

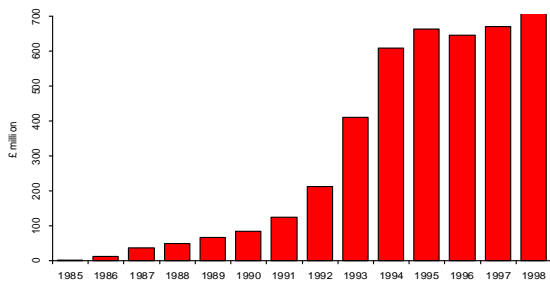
Enhancing the Profitability of Healthcare Business: The case for Effective Pricing

Healthcare Conference 2006
James Tanser FIA
Watson Wyatt Limited

Agenda

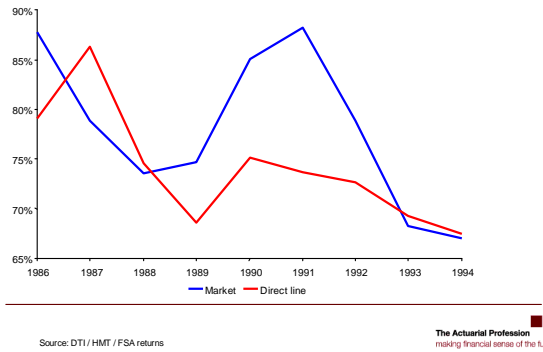
- The case for effective pricing
- Overview of GLMs with examples
- Other uses of GLMs

Direct Line (UK) – written premium 1985 to 1998

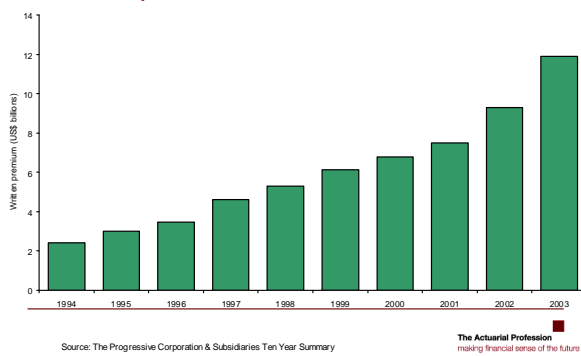


Source: DTI / HMT / FSA returns

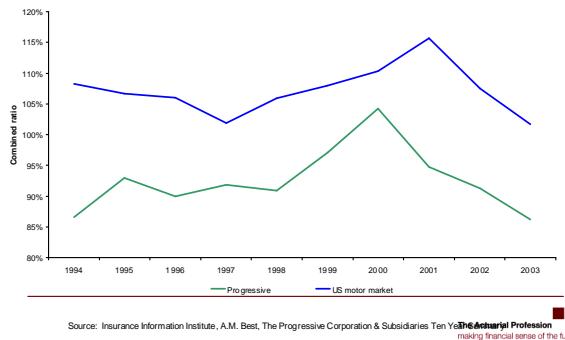
UK motor market loss ratio



Progressive (US) – written premium 1994 to 2003



US motor market combined ratio



Case study – Insurance company in Eastern Europe

- Third party liability motor insurance
- Recently deregulated market
- First multivariate analysis of claims
- Rating factor loadings amended to move towards theoretically indicated relativities
- Changes implemented for all business written in 2004
- Results...

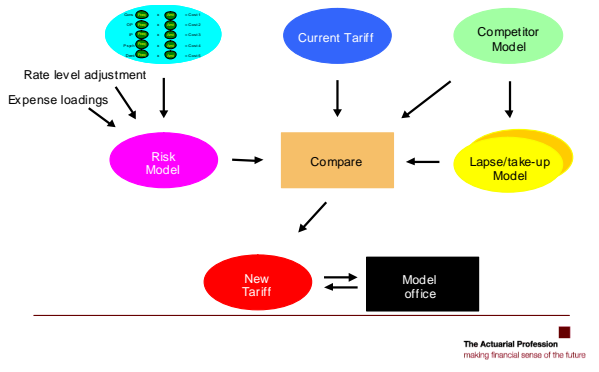
Case study – Insurance company in Eastern Europe

	Frequency		Loss ratio	
	@ 6 months	@18 months	@ 6 months	@18 months
2003 (old rates)	7.1%	7.2%	64%	86%
2004 (new rates)	6.4%		49%	

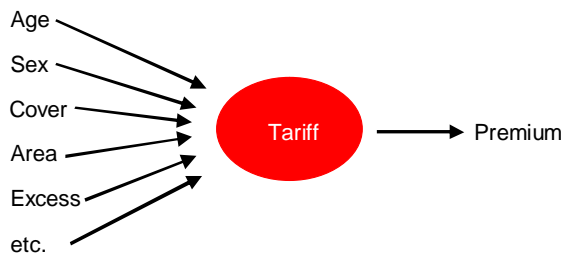
Agenda

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- Overview of GLMs with examples
- Other uses of GLMs

The premium rating process



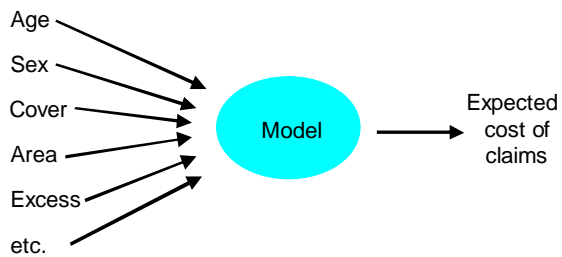
Objective



"Tariff" in this context means "rating structure" - it does not imply regulated fixed tariff, nor anything related to tax!

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Modelling the cost of claims



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Modelling the cost of claims

Consultation $\text{Freq} \times \text{Amt} = \text{Cost 1}$

Out patient $\text{Freq} \times \text{Amt} = \text{Cost 2}$

In patient $\text{Freq} \times \text{Amt} = \text{Cost 3}$

Psychiatry $\text{Freq} \times \text{Amt} = \text{Cost 4}$

Dental $\text{Freq} \times \text{Amt} = \text{Cost 5}$

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Modelling the cost of claims

- Data & rating factors
- Statistical techniques

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Data required

- For each policy:
 - period of exposure
 - rating factors applicable at time
 - number of claims (by type) during period
 - paid claim information, by claim type, based on most recent estimates
 - earned premium (current basis)

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Data required

- Cancellations / amendments
- Factors applicable at time (but categorised on current basis)
- Delay to reduce effect of IBNR & reserve inaccuracy
- Time
- External data

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Data required

- Claims could be classified by ICD or OPCS codes
- Preferable to link all claim payments to a single medical event
- Individual claim payments can be individually dependent
 - eg visit to a doctor, followed by visit to the specialist, hospital and surgeon etc
- Where claim payments cannot be linked to a medical event then consider grouping within claim types by period of time

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Example PMI rating factors

- Standard factors:
 - Age of member
 - Cover
 - Age / number of additional member(s)
 - Excess
 - Optional benefits
 - Hospital band
- Enhanced factors:
 - Sex
 - Marital status
 - Occupation
 - Postcode
 - Lifestyle
 - Medical history
 - Payment frequency
 - NCD / previous claims
- External data:
 - individual data
 - geodemographic data
 - geophysical data
- Data from other products:
 - banking data
 - other insurance data

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The failings of one way analysis

True risk * 2			Claims			
	Old	Young		O	Y	Total
M	40%	20%	M	80	20	100
F	20%	10%	F	20	20	40
			Total	100	40	140

Exposure				One-way * 2.5			
	O	Y	Total		Exp	Claims	Ratio
M	200	100	300	M	300	100	33.3%
F	100	200	300	F	300	40	13.3%
Total	300	300	600				
				O	300	100	33.3%
				Y	300	40	13.3%

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Generalised linear models

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

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

- Consider all factors simultaneously
- Allow for nature of random process
- Robust and transparent
- EU and increasingly global industry standard

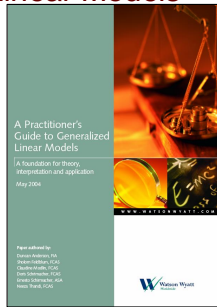
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Why GLMs over other methods

- One-way and two-way analyses
 - distorted by correlations, no diagnostics
- Iteratively standardised one-ways
 - no diagnostics, computationally inferior to GLMs (no faster), less flexibility for allowance of random process, not always tractable solution
- Neural networks
 - not transparent, hard to interpret, can be unstable with new types of policy, easy to over/under fit
- Cluster analyses / "segmenting"
 - suitable for marketing but less appropriate for assessing continuous risk; does not fit with rating structures

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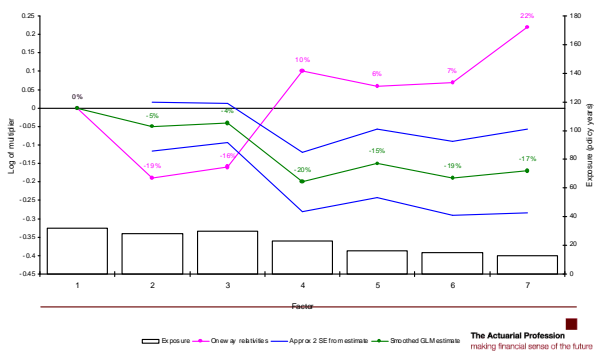
"A Practitioner's Guide to Generalized Linear Models"



- CAS 2004 Discussion Paper Program
- Copies available at www.watsonwyatt.com/glm
- Section 1 to be added to CAS Exam 9 syllabus in 2006

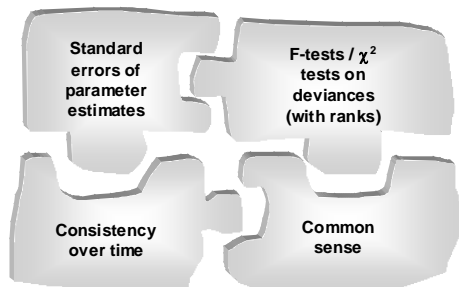
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Example of GLM output (real UK data)



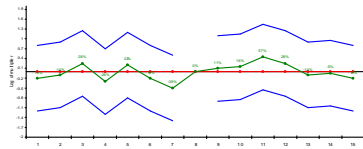
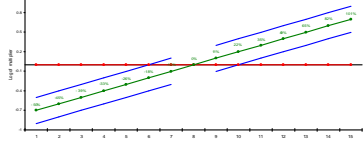
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Model iteration



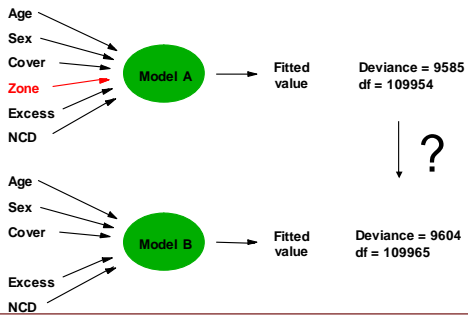
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Standard errors of parameter estimates



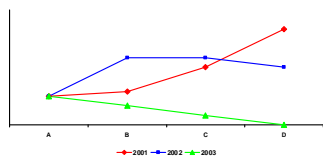
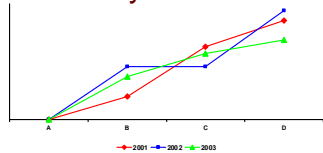
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Deviances



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Consistency over time



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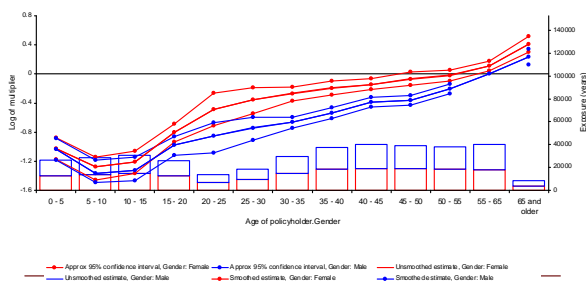
Common sense

- Does it make sense given correlations?
- Are ordered categorical variables well behaved?
- Can you believe it?
- Can the underwriters believe it?
- Consider results for frequency and amounts at the same time
- Consider results for each claim type at the same time

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Interactions

Example job
Run 63 Model 2 - Small Interaction



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Interactions

No interaction

	A	B	C	D
A	x	-	x	x
B	-	x	-	-
C	x	-	x	x
D	x	-	x	x

Marginal interaction

	A	B	C	D
A	x	-	x	x
B	x	x	-	-
C	x	-	x	x
D	x	-	x	x

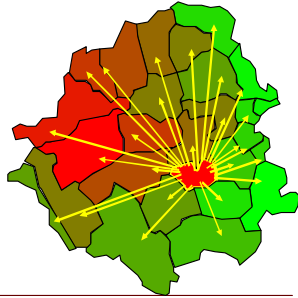
Full interaction

	A	B	C	D
A	x	x	x	x
B	x	-	x	x
C	x	x	x	x
D	x	x	x	x

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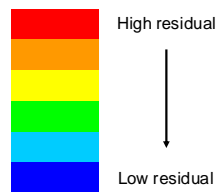
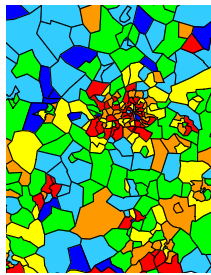
Spatial smoothing

- Blends experience of one region with that of surrounding regions according to distance and credibility
- Credibility and spatial smoothing parameters are trained on sample dataset



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Residual risk



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Model

$$r_i^* = Z(e_i) \cdot r_i + (1 - Z(e_i)) \frac{\sum_j e_j \cdot r_j \cdot f(d_{ij})}{\sum_j e_j \cdot f(d_{ij})}$$

where

r_i^* = smoothed residual r_i = unsmoothed residual

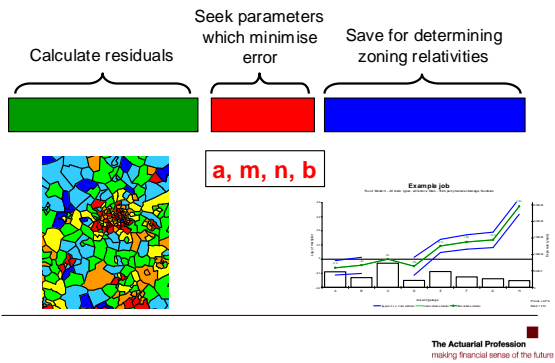
$Z(e_i) = \{ e_i / (e_i + a) \}^m$ e_i = exposure in region i

$$d_{ij} = \{ (x_i - x_j)^2 + (y_i - y_j)^2 \}^{1/2}$$

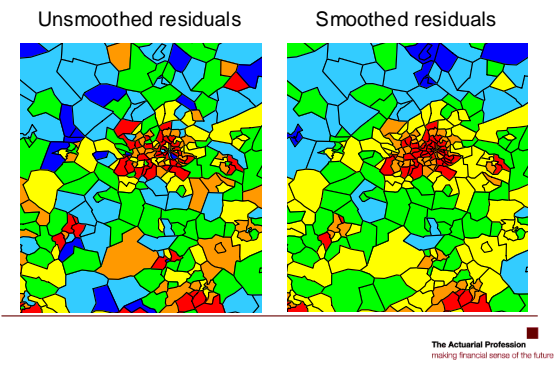
$$f(d_{ij}) = 1/d_{ij}^n \text{ or } 1/(d_{ij}^n + b^n) \text{ or } \exp(-n \cdot d_{ij})$$

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Finding the parameters

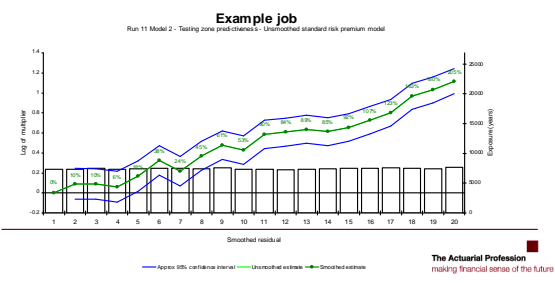


Example results

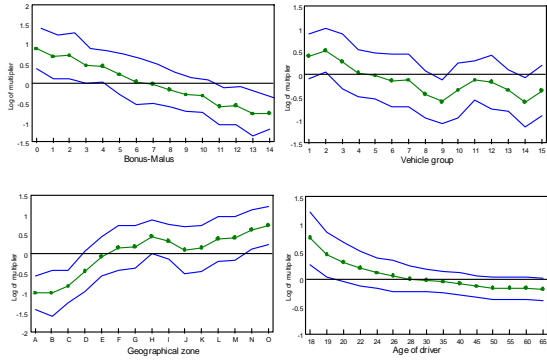


Spatial smoothing

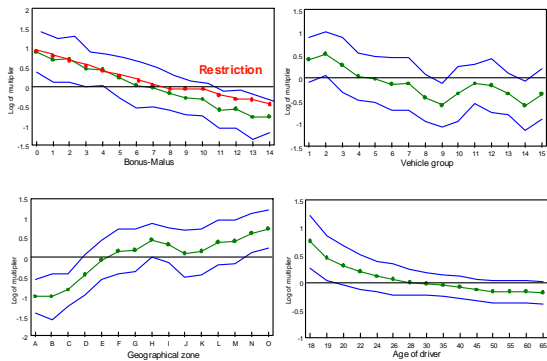
- Postcode quite predictive of PMI experience
- Potential correlations with Hospital Band/list



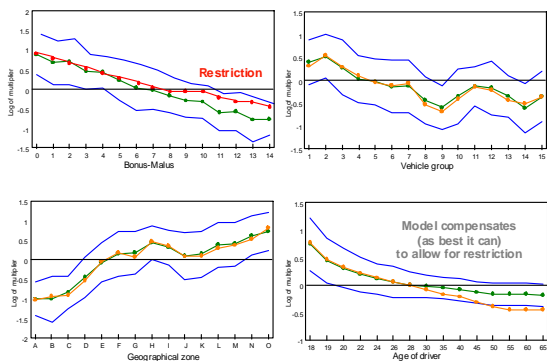
Restricted models



Restricted models

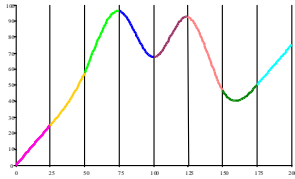


Restricted models



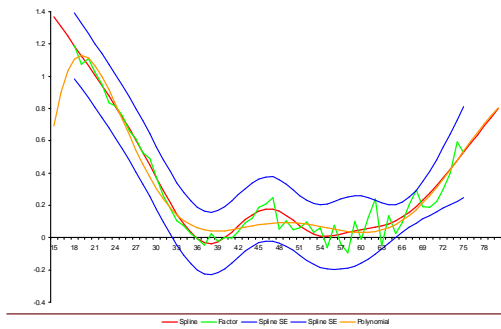
Splines

- A series of polynomial functions, with each function defined over a short interval
- Intervals are defined by $k+2$ knots
 - two exterior knots at extremes of data
 - variable number (k) of interior knots
- At each interior knot the two functions must join "smoothly"



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Splines



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Modelling cash benefits

- For hospitalisation cash benefits modelling average duration of stay in hospital in addition to claim frequency can increase model accuracy
- Claim amount can then be fixed amount (eg cost per day of stay negotiated with hospital)

$$\text{Freq} \times \text{Dur} \times \text{Amt} = \text{Hospital cost}$$

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Combining claim elements

$$\text{Cons Freq} \times \text{Amt} = \text{Cost 1}$$

$$\text{OP Freq} \times \text{Amt} = \text{Cost 2}$$

$$\text{IP Freq} \times \text{Amt} = \text{Cost 3}$$

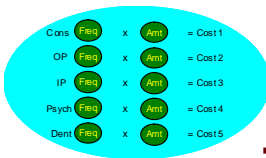
$$\text{Psych Freq} \times \text{Amt} = \text{Cost 4}$$

$$\text{Dent Freq} \times \text{Amt} = \text{Cost 5}$$

- Claim models can be combined by individual claim type
 - where products are modular
 - or when separate components can be calculated at the point of sale

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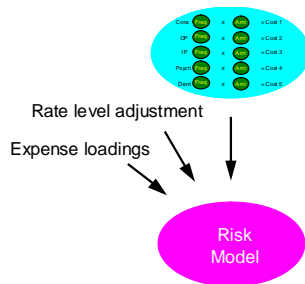
Combining claim elements



- Claim models can be combined across claim types
 - where the product (or part of the product) is a package across covers
 - for ease of understanding even when premiums can be priced by component at point of sale
- Claim types combined by using GLM to average relativities implicit in fitted values from other GLM results

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The premium rating process

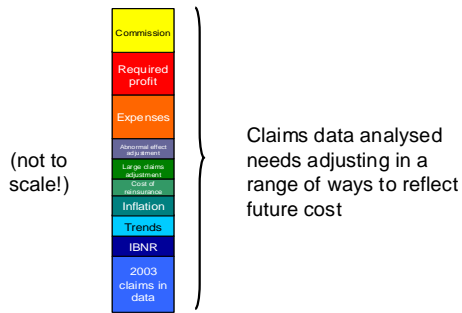


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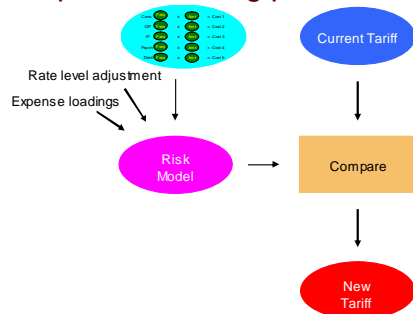
Expense loadings

- Percentage
- Per policy
- Per expected claim
- Multivariate
 - analyse expenses by factors eg do young policyholders amend policy more often?
 - take into account expected lifetime of policy (using retention analysis), amortising initial expenses accordingly
- Can be
 - explicit part of rating algorithm
 - embedded within relativities using GLM fitted to (claims + expenses)

Overall rate level need



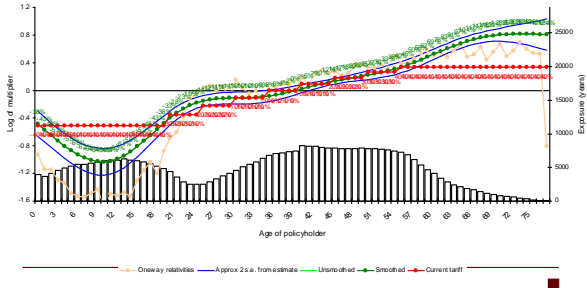
The premium rating process



Factor effect analysis

Example job

Run 62 Model 2 - Risk premium run - Unsmoothed standard risk premium model

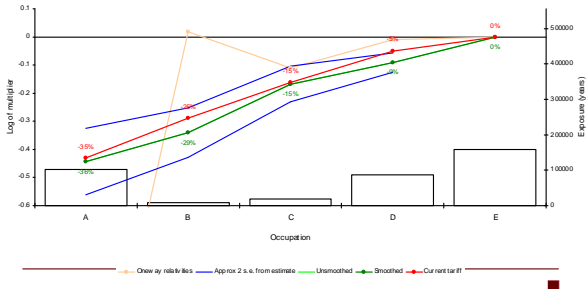


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Factor effect analysis

Example job

Run 62 Model 2 - Risk premium run - Unsmoothed standard risk premium model

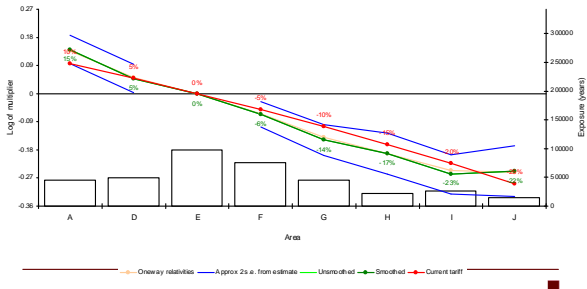


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Factor effect analysis

Example job

Run 62 Model 2 - Risk premium run - Unsmoothed standard risk premium model

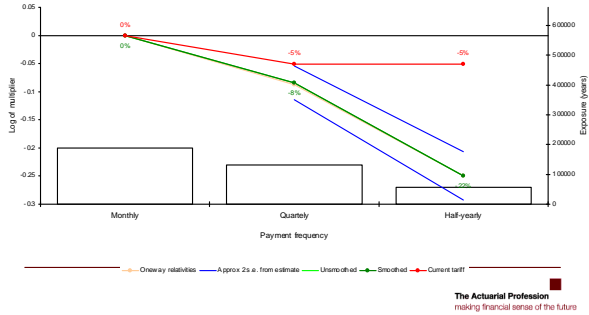


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Factor effect analysis

Example job

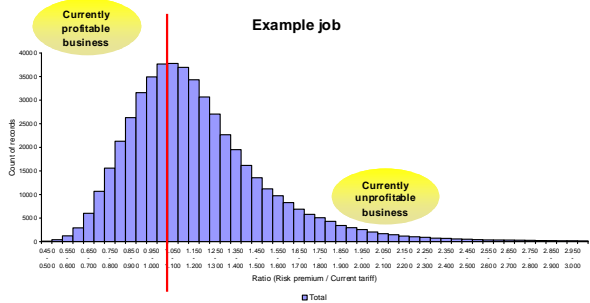
Run 62 Model 2 - Risk premium run - Unsmoothed standard risk premium model



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Impact analysis

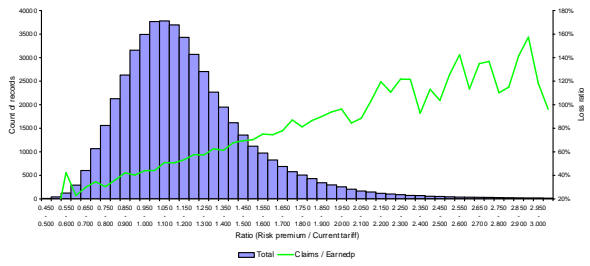
Example job



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Impact analysis

Example job

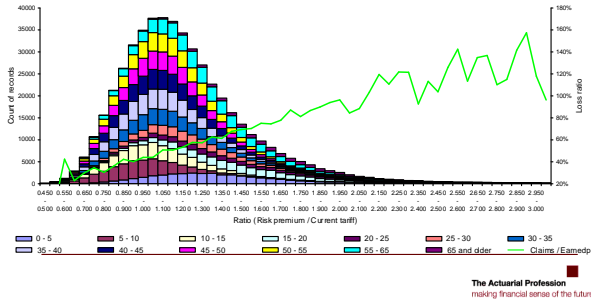


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Impact analysis

Example job

Age of policyholder

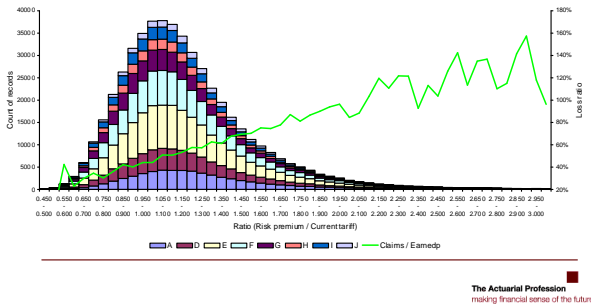


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Impact analysis

Example job

Area

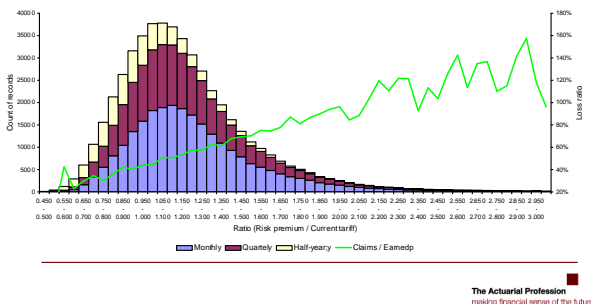


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Impact analysis

Example job

Payment frequency



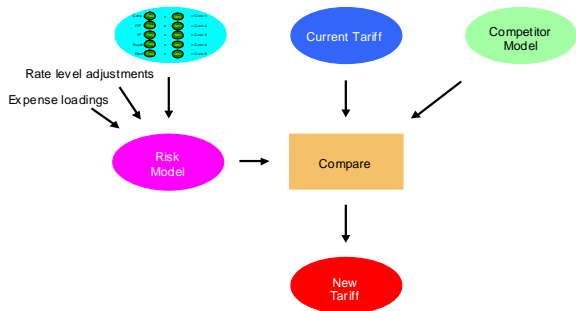
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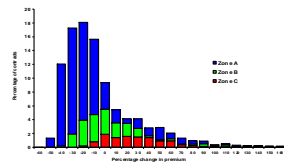
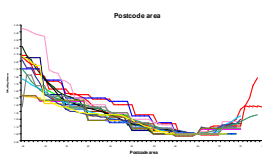
The premium rating process



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Competitive position

- Survey market
 - broker quotation systems
 - question policyholder
 - mystery shopping
- Investigate competitors' structures
- Apply "cheapest" tariff to own portfolio



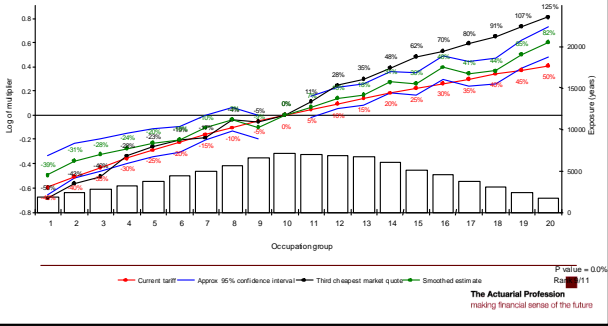
- Use in retention / new business model

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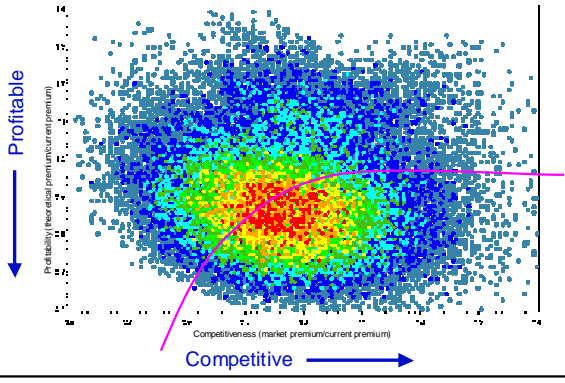
Considering the competitive position

Example of competitor analysis

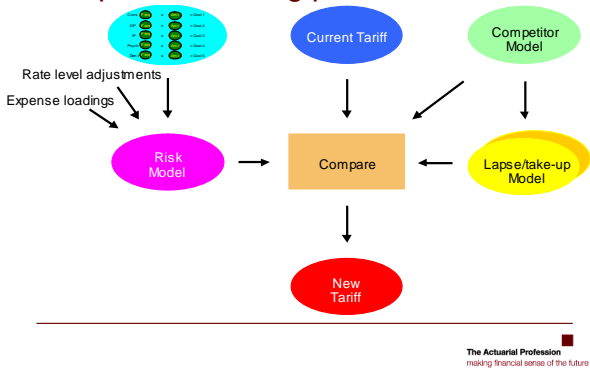
Out patient cover



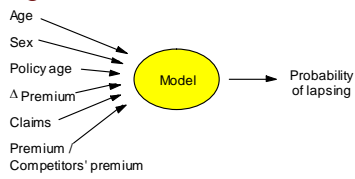
Considering the competitive position



The premium rating process



Modelling retention

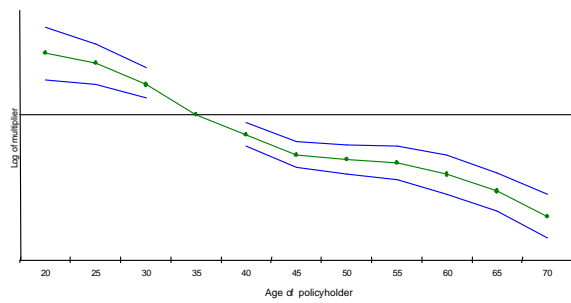


Model

- rating factors
- payment method
- NCD expectation
- source
- claims history
- other products held
- change in cover
- plus...*
- change in premium
- competitiveness

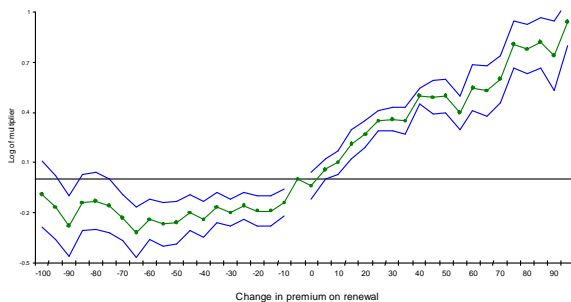
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Lapse model - Change in premium



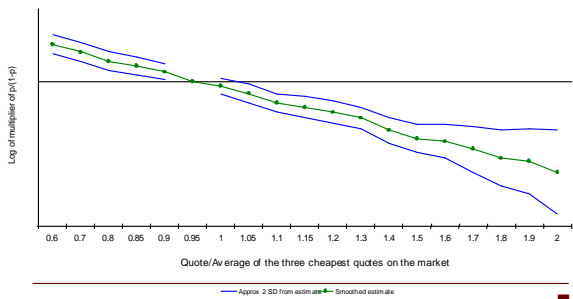
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Lapse model - Change in premium



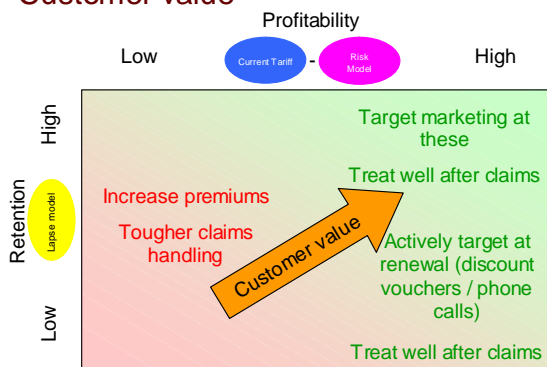
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New business conversion model Competitiveness of premium

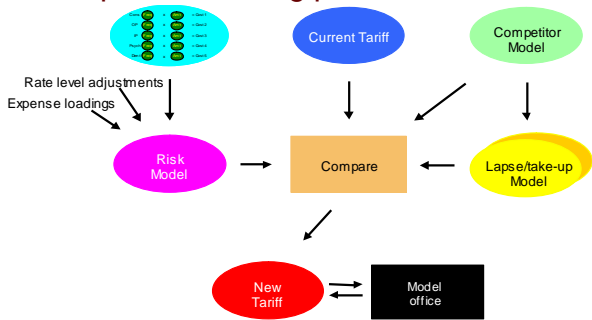


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Customer value



The premium rating process

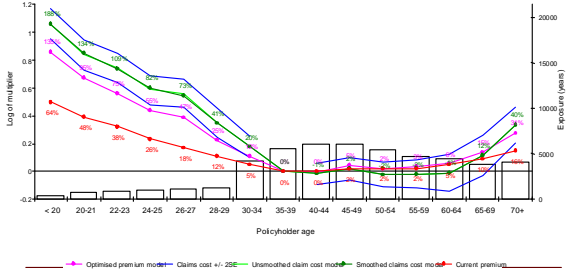


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Optimised rating structure

Optimised premium motor example

Comparison with claims model and current premium

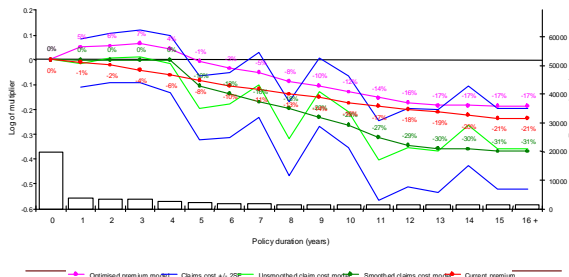


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Optimised rating structure

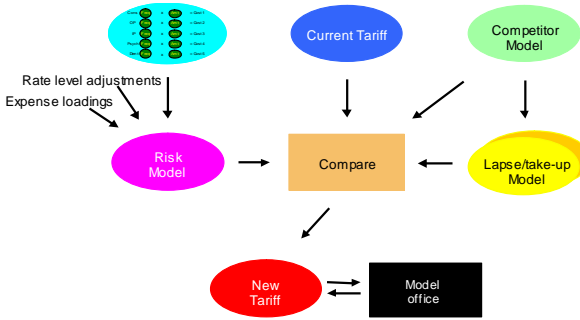
Optimised premium motor example

Comparison with claims model and current premium



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The premium rating process



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