The Actuarial Profession
making financial sense of the future

GIRO Convention

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Granular Loss Modelling

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Granular Loss Modelling

- This workshop presentation can be regarded as an extension of our workshop given at GIRO 2007:
  - **Granular Reserving – Making Best Use of Your Claims and Policy Data**
- Specifically we are going to:
  - Consider IBNER, ie reserves on those losses already reported
  - Describe our general approach for model building and validation
  - Illustrate the benefits of such an approach

Granular Loss Modelling: Summary

- Introduction to Some More Sophisticated Approaches to Reserving
- Granular Loss Models (GLM)
- Data Example
- Effect on Reserving
- Effect on Pricing
- Effect on Capital
- Close

More Sophisticated Approaches to Reserving

- Granular Data
- Generalized Linear Models
- More Complex Models
- Pros and Cons

More Sophisticated Approaches to Reserving

What we mean by Granular?

- Claim by claim database:
  - Time series of paids, incurreds, status, etc.
  - Other data relating to the claim such as; cause of claim, claims handler, etc.
- Policy by policy database:
  - All rating factors used in pricing the policy
  - Other data entered onto the underwriting system such as underwriter, etc.

More Sophisticated Approaches to Reserving

Granular Data

- Data Structure: Traditional triangle => granular triangle => Design matrix and response vector

- Traditional Triangle

RP	DP1	DP2	DP_3	….	Ultimate
2004	Paid2004_DP1	Paid2004_DP2	Paid2004_DP3	….	FinalLoss_2004
2005	Paid2005_DP1	Paid2005_DP2	Paid2005_DP3	….	FinalLoss_2005
…	…..	…..	…..		…..

- Granular Triangle

RP	DP1	DP2	DP_3	….	Ultimate
2004	Paid_Claim1_DP1	Paid_Claim1_DP2	Paid_Claim1_DP3	….	Final_Paid_Claim1
2004	Paid_Claim2_DP1	Paid_Claim2_DP2	Paid_Claim2_DP3	….	Final_Paid_Claim2
2004	Paid_Claim3_DP1	Paid_Claim3_DP2	Paid_Claim3_DP3	….	Final_Paid_Claim3
…	…..	…..	…..		….

- Design and Resposne

Design Matrix and Vector of Responses

ID Paid DP Region Premium OS AY ….		Paid_Next_DP
…….		…….
…….		…….

More Sophisticated Approaches to Reservings

Generalized Linear Models (1)

- The Linear Model:

$$\text{Data} = \text{Signal} + \text{Noise}$$

$$\mathbf{Y} = X\beta + \boldsymbol{\varepsilon}$$

where $\boldsymbol{\varepsilon} \sim N(0, \sigma^2 I)$

This is equivalent to saying $\mathbf{Y} \sim N(X\beta, \sigma^2 I)$

More Sophisticated Approaches to Reserving

Generalized Linear Models (2)

- The Linear Model: $\mathbf{Y} \sim N(\mu = X\beta, \text{VarCov} = \sigma^2 \, \text{diag}(1))$
- The GLM: $\mathbf{Y} \sim F(\mu = h(X\beta), \text{VarCov} = \sigma^2 \, \text{diag}(v(\mu_i)))$
- Extensions:
  - Normal distribution may be replaced by Gamma, Binomial, etc
  - Expectation is no longer necessarily a linear function
  - Variance is no longer necessarily constant

More Sophisticated Approaches to Reserving

More Complex Models

- Mixed Models
- Correlated Observations
- Non parametric link functions
- Generalized Additive Models

Eg Repeatedly observing the same claim

More Sophisticated Approaches to Reserving

Advantages of Granular

- Multi-way analysis of individual claim and policy information
  - Eg One way vs Two way analysis
- Deeper understanding specific to Class of Business
- Data collection and recording processes
- Direct benefits: reserving, pricing, capital

More Sophisticated Approaches to Reserving

Advantages of Granular

Standard Pricing Example (1) of how mix changes can lead to a distorted view when performing one way analyses:

Two-Way analysis

		Car Value		
LR		**Low**	**High**	
Driver Age	**Young**	57%	90%	59%
	Old	30%	40%	35%
		54%	54%	

		Car Value		
Exposure		**Low**	**High**	
Driver Age	Young	700	40	740
	Old	100	100	200
		800	140	940

One-Way Analyses

Car Value	
Low	**High**
54%	54%

Driver Age	
Young	**Old**
59%	35%

More Sophisticated Approaches to Reserving

Advantages of Granular

Standard Pricing Example (2) of how mix changes can lead to a distorted view when performing one way analyses:

Two-Way analysis

LR		District A	District B	
Driver Age	Young	80%	80%	80%
	Old	40%	40%	40%
		48%	72%	

Exposure		District A	District B	
Driver Age	Young	200	800	1000
	Old	800	200	1000
		1000	1000	2000

One-Way Analyses

District A	District B
48%	72%

Driver Age Young	Driver Age Old
80%	40%

More Sophisticated Approaches to Reserving

Disadvantages

- Cost –time, people, complexity
- Not trivial to improve on the VWCL
- Model Error (do not press the button !!!)

Granular Loss Model

Model Building and Validation

- Our General Approach
  - Data Collection and Manipulation
  - Identifying Main Drivers
  - Model Comparison and Validation
- Example

Granular Loss Model

Data Collection and Manipulation

- The Importance of Transforming and Grouping
- The way rating factors are grouped or transformed is **PART** of the model
  - Eg. Age, Premium etc: qualitative or quantitative?
  - Eg. Post-Code
- The “bad” approach
- Simplicity vs Fit

Granular Loss Model

Identifying Main Drivers

- Literature suggestions
  - P-values, F-test. AIC, BIC, etc
  - Fwd and Bkwd Variable Selection procedures
  - Data reduction techniques (PCA)
  - Analysis of Residuals

- Our suggestion: Simplicity & Meaningfulness & AvE

Granular Loss Model

Model Comparison and Validation

- **Our Approaches**

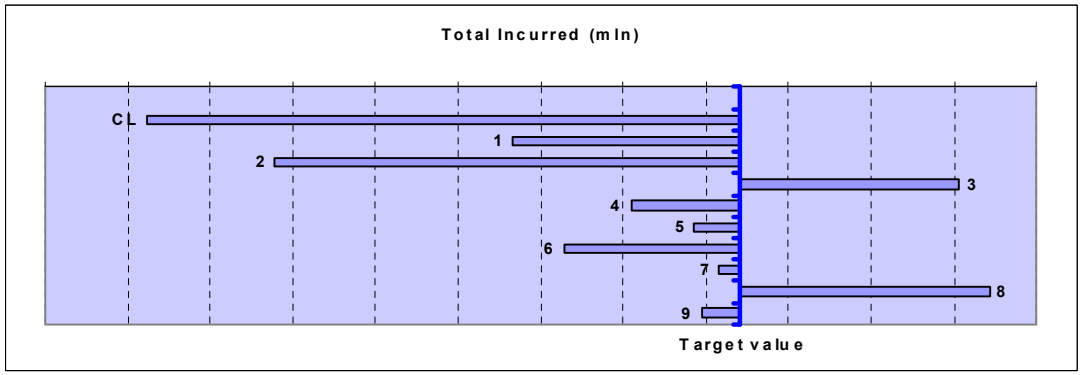
- **1. Performance on Diagonals**
  - Exclude the last observed loss for each claim
  - Fit the model on the remaining history and then evaluate the model in predicting the last development of the claims

- **2. Hold in-out Bootstrap**
  - 1. Split Data into Hold-IN data (to fit model) and Hold-OUT data (to evaluate model)
  - 2. Simulate Hold-IN and Hold-OUT data by random splitting
  - 3. Fit models on Hold-IN data and evaluate them in terms of average errors on Hold-OUT data

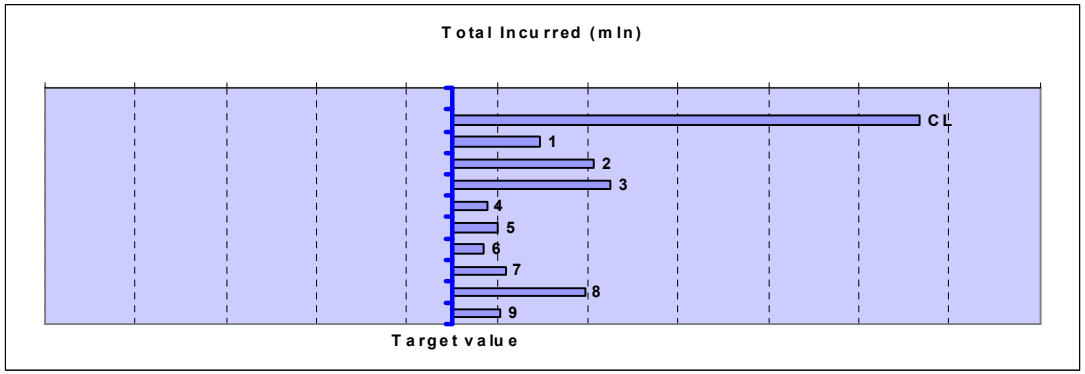
Granular Loss Model

Model Performance on Diagonals (Eg another LM class)

Incurred and Model Errors on last Reporting Period



Incurred and Model Errors on penultimate Reporting Period



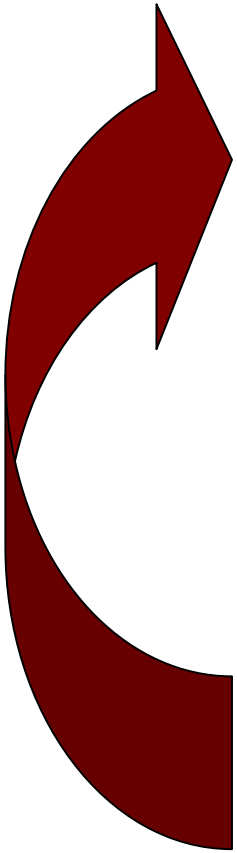
Granular Loss Model

- **Hold IN - OUT Bootstrap (1)**

- Reserving models use historic claims experience to benchmark future claims experience.
- It is standard practice in statistical analysis (and Pricing) to split the data **randomly** into two sets
  - Hold in sample: Fit model to data
  - Hold out sample: Test fitted model against remaining data
- This allows us to test for spurious over-fitting of models
- However, it is possible that the resultant split happens to suggest a good fit by chance.

Granular Loss Model

Hold in-out Bootstrap (2)



- Select Subset of Claims
  - Randomly split the data into hold-in and hold-out subsets
- Fit Model to One Subset of Data
  - For the relevant reserving approach we will fit the model to the hold in sample.
- Use this to Benchmark Remaining Claims
  - Use the fitted model to predict the development of claims included in the hold-out data
- Calculate Error on Data left out from fitting
  - We compare this prediction to the actual development of the hold-out claims.

Data Example

- Commercial Property class
  - This is real data, not artificially created.

- Rating Factors we will consider by claim
  - Paid in previous development period
  - Development Period in question
  - Zero Paid before
  - Cat flag
  - Status in previous development period (open, closed, etc)
  - Case estimates in previous development period
  - Premium for policy
  - etc

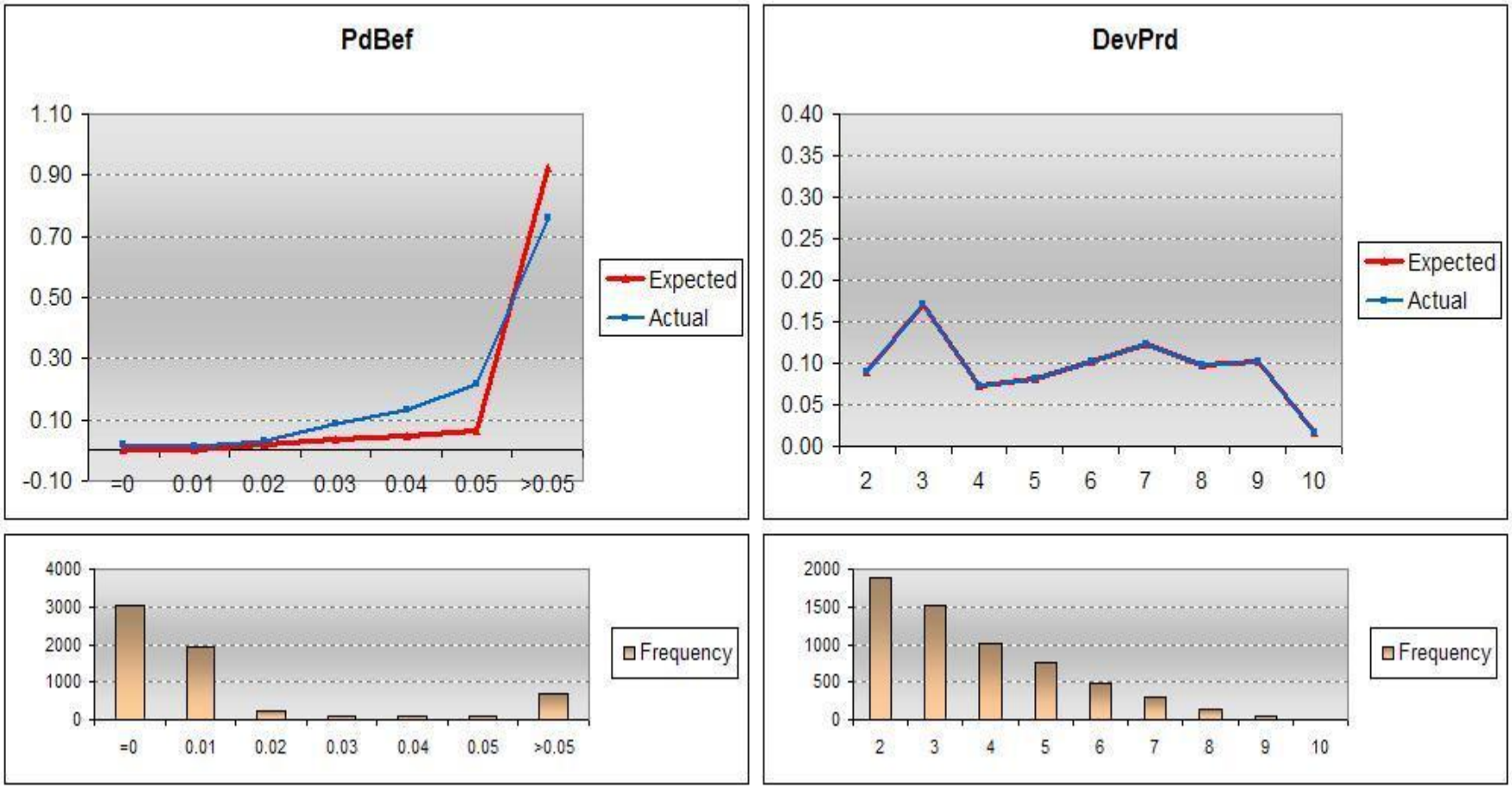
- Some of these are from the claims database and some from the policy database. These are easily extendable.

Data Example

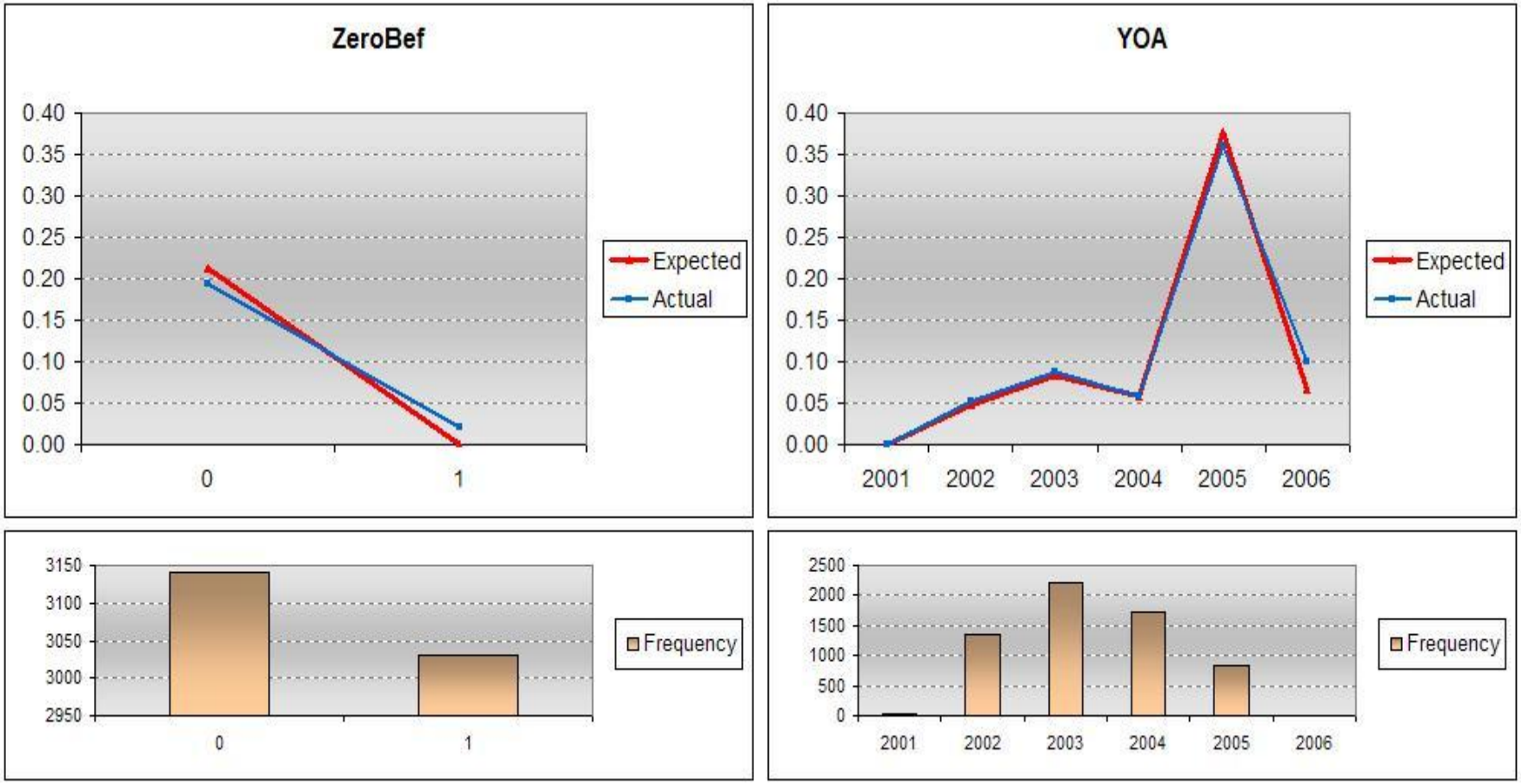
Actual vs Expected plots for model identification

- The following graphs take the results from fitting the VWCL to the entire triangle and compare how effective the resultant predictions are by rating factor.
- These AvE plots are our built-in variation of the analysis of residuals traditionally suggested in statistical textbooks. The main idea is to observe the fitting errors versus any rating factor, either included or not in the model.
- The top graphs show the average VWCL predictions (expected) against the average amounts (actual) for each category of the rating factor.
- The bottom histogram shows the number of claims for each value of the rating factors.

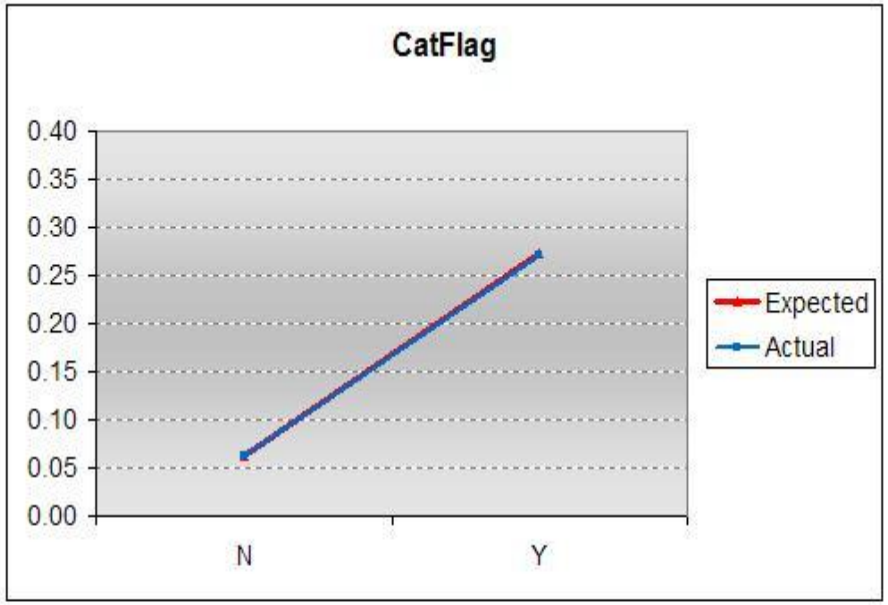
Data Example

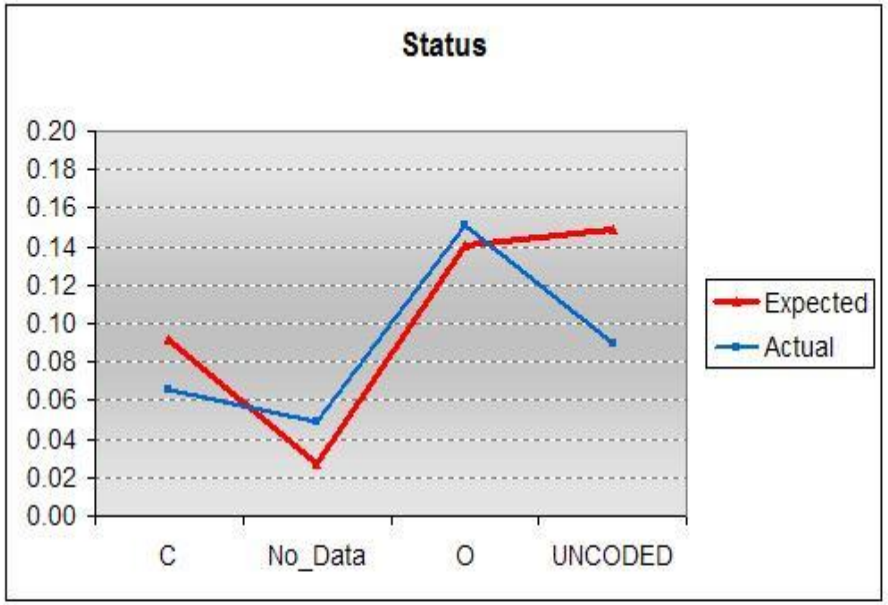


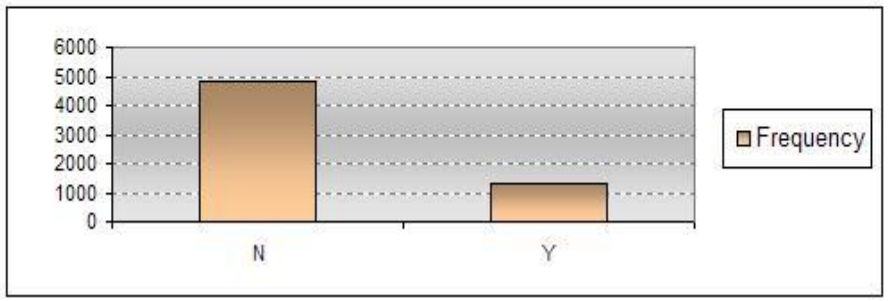
Data Example

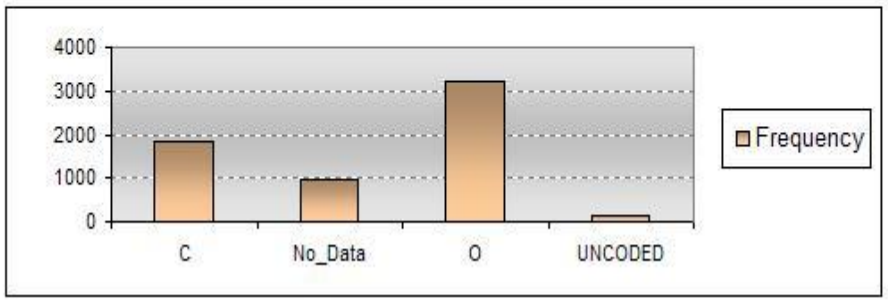


Data Example

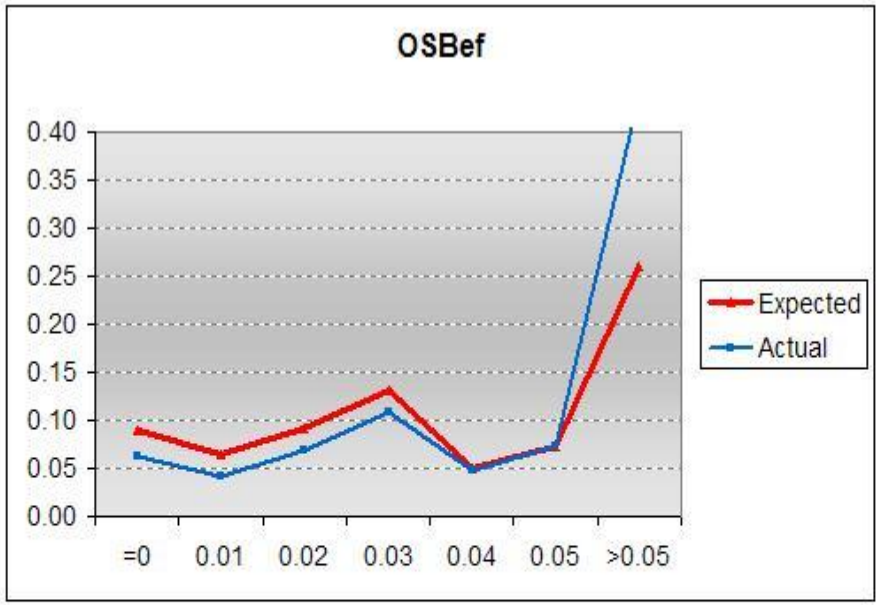


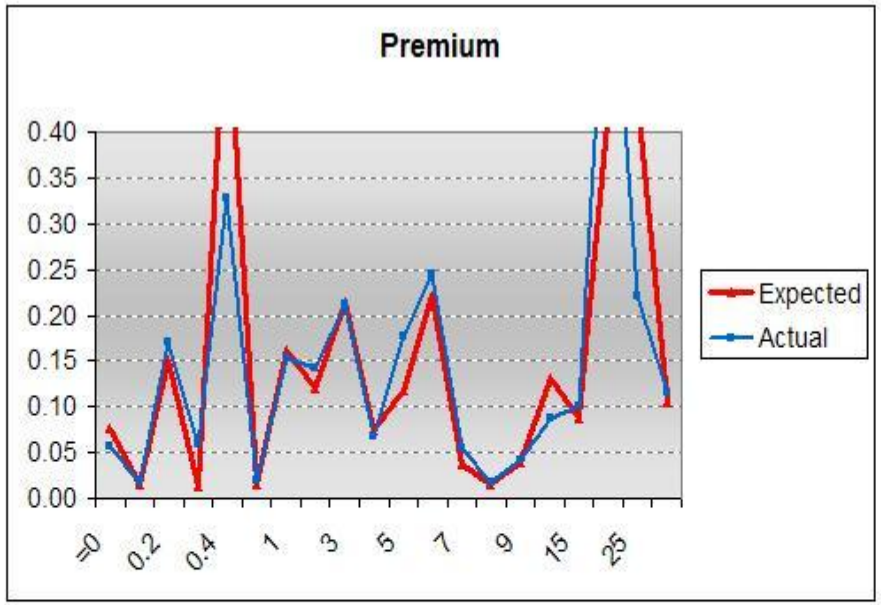


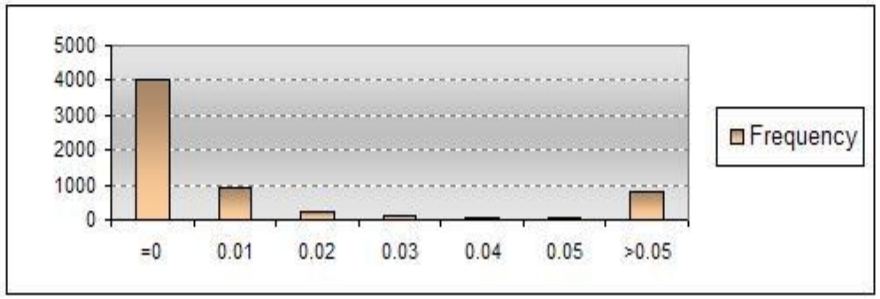


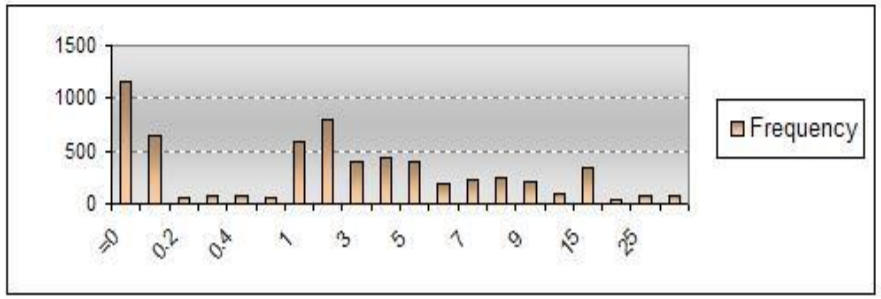


Data Example









Data Example

Actual vs Expected plots for model identification: summary

- The VWCL gives a good fit to the history.
- However, there is some room for improvement by using more rating factors, for example by using the case estimates (as suggested by the OS before AvE plot).

Data Example

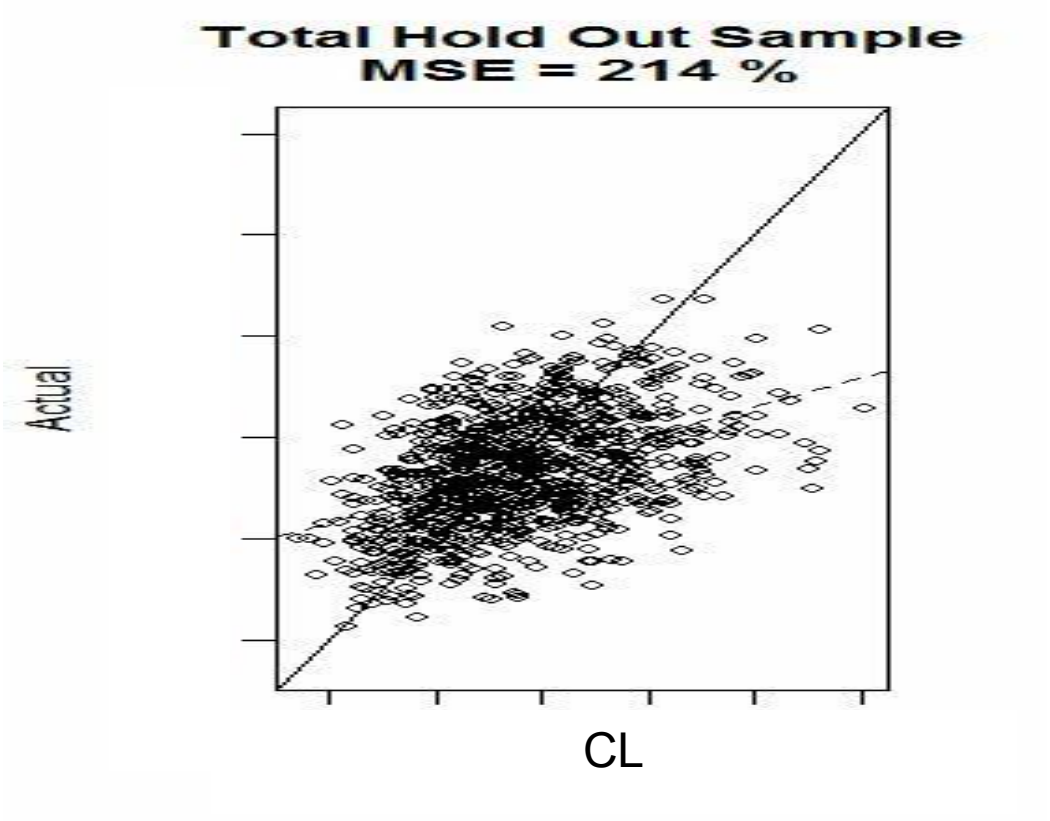
Hold in-out Bootstrap

- The following graph shows the simulation of the total actual claim amounts (actual) against the predicted claim amounts (CL), where each point represents a different randomly generated hold out sample.

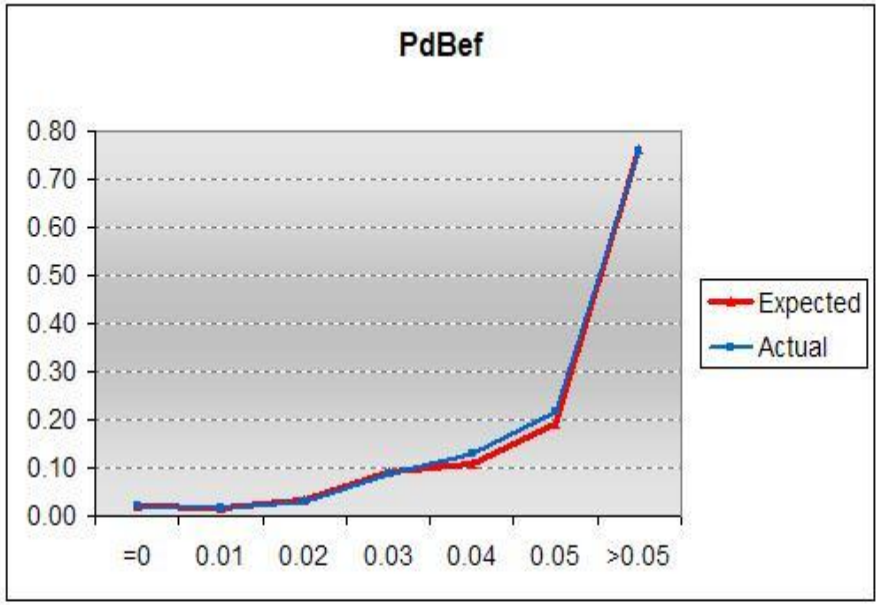
- It shows that the VWCL is not very good at predicting future claim movements.

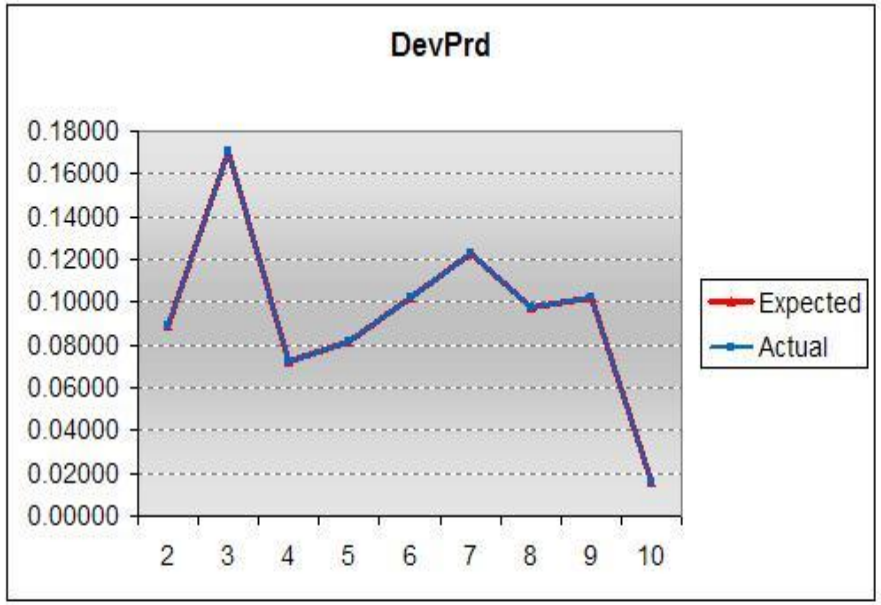
Data Example

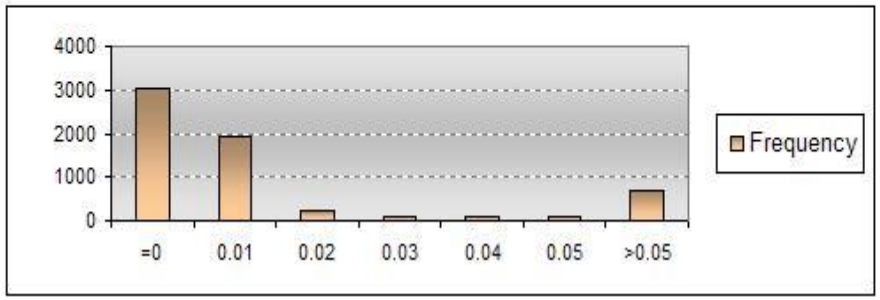
CL: Hold In-Out Bootstrap results

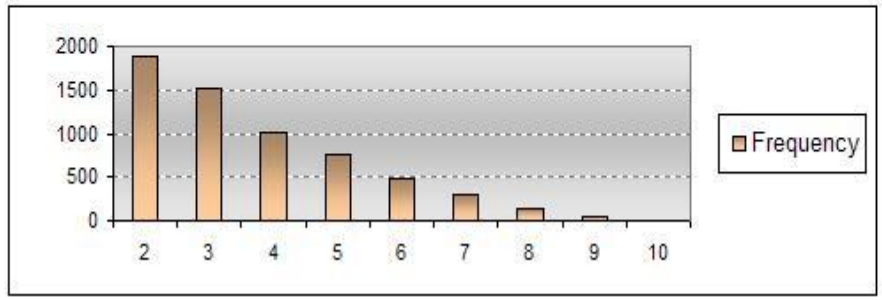


Regressing the OLS.









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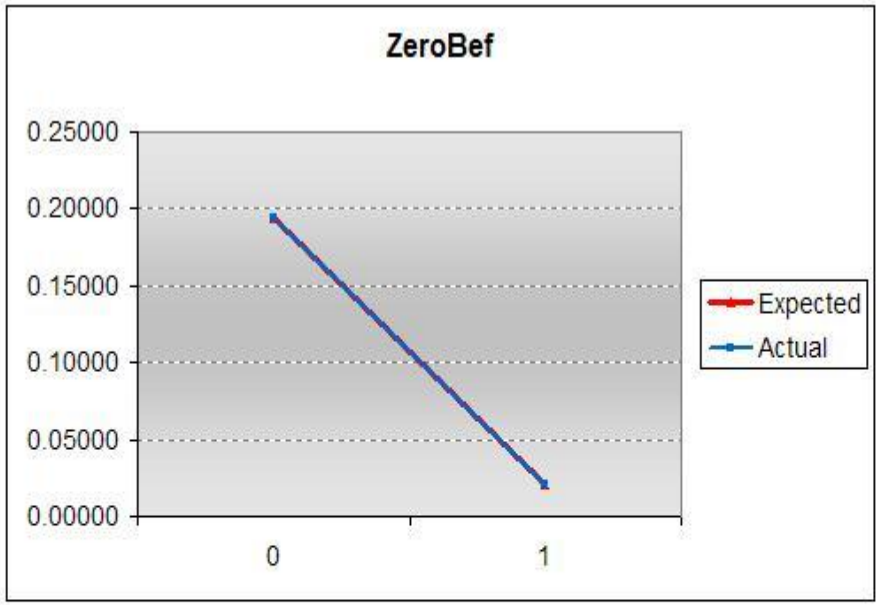

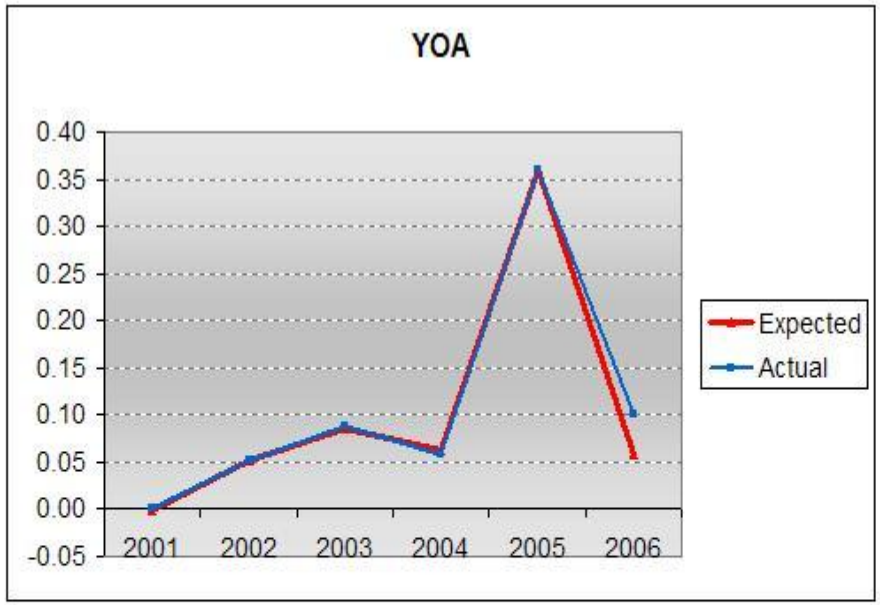

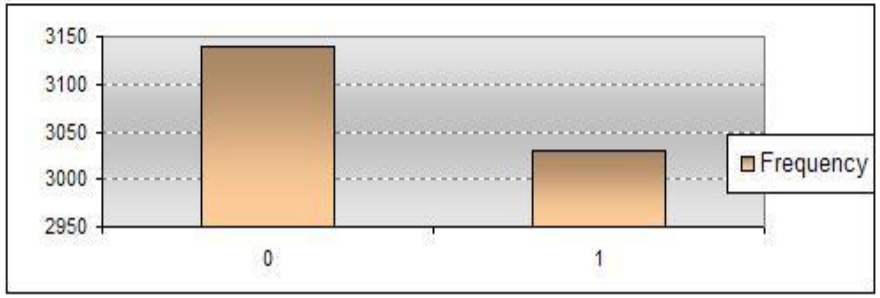

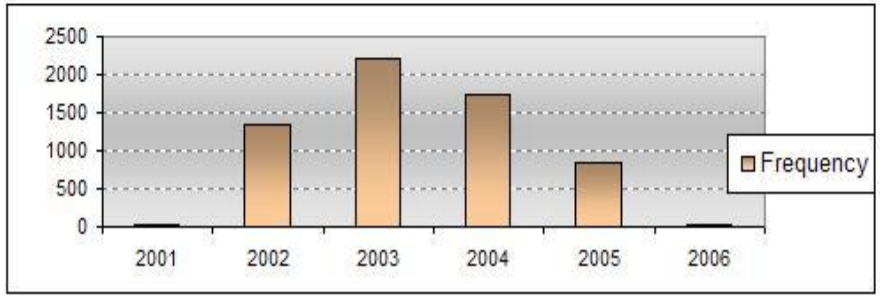

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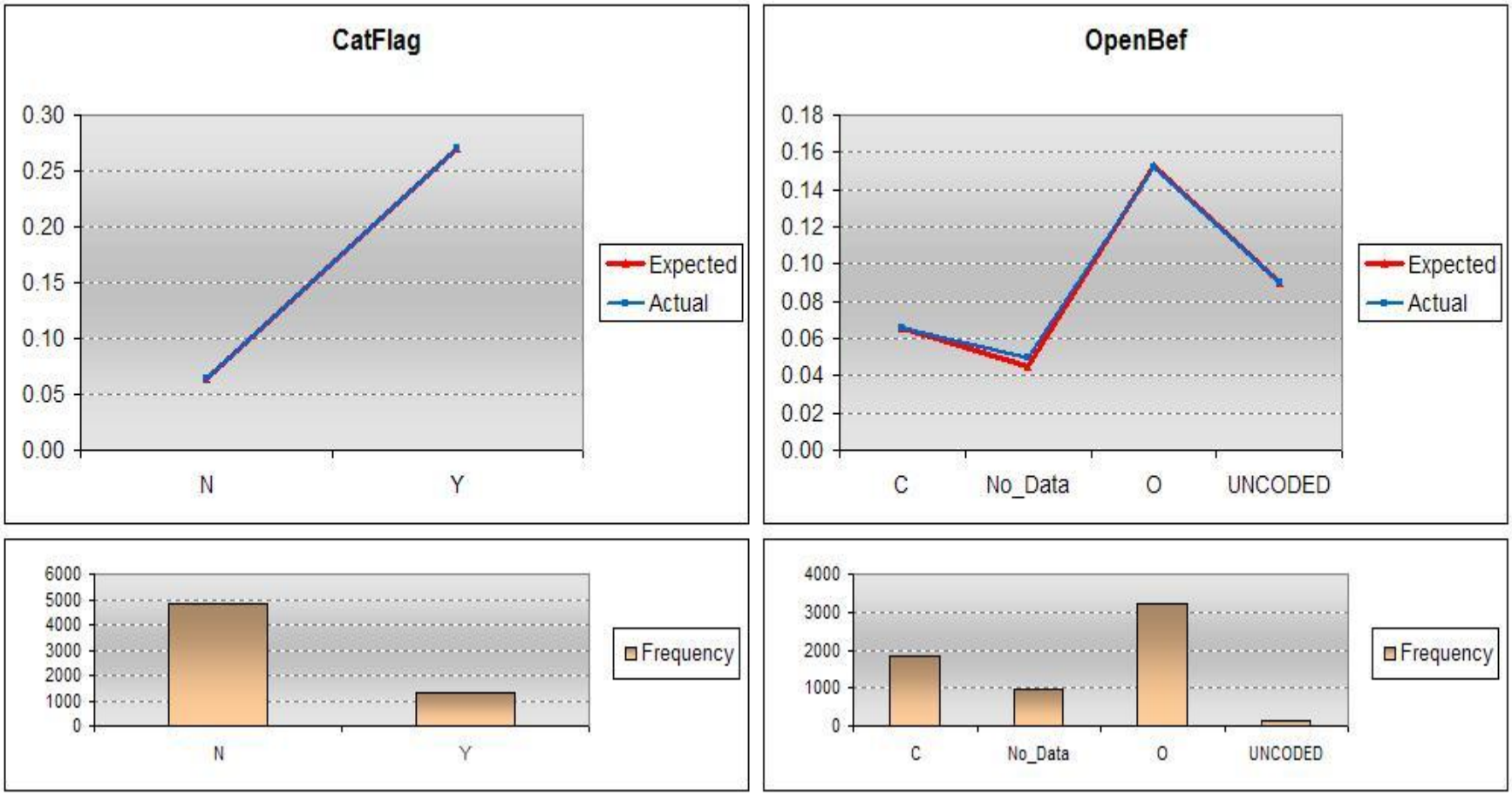

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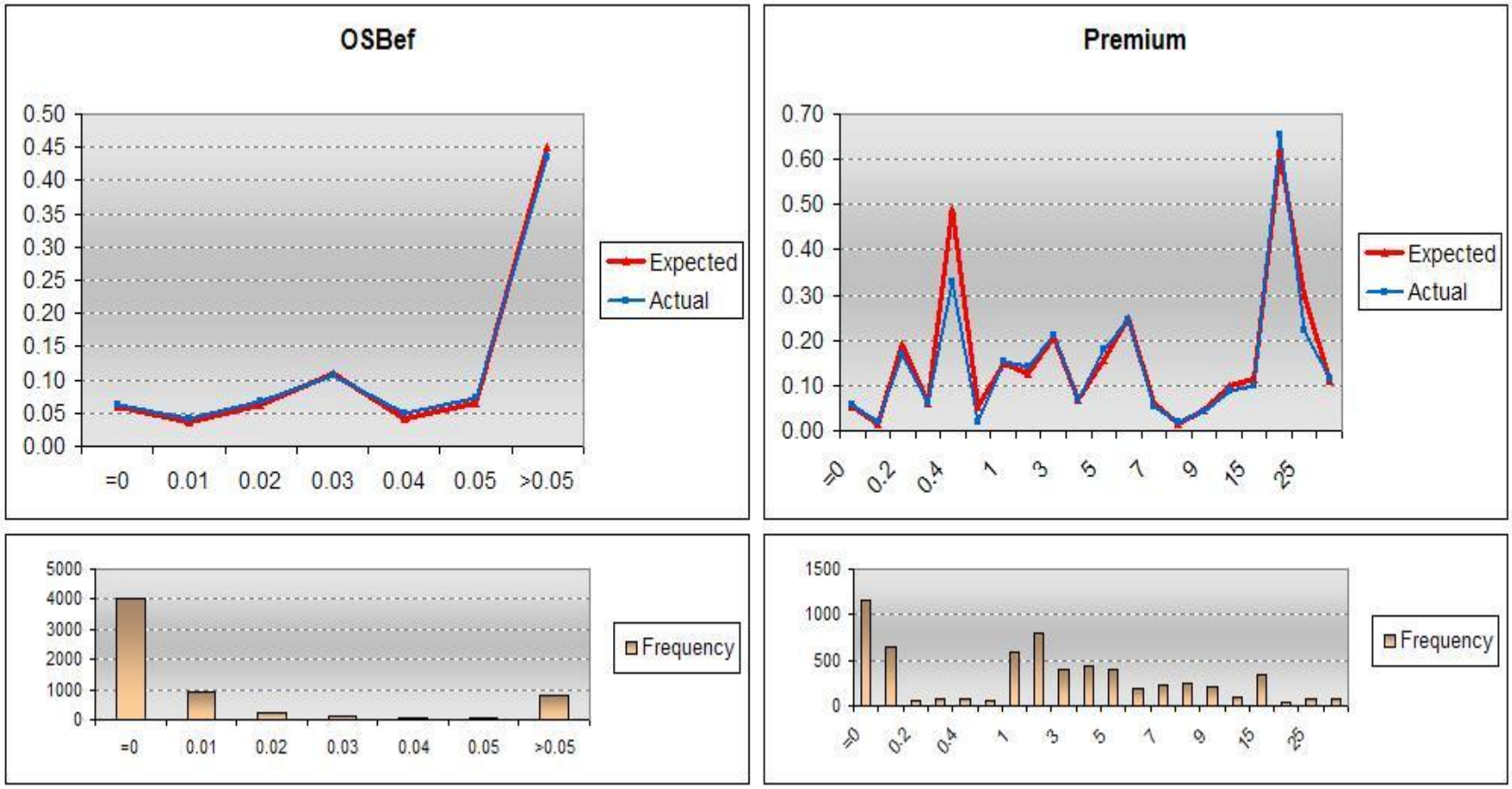
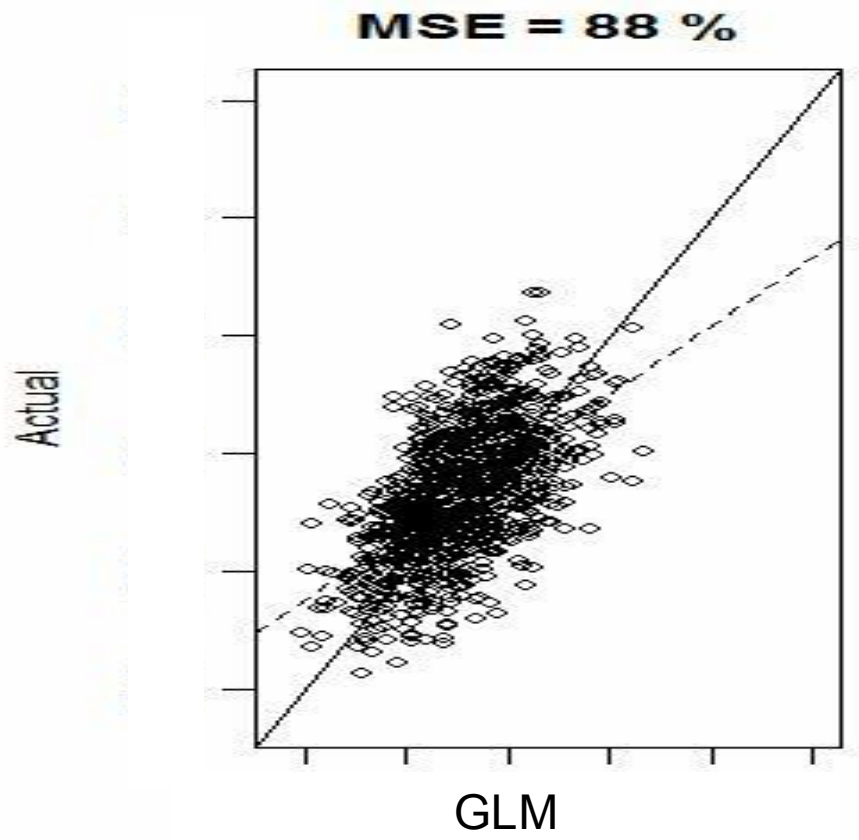


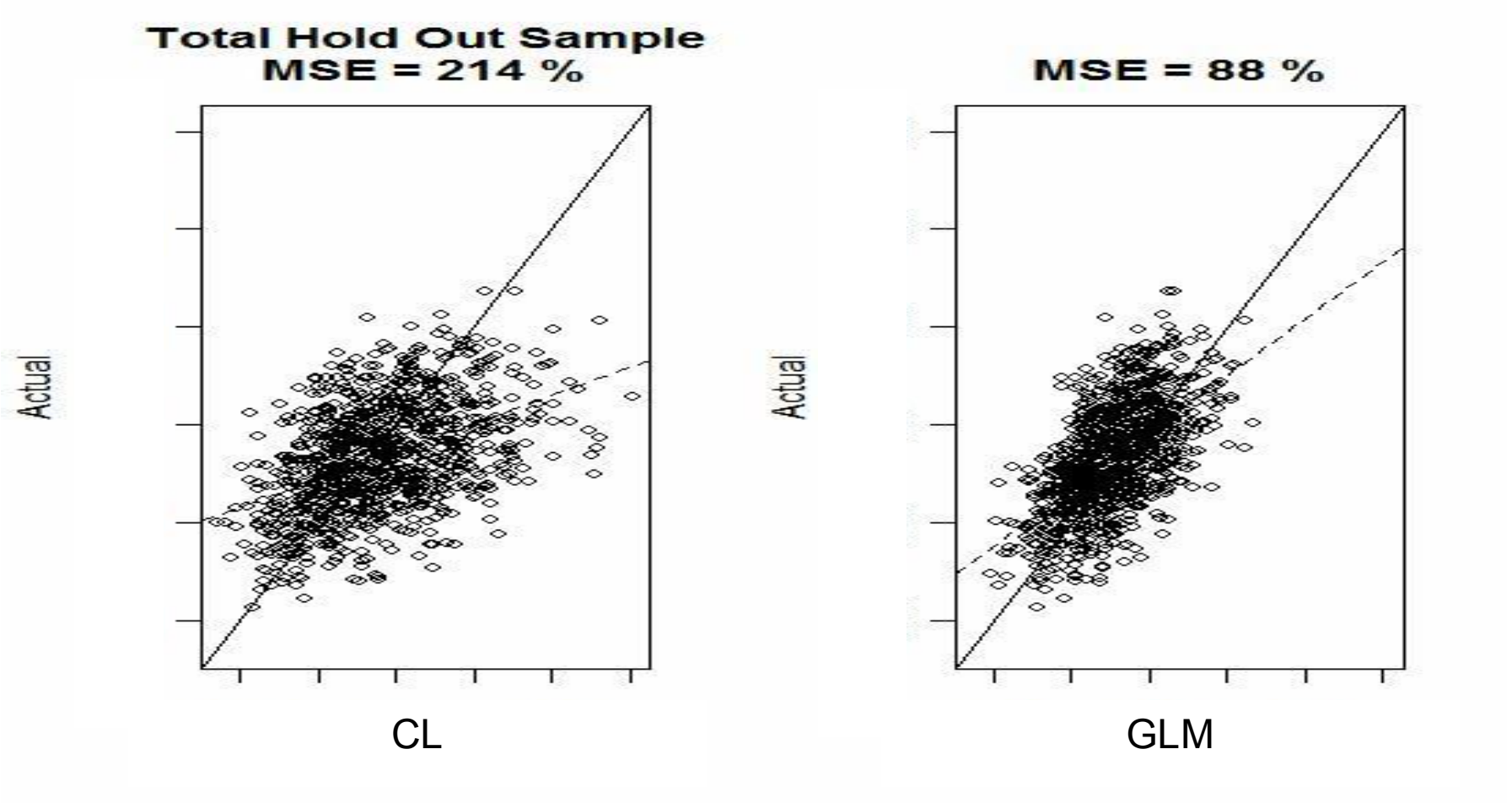
Regressing the OLS.

- As with the VWCL we can get a very good fit to the data.
- However, the acid test is “How good is this model at predicting claim behaviour?”

Regressing the OLS.



Results: Comparison GLM vs VWCL



More Sophisticated Approaches to Reserving

Moving this one-step model into a model for reserves

- For the VWCL moving a model from a single step to a multi-step model is trivial, namely by multiplying development factors.
- For our model we have separate GLM's for each time dependent covariate as well as a GLM for the paid movements.

More Sophisticated Approaches to Reserving

Moving this one-step model into a model for reserves

- These models then need to be co-integrated to result in an expected value for our paids at ultimate.

What is the effect on Reserving

Reduction in volatility

- Part of the volatility in held reserves is due to the limitations of the predictive power of traditional actuarial models. Many characteristics of the underlying exposures and claims change over time and traditional approaches are not capable of recognising these changes in a timely fashion.
- Traditional actuarial methods have been criticised, for example by rating agencies, for not being fast enough in recognising changes in market profitability.
- Also GRIT (General Insurance Reserving Issues Taskforce) suggests the focus for enhancement and research should be in reserving methodologies better linked into the underlying exposures written.

What is the effect on Reserving

Reduction in volatility

- Granular loss modelling is a framework sufficiently flexible and sophisticated to allow for these issues and thus reduce the bias inherent in traditional approaches.
- Validation has proved that granular loss modelling can often pull out much more of the predictive aspects from the development of claims than is possible from traditional actuarial approaches.
- Our experience has shown us that this can give a reduction in potential error of the order of magnitude of 40% to 60%, depending on the nature of the business and the volume and quality of data available.
- This results in a similar 40% to 60% reduction in potential total held reserve fluctuation.

What is the effect on Reserving

Change your understanding of the business

- This can make a real difference to the reserves that you might recommend holding by class and by year. Having better statistical models to inform judgement, can significantly change your view as to the appropriate level of reserves to hold.
- Similarly, having models that give appropriate weights between alternative rating factors gives a natural allocation to each potential segment.
- As a result this can materially change the conclusions of analyses performed off the back of the projections results. An example would include levels of historic profitability by segment
- Similarly, having models that give appropriate weights between alternative rating factors gives a natural allocation to each potential segment.

What is the effect on Reserving

Change your understanding of the business

- As a result this can materially change the conclusions of analyses performed off the back of the projections results. An example would include levels of historic profitability by segment.
- Similarly our approach can lead to better management information and change your view of the drivers of claims reporting process and the resultant effects on the potential for claims deterioration.
- In our experience moving to a more statistically informed process can lead to a change in the technical reserves of the order of magnitude of about 2% to 10%, especially impacting the later years.
- Similarly, our approach can give significant insight into the appropriate level of case estimates and associated trends.

What is the effect on Reserving

Changes in your book

- A particular limitation of traditional actuarial approaches is that they struggle to identify the reasons why the behaviour of a book of business is changing over time.
- Traditional approaches find it very difficult to separate changes over time due to mix changes and due to fundamental changes in the way claims are behaving.
- Our approach explicitly allows for changes in the mix of claims and policies over time and as a result trends can more readily be identified.

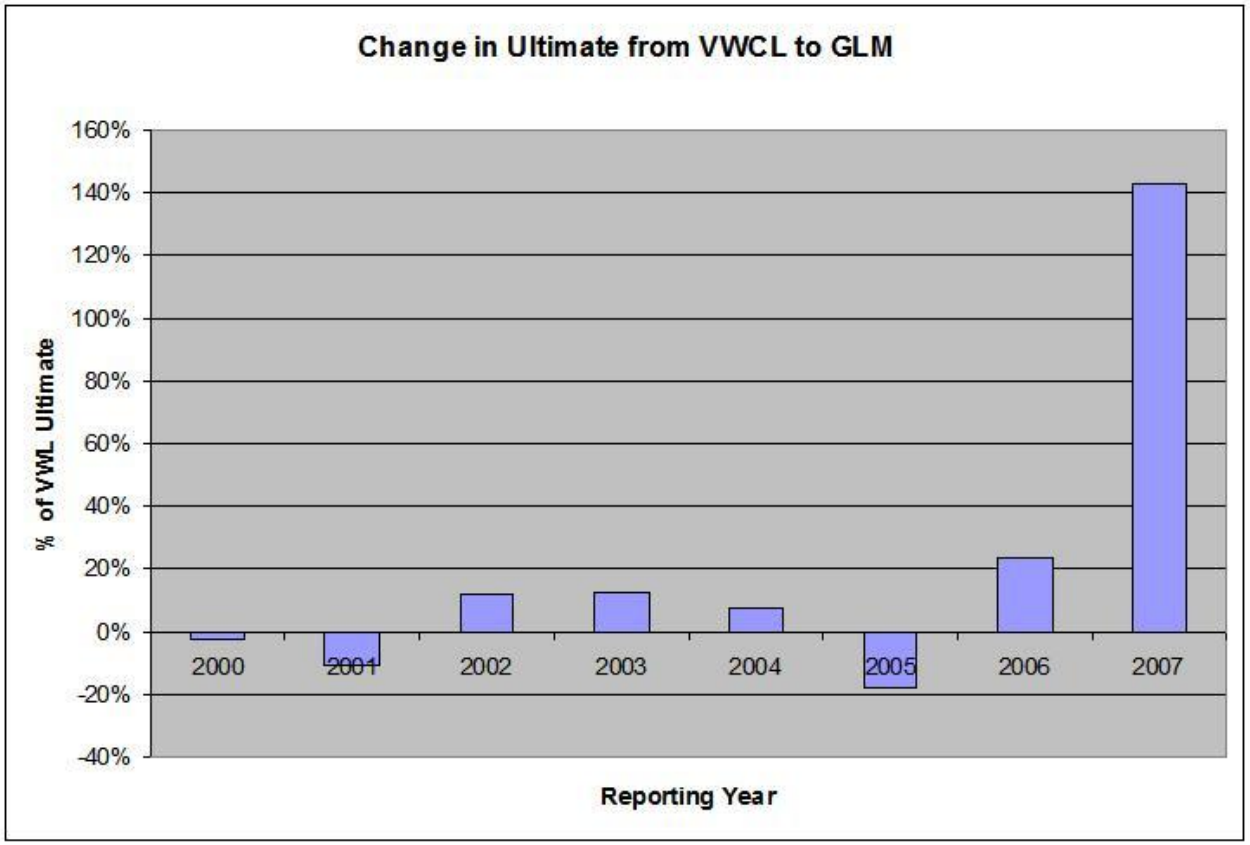
What is the effect on Reserving

Schemes, binders, etc

- Traditional approaches to reserving find it difficult to allow for the effect of claims from different distribution channels.
- Our approach naturally allows you to identify this effect which results in better reserves by agreement, which in turn can allow for lower margins inherent in these arrangements, and an earlier intervention if the terms of such agreements need to be challenged.

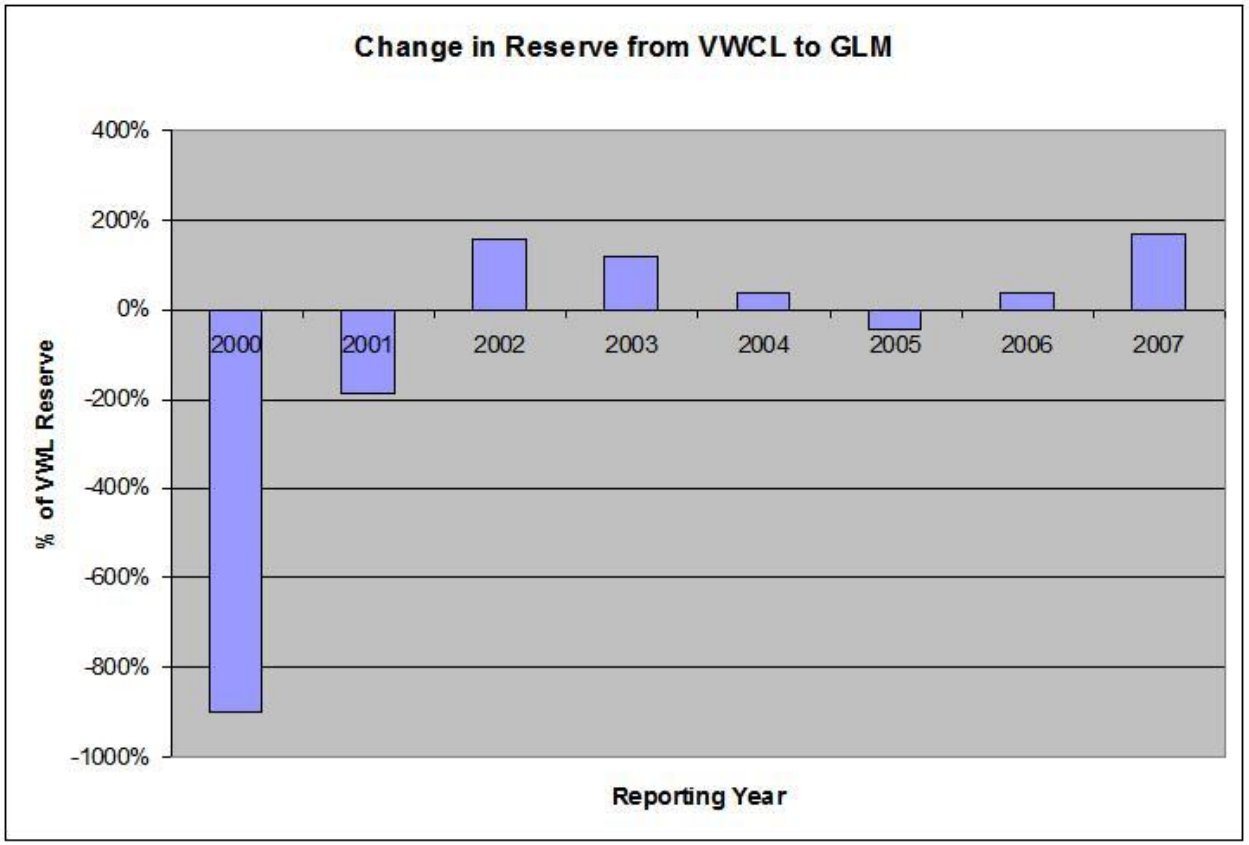
What is the effect on Reserving

Example: Overall a 7% reduction in Ultimate



What is the effect on Reserving

Example: Overall a 19% reduction in Reserve



What is the effect on Pricing

Severity modelling

- The traditional approach to modelling the severity of claims is to perform projections at some aggregate level and then allocate IBNER back down to each claim and then fit the appropriate distribution to the resultant ultimates. This effect is much more significant for longer tailed claims such as bodily injury or liability claims.
- Unfortunately this results in a conflict between:
  - Using up to date claim by claim ultimates containing a significant element of IBNR that has been to some extent or other arbitrarily allocated down to segment, thus losing some of the effects of the rating factors, and
  - Using older claim by claim ultimates containing a less significant element of IBNR, which will be less relevant due to their age, but will allow for the effects of the rating factors.

What is the effect on Pricing

Severity modelling

- Our approach naturally allows for a statistically valid allocation of IBNER to each claim. As a result more recent data can be used, without losing the potentially significant effects of the rating factors.

Trends

- Through being able to use more recent data, recent trends in the effect of different rating factors can be more readily identified and allowed for in the parameters of the resultant pricing model.

Emerging Issues

- Being able to use more recent data can give an earlier warning and a resultant earlier quantification of the effect of emerging issues.

What is the effect on Pricing

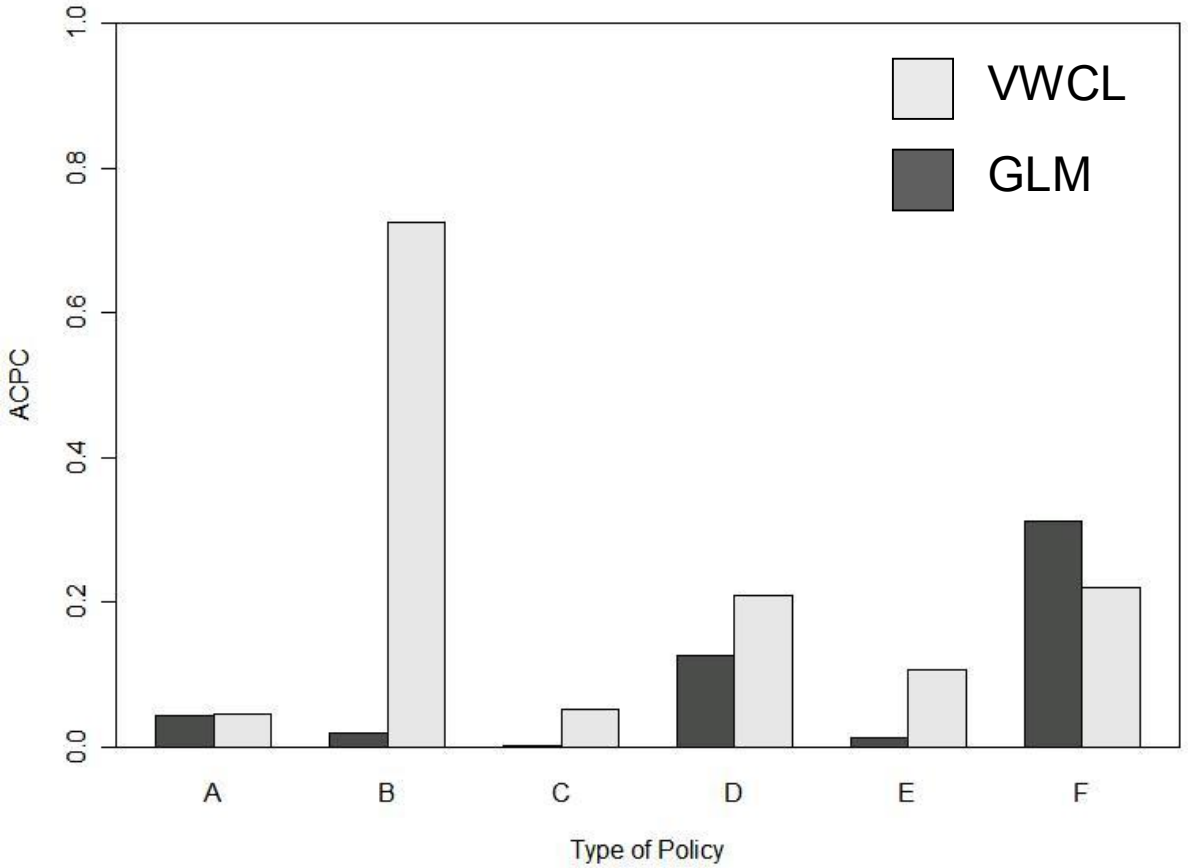
Importance of Pricing Model

- Clearly having a better view of the “true” technical price of any policy can significantly impact the profitability of an organisation. In competitive markets, being better able to rate than your competitors results in a gearing where you attract better risks and apparently small changes in price can result in much larger increases in profitability.

What is the effect on Pricing

Example:

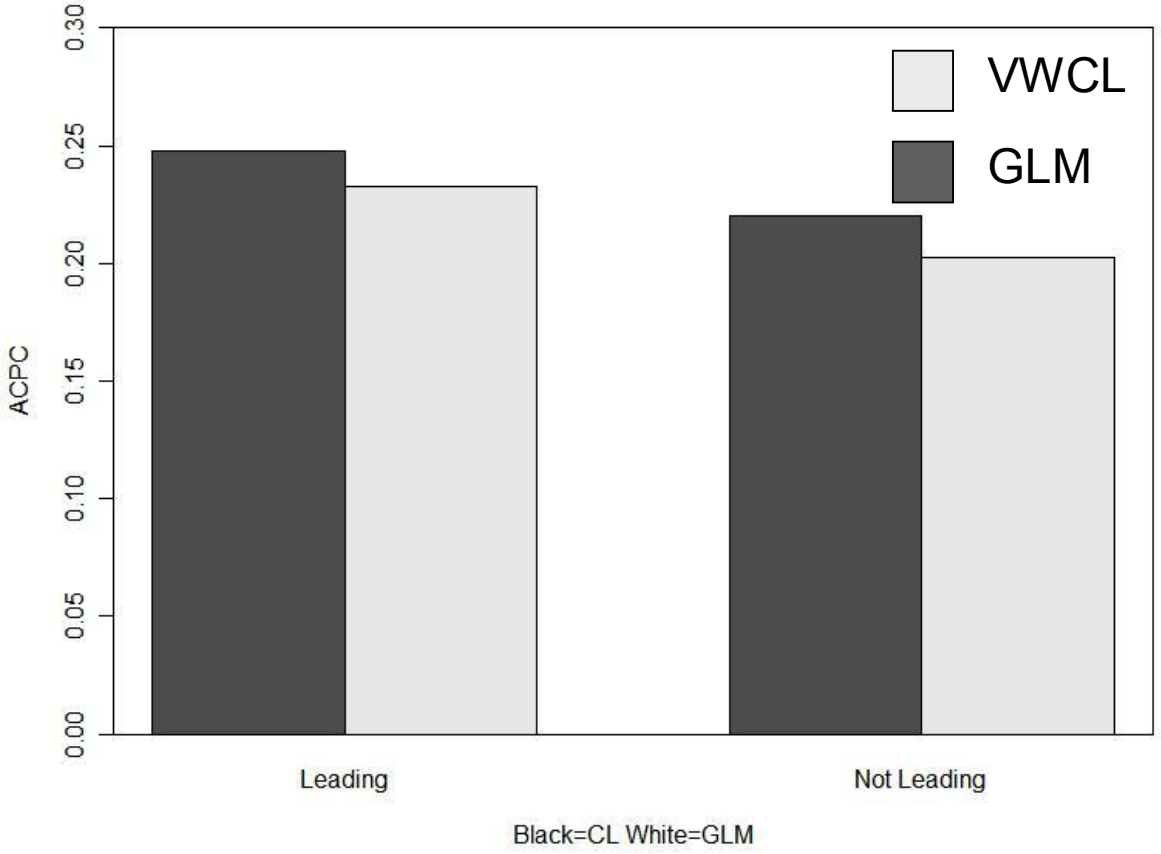
Average cost per claim by policy type where the claims reserves is calculated by the VWCL and GLM.



What is the effect on Pricing

Example:

Average cost per claim by whether policy is led where the claims reserves is calculated by the VWCL and GLM.



What is the effect on Capital

Lower capital requirement

- Our approach better identifies the predictable aspects of claim development and emergence than traditional actuarial approaches. As a result analyses of historic variability of reserves, which are all in some way based upon the size of historic actual development in relation to historic estimates of the mean, result in a reduction in the view of how far from the new ultimate estimate claims will result.
- This results in a lower capital estimate.
- The financial gain in capital reduction from this analysis, could potentially be offset if our approach recommends holding larger reserves. However, in most cases we expect there to be an overall financial benefit to a firm in applying better reserving approaches.

What is the effect on Capital

Lower capital requirement

- For example, based upon our case study we would expect a drop in reserving risk (stand alone capital) of about 25% and a resultant overall drop in capital of about 5%

Embedding

- Our approach explicitly uses validation to choose between alternative reserving approaches, which implicitly uses reduction in volatility estimators as a criterion for model choice. As a result we effectively choose models that have the lowest capital requirements.
- It is thus fair to say that our approach links capital requirements and reserving exercises.

What is the effect on Capital

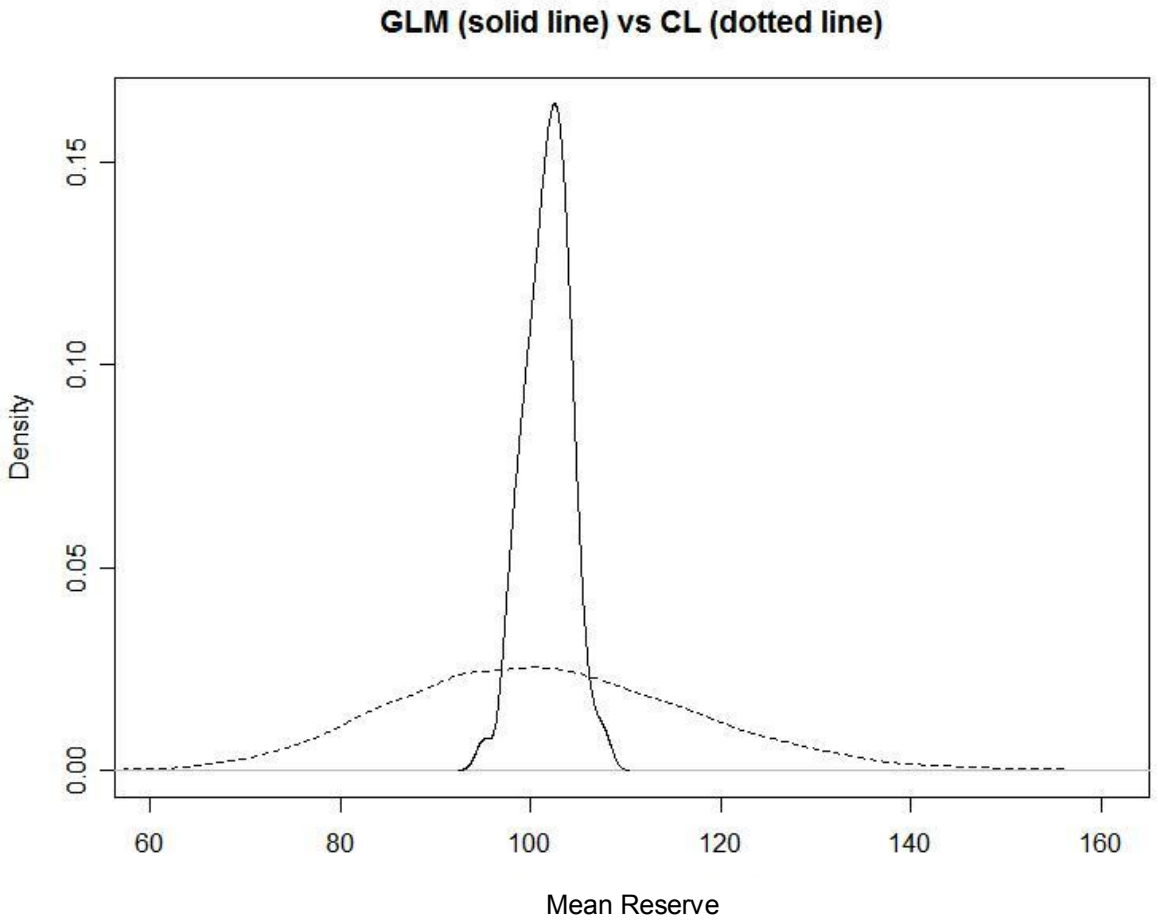
Solvency II

- Using the same rationale as above, through using more rigorous reserving approaches we would expect to achieve a reduction in market value margins associated with the Solvency II regime. This in turn would result in lower capital requirements.

What is the effect on Capital

Example:

Parameter Error calculated by bootstrapping the reserve calculated by the VWCL and GLM.



What are the other effects

Change in Loss Development

- Claims development can be potentially different according to various factors. Given that our approach allows alternative profiles to be applied separately to each loss rather than traditional approaches which apply the same “average” profile to all losses in a cohort, we can perform analyses at any level of segmentation with equal confidence.
- We can also quantify more effectively the effect of changes in the claims environment such as changes to the case estimation process, changes to the claims systems, changes in staff, etc.

What is causing development to change

- Similarly where the cause of changes in development profile are unknown we can perform investigations as to the drivers of changes and the resultant impact of those drivers on claims reserves and potentially expected profitability.

What are the other effects

Regulatory Impact

- The insurance industry has yet to go through the Basel II process which has impacted the banking industry, where banks have been asked to justify the appropriateness of their models and parameters.
- Our approach implicitly uses validation to choose between alternative models. Given the volumes of data available in the aggregations used within traditional reserving approaches, it has been claimed by the insurance industry that validation is uninformative.
- We have shown this to not be true, however, when these techniques are used they do not support the use of traditional approaches, but indicate that more granular approaches are more desirable.

What are the other effects

Disclosure

- There is a trend in the markets towards increased disclosure, fuelled by initiatives such as Solvency II. In this environment it will be difficult to justify the use of models (such as more traditional reserving approaches) that do not pass associated validation tests.

IFRS

- As with Solvency II, IFRS Phase II will require insurance companies to publish economic balance sheets.
- The reduction in uncertainty due to more accurate reserving approaches, such as the granular approach, is likely to make this more palatable with the resultant smaller Market Value Margin's.

What are the other effects

Profit Emergence

- Having a better understanding of the expected reserves required to support the earned and written business allows for a more timely distribution of company profits where available.
- A more timely identification of any future losses allows more time for management to put processes in place to manage any associated issues.

Summary

We have discussed:

- The benefits of applying more sophisticated approaches to modelling claims development and emergence.
- How more sophisticated approaches can change our view of reserving, pricing and capital requirements.

Questions/Discussion

Ciao