

## 34TH ANNUAL GIRO CONVENTION

CELTIC MANOR RESORT, NEWPORT, WALES

A09: Wider uses of GLMs

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Are you in the right room?

**“A09 Actuaries without Frontiers” has been cancelled!**

**Welcome to:**

**A09 Wider uses of GLMs**

## Generalised linear models

$$E[\underline{Y}] = \underline{\mu} = g^{-1}(\underline{X}.\underline{\beta} + \underline{\xi})$$

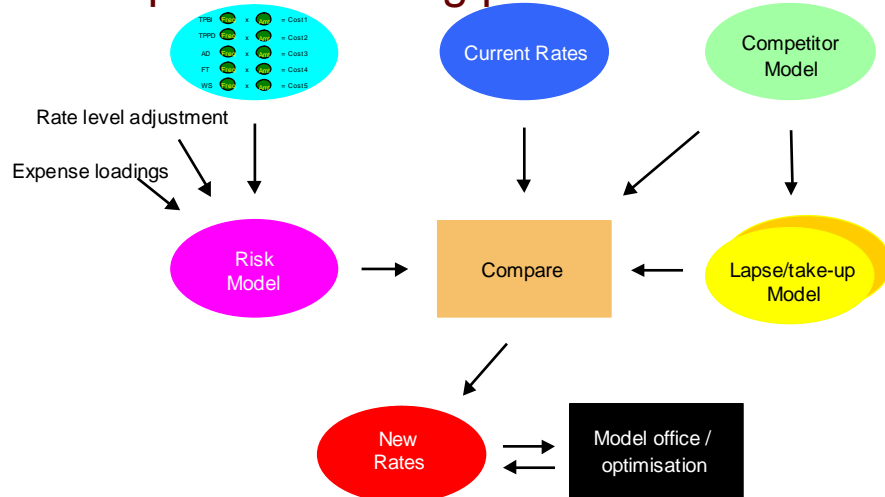
$$\text{Var}[\underline{Y}] = \phi.V(\underline{\mu}) / \underline{\omega}$$

- Consider all factors simultaneously
- Provide powerful diagnostics
- Allow for nature of random process
- Robust and transparent
- Global industry standard

## Tradition uses of GLM

- Frequency / Severity modelling for pricing
  - Motor, Household, Creditor, Pet, Roadside assistance, Travel, Healthcare, ...
- Probability modelling
  - Lapse, Conversion, ...

## The premium rating process



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## Wider uses of GLMs

- Understanding complex models
  - Competitor premium structures
  - Optimised premiums
  - DFA simulations
- Marketing and broker compensation
- Initial loss estimates
- Mortality analysis

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## Understanding complex models

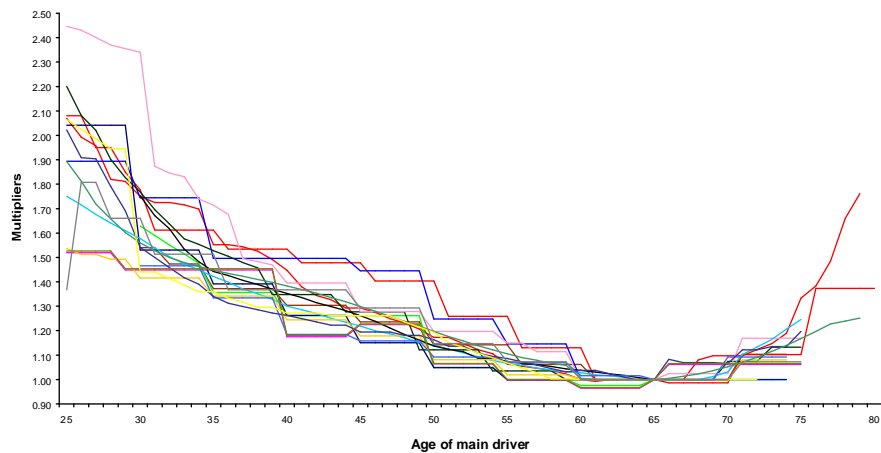
- If you have:
  - A numerical (or limited discrete) outcome
  - Many pieces of information which effect outcome
  - Many observations
- Then a GLM can help understand the model

## Competitor premium structure

- WhatIf gives premiums for a sample of policies
- Can be time consuming to run entire portfolio
- Fit a model which estimates competitor rates based on rating factors

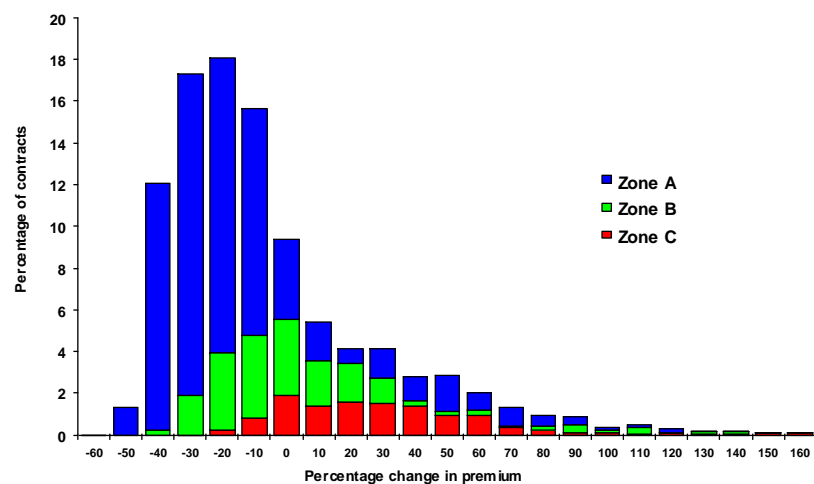
## Surveying the market

Age of main driver



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## Comparison with competitors

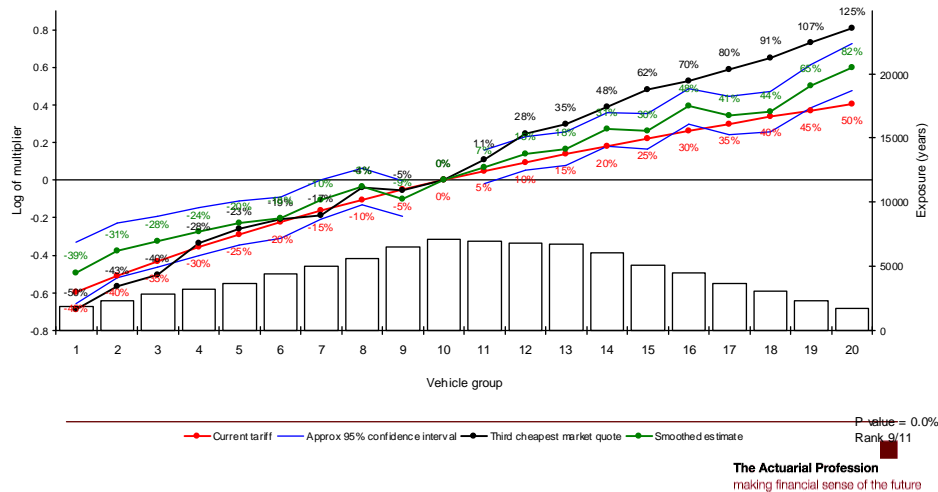


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# Considering the competitive position

## Example of competitor analysis

Third party cover



## Wider uses of GLMs

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## Optimised premiums

- Results of price optimisation is a set of individual premiums
- This is not always what is actually wanted
- In any case, don't you want to know what is going on?

## What is price optimisation?

- Price optimisation is a term used to describe a range of techniques which combine information on risk, expenses and behaviour to produce a premium tailored to meet a specific target

## Implementing individual price optimisation

- Back office solution
  - Regular (monthly) runs to determine renewal premiums for following month
  - Model optimised premium to determine the new business rates eg for broker quotation systems and aggregators
  - Simple to implement, will lag behind ideal position

## Implementing individual price optimisation

- Point of sale solution
  - Replicate the model office in sales system
  - Regularly (monthly) runs to review parameters
  - Hard to implement, responsive to changes

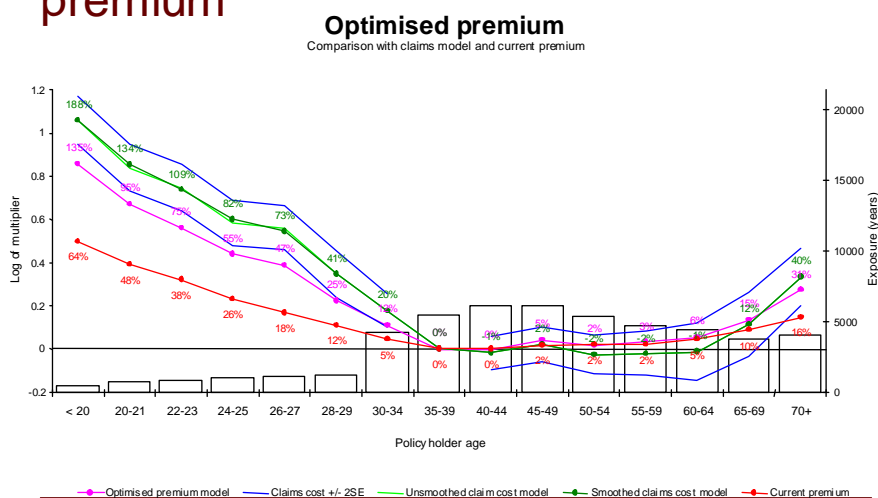


## Modelling optimised premiums

- Can fit GLM to individually optimised rates
- Will only be approximate:
  - optimised rates can be rather non-linear
  - a few interactions can be needed to approximate well
- Nevertheless, useful
  - where backroom individual rates or dynamic point of sale cannot be undertaken
  - for new business when renewals done in backroom
  - to understand results in any case

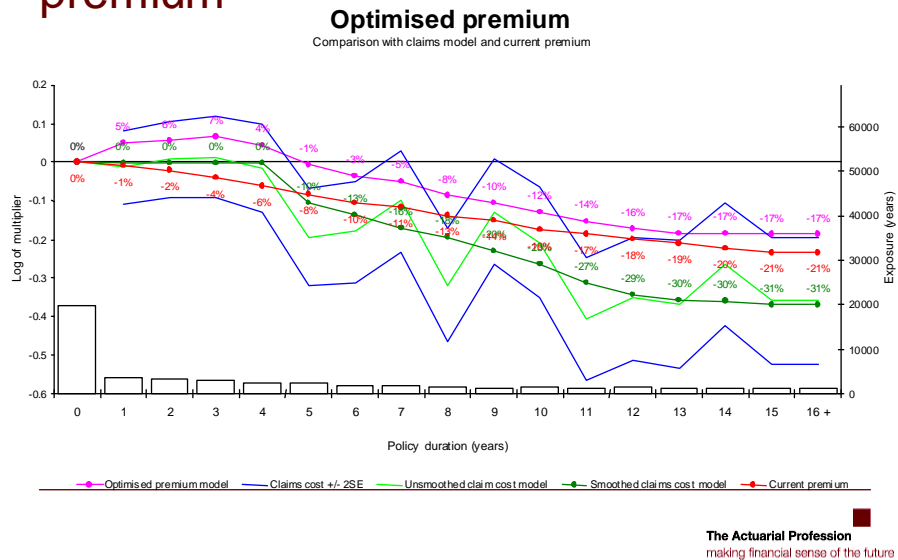
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## Example of model fitted to optimised premium



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## Example of model fitted to optimised premium



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## DFA simulations

- A stochastic model has:
  - A numerical output (eg capital)
  - Many inputs
  - Much complexity
- Seems to be suitable...

## DFA simulations

- Fitting a GLM to the simulations can help understanding of what drives the worst outcomes
- This highlights key parameters to stress test
- Can provide quick check of underlying calculations

## DFA simulations: Life insurance

- Take existing life model results and use these to model:
  - PVFP as function of sum assured, premium, term, duration, age, sex, assumed renewal expenses (looking over a large portfolio)
  - End year 1 surplus as a function of economic factors (looking over a large set of economic scenarios)

## DFA simulations: Life insurance

- We were quickly able to:
  - Check which factor results seemed sensible, and which looked wrong (for follow-up investigation by client)
  - Check the correlations between factors (eg equity/property?)
  - Better understand the 'explanatory power' of factors
  - Decide which factors to adjust and which to drop from model
  - Generate a closed-form solution for the end year 1 capital
  - Advise on a set of 'equally bad' parameters for the 1/200 tail

## GLM for ICA work: correlations

Preliminary analysis of yr 1 capital projection  
Cramer's V for 'Capital'

Highlight cells with statistic greater than 20 %

	Change credit spread A	Change credit spread AA	Change credit spread AAA	PC1	PC2	PC3	Equity return	Property return
Change credit spread A								
Change credit spread AA	73%							
Change credit spread AAA	66%	67%						
PC1	3%	3%	4%					
PC2	3%	3%	3%	7%				
PC3	3%	3%	4%	51%	5%			
Equity return	2%	2%	3%	4%	5%	5%		
Property return	2%	2%	3%	3%	2%	3%	4%	

- Calculation of correlations between factors allow user to understand what is happening in the model and to check those pairs where there is high correlation or where high correlation is expected

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## Marketing and broker compensation

- Many situations require a simple method to transfer complex models from actuaries to non-actuaries
- Creating a score is one such way

## Generalised linear models

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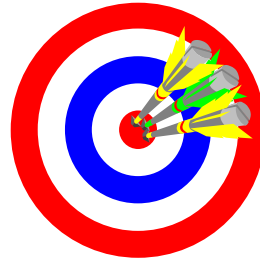
- Consider all factors simultaneously
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## How do you produce a score?

- Take any GLM
- Find the linear part ( $\underline{X}.\underline{\beta}$ )
- Shift and rescale to get desired range (eg 0 to 1000)

## Profitability scoring

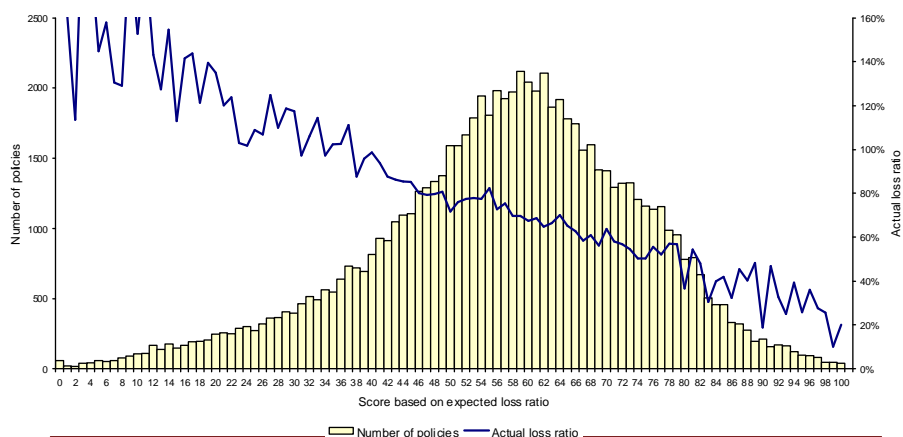
- Construct profitability score based on expected loss ratio
- Profitability score can then be used to target sections of a portfolio
- Expected loss ratio can be modeled using a risk premium model offset by current premium rates
- Expected loss ratio can be banded into discrete bands if desired



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## Profitability scoring

Distribution of score



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## Initial loss estimates

- Fit a GLM to ultimate claim cost using accident information
- Result is a predictive model which can be used for setting initial reserve estimates

## Other uses of model of claims

- Results can also be used to:
  - Identify claims which will benefit from rehabilitation
  - Assessing claim handlers' performance

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## Mortality analysis

- Impaired life annuities can have multiple factors which contribute to changes in mortality
- Useful to our colleagues in life and pensions...
- ... but general insurers are at risk of picking up an impaired life annuity portfolio by the back door

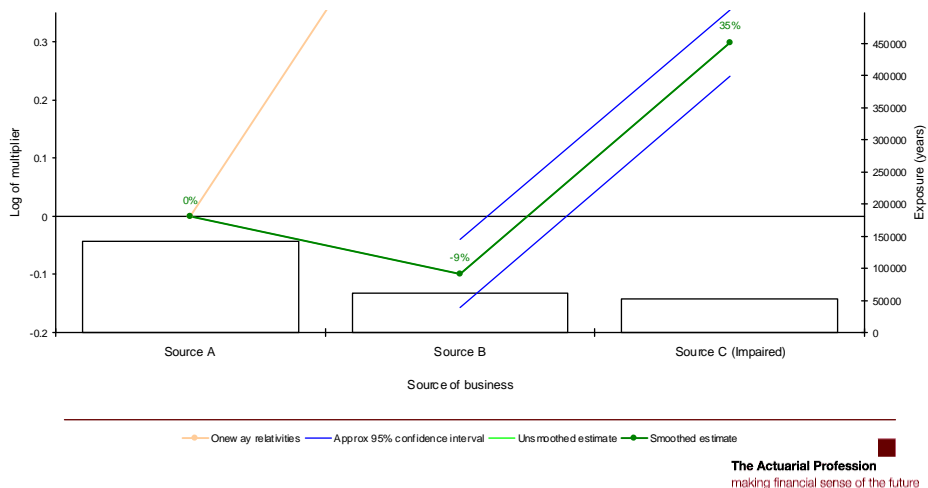
## Model form

- People only die once
- Most appropriate form is a "logistic" model which considers multipliers of  $p/(1-p)$
- Hard to interpret, so results shown here are in multiplicative form
- Conclusions and general appearance of the results unchanged, however any calculations should use logistic version

## Example results

### Mortality Investigation

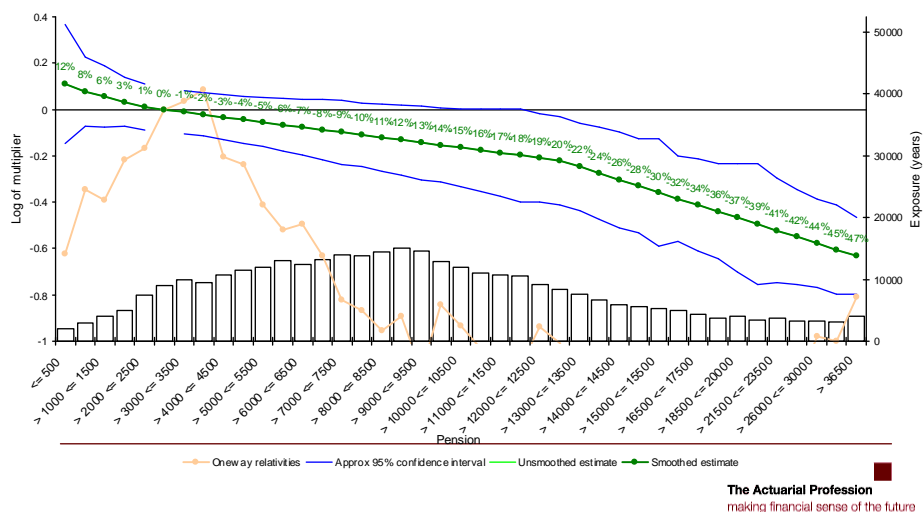
Male pensioners only



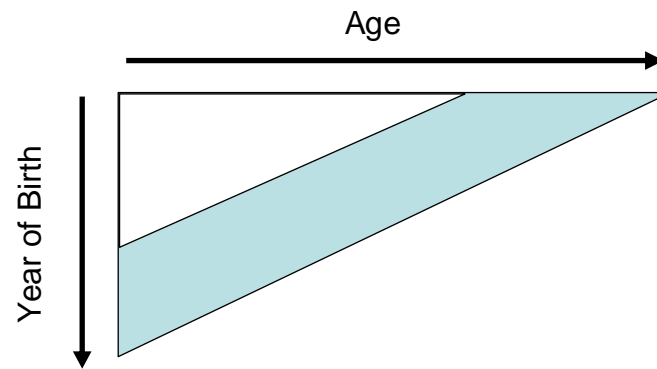
## Example results

### Mortality Investigation

Male pensioners only



## Age and YOB

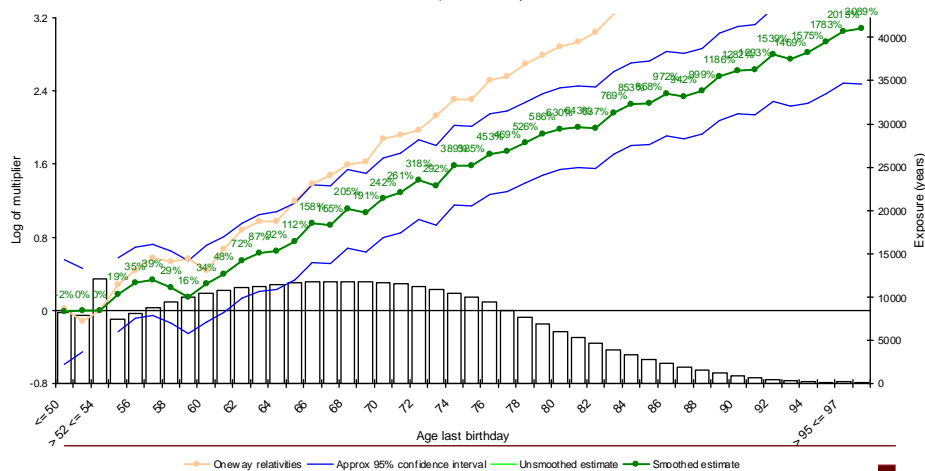


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## Example results

### Mortality Investigation

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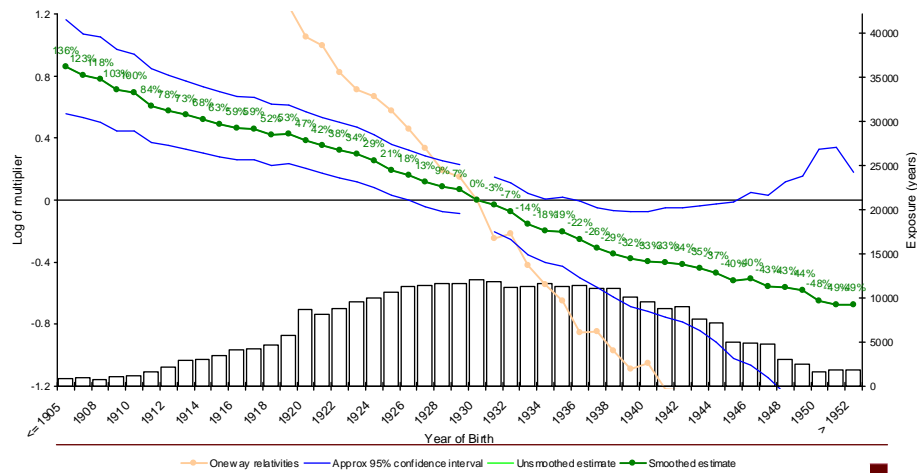


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## Example results

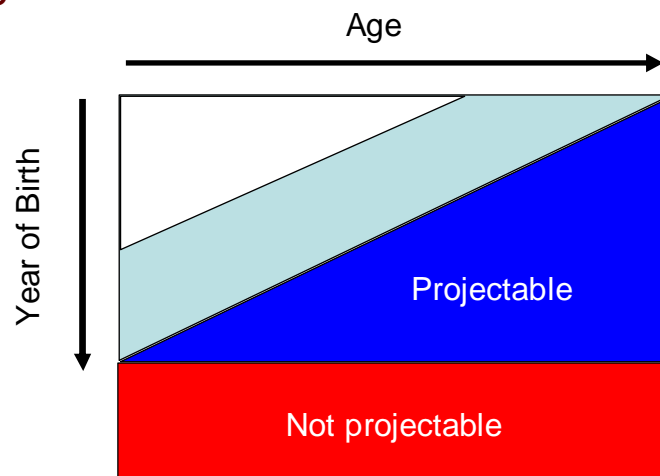
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## Age and YOB



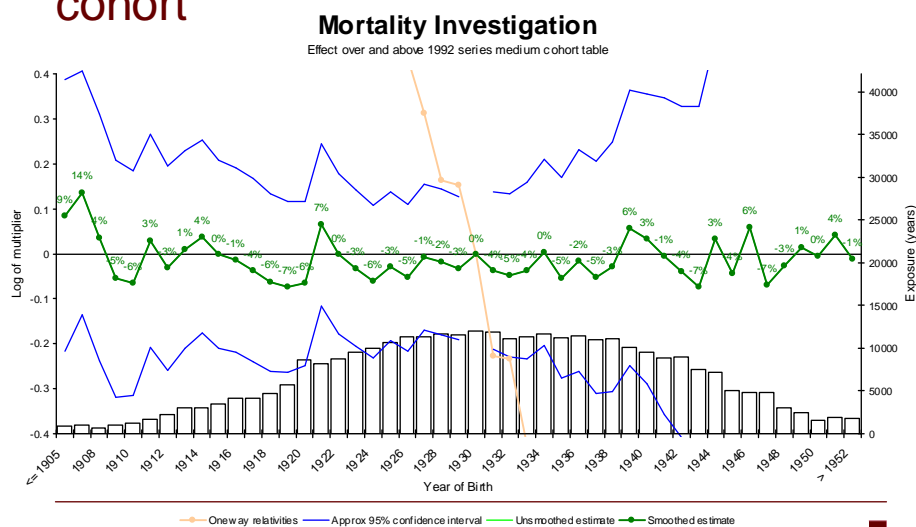
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## Comparison with existing mortality tables

- GLM allows statistical comparison with existing mortality tables
- Shows effect of factors over and above that assumed by existing mortality tables
- For example, compare against:
  - 1992 series medium cohort
  - Age adjustment for impaired lives

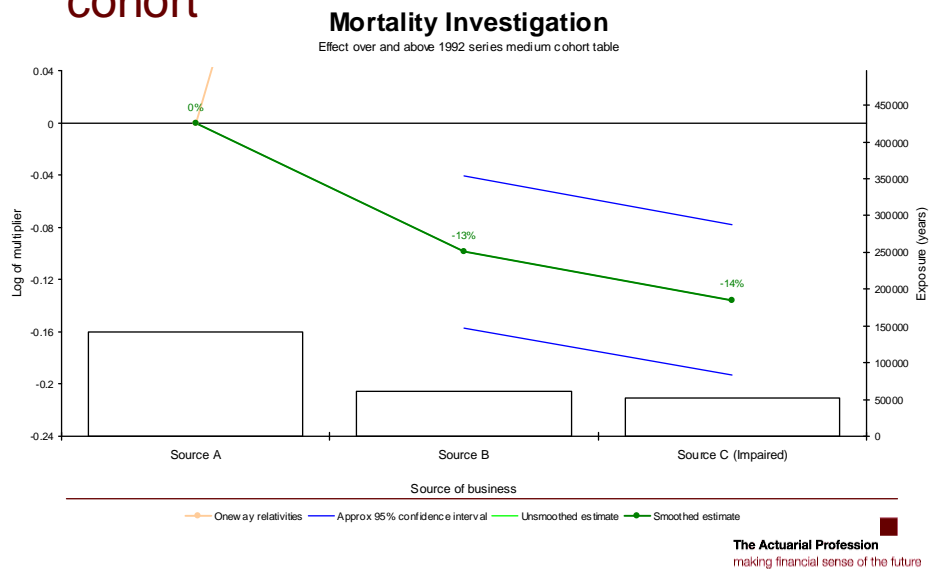
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## Comparison with 1992 series medium cohort



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## Comparison with 1992 series medium cohort



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