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Price optimization – Theory and Practice

CAS Predictive Modeling Seminar

James Tanser
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Agenda

- Theory: Elasticity Models
- Practice: Rating plan design
- Practice: Life Cycle
- Theory: Philosophy

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Agenda

- **Theory: Elasticity Models**
- Practice: Rating plan design
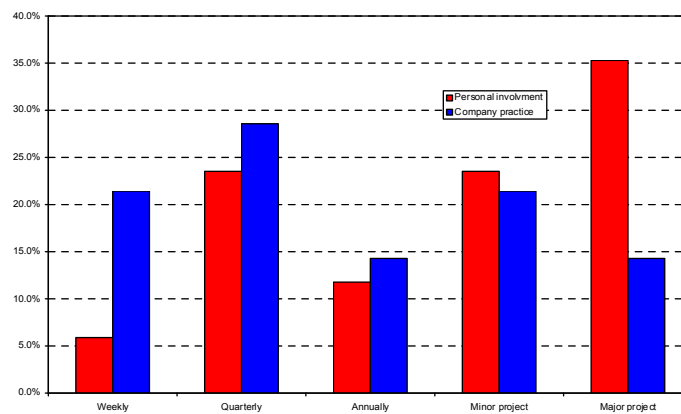- Practice: Life Cycle
- Theory: Philosophy

Elasticity models

- UK Actuarial profession's GIRO working party on "Demand models"
- James Tanser (Chair), John Light, Sophia Mealy, Owen Morris
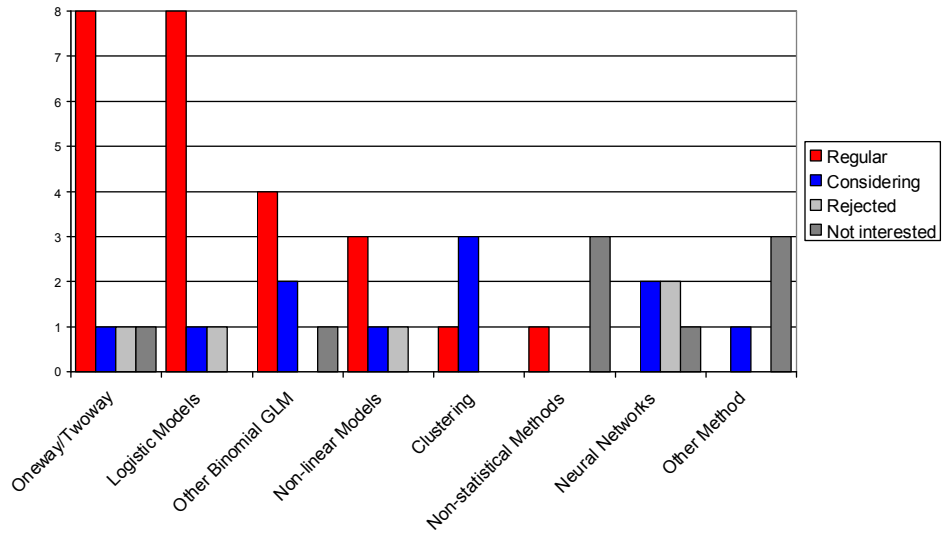- What sort of models are used and should be used?

Survey

- Small response: 32 started and 11 finished
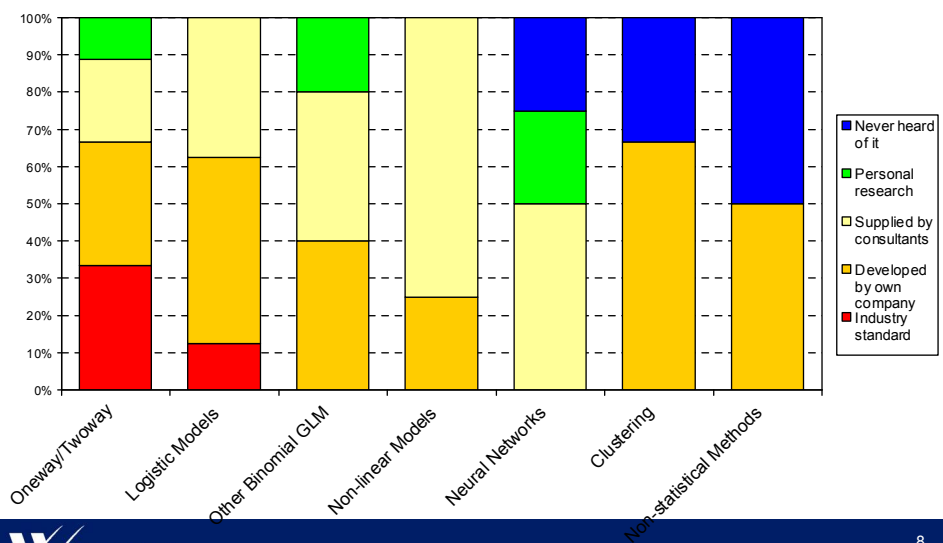- Results interesting despite low response

Frequency of analysis

Methods in use

Chart — categories: Oneway/Twoway, Logistic Models, Other Binomial GLM, Non-linear Models, Clustering, Non-statistical Methods, Neural Networks, Other Method

Legend:
- Regular (red)
- Considering (blue)
- Rejected (light grey)
- Not interested (dark grey)

Source of models

Chart — categories: Oneway/Twoway, Logistic Models, Other Binomial GLM, Non-linear Models, Neural Networks, Clustering, Non-statistical Methods

Legend:
- Never heard of it (blue)
- Personal research (green)
- Supplied by consultants (light yellow)
- Developed by own company (orange)
- Industry standard (red)

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Generalised linear models

$$E[\underline{Y}] = \mu = g^{-1}(\mathbf{X}.\underline{\beta} + \xi)$$
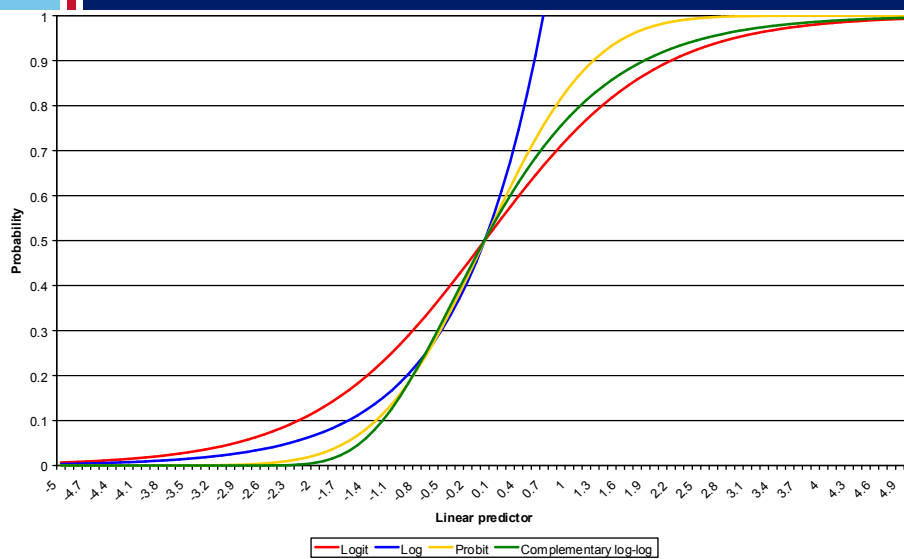
$$Var[\underline{Y}] = \phi.V(\mu) / \underline{\omega}$$

Models: traditional view

- A logistic model is most appropriate
  - considers log(p / [1-p]) with binomial error
  - maps [0,1] to [- ∞, ∞]
  - invariant to whether you model success or failure
- If lapses are low and results not to be used directly, a Poisson multiplicative model can help
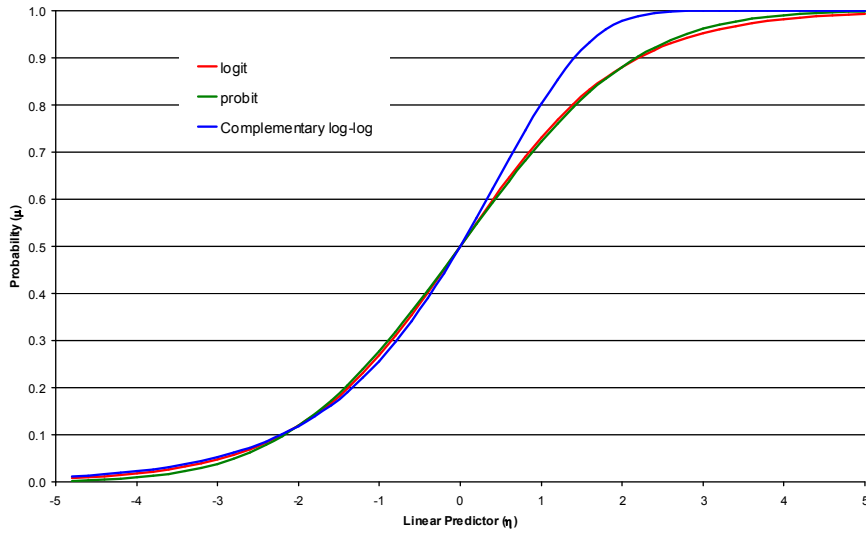 - theoretically wrong (can predict multiple lapses), but easier to communicate

Other models

- Could try:
  - log link
  - probit link
  - complementary log-log link
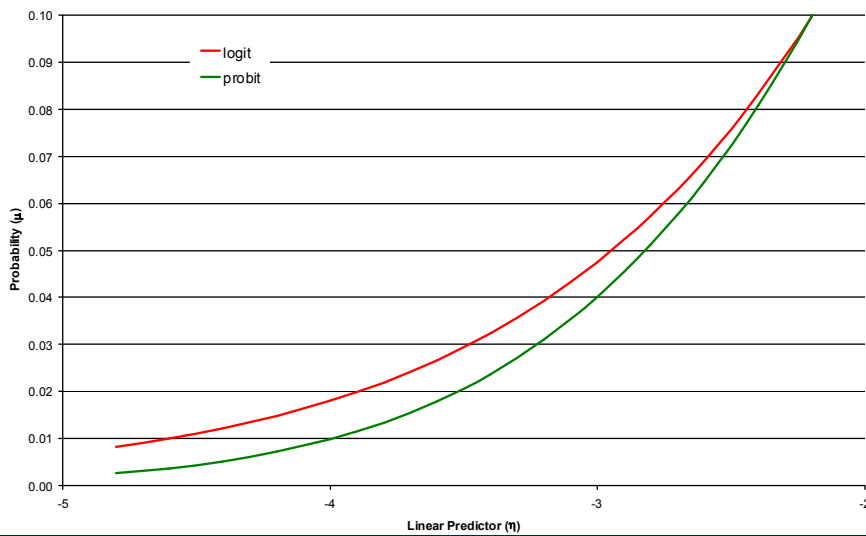- Transform the data
  - Sampling

Link functions
Rescaled so 0 => 0.5

Link functions
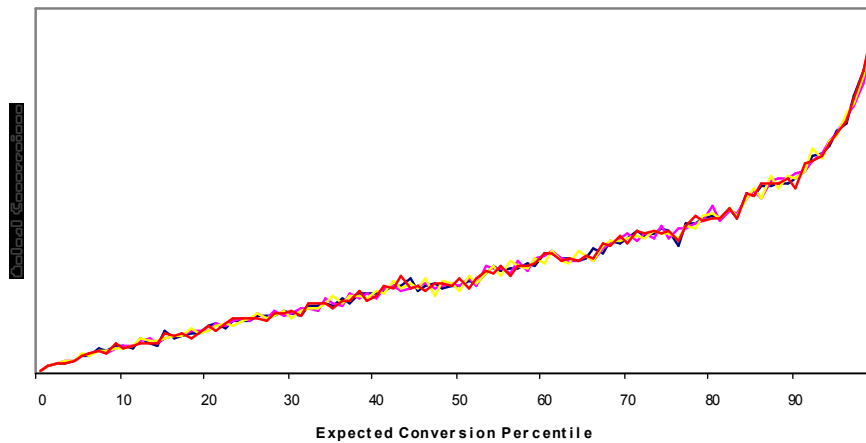### Rescaled to be the same at 0 and -2

Link functions
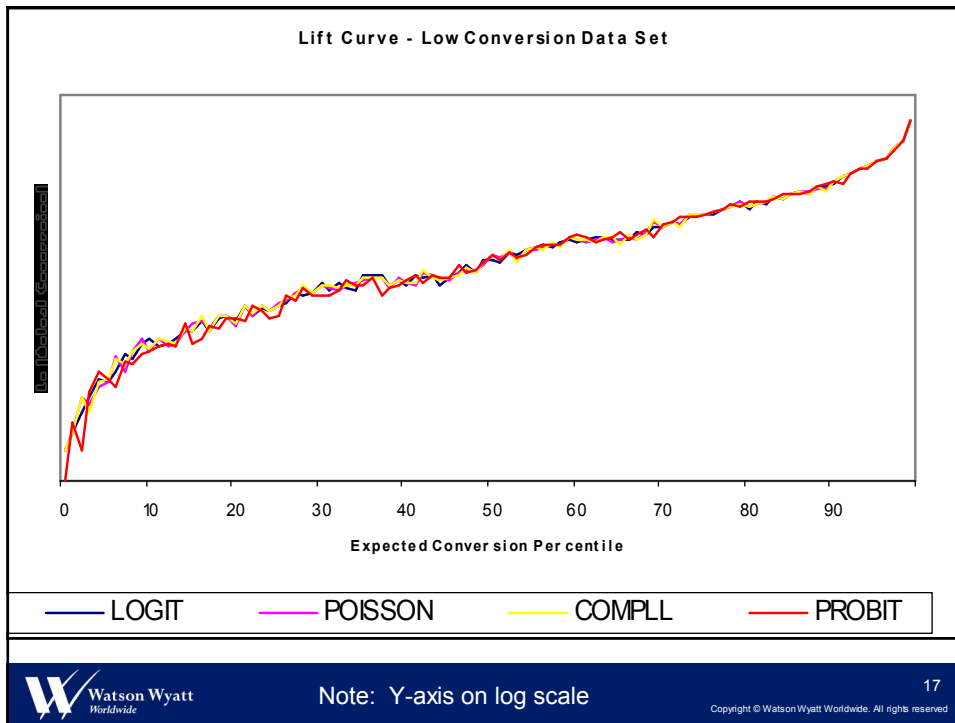### Rescaled to be the same at p=0.1

Data analysis

- Two datasets examined:
  - "High" typical of traditional channels
  - "Low" typical of new channels
- Data split into Train and Test using time split
- Base model was Logistic
  - Briefly iterated to get reasonable model
  - Same variable selection applied everywhere

Lift Curve - High Conversion Data Set

LOGIT   POISSON   COMPLL   PROBIT

Lift Curve - Low Conversion Data Set

Expected Conversion Percentile

LOGIT   POISSON   COMPLL   PROBIT

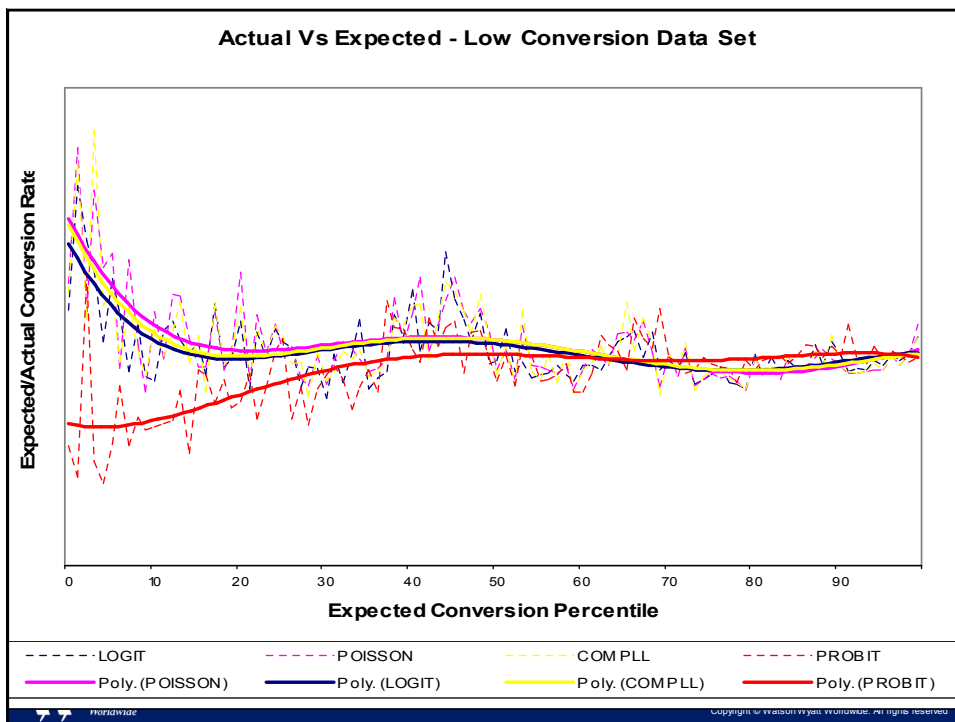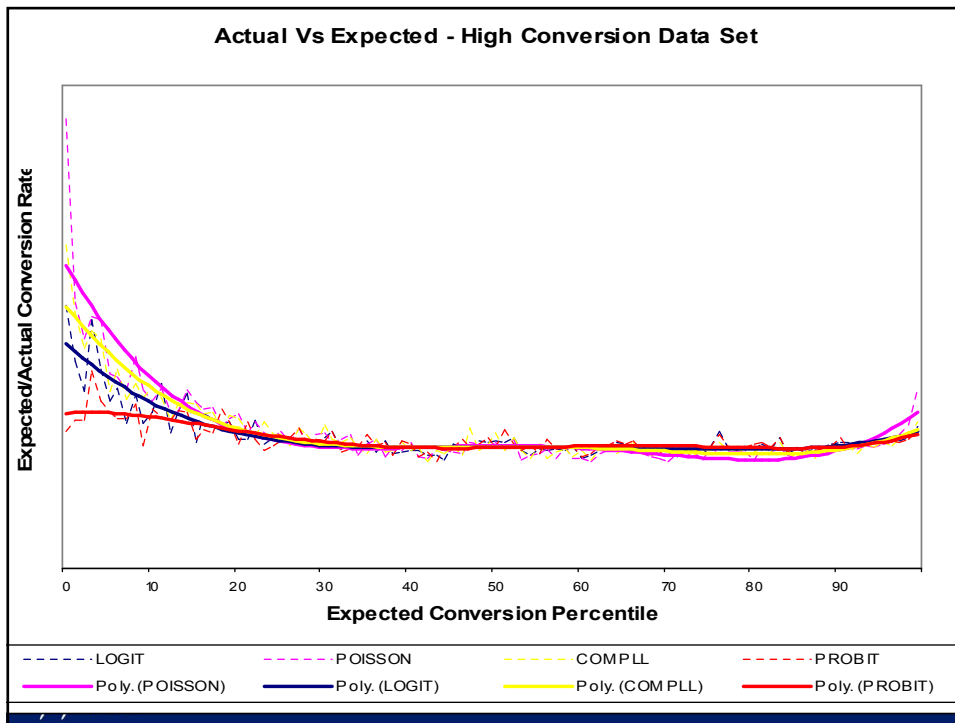Watson Wyatt Worldwide

Note: Y-axis on log scale

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Lift curves: Conclusions

- All models appeared to do equally well in separating high and low conversion segments

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Actual Vs Expected - High Conversion Data Set

Actual Vs Expected - Low Conversion Data Set

Actual versus Expected: Conclusions

- Within any given model, there appears to be a systematic overestimation of low conversion segments
- Poisson/Log link is worst option
  - Poor at both ends for high conversion!
- Binomial/Probit appears flatter
  - Not clear what is happening for low conversion
- Binomial/Logit next best shape (but marginally better predictor)
  - Methodology may bias analysis to prefer this method

Agenda

- Theory: Elasticity Models
- **Practice: Rating plan design**
- Practice: Life Cycle
- Theory: Philosophy

Optimization output

- Optimized premium for each risk
- Cannot be captured in typical rating structures
- GLM fitted to optimised premium allows partial benefits
  - More complex premium structures allow more to be captured!

Rating plan design

- In principle, rating plan designs *should be* very flexible:
  - Tiers
  - Mix of Additive and Multiplicative
- In practice, often less so:
  - Common relativities for all tiers
  - Inflexible template

Tiers

- Often risk based
- Post optimization, could be risk and behaviour based:
  - High retention/high risk
  - High retention/low risk
  - Low retention/high risk
  - Low retention/low risk
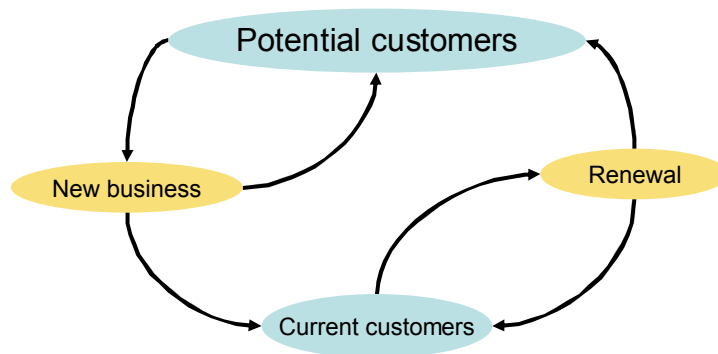- Different relativities by tier allow more accurate reflection of optimized rates

Optimization time horizon

- One year, two years, 10 years?
- Even for actuaries, the future is hard to predict!
- Why go long?
  - Reflect real customer behaviour
  - Allows model to blend in changes over time
  - It's what life and benefits actuaries do
- Why not?
  - Rapid market change
  - Model uncertainty
  - Cost/benefit

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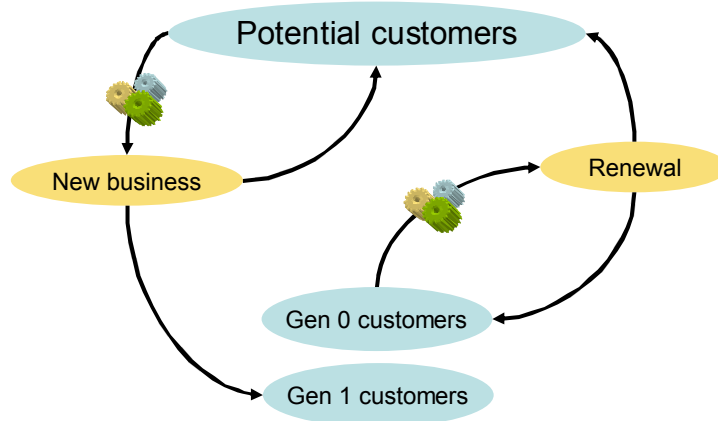- **Practice: Life Cycle**
- Theory: Philosophy

Pre-optimization life cycle

Pre-optimization life cycle

- New business and renewal relativities often the same, with some tenure discount
- May have several generations corresponding to the introduction of new rating variables
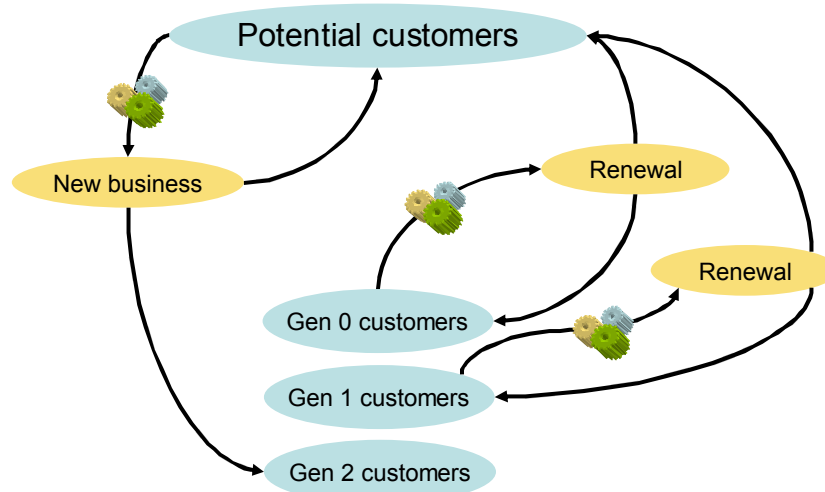- Complications with tiers also present

New life cycle with optimisation

New life cycle with optimisation

- New and renewal relativities potentially different
  - Treat as separate tiers?
- Generation 0 not homogeneous
  - Split to generations 0, -1, -2, -3, …
- Generation 1 new business premiums are not the same as Generation 0 new business premiums….

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New life cycle with optimisation

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New life cycle with optimisation

- Generations increase over time
- This looks like quite a lot of work…

Practical considerations

- Pre-planning
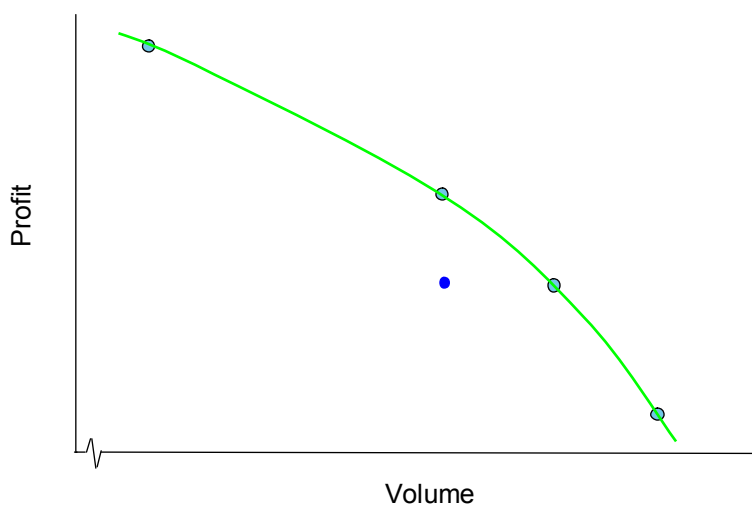- First application
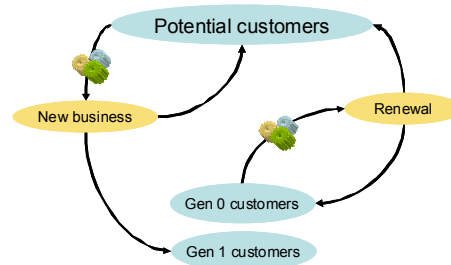- Second application

Pre-planning

- What is possible and practical?
  - Number of tiers & tiering rules
  - Consistency of relativities
  - Number and complexity of rating variables and interactions
- What are the targets and constraints?
  - Price and other marketing promises
  - Market position

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Market position

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First application

- Tier definitions
- "Logical" relativities
- Testing times
- Mid-term adjustments
- Frequency of updates

Potential customers

New business

Renewal

Gen 0 customers

Gen 1 customers

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Tier definitions

- Tier based on some or all of:
  - Risk
  - Tenure
  - Behaviour
- Indicated versus Selected relativities
- Even optimising base rate for each tier has some benefits…
- … but more flexibility gives more benefit

Balance flexibility and complexity

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"Logical" relativities

- Customers (regulators) have some expectations
- Risk based relativities can break these (eg deductible)
- Optimised relativities have same issues
- Consider unconstrained results and move to practical rates, understanding losses at each stage

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Testing times

- Ideal implementation is on subset of data
  - This is hard when rates must be filed
- Data requirements are demanding
  - GIGO
  - Claims, Retention, Conversion
  - Premium data hard to come by
- Consider:
  - New business only
  - Old (5+, say) business only
  - High (Low) risk tiers only

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Mid-term adjustments

- Different targets = Different premiums
  - Use original premium relativities for minor changes
  - Use new premium structure for major changes
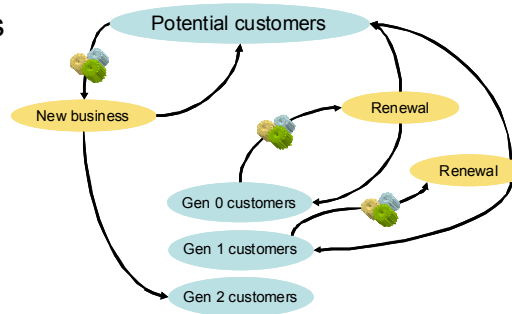- Take care with multiple policy discounts

Frequency of updates

- Dependent on market dynamics
  - Monthly / weekly / daily / hourly / …
- Rate filing adds delays, and makes life harder
- One revision a year will not deliver the same benefits as 2, or 4, …
- A moving target is harder to hit
  - Out-optimise the competition?

Second application

- Generations and Tiers
- Monitoring

Generations and Tiers

- How complicated do you want it to get?
- Can maintain constant level of complexity
  - Some loss of optimality

Monitoring

- The model is not reality
  - See world finance industry for details
- Learn from deviations
- Be prepared to make changes
  - You may be filing more often than you are used to
- Management buy-in is vital

Agenda

- Theory: Elasticity Models
- Practice: Rating plan design
- Practice: Life Cycle
- **Theory: Philosophy**

Philosophy of optimisation

- Who benefits?
- What is insurance for?
- What is fair?
- How do we deliver value to the owners of capital?

Who benefits?
Customer point of view

- Assuming a free market, price is the main driver of choice
- Some premiums go up and some down
  - Not a "zero-sum game"?
  - In long run competition will keep profitability at "sensible" levels
- Loyal customers represent useful future income
- Low retention customers make suitable contribution to expenses

Who benefits?
Company point of view

- All about information and relationships
- Better risk and behaviour models give better targeted premiums
- Affinity groups and intermediaries in strong position
  - Variable commission common in UK

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What is insurance for?

- Social good implies:
  - Community rating
  - Large scale cross subsidies
  - But – discouraging risky behaviour?
- Commercial enterprise implies:
  - Fee for service, willing buyer/willing seller
- Most countries have a compromise position
  - Wide variation within US

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What is fair?

- Risk based pricing?
  - Regulations prevents use of risk factors forcing cross subsidy
  - Higher returns on higher risks?
- Optimisation moves away from risk based
  - Does not necessarily penalise the loyal
  - Does move towards insurance as commercial enterprise

How do we deliver value to the owners of capital?

- Insurance is NOT run by the state
- The owners of capital expect a return for the risk they run
- Heavily regulated markets tend to be more profitable
  - The free market works?
- Optimization allows premiums to be set to meet the targets (and hence risk appetite) of the business
- Cost/benefit balance, as in all things

Questions

- James Tanser
  - +44 1737 274249
  - james.tanser@watsonwyatt.com

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