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Adjusting volatility for volume – how to turn up the noise for smaller books

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22 April 2024

Agenda

- **Specifying the problem**: what are we trying to achieve, and why?
- **Developing the solution:**
  - Bucket analysis of historical data
  - Bootstrapping
  - Survey data
- **Monitoring the results**: suggested parameters and next steps

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Specifying the problem

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Some case studies

Reserve risk:

- CoVs parameterised during 2024Q1, based on 2023 year-end data
- Used during 2024Q3, based on data as at 2024Q2, projected to 2024 year-end
- Mismatch between parameterised CoV and modelled reserves

Validation:

- Market benchmarks may be used to sense check selected volatility parameters
- The market will typically be much larger than a single firm, and hence less volatile
- Mechanism is needed to ensure a fair comparison

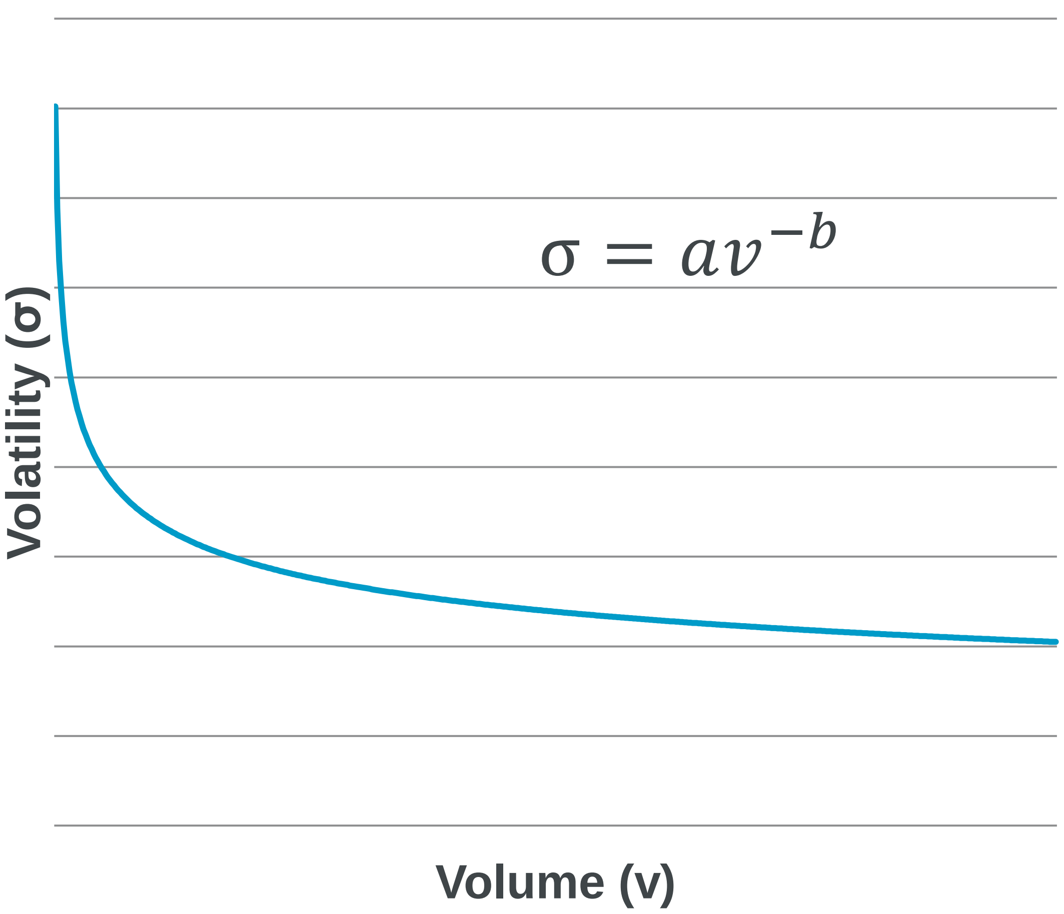
Sensitivity/scenario testing:

- Change to volume, eg stretch view of business plan
- All else being equal, this would imply a reduction in volatility
- Unlikely the capital team have scope or appetite to re-parameterise from scratch

Roll-forward:

- Not every parameter in a capital model needs to be updated every year
- However, making no adjustment leaves door open for validation challenge
- Growing books would expect to see year-on-year reductions in volatility (and vice versa)

Approach



- Power curve
- “a” parameter does not affect calculations: focus is on fitting “b”
- **Core concept**: b takes non-negative values:
  - Zero implies no sensitivity: volatility is invariant to volume (unlikely)
  - 1 implies volatility is inversely proportional to volume (also unlikely)
  - Higher values of b imply increasing volume has greater effect on volatility, ie the business has more specific risk
  - Conversely, lower values of b imply more systemic risk

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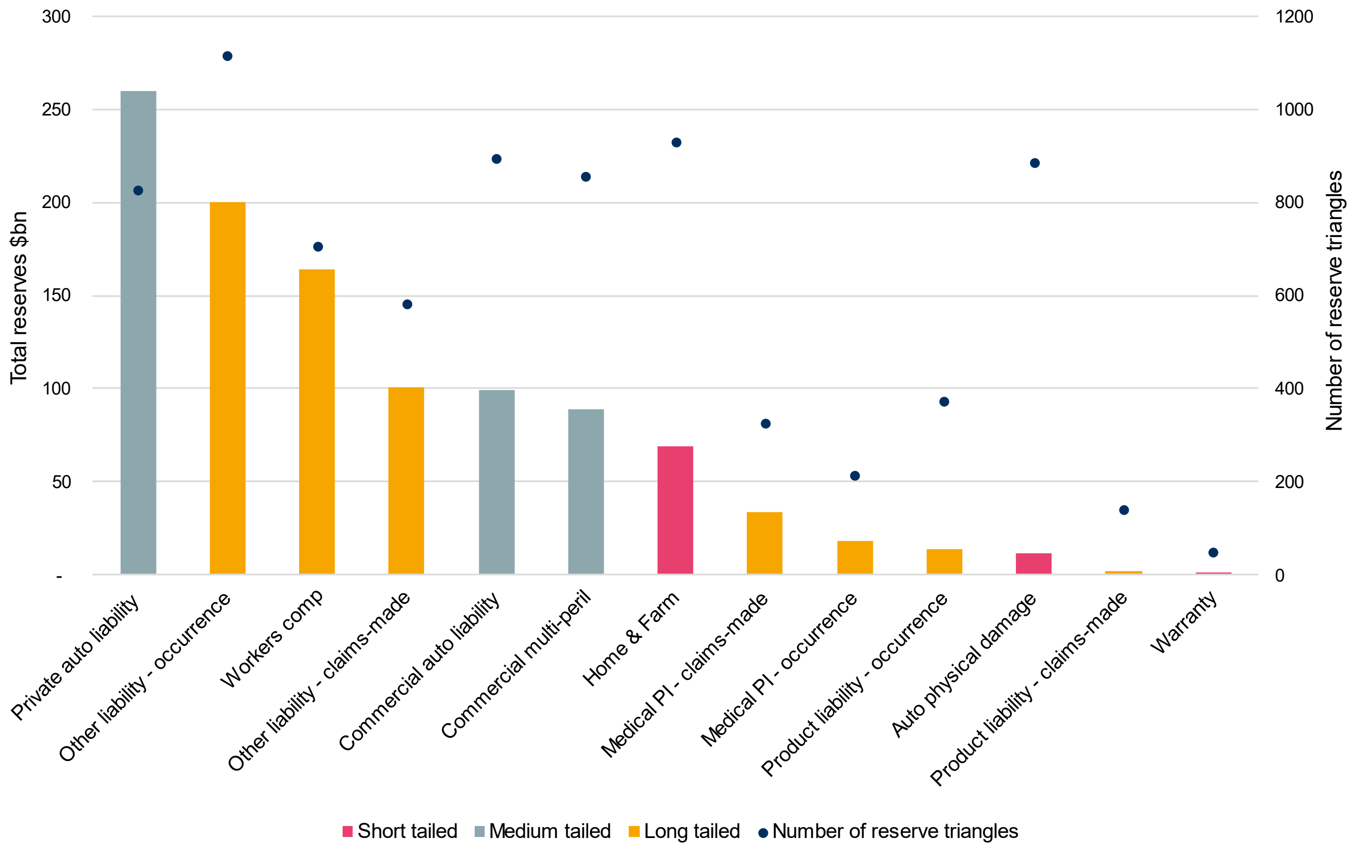
Approach

- Biggest and most comprehensive dataset we have access to is Schedule P of the National Association of Insurance Commissioners (NAIC) return
- We have used two different high-level approaches:
  - Bucket analysis of one-year reserve movements observed historically
  - Bootstrapping of reserve triangles and analysis of the calculated CoVs
- Other supporting analyses:
  - Additional factors: class of business and/or cohort
  - Data from APRA (Australian Prudential Regulation Authority)
  - LCP capital benchmarking survey data

Schedule P dataset



- Total reserves of $937 bn
- 13 reserving classes
- Data over the period 2011 - 2022
- Data cleaning:
  - Removed outlier reserve deteriorations
  - Removed negative reserves

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Designing the solution

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Bucket analysis

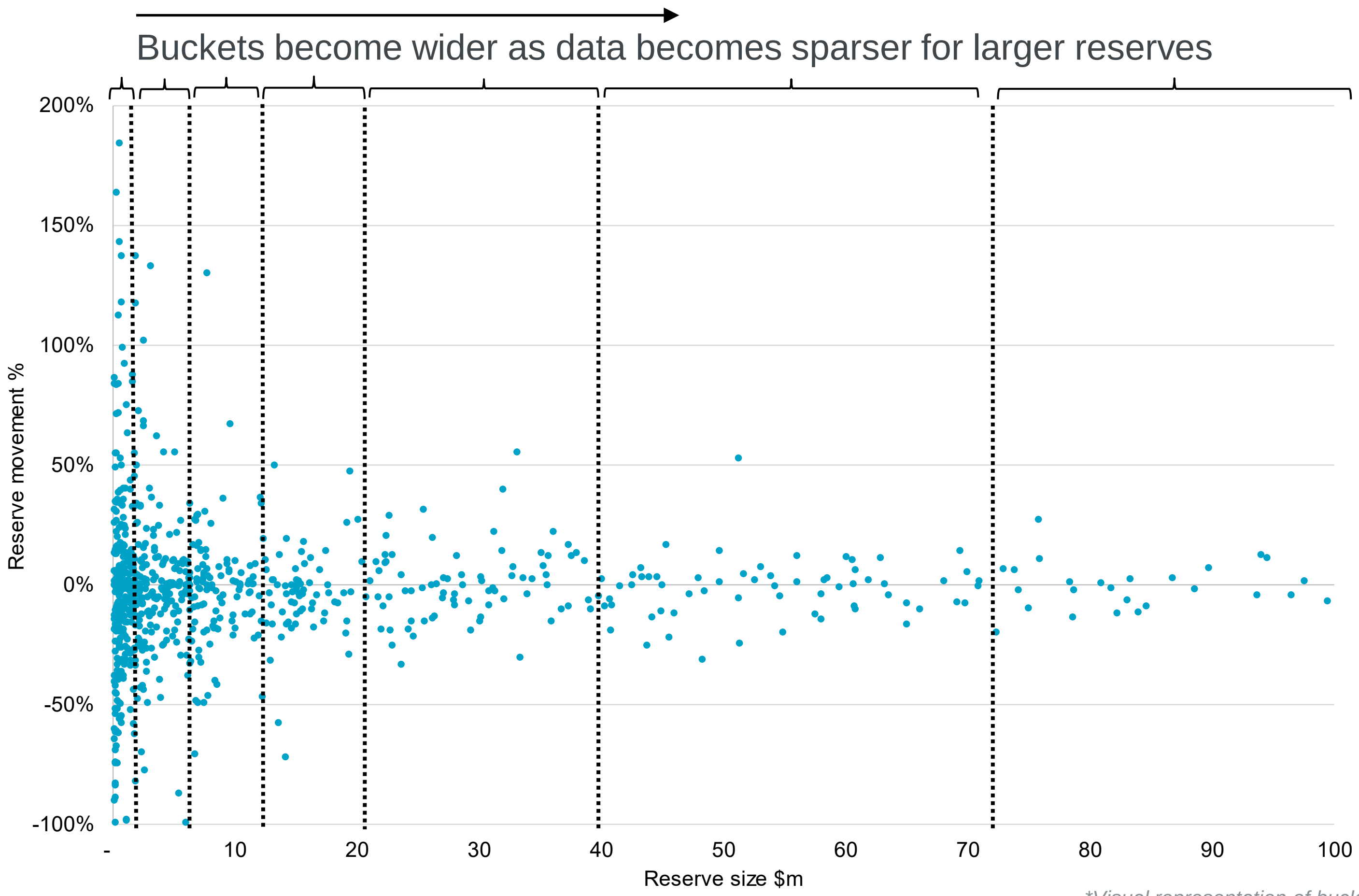
Calculate reserve deteriorations → Order deteriorations by reserve size

↓

Partition data into buckets of uniform reserve size → Calculate volatility of deteriorations in each bucket

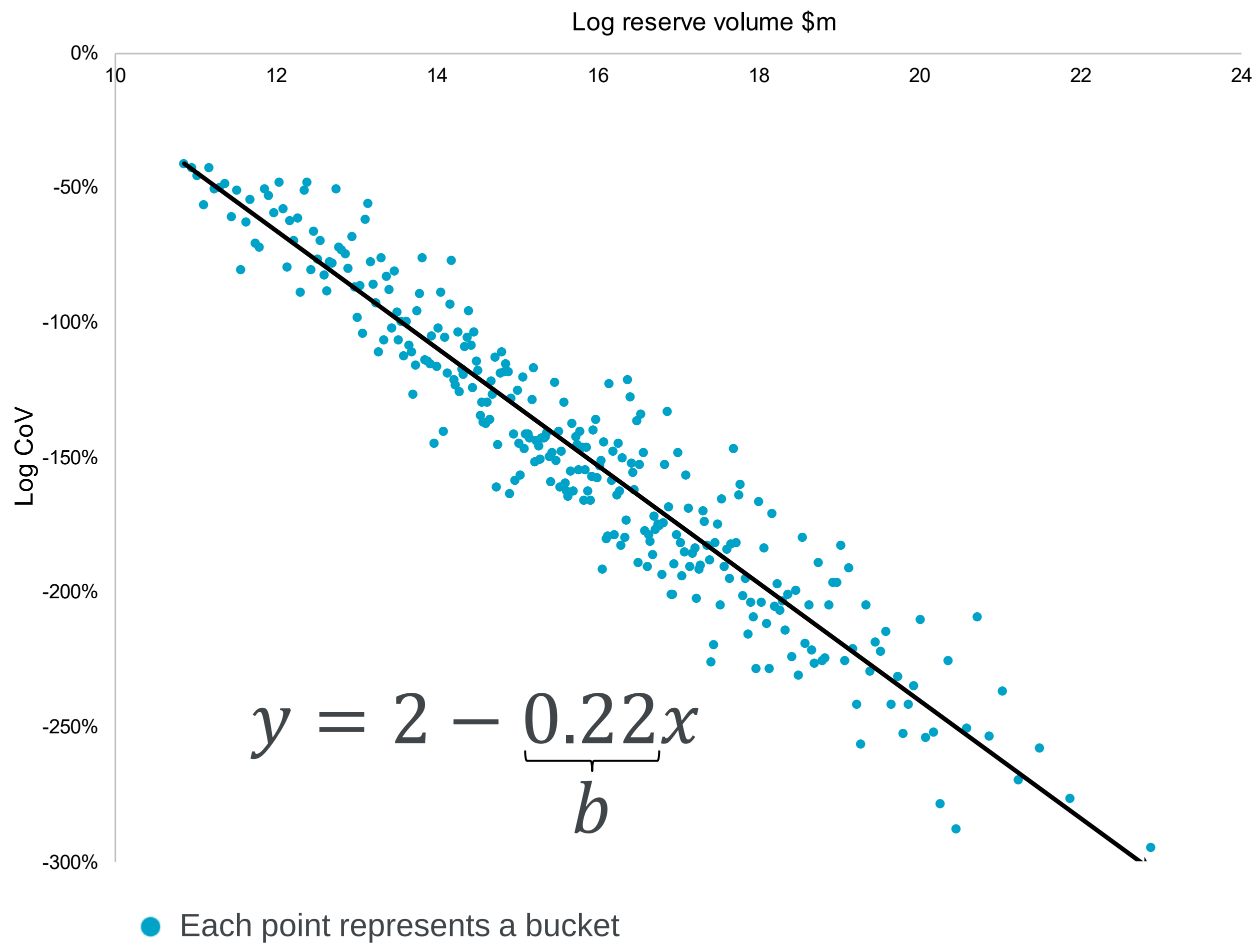
↓

Bucket volatility vs Bucket mean reserve size



*Visual representation of bucketing

Bucket analysis results – total level



- **Strong log-linear relationship between reserve volume and volatility**
- Implies the relationship $\sigma = av^{-b}$ holds, with **b = 0.22**
- Observed r-squared value of 91% – great model fit!
- Further attempted to fit model $\sigma = av^{-b} + \rho$ where ρ can be interpreted as systemic, undiversifiable volatility
- Findings: $\rho = 0$ provided the best model fit

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Results – class level

$$\sigma = a_i v^{-b}$$

Model now also using class as a predictor:

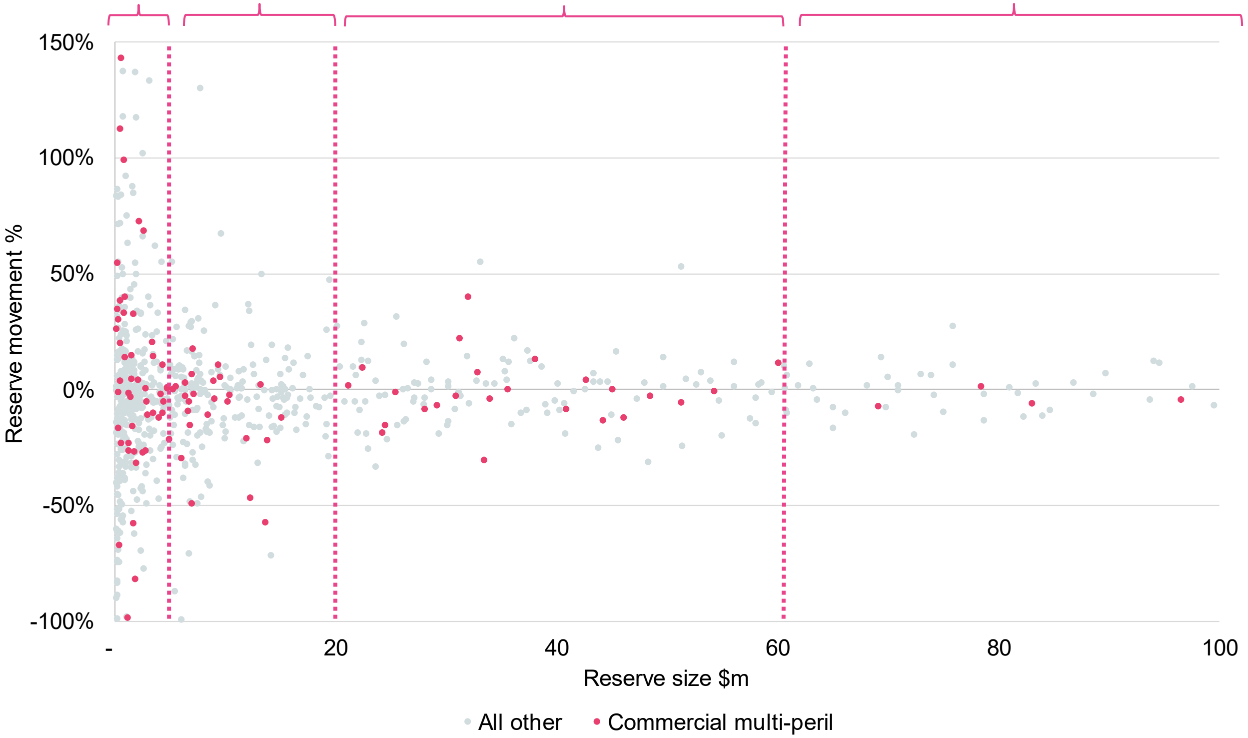
- Specific a_i for each class of business
- Obtain value of $\hat{b} = 0.22$
- R-squared value of 90% - lower than total model

$$\sigma = a_i v^{-b_i}$$

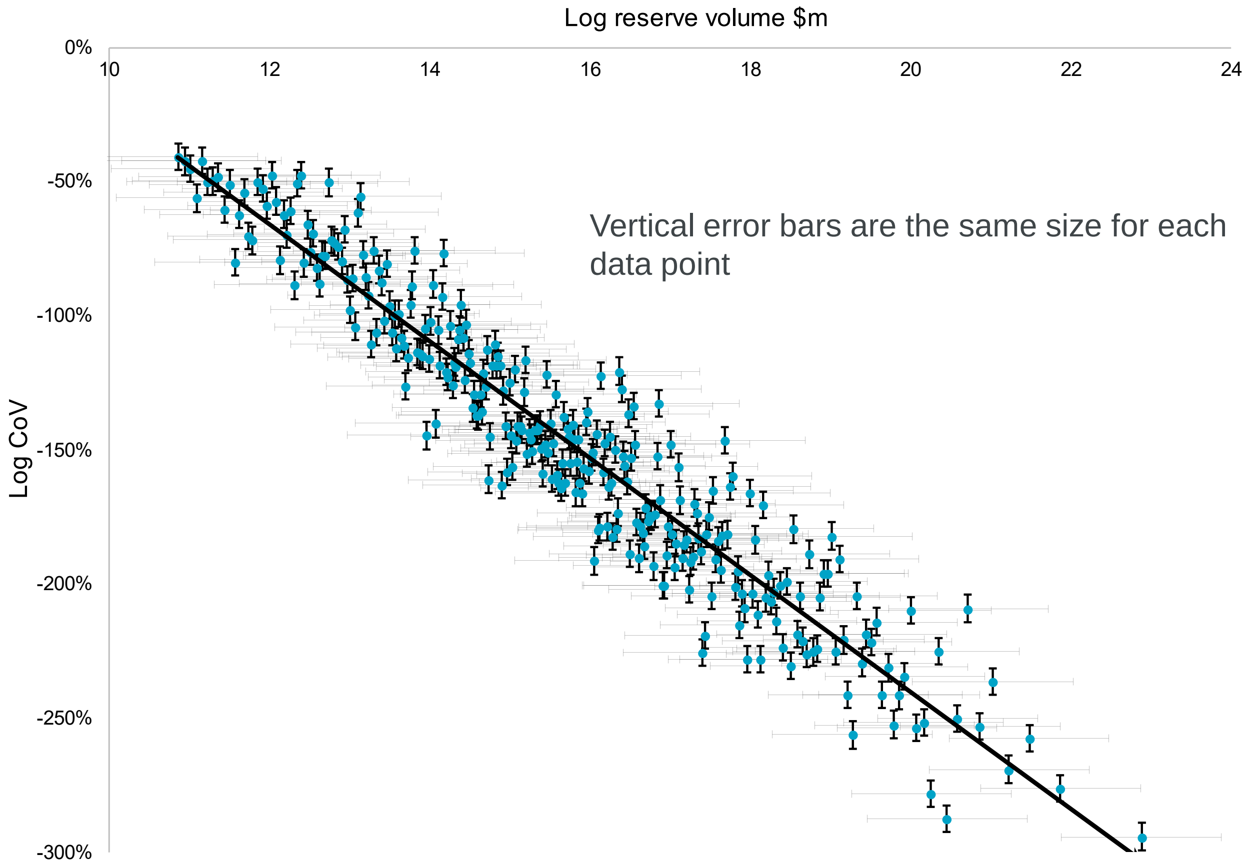
- Specific a_i and b_i for each class of business
- $\hat{b_i}'s$ range from 0.12 to 0.28
- R-squared value of 92% - only slight improvement

Trade-off between homogeneity in class vs reserve size

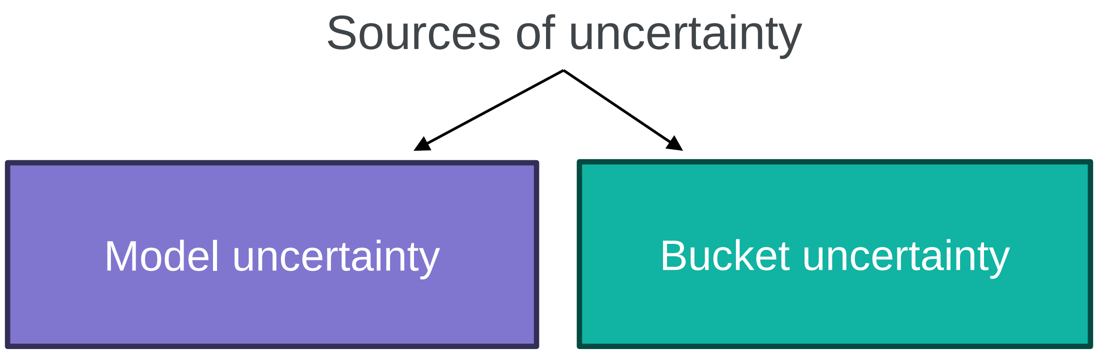
Class specific buckets are wider – less homogeneity in reserve size within each bucket



Bucket analysis – uncertainty



Vertical error bars visualise uncertainty in the CoV estimate of the bucket



- Model uncertainty is very low: $se(\hat{b}) = 0.004$
- Quantifying CoV for each bucket creates **vertical bucket uncertainty**

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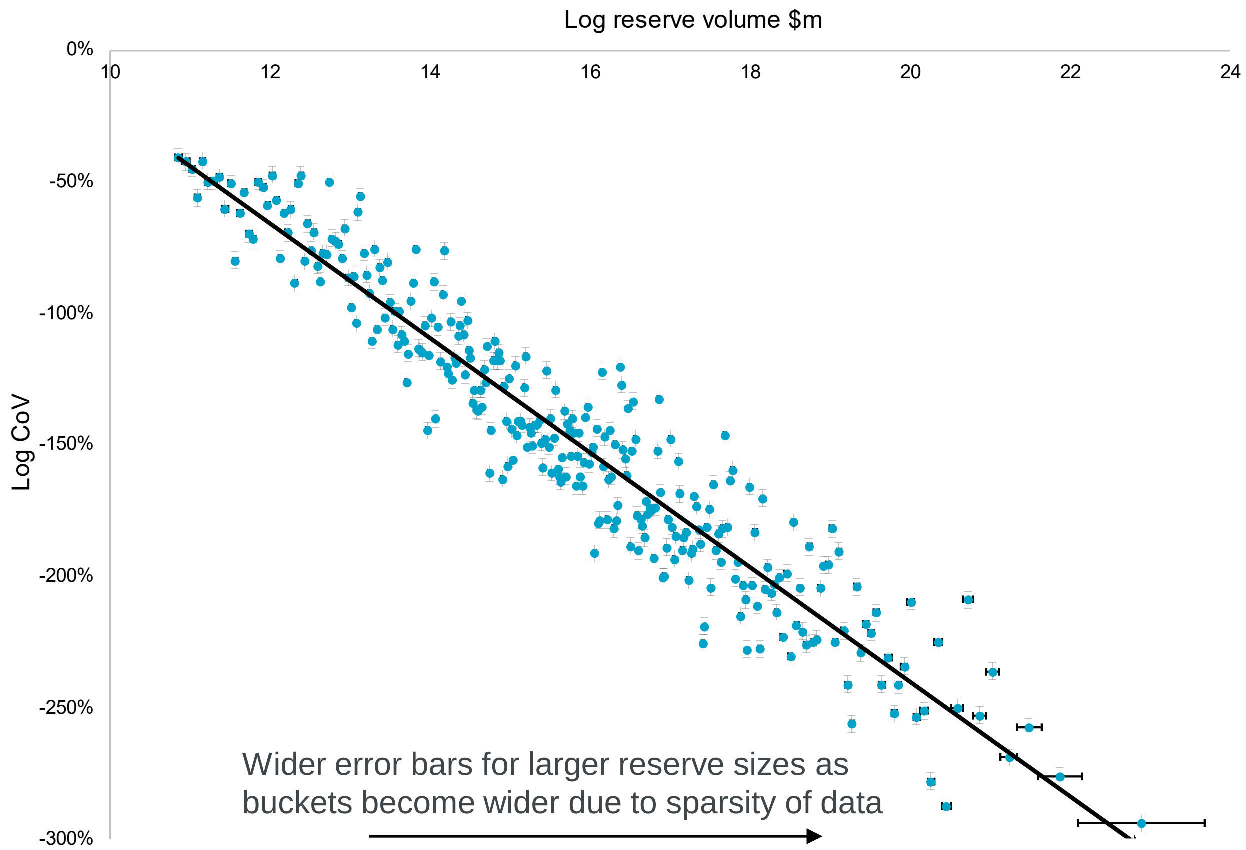
Bucket analysis – uncertainty



Horizontal error bars visualise range of reserve sizes within a bucket

Sources of uncertainty

Model uncertainty

Bucket uncertainty

- Model uncertainty is very low: $se(\hat{b}) = 0.004$
- Quantifying reserve volume for each bucket creates **horizontal bucket uncertainty**

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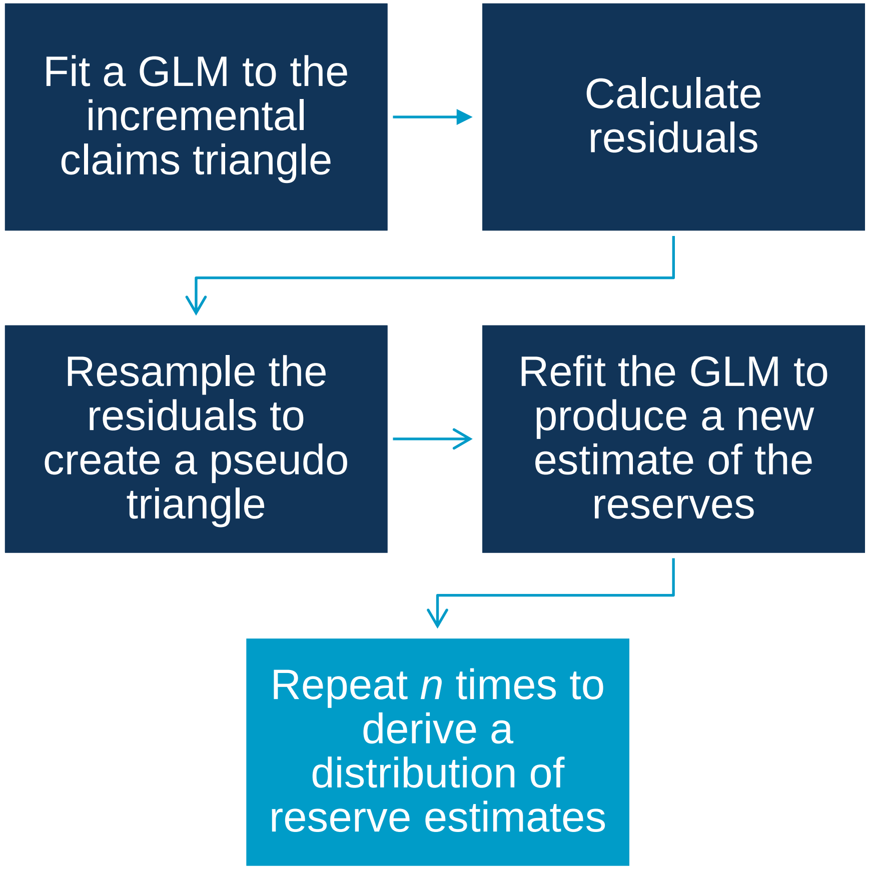
Bootstrapping



Benefits

- Purely data driven – not reliant on reserving actuary's estimates
- 10,000 simulations used – low uncertainty in CoV estimate

Limitations

- Data:
  - Market data
  - High residuals and therefore CoVs
- No tail factor used

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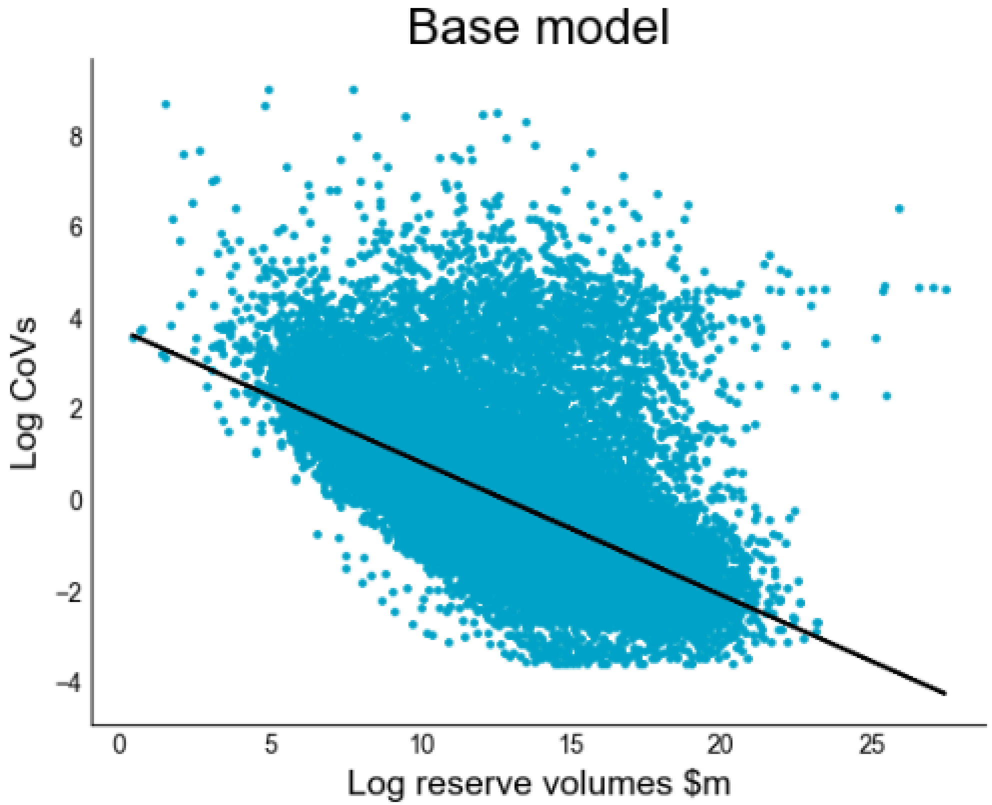
GLM



Model		$\hat{b}$	R-squared
Base model	$\sigma = av^{-b}$	0.29	33%
Class model	$\sigma = a_i v^{-b}$	0.28	40%
Cohort model	$\sigma = a_j v^{-b}$	0.26	35%
Class and cohort model	$\sigma = a_{ij} v^{-b}$	0.25	42%

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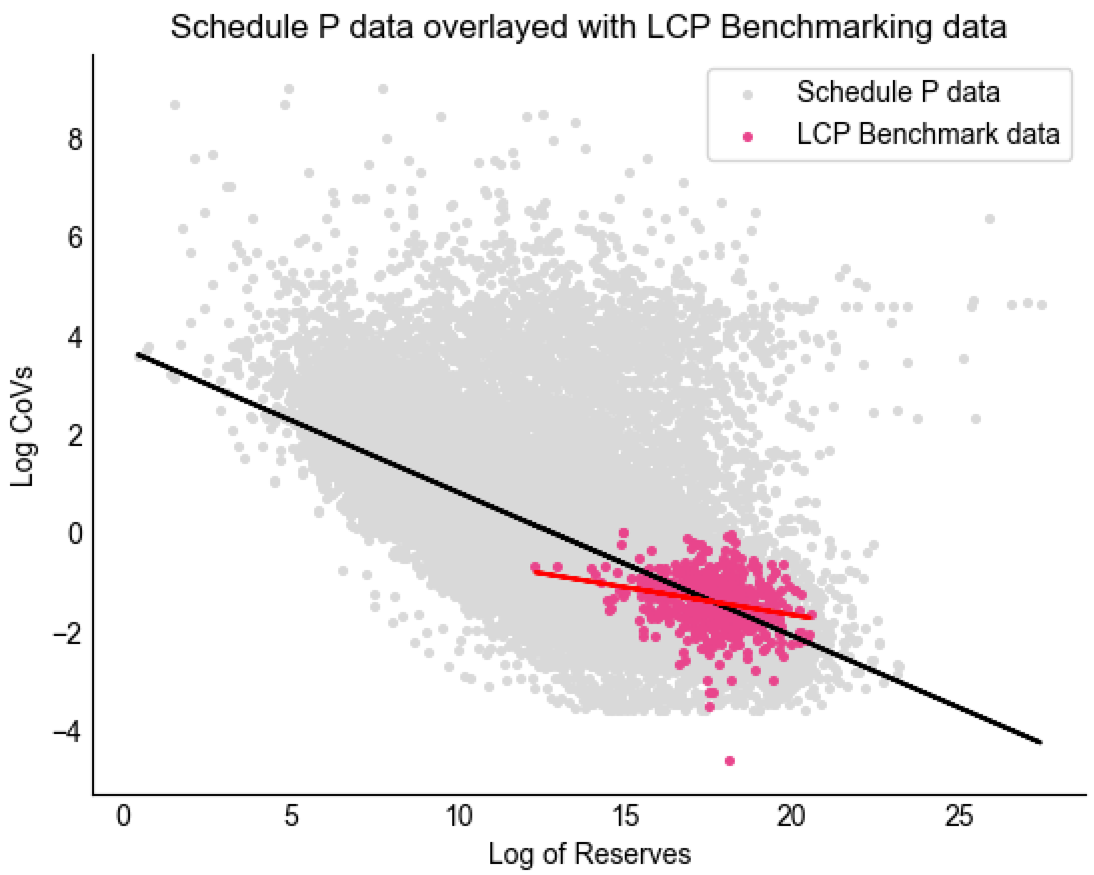
LCP Capital benchmarking survey

- 37 respondents across the London market during April 2024
- Collected data on reserve volume and CoVs for each respondent's classes of business

$$\sigma = av^{-b}$$

Model fit to LCP benchmarking data:

- Obtained value of $\hat{b} = 0.11$
- Low sensitivity of parameterised CoVs to changes in reserve volume

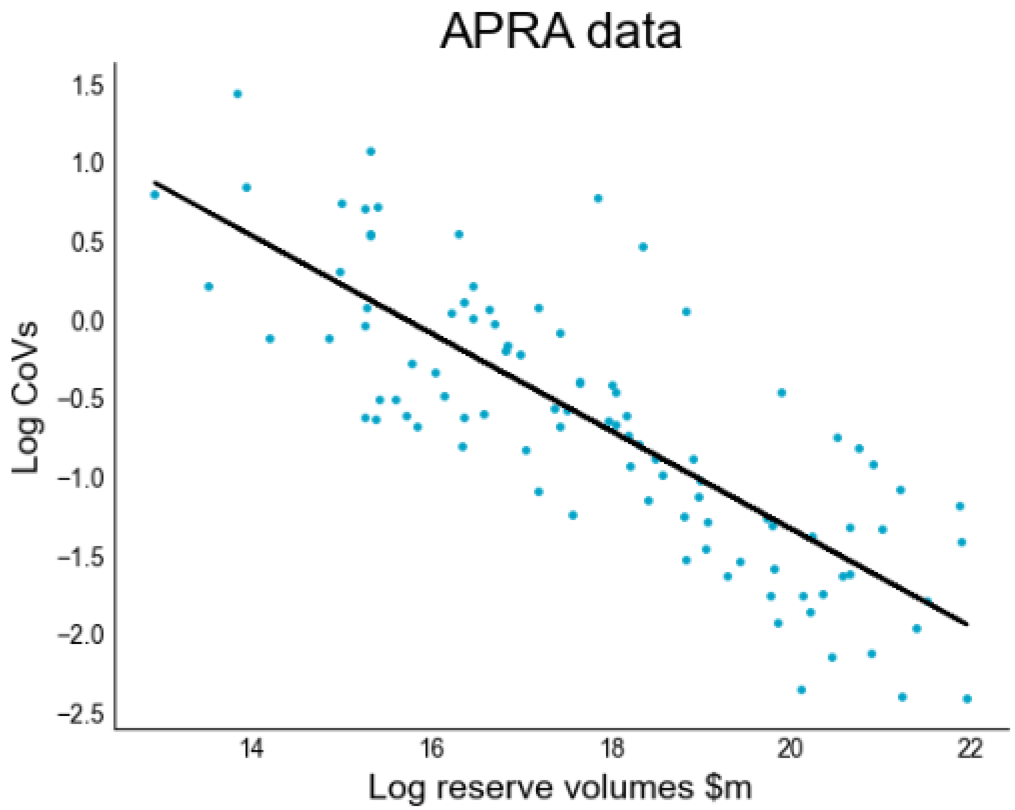


Other market datasets: APRA

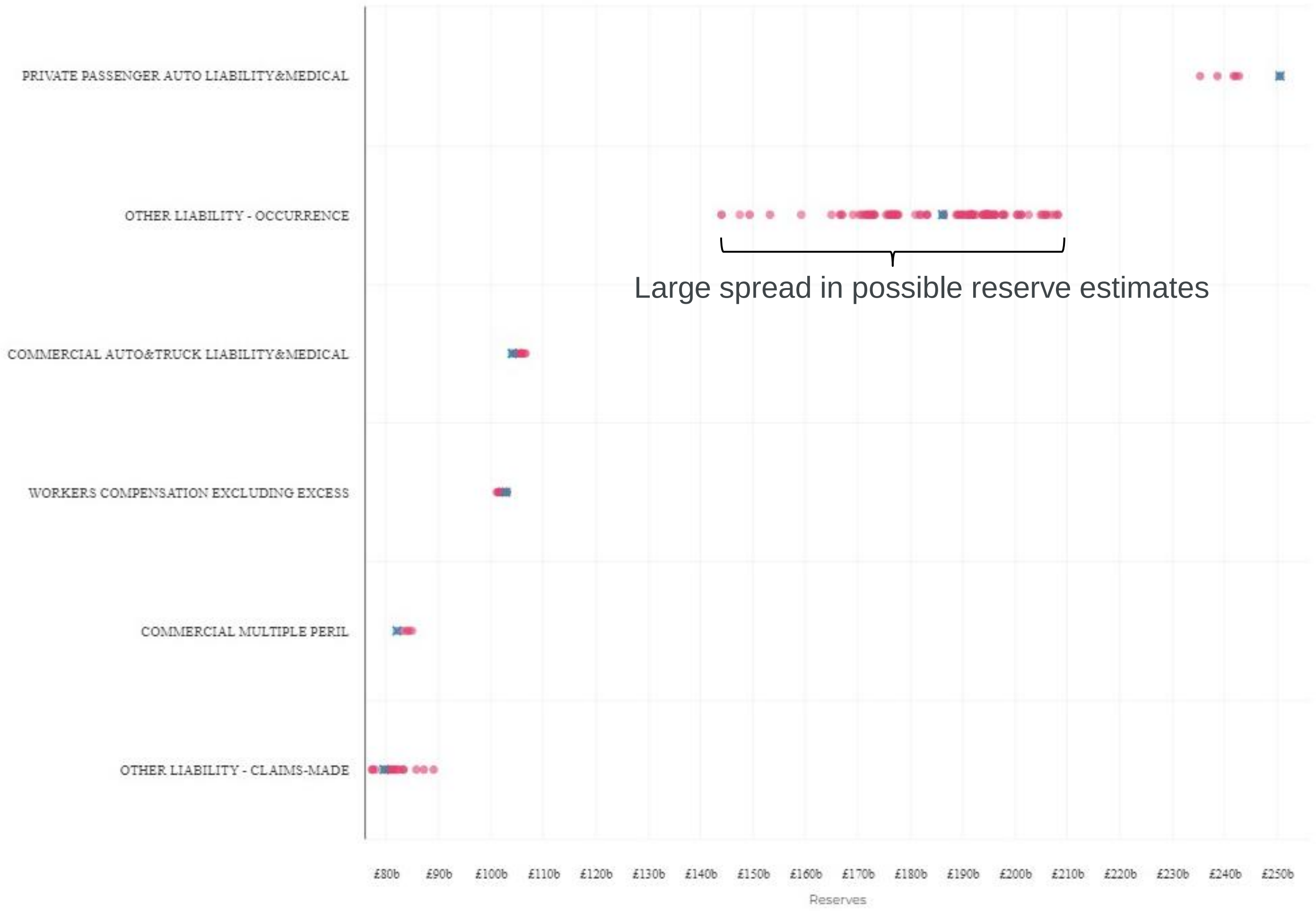
- Australian equivalent to Schedule P data
  - Total reserves < $50bn (AUD)
  - 16 classes of business

$$\sigma = av^{-b}$$

- Obtain value of $\hat{b} = 0.31$
- R-squared value of 66% - significantly better model fit than Schedule P



Universe of reserves



- InsurSight – LCP's analytics reserving software
- Chart shows the possible range of reserve estimates from using different reserving assumptions

- Each pink dot represents a different set of reserving assumptions
- ✖ Blue cross represents Insursight's automatic selection

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Monitoring the solution

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Conclusion

Summary of results

	Dataset	Segmentation	$\hat{b}$	R-squared
Bucket Analysis	**Schedule P**	**Base model**	**0.22**	**91%**
	Schedule P	Class model 1	0.22	90%
	Schedule P	Class model 2	0.12 – 0.28	92%
Bootstrap	Schedule P	Base model	0.29	33%
	Schedule P	Class model	0.29	40%
	Schedule P	Cohort model	0.26	45%
	Schedule P	Class and cohort model	0.25	42%
	APRA	Base model	0.31	66%
Survey data	LCP Benchmarking	Base model	0.11	10%

Some maths

Equation 1: $\sigma_T = a v_T^{-b}$

Equation 2: $\sigma_R = a v_R^{-b}$

Where σ_T and v_T are the volatility (CoV) and volume of the target distribution, and σ_R and v_R are the volatility (CoV) and volume of the reference distribution

Eq 1 divided by Eq 2 gives: $\frac{\sigma_T}{\sigma_R} = \frac{a v_T^{-b}}{a v_R^{-b}} \implies \sigma_T = \sigma_R \left(\frac{v_T}{v_R}\right)^{-b}$

or, equivalently: $\sigma_T = \sigma_R \left(\frac{v_R}{v_T}\right)^{b}$

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Uses

Reserve risk:

- CoVs parameterised during 2024Q1, based on 2023 year-end data
- Used during 2024Q3, based on data as at 2024Q2, projected to 2024 year-end
- Adjust CoVs for movement in reserves between year-ends

Validation:

- Market benchmarks may be used to sense check selected volatility parameters
- The market will typically be much larger than a single firm, and hence less volatile
- Scale down market benchmarks to compare on like-for-like basis with model

Sensitivity/scenario testing:

- Change to volume, eg stretch view of business plan
- All else being equal, this would imply a reduction in volatility
- Adjust selected parameters to allow for proposed changes

Roll-forward:

- Not every parameter in a capital model needs to be updated every year
- However, making no adjustment leaves door open for validation challenge
- Decrease parameters to allow for year-on-year increases in volume (and vice versa)

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Next steps

- Suggested parameter: b = 0.22
- Some possible refinements to model: eg to better understand effects of class
- Further research angles possible:
  - Comparisons of industry data with benchmark data
  - Analysis of capital axioms, eg use of lognormal to model reserve deteriorations
- Please get in touch if you have suggestions!

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Questions

Comments

Expressions of individual views by members of the Institute and Faculty of Actuaries and its staff are encouraged.

The views expressed in this presentation are those of the presenter.

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