Institute and Faculty of Actuaries

Stochastic Reserving: Lessons Learned from General Insurance

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Session F01
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Agenda

- Aims
- What is the bootstrap?
- Mortality example
- Back-test results
- Does the bootstrap underestimate extreme percentiles?
- Conclusions

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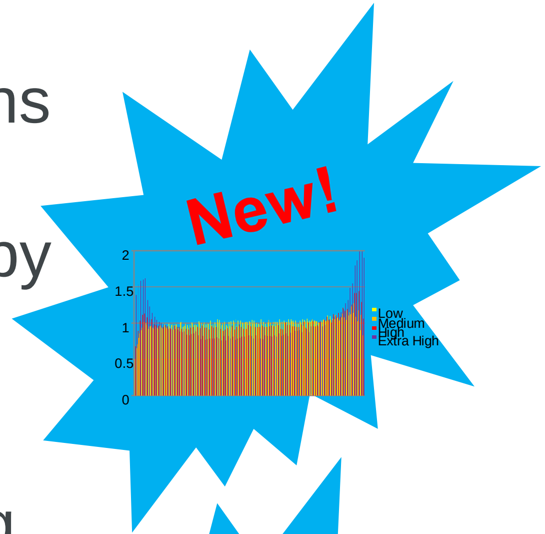
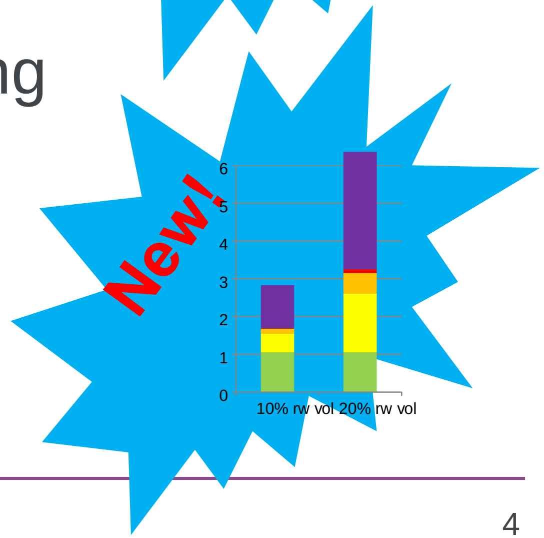
Aims of our investigation

We ***are*** aiming to:

- Get a better understanding of the strengths and limitations of the over-dispersed Poisson bootstrap (ODPB) as described by England & Verrall (2002)
- Compare the predictive distribution from ODPB against the actual outcomes, using generated data
- Investigate the robustness of the ODP bootstrap's predictions when the model assumptions are violated





Aims of our investigation

We ***are not*** aiming to:

- Compare the performance of the ODP bootstrap with that of other mechanical or judgement based methods
  - Bootstrap methods applied to *paid* claims; we do not consider incurred triangles or frequency/severity models here
- Promote or discourage the use of:
  - The ODP bootstrap
  - Other mechanical methods
  - Judgement based methods

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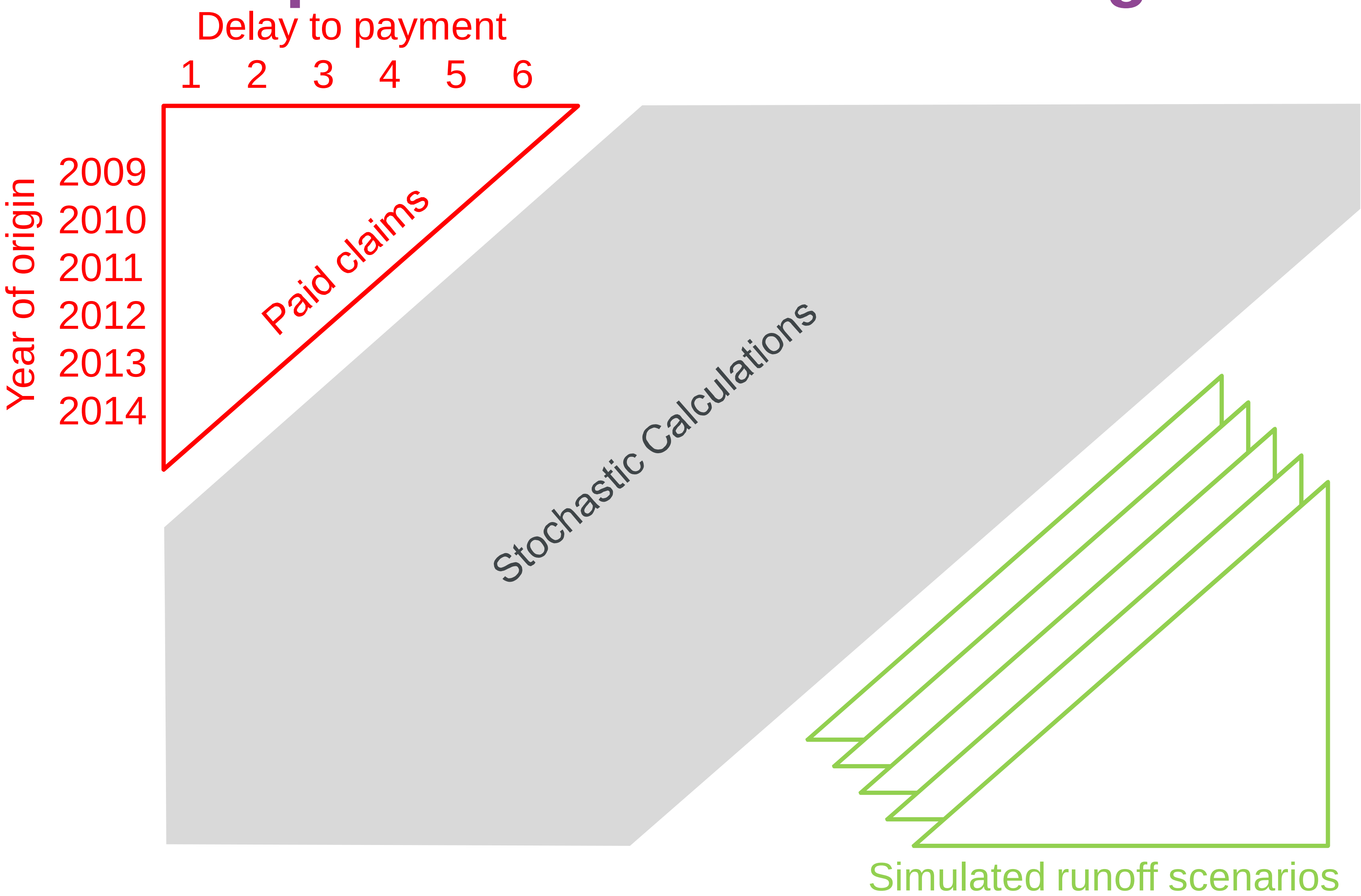
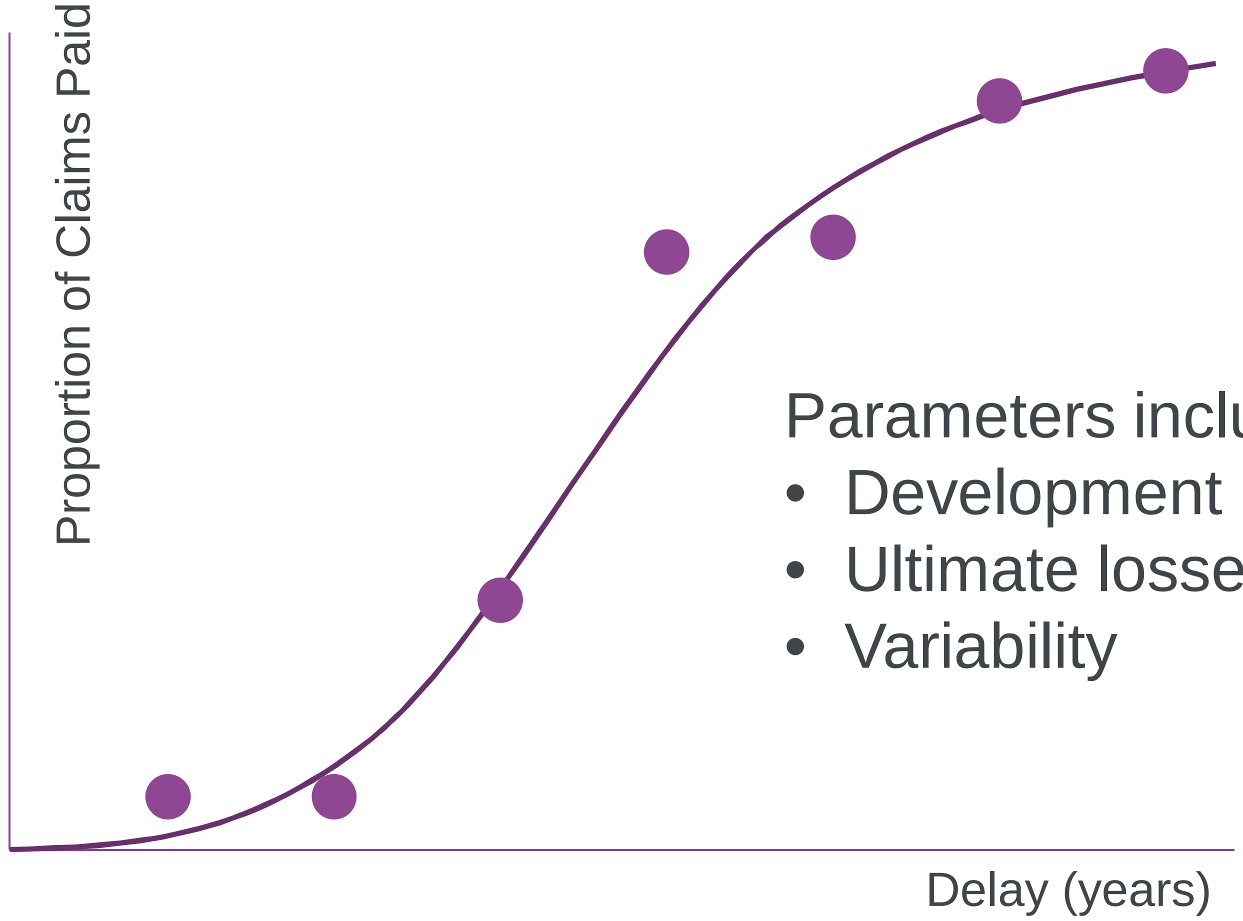
Bootstrap in Stochastic Reserving



Bootstrap Steps: Parameter Estimates

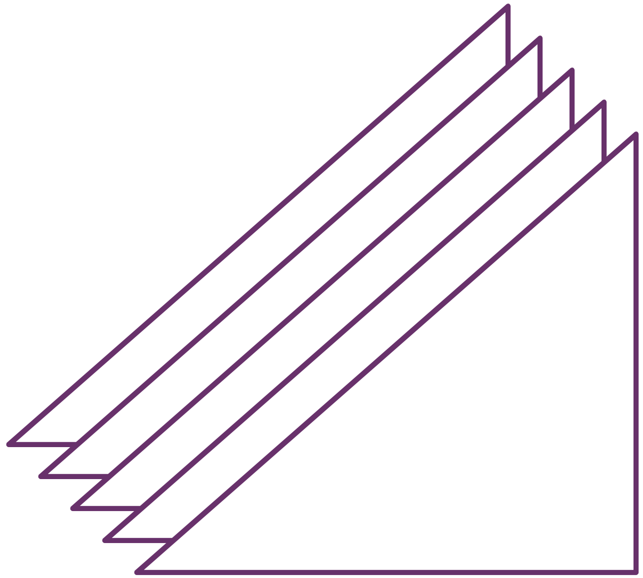


Parameters include:

- Development patterns
- Ultimate losses
- Variability

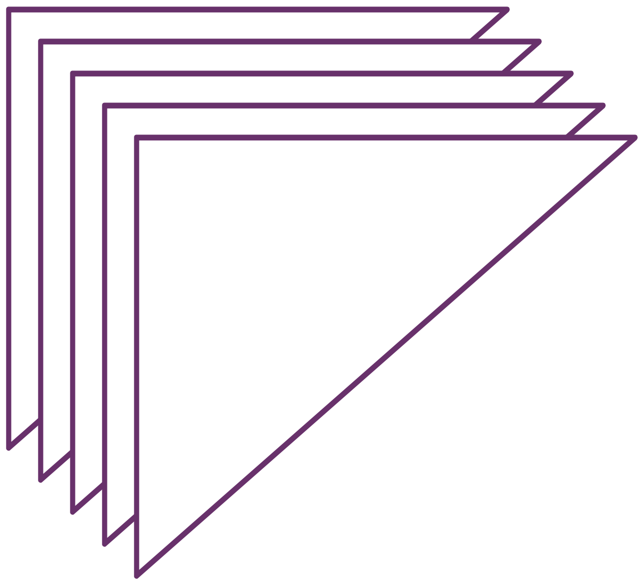
Bootstrap Steps: Forecasting

- Also called “noise” or “process error”
- Simulating one or more future claim scenarios based on estimated parameters (we use gamma distributions here)
- This is a familiar approach for many other risks besides reserving uncertainty

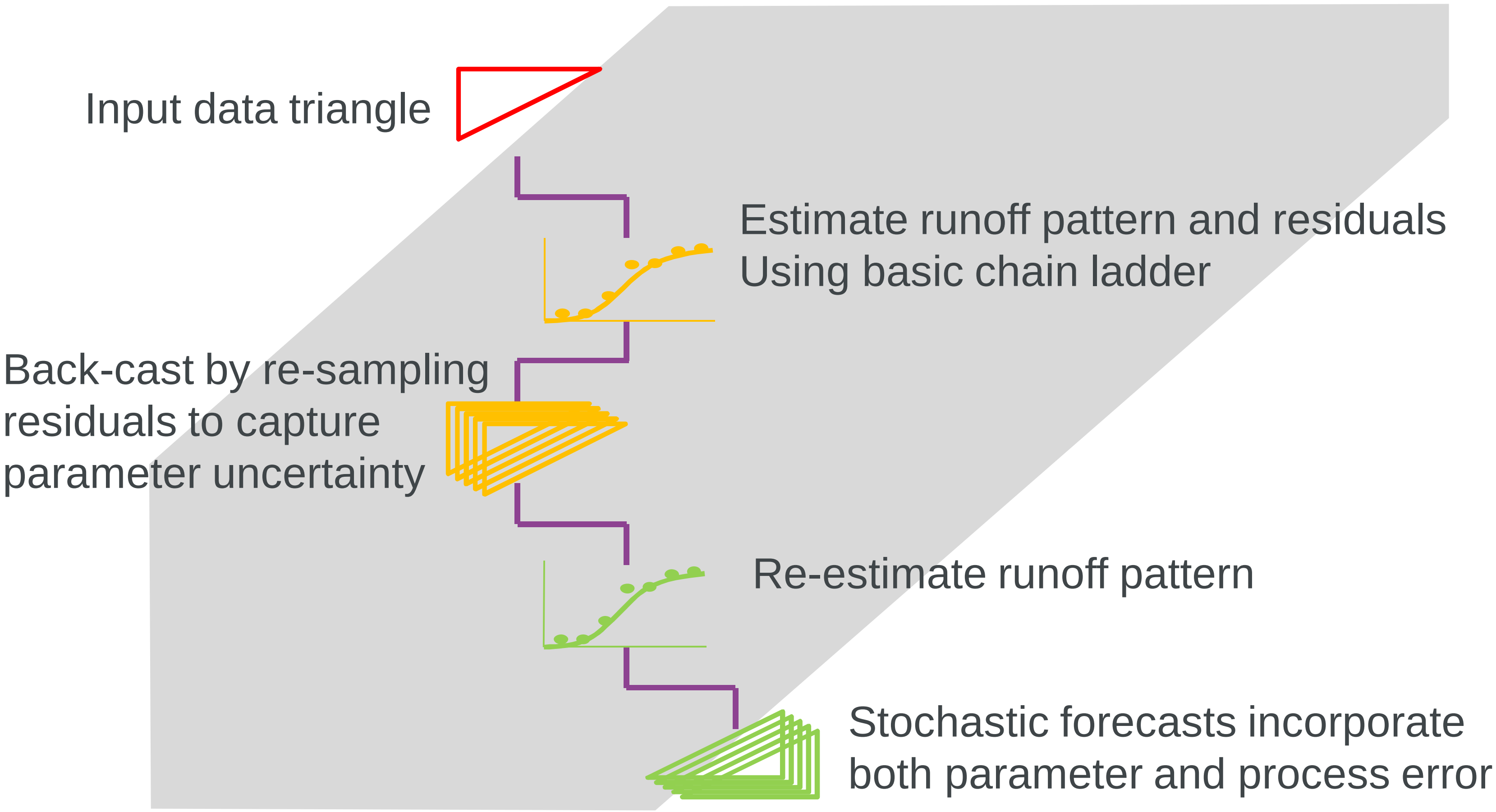


Bootstrap Steps: Back-Casting

- Re-creating hypothetical historical claim scenarios based on estimated parameters
- May use re-sampled residuals (non-parametric) or analytical distributions (parametric)



How the Steps Fit Together



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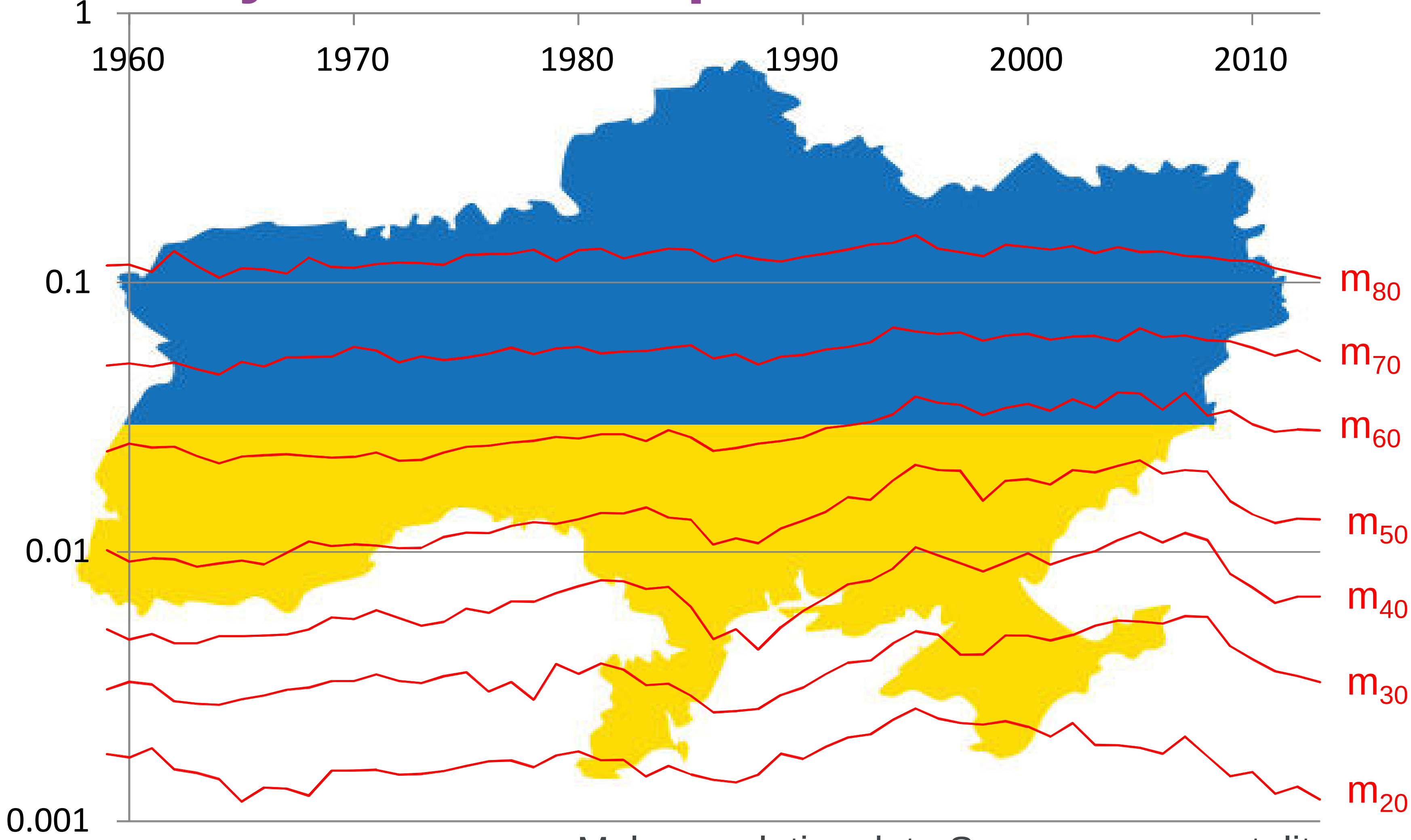
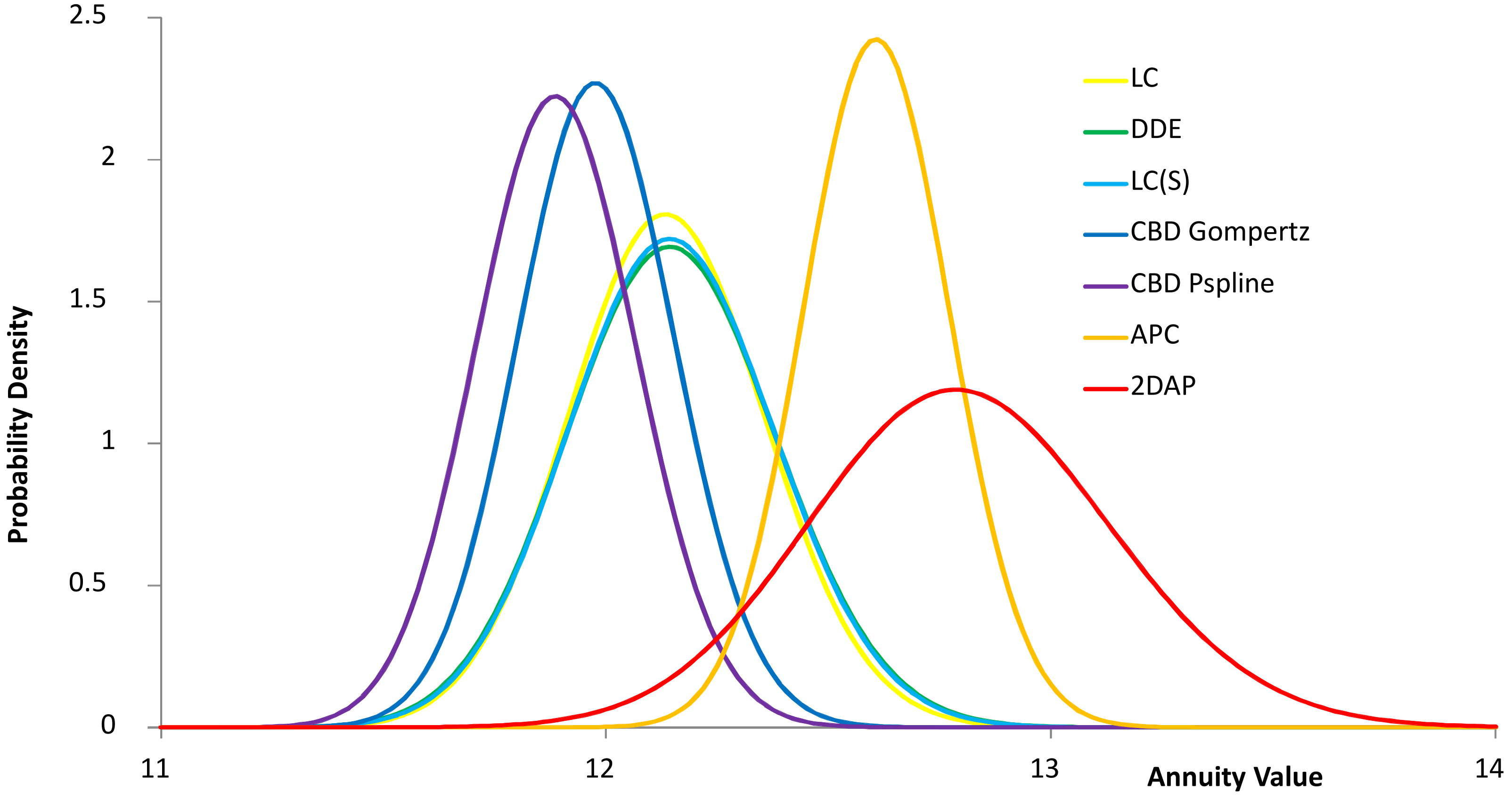
Mortality Rates Example



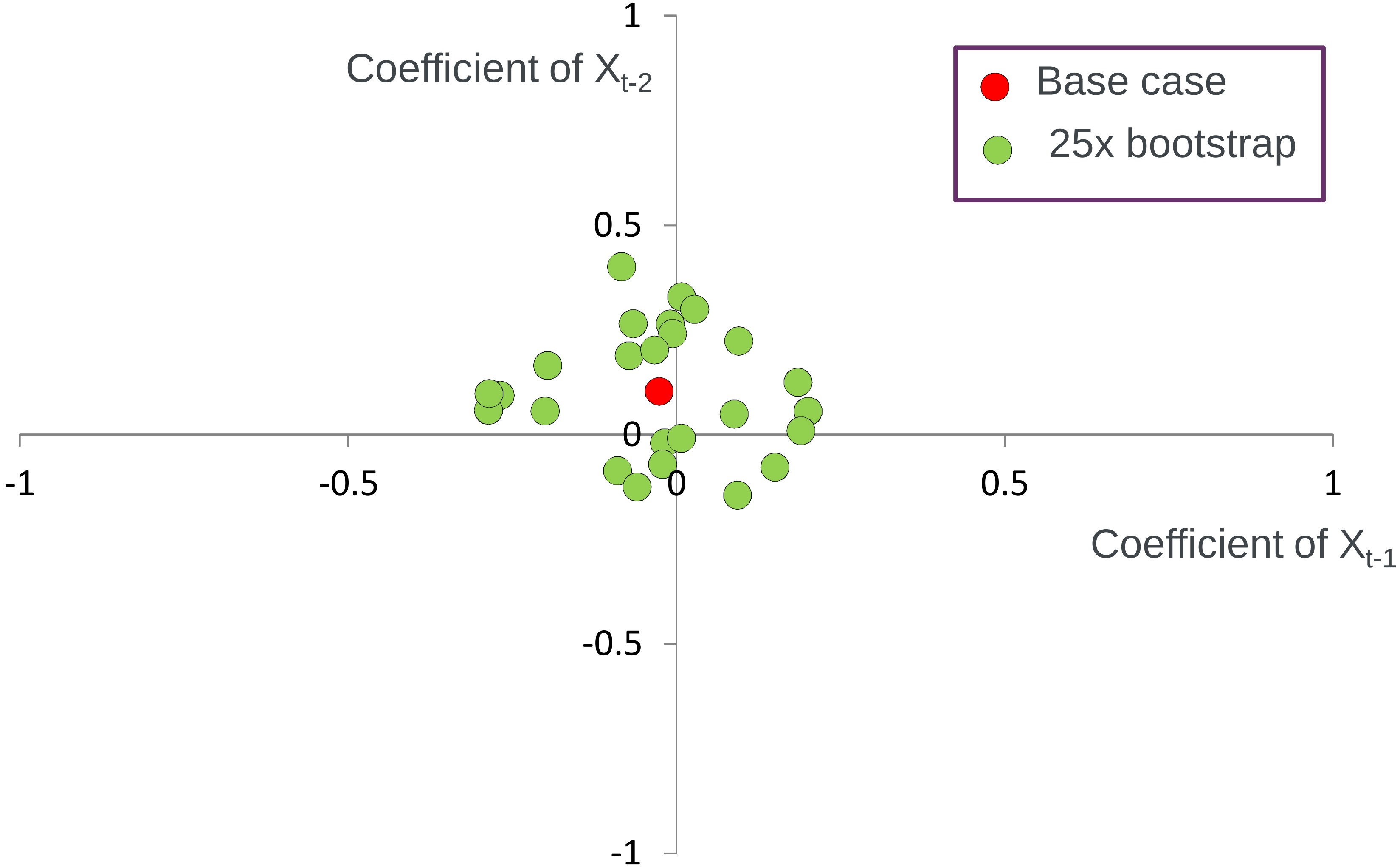
Male population data.Source: www.mortality.org

Model Uncertainty for Longevity Risk

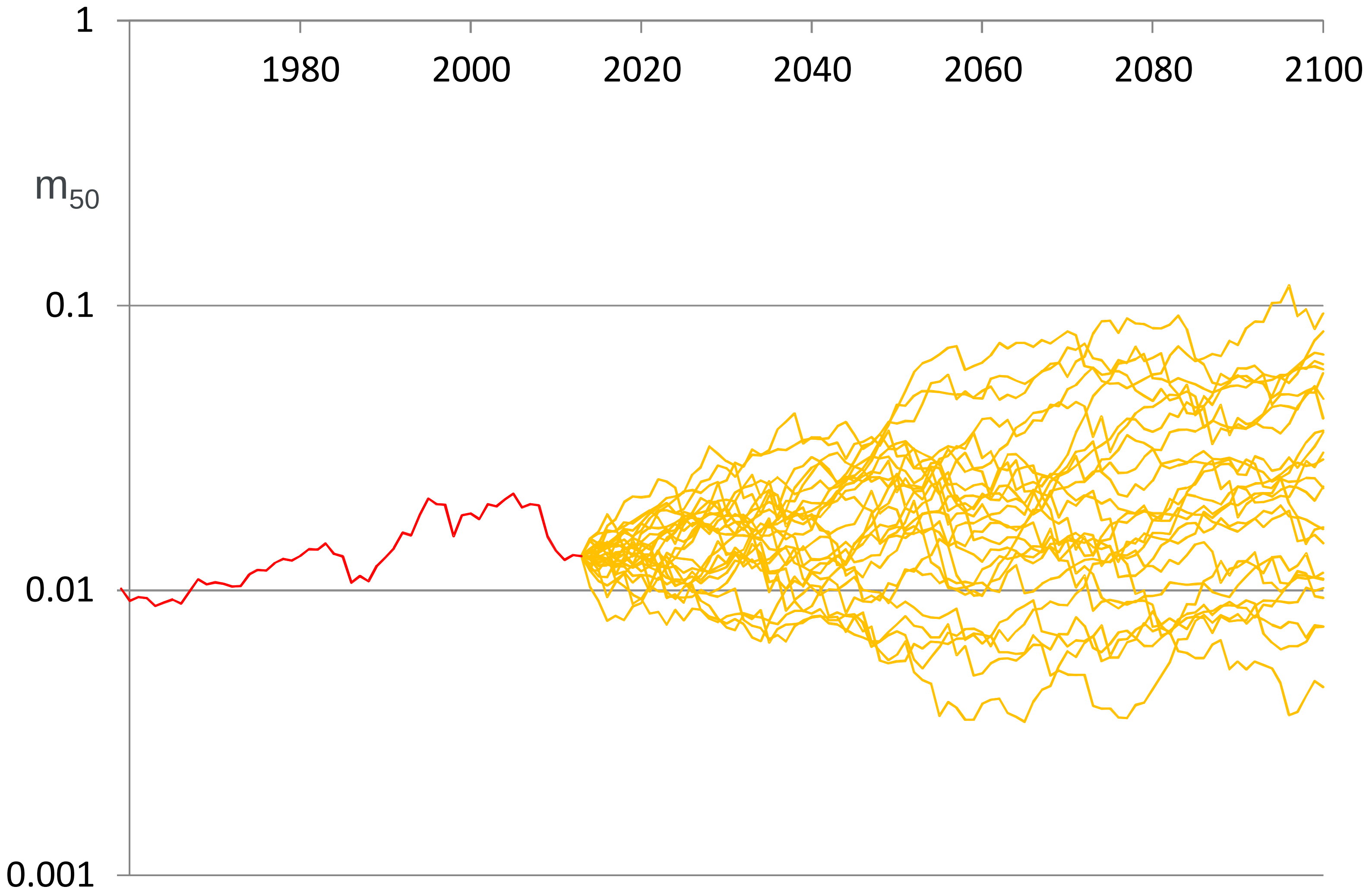
Probability Distributions for UK Male Annuity aged 65 (Based on Currie et al, 2013)



Fitting an AR2 Model to $\Delta \ln[m_{50}]$



Projections under the Base Model



What Lies behind the Patterns?

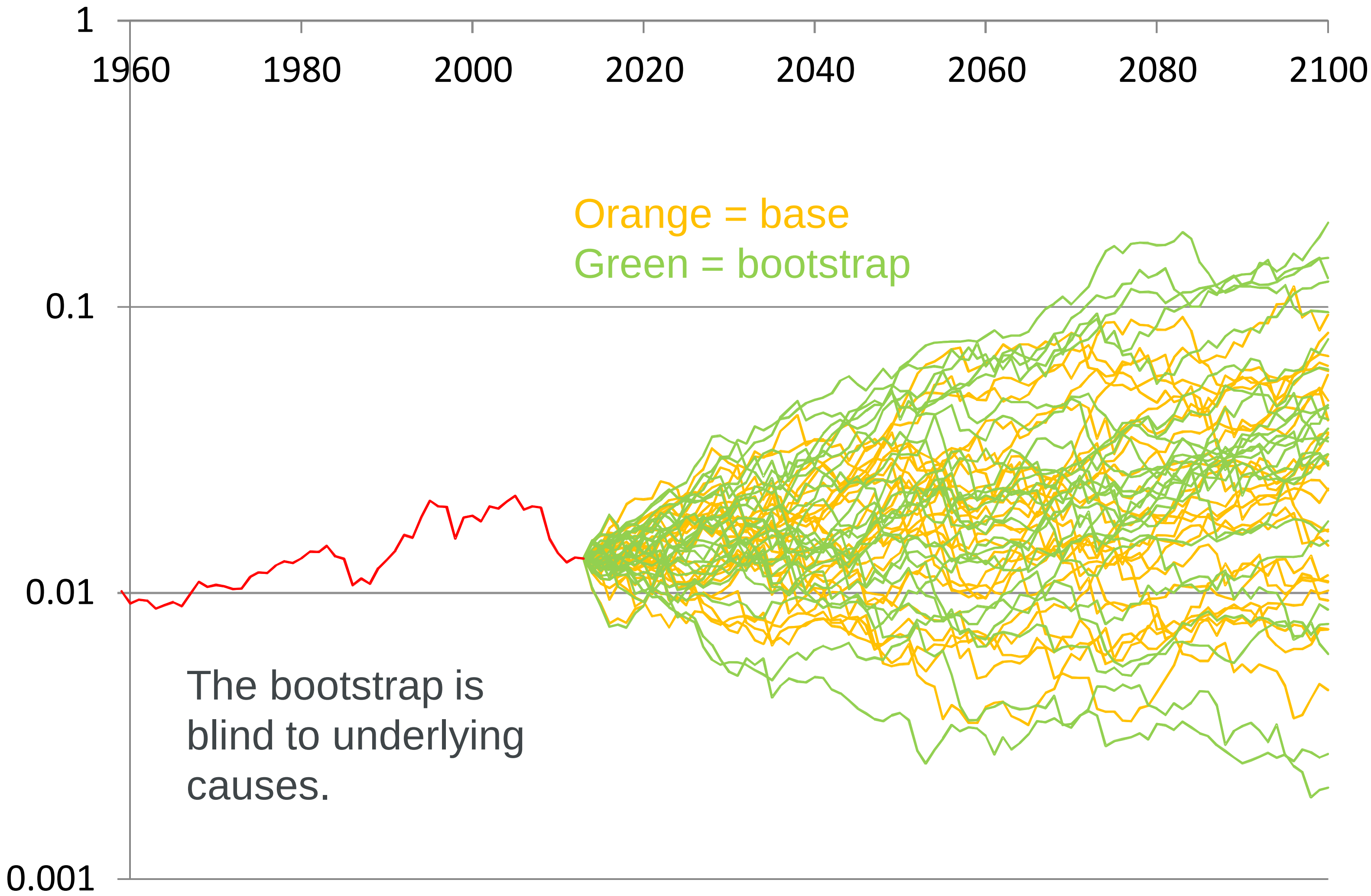
- Although there is a general increasing trend in life expectancy, we know that some historic causes have had particularly large impact:
  - Discovery of antibiotics (penicillin etc)
  - Reduction in smoking
- Smoking in the UK has fallen from 50% to 20% in the last 40 years and it cannot feasibly fall to -10% over the next 40 years

What future events are we aware of today whose occurrence is likely to be coupled with a significant impact on UK longevity?"

- Introduction of plain cigarette packaging in the UK
- Use of novel diagnostic biomarkers
- KRAS targeted cancer treatment
- Genetic screening
- NHS Bowel Cancer Screening Programme
- Stem cell therapy and Parkinson's disease
- Polypill scenario
- Development of a universal influenza vaccine

Source: Longevity Catalysts working party

Bootstrap Projections → More Extremes



Two Dimensional Examples

- We have shown one dimension of stochastic mortality models
- Two-dimensional (stochastic sheet) models have now become market standard. Several models proposed by Cairns-Blake-Down and by Plats
- Same principles apply for two-dimensional bootstraps (permuting residuals across calendar years and, within limits, across age at death)
- As in the univariate case, the bootstrap impact is to widen funnels of doubt, especially at extreme percentiles and over long time horizons.

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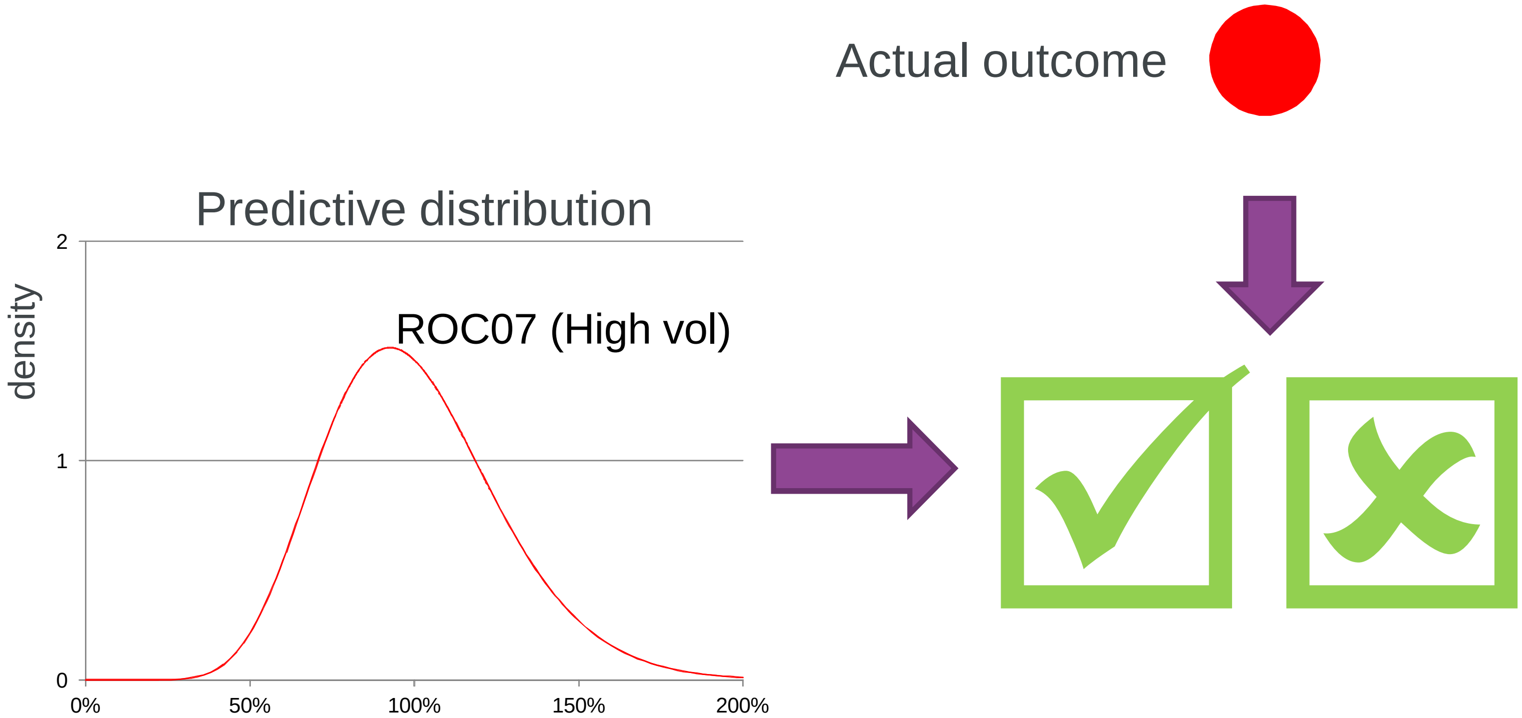
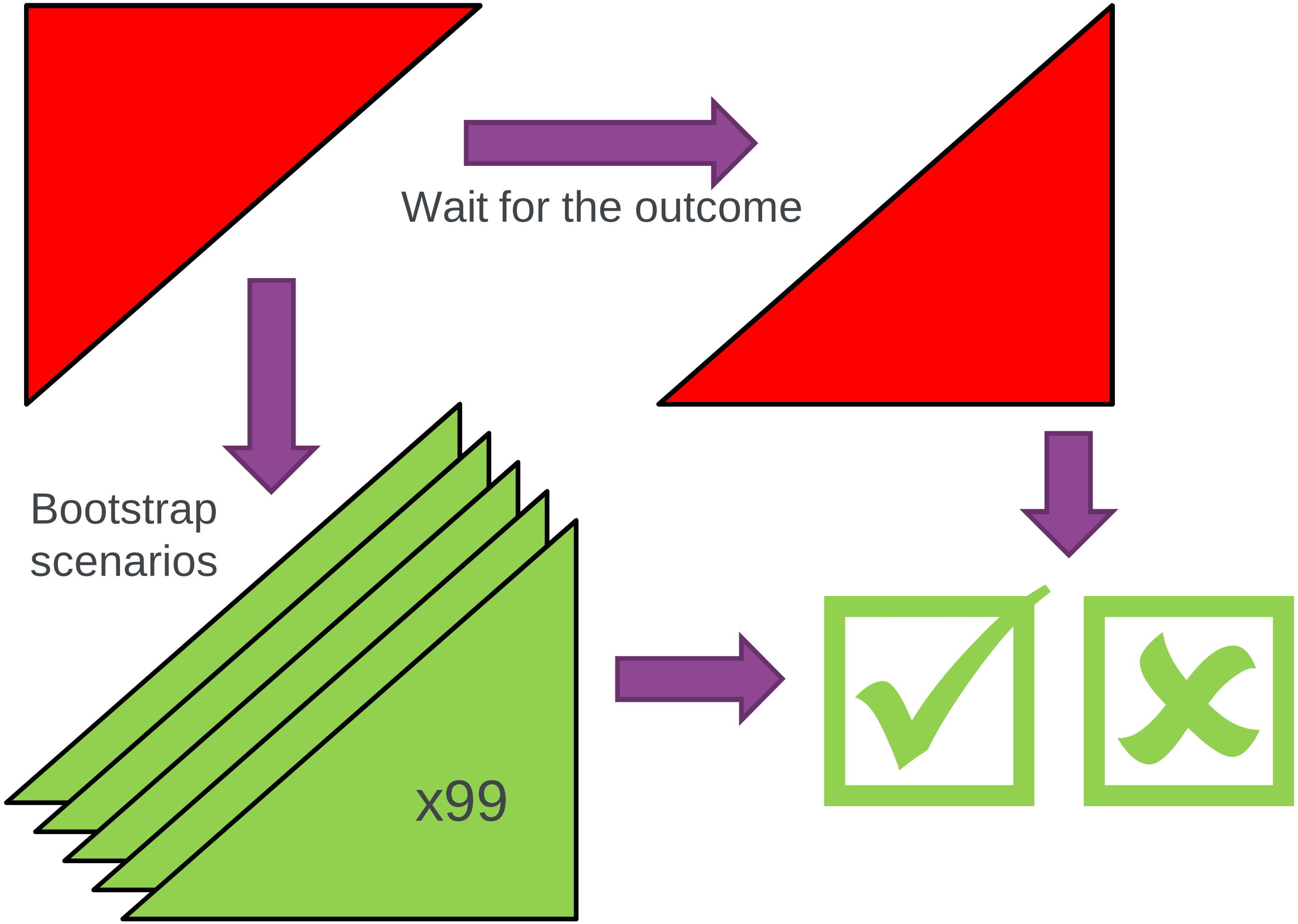
Back-Testing

- Compare actual outcomes to a predictive distribution



Back-Testing the ODP Bootstrap

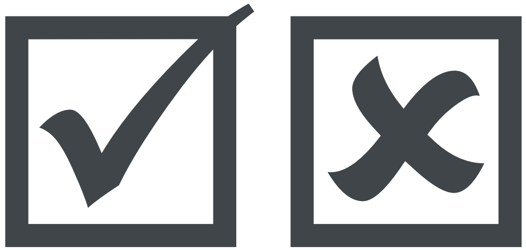


Ranking the Outcomes

- Take 100 future claim scenarios
  - 1 actual outcome ● and 99 from bootstraps ●
- Sort into increasing order of outstanding claims
- Divide into 10 buckets, each containing 10 observations

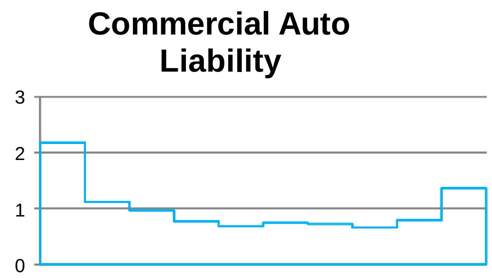
- Suppose the actual outcome and the bootstrap are independent samples from the same distribution
- Then there is 1-in-10 chance the red lies in each bucket

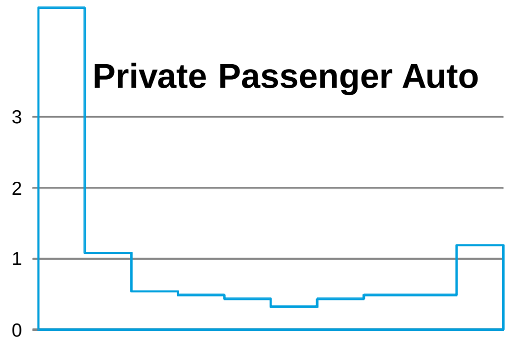
The Back-Test

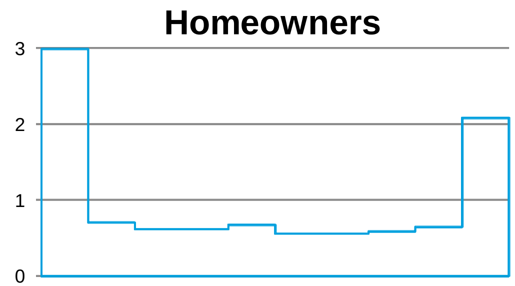


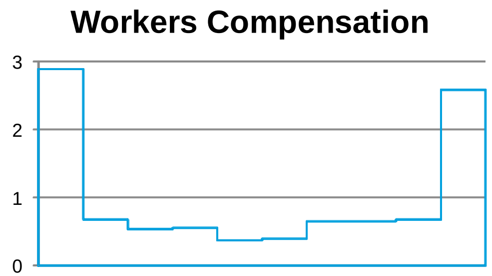
- Bootstrap multiple historical claim triangles
  - Multiple insurers
  - Multiple projection years
  - Or multiple random “realistic” triangles
- Aggregate the bucket counts across bootstraps
- Back-test passes if 10% of actual outcomes lie in each bucket
  - Within random sampling tolerance

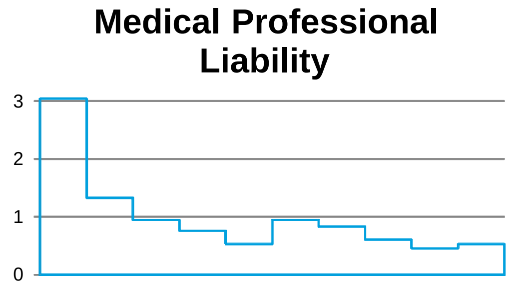
Back-test on Real Data: Leong et al (2012)

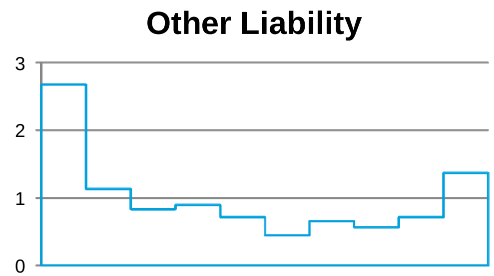


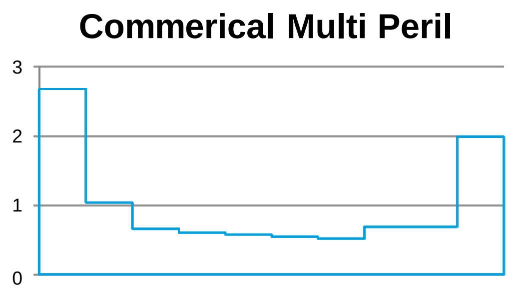








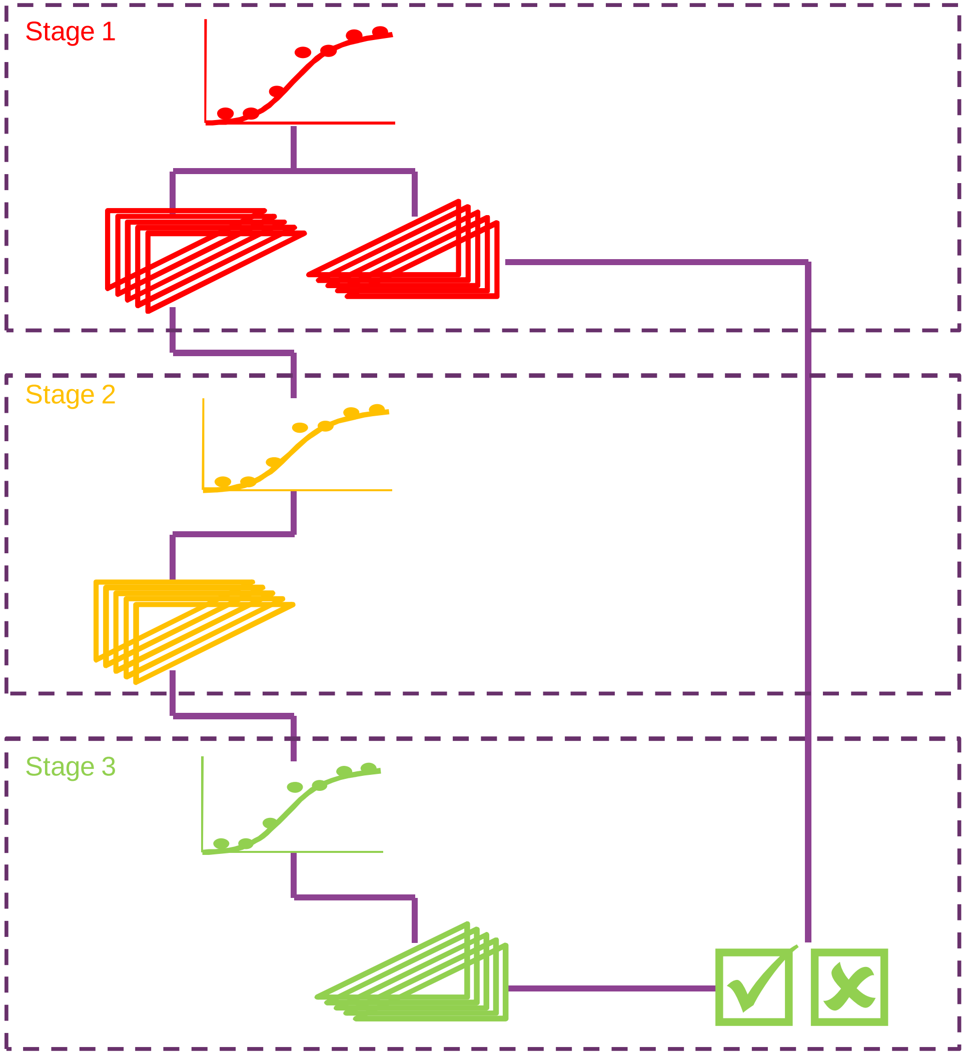




Too many actual outcomes lie in the top and bottom bootstrap deciles, so bootstrap distribution too narrow

Different companies / years not independent so we do not know how significant this effect is

The Monte Carlo Back-Test (MCBT)



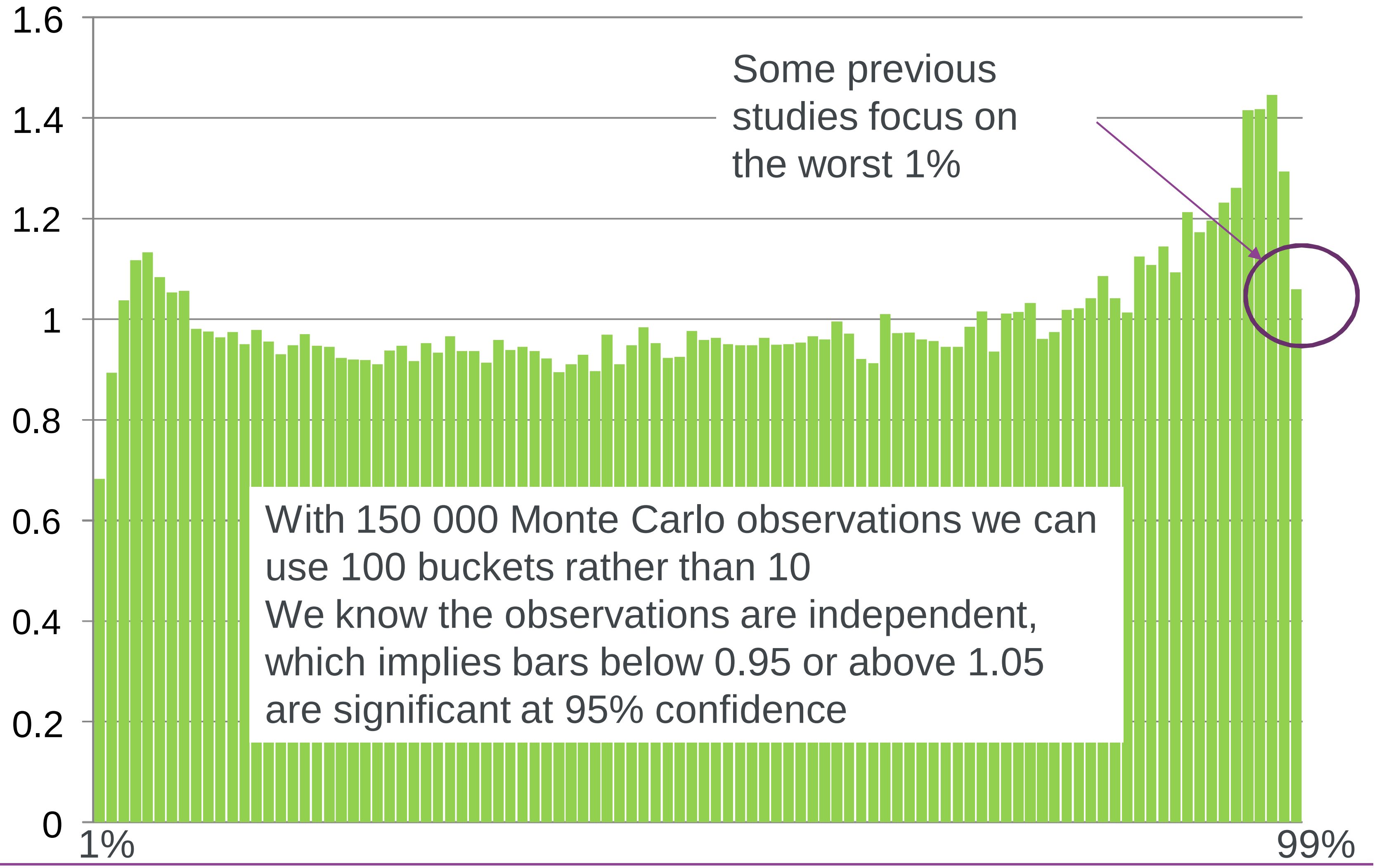
Parametric back-cast

One set of stage 2 parameters for each stage 1 back-cast triangle

Non-parametric back-cast

One set of stage 3 parameters for each stage 2 back-cast triangle

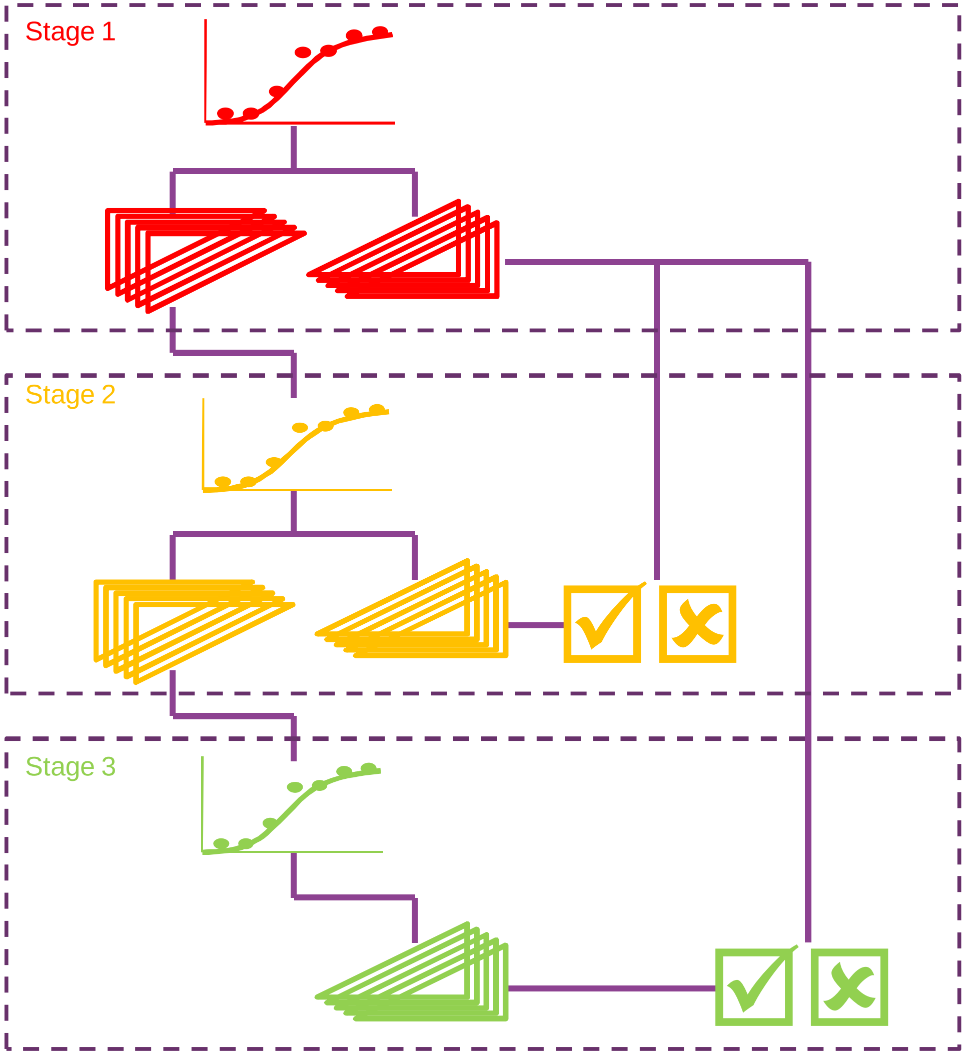
Example Output (Long dev, High vol)



MCBT Results: Proportion > 99%-ile

Gamma Volatility	Development pattern length			
	Short	Medium	Long	Extra Long
Low	1.1%	0.7%	0.7%	0.6%
Medium	1.5%	1.1%	0.8%	1.1%
High	1.9%	1.5%	1.1%	1.5%
Extra High	3.0%	2.7%	1.9%	2.7%

Experiment: Omitting the Back-Cast

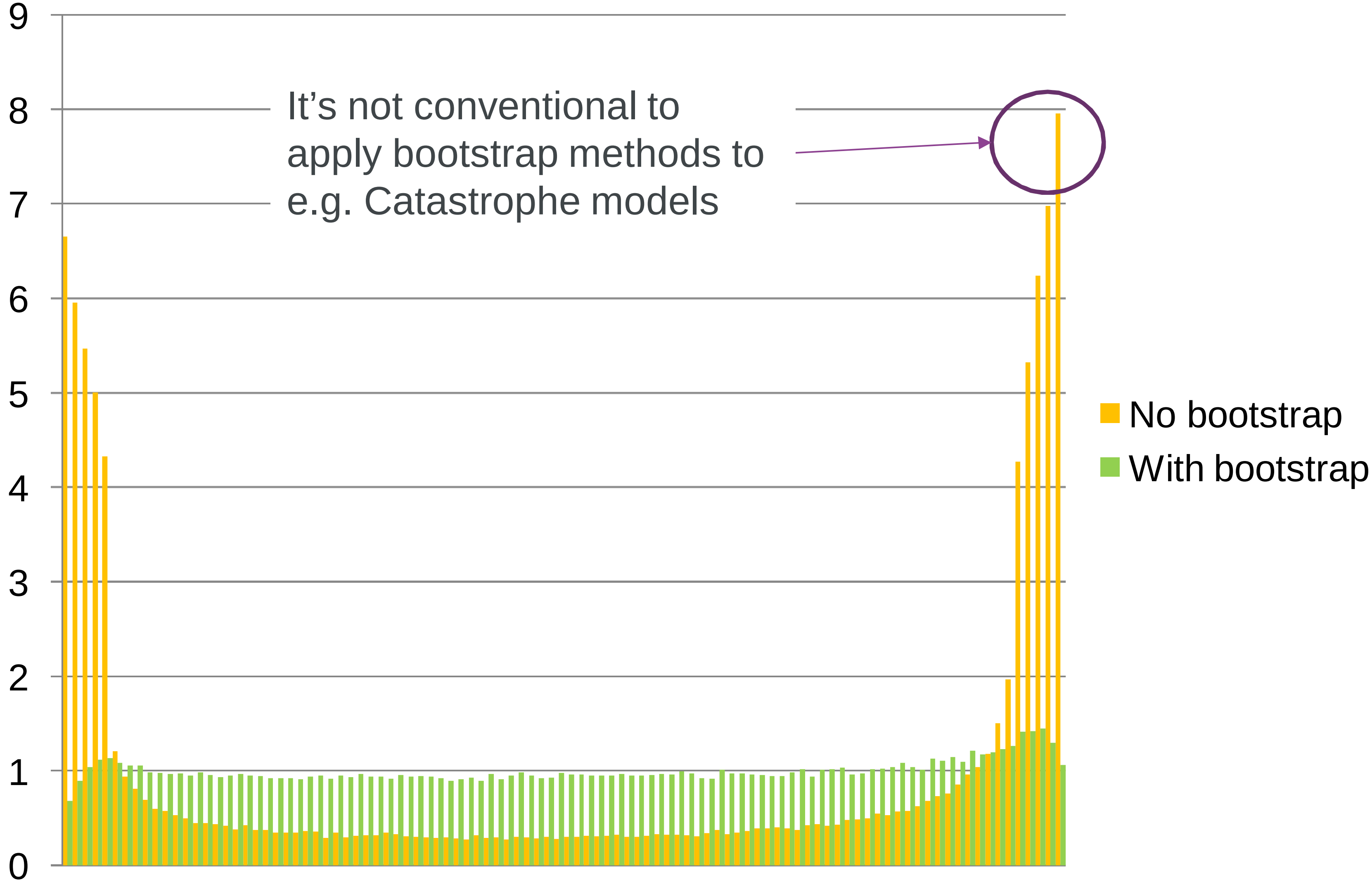


How much is the bootstrap adding?

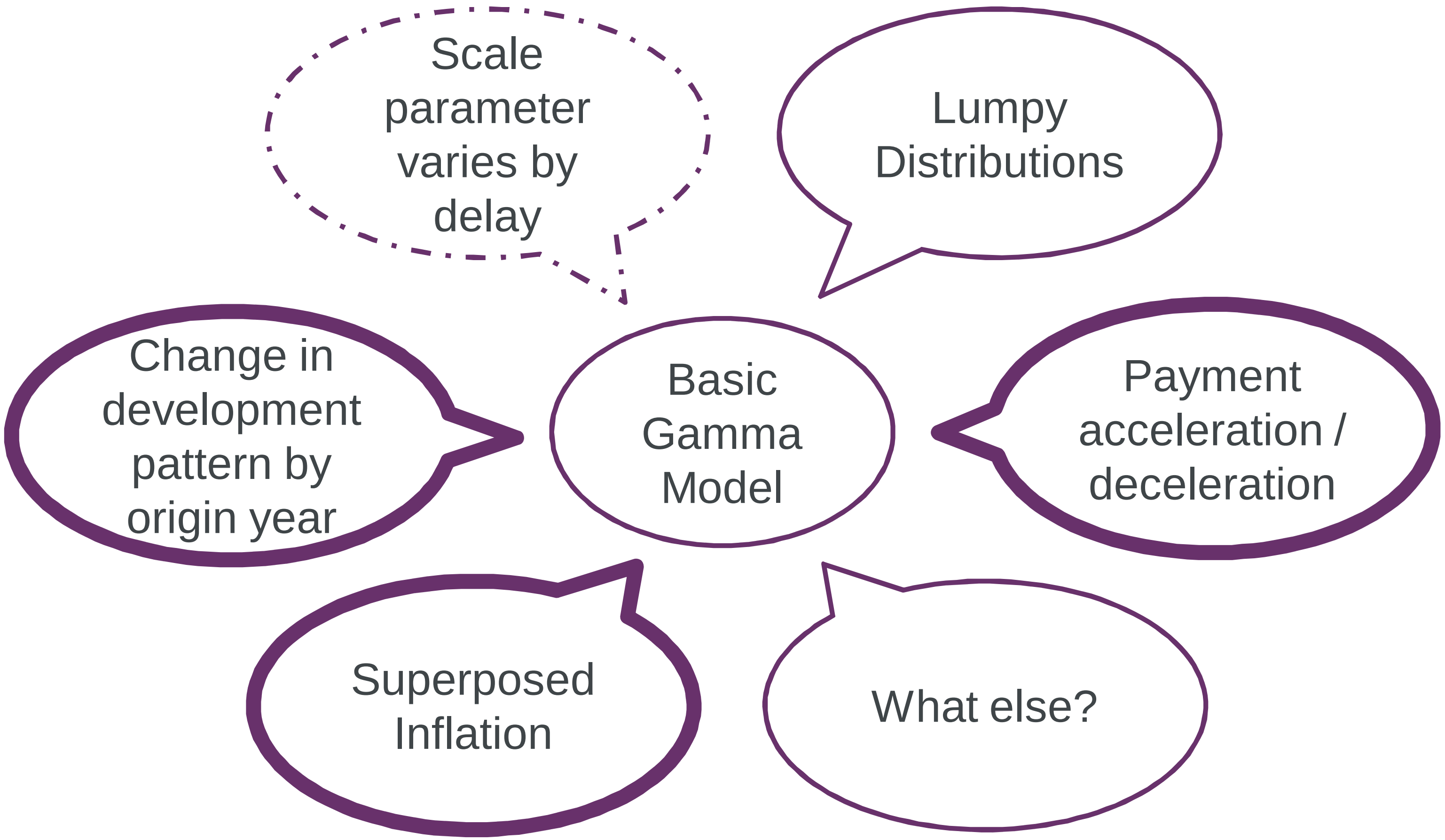
- Perform the Monte Carlo Back Test using stochastic projection of the step 2 fitted parameters

- Therefore have no allowance for parameter uncertainty

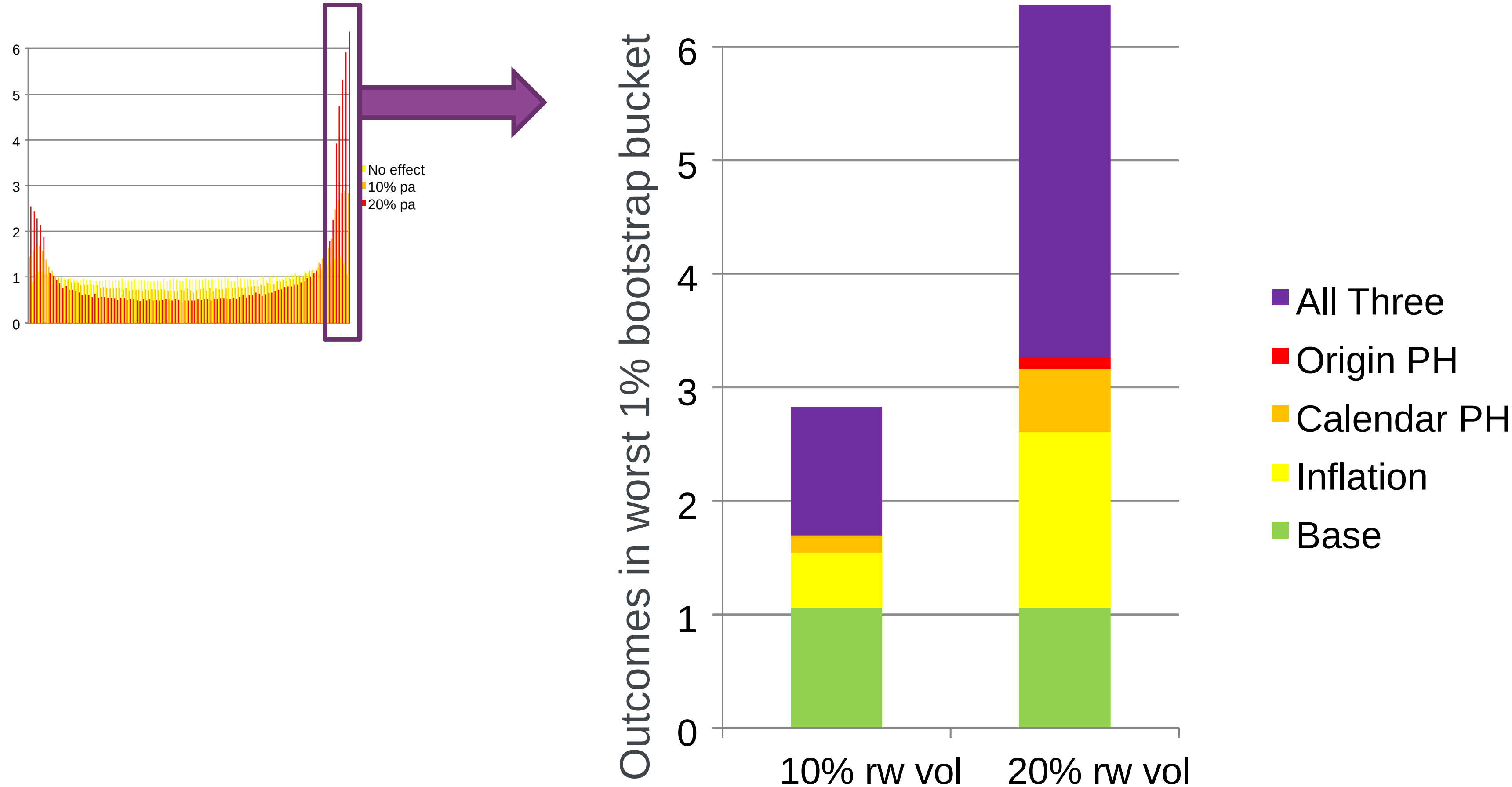
Unbiased Parameters fail Back-Test



Making Triangles More Realistic

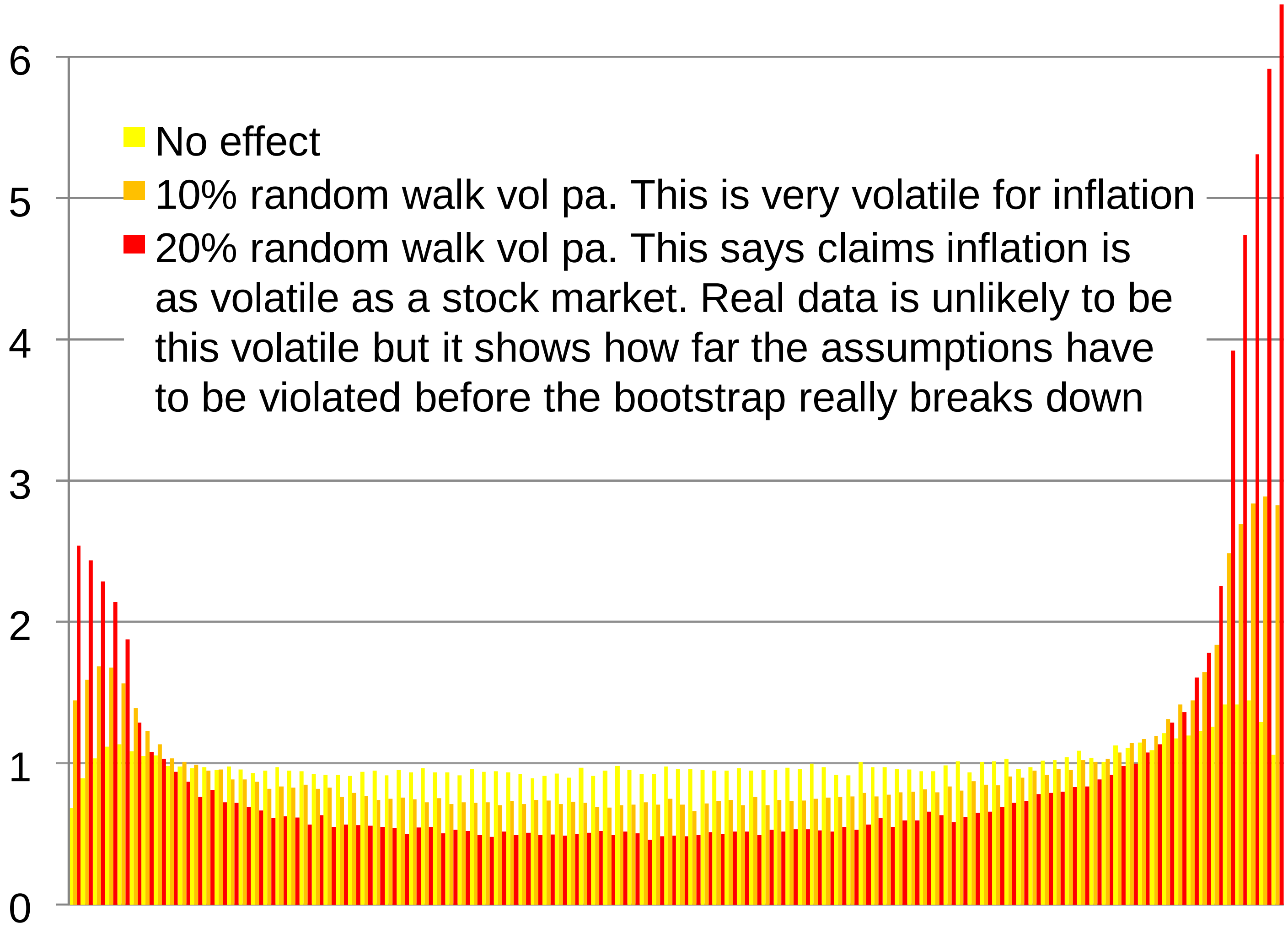


Origin Year and Calendar Year Effects



These figures relate to the long development pattern, and high gamma volatility

Origin Year and Calendar Year Effects



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Extreme Percentile Underestimation

- Given how simple the concept is, the bootstrap does well for most of the distribution
- We replicate results of ROC and others that bootstrap does not perfectly capture extreme tails
  - In some instances the bootstrap distribution is less extreme than reality, and in others it is more extreme
  - We would not expect perfection
- Bootstrap is remarkably robust to moderate assumption violations

Some alternatives to the Bootstrap

- Bootstrap is not the only way to address parameter uncertainty
- Classical methods estimate parameters by maximum likelihood and derive standard errors from the Fisher information matrix
- Bayesian methods (England & Cairns, 2009)
- Single (non-bootstrap) forecast, with the standard deviation multiplied by an "adjustment factor"
  - Use the Monte Carlo Back Test to solve for the adjustment factor
- Retain unbiased point estimates as a control

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The Importance of Quantitative Testing

	Rhetorical	Quantitative
Mechanical Methods	Bootstrap takes account of parameter error Assumptions do not hold in practice Frequentist peg in a Bayesian hole	**Prob**{outcome > 99%-ile} Robustness to model mis-specification Unbiasedness / efficiency
Subjective methods	Use underwriting knowledge, common sense, relevant for the board, practical decisions Telling management what they want to hear, profit smoothing.	? Wanted: outcome-based tests for subjective methods

Points for Discussion (1)

- What to do about known changes affecting past mortality?
  - Examples: medical breakthroughs, smoking, alcohol consumption, cohort effects?
  - Should we strip them out of the data and put them back into the forecast? Or is that part of the noise we're trying to measure and extrapolate?
  - The bootstrap allows for these mechanically, but only to the extent that these fluctuations affect the past and the future

Points for Discussion (2)

- Parameter and model errors pervade many risk models: market risks, longevity / mortality and, in general insurance, premium risk, cat risk, reserving risk, credit risk, market risk etc.
  - For reserving risk we have the bootstrap. It’s not perfect but we’d give it 8/10 for capturing model and parameter uncertainty
  - For the other risks, we probably ignore model and parameter error, scoring 0/10
  - We can try to perfect the bootstrap, but should we prioritise other risks?

Acknowledgements

- We are grateful for the support from the Managing Uncertainty Qualitatively working party, the Managing Uncertainty with Professionalism working party and from our employers
- Special thanks to Sarah MacDonnell, Tom Wright and Peter England for detailed comments on earlier drafts
- All views expressed and any remaining errors are ours alone

Further Reading

Cairns M and England P D (2009) Are the upper tails of predictive distributions of outstanding liabilities underestimated when using bootstrapping? General Insurance Convention (presentation only) http://www.actuaries.org.uk/sites/all/files/documents/pdf/a09england.pdf

England, P.D. and Verrall, R.J. (2002) Stochastic Claims Reserving in General Insurance (with discussion). British Actuarial Journal, 8, pp 443-544 http://www.actuaries.org.uk/sites/all/files/documents/pdf/sm0201.pdf. Note that this link is to the originally distributed sessional meeting paper. The is a crucial typographical error for the residual adjustment in Appendix 3 which is corrected in the paper finally published in the BAJ, and also in this paper.

Efron B & Tibshirani, R J (1993). An introduction to the bootstrap. Chapman and Hall.

General Insurance Reserving Oversight Committee Working Party (Chair: Lis Gibson, 2007) Best Estimates and Reserving Uncertainty.

General Insurance Reserving Oversight Committee Working Party (Chair: Neil Bruce, 2008) Reserving Uncertainty.

Previous two papers available here: http://www.actuaries.org.uk/practice-areas/pages/general-insurance-reserving-oversight-committee-gi-roc-0

Leong J, Wang S and Chen H. (2012) Back-Testing the ODP Bootstrap of the Paid Chain-Ladder Model with Actual Historical Claims Data. Casualty Actuarial Society E-forum. http://www.casact.org/pubs/forum/12sumforum/leong_wang_chen.pdf

Pinheiro, P J. R; João Manuel Andrade e Silva and Maria de Lourdes Centeno. (2003). Bootstrap Methodology in Claim Reserving. The Journal of Risk and Insurance, 70: 701-714.

Shapland M R and Leong, J. (2010) Bootstrap Modeling: Beyond the Basics. Casualty Actuarial Society E-forum.

Questions

Comments