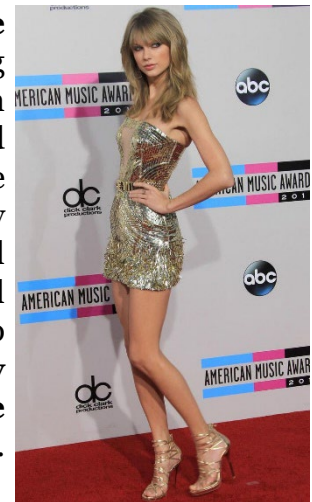
Source: Maurice R. Greenberg and L. Cunningham "The AIG Story" (2013), D&O market triggered by a visit from the Chairman of Marsh in 1968
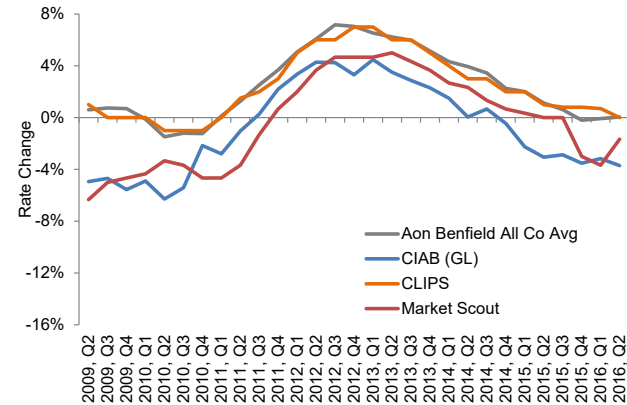Ed Noonan, Validus Q2 2015 Earnings Conference Call

Example of price monitoring

Comparison of commercial casualty rate indices

Casualty lines rate changes by quarter as reported

Year	Qtr	CIAB (GL)	Market Scout	CLIPS	All Co. Avg	Specialty Co. Avg	Standard Co. Avg
					Aon Benfield Company Sample		
2009	Q2	-4.9%	-6.3%	1.0%	0.6%	0.0%	1.2%
2009	Q3	-4.7%	-5.0%	0.0%	0.7%	0.6%	0.9%
2009	Q4	-5.6%	-4.7%	0.0%	0.7%	0.7%	0.5%
2010	Q1	-4.9%	-4.3%	0.0%	-0.1%	-1.0%	0.7%
2010	Q2	-6.3%	-3.3%	-1.0%	-1.5%	-2.5%	-0.1%
2010	Q3	-5.4%	-3.7%	-1.0%	-1.2%	-1.7%	-0.6%
2010	Q4	-2.2%	-4.7%	-1.0%	-1.2%	-2.1%	-0.6%
2011	Q1	-2.8%	-4.7%	0.0%	0.1%	-0.5%	0.4%
2011	Q2	-1.0%	-3.7%	1.5%	1.3%	0.0%	1.8%
2011	Q3	0.3%	-1.3%	2.0%	2.5%	0.9%	3.3%
2011	Q4	2.2%	0.7%	3.0%	3.7%	2.0%	4.6%
2012	Q1	3.4%	2.0%	5.0%	5.1%	4.3%	5.4%
2012	Q2	4.3%	3.7%	6.0%	6.1%	5.6%	6.6%
2012	Q3	4.2%	4.7%	6.0%	7.2%	6.6%	7.7%
2012	Q4	3.3%	4.7%	7.0%	7.0%	6.8%	7.3%
2013	Q1	4.5%	4.7%	7.0%	6.5%	6.4%	7.2%
2013	Q2	3.5%	5.0%	6.0%	6.2%	5.9%	7.1%
2013	Q3	2.9%	4.3%	6.0%	6.0%	6.0%	6.4%
2013	Q4	2.3%	3.7%	5.0%	5.1%	5.1%	5.8%
2014	Q1	1.5%	2.7%	4.0%	4.3%	4.4%	4.7%
2014	Q2	0.1%	2.3%	3.0%	3.9%	3.4%	4.1%
2014	Q3	0.7%	1.3%	3.0%	3.4%	2.9%	3.6%
2014	Q4	-0.5%	0.7%	2.0%	2.3%	2.9%	1.8%
2015	Q1	-2.3%	0.3%	2.0%	2.0%	2.8%	1.3%
2015	Q2	-3.1%	0.0%	1.0%	1.1%	1.6%	1.0%
2015	Q3	-2.9%	0.0%	0.8%	0.6%	1.1%	0.7%
2015	Q4	-3.5%	-3.0%	0.8%	-0.2%	-0.2%	-0.1%
2016	Q1	-3.2%	-3.7%	0.7%	-0.1%	-0.1%	-0.3%
2016	Q2	-3.7%	-1.7%	--	0.0%	-0.1%	0.0%

Annual

Year		CIAB (GL)	Market Scout	CLIPS	All Co. Avg	Specialty Co. Avg	Standard Co. Avg
2008		-10.0%	-11.1%	-5.0%	-5.8%	-6.2%	-4.7%
2009		-4.9%	-6.0%	0.3%	0.4%	0.1%	0.5%
2010		-4.7%	-4.0%	-0.8%	-1.0%	-1.8%	-0.1%
2011		-0.3%	-2.3%	1.6%	1.9%	0.6%	2.5%
2012		3.8%	3.8%	6.0%	6.3%	5.8%	6.8%
2013		3.3%	4.4%	6.0%	6.0%	5.8%	6.6%
2014		0.4%	1.8%	3.0%	3.5%	3.4%	3.6%
2015		-2.9%	-0.7%	1.2%	0.9%	1.3%	0.7%
2016		-3.3%	-2.1%	0.8%	0.1%	0.2%	0.1%

Aon Benfield | Analytics | Market Analysis
Proprietary & Confidential

Source: Aon Benfield Inc., CIAB, CLIPS and Market Scout

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- Casualty lines under the most rate pressure in the second quarter include workers compensation, medical professional liability, general liability and large account D&O
- Consistent with commercial property, there is more competition on the larger accounts
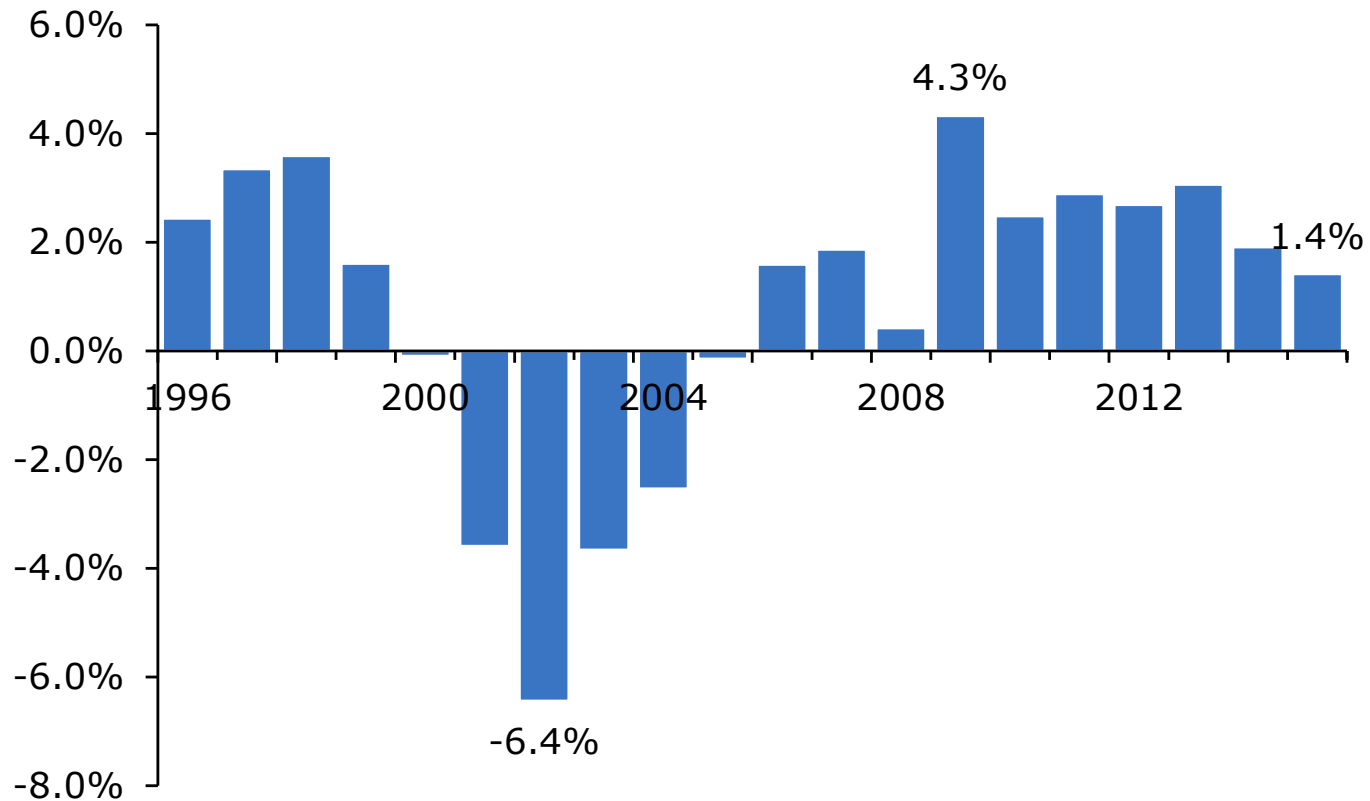
AON Empower Results®

Example risk disclosure

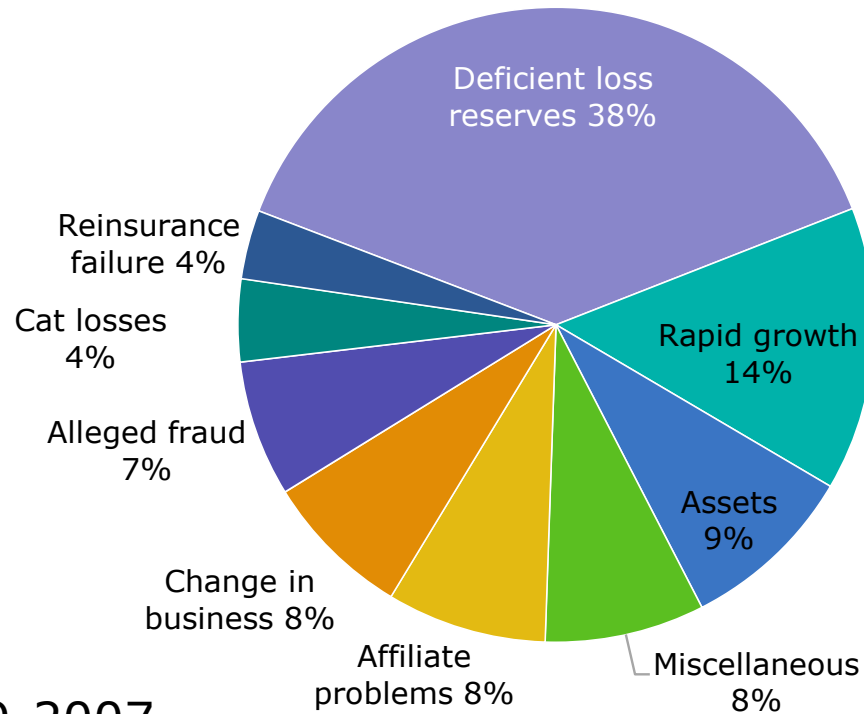| At January 1, (in millions of U.S. dollars)		2016			2015		
Single zone/single event	Perils	50 Year Return Period	100 Year Return Period	250 Year Return Period	50 Year Return Period	100 Year Return Period	250 Year Return Period
Southeast	U.S. Hurricane	$ 511	$ 729	$ 907	$ 548	$ 773	$ 947
Northeast	U.S. Hurricane	40	137	299	55	177	325
Mid-Atlantic	U.S. Hurricane	104	305	668	98	305	758
Gulf of Mexico	U.S. Hurricane	308	442	614	351	508	773
California	Earthquake	342	532	698	379	544	702
Europe	Windstorm	153	210	284	151	224	291
Japan	Earthquake	123	228	308	165	270	447
Japan	Windstorm	42	71	102	52	83	120

- Disaggregation of aggregation exposure
- Burlesque
- Can backfire

Source: Company 10K Report, year end 2015

Ten straight years of favorable development

Favorable development as percent of Net Premium Earned

The old A.M. Best P&C impairment story

Deficient loss reserves 38%

Rapid growth 14%

Assets 9%

Miscellaneous 8%

Affiliate problems 8%

Change in business 8%

Alleged fraud 7%

Cat losses 4%

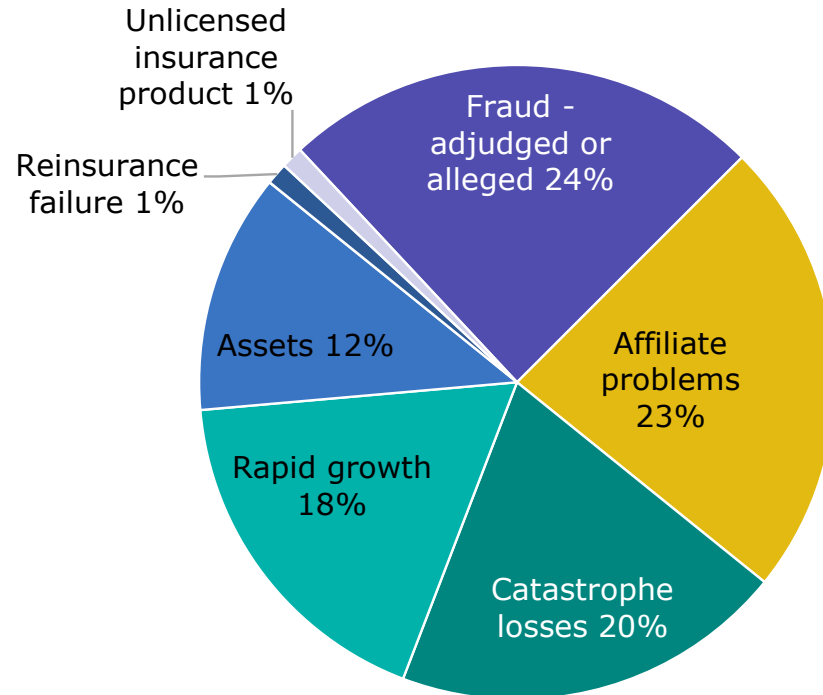Reinsurance failure 4%

- Data 1969-2007

- Dominated by problems from soft-markets

- Reserves and rapid growth (underpricing = later development) accounts for up to **52% of impairments**

Source: A.M. Best Research Special Report, "P/Cs Low Impairment Trend Likely to Have **Hit Bottom of Trough in 2007**" (May 2008)

The latest A.M. Best P&C impairment story

Pie chart:
- Fraud - adjudged or alleged 24%
- Affiliate problems 23%
- Catastrophe losses 20%
- Rapid growth 18%
- Assets 12%
- Reinsurance failure 1%
- Unlicensed insurance product 1%

- Data 2000-2015: no reserve issues
- Greater focus on catastrophes: thinly capitalized companies
- Only **90 out of 323** impairments had a specific cause noted

Lumbermens Mutual Casualty case study

During 2002 & 2003 LMC lost 84% of stat surplus…

|	2003	2002
CAPITAL AND SURPLUS ACCOUNT		
21. Surplus as regards policyholders, December 31 prior year (Page 4, Line 38, Column 2)	696,846,043	1,266,575,405
GAINS AND (LOSSES) IN SURPLUS		
22. Net income (from Line 20)	(517,377,785)	(205,919,979)
23. Change in net unrealized capital gains or (losses)	107,581,822	(178,437,296)
24. Change in net unrealized foreign exchange capital gain (loss)	3,626,227	(3,552,895)
25. Change in net deferred income tax	119,349,325	32,093,982
26. Change in nonadmitted assets (Exhibit 1, Line 5, Col. 3)	(253,496,319)	(94,965,783)
27. Change in provision for reinsurance (Page 3, Line 16, Column 2 minus Column 1)	84,106,200	(36,727,200)
28. Change in surplus notes		54,312
29. Surplus (contributed to) withdrawn from protected cells		0
30. Cumulative effect of changes in accounting principles		111,346,668
31. Capital changes:		
31.1. Paid in		
31.2. Transferred from surplus (Stock Dividend)		
31.3. Transferred to surplus		
32. Surplus adjustments:		
32.1. Paid in		
32.2. Transferred to capital (Stock Dividend)		
32.3. Transferred from capital		
33. Net remittances from or (to) Home Office		
34. Dividends to stockholders		0
35. Change in treasury stock (Page 3, Lines 34.1 and 34.2, Column 2 minus Column 1)	0	0
36. Aggregate write-ins for gains and losses in surplus	(38,209,548)	(193,621,171)
37. Change in surplus as regards policyholders for the year (Lines 22 through 36)	(494,420,078)	(569,729,362)
38. Surplus as regards policyholders, December 31 current year (Line 21 plus Line 37) (Page 3, Line 35)	202,425,965	696,846,043

Two year decline: $1.1B

…and **92%** over five years, from 1999

LMC Year end statutory surplus, USD million

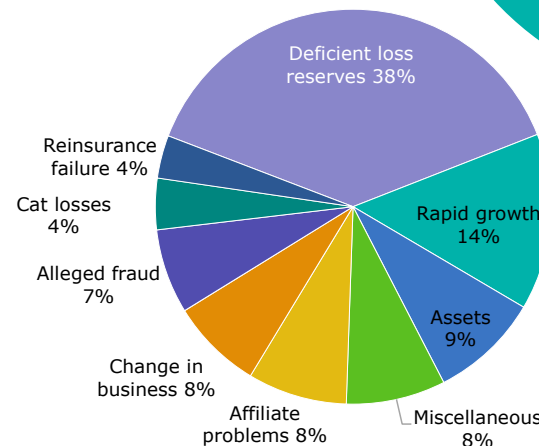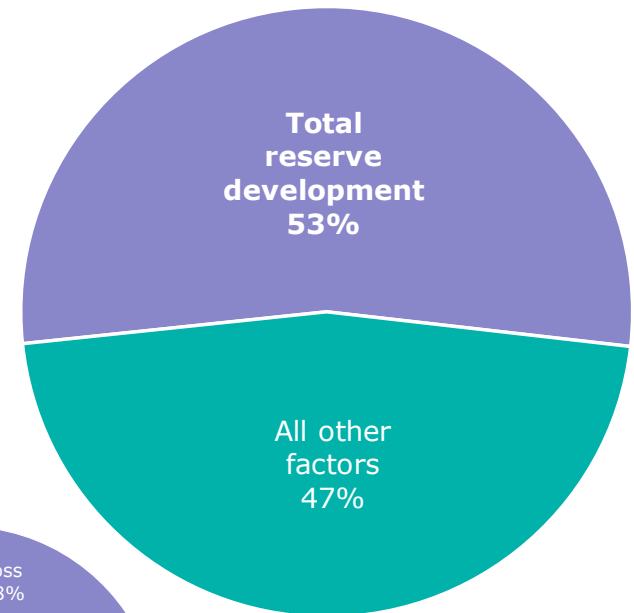| Year	Surplus	Change
1999	2,404	
2000	1,813	-591
2001	1,267	-546
2002	697	-570
2003	202	-494

Cumulative five year decline: $2.2B
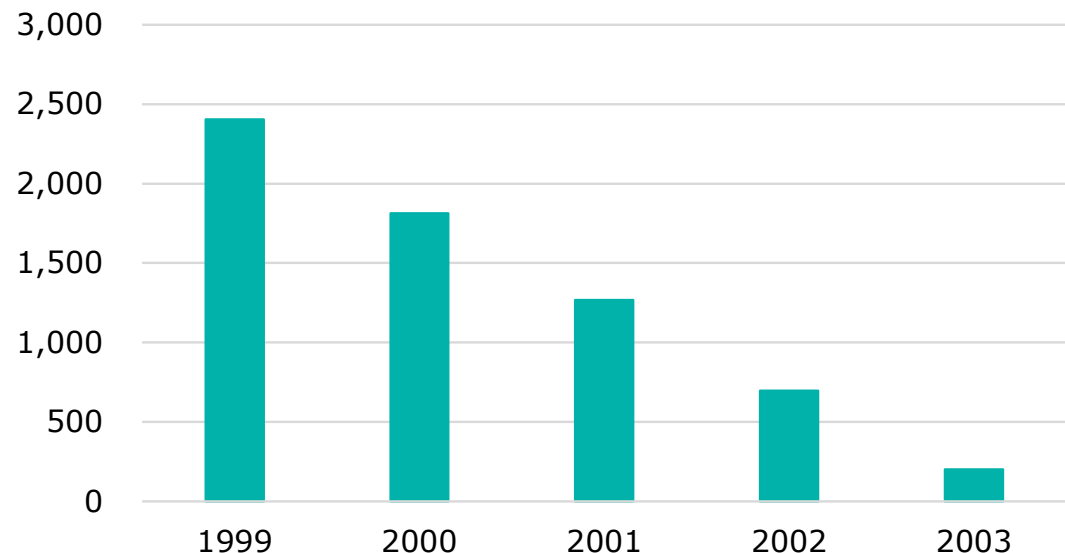
Surplus decline 1999-2003: **short story=reserves**

Components of decline in surplus, 2000-2003

	USD million	Pct Change
Starting surplus	2,404.4	
Ending surplus	202.4	-92%
Change	2,202.0	
Total reserve development	**1,177.6**	**53%**
All other factors	1,024.4	47%

Total reserve development 53%

All other factors 47%

Deficient loss reserves 38%
Reinsurance failure 4%
Cat losses 4%
Alleged fraud 7%
Change in business 8%
Affiliate problems 8%
Miscellaneous 8%
Assets 9%
Rapid growth 14%

Old AMB story 52% reserves/growth

Source: LMC Audited financials, 2000-2003

Surplus decline 1999-2003: **short story=reserves**

Components of reserve development by calendar year, USD 000

	2000	2001	2002	2003	Total
Prior year development incurred (reported)	**90,078**	**50,601**	**343,403**	**-579,900**	**-95,818**
Normal business	69,014	73,800	279,700	146,100	568,614
A&E related	21,064	160,800	63,700	26,100	271,664
Cessions on PY reinsurance		-184,000			-184,000
Discounting				-548,800	-548,800
Novation				-203,300	-203,300
Change in accounting principles (SSAP55)		337,337			337,337
Record A&E and mass tort reserves at midpoint		260,337			260,337
Record reserves at management's best estimate		77,000			77,000

-$515.8M

Development including change in accouning principles but excluding discounting, reinsurance and novation

	2000	2001	2002	2003	Total
Normal business	69,014	150,800	279,700	146,100	645,614
A&E related	21,064	421,137	63,700	26,100	532,001
Total reserve change	**90,078**	**571,937**	**343,400**	**172,200**	**1,177,615**

Major line items in LMC surplus decline, 2002-03

	USD million
Starting Surplus at 12/31/2001	**1,266.6**
Normal Business	**62.9**
Reserves	**-515.8**
PY development	-425.9
A&E incurred loss	-89.9
Operations	**-388.8**
Retroactive reinsurance gain(loss)	-328.3
Correction of error in reinsurance accounting (fails risk transfer, unwind surplus benefit)	-60.5
Assets	**-199.7**
Change in MPL	-101.3
Joint venture impairment writedown	-98.4
Fraud	**-75.4**
Reinsurance	**-22.6**
Cascade	**-584.8**
Affiliated stocks and bonds	-501.5
Change in net DTA	-146.4
Change in non-admitted assets related to EDP and software, furniture etc.	-82.1
Loss on sale of assets	-69.0
Distress releated expenses	-66.9
Fixed asset writedowns	-62.9
Deferred gain on investment transfers from subs	-12.4
Real estate	-3.2
Change in non-admitted assets related to all other items	31.5
Renewal Rights revenue	44.3
Novations	54.6
AMM Reinsurance Transaction	229.2
Regulatory Largesse	**660.1**
Permitted practice to discount	548.8
Cumulative effect of changes in accounting principles	111.3
Ending surplus at 12/31/2003	**202.4**

Major components of LMC surplus decline, 2002-03

	USD million
Starting Surplus at 12/31/2001	**1,266.6**
Normal business	62.9
Reserves	-515.8
Operations	-388.8
Assets	-199.7
Fraud	-75.4
Reinsurance	-22.6
Sub total	-1,139.5
Cascade	**-584.8**
Ending surplus without accounting adjustments	-457.7
Regulatory Largesse	**660.1**
Ending Surplus at 12/31/2003	**202.4**

- Surplus without regulatory largesse $(457.7)M
- Cascade effects are **separate** from operational risk components
- Exacerbates rather than causes impairment

> "How did you go bankrupt?"
> "Two ways. Gradually, then suddenly"
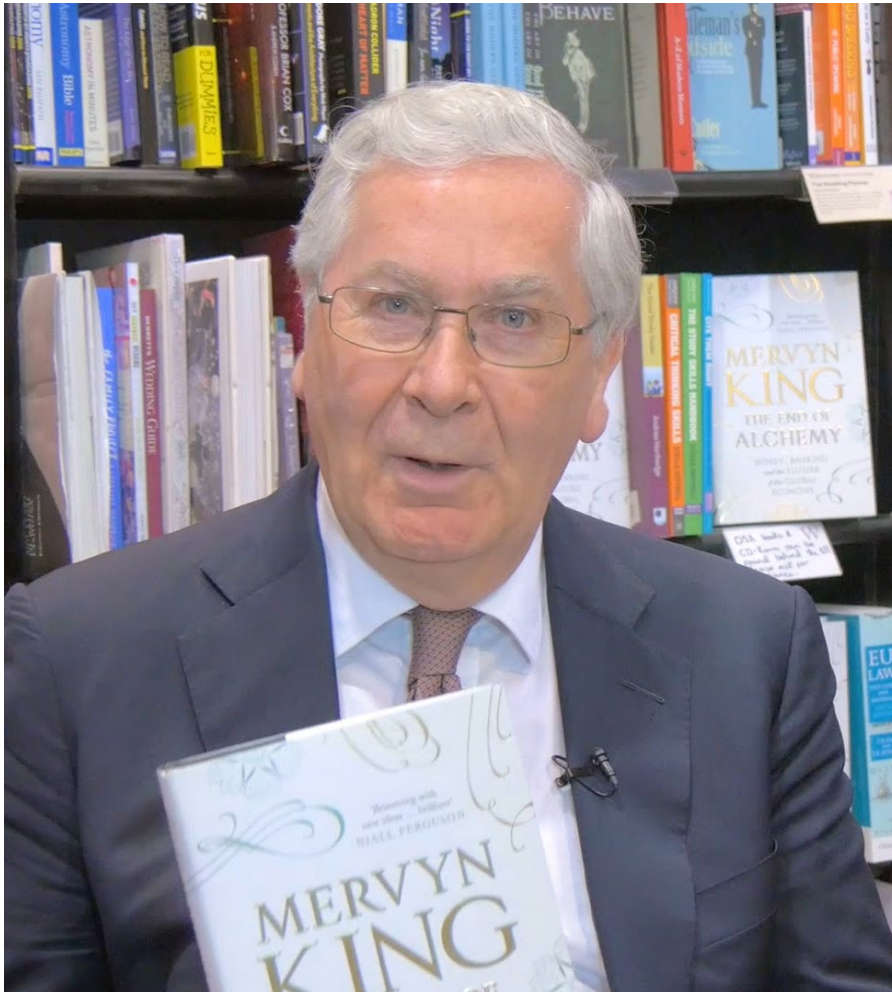> Ernest Hemingway, The Sun Also Rises

...and we haven't even discussed liquidity

...and we haven't even discussed liquidity

...should we model liquidity or solvency?

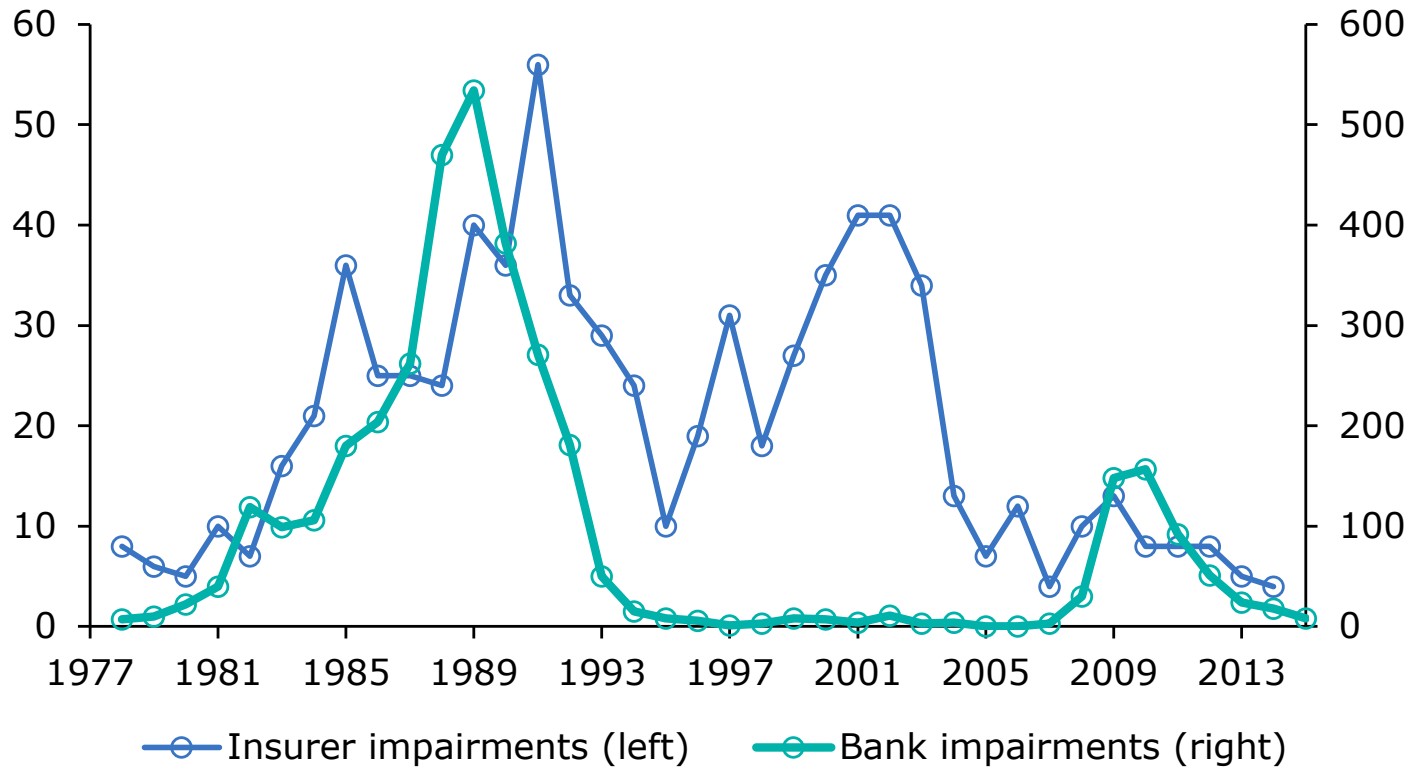Liquidity is a test you must pass everyday

Insurers are anti-banks

"What makes banks special?"

- Assets
  - Long-term
  - Illiquid
  - Risky

- Liabilities
  - Short-term
  - Liquid
  - Perceived as safe

Mervyn King "The End of Alchemy" (2015)
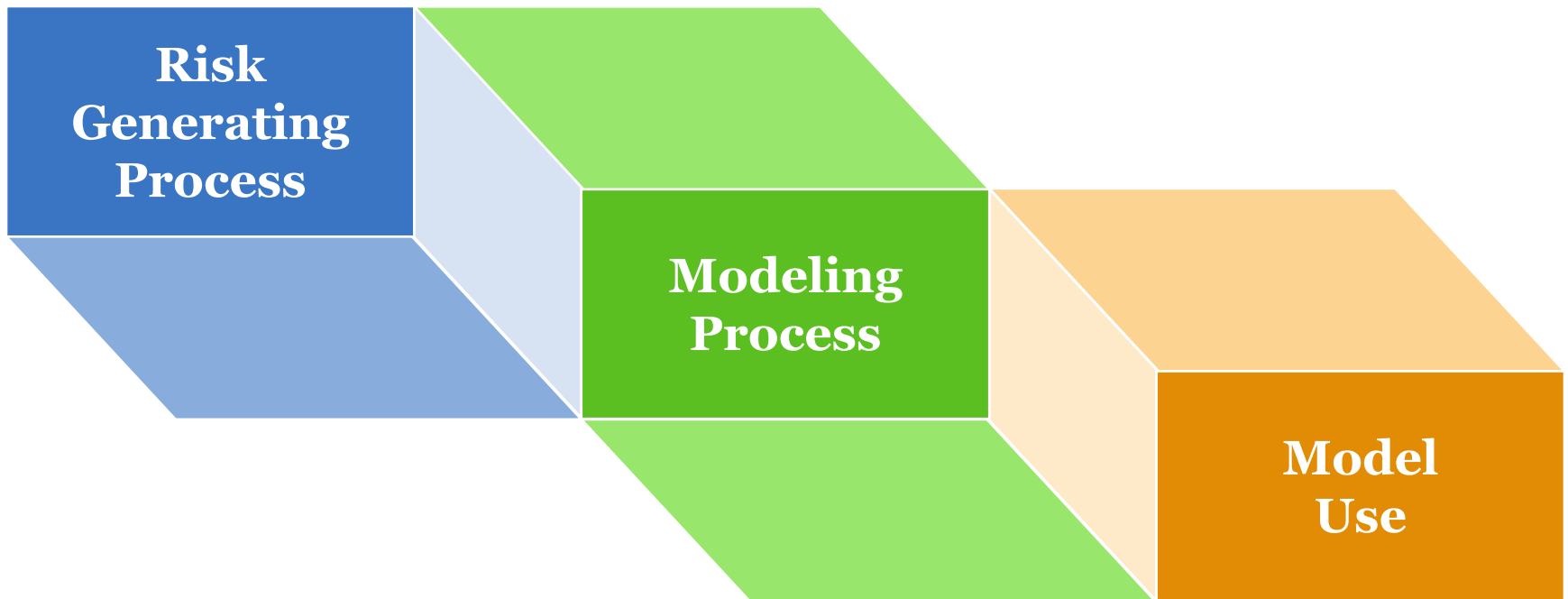Governor of the Bank of England 2003-2013

Bank and insurer impairment rates
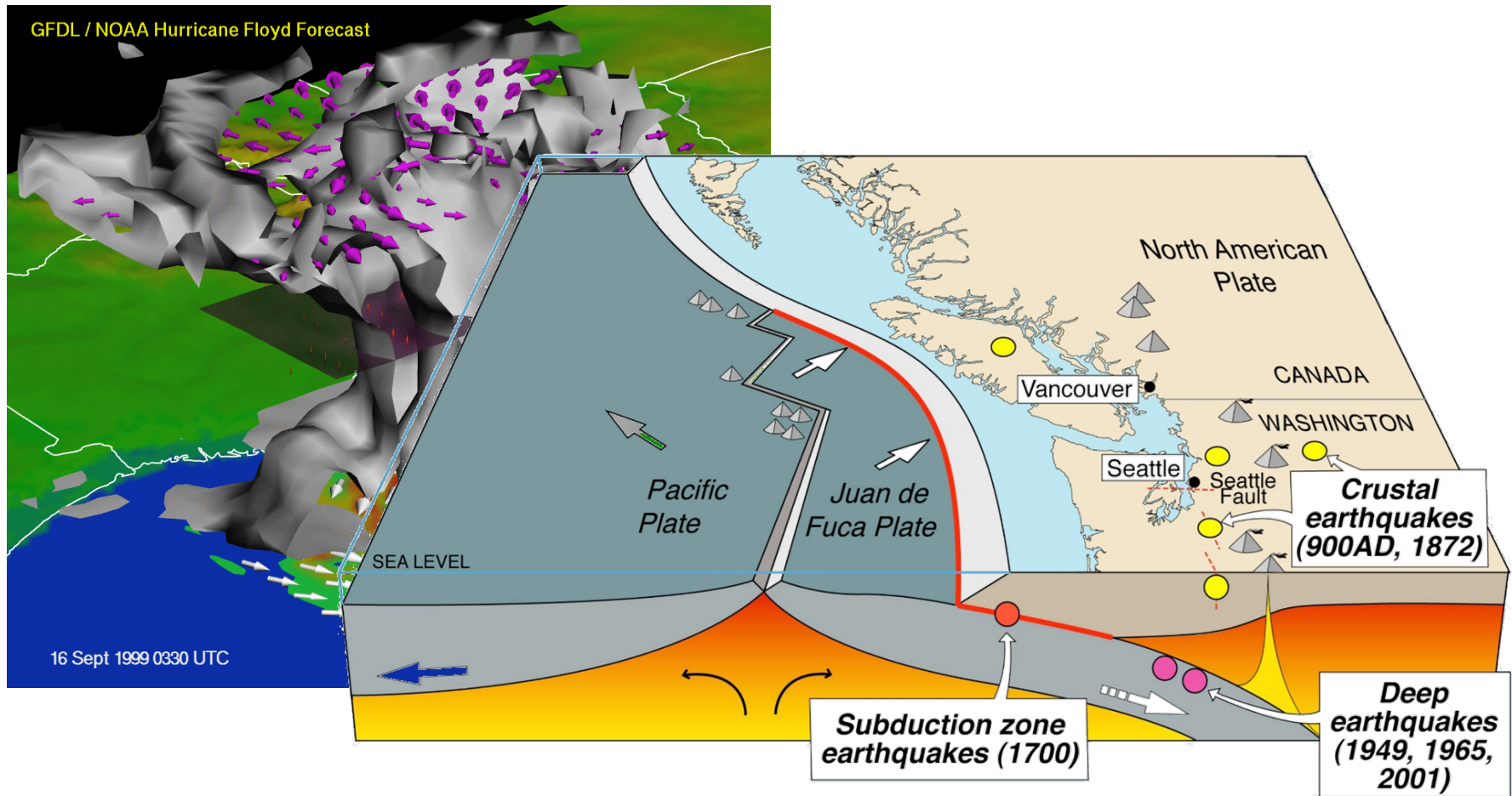
Section 3: Insurer risk modeling spectrum

- Scientific problems
- Social-scientific problems

Insurer risk spectrum operates at three different levels

Risk Generating Process

Modeling Process

Model Use

Insurer risk modeling spectrum: scientific problems

Catastrophe risk generating process: scientific

Modeling process: measures beyond the coherent

- **Coherent** risk measure
  - Cash invariant: risk(X+$) = risk(X) – $
  - Positive homogeneous: risk(kX) = k risk(X) for k>0
  - Subadditive: risk(X+Y) ≤ risk(X) + risk(Y)

- **Convex** monetary risk measure
  - Cash invariant
  - Monotone: if X(w)<Y(w) for all states w then risk(X)<risk(Y)
  - Convex: risk(aX + (1-a)Y) ≤ max{risk(X), risk(Y)}, 0<a<1

- Convex + positive homogeneous ➔ coherent

- Positive homogeneous is a real problem
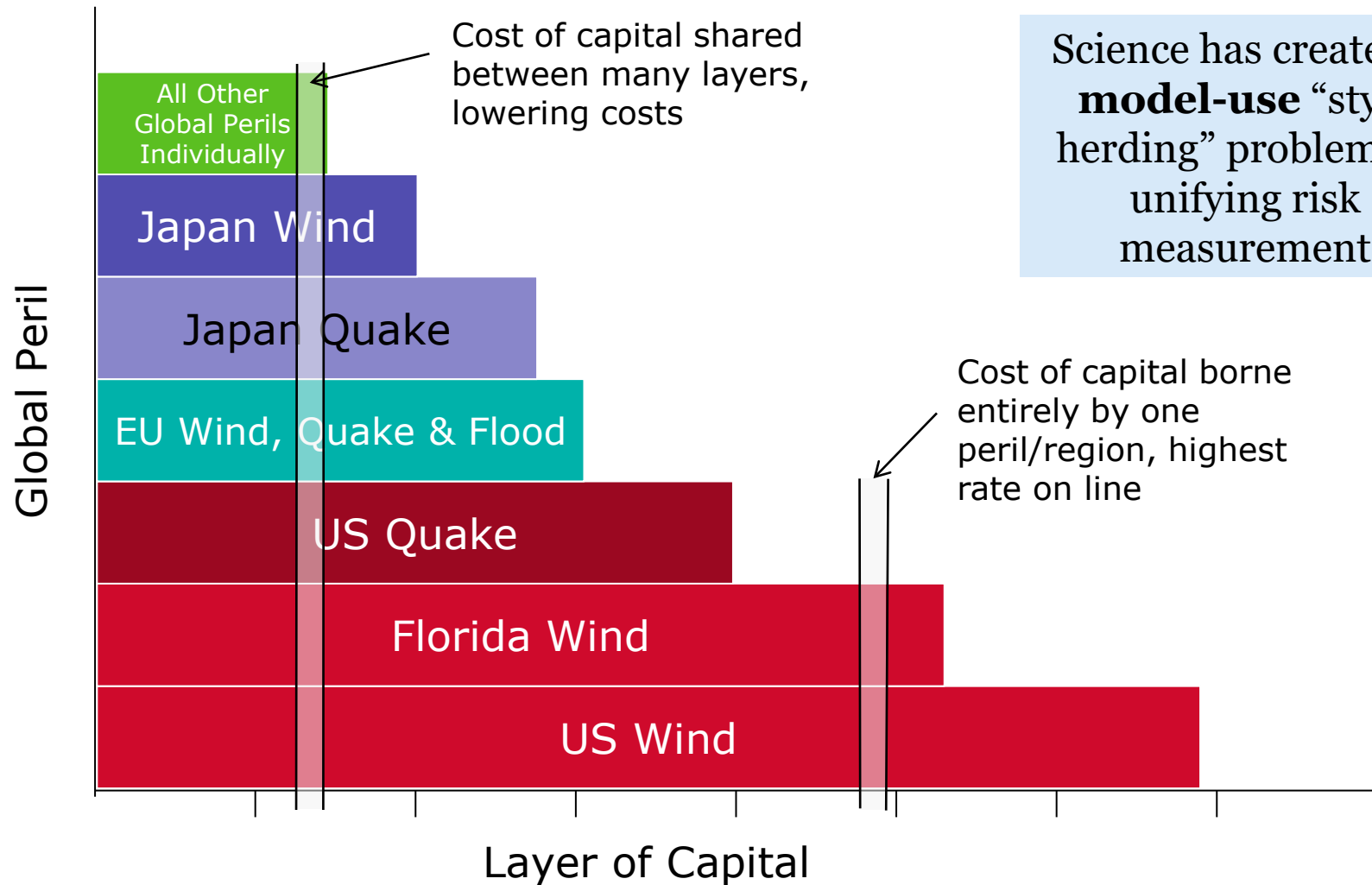 - Investment style herding, large positions in illiquid assets etc.

Modeling process: risk measure miracle

- All convex risk measures have the form

$$\text{risk}(X) = \max_{\{\text{Scenarios } Q\}} (E_Q(X) - \beta(Q))$$

- Scenarios taken "more or less seriously" according to the size of penalty $\beta(Q)$
  – E.g. β could measure distance from best estimate probability

- Coherent iff $\beta=0$ on some scenarios and ∞ on all the others

- Coherent example
  – 99% TVaR: scenarios are assignments of probabilities to individual events, where only subsets of P-probability 1% have non-zero weight

- **Miracle: this is exactly how we think about risk**

Source: Follmer, Hans, and Alexander Schied. "Convex and coherent risk measures." *October* 8 (2008); http://www.alexschied.de/Encyclopedia6.pdf

Cost of capital shared between many layers, lowering costs

Science has created a **model-use** "style herding" problem by unifying risk measurement

Cost of capital borne entirely by one peril/region, highest rate on line

All Other Global Perils Individually

Japan Wind

Japan Quake

EU Wind, Quake & Flood

US Quake

Florida Wind

US Wind

Global Peril
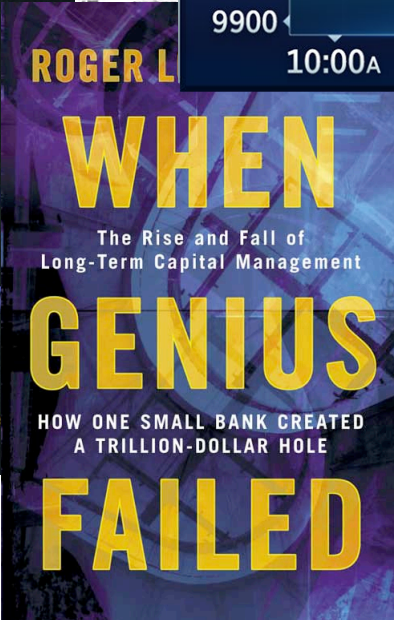
Layer of Capital

Evidence 2 of 2: California earthquake cover

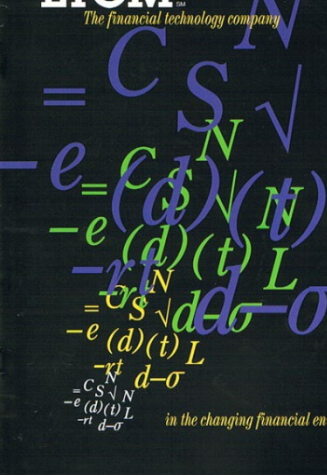## No writer of stand alone earthquake appears happy

Strategy\Outcome	No Loss, probability 98%	Loss, probability 2%

No writer of stand alone earthquake appears happy

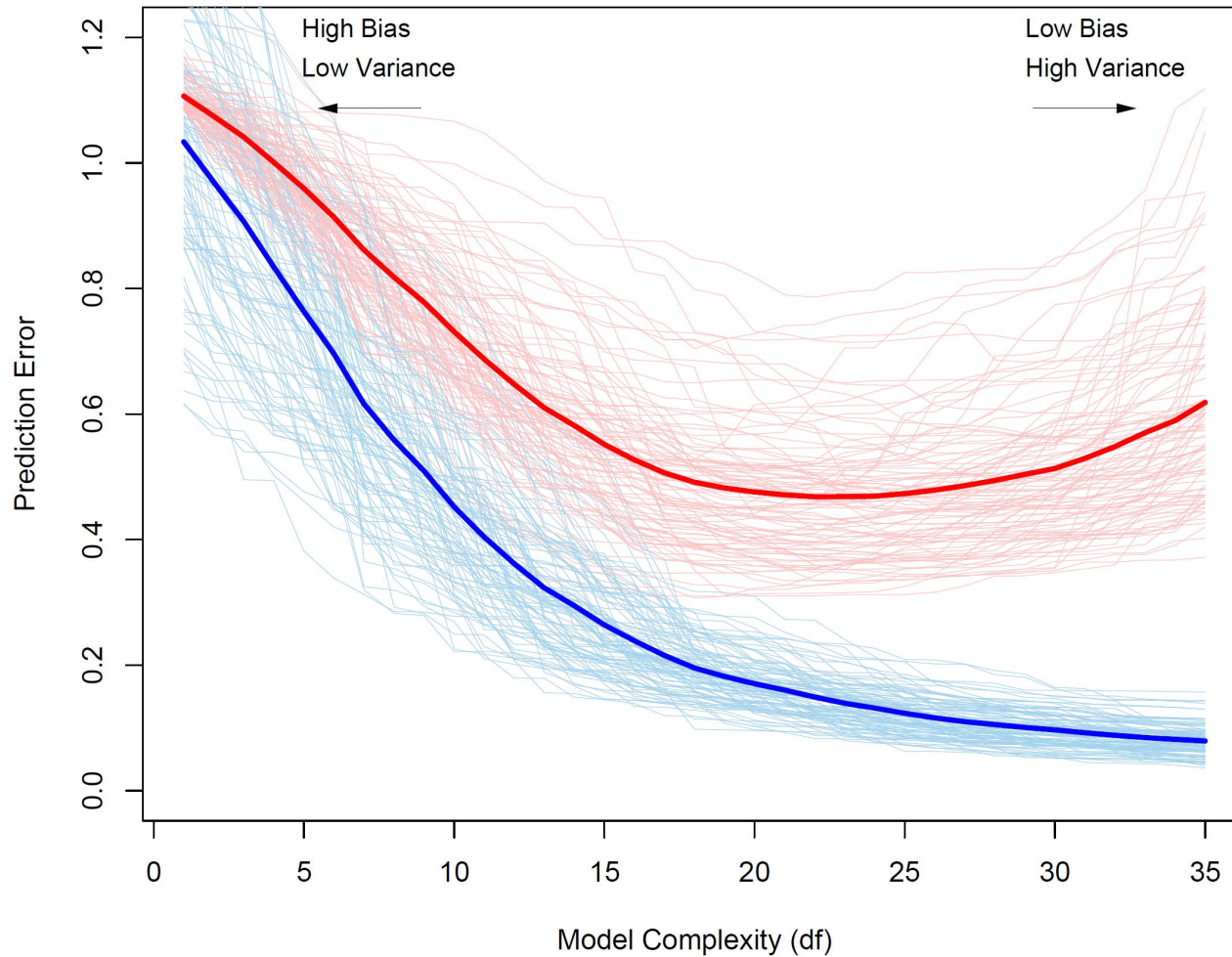| Strategy\Outcome	No Loss, probability 98%	Loss, probability 2%
Continue to write EQ	▪ Generate "free income" ▪ Maintain premium volume ▪ Keep up with peers ▪ **Stock analysts happy**	▪ Market will turn ▪ Rely on reinsurance ▪ Loss no worse than peers ▪ **Stock analysts understand**
Drop EQ	▪ Lower income & EPS ▪ **No model capital credit** ▪ Pressure top line ▪ Fall behind peers ▪ **Stock analysts unhappy**	▪ **Look brilliant…but very small probability**

Insurer risk modeling spectrum: social-scientific problems

Asset risk generating processes: social science

Asset risk

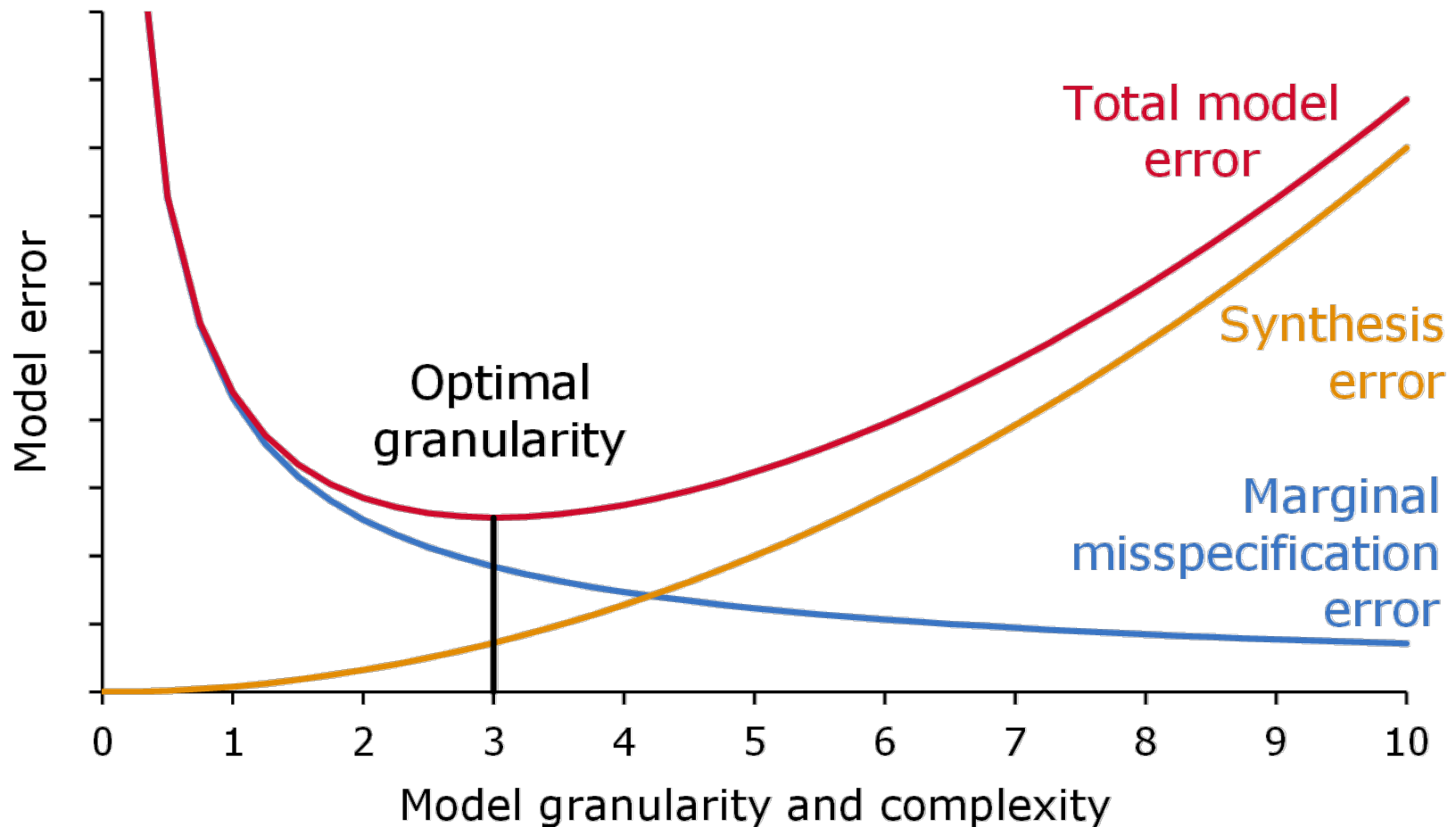# Variance-bias tradeoff from predictive modeling…

Source: Friedman, Hastie, Tibshirani The Elements of Statistical Learning, Second Edition (2008)

…translates to **modeling process, model-use** ECM problem: user pressure for excessive granularity

Paradox of **model use**

Calibrated to worst outcomes, models are used all the time

- Bad times are quantitatively different…
  - Cascade effect
  - Taxes change
  - Exact accounting matters
  - Legal entity matters, especially tricky for mutual companies

- Model is not, and should not be, a "how-to" manual for managing through difficult times

- Yet models must account for what happens in stressed environ-ments to realistically measure tail
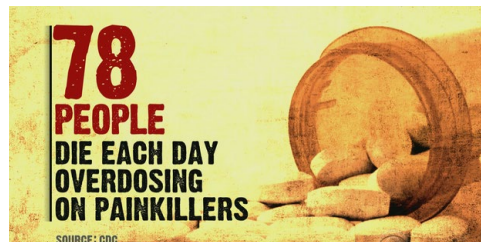 - You can't use your own "economic valued added" accounting

What is the **risk generating process** of non-cat lines?

Non-cat risks span full risk spectrum

Asset risk | **Non-cat risk** | **Cat risk**

INFLATION

78 PEOPLE DIE EACH DAY OVERDOSING ON PAINKILLERS
SOURCE: CDC

Underwriter

Hacker computer

Driverless cars

INSURANCE FRAUD

regulations risk rules strategy standards COMPLIANCE practices security governance policy laws
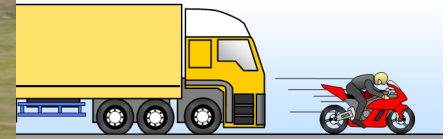
Section 4: What we believe that ain't so

Personal auto needs capital...and other regulatory distortions

What if everyone thought that way?

The plan is unbiased

Section 5: What would improve ECM?

- Technical advances
- Social advances

What is "The Model"?

- Do you need a **fully stochastic** model?
  - Beware building in known relationships, believed to hold until they don't
  - Irreducible uncertainty: risk for multi-period models

- Optimal model likely **simpler** than your model
  - What machinery balanced on precarious parameterization?
  - Output often (appropriately) condensed to target combined ratios

- Better use law of large numbers, central limit theorem, and theory of sub-exponential distributions (slowly varying functions) to short-circuit model components
  - Thickest tail dominates
  - **Embrace simplicity**

On- and off-balance sheet capital

- Available capital need not be on-balance sheet
  - Pre- and post-event funding cost differentials
  - Dilution
  - Multiyear reality of business
  - Bob Hope paradox

- Bauer & Zanjani work

A bank is a place that will lend you money if you can prove that you don't need it.
Bob Hope

The volatility-survival tradeoff

- Adaptive markets theory: it's all about survival…

- Need analytical shortcuts for optimizing risk-return tradeoff
  - High profit with high probability of insolvency vs.
  - Lower profit over longer time frame
  - E.g. Milevsky work on portfolio survival and inverse gamma approximation to geometric Brownian motion walk

- Present value of future dividend models

Set achievable goals for the model

Can the model solve the problem?

All models are wrong,
but some are useful
George E.P. Box

Risk tolerance disclosures show stark contrast between catastrophe & non-cat property risk

Surplus $29.6B

Rating A++

- "Ace Limited utilizes reinsurance to limit its liability and impact on operations to a maximum amount on any one loss of: **$3.75 million for property** and boiler and machinery…and US $1.5 million for accident and sickness."

- Property [risk] retention **0.01%** of capital and surplus

- "For 100-year return scenario, modeled annual aggregate pre-tax PML for U.S. hurricane is **$1.757B** (**1.1%** of industry aggregate losses, **5.9%** of total shareholder equity. For 250 year … $2.383B (8.1% of shareholder equity)"

Surplus $24.8B

Rating A++

- "For commercial property exposures excess of loss reinsurance generally limits net retained amounts per risk to **$20 million** per occurrence. Business unit-specific treaties are utilized to further reduce net retentions accordingly."

- Property [risk] retention **0.09%** of capital and surplus

- Net, single U.S. hurricane 1:100 is **9.2%** (6% after-tax) of shareholder equity, 1:250 is 12.2% (8% after-tax)

- **$2.3B** 100 year event

Cat risk tolerance **100 to 500x higher** than non-cat risk tolerance for two highly respected US companies

Communicate clearly

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Graphic note: County size scaled to RMS loss estimates for hurricane, earthquake and severe weather using Gastner & Newman algorithm