The Actuarial Profession
making financial sense of the future

GIRO Conference and Exhibition 2011
Ji Yao

The Marginal Value of Individual Rating Factors in Pricing

11-14 October 2011

Agenda

- Introduction
- Previous analysis
- Modelling options
- Further thoughts and game theory
- Conclusion

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Introduction

- There may soon be more restriction on factors that can be used in pricing
  - Gender Directive
  - Postcode discrimination – Jack Straw's bill
  - Age?
  - Credit score?
- How will one single factor affect pricing model?
- Any solutions to reduce the impact?

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Previous Analysis

- There are several papers thoroughly analyse the impact of excluding one single factor, from view of
  - Consumer
  - Insurer/shareholder
  - Whole society
- ABI report
- CEA report
- Also study from USA where similar restriction is applied in some states

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Previous Analysis

- First order impact
  - Redistribution
    - Low-risk overpays to subsidise high-risk
  - GLM
- Second order impact
  - Market wide
    - High-risk tend to buy more insurance
    - Mixture of risk will change overall
  - Company wide
    - Similar change, but depends on company strategy
- A single factor could have significant impact on rating structure

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Focus of this workshop

- How to build a better rating structure when a single factor is excluded from model?
- Focus on modelling technique

- There are other considerations to this issue
  - Other source of information/data
    - On-going
    - Expense
  - Interpretation of rules
    - Renewal
    - Indirect discrimination

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Focus of this workshop

- Other considerations
  - Telematics
    - Technique
    - Practice
    - Privacy
  - Strategy

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Option 1: Drop the single factor out of rate table

- Method
  - Drop the single factor out of all rating tables without refreshing model.
  - Need to make assumption on mixture when drop it from multi-way tables
    - The assumption could be made from historical data as well as judgement
  - Example: Gender & Age
    - Assumption of gender distribution by age

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Option 1: Drop the single factor out of rate table

- Advantage
  - Simple to implement
- Issue
  - Parameters of other factors in the model might change
  - The assumption of distribution of the single factor in multi-way table might be difficult to make
    - Table is more than two ways
      - Smoothing
    - Distribution might change before and after excluding the single factor

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Option 2: Refresh GLM

- Method
  - Exclude the single factor from the model setting
  - Train a GLM on historical available data
- Advantage
  - GLM is a standard practice in industry
  - Simple to explain/implement
  - Parameters of other factors in the model will adjust automatically.

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Option 2: Refresh GLM - Issue

- It assumes that the correlation between factors won't change in the future
  - Might not be true when rating structure is changing significantly
    - Age & Car age
    - Age & Car Value
- Output of GLM *depends* on the mixture of book/correlation between factors if the true model structure underlying the data is *not* linear.

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Option 2: Refresh GLM - Issue

- If the true model structure underlying the data is linear, GLM result is independent of mixture of book.
- Example 1: true structure is multiplicatively linear

Relativity	Factor 1 - A	Factor 1 - B
Factor 2 - 1	1	1.2
Factor 2 - 2	1.7	2.04 (=1.2*1.7)

Option 2: Refresh GLM - Issue

- Standardized mixture of book

Standardized Exposure	Factor 1 - A	Factor 1 - B
Factor 2 - 1	20	36
Factor 2 - 2	2	1

- Log link and Gamma distribution

	Parameter Estimation
Intercept	0.7129
Factor 1 - A	- 0.1823
Factor 2 - 1	- 0.5306

Option 2: Refresh GLM - Issue

- Different standardised mixture of book

Standardized Exposure	Factor 1 - A	Factor 1 - B
Factor 2 - 1	20	36
Factor 2 - 2	2	2

	Parameter Estimation
Intercept	0.7129
Factor 1 - A	- 0.1823
Factor 2 - 1	- 0.5306

Standardized Exposure	Factor 1 - A	Factor 1 - B
Factor 2 - 1	20	36
Factor 2 - 2	2	4

	Parameter Estimation
Intercept	0.7129
Factor 1 - A	- 0.1823
Factor 2 - 1	- 0.5306

- no matter what mixture of book is assumed, the output will be exactly same!

Option 2: Refresh GLM - Issue

- Example 2: true structure is *not* multiplicatively linear

Relativity	Factor 1 - A	Factor 1 - B
Factor 2 - 1	1	1.2
Factor 2 - 2	1.7	2.55 (=1.5*1.7)

- Same Log link and Gamma distribution
- Apply the different assumption on the mixture of book

Option 2: Refresh GLM - Issue

Standardized Exposure	Factor 1 - A	Factor 1 - B
Factor 2 - 1	20	36
Factor 2 - 2	2	1

	Parameter Estimation
Intercept	0.8000
Factor 1 - A	- 0.1936
Factor 2 - 1	- 0.6136

Standardized Exposure	Factor 1 - A	Factor 1 - B
Factor 2 - 1	20	36
Factor 2 - 2	2	2

	Parameter Estimation
Intercept	0.8379
Factor 1 - A	- 0.1983
Factor 2 - 1	- 0.6498

Standardized Exposure	Factor 1 - A	Factor 1 - B
Factor 2 - 1	20	36
Factor 2 - 2	2	4

	Parameter Estimation
Intercept	0.8729
Factor 1 - A	- 0.2026
Factor 2 - 1	- 0.6833

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Option 2: Refresh GLM - Issue

Standardized Exposure	Factor 1 - A	Factor 1 - B
Factor 2 - 1	0.9928	1.2049
Factor 2 - 2	1.8338	2.2255

Standardized Exposure	Factor 1 - A	Factor 1 - B
Factor 2 - 1	0.9899	1.2070
Factor 2 - 2	1.8957	2.3115

Standardized Exposure	Factor 1 - A	Factor 1 - B
Factor 2 - 1	0.9871	1.2088
Factor 2 - 2	1.9548	2.3938

- High exposure segment have very limited impact
- Low exposure segment could change as much as 7%

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Option 2: Refresh GLM - Issue

- This shows that for data with a non-linear underlying structure, the GLM estimation depends on the mixture of book
- A practical solution to this is to add interactive term into GLM to make it linear
- However, it is hard to check all factors to make sure the model is linear

- Need to be careful in using this approach

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Option 3: Non-linear models

- When there is no evidence that the underlying data structure is linear, non-linear models could be used
- General benefit
  - Non-standard: competitive edge
  - Understand the risk better
  - Develop new rating factors
  - Identify profitable niche segment
- More software is available and become more standard
  - R
  - SAS

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Option 3: Non-linear models: Decision tree

- Advantage
  - Simpler than other types of non-linear model
    - Much easier to understand
  - No assumption to make on distribution or function between responce and explanatory variables
  - Model interactive term naturally
- Disadvantage
  - Result is normally worse than other non-linear models

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Option 3: Non-linear models : GAM/GAMLSS

- Generalized additive model (1986)
  - Nonlinear/non-parametric estimation
  - But more parameters/method to choose when setting up the model than GLM
  - Difficult to model interactive term
  - The additive structure is less intuitive in insurance rating structure
  - Much less used than GLM
- Generalized additive model for Location, Scale and Shape GAM (2001)
  - Limited research on how it is compared to GLM

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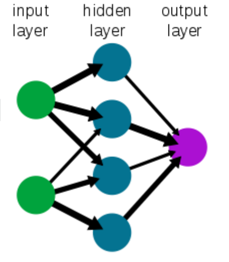
Option 3: Non-linear models : Neural Network

- Advantage
  - 'Generalised' GLM
  - Non-linear
  - Usually gives better result than GLM when set up properly
- Issue
  - Over-fit
    - Lack of statistical testing theory
  - Black-box
    - Lack of understand and difficult for communication

A simple neural network



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Option 4: Better model of other existing factors

- Other existing factors will become more important
  - More complicated structure
- NCD system
  - Markov chain
  - But treated as a normal rating factor within GLM.
- Claim history
- Conviction history

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What if one company find another predictive factor?

- Consider a very simple scenario
  - Market consists of high-risk and low-risk only; High-risk need £600 to achieve required ROE and low-risk need £400
  - Company A – one rating factor, with premium £400 and £600, respectively
  - Company B – no rating factor, flat premium £500
- B will be selected against – write all high-risk and make loss
- A will write all low-risk and break even

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What if one company find another predictive factor?

- However, B will realize its loss and, based on the claim experience, increase premium to £600
- B will write half of the high-risk, make even
- A will write all low-risk plus half of the high-risk, make even
- This state is stable…
- until A realise its advantage and increase premium for low-risk
  - A will then make profit

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What if one company find another predictive factor?

- The advantage of extra rating factor need to be combined with acute market awareness to get real benefit
  - Mixture of book
  - Conversion
- Company with less rating factor can still run business in the high-risk segment
  - Volume will be limited
  - But not a problem for small/niche market player
- Pricing strategy and game theory

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Conclusion

- Single factor could have a significant factor in pricing
- GLM might not work proper when the mixture of book change significantly;
- There are other options to improve model:
  - Non-linear models
  - Existing rating factor/system, such as NCD
- Strategic pricing become more important: game theory could be used in analysis.

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Questions or comments?

Expressions of individual views by members of The Actuarial Profession and its staff are encouraged.

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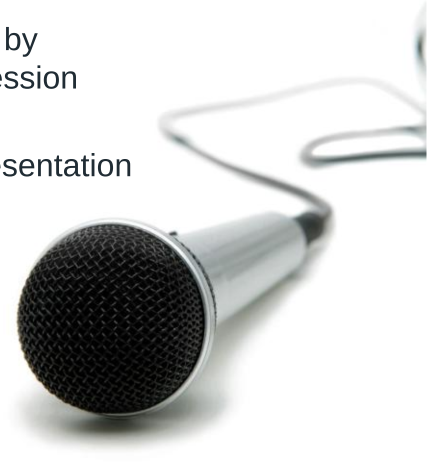

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