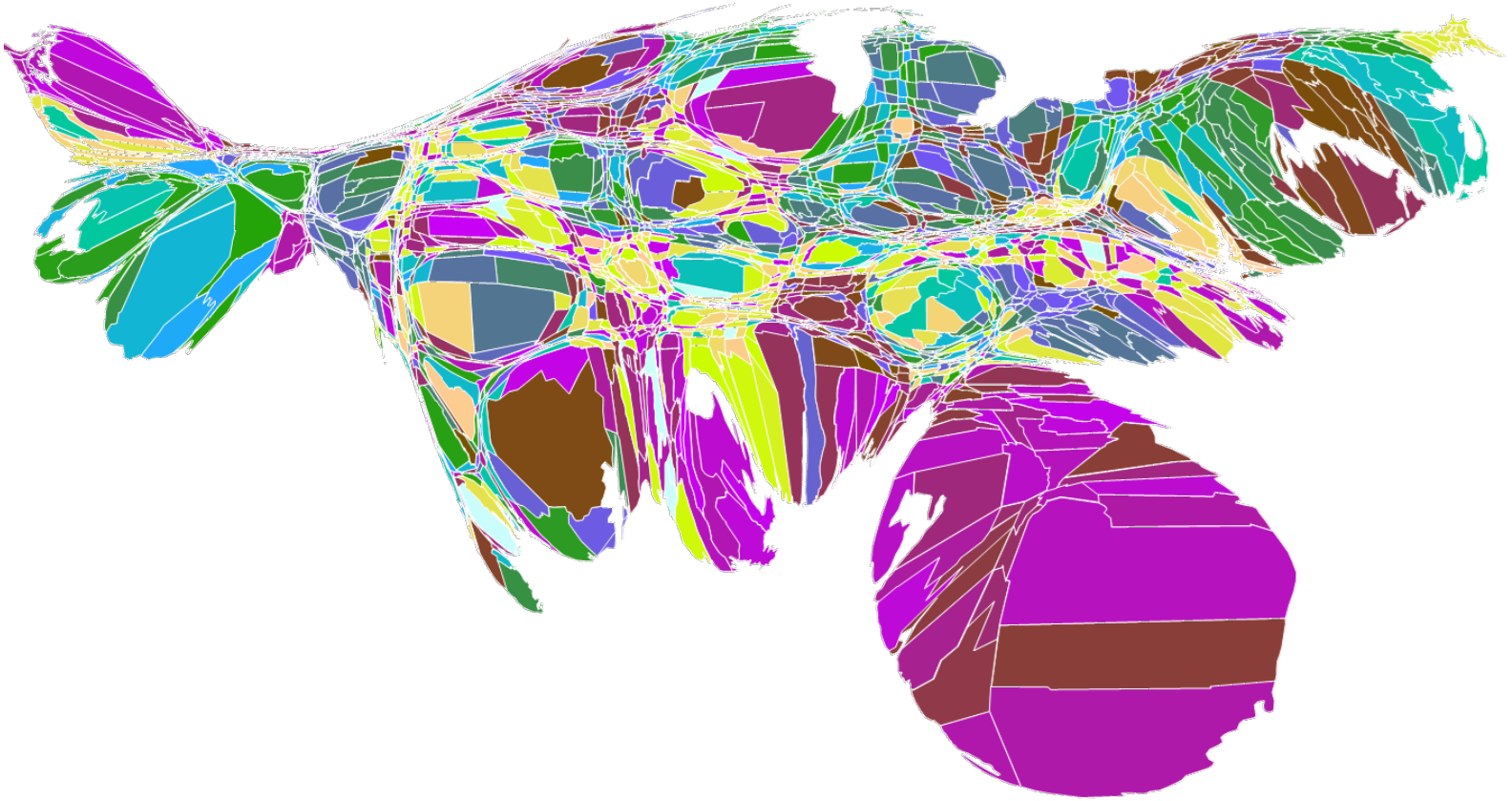

Risk Management: Theory and Practice

Stephen J. Mildenhall
Ronald H. and Mary E. Simon Actuarial Science Lecture
Michigan State University
November 13, 2015

Aon Center for Innovation and Analytics, Singapore

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リスク管理に関しての7つの未決問題
1997年から先月までの

Question
リスク許容度またはリスク選好度をどのように**決める**か?
自然災害リスクのリスク許容度をどのように決めるか?
通常災害リスクのリスク許容度をどのように決めるか?
これらは同じであるべきか?
ポートフォリオの大小では違いはあるか?
財産と賠償責任では違いはあるか?
リスク許容度はどのように開示されるべきか?

Seven open Risk Management questions
From last month and from 1997

Question	Translation
リスク許容度またはリスク選好度をどのように**決める**か?	How do you **determine a risk tolerance** or risk appetite?
自然災害リスクのリスク許容度をどのように決めるか?	How do you determine a risk tolerance for **catastrophe risks**?
通常災害リスクのリスク許容度をどのように決めるか?	How do you determine a risk tolerance for **non-catastrophe risks**?
これらは同じであるべきか?	**Should they be the same?**
ポートフォリオの大小では違いはあるか?	Does the **size** of the book make a difference?
財産と賠償責任では違いはあるか?	Does **property vs. liability** make a difference?
リスク許容度はどのように開示されるべきか?	How should risk tolerance be **disclosed**?

Seven open Risk Management questions
From last month and from 1997

Question	Answer
How do you **determine a risk tolerance** or risk appetite?	Develop a framework to balance [marginal] risk to [marginal] return
How do you determine a risk tolerance for **catastrophe risks**?	Manage return to Probable Maximal Loss (PML) aka Value at Risk
How do you determine a risk tolerance for **non-catastrophe risks**?	**Lack tools and data to quantify underlying risk drivers; responsible for last soft market**
Should they be the same?	No, they reflect very different types of risk
Does the **size** of the book make a difference?	The overall size of the market and the volume of data used to price are most important
Does **property vs. liability** make a difference?	Yes – because of the payout tail, but we won't have time to consider
How should risk tolerance be **disclosed**?	…very carefully

Catastrophe risk tolerance: post-Katrina

- Typical CRO/CFO Risk Tolerance Questions
  - What proportion of one years earnings can be lost in a single event without an adverse stock price reaction?
  - What proportion of GAAP equity?
- Post-event share price decline best predicted by reported Katrina losses alone, rather than Katrina, Rita and Wilma losses combined
  - Indicates a greater sensitivity to a single large loss than an aggregation of events

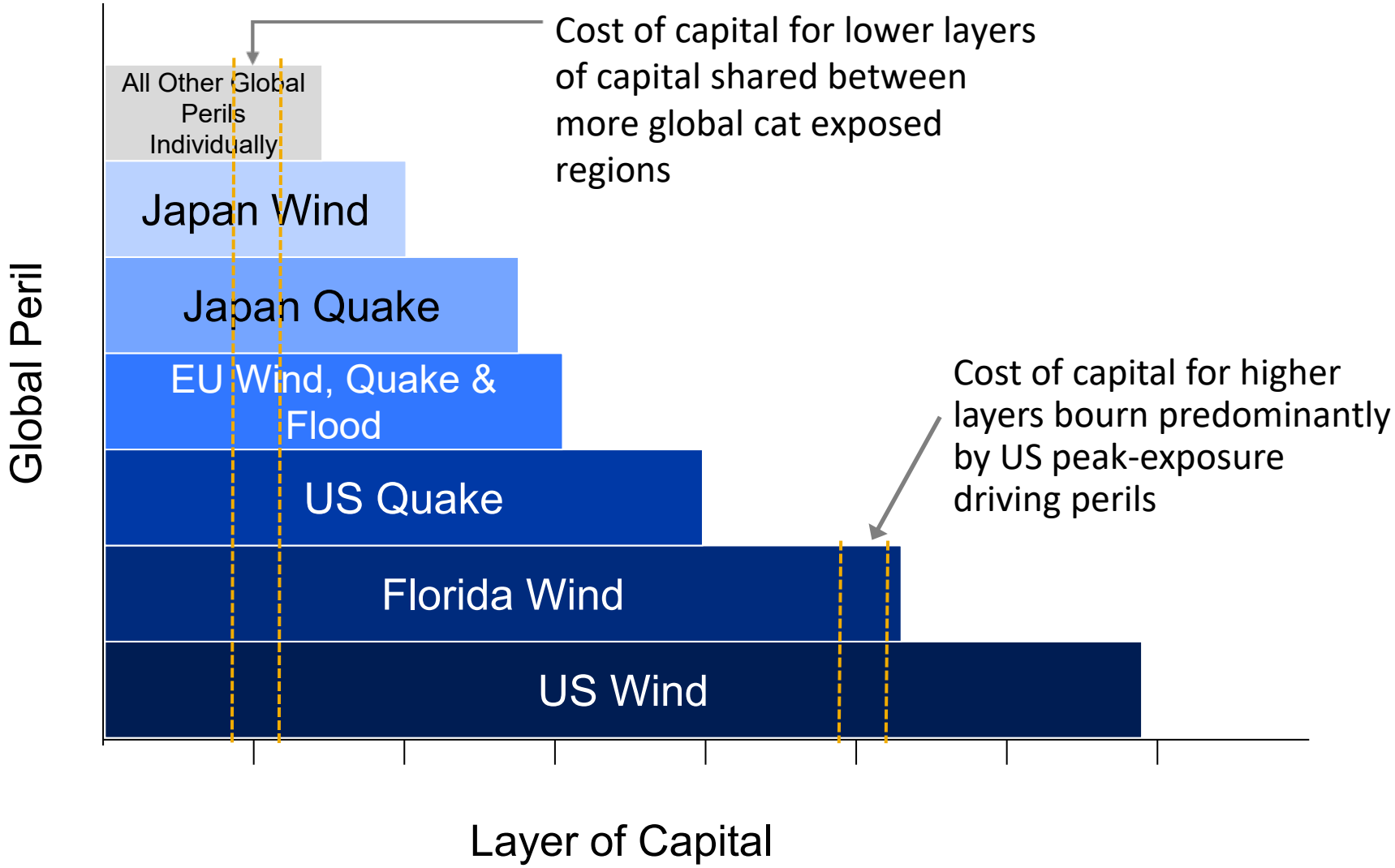
	Katrina Study Loss % Ranges*		YE 1:100 PML Disclosure Mean As a % of Equity*		
Sector	As % of Equity	As % of Prospective Consensus Earnings	2012	2013	2014
Primary Insurers	3% to 6%	21% to 34%	4%	4%	4%
Reinsurers	12% to 19%	107% to 110%	14%	14%	13%

* Shown on a net post-tax basis

- **Majority of commercial insurers and reinsurers with strong or adequate risk management report risk tolerance using PML or similar variant**

Evidence from the real world

Global cost of catastrophe reinsurance consistent with marginal VaR capital approach



Property risk tolerance disclosures show stark contrast between catastrophe (cat) vs. 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

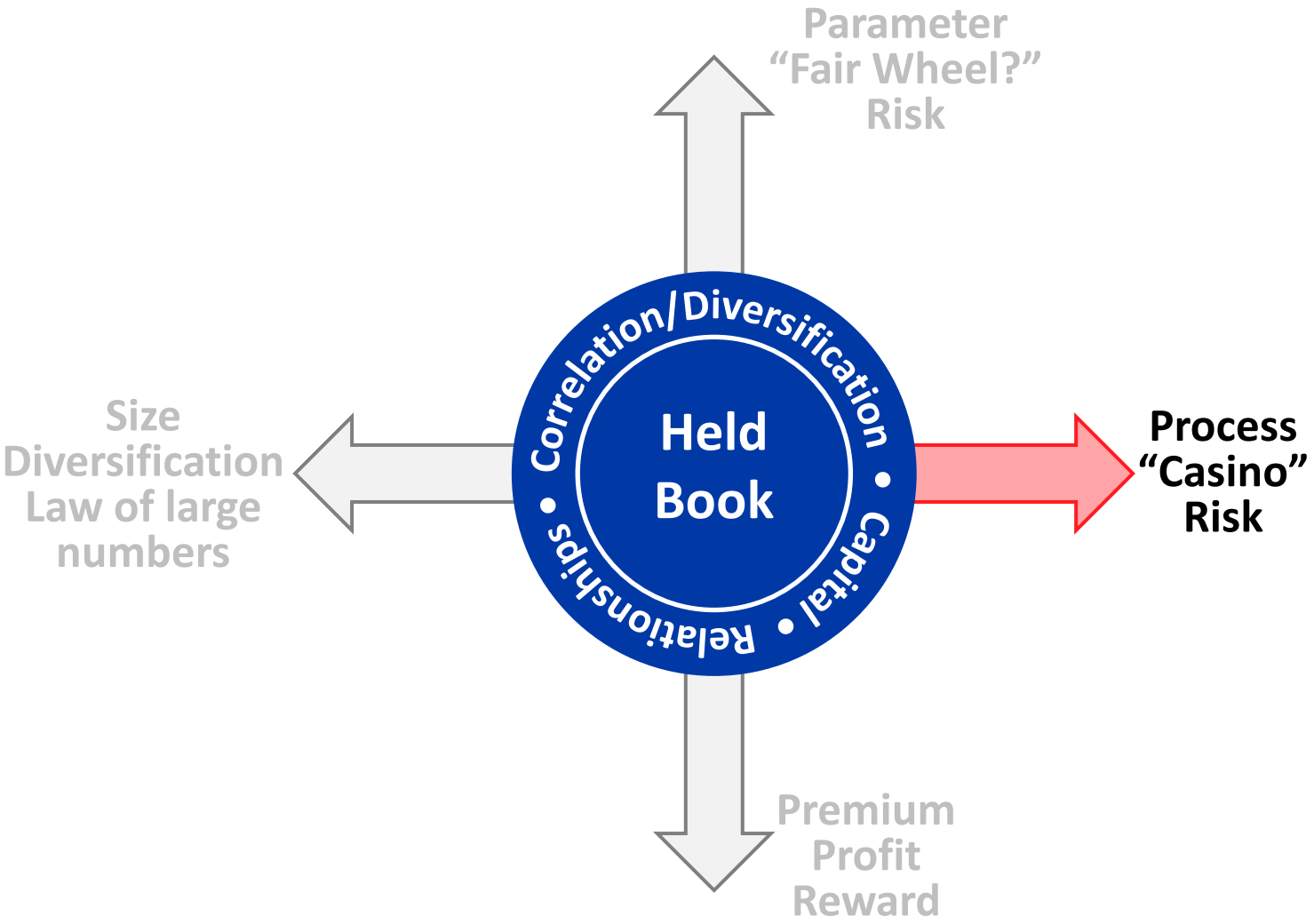
Rating
A++

- "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

Sources: ACE 2014 10-K Filing, Catastrophe Risk Management section; AM Best Credit Report #85760 ACE INA Insurance; Travelers 2014 10-K Filing, Catastrophe Risk Modeling Section; AM Best Credit Report #18674 Travelers Group

Section 1: Insuring Process Risk



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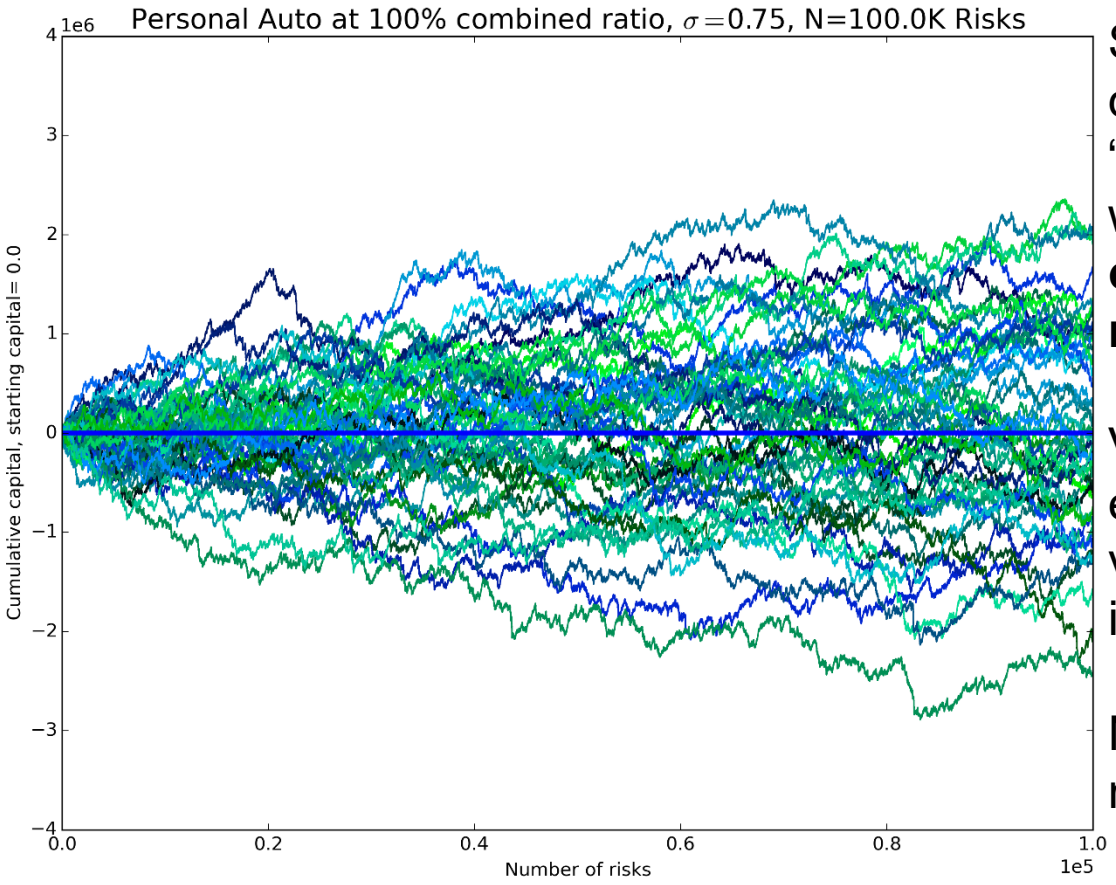
Classic “random walk” for **personal auto** underwriting result

Cumulative underwriting surplus process



Standard deviation (SD) or “spread” grows with **square root of number of risks**

Variance of sum equals sum of variance for independent risks

No trend because no profit

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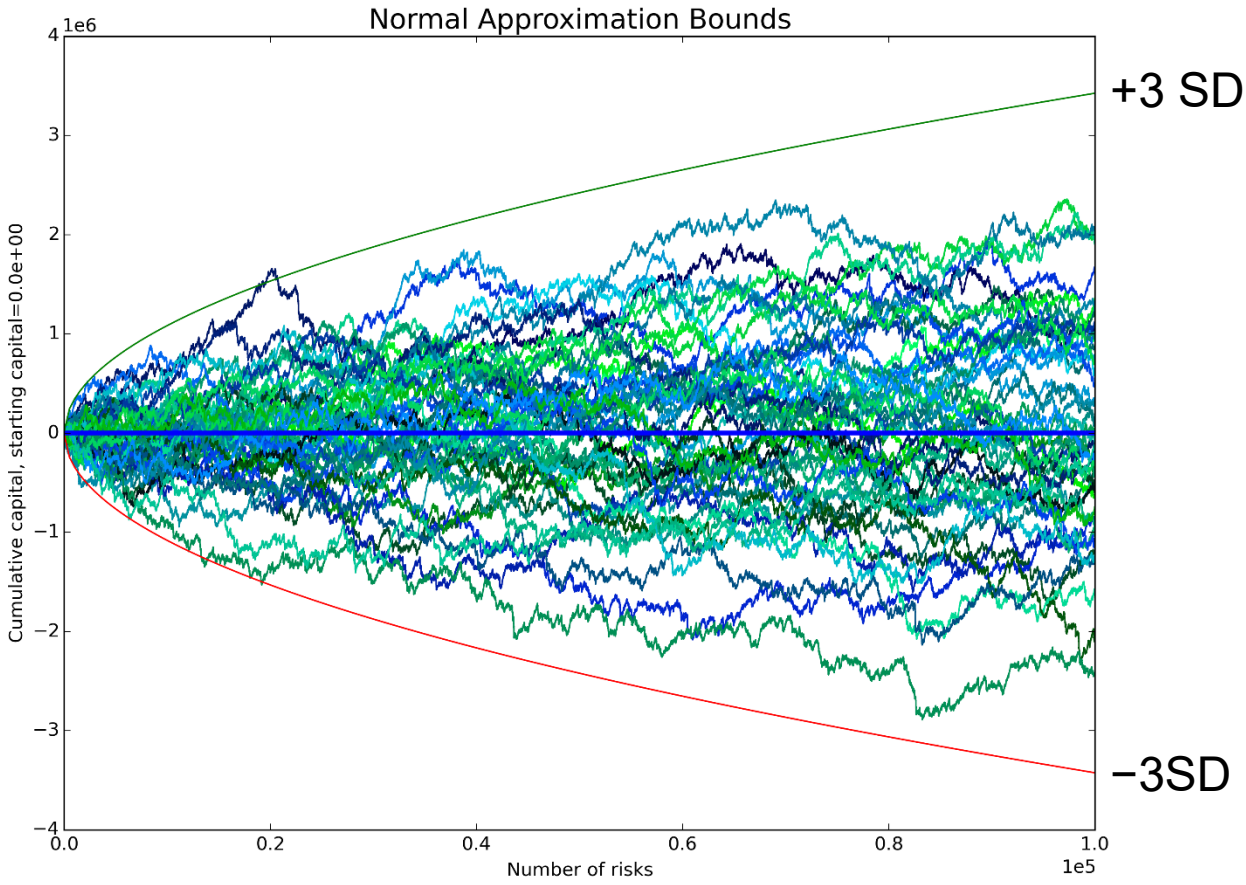
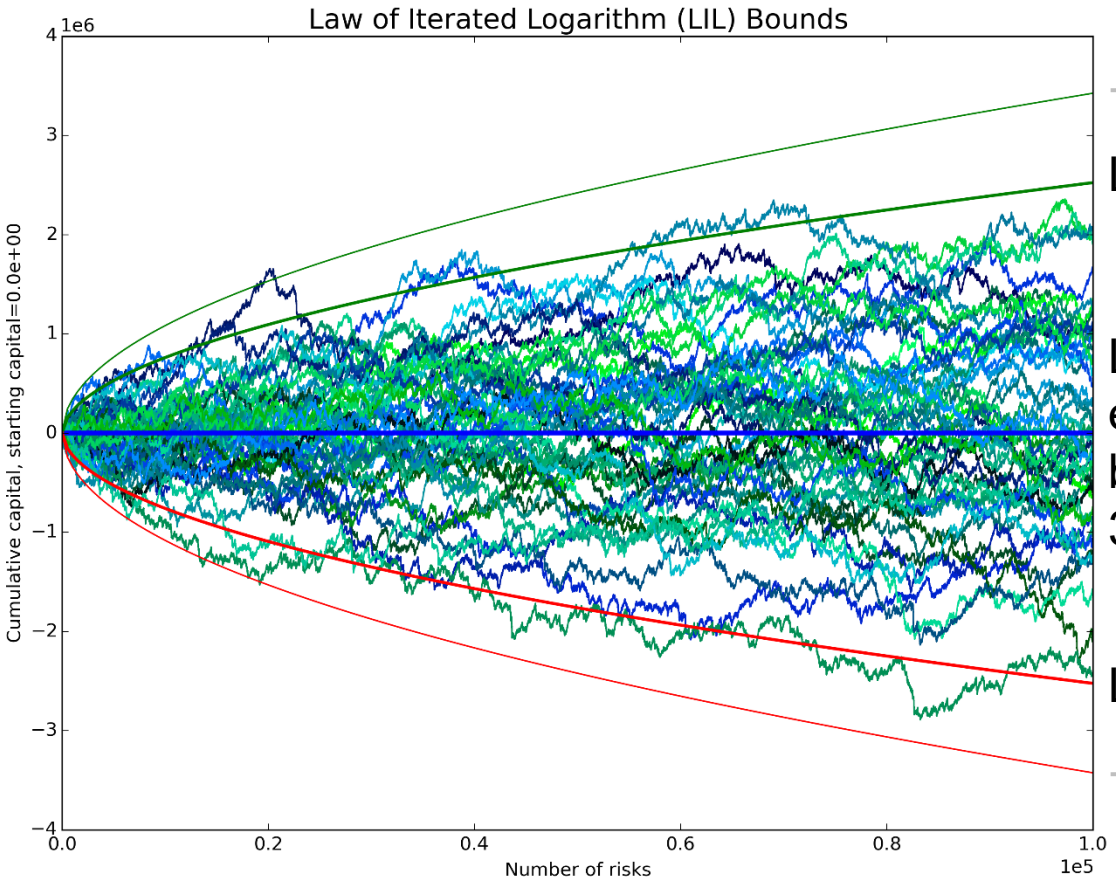
Naïve bounds on the random walk: ±3 standard deviations



Law of Iterated Logarithm: best possible “bound” on random walk



+3 SD

LIL upper bound

LIL bounds eventually broader than 3SDs

LIL lower bound

−3SD

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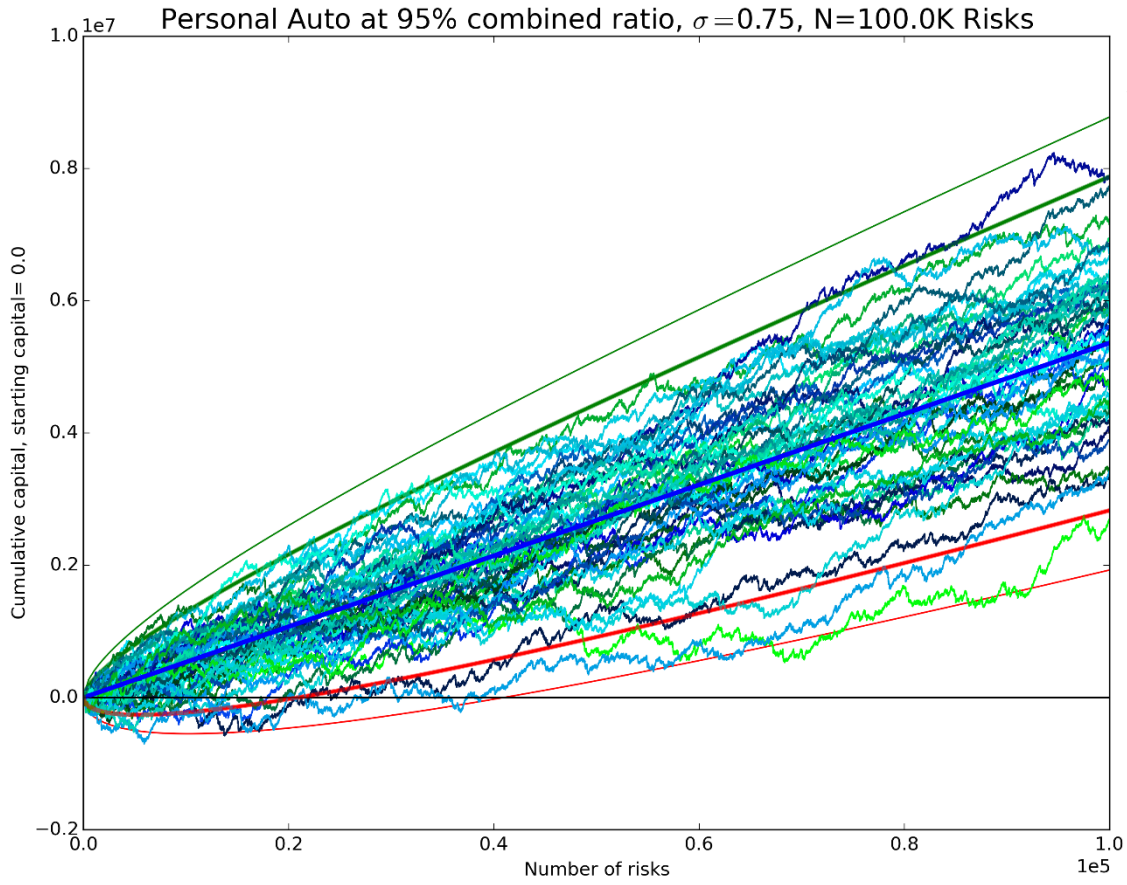
Underwriting profit introduces positive drift to surplus process

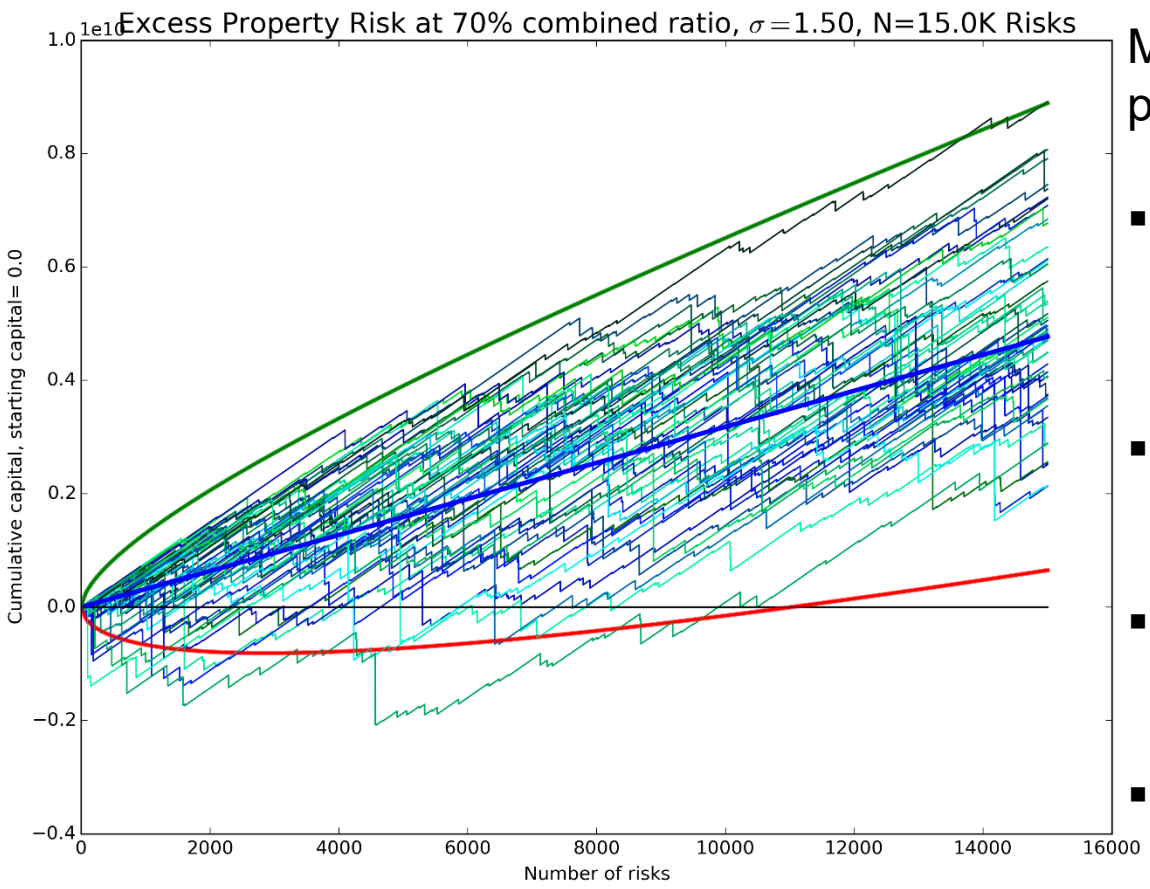


Expected under-writing result at 95% combined ratio pricing

Zero failures out of 50 paths, despite no starting surplus

Excess property risk – large fire property insurance

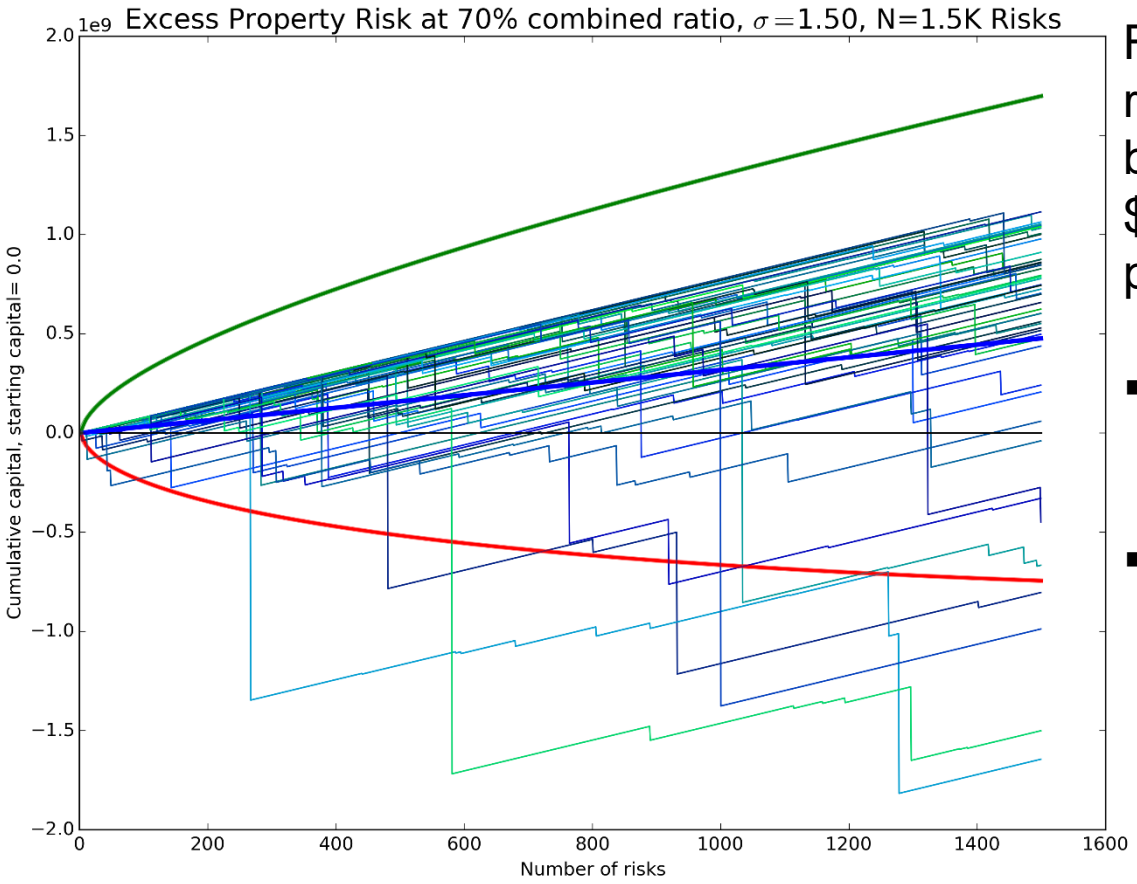
$10 billion



More volatile risk process

- 70% combined ratio…steeper blue profit line
- Large jumps in loss visible
- Skewness evident
- Larger policies, $16B premium

Excess property risk at more realistic volumes



Re-scale to realistic volume of business, approx. $1.6 billion premium

- Jump size more relevant
- 16% failure rate, even with high profitability

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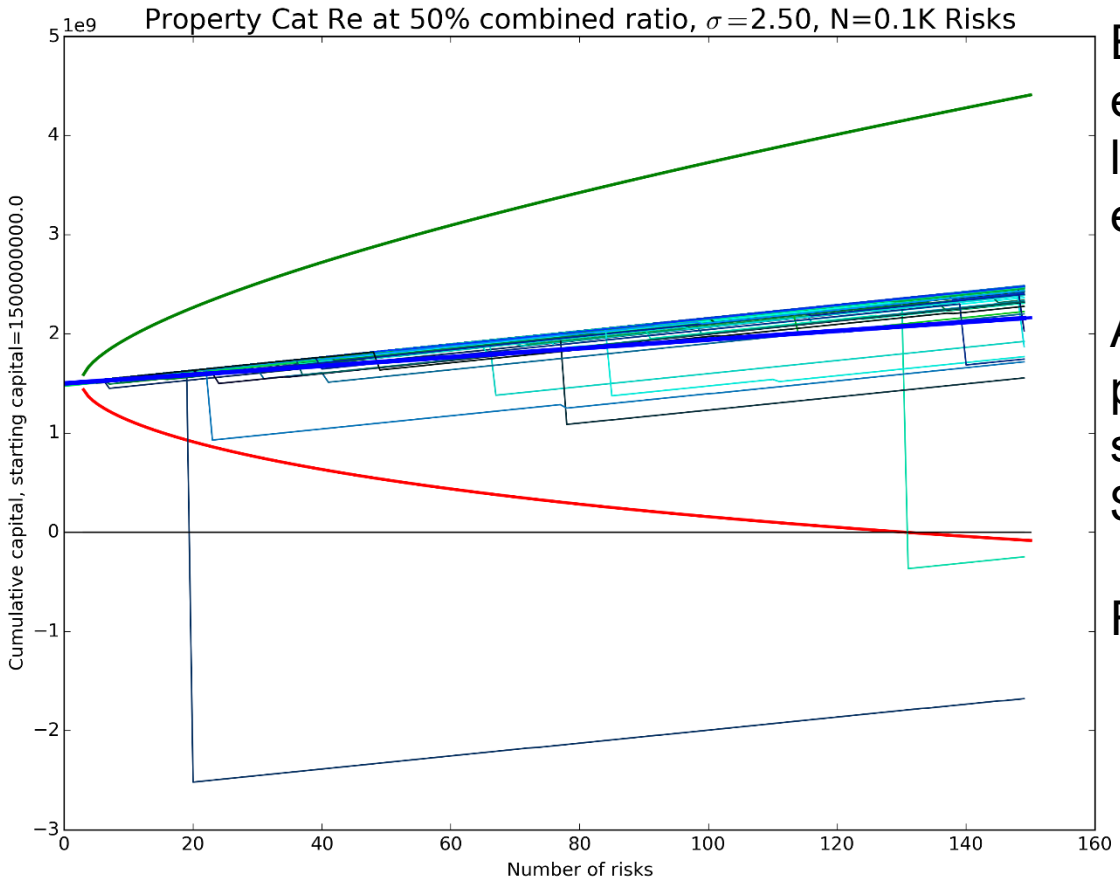
Property cat reinsurance

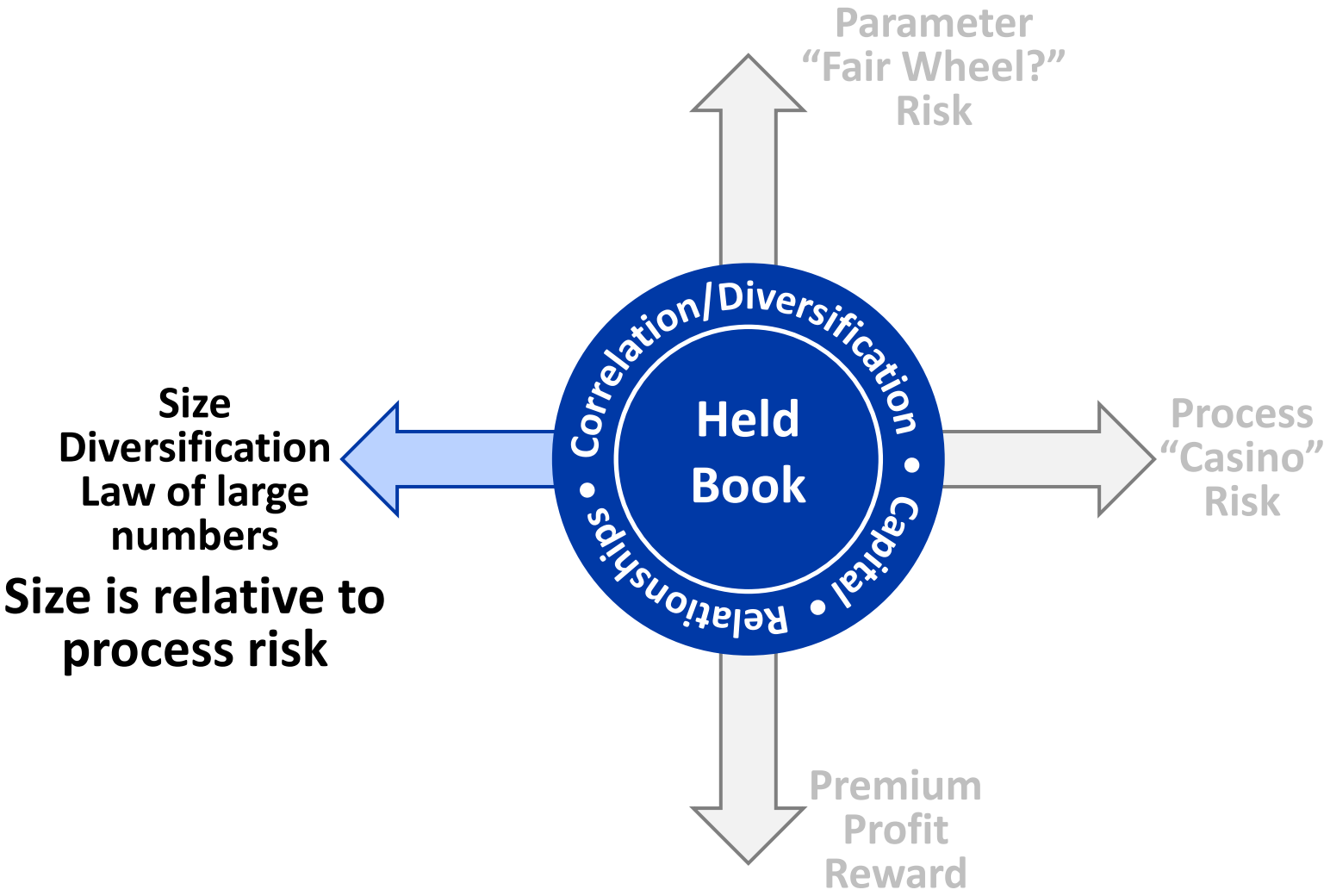


Even more extreme nature of loss process evident

Approx. $1.4B premium supported by $1.5B capital

Failure rate 4%

Section 2: What is the impact of size?

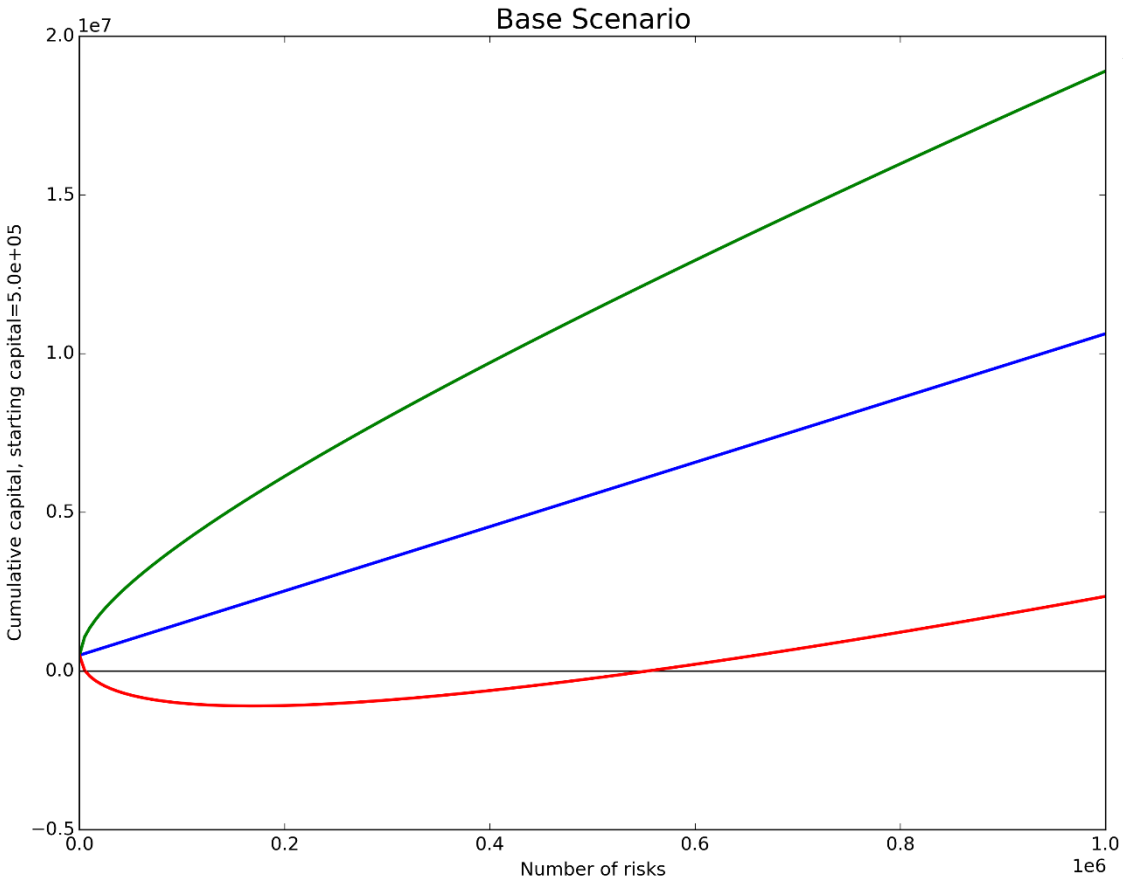


The impact of size: comments from earnings call transcript

- Analyst question
  - The first question is related to the […] book. If I heard correctly, you have $50 million of premiums. As you mentioned, the loss is up by $30 million this year. So there seems to be a 60-point charge on the combined ratio.

- CEO reply
  - Absolutely. As I said, this is an **unbalanced book**. If you have a $10 million line, three full-limit losses is $30 million. The problem with that book is that it is small and it cannot absorb an increase in the frequency of volatility. **That is a real issue**.
  - …
  - Again, I think what is really important is that when you have over 20 different portfolios […] across the Company, some are going to perform a little bit better, some are going to perform a little bit worse. But the totality of the portfolio, when you get the **benefit of the balance and the diversification** in that portfolio, that totality of that portfolio continues to perform very well.

Personal Auto capital requirements with size of book



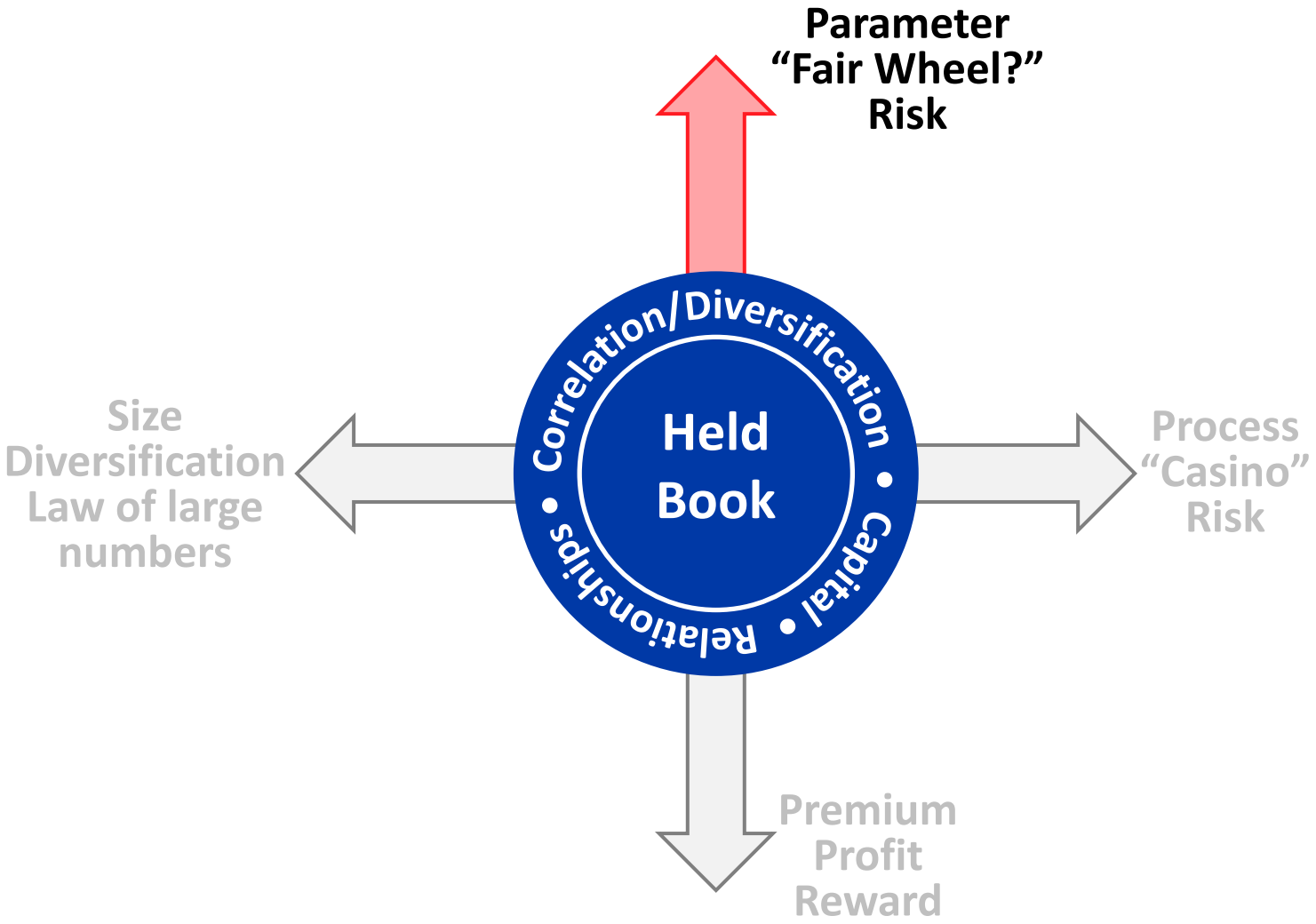
Auto policies at 99% combined ratio can be supported with minimal capital

Size measured at the rate-making unit?

Write a very few risks, "**less than**" zone

"**More than**" zone: market supports critical mass book, ~$600M+ premium

Section 3: Enter parameter risk – and practice



"Actual results may vary!"

Four different types of risk with different impacts

Process Risk

- Diversifying, square-root rule variability in loss results
- Irrelevant beyond certain size
- Threshold size may not be achievable in market

➔ **Diversifying loss variability**

Correlation ✓

Unknown State Variables

- Non-cat weather
- Inflation, medical inflation
- Gas prices
- Economic activity, unemployment
- Court decisions

➔ **Market loss variability**

Correlation ✓

Parameter Estimation Risk

- Not enough data to estimate true underlying frequency
- Not enough data to estimate true severity
- Driven by size & process risk

➔ **Market premium variability**

Competitive Market Cycle

- Capital driven changes in target profit margins
- Winner's curse, adverse selection: company level
- Is the effect predictable?

➔ **Market premium variability**

Correlation ✓

Process risk diversifies, leading to a testable hypothesis

- Standard deviation of loss grows with the square root of the number of independent risks
- Testable hypothesis: If there is no parameter risk then the standard deviation of loss ratio **tends to zero** for large portfolios

No parameter uncertainty: distribution of normalized loss ratio becomes tighter and tighter as portfolio becomes larger and larger

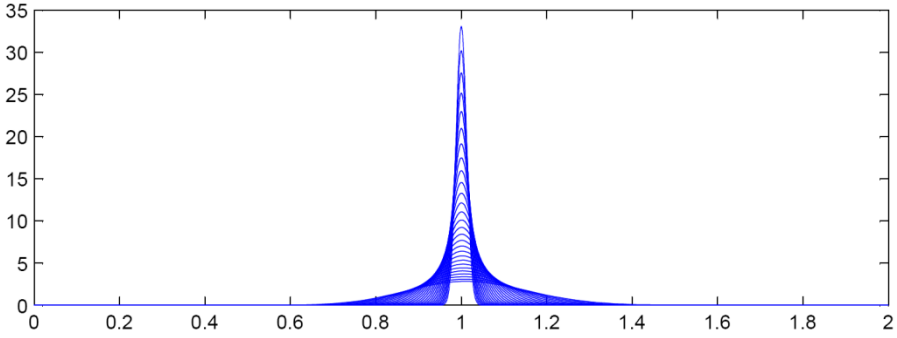


Illustration shows aggregate distributions with Poisson frequency and larger & larger values of expected loss

With parameter uncertainty: distribution of normalized loss ratio converges to that of underlying parameter risk as portfolio grows

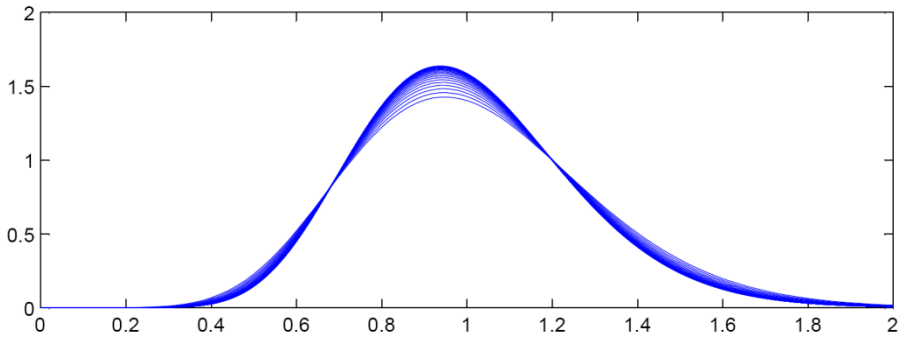
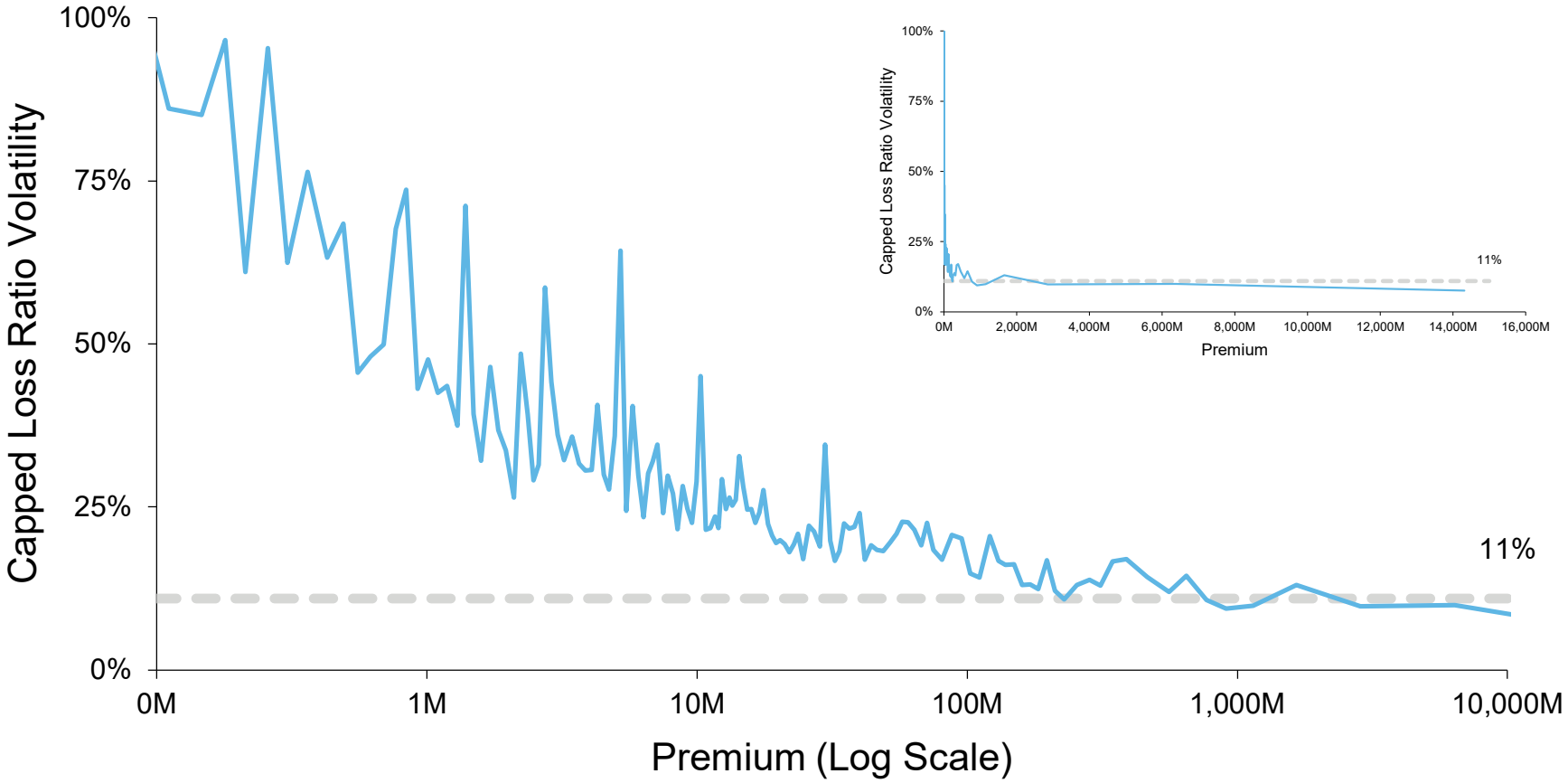


Illustration shows aggregate distributions with negative binomial frequency (gamma distribution induced parameter uncertainty) & larger values of expected loss

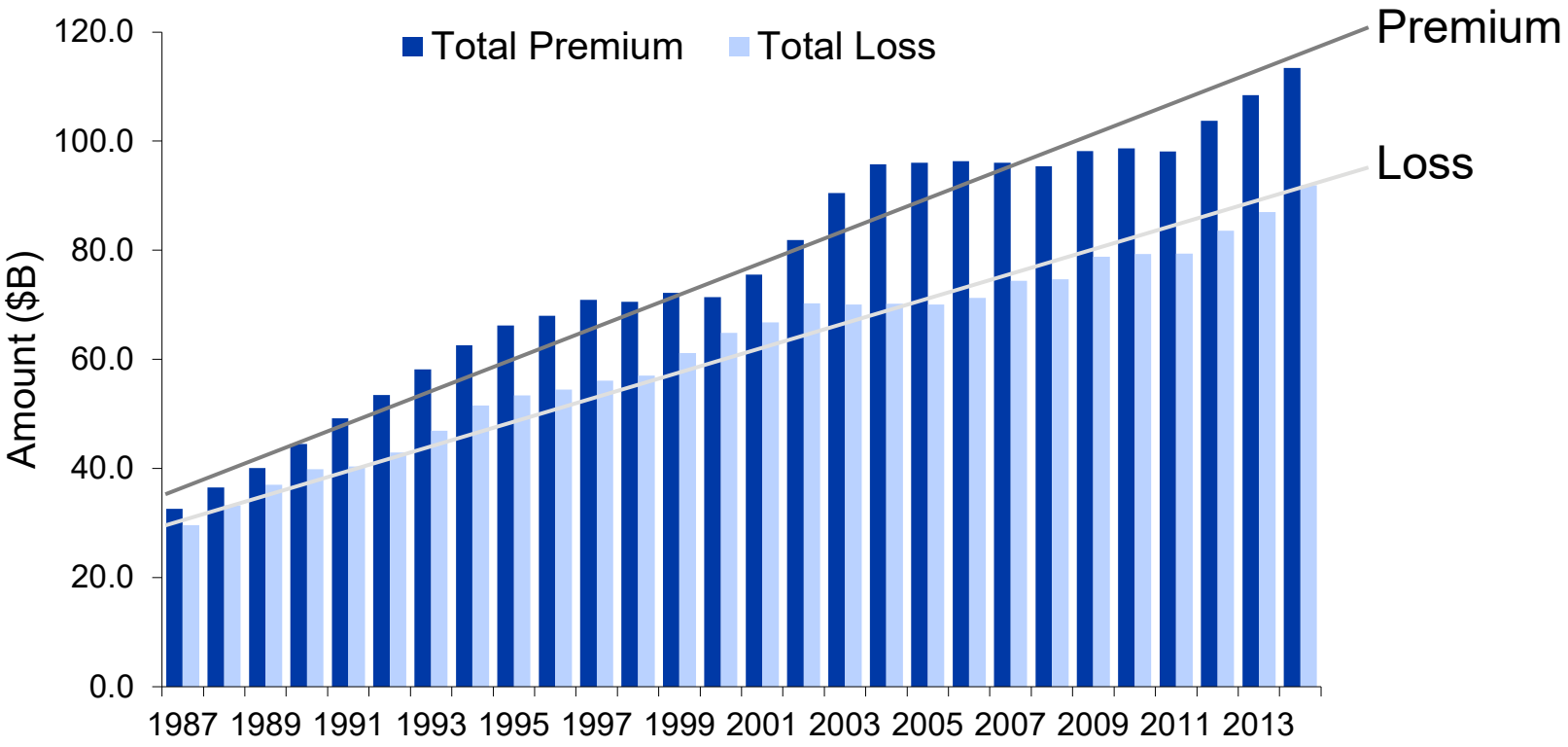
Data for Personal Auto shows clear evidence of parameter risk…



…as do the loss ratios of every other line in every other country reviewed

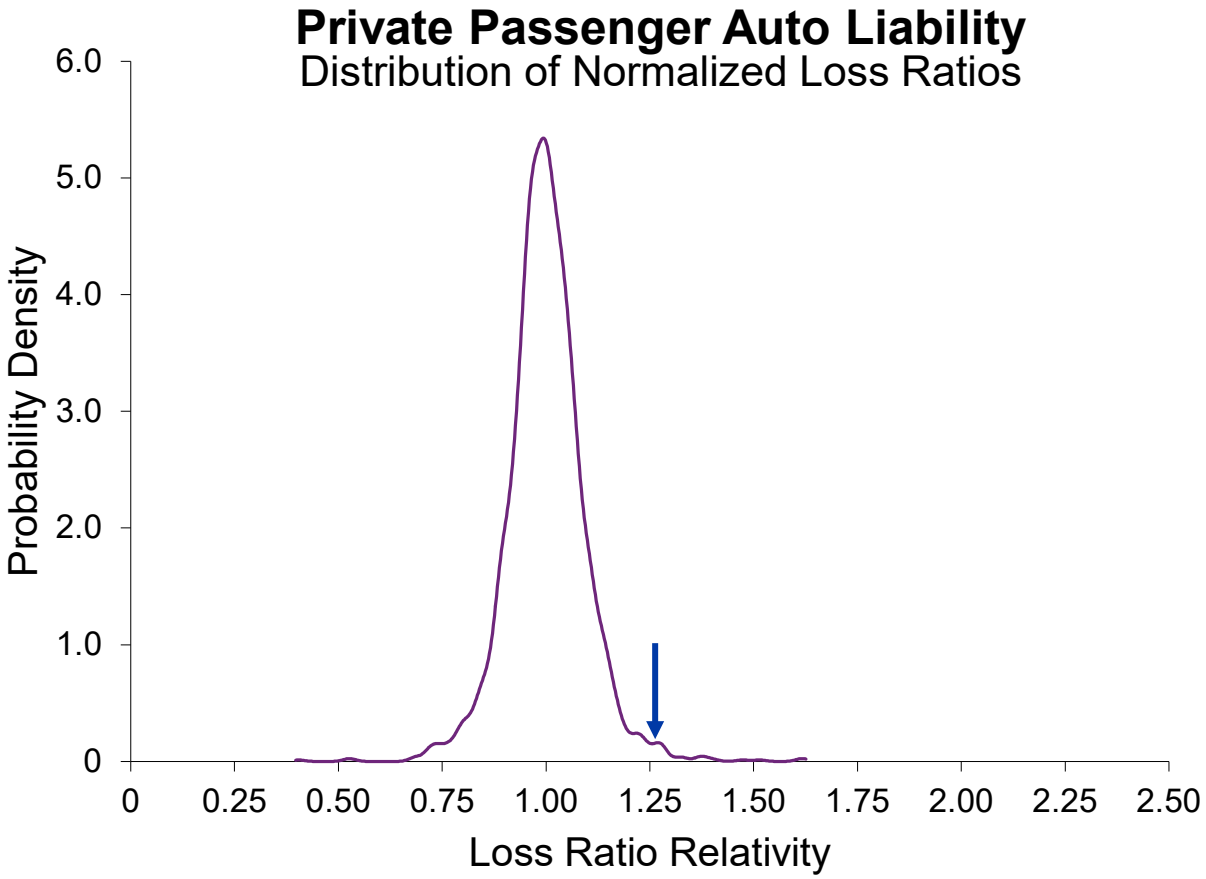
Source: Aon Benfield Insurance Risk Study Detail, 2015

Industry total premium and loss for private passenger auto



- Losses follows trend line **very** closely: **very** little process or parameter risk
- Premium slightly more volatile around trend line: competitive market introduces volatility!
- Conscious volatility?

Quantifying parameter uncertainty…making the invisible visible



Unknown State Variables

- Non-cat weather
- Inflation, medical inflation
- Gas prices
- Economic activity, unemployment
- Court decisions

➔ **Market loss variability**

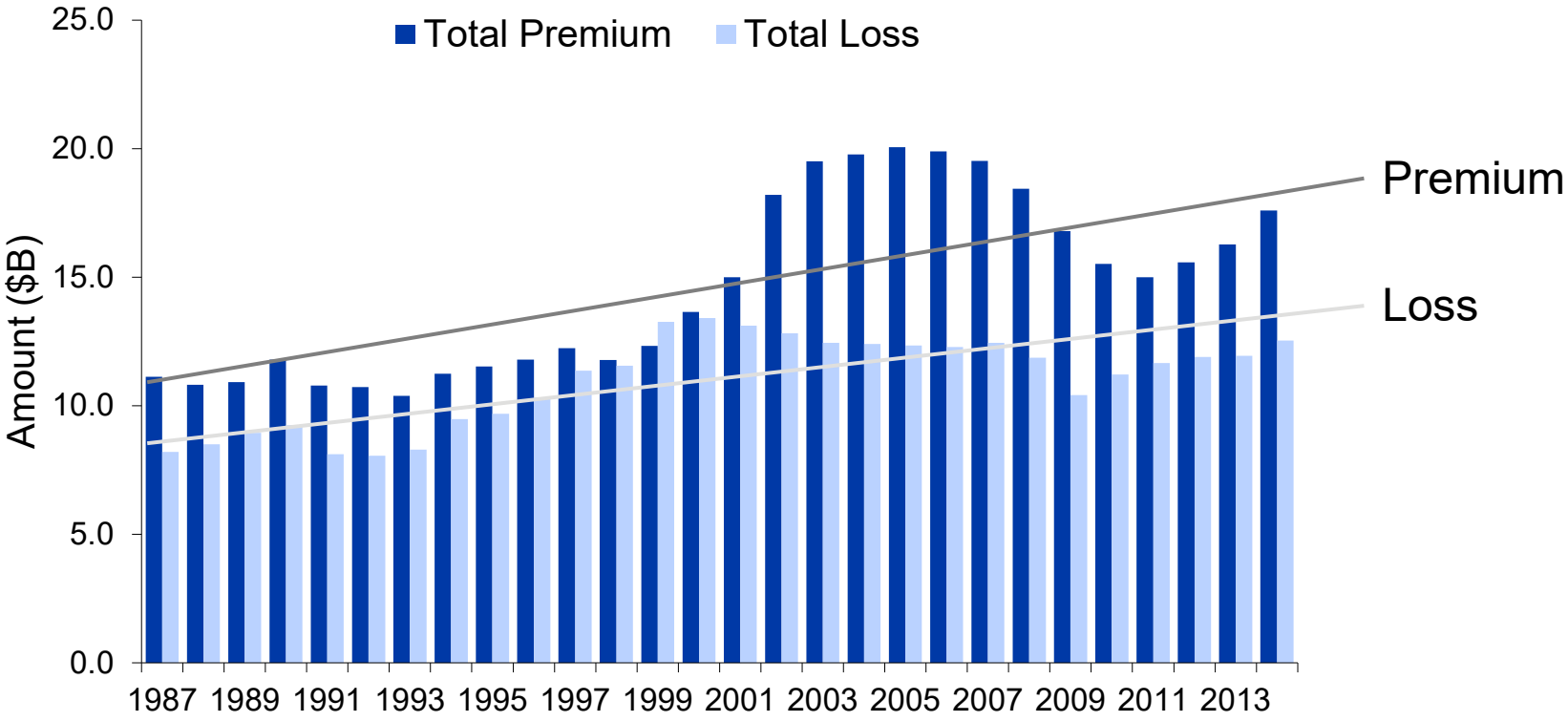
Parameter Estimation Risk

- Not enough data to estimate true underlying frequency
- Not enough data to estimate true severity
- Driven by size & process risk

➔ **Market premium variability**

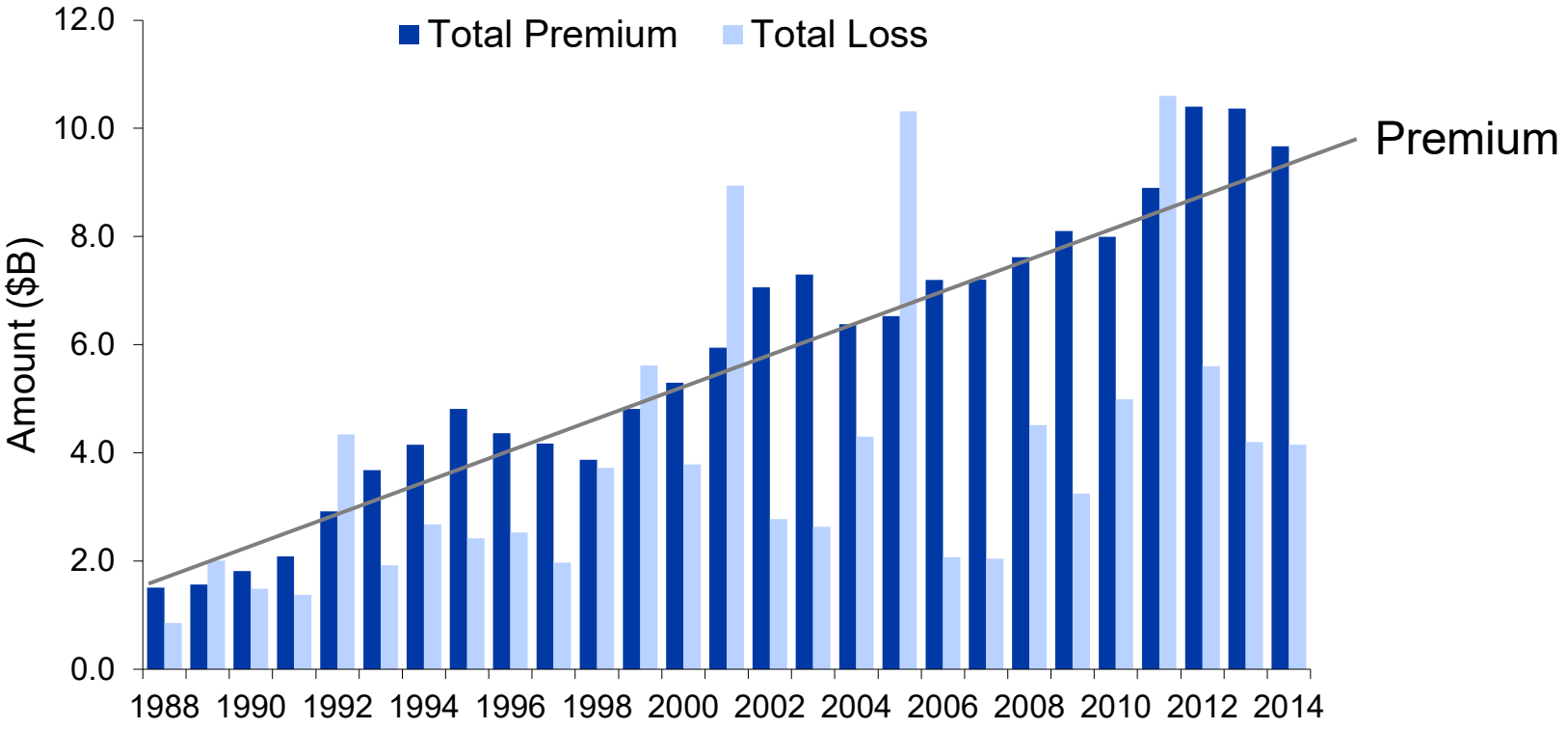
- Fitted distribution of loss ratios over companies and accident years adjusted for market cycle and known company effects such as expense ratios
- Indicated parameter risk factor 1.26

Industry total premium and loss for commercial auto



- Losses follows trend line closely: little process or parameter risk, but note 2009
- Premium **much** more volatile around trend line: competitive market introduces volatility!

Industry total premium and loss for reinsurance – property



- Premium follows trend line: competitive market cycle plus parameter (re-)estimation risk plus rating agency process changes (stress test post-2005)
- Losses **much** more volatile around trend line: all process risk driven volatility

Hurricane parameter uncertainty

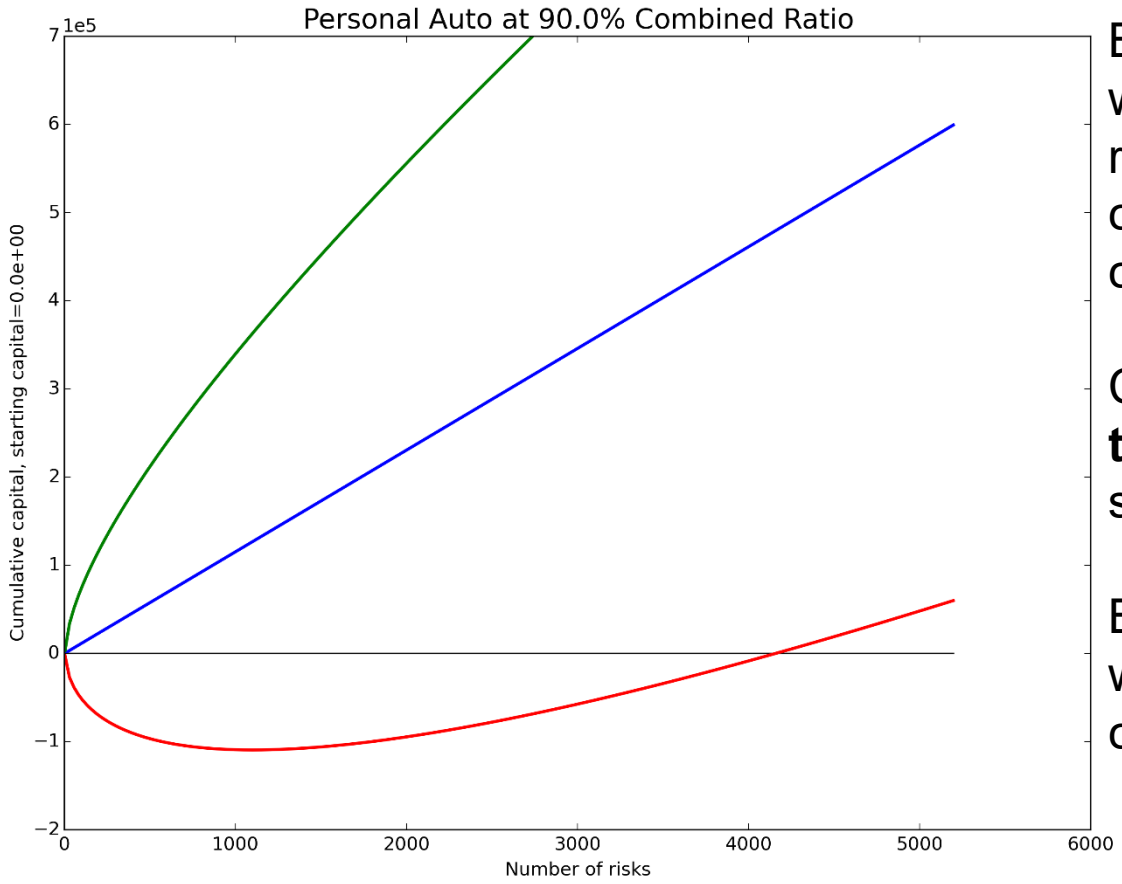
Hurricane Landfall Frequency Relativities by ENSO State

	Atlantic Basin		Western Pacific		Atlantic + Pacific		Global	
Relativities	Landfalling	Major LF	Landfalling	Major LF	Landfalling	Major LF	Landfalling	Major LF
Neutral	1.04	0.81	1.11	1.04	**1.09**	**0.98**	1.03	0.92
Warm	0.58	0.68	1.00	0.89	**0.90**	**0.83**	0.95	0.93
Cool	1.33	1.54	0.86	1.05	**0.97**	**1.19**	1.01	1.16
Total	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**

Major events are category 3 and above

- Numerous physical models of expected hurricane frequency
  - Colorado State University, Dr. Gray
  - NOAA
  - Tropical Storm Risk
- ENSO has a material impact on Atlantic hurricane frequencies but an offsetting impact on Western Pacific (China, Taiwan, Philippines) typhoon events
- High-frequency to mean-frequency regime ratio: 1.19x

Personal Auto “parameter risk pivot”

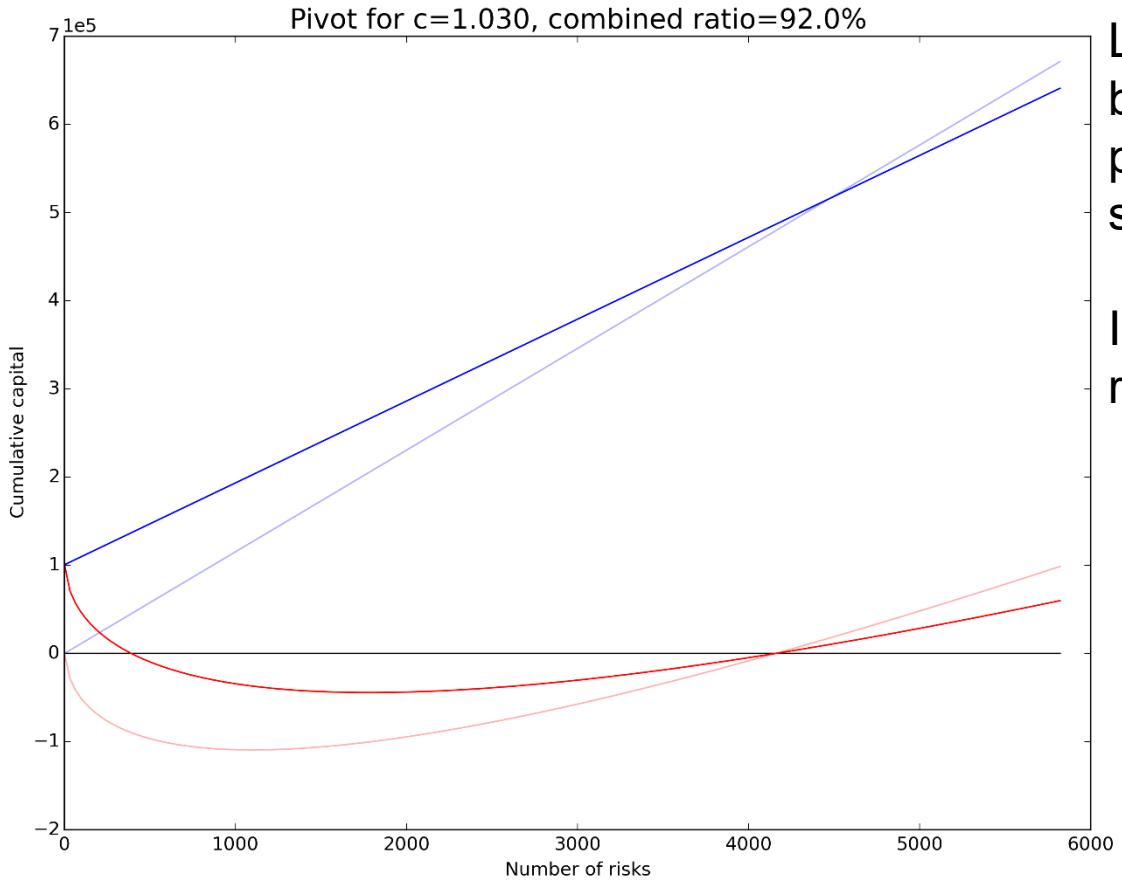


Base scenario with 4,158 risks required for “no capital” at 90% combined ratio

Can write **more than** 4,158 risks safely

But are you writing to a 90% combined ratio?

Personal Auto “parameter risk pivot”

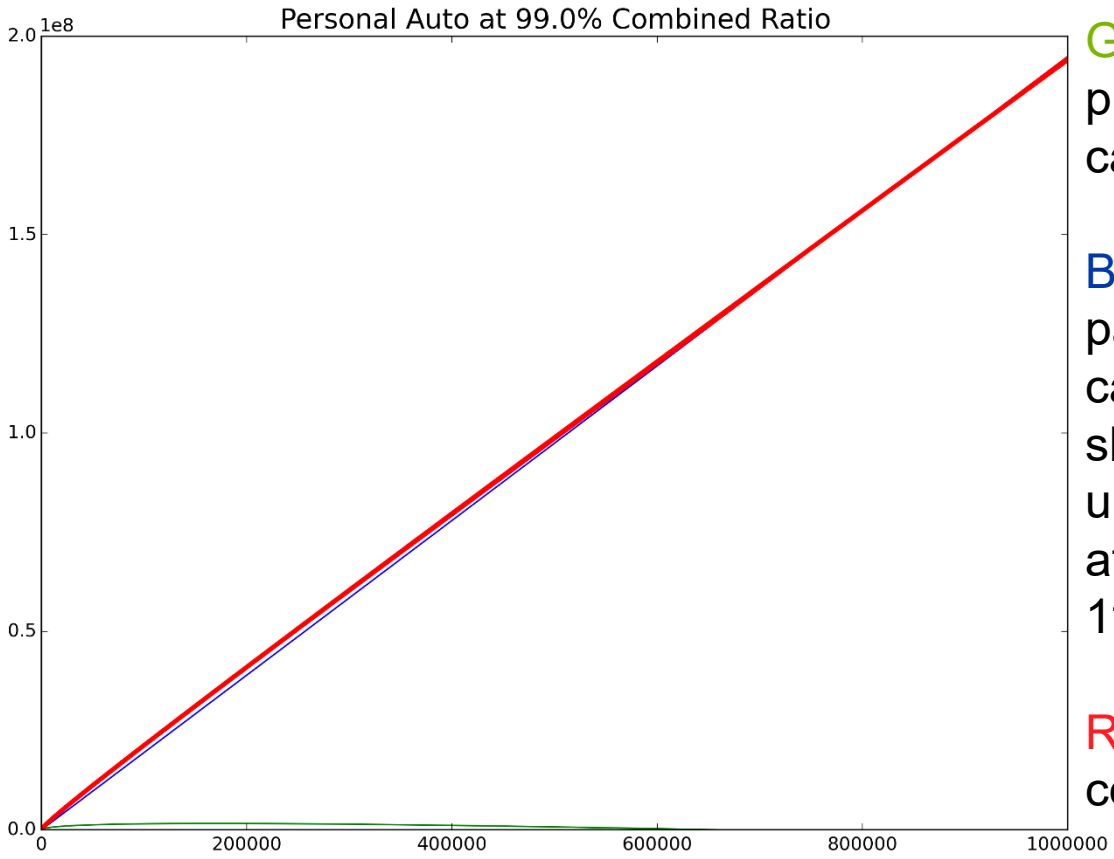


Lower profitability, blue expected profit line less steep

Increased capital requirement

Components of capital - Personal Auto example

Consistent with managing to a constant premium to surplus ratio

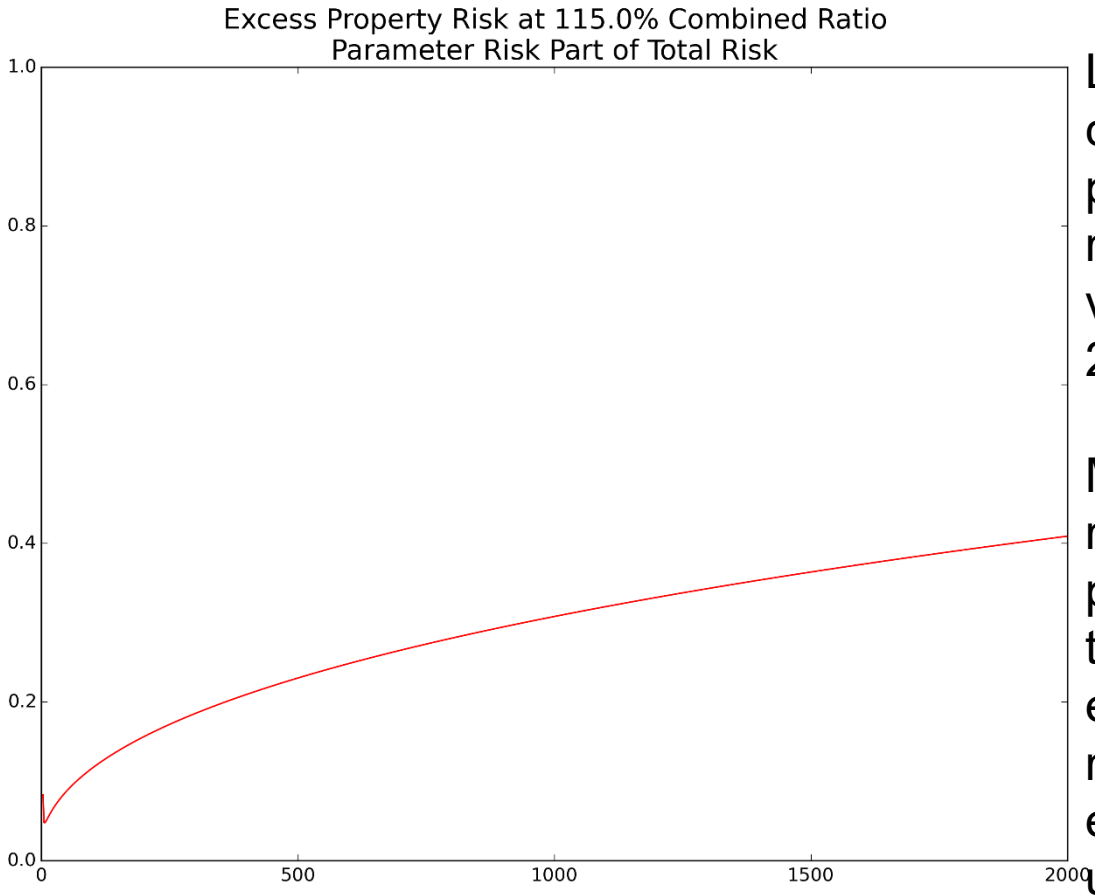


Green line shows process risk LIL capital

Blue line shows parameter risk capital to fund shortfall expected underwriting profit at stressed 118.2% combined

Red line shows combined capital

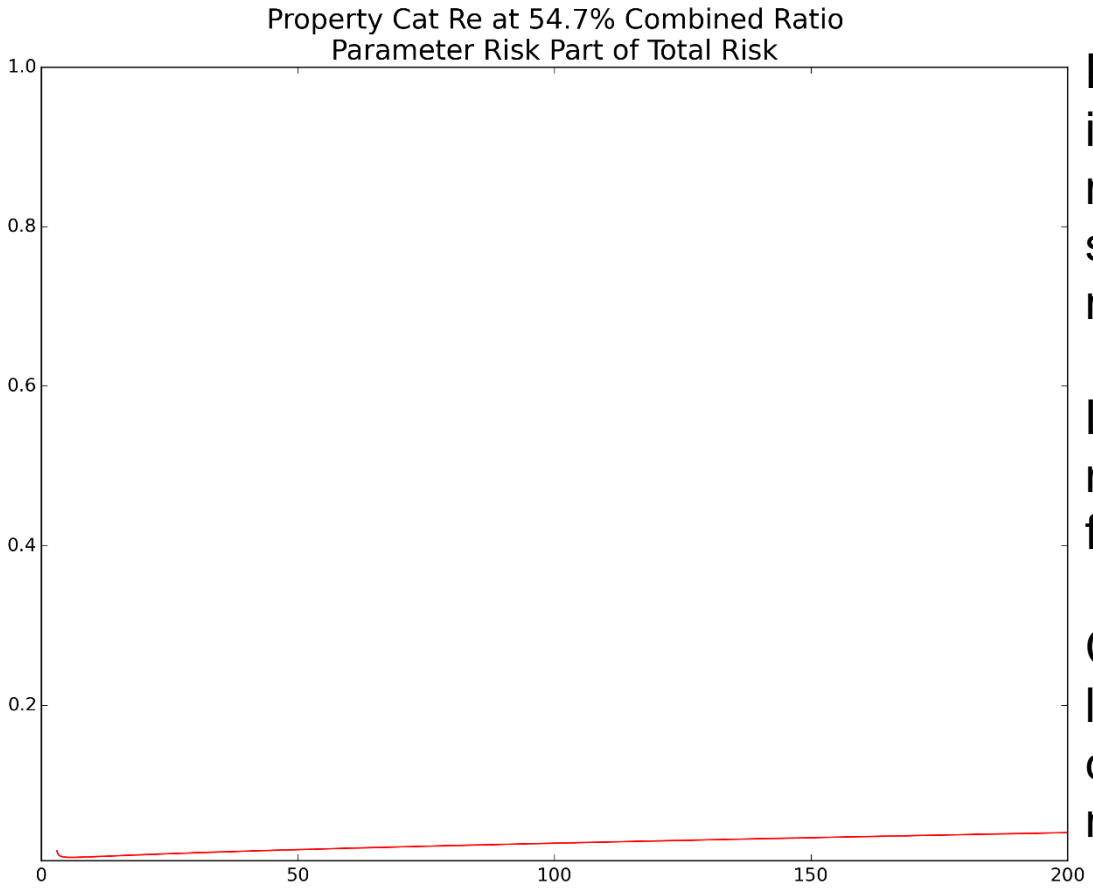
Proportion of capital from parameter risk component



Less than 40% of capital from process risk at reasonable volumes of 100 to 2000 risks

Material process risk contributes to parameter risk through estimation risk rather than external unobserved variable risk

Proportion of capital from parameter risk component

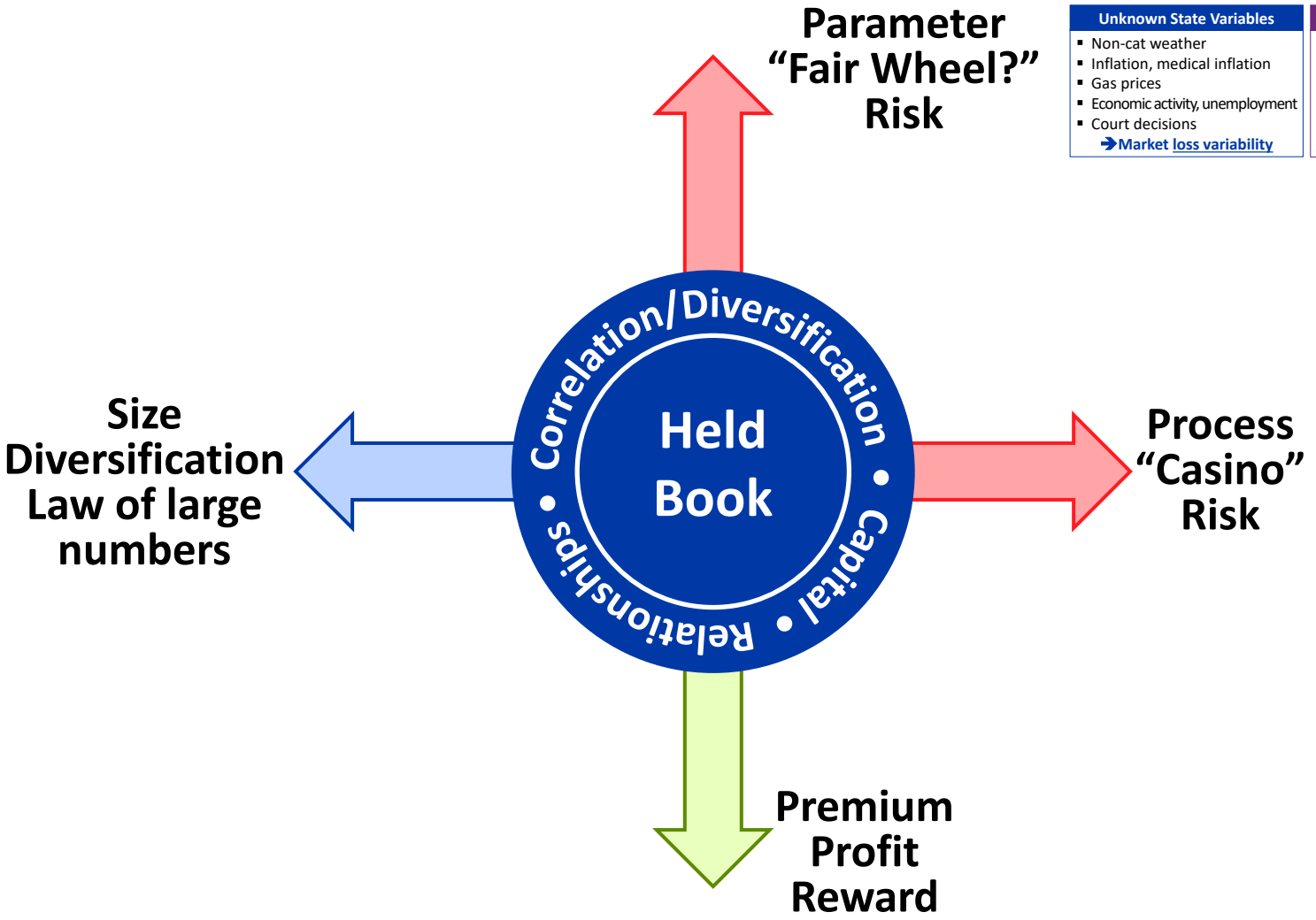


Parameter risk immaterial at realistic portfolio sizes, 10-200 risks

Loss experience not used directly for pricing

Claimant level losses used to calibrate cat models

Section 4: Profit – Tying it all Together



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What happens in the **Property Cat Reinsurance** market?

Process Risk

- **Large, solvency threatening, immediate**
- Tail risk management methods work well
- Methodology evident in market pricing

Unknown State Variables

- **Irrelevant as regards losses**, e.g. ENSO offsetting Pacific/Atlantic effects
- System-generated effects exist, e.g. rating agency methodology change

Parameter Estimation Risk

- Existence of property cat models replaces rating directly from loss experience
- Science based: wind tunnels
- **Model revision risk** incorporating lessons of each event

Competitive Market Cycle

- **Important** capital driven premium variability
- Uberization of capital supply, breaking down impediments to free flowing capital since 1992

What happens in the **Personal Auto** market?

Process Risk

- **Irrelevant**: large companies need very little capital
- Can bid the price down to drive up capital requirements for smaller players

Unknown State Variables

- **Dominate** loss variability
- Level of risk implies allowable P:S of 5.1 to 1; PGR writes at 2.8; industry average 0.8
- Excess capital generally absorbed by homeowners

Parameter risk dominates for Personal Auto

Allstate Maintains Focus on Profitability

- Operating profit of $262 million declined due to increased auto losses
- Comprehensive auto profit improvement plan has been implemented to meet full year combined ratio goal

Broad-Based Increase in Auto Losses

- Frequency increases have been observed broadly across geographies, segments, rating plans and customer tenure
- Macroeconomic indicators with historically tight correlation to Allstate's auto frequency continue to be the principal driver of this trend
- Recent growth in new business increased auto losses, as new auto business typically has higher relative frequency, but is not the primary driver of the higher Allstate brand auto combined ratio

Source: Allstate Corporation, Earnings Release Presentation, August 4, 2015

What happens in the **Personal Auto** market?

Process Risk

- **Irrelevant**: large companies need very little capital
- Can bid the price down to drive up capital requirements for smaller players

Unknown State Variables

- **Dominate** loss variability
- Level of risk implies allowable P:S of 5.1 to 1; PGR writes at 2.8; industry average 0.8
- Excess capital generally absorbed by homeowners

Parameter Estimation Risk

- Largely **irrelevant**
- Only an issue for small companies, operating below scale, who are more reinsurance dependent

Competitive Market Cycle

- Important and subtle point
- Hard to quantify: need to understand price elasticity
- Reduced as pricing sophistication increases

What happens in the **Excess Property Risk** market?

Process Risk

- Large, but not solvency threatening
- Cat-based tail risk management methods fail
- **Drives material parameter risk**

Unknown State Variables

- Secondary importance

Parameter Estimation Risk

- **Material** risk: neither industry level models nor industry-wide statistics available
- **Material re-pricing risk**
- **Material use of reinsurance** to lower net risk

Competitive Market Cycle

- Not materially more important than for other commercial lines
- Mitigated by underwriter rules of thumb and market conventions

Reduce incidence of disruptive re-underwriting
Comments from earnings call transcript

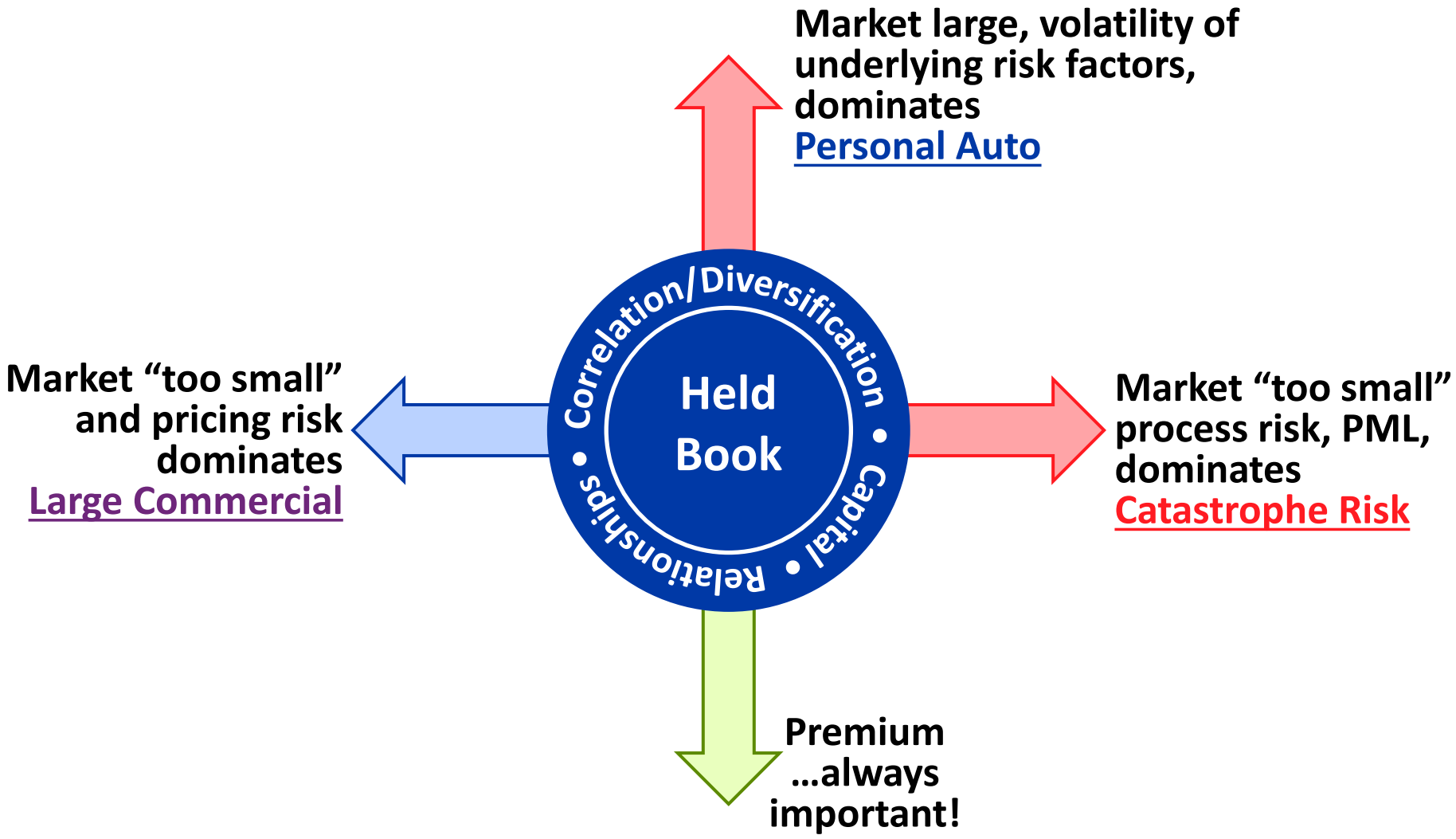
- CEO introductory remarks
  - …this quarter was adversely impacted by exposure to rising claims costs for the […] business in recent accident years. I assure you that we are all focused on **making the changes in our portfolio** as necessary to reduce the likelihood of these types of issues.

- CFO commentary
  - The […] losses incurred also led to an associated **increase in the underlying loss ratios** for that line of business. [i.e. a change in prospective view of business]

- CEO
  - We react quickly when faced with new data ... But our goal is to **reduce the likelihood of such events with enhanced data and analytics**, and **dilute their impact with a broader, more diversified, more balanced** book of business.
  - …Obviously we are not pleased with this development. …We have **made changes to our underwriting, our pricing**, … and we will keep very close eye on it to ensure we get the results we expect.

The line is managed to **minimize potential disruption to customers** from re-parameterization, re-underwriting and re-pricing triggered by adverse losses

Conclusion


Market large, volatility of underlying risk factors, dominates
Personal Auto
Market "too small" and pricing risk dominates
Large Commercial
Correlation/Diversification • Capital/ • Relationships •
Held Book
Market "too small" process risk, PML, dominates
Catastrophe Risk
Premium …always important!