Stochastic Reserving Methods

Advantages, Disadvantages, Key Issues and Lessons Learnt

by

Andrew Smith & Mitchell Prevett

Agenda

1. **Introduction**

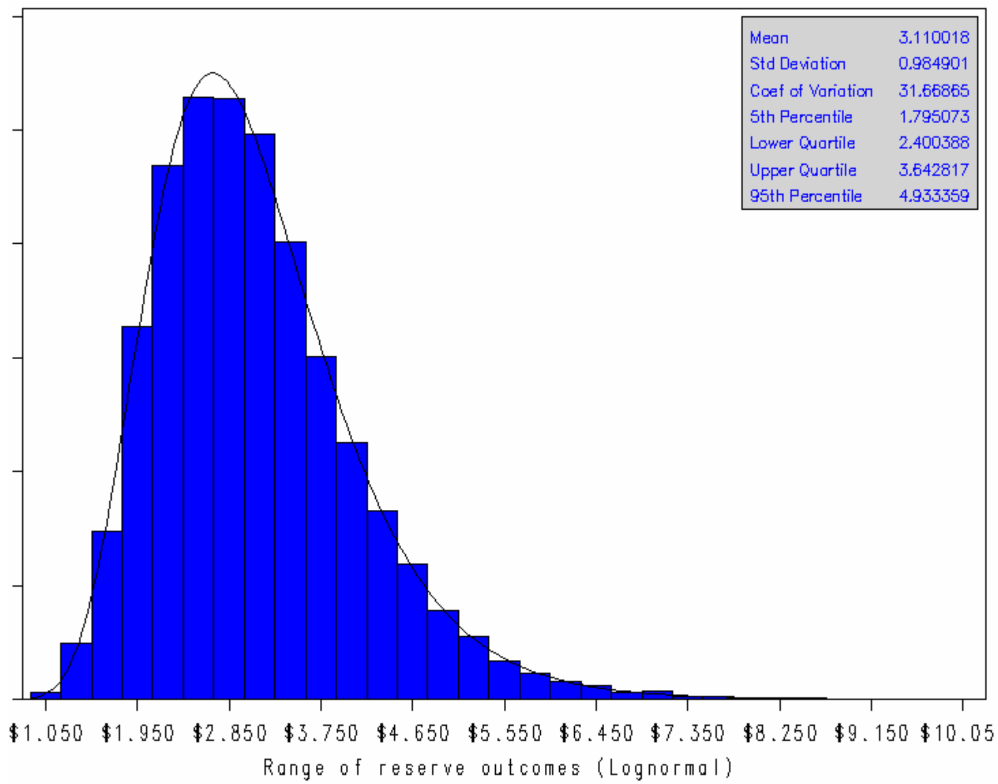
2. **Case study**

3. **Summary**

Intro - Stochastic reserving?

- A Stochastic Model is any model that includes a random error term
- Stochastic reserving is used "*to estimate the full distribution of possible outcomes…*" *

  not just the mean.



* Source: England and Verrall (2002)

Intro - The Reserving Continuum

Deterministic	Sensitivity Testing	Scenario/ Stress Testing	Stochastic Overlay	Stochastic
1970s + Still used widely and is the basis of our education system	**Early 1990s** Introduction of PS300 in May 1994	**Mid 1990s** Scenario testing to enhance understanding of uncertainty	**Mid 1990s/ 2000s +** Risk Margin discussions/ bootstrapping/ supplementary stochastic analysis	**2001 +** Limited use of stochastic techniques but is on the increase

Intro - What are the Techniques?*

Techniques in common use…

- Generalised linear models
- Bootstrapping of deterministic models
- Top down risk quantification

Others…

- Bayesian or credibility models
- Kalman filter
- Wrights model
- Hoerl curve

* Sources: England and Verrall (2002), Taylor (2000), O'Dowd et al (2005)

Case study – Weekly Comp PPAC GLM

What?

Weekly compensation for a large accident compensation scheme

Why?

1. Superimposed inflation? Is it evident? What is the level?
2. Better understand the uncertainties in the reserving?
3. What insights can we derive to build into the main valuation?
4. Estimation of risk margins

How?

$E(Pmts_{i,j}) = Actives_{i,j-1} \times E(ContRate_j) \times E(PPAC_j)$, *where* $i = devqtr$, $j = accqtr$

GLM1 – $ContRate_{i,j} = Actives_{i,j} / Actives_{i,j-1} = f(i, j, i+j) + error$

GLM2 – $PPAC_{i,j} = Pmts_{i,j} / Actives_{i,j} = f(i, j, i+j) + error$

Continuance rates GLM → PPAC GLM → Superimposed inflation → Full reserve distribution

Fitted GLM

- Short, medium and long term rates are modelled separately
- Over-dispersed Poisson / Log GLM on $\text{Active}_{i,j}$
- Offset - $\text{Log}(\text{Active}_{i,j-1})$
- Binary and linear segment transforms are used

Model Parameter Estimates - Short Term

Model Predictor	Formula	Estimate	Multiple
Intercept		0.0000	
Development Quarter = 1	(devqtr = 1)	-0.1154	89%
Development Quarter = 2	(devqtr = 2)	-1.1367	32%
Development Quarter = 3	(devqtr = 3)	-0.4618	63%
Development Quarter (linear 4 to 7)	min(max(devqtr-4,0),7-4)	0.0498	105%
Development Quarter (linear 11 to 15)	min(max(devqtr-11,0),15-11)	0.0089	101%
Development Quarter (linear from 15)	max(devqtr-15,0)	0.0012	100%
Development Quarter (greater than 3)	(devqtr ge 4)	-0.2958	74%
Experience Quarter (step to 30 June XX)	(expqtrdate lt '30junXX'd)	0.0233	102%
(Development Quarter = 1) and Exp Qtr (prior to 30 June XX)		0.2132	124%
(Development Quarter = 2) and Exp Qtr (prior to 30 June XX)		-0.0708	93%

Model Parameter Estimates - Medium Term

Model Predictor	Formula	Estimate	Multiple
Intercept		-0.0264	
Development Quarter (after 44)	(devqtr ge 44)	0.0128	101%

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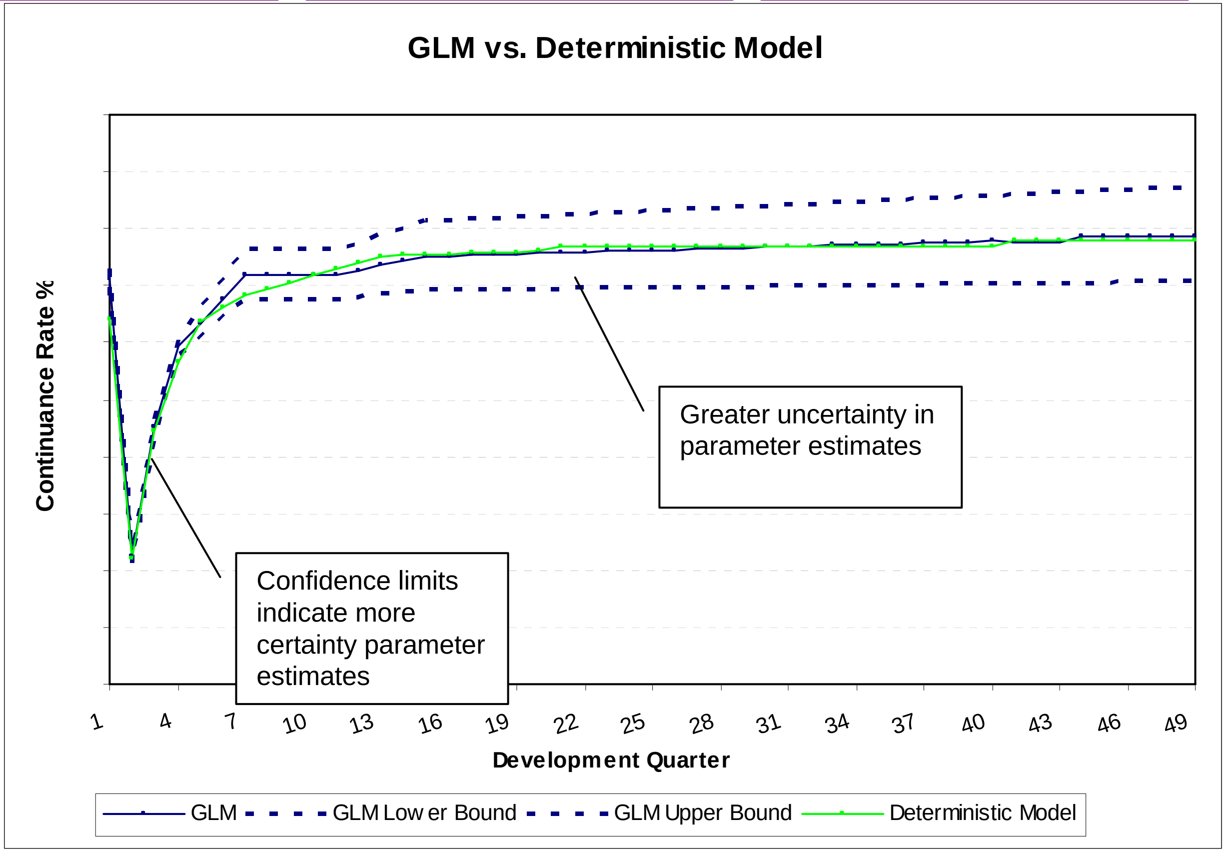
Comparison to deterministic model

- GLM fitted rates compare well with the deterministic fitted rates
- Confidence limits can be calculated for the GLM fitted function (this assumes no correlations in estimates)



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Fitted GLM

- Over-dispersed Poisson / Log GLM on $\text{Pmts}_{i,j}$
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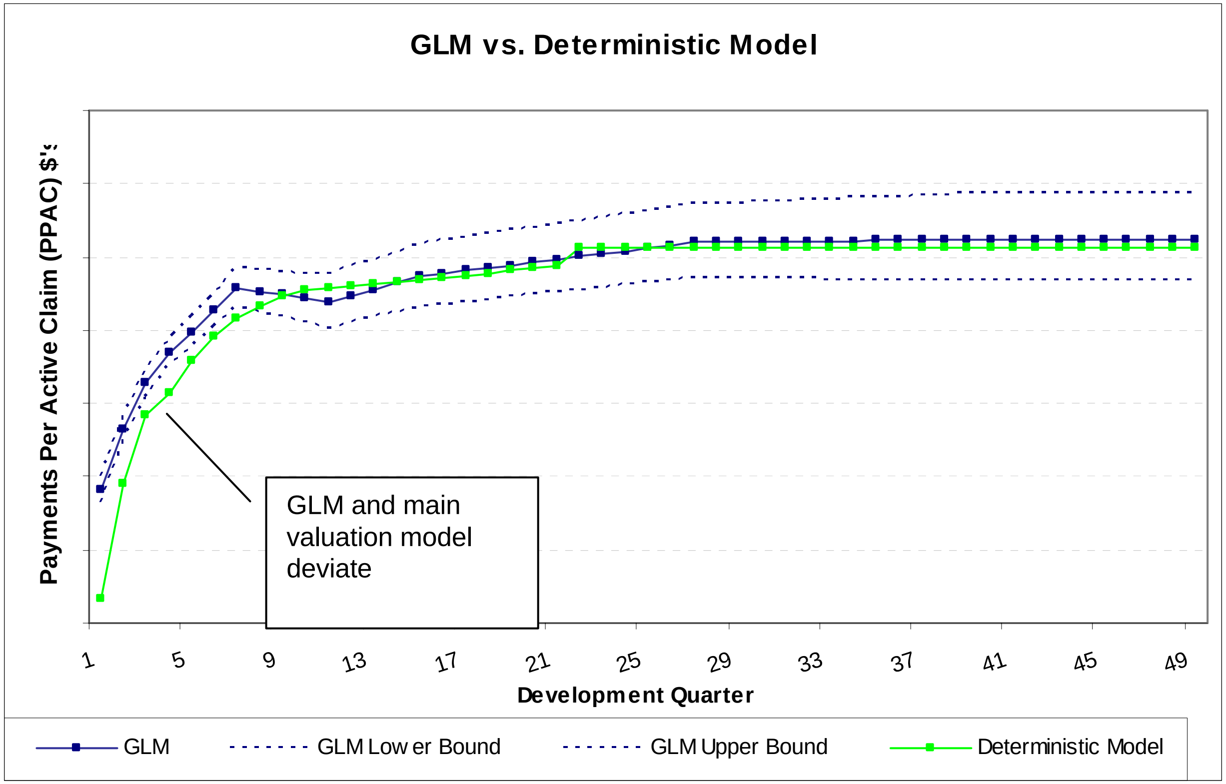
Model Parameter Estimates

Model Predictor	Formula	Estimate	Multiple
Intercept		10.4478	
Development Quarter = 0	(devqtr = 0)	-0.9972	37%
Development Quarter = 1	(devqtr = 1)	-0.5187	60%
Development Quarter = 2	(devqtr = 2)	-0.2301	79%
Development Quarter = 3	(devqtr = 3)	-0.0436	96%
Development Quarter (linear 3 to 7)	min(max(devqtr-3,0),7-3)	0.0624	106%
Development Quarter (linear 7 to 11)	min(max(devqtr-7,0),11-7)	-0.0090	99%
Development Quarter (linear 11 to 15)	min(max(devqtr-11,0),15-11)	0.0166	102%
Development Quarter (linear 15 to 27)	min(max(devqtr-15,0),27-15)	0.0067	101%
Development Quarter (linear 27 to 39)	min(max(devqtr-27,0),39-27)	0.0006	100%
Experience Quarter (linear 30 Jun XX to 31 Dec XX)	min(max(expqtr-93,0),30)	0.0036	100%

Continuance rates GLM | PPAC GLM | Superimposed inflation | Full reserve distribution

Comparison to deterministic model

- Some differences in the GLM for early development qtrs
- Compare well after qtr 12
- Should we investigate why there is a difference?



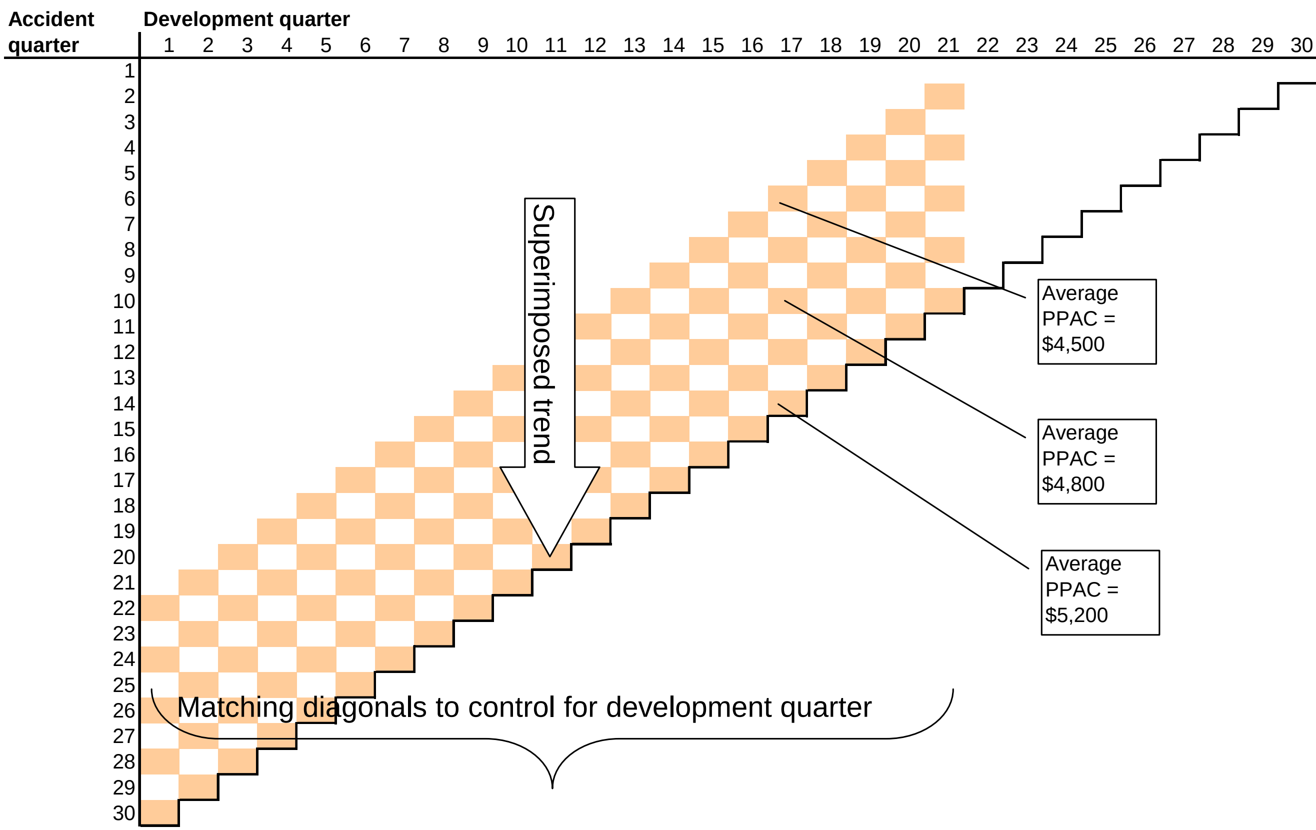
Continuance rates GLM → PPAC GLM → Superimposed inflation → Full reserve distribution

What is SI?

- SI - increase in claims costs across time (payment quarter), after controlling for all known cost drivers (Devqtr and Accqtr)

Deterministic estimation

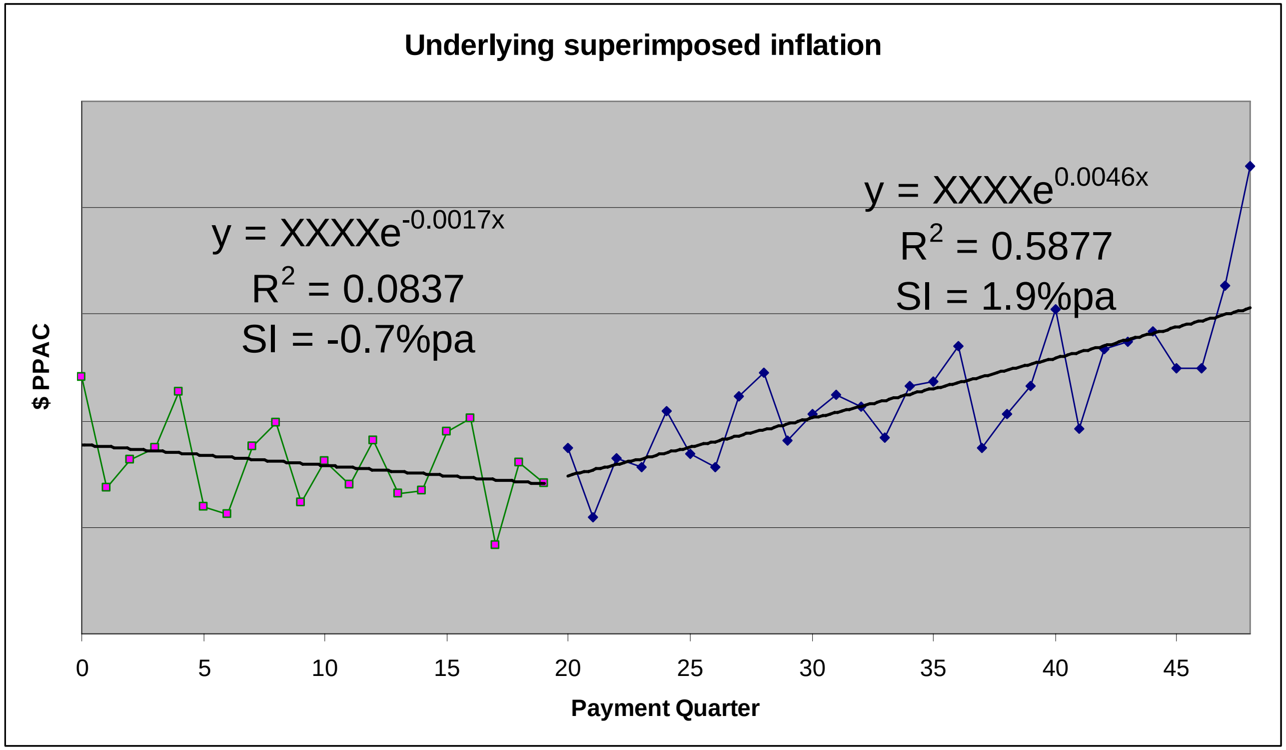
- Choose matching diagonals (or single Devqtrs)
- Estimate the increases in PPACs for the matched diagonals



Continuance rates GLM → PPAC GLM → **Superimposed inflation** → Full reserve distribution

Deterministic - Superimposed inflation in PPACs

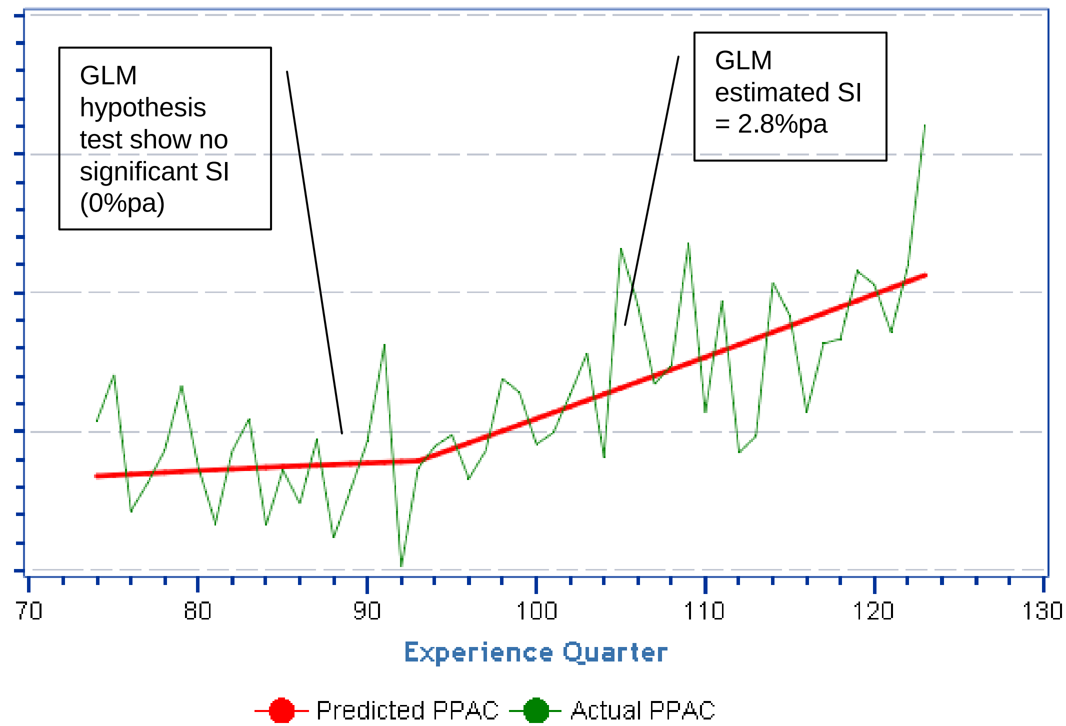
- Appears to be a flat period followed by an upward trend
- Log regression is used to estimate the underlying rates
- What R^2 is significant?



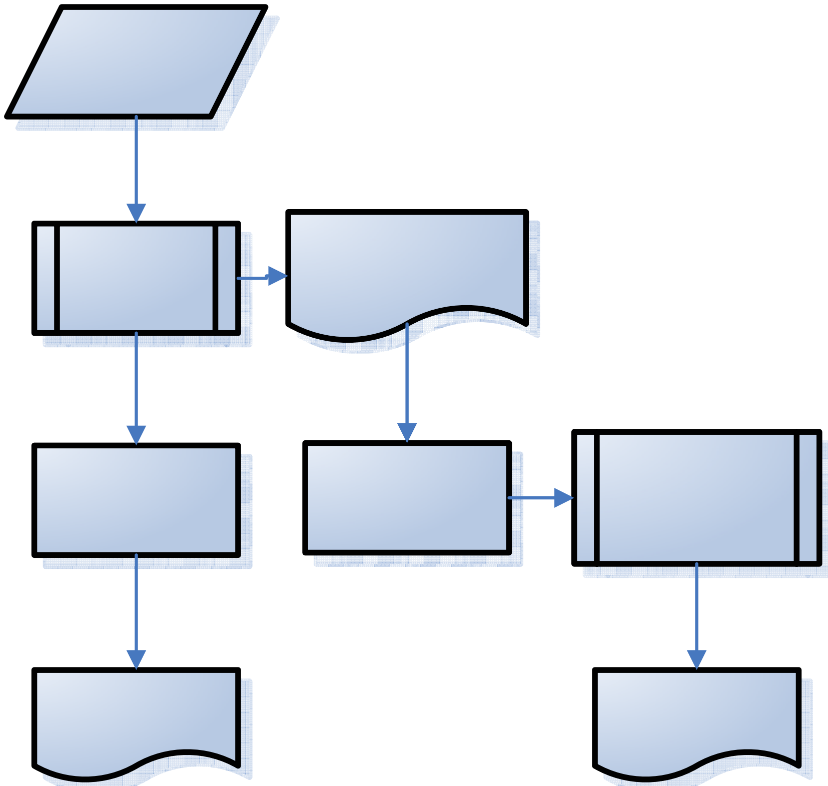
GLM Superimposed inflation in PPACs

- A linear segment is added from the beginning of the trend
- Slope of the estimate indicates an underlying SI of 2.8%pa
- Why might this be different? – Uses full triangle and correct error distribution
- But… what's the cause of the SI?

Underlying Superimposed Inflation from PPAC GLM



Continuance rates GLM → PPAC GLM → Superimposed inflation → **Full reserve distribution**



Process - Simulate from the GLM Parameters*

Step 1 - Generate a series of random sets of parameters for each model (continuance rates and PPAC). The distribution of the GLM parameters is assumed to be Multivariate Normal

Step 2 - Calculate the model predictions using each of the sets of parameters

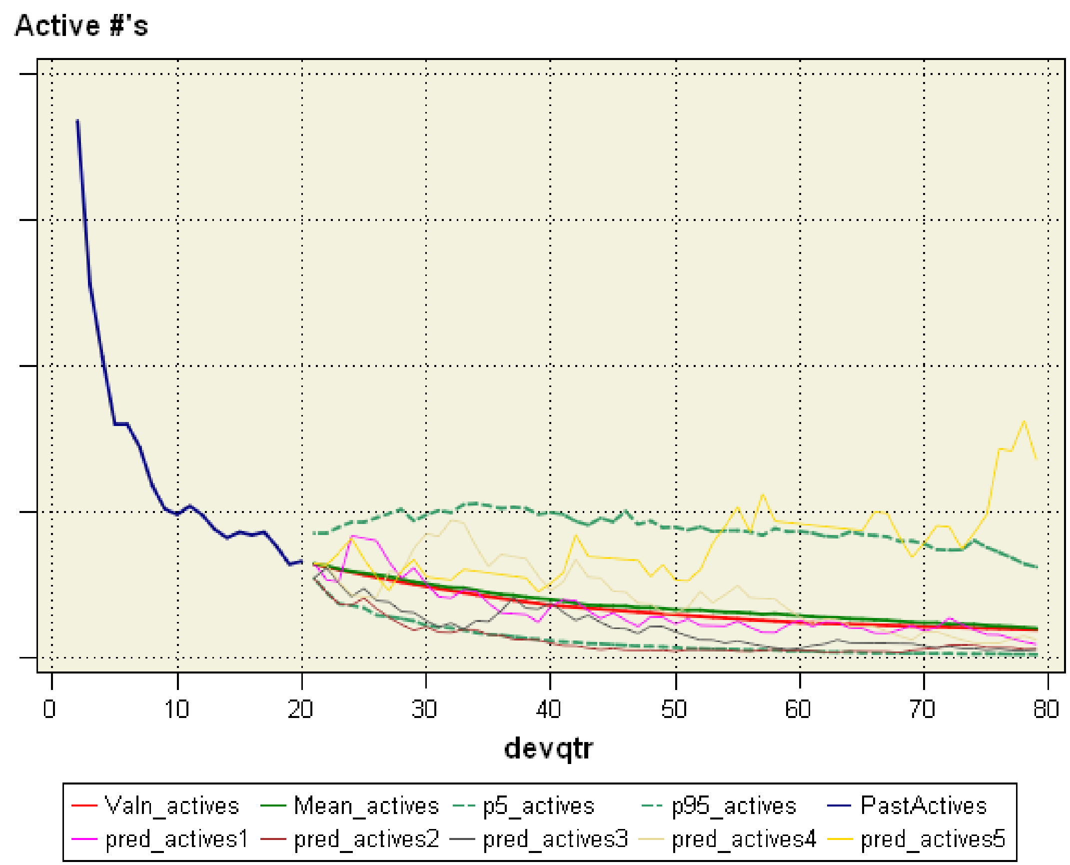
Step 3 - Generate a random observation from the process distribution (i.e. Poisson, Gamma)

Repeat for all future projection quarters, for each accident quarter.

* Source: England and Verrall (2002)

Simulation of Active Claim Numbers

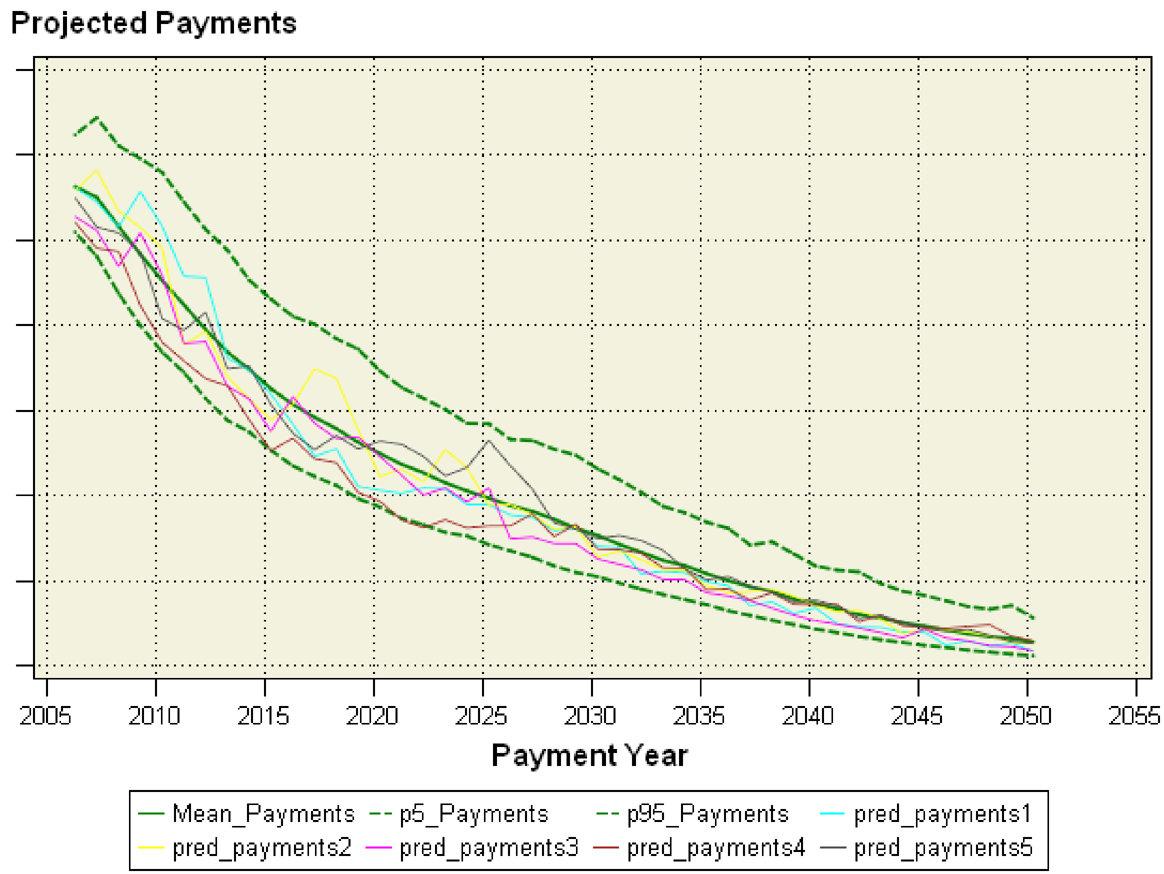
- A selected accident quarter’s projections are shown
- 5 simulations are displayed as well as the mean and 5th and 95th percentiles
- GLM simulated mean compares well with the valuation for this accident period



Continuance rates GLM → PPAC GLM → Superimposed inflation → Full reserve distribution

Simulation of Active Claim Numbers and PPACs

- Simulated cash flows are projected for the liability as at the valuation date
- The mean and 5th and 95th percentiles are calculated to show the implied the uncertainty



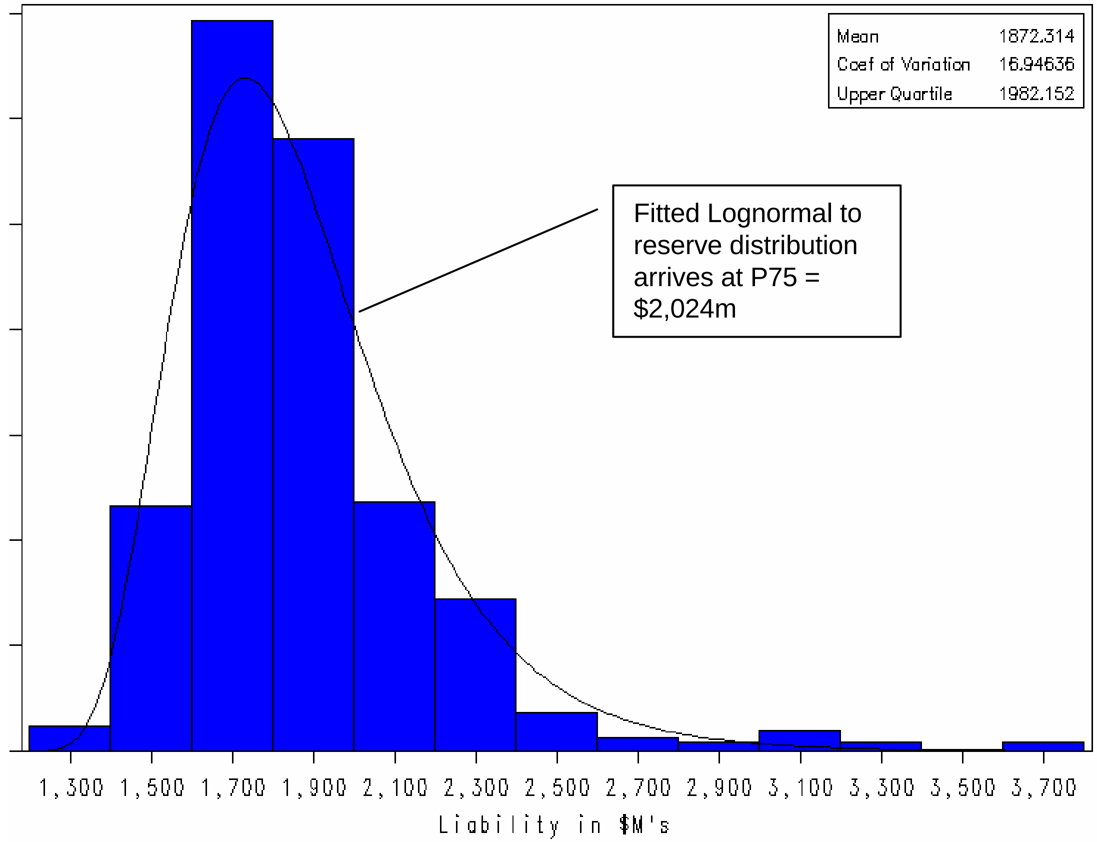
Continuance rates GLM → PPAC GLM → Superimposed inflation → **Full reserve distribution**

Central estimate

- Will not equal non-stochastic projection (must consider Jensen's inequality*)

Distribution of reserves

- Close to Lognormal but with a heavier tail (>99%)
- CoV and P75 can be determined directly



* Source: Taylor and Mulquiney (2005)

Advantages of Stochastic Reserving

1. **Superimposed inflation and trends** – statistical significance can be used to determine if trends are "real".
2. **Hypothesis testing** – impact of legislative changes, benefit changes, or any other claims administration changes
3. **Downside risk** - through estimation of full distribution the downside risk and hence risk margins can be estimated
4. **Individual claims modelling** – stochastic models are suitable for individual claims modelling
5. **Model update (control cycle)** – testing recent experience against the model we can determine if it needs to be updated

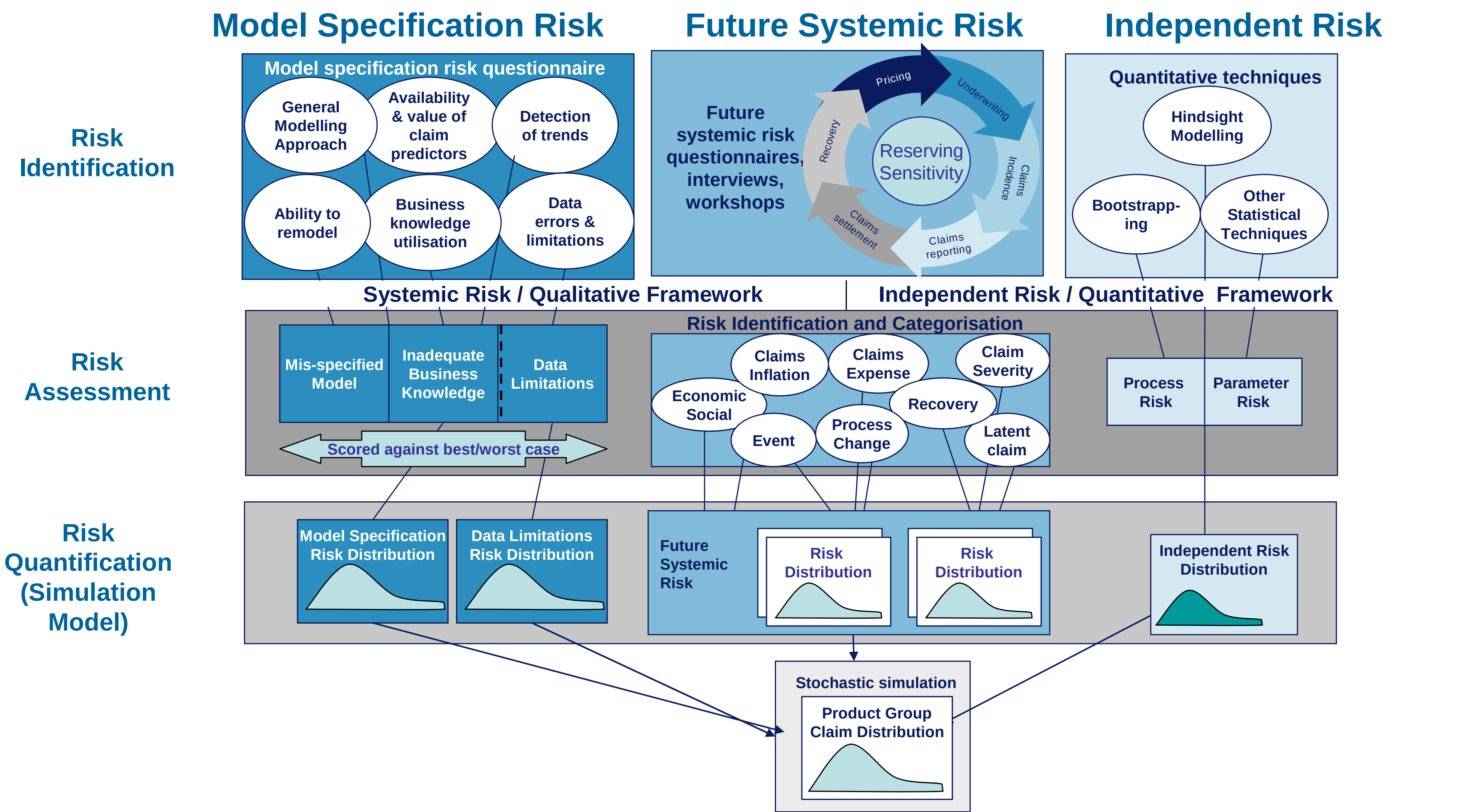
Disadvantages of Stochastic Reserving

1. **Less transparent** – can be harder to explain to management
2. **Reliable data** – generally more reliable data is required to construct a more sophisticated model
3. **Incorporating judgement** – more complex to overlay judgment based adjustments
4. **Costly and time consuming** – can be difficult to articulate the value
5. **Seen as the fix all** - If traditional methods fail then SR is unlikely to succeed…it's not an automatic fix
6. **Model variability NOT risk** – the past may not be a guide to the future

Risk Framework

Empirical estimation of the claims distribution….

- Workshop the key risk drivers
- Use qualitative and quantitative methods to assess the range of scenarios / outcomes due to a given risk driver.
- Risk assessment phase likely to include stochastic analysis
- Determine a distribution for each risk driver
- Use stochastic simulation to combine the major sources of uncertainty


Model Specification Risk
Future Systemic Risk
Independent Risk
Risk Identification
Model specification risk questionnaire
General Modelling Approach
Availability & value of claim predictors
Detection of trends
Ability to remodel
Business knowledge utilisation
Data errors & limitations
Future systemic risk questionnaires, interviews, workshops
Pricing
Underwriting
Claims Incidence
Claims reporting
Claims settlement
Recovery
Reserving Sensitivity
Quantitative techniques
Hindsight Modelling
Bootstrapp-ing
Other Statistical Techniques
Systemic Risk / Qualitative Framework
Independent Risk / Quantitative Framework
Risk Assessment
Mis-specified Model
Inadequate Business Knowledge
Data Limitations
Scored against best/worst case
Risk Identification and Categorisation
Claims Inflation
Claims Expense
Claim Severity
Economic Social
Recovery
Event
Process Change
Latent claim
Process Risk
Parameter Risk
Risk Quantification (Simulation Model)
Model Specification Risk Distribution
Data Limitations Risk Distribution
Future Systemic Risk
Risk Distribution
Risk Distribution
Independent Risk Distribution
Stochastic simulation
Product Group Claim Distribution

Summary

- Stochastic techniques are continuing to gain favour – part of tool suite
- They are not the magic answer but an important supplement / extension to current reserving practices
- Quantitative assessments should be combined with qualitative assessments to capture all aspects of risk

References

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