CAS LAS – Taming cats

Tim Tetlow - Incorporating Cat Model Data into Economic Capital Models

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PHYSICS ENVY AND SPURIOUS PRECISION

Some thoughts on ICM in the context of banking crises

- US hedge fund Long-Term Capital Management (LTCM) failed spectacularly in 1998.
- Trading strategies based on modeling developed by two Nobel Prize winners, Myron Scholes and Robert Merton.
- LTCM's models under-estimated the tail of modeled distributions.
- Assumed:
  - Normal distributions between risks
  - Liquidity always available
  - Deep markets
- Highly leveraged.
- According to their model the scenario which caused LTCM's failure had a one in 1,000 year likelihood of occurrence.
- Jorion[1] showed that using a student t-dependence structure with four degrees of freedom (a heavier-tailed distribution), the modeled likelihood of occurrence would have been once in eight years.
- The assumed dependency structure, student t, is quite similar to a Normal distribution and easy to develop and apply.

1 - Jorion 2000, *European Financial Management*, 6:277-300.
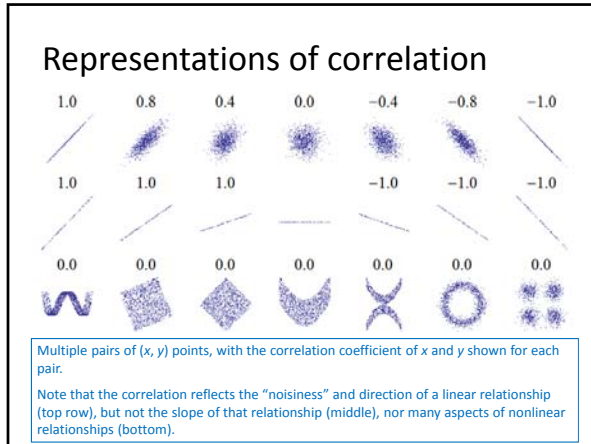
Ten years later…

- David Li introduced the rapidly standardized "single factor Gaussian copula"
  - Mathematically convenient as financial distributions are not normal:
    - "We were seeing things that were 25-standard-deviation events, several days in a row," - David Viniar, CFO Goldman Sachs
- This copula underlay much of the mathematical justification of the "value" of CDO's and was part of the caused of the 2008 financial crisis.
- Assumed liquidity.
- Significant mismatches in durations of assets and liabilities.

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Do actuaries suffer from these challenges? Are we falling into similar traps with our Economic Capital Models?

CORRELATION

Representations of correlation

Multiple pairs of (*x*, *y*) points, with the correlation coefficient of *x* and *y* shown for each pair.

Note that the correlation reflects the "noisiness" and direction of a linear relationship (top row), but not the slope of that relationship (middle), nor many aspects of nonlinear relationships (bottom).

Correlation is a first order problem, copula a second+ order problem

- Two lines of business have 15 years of data – the actual correlation coefficient is 50%
- Question what is the 95% confidence interval for the correlation coefficient given you have 15 years of data?
  - 95% confidence interval on correlation coefficient is 0.03 to 0.81
- How often does one have more than 15 years of data?
- If you do how often are the data series unaffected by other changes that are hard to adjust for?
  - Changes in policy terms
    - E.g. exclusion of terrorism from general reinsurance contracts

Limitations on correlation coefficients

- The information given by a correlation coefficient is not enough to define the dependence structure between random variables.
  - In a similar way that the mean of a distribution does not tell us how variable the distribution is.
- The correlation coefficient completely defines the dependence structure only in very particular cases, for example when the distribution is a multivariate normal distribution.
  - ⇒ Normal distributions exceptionally rare in the risks assumed by (re)insurance companies.
  - Additionally, even for a very high correlation coefficient, the variables behave independently if you move far enough into the tail.

OK so what does this mean and what is done to address the intuitive and measured reality that certain risks are correlated?

First order and second order problems

- Natural hazard flood models are three dimensional in space whereas hurricane and EQ models need only describe two dimensions
- First order problem in correlation is to determine the amount of correlation
  - = Correlation coefficient
- Second order problem is to determine the type of dependency structure
  - = Copula
- Personally not convinced that second order problems can be resolved.

The shadow of correlation

It is worth reflecting that physics has its "unknowables".

Heisnenburg's uncertainty principle as paradoxical as this seems to common sense states that at the quantum level there is a boundary on our ability to resolve certain paired variables.

For example in attempting to precisely define the position of an electron requires one to use shorter and shorter wavelengths of electromagnetic radiation. As a consequence the larger and larger energy of the radiation influences the electrons momentum leading to less ability to be precise about its momentum.

POLICYHOLDER OPTIONS

Options and financial guarantees

SII principle	Material options	Examples
*"Insurance and reinsurance undertakings **shall accurately assess the particular risk associated with financial guarantees and any contractual options in their internal model, where material**. They shall also assess the risks associated with both policy holder options and contractual options for insurance and reinsurance undertakings. For that purpose, they shall take account of the impact that future changes in financial and non-financial conditions may have on the exercise of those options." – A121*	Special termination or "downgrade" clause	• PXRe • AIG
	Reinstatement in the same event	• Hurricane Andrew • Hurricane Katrina

BMA on options and financial guarantees

"Risks associated with derivatives, guarantees and any contractual options, where material, should be accurately assessed and reflected in the ICM, including any off-balance sheet exposures."

Source: Standards and Application Framework for the Use of Internal Capital Models for Regulatory Capital Purposes Revised – March 2011

Draft widely issued to industry by Brant Kizer of the BMA March 10 2011

Informal Bermuda market survey

Question	Yes/Total	Is this feature included in the ICM?
Is the option for insurers to remove you from (re)insurance contracts under the special termination clause or downgrade clause "material" in your business?	5/5	0/5
Is the option to reinstate in the same event "material" in your business?	2/5	0/5

Informal Bermuda market survey

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Survey companies write the same business. Foresee a debate on what constitutes "material".

Risk mitigation

- Would seem to imply that reinsurance recoverability and default should be reflected in gross to net numbers for catastrophe.
- Expect as industry loss increases that recoverables may decrease due to defaults on non-collateralized reinsurance.
- Are credit transition matrices published by rating agencies appropriate for parameterizing these transition matrices?
  - Probably not
  - Probably need correlation to tend to 100% as industry loss increases.
  - => Use cat model for credit transition framework

"Insurance and reinsurance undertakings may take full account of the effect of risk-mitigation techniques in their internal model, as long as credit risk and other risks arising from the use of risk-mitigation techniques are properly reflected in the internal model." – A121

Downgrade clauses

- Would seem to suggest that ICM's must include modeling for downgrade clause otherwise will systemically underestimate capital requirements due to "death spiral" effects.
- Complicated as clause is at the option of the reinsured and is not compulsory.
  - Typically 3 "or" triggers when:
    - S&P drops below A- *or*
    - AM Best drops below A- *or*
    - Company looses more than 20% of its capital and surplus

"Insurance and reinsurance undertakings shall accurately assess the particular risk associated with financial guarantees and any contractual options in their internal model, where material. They shall also assess the risks associated with both policy holder options and contractual options for insurance and reinsurance undertakings. For that purpose, they shall take account of the impact that future changes in financial and non-financial conditions may have on the exercise of those options." – A121

Cat model runs – external assumptions

- For those who use:
  - Cat model with the lowest view of risk
  - Have significantly low loss modification factors
  - Are deemed to not have comprehensive accumulations

Potentially use externally provided ground up severity modification factors that act to adjust modeling to "average".

  - Key that these are applied on a ground up basis given non-linear impact of severity modification factors.

"Supervisory authorities may require insurance and reinsurance undertakings to run their internal model on relevant benchmark portfolios and **using assumptions based on external rather than internal data** in order to verify the calibration of the internal model and to check that its specification is in line with generally accepted market practice." – A122

Conclusions

Main topic	Thoughts
Flexible framework to adjust ground up losses	Sensitivity and scenario framework extremely valuable.
	Ability to understand capital gradient response.
	Ability to address "true" view of risk issues.
	Not clear if documentation and by extension ability to demonstrate robustness of model will be available from cat modeling firms.
Strong audit capability	Demonstrate "completeness" in risk capture and representation.
	Ability to view risk from a variety of perspectives.
Credit risk	Use cat model framework rather than transition matrices.
Downgrade and reinstatement in the same event options	Material options that should be included in ICM. Methods to consider both options are straightforward.

Richard Feynman on social sciences

Because of the success of science, there is, I think, a kind of pseudoscience. Social science is an example of a science which is not a science; they don't do [things] scientifically; they follow the forms -- you gather data, you do so-and-so and so forth but they don't get any laws, they haven't found out anything.... You see, I have the advantage of having found out how hard it is to get to really know something, how careful you have to be about checking the experiment, how easy it is to make mistakes and fool yourself. I know what it means to know something, and therefore I see how they get their information and I can't believe they know it, they haven't done the work necessary, haven't done the checks necessary, haven't done the care necessary. I have a great suspicion that they don't know, that this stuff is [wrong], and they're intimidating people.

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APPENDIX

THE ASSUMPTION OF CORRECTNESS

## It's not how good your good shots are it's how good your bad shots are….

The Japan Tohoku EQ shows us that the energy release in all vendor cat models was underestimated by a factor of ~16 for an 8.2 vs a 9.0.

- Energy release of an earthquake, which closely correlates to its destructive power, scales with the $3/2$ power of the shaking amplitude.

| EQ magnitude error	Implied energy error	Math(s)
1.0	32	$31.6 = (10^{1.0})^{(3/2)}$
2.0	1000	$1000 = (10^{2.0})^{(3/2)}$

Minimum hurricane central pressure of 884mb (Hurricane Gilbert 1988) is the theoretical floor in one hurricane model?

Uncertainty in hurricane central pressure cumulative distribution function
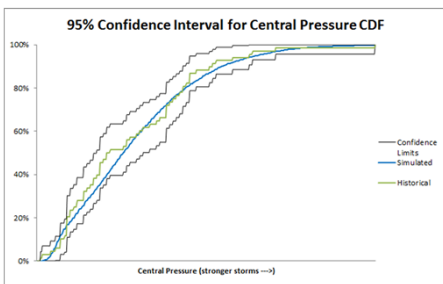
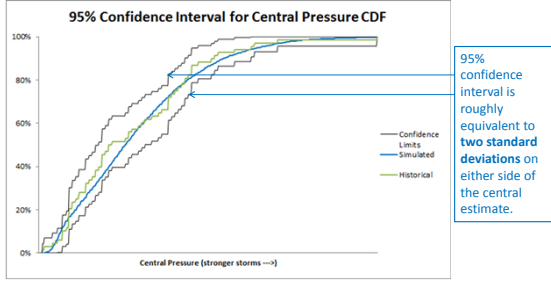Source: AIR presentation at 2011 RAA presentation and private exchange with AIR.

Uncertainty in hurricane central pressure cumulative distribution function
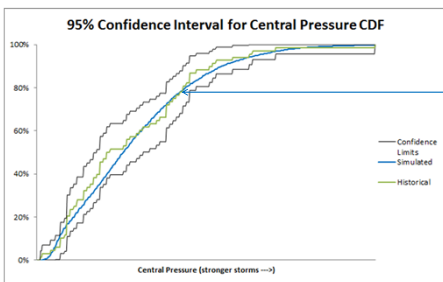
Model selects **only** the central estimate.

No distribution for parameter uncertainty.

Source: AIR presentation at 2011 RAA presentation and private exchange with AIR.

Uncertainty in hurricane central pressure cumulative distribution function

95% Confidence Interval for Central Pressure CDF

95% confidence interval is roughly equivalent to **two standard deviations** on either side of the central estimate.
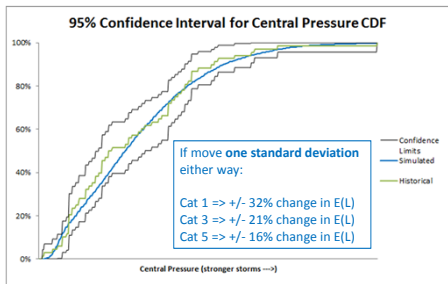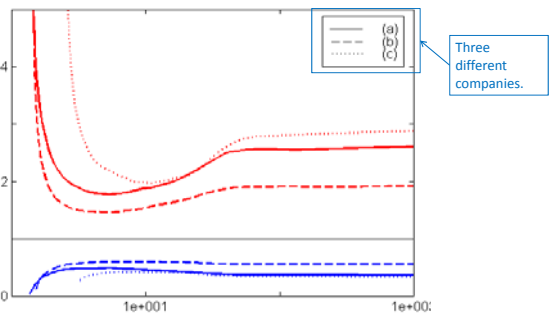
Source: AIR presentation at 2011 RAA presentation and private exchange with AIR.

Uncertainty in hurricane central pressure cumulative distribution function

95% Confidence Interval for Central Pressure CDF

If move **one standard deviation** either way:

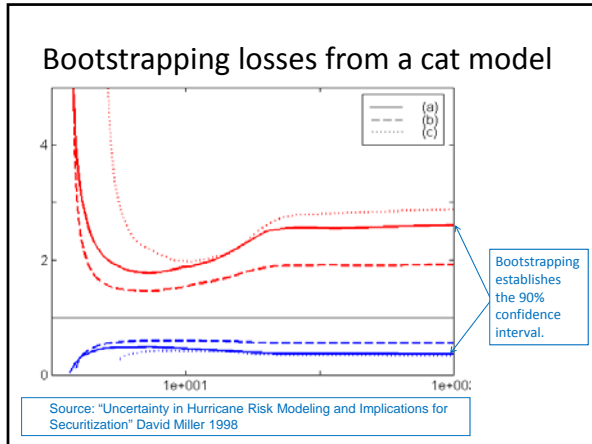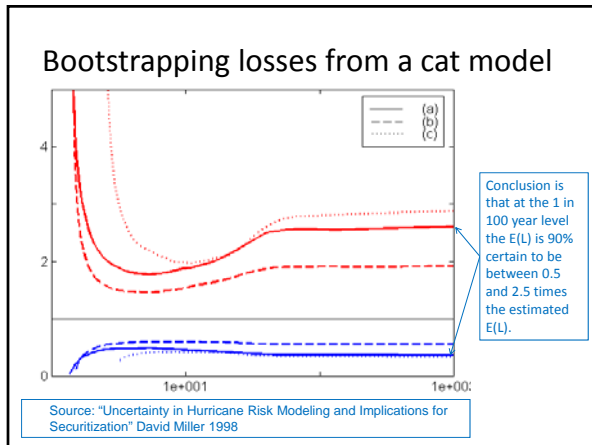Cat 1 => +/- 32% change in E(L)
Cat 3 => +/- 21% change in E(L)
Cat 5 => +/- 16% change in E(L)

Source: AIR presentation at 2011 RAA presentation and private exchange with AIR.

Bootstrapping losses from a cat model

Three different companies.

Source: "Uncertainty in Hurricane Risk Modeling and Implications for Securitization" David Miller 1998

Bootstrapping losses from a cat model

Bootstrapping establishes the 90% confidence interval.

Source: "Uncertainty in Hurricane Risk Modeling and Implications for Securitization" David Miller 1998

Bootstrapping losses from a cat model

Conclusion is that at the 1 in 100 year level the E(L) is 90% certain to be between 0.5 and 2.5 times the estimated E(L).

Source: "Uncertainty in Hurricane Risk Modeling and Implications for Securitization" David Miller 1998

Identical "true" risk – massive difference in "apparent" risk

Four reinsurers, six layer program, losses for a UK/European program. Across the program the high and the low view of risk differs by 80%. Maximum individual layer difference 93%, minimum 75%.

AIR seminar January 2009 - sample of cat loss costs for UK/European program - source: http://www.somethingelse.bm/2010%20AIR%20Presentation%20-%20EXTERNAL%20FINAL.pdf

Why the differences?

In general companies have relatively standardized approach of considering risk varying:

- Cat model blend
- Loadings/approaches for inadequately modeled perils
- Loadings/approaches for non-modeled perils

Implications and observations

- Obviously the "true" risk for these programs are identical. The "perceived" risk is dramatically different.
- Standardization of underwriting approaches will tend to imply that this effect will be systemic across companies portfolios and not diversified away.
- Issue has not been well handled historically by rating agencies and regulators.
  - Larger issue in the US now given model divergence for US hurricane.
  - BMA has introduced catastrophe return requirements that contemplate the differences in modeling approach.

Conclusions on correctness

- We need to move to a view of risk that:
  - Allows for the fact that there are different views of risk.
  - Allows us to view multiple views of risk simultaneously.
  - Recognizes systemic influences within the cat models:
    - US hurricane - HURDAT
    - US EQ – USGS
    - Japan EQ - HERP
  - Includes all sources of uncertainty and comprehensively handles parameter uncertainty e.g.:
    - Full distributions in underlying models – central pressure
    - Frequency uncertainty
  - Is granular enough to allow constituents of the risk to be isolated:
    - Modeled
    - Non-modeled
    - Inadequately modeled
  - Contemplates scenario and stress testing robustly.

Tough remit – probably not going to happen soon….

Sensitivity framework

Principle	Advantages
Framework for considering loss potential includes ability to systemically vary region-peril severities and frequencies to allow sensitivity and scenario testing.	Allows the sensitivity of the capital gradient to a systemic change in the view of risk for cat model changes: • Proxy for the exploration of parameter uncertainty. Allows impact of "black swan" events to be quickly considered. Allows requests for a different view of risk to be implemented: • Regulator may disagree with your cat model selection, relatively straightforward to implement a different view of risk.

Suggestions for cat modeling firms

Suggestion	Comment	Examples
Include "black-swan" events within the event-sets	Very low probability of occurrence to not distort the stochastic framework but to allow the scenario to be tracked.	For each and all earthquake zones include earthquakes of 1 and 2 magnitudes greater than that currently established. Category 5 hurricanes hitting the northeast.
Help users understand model limitations more fully.	Hard with "black box" for users to assess	"Convergence" resolution: • How many model years required to ensure 5% error in estimated loss cost at the 1 in 100 year level for 100, 1,000 or 10,000 locations? Ignoring statistical limitation challenges.... Statistical limitation challenges in the model: • How confident can I be at the 1 in 100 year level of my losses? E.g. if hurricane central pressure is taken as a distribution not as a central estimate etc.