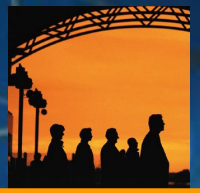
Modern methods in personal lines pricing

CAE/DAV Meeting

Berlin

29 April 2005



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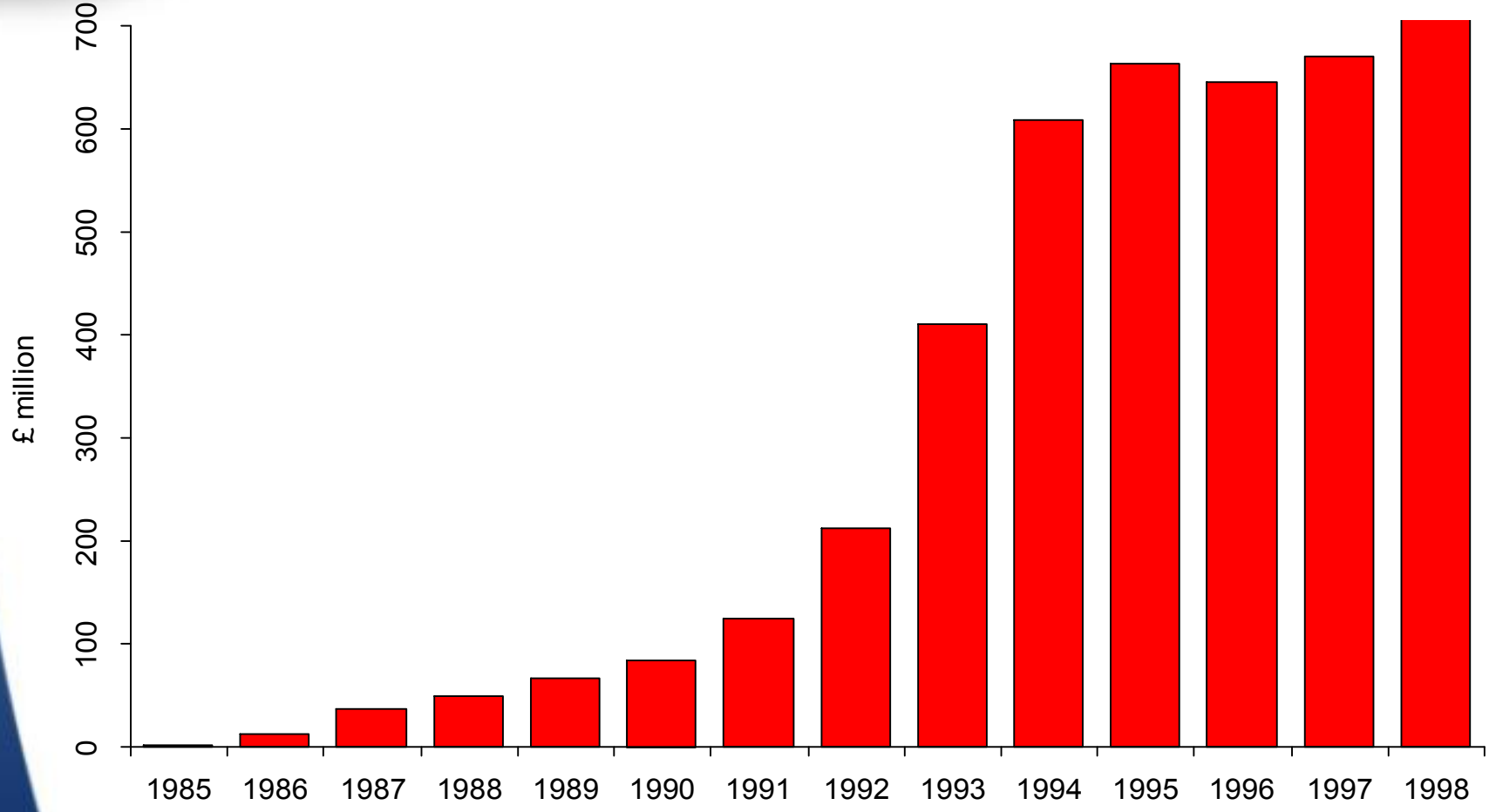
Duncan Anderson

Watson Wyatt Worldwide

Agenda

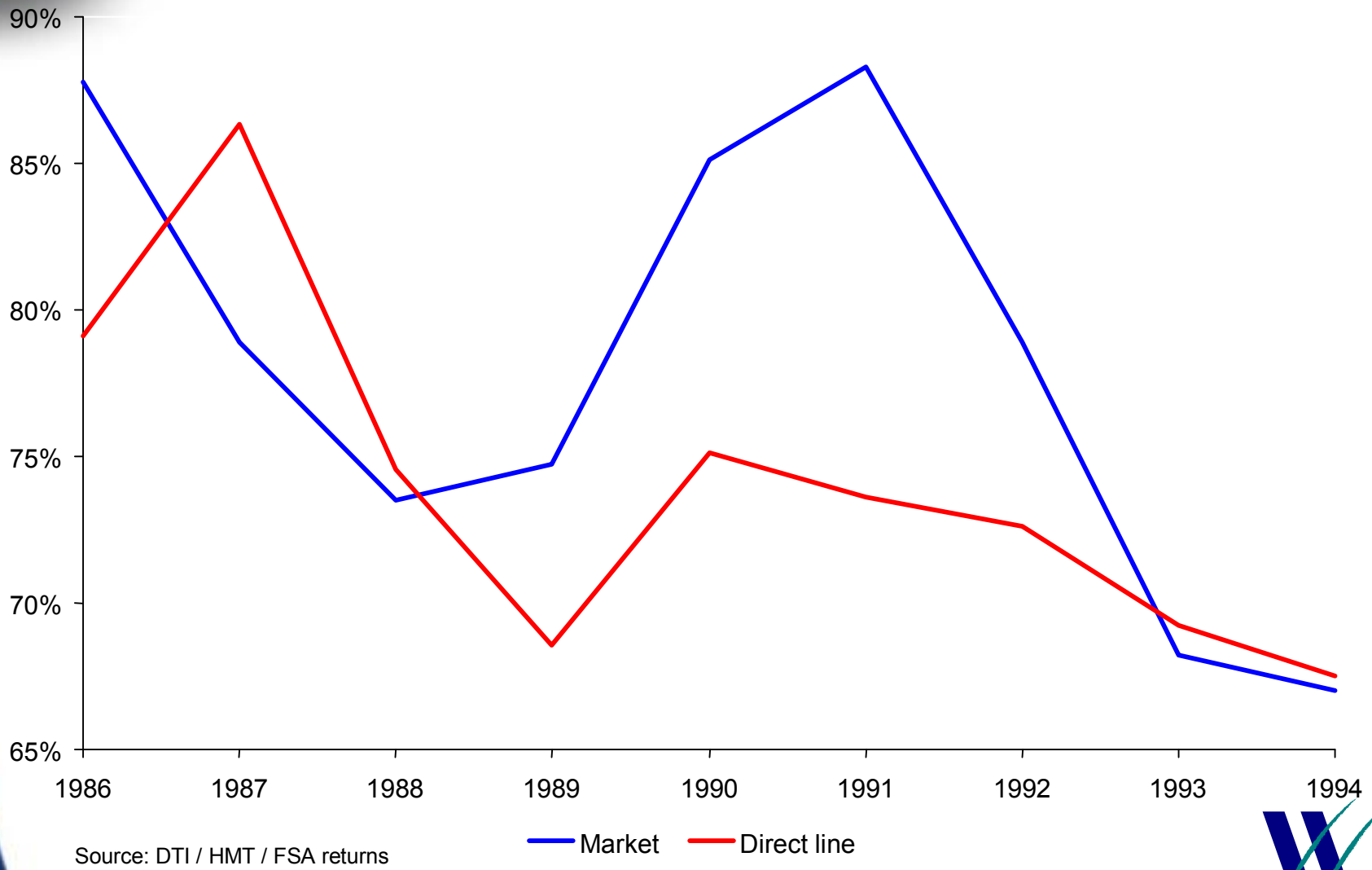
- The case for effective pricing
- Analysing claims
- Comparing claims models with current rates
- Competitor analyses
- Retention / new business analyses
- Price optimisation

Direct Line (UK) – written premium 1985 to 1998



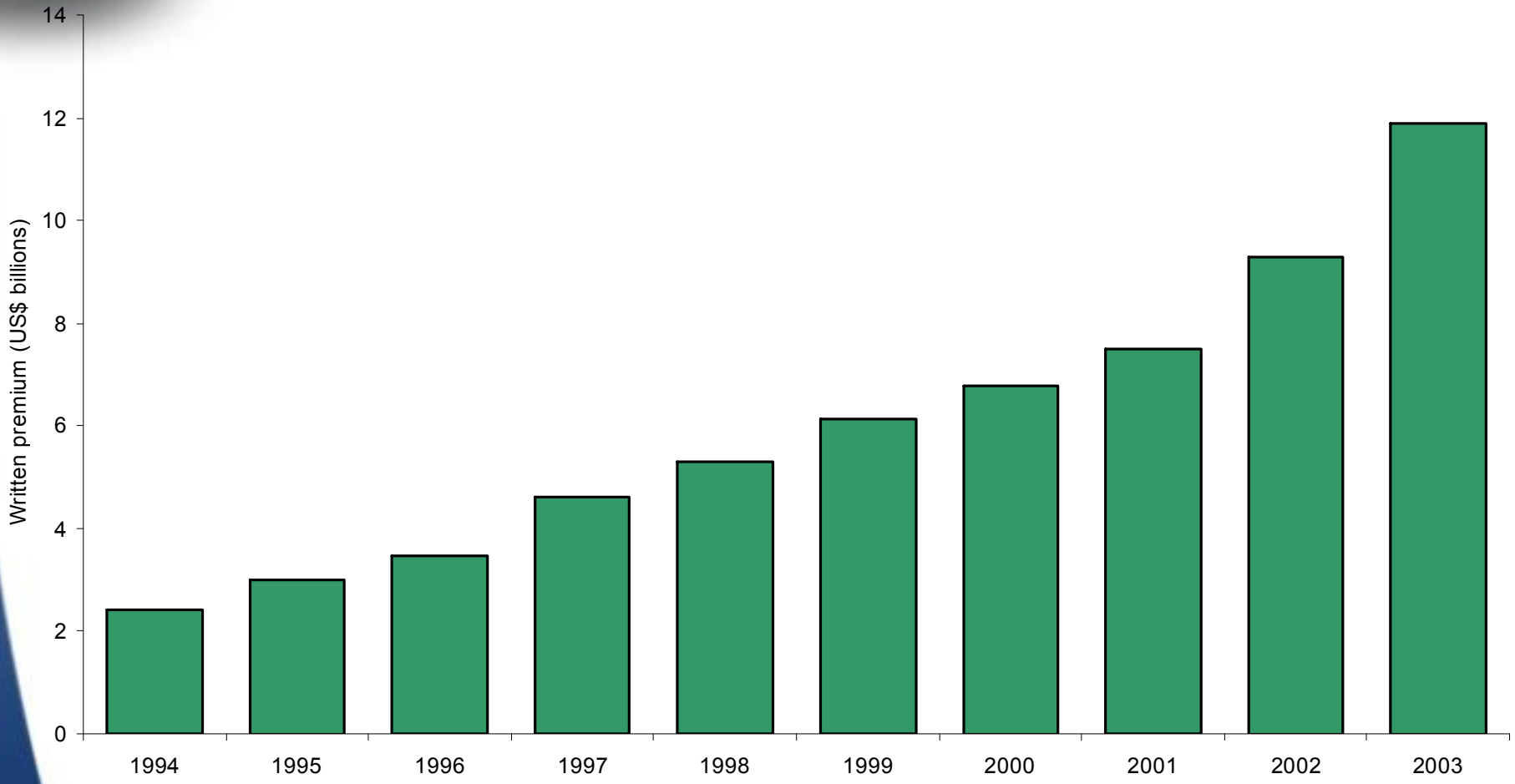
Source: DTI / HMT / FSA returns

UK motor market loss ratio



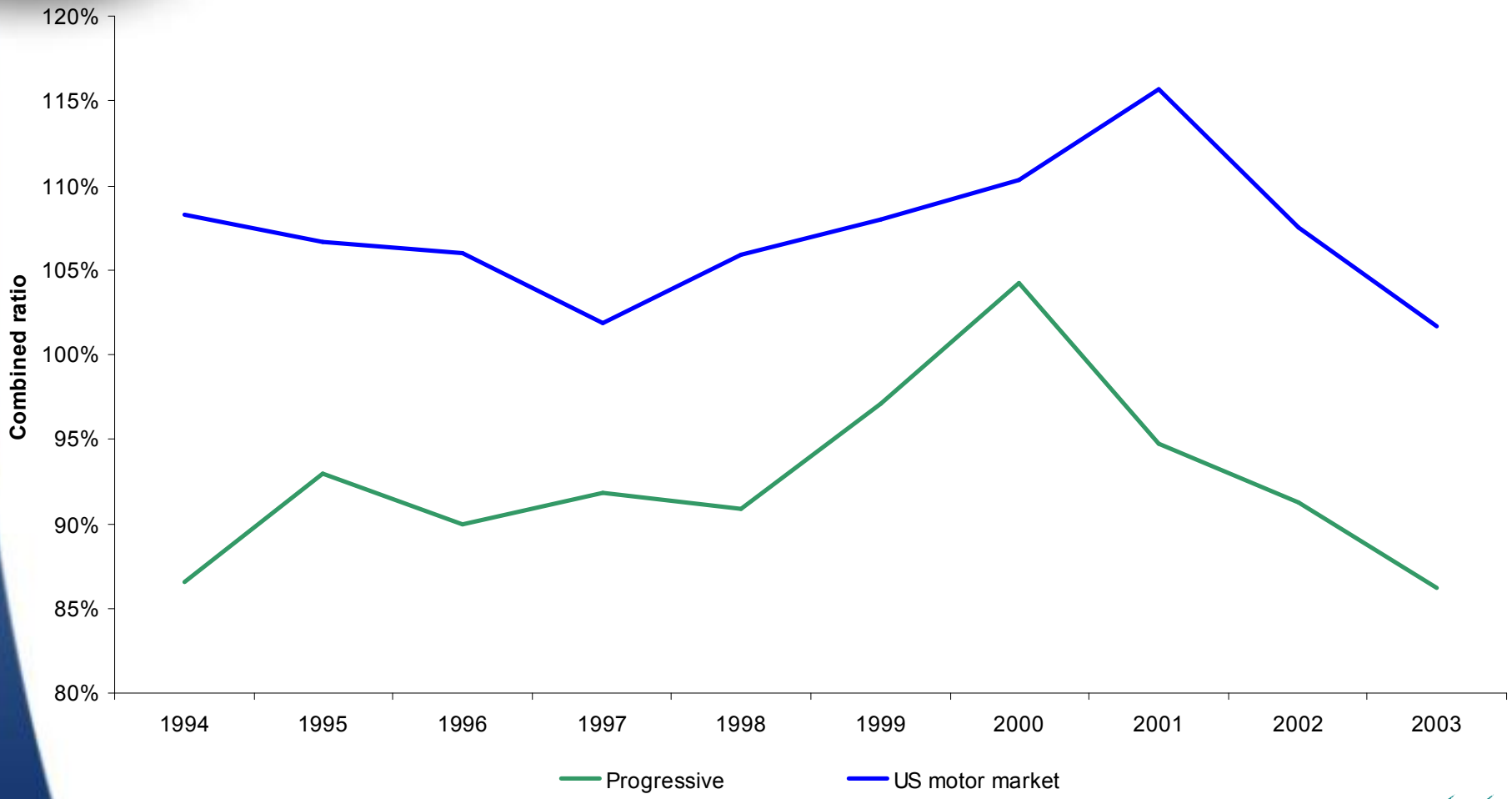
Source: DTI / HMT / FSA returns

Progressive (US) – written premium 1994 to 2003



Source: The Progressive Corporation & Subsidiaries Ten Year Summary

US motor market combined ratio

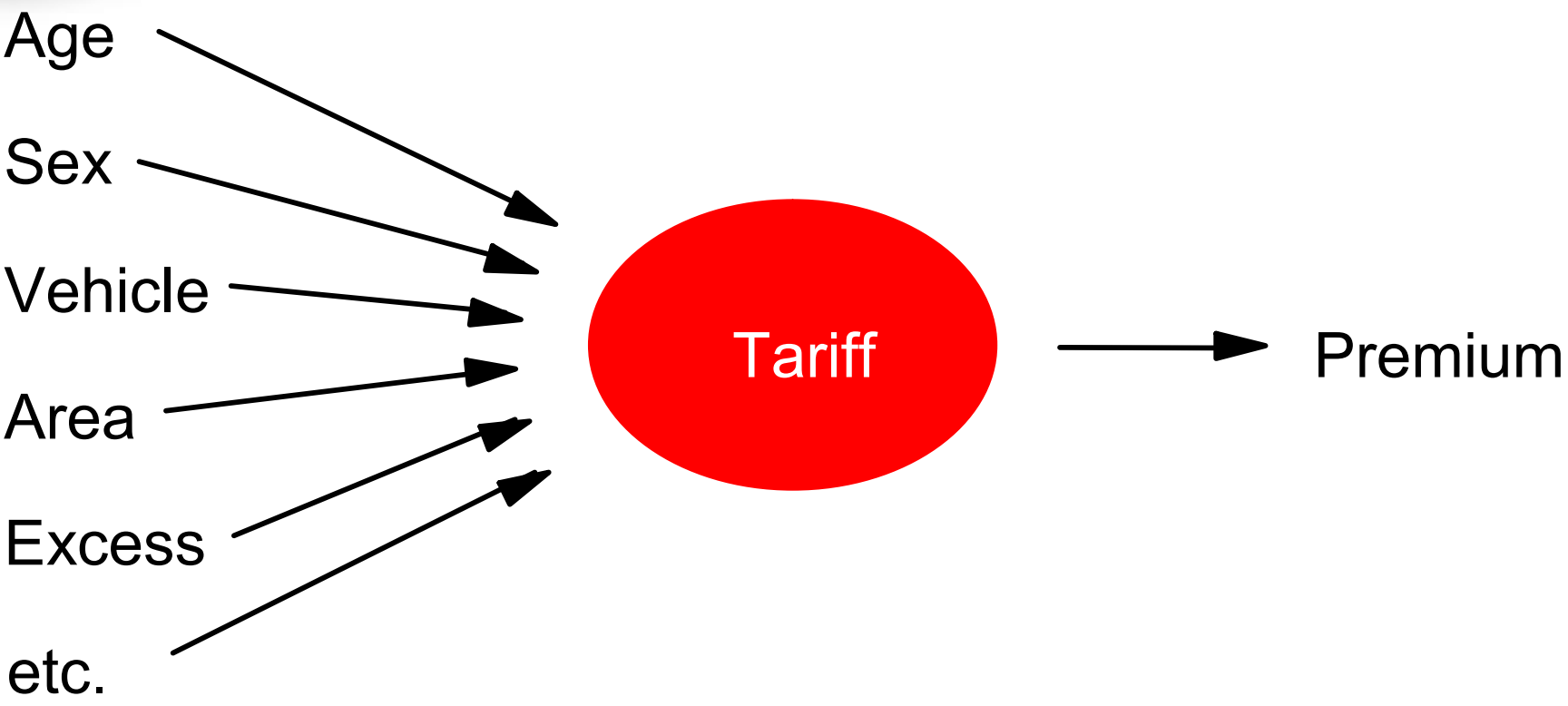


Source: Insurance Information Institute, A.M. Best, The Progressive Corporation & Subsidiaries Ten Year Summary

Case study – company in Eastern Europe

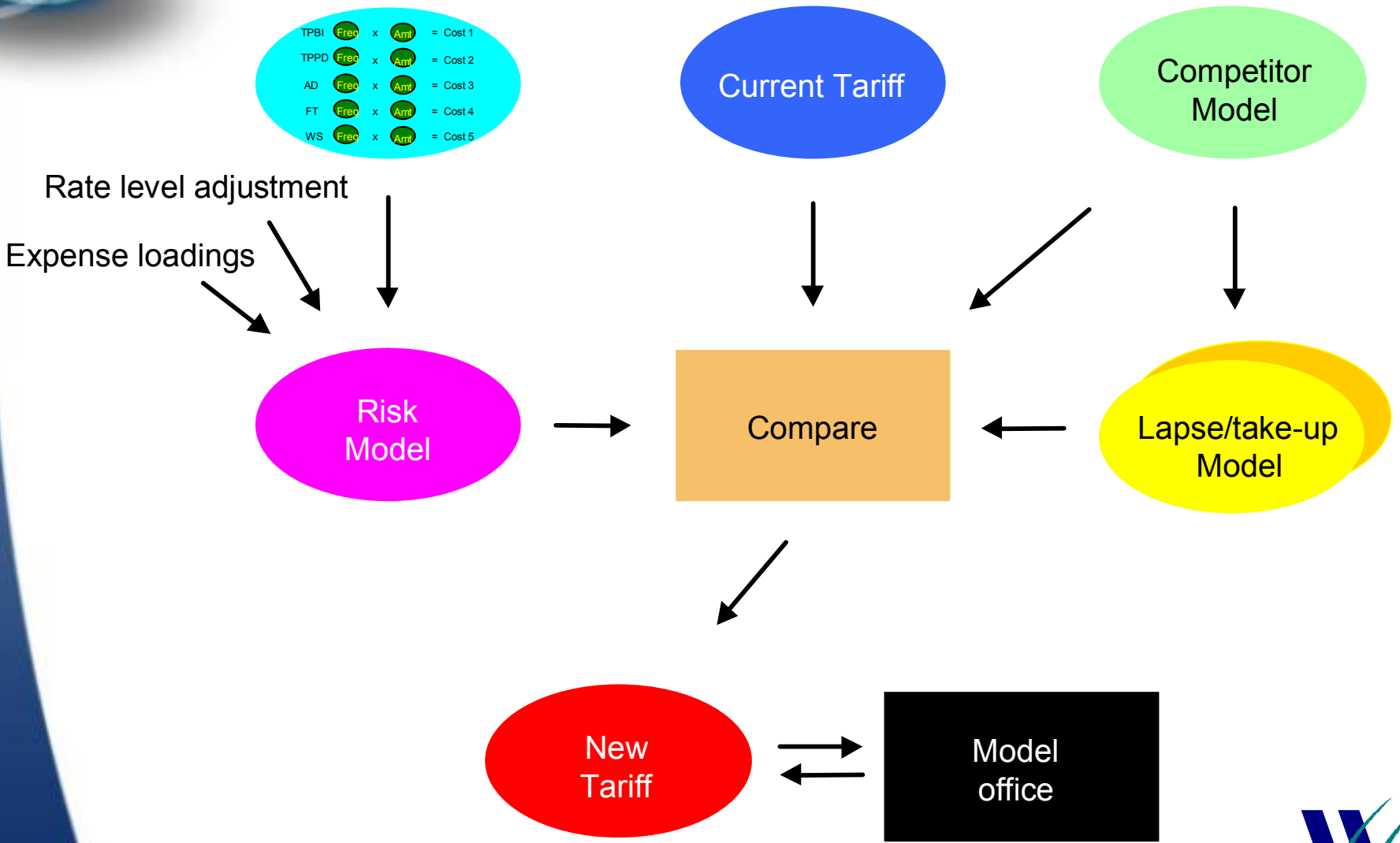
	Frequency		Loss ratio	
	@ 6 months	@18 months	@ 6 months	@18 months
2003 (old rates)	7.1%	7.2%	64%	86%
2004 (new rates)	6.4%		49%	

Objective

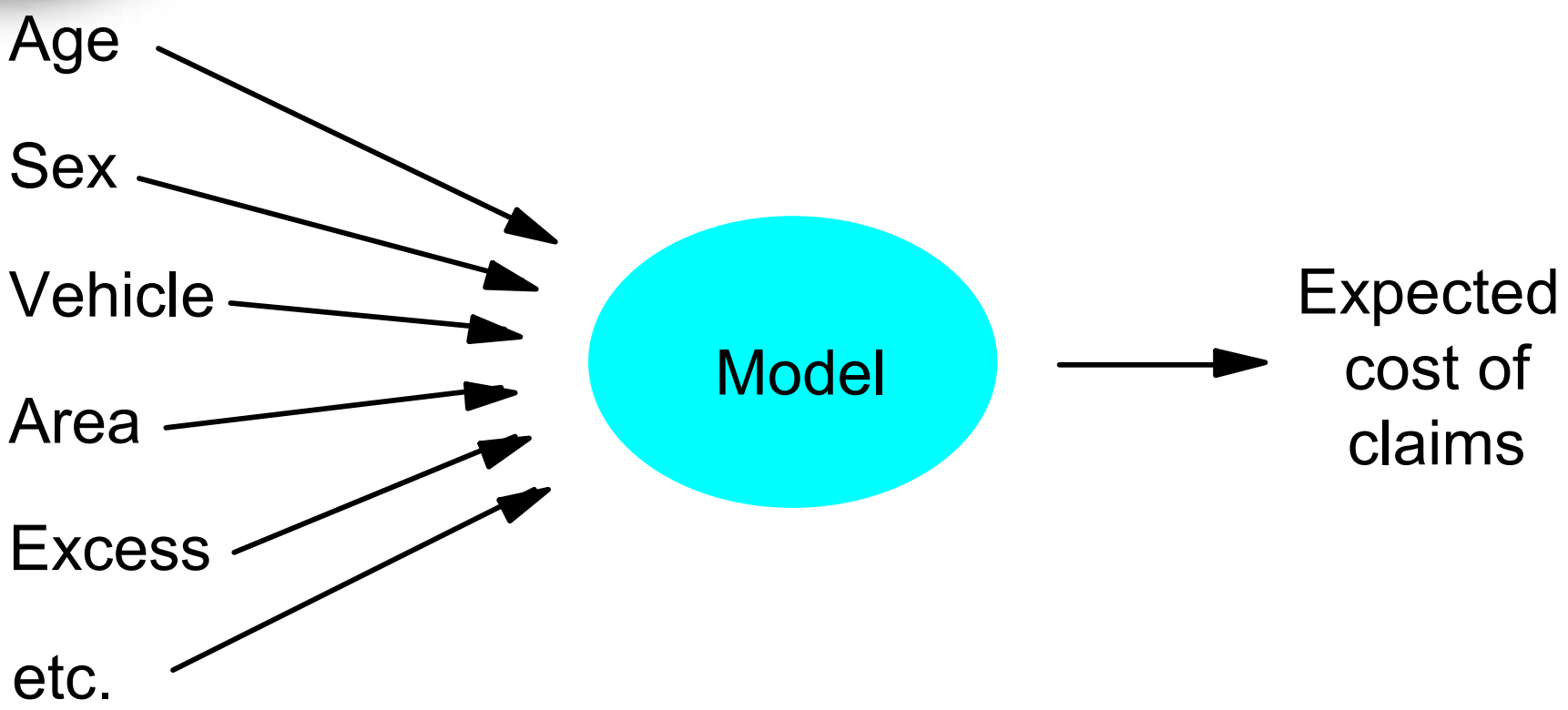


"Tariff" is this context means "rating structure" - it does not imply regulated fixed tariff, nor anything related to tax!

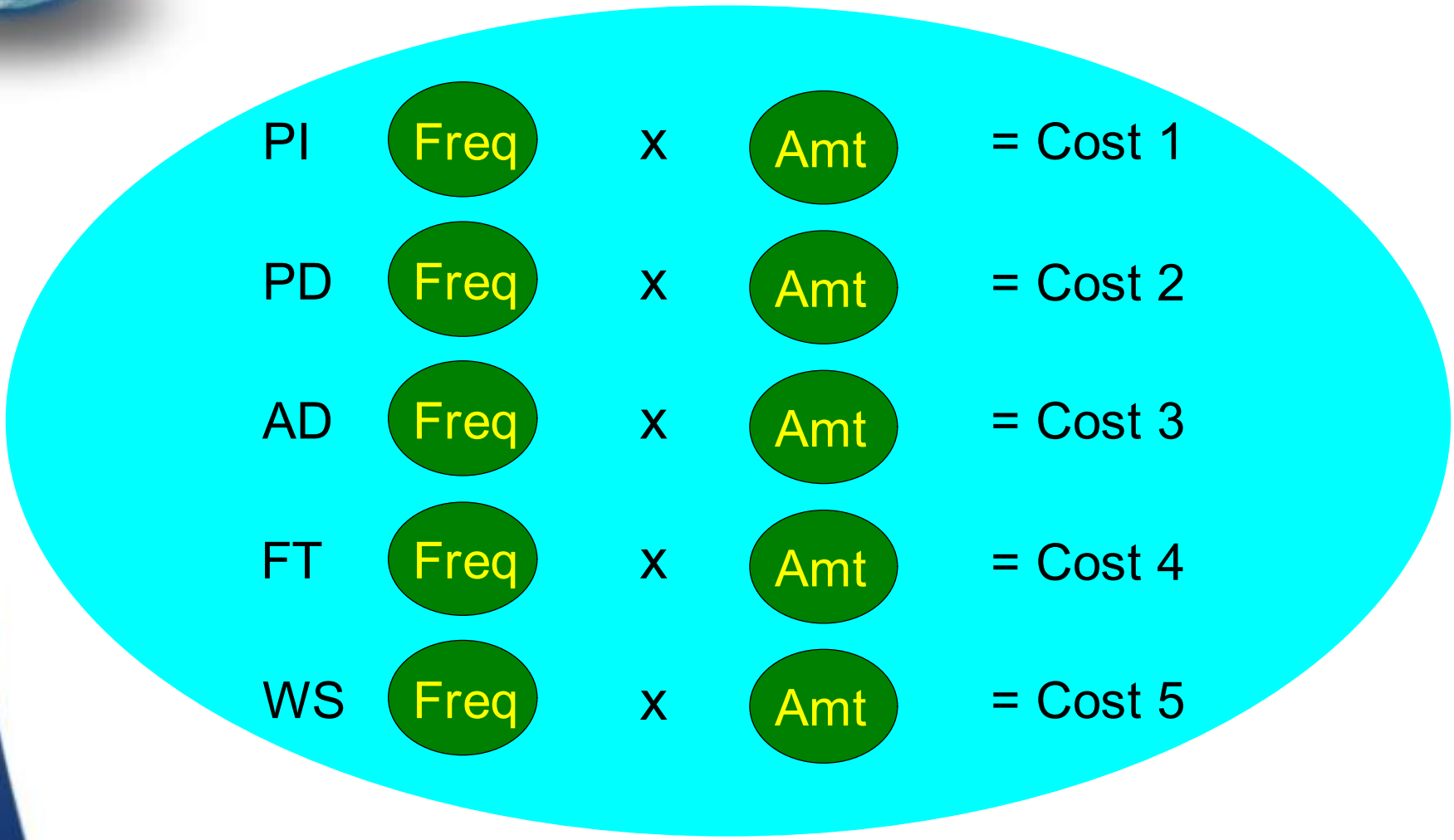
The premium rating process



Modelling the cost of claims



Modelling the cost of claims



Modelling the cost of claims

- Data & rating factors
- Statistical techniques

Example motor rating factors

- Standard factors:
  - Age of main driver
  - Sex
  - Marital status
  - Age of licence
  - Occupation
  - Residency
  - Convictions
  - Home-owner?
  - Postcode
  - Vehicle group
  - Age of vehicle
  - Value of vehicle
  - Alarm/immobiliser
  - Modifications?
  - Garaged?
  - Use of vehicle
  - Mileage
  - Cover
  - Age / number of additional driver(s)
  - Previous claims
  - Excess
  - Payment frequency
  - NCD
  - Protected NCD?
- External data:
  - individual data
  - vehicle data
  - geodemographic data
  - geophysical data
- Data from other products:
  - banking data
  - other insurance data

Generalised linear models

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

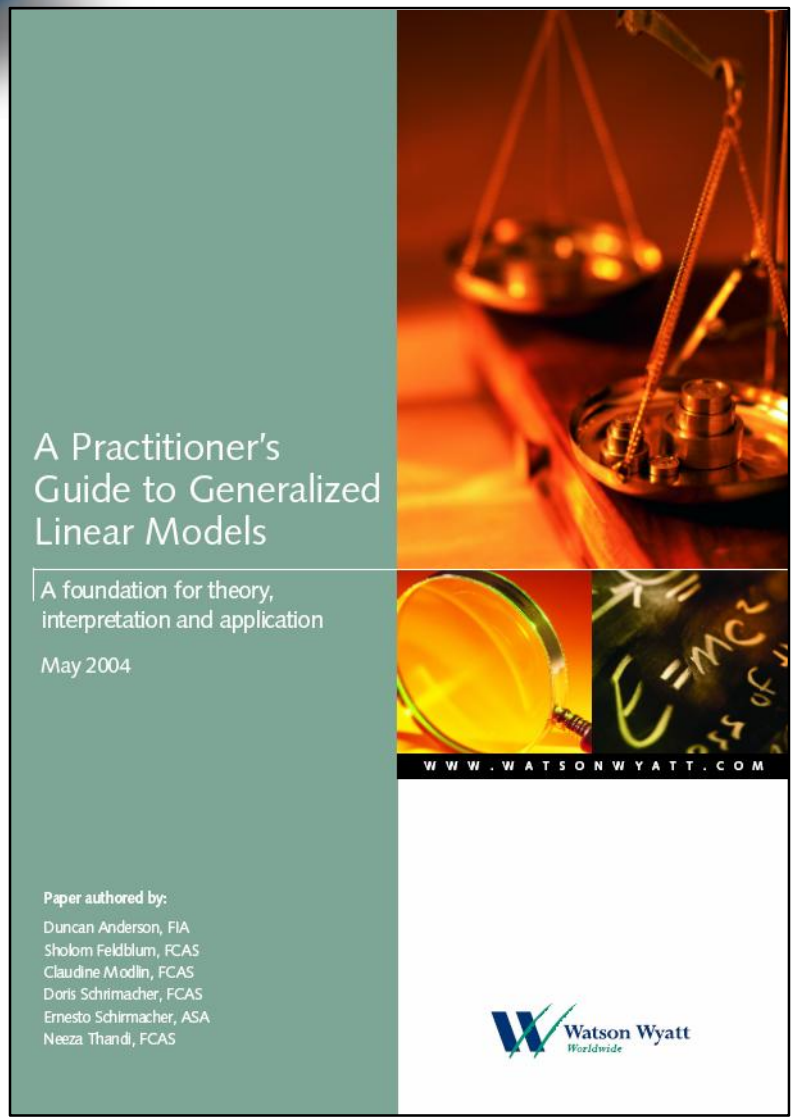
$$Var[\underline{Y}] = \phi.V(\underline{\mu}) / \underline{\omega}$$

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

Why GLMs over other methods

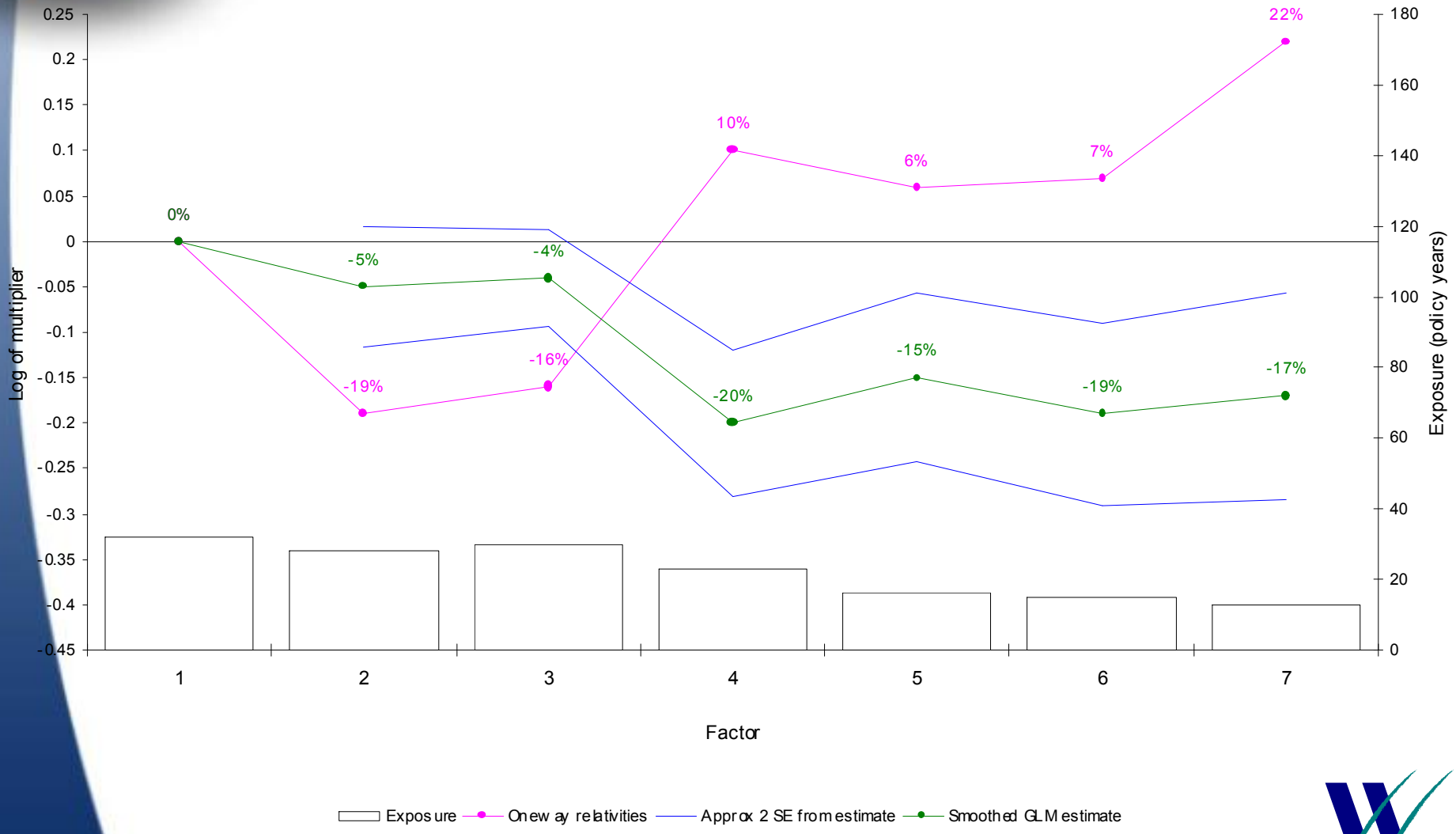
- One-way and two-way analyses
  - distorted by correlations, no diagnostics
- Iteratively standardised one-ways
  - no diagnostics, computationally inferior to GLMs (no faster), less flexibility for allowance of random process, not always tractable solution
- Neural networks
  - not transparent, hard 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

"A Practitioner's Guide to Generalized Linear Models"

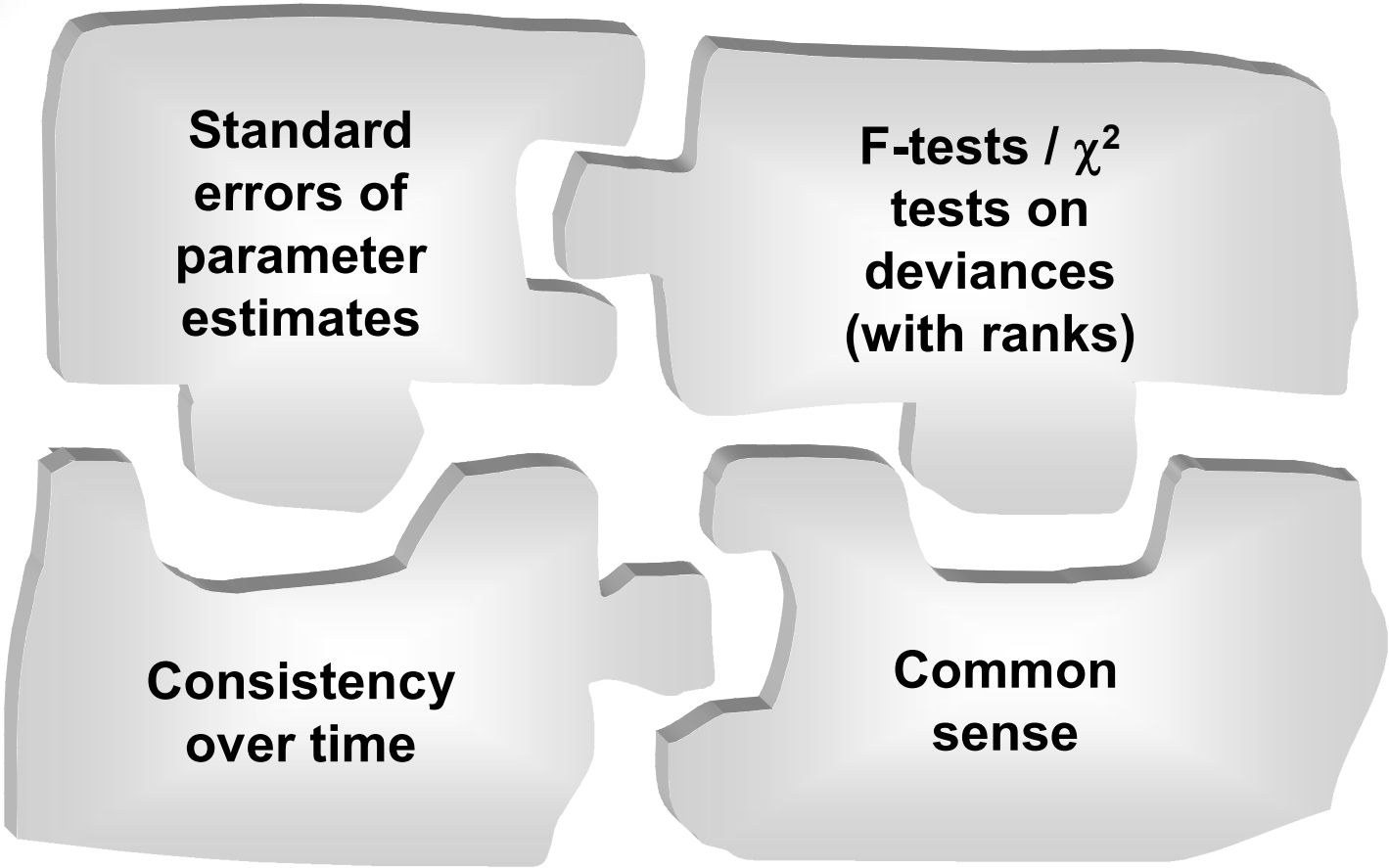


- CAS 2004 Discussion Paper Program
- Copies available at www.watsonwyatt.com/glm
- Section 1 to be added to CAS Exam 9 syllabus in 2006

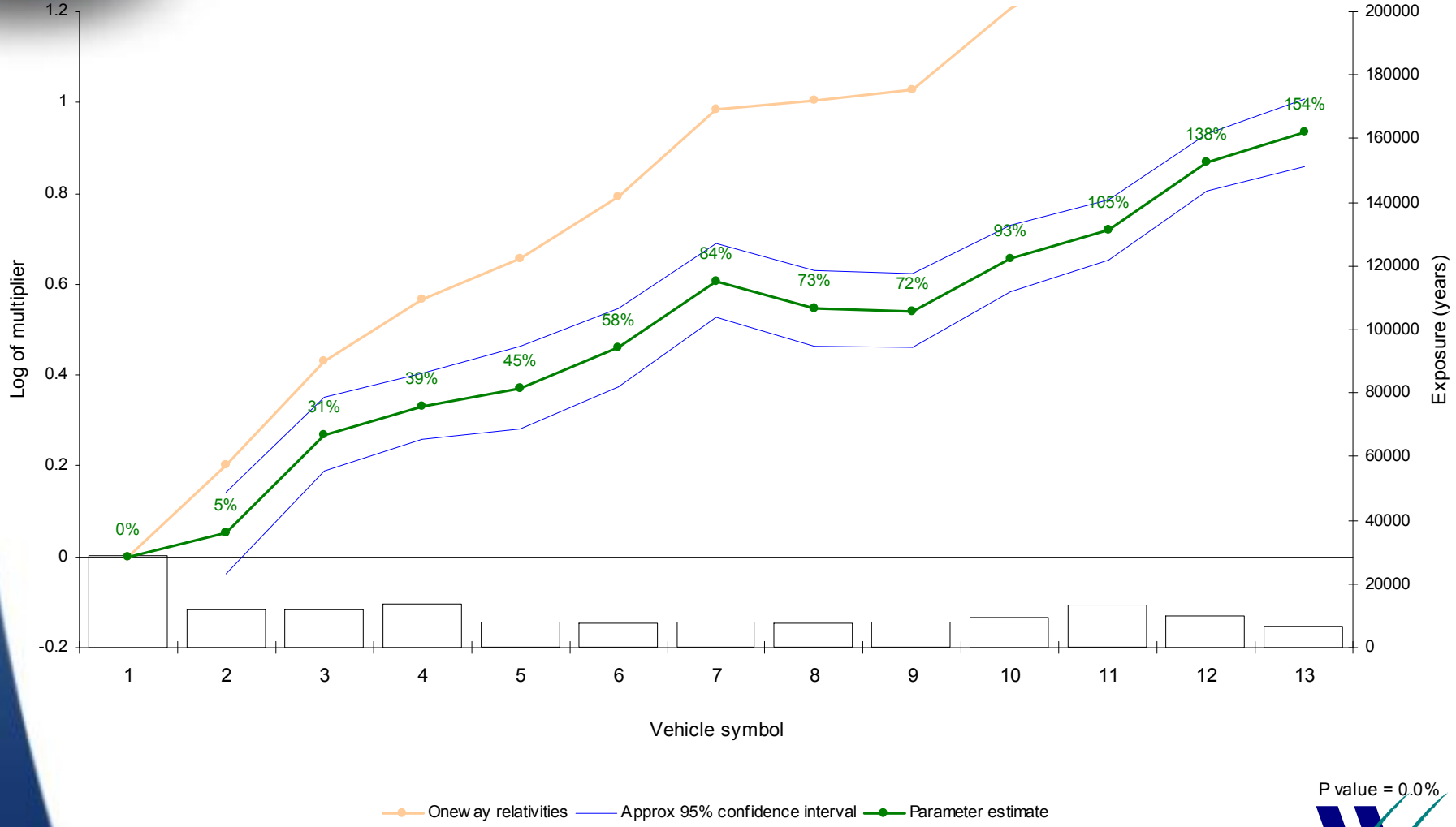
Example of GLM output (real UK data)



Model iteration

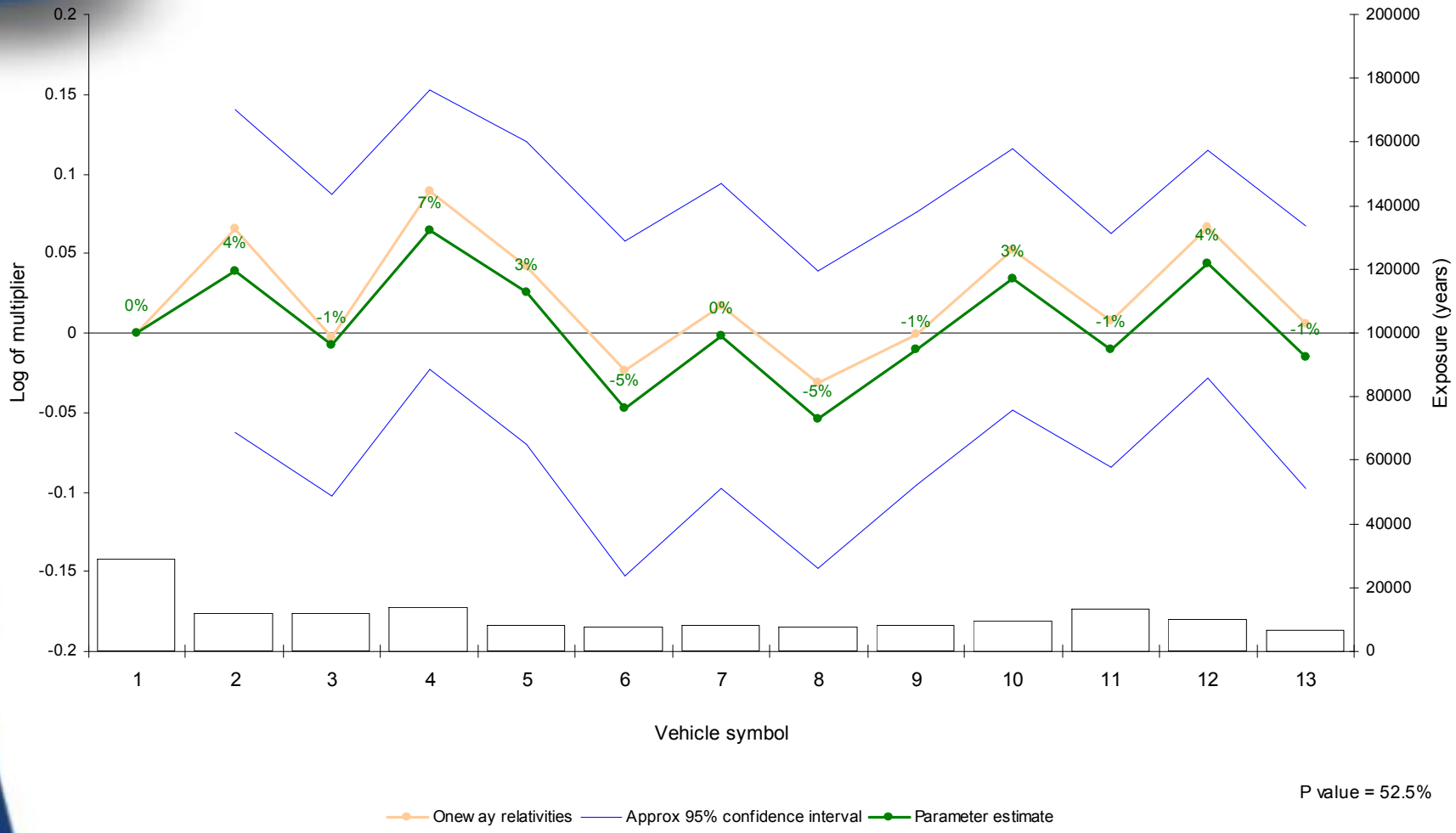


GLM output (significant factor)



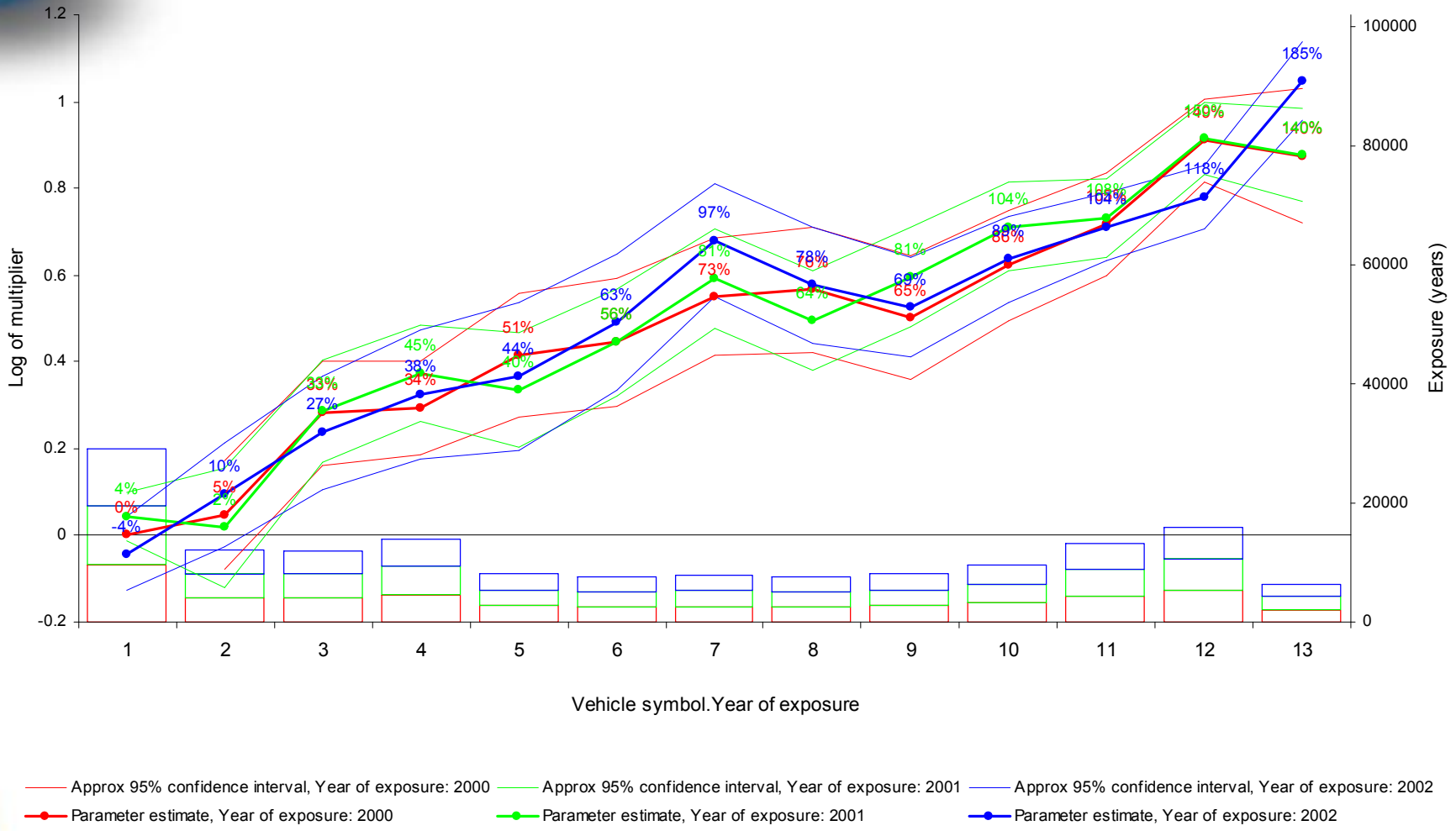
P value = 0.0%

GLM output (insignificant factor)

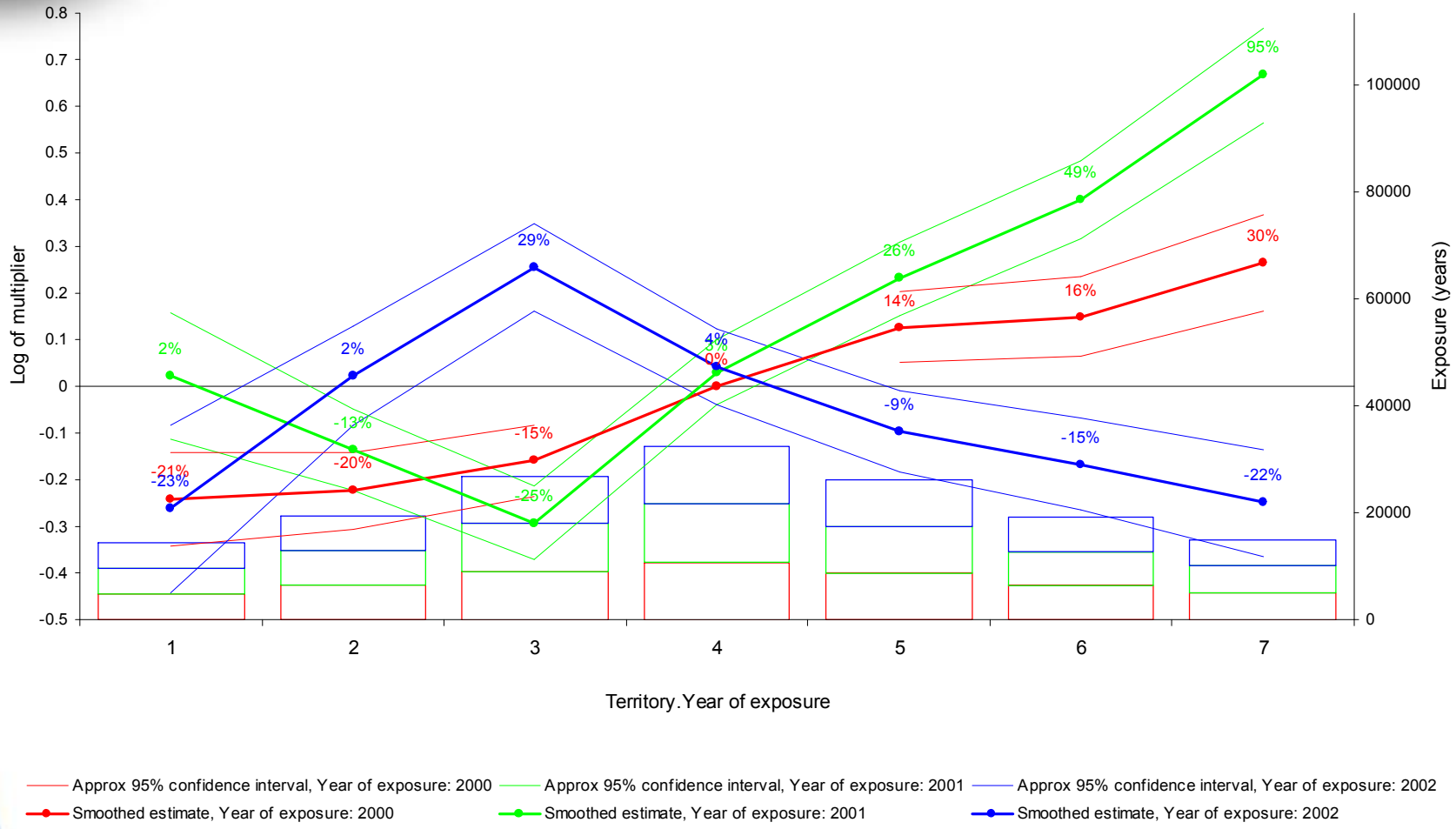


P value = 52.5%

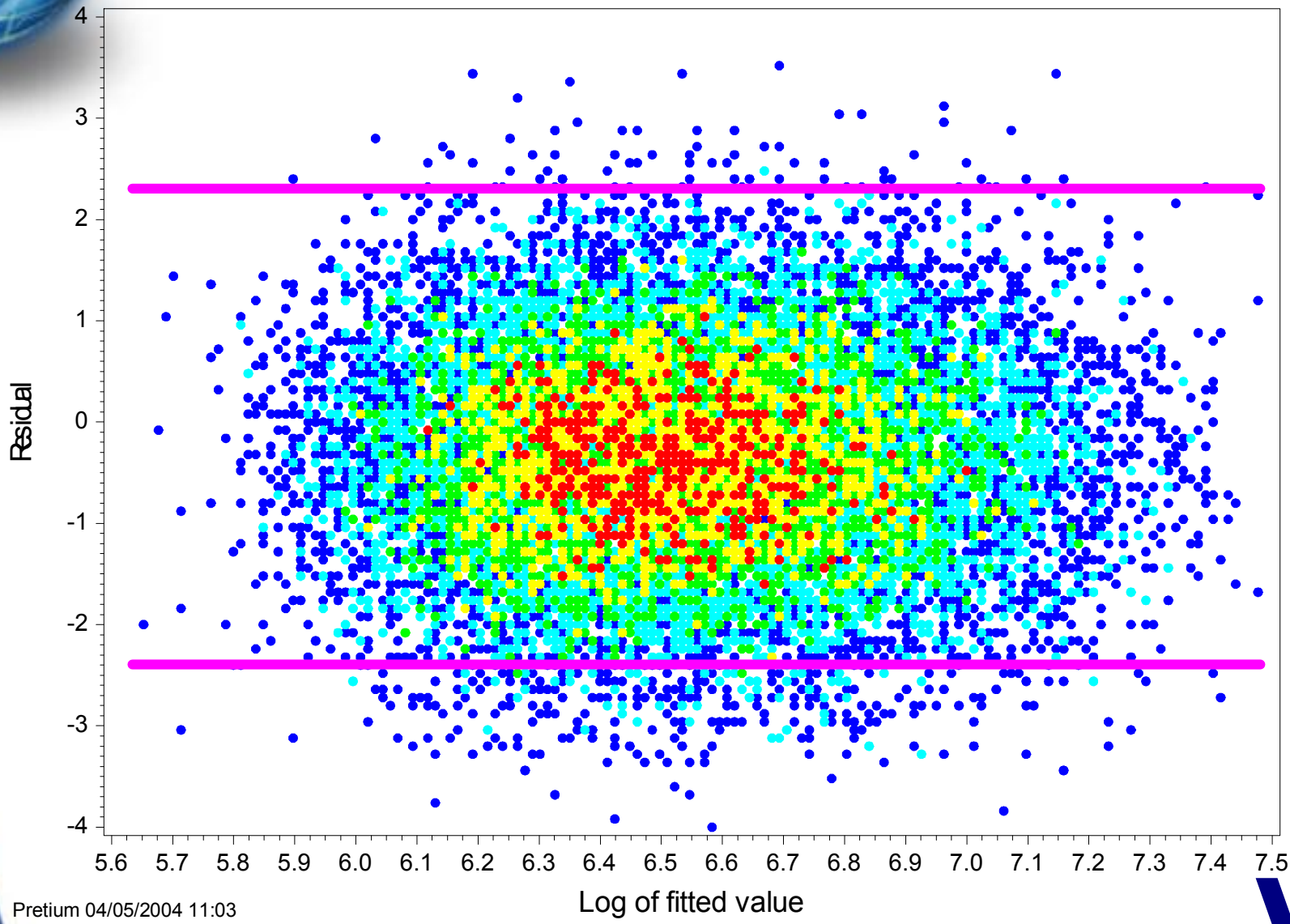
Consistency over time



Consistency over time



Residuals



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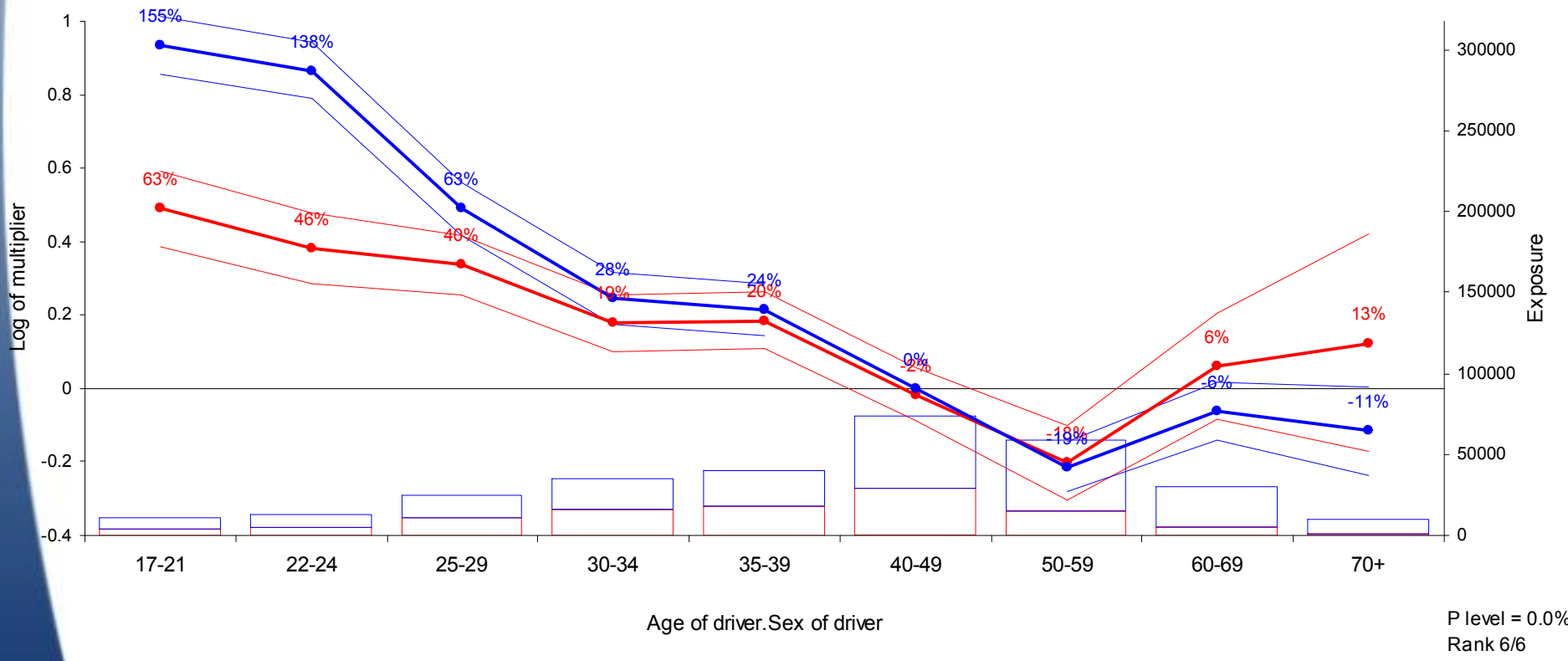
Interactions

Example job

Run 5 Model 3 - Small interaction - Third party material damage, Numbers



Box-Cox link function investigation

- GLM structure is

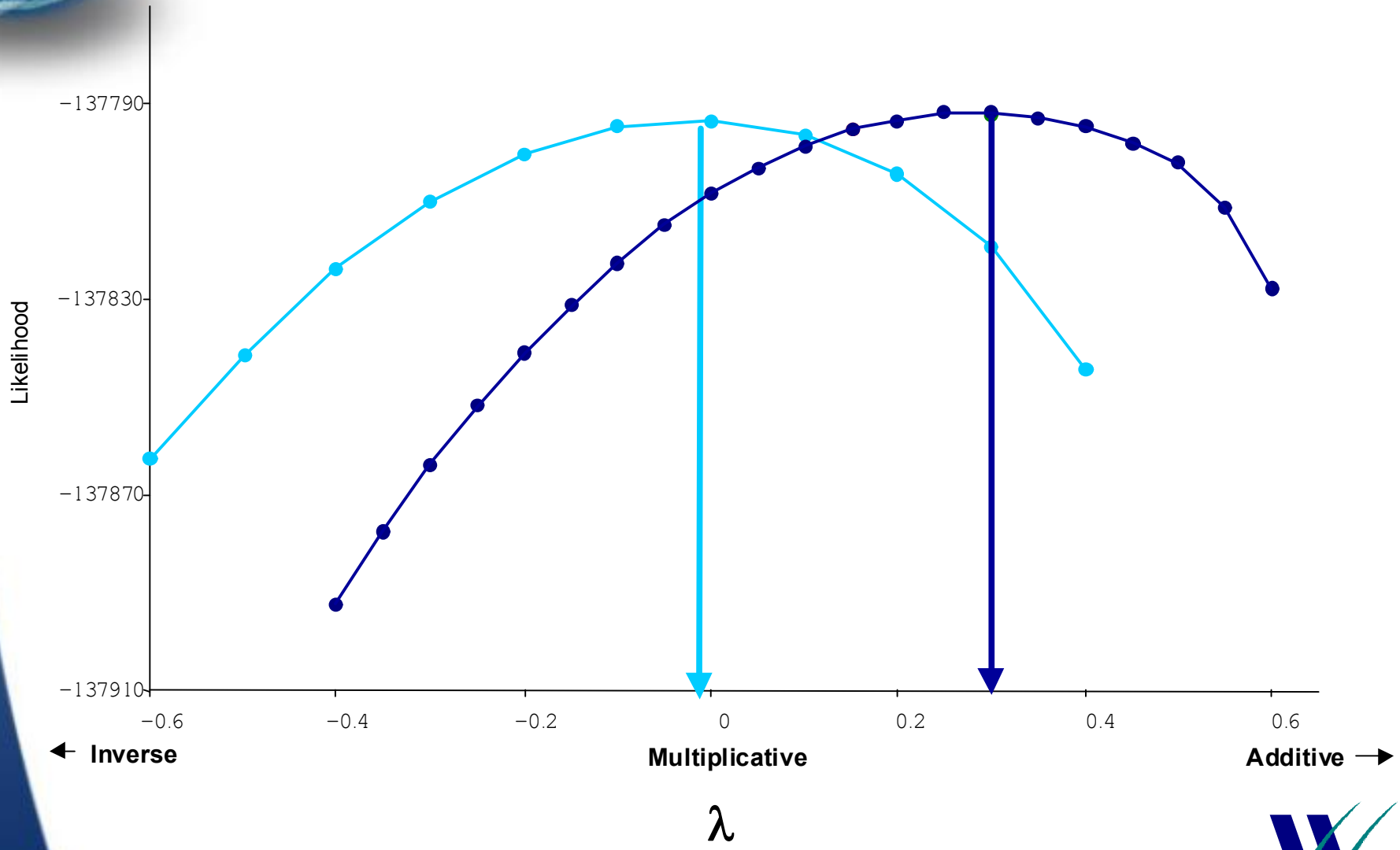
  $E[\underline{Y}] = \underline{\mu} = g^{-1}(\mathbf{X}.\underline{\beta} + \underline{\xi})$ $Var[\underline{Y}] = \phi.V(\underline{\mu}) / \underline{\omega}$

- Box Cox transforms defines

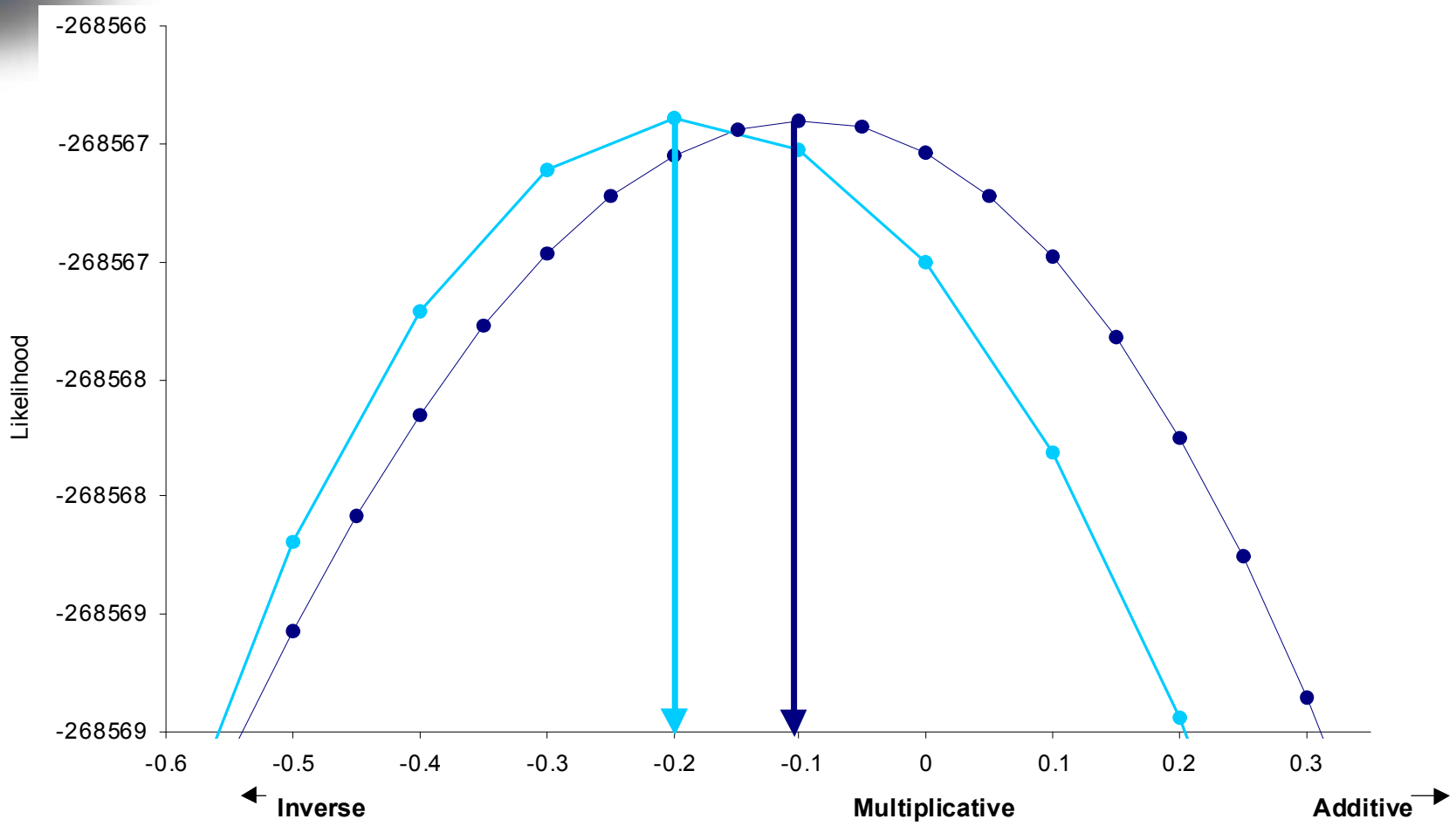
  $g(x) = (x^{\lambda} - 1) / \lambda$ for $\lambda \neq 0$, $\ln(x)$ for $\lambda = 0$

- $\lambda = 1 \Rightarrow g(x) = x - 1 \Rightarrow$ additive (with base level shift)
- $\lambda \rightarrow 0 \Rightarrow g(x) \rightarrow \ln(x) \Rightarrow$ multiplicative (via maths)
- $\lambda = -1 \Rightarrow g(x) = 1 - 1/x \Rightarrow$ inverse (with base level shift)
- Try different values of λ and measure goodness of fit to see which fits experience best

Box-Cox link function investigation
Motor third party property frequencies

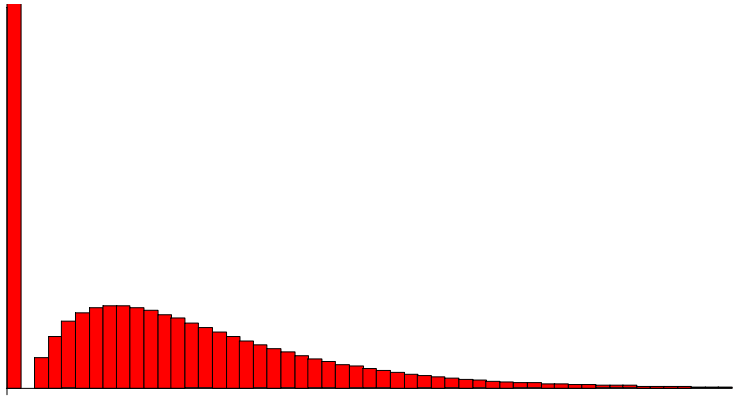


Box-Cox link function investigation
Motor third party property average amounts



Tweedie distributions

- Incurred losses have a point mass at zero and then a continuous distribution
- Poisson and gamma not suited to this

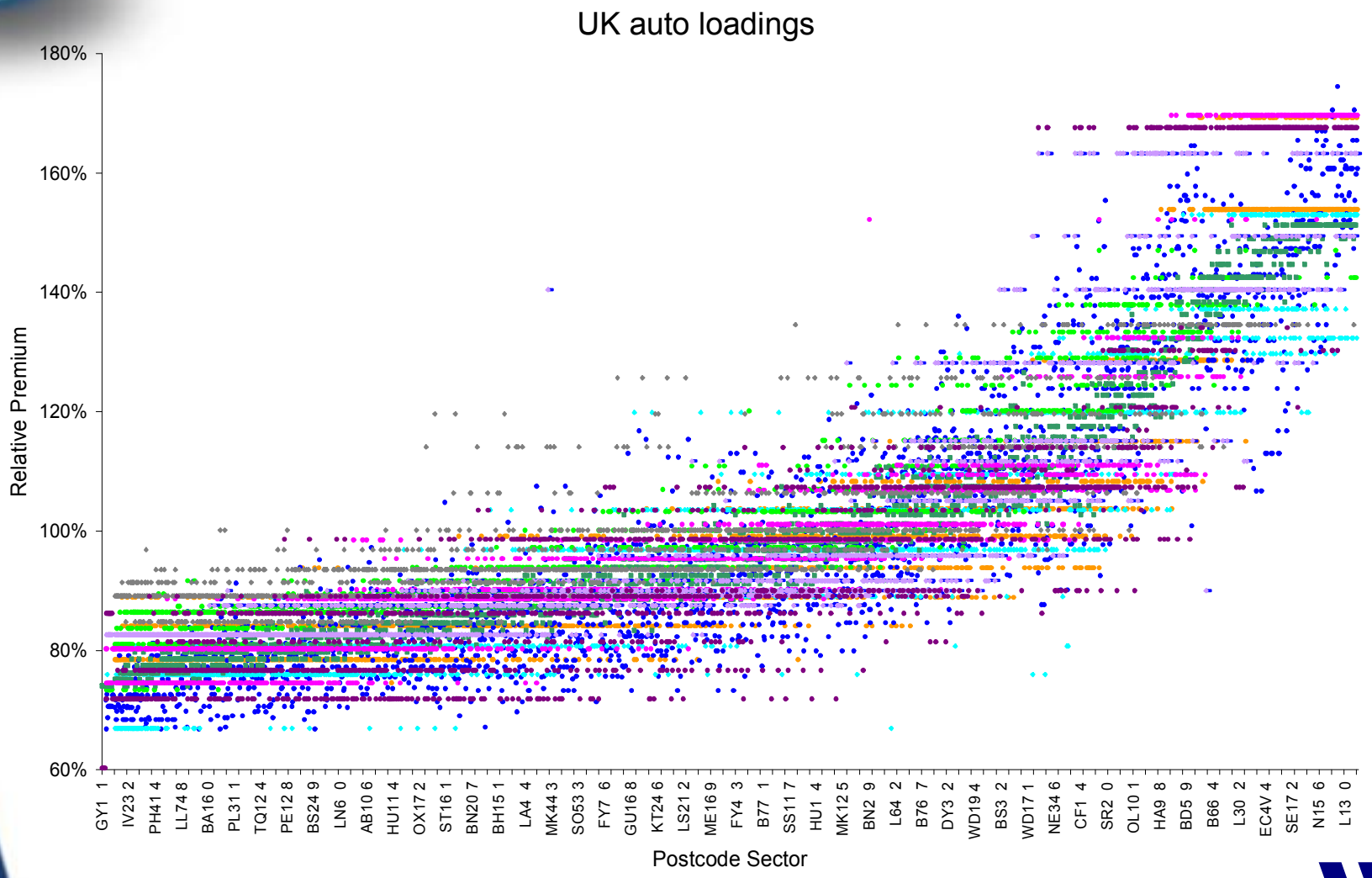


- Tweedie distribution has point mass and parameters which can alter the shape to be like Poisson and gamma above zero

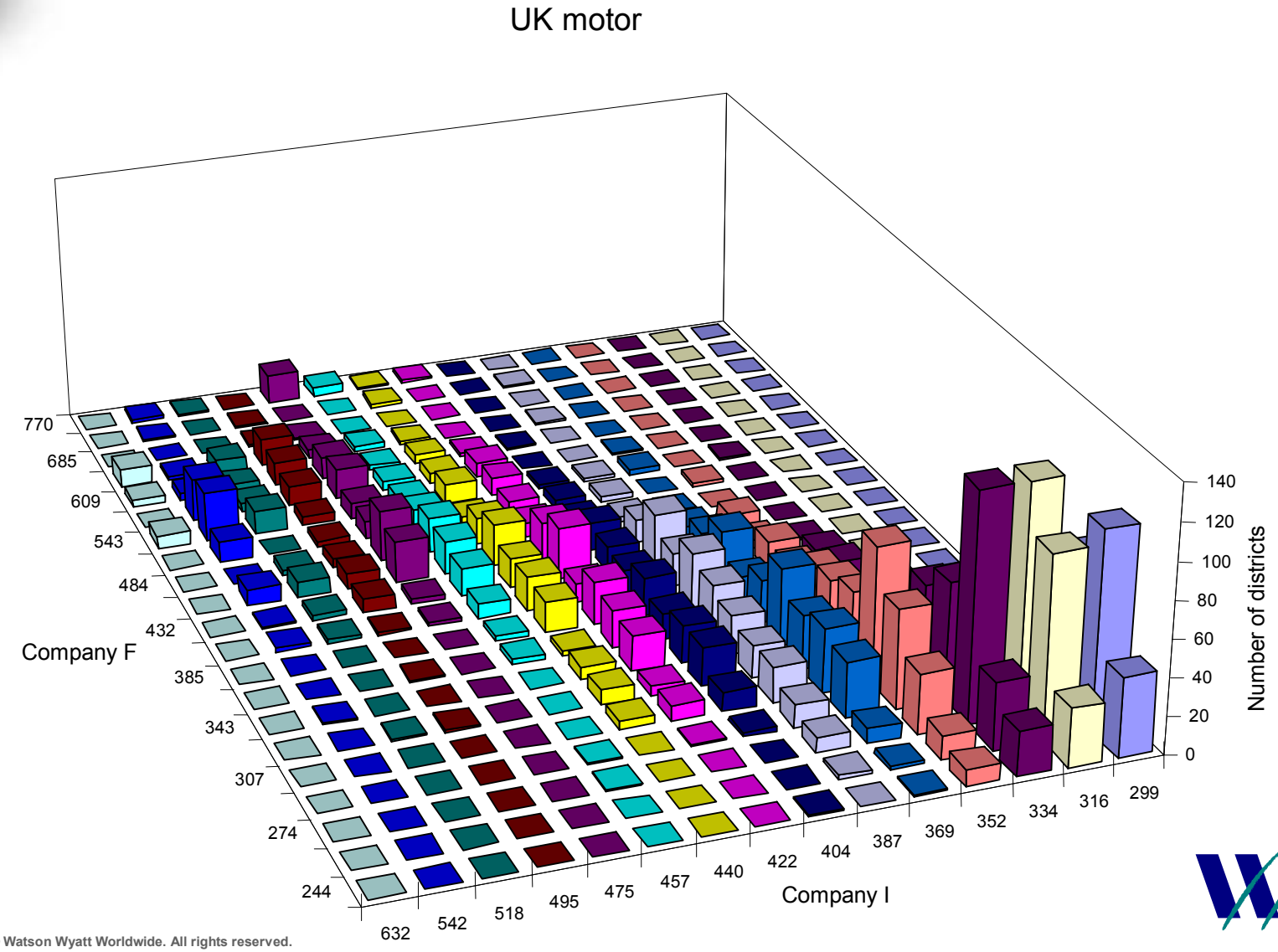
$$f_Y(y;\theta,\lambda,\alpha) = \sum_{n=1}^{\infty} \frac{\left\{(\lambda\omega)^{1-\alpha}\kappa_\alpha(-1/y)\right\}^n}{\Gamma(-n\alpha)n!\,y}.\exp\left\{\lambda\omega[\theta_0 y - \kappa_\alpha(\theta_0)]\right\} \quad \text{for } y>0$$

$$p(Y=0) = \exp\left\{-\lambda\omega\kappa_\alpha(\theta_0)\right\}$$

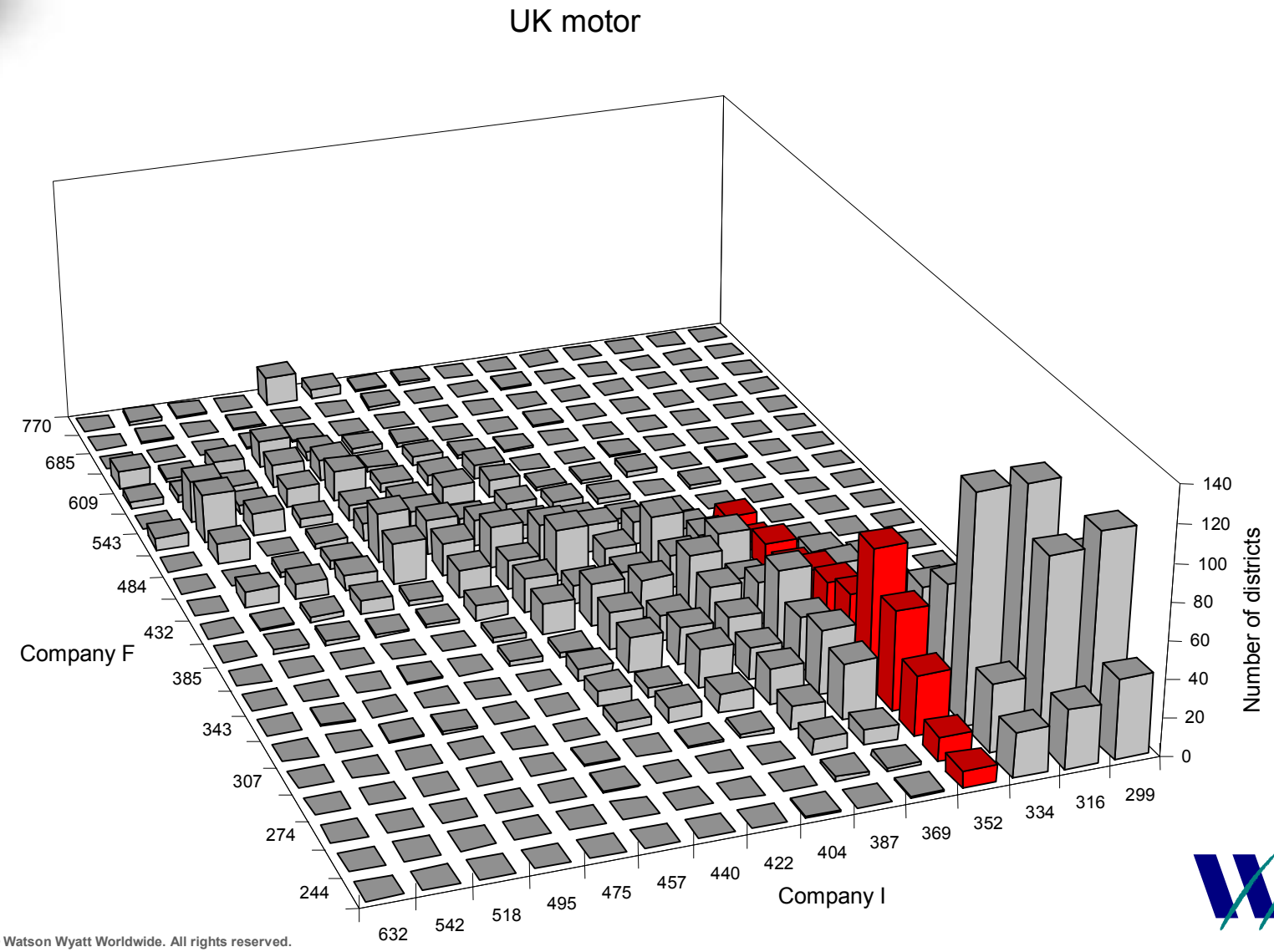
The problem with area



Example of market disparity



Example of market disparity



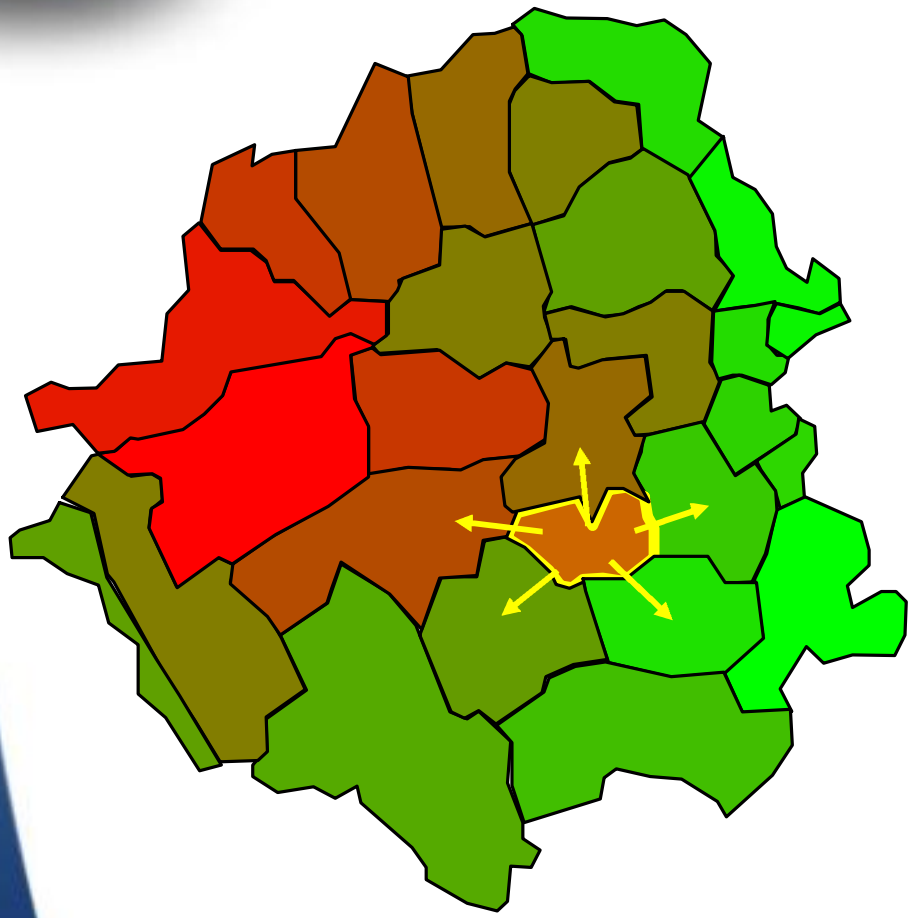
General approach

1. Assess true area risk as well as possible

2. Define "zones" containing areas of similar risk (may or may not be contiguous)

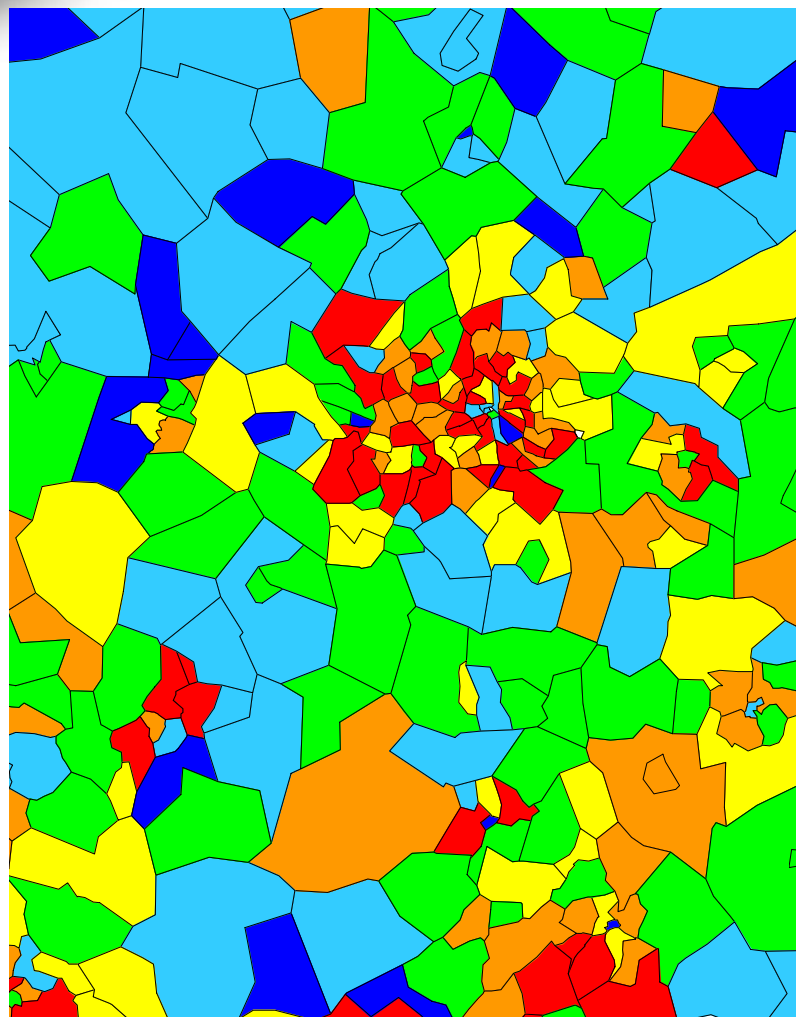
3. Determine relativities applicable to "zone"

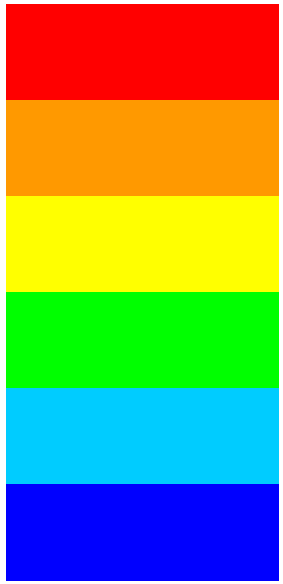
Proximity



- Key assumption is that "close" areas are similar
- May not be a perfect assumption
- Nevertheless it seems consistently to yield good results in practice

Example residual risk





High residual

Low (negative) residual

Watson Wyatt model

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

where

r_i^* = smoothed residual r_i = unsmoothed residual

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

$$d_{ij} = \{ (x_i - x_j)^2 + (y_i - y_j)^2 \}^{½}$$

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

Finding the parameters

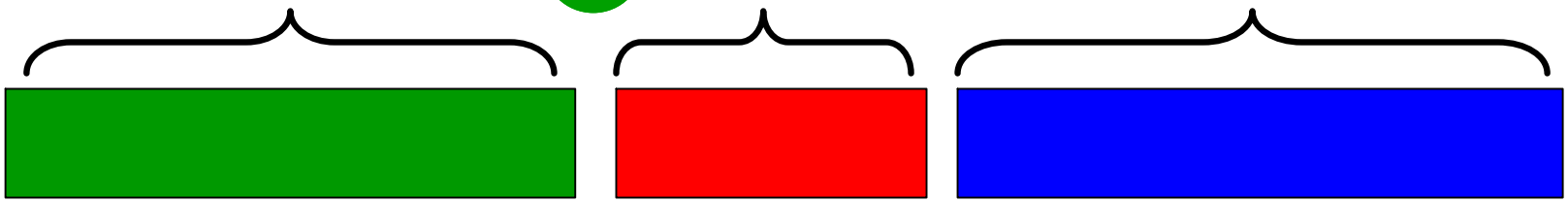
Calculate residuals

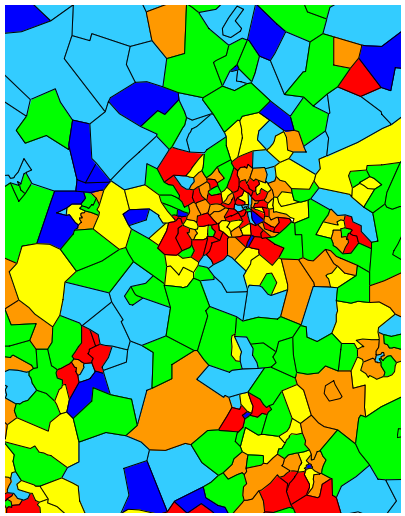
1

Seek parameters which minimize error

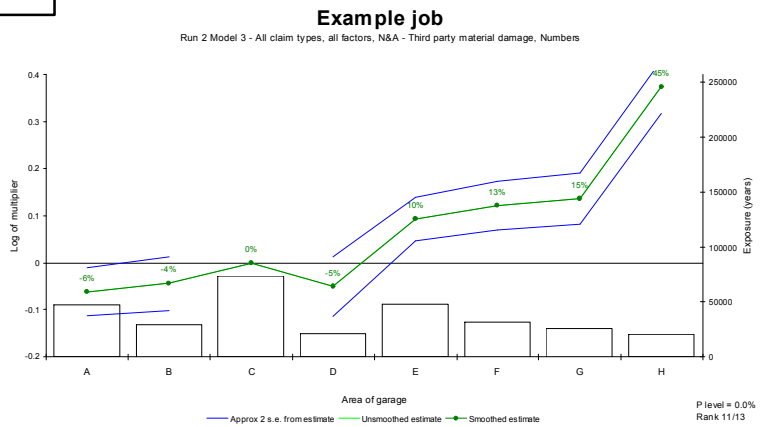
3

Save for determining zoning relativities



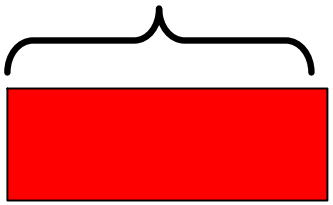


a, m, n, b



Finding the parameters

Seek parameters which minimize error

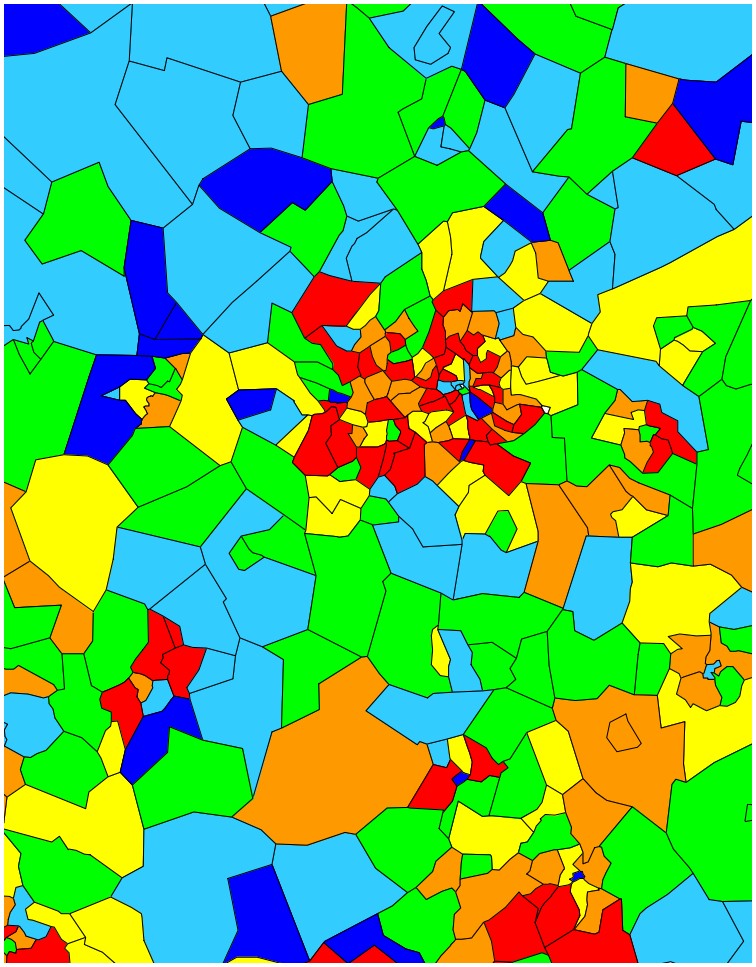


a, m, n, b

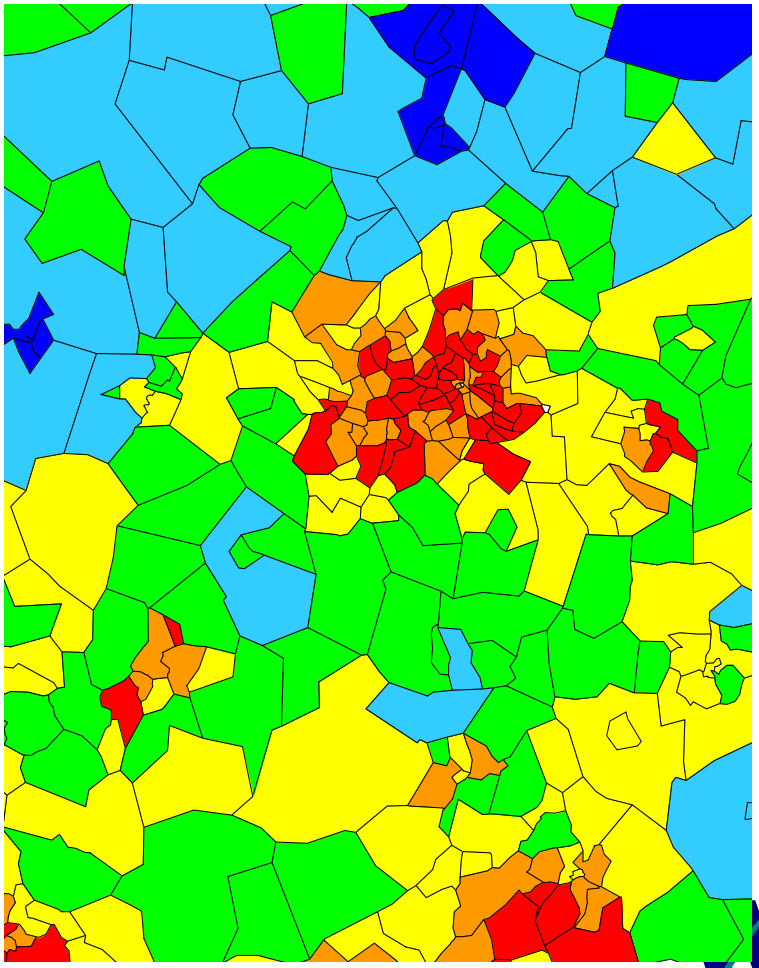
	n	e for Z=20%
USA	2.5	127
USA	1.9	106
France	2.0	104
France	1.9	146
Italy	1.4	87
Netherlands	1.8	61
South Africa	2.2	106
Spain	2.1	17
UK	1.9	146
UK	2.2	152
UK	1.8	78

Example results

Unsmoothed residuals

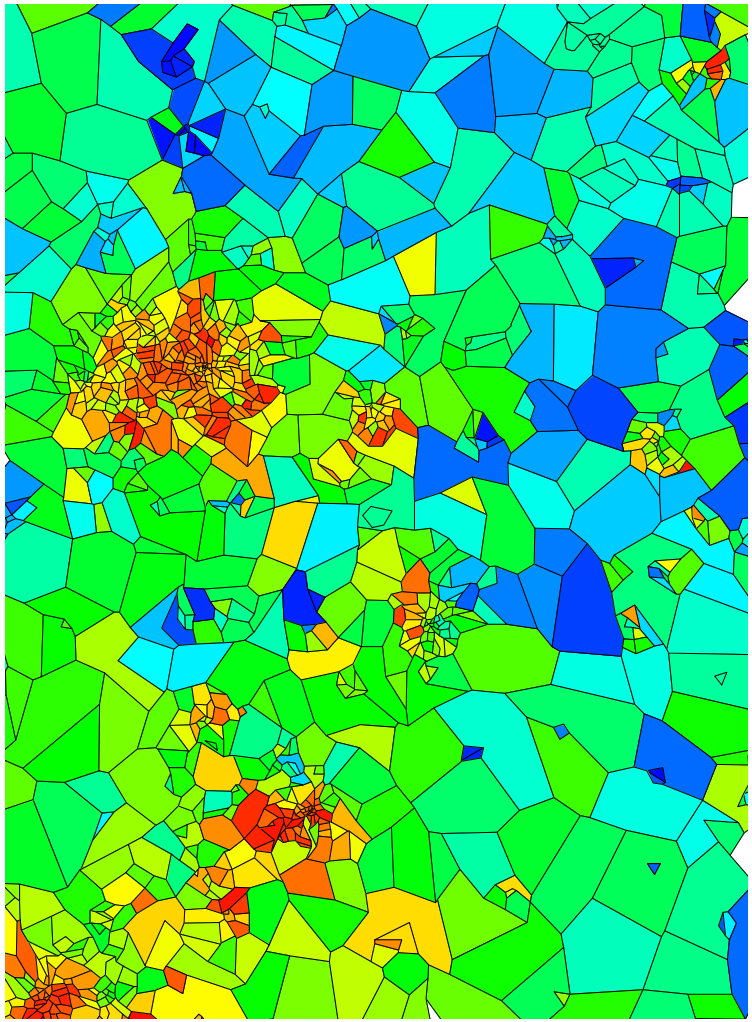


Smoothed residuals

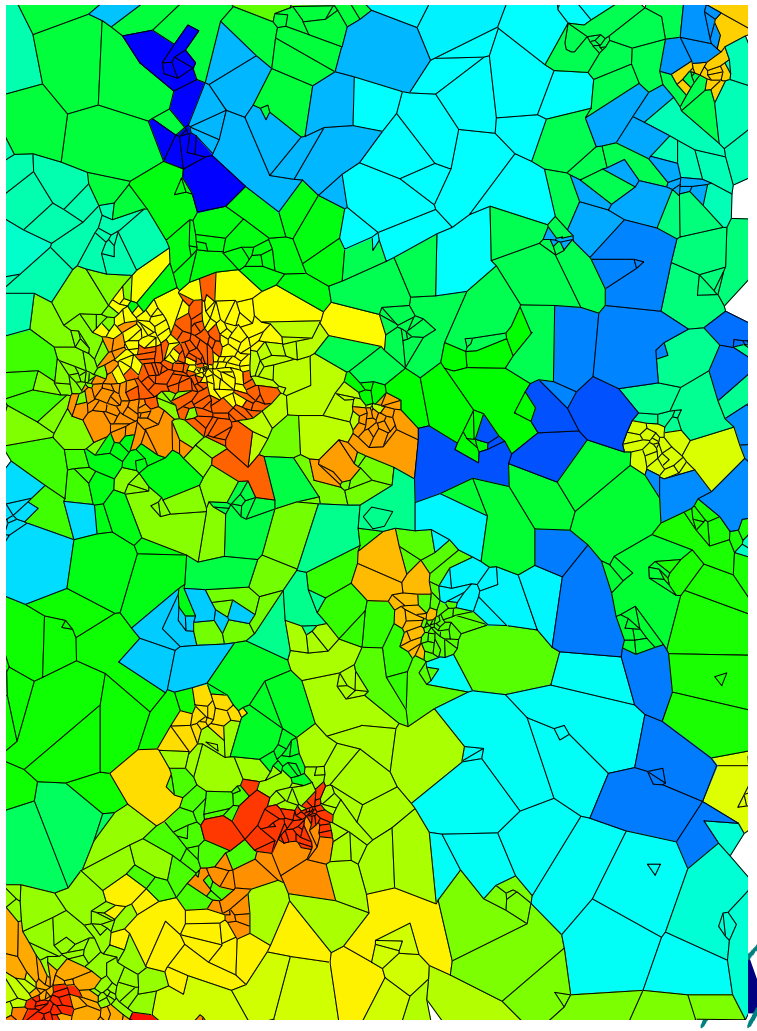


Contiguity clustering

Exposure/risk based "manual" grouping



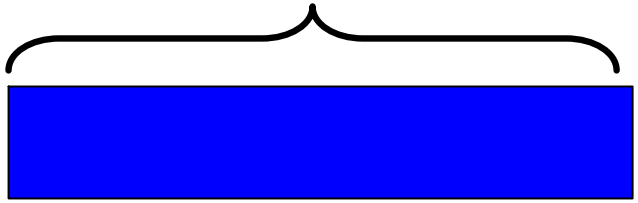
Contiguity clustering algorithm

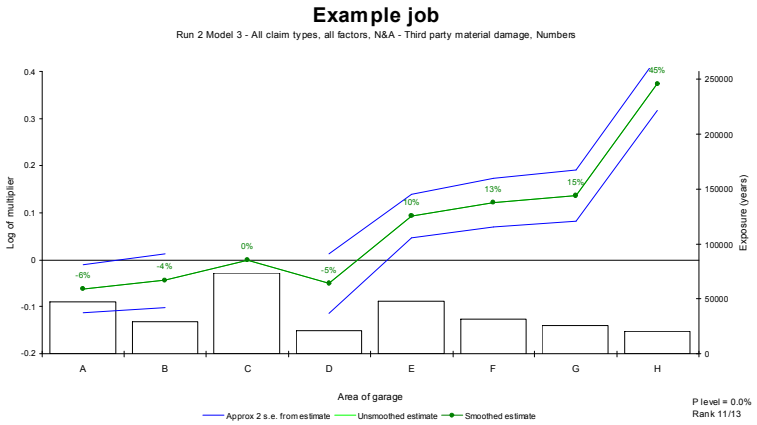


Finding the parameters

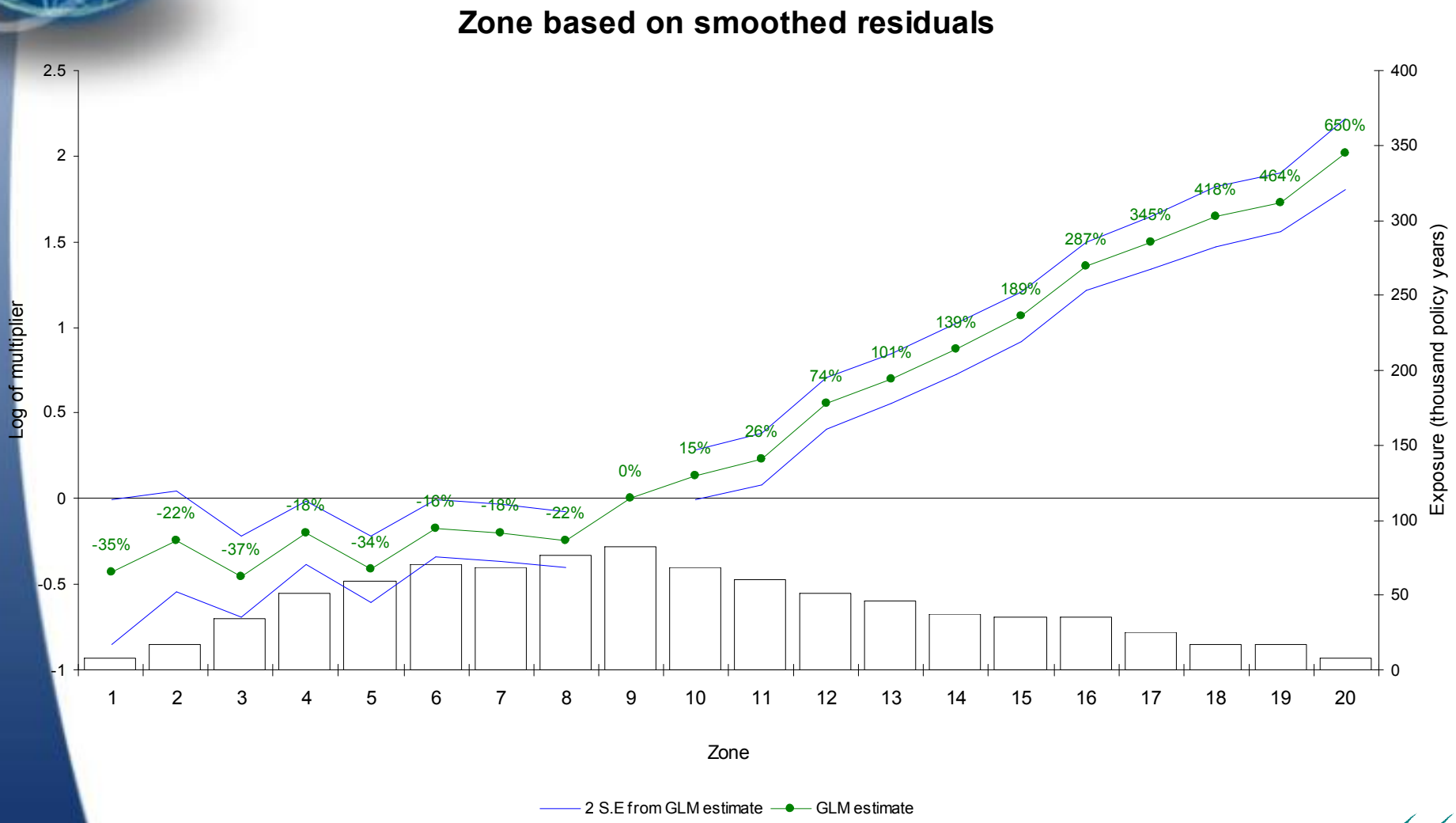
- Fit new zone definition in GLM to assess true predictive power
- Fresh data required to avoid self-fulfilling prophesies
- Compare against existing territory definition

Save for determining zoning relativities

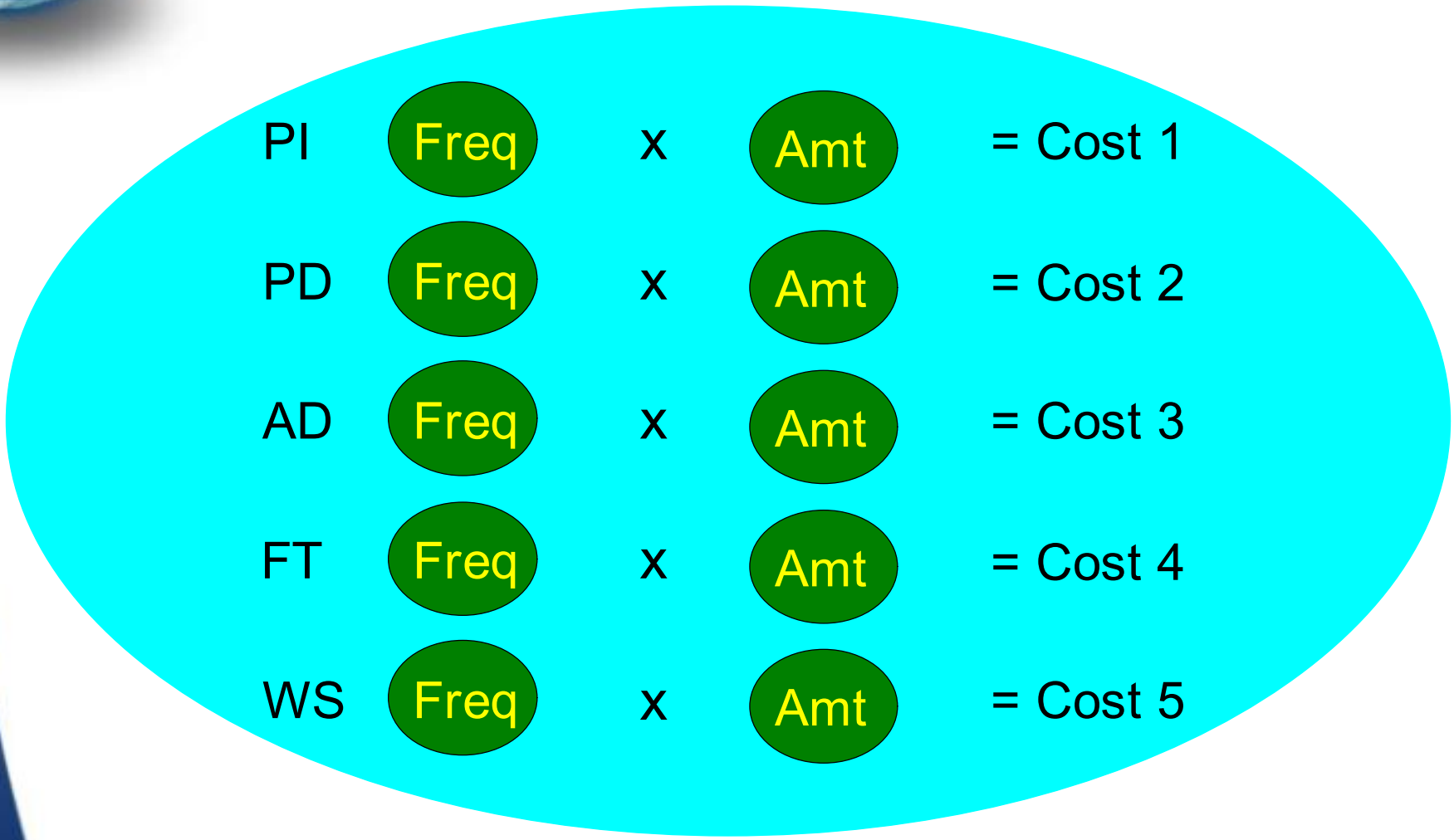




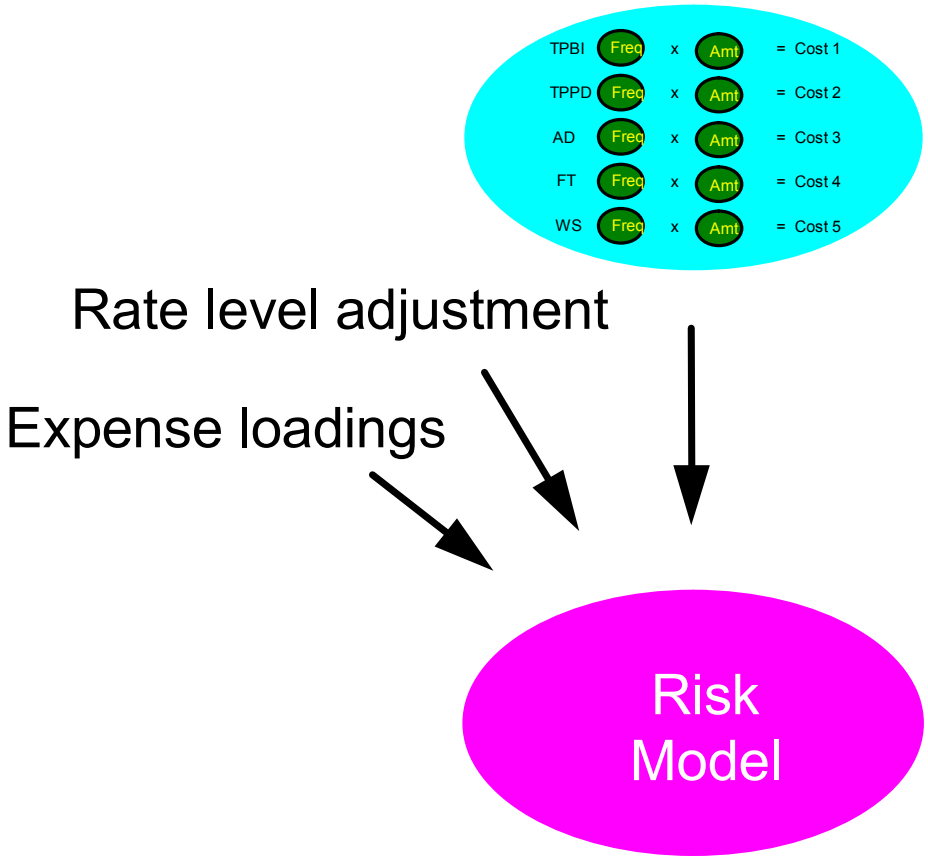
Finding the parameters
Effect of smoothed residual zone on fresh data



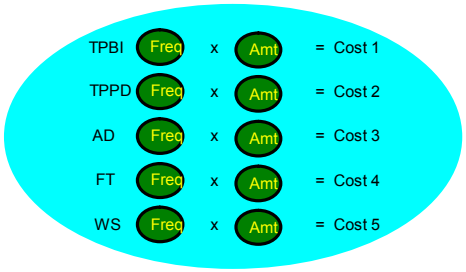
Modelling the cost of claims



The premium rating process



The premium rating process



Current Tariff

Rate level adjustment

Expense loadings

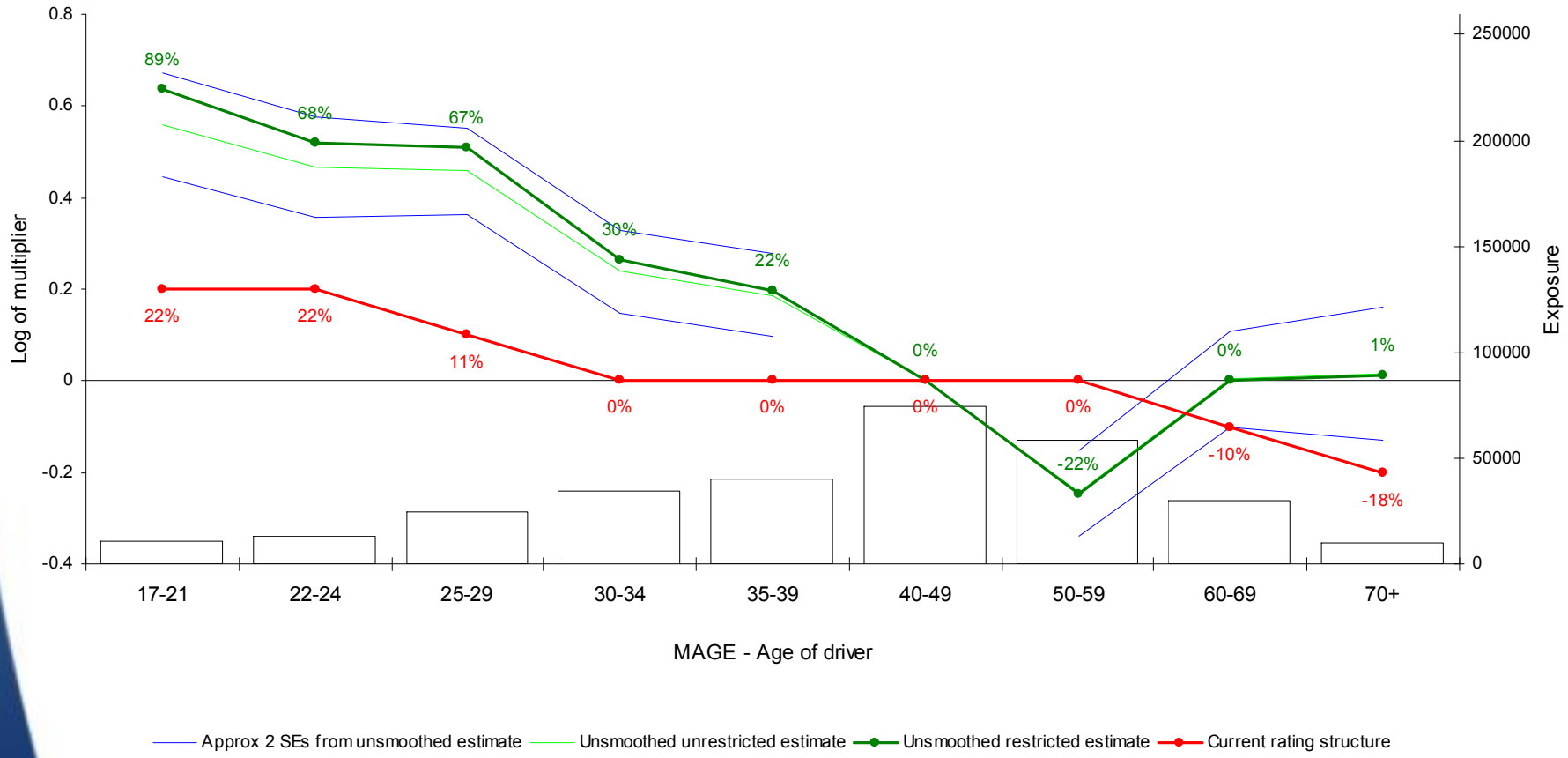
Risk Model

Compare

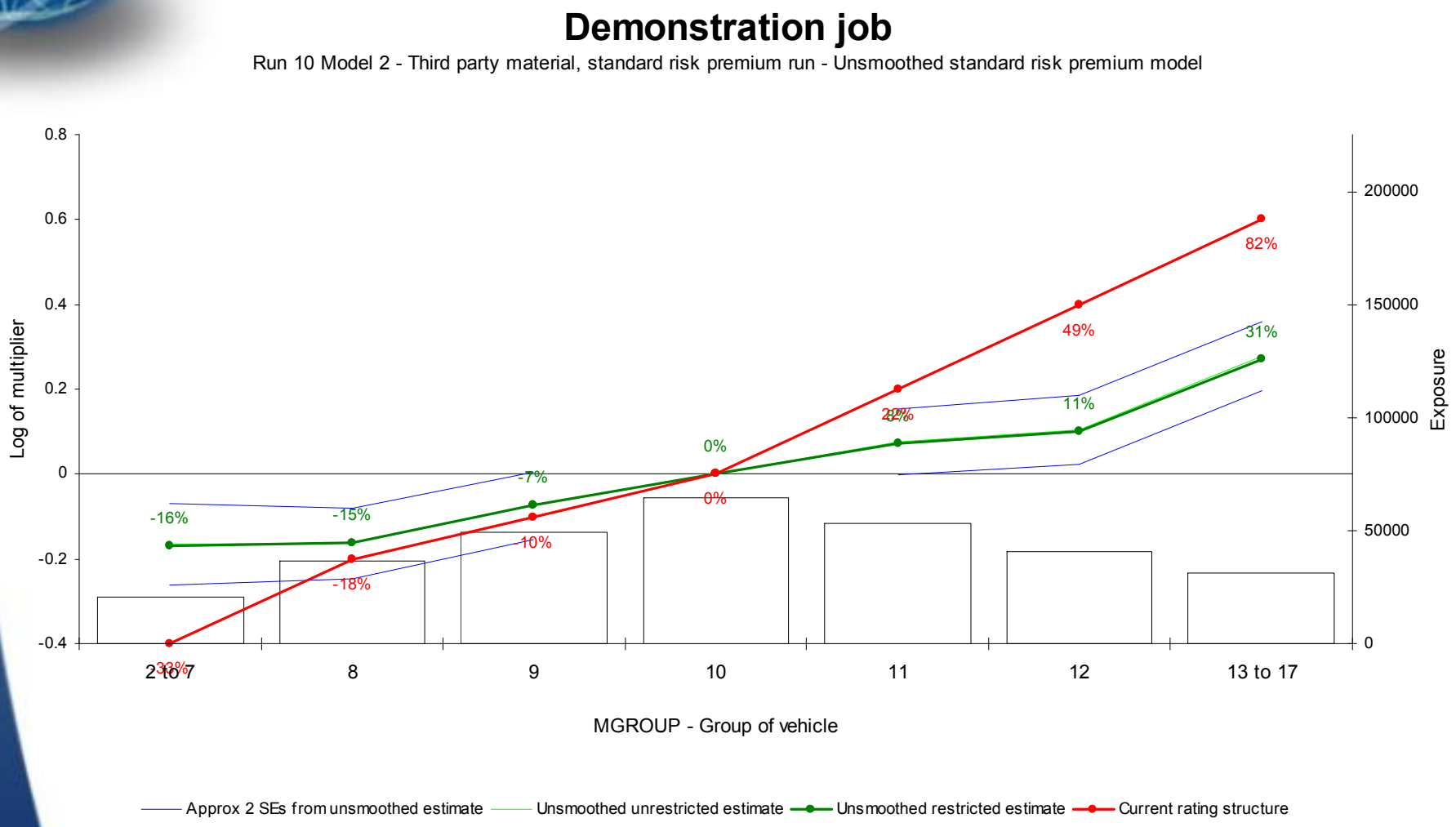
Factor effect analysis

Demonstration job

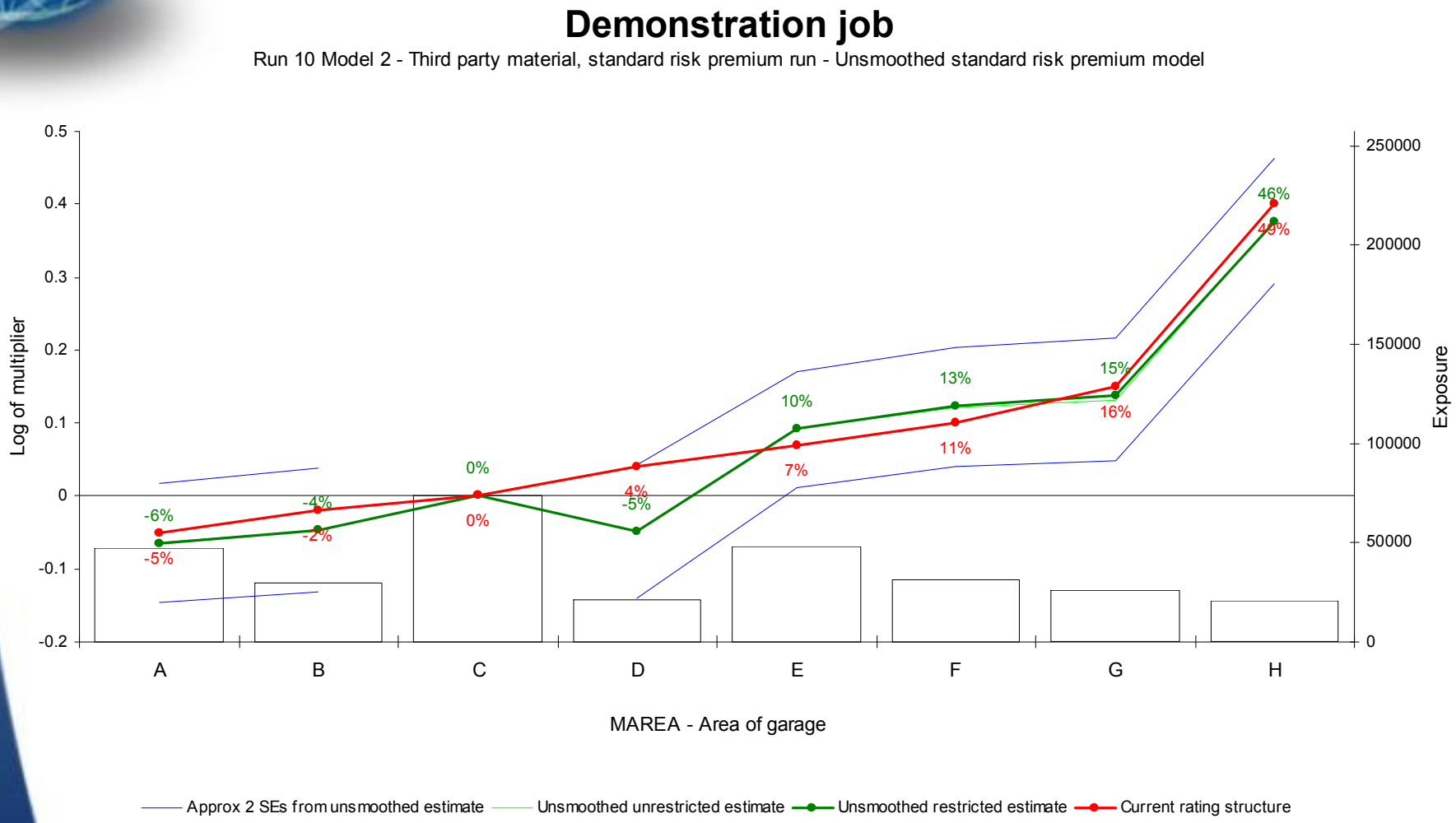
Run 10 Model 2 - Third party material, standard risk premium run - Unsmoothed standard risk premium model



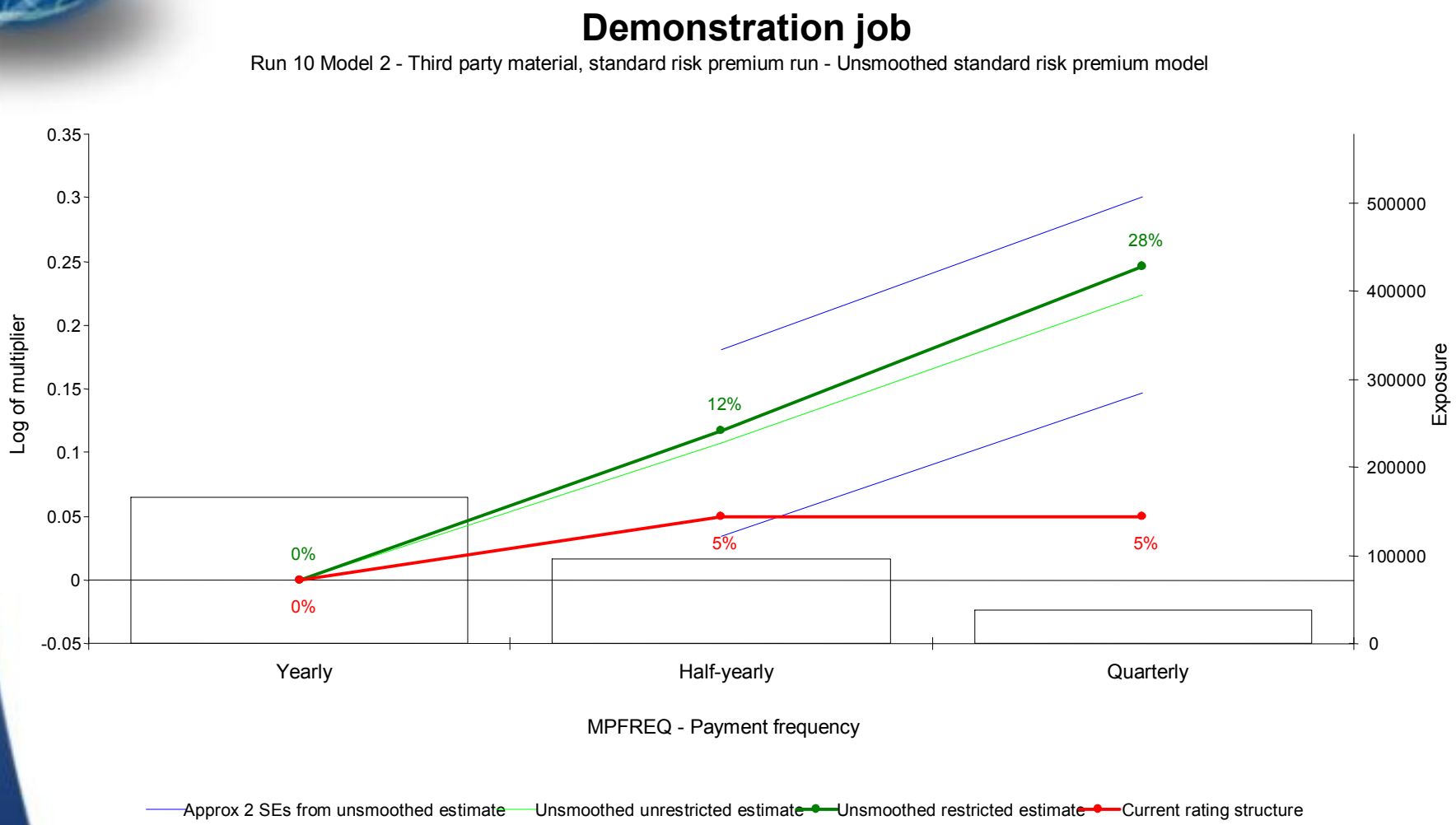
Factor effect analysis



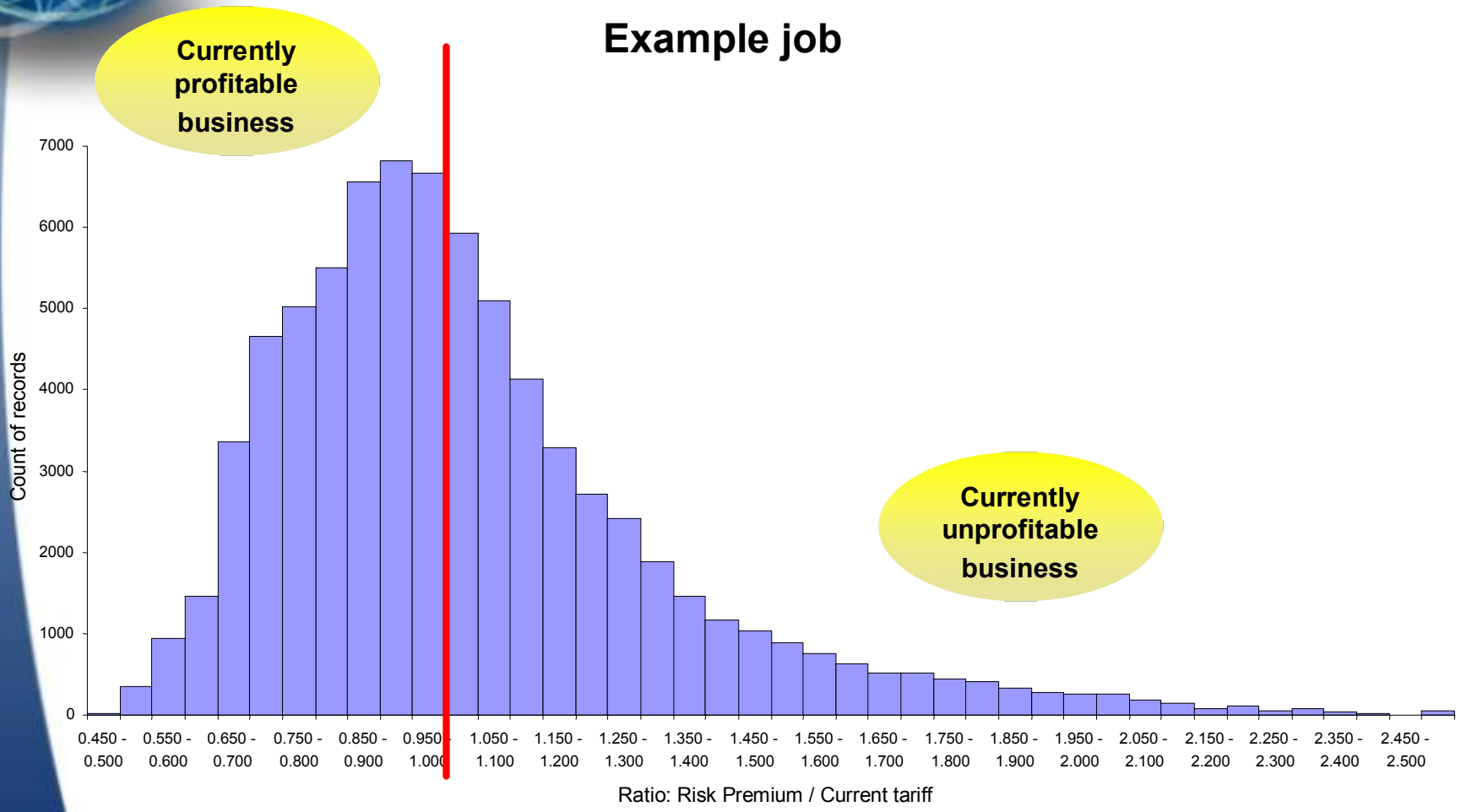
Factor effect analysis



Factor effect analysis

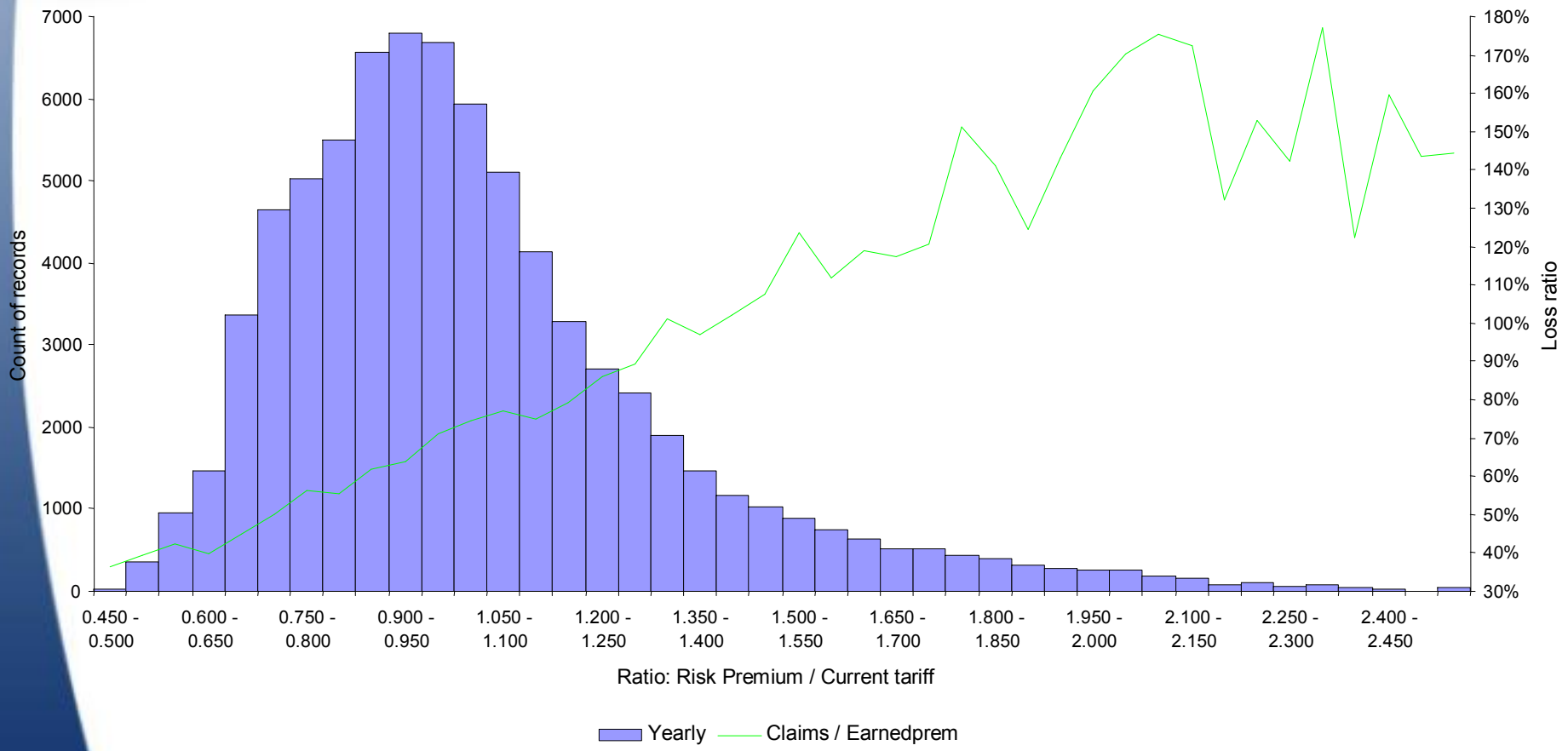


Impact analysis



Impact analysis

Example job



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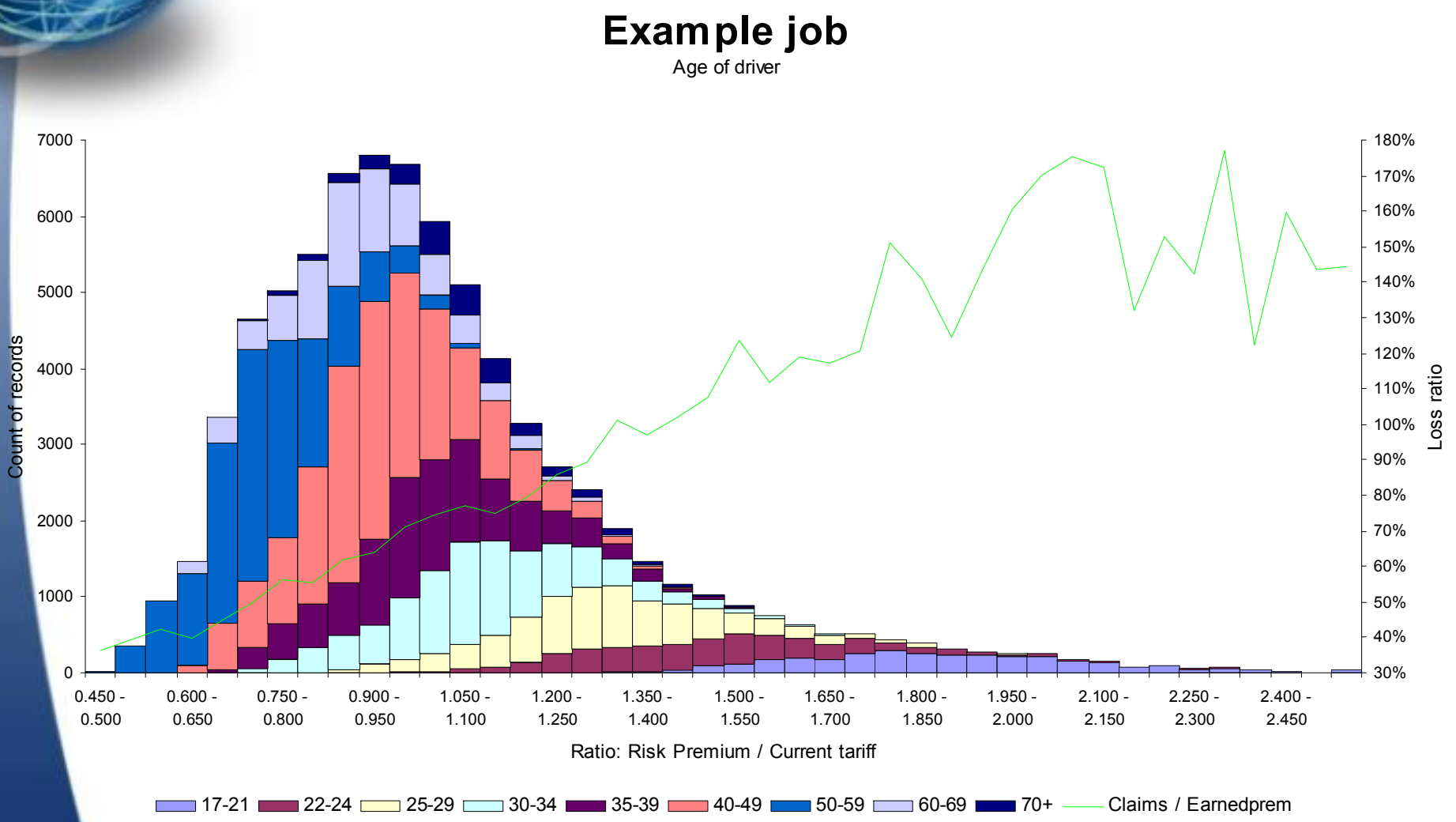

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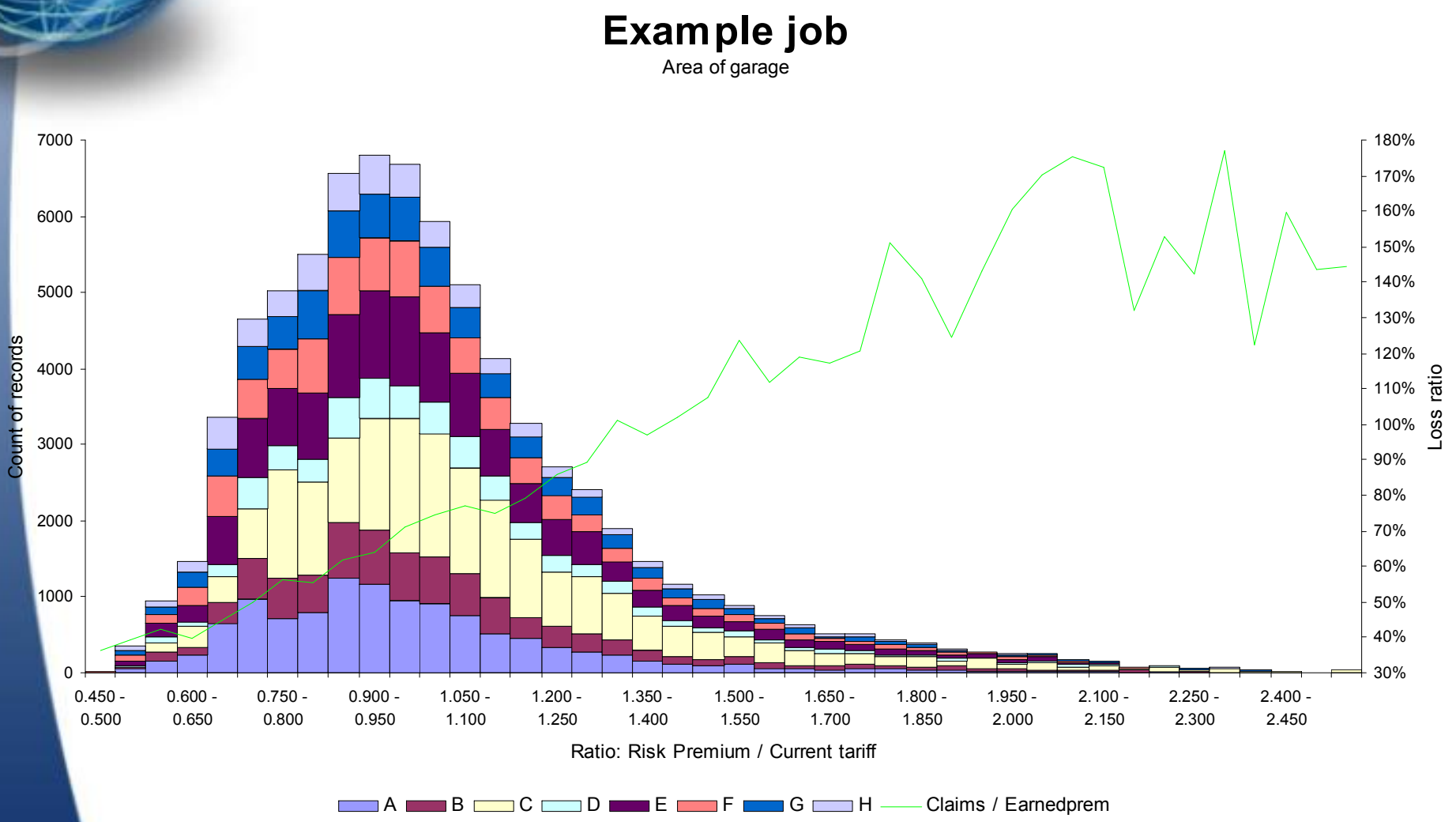

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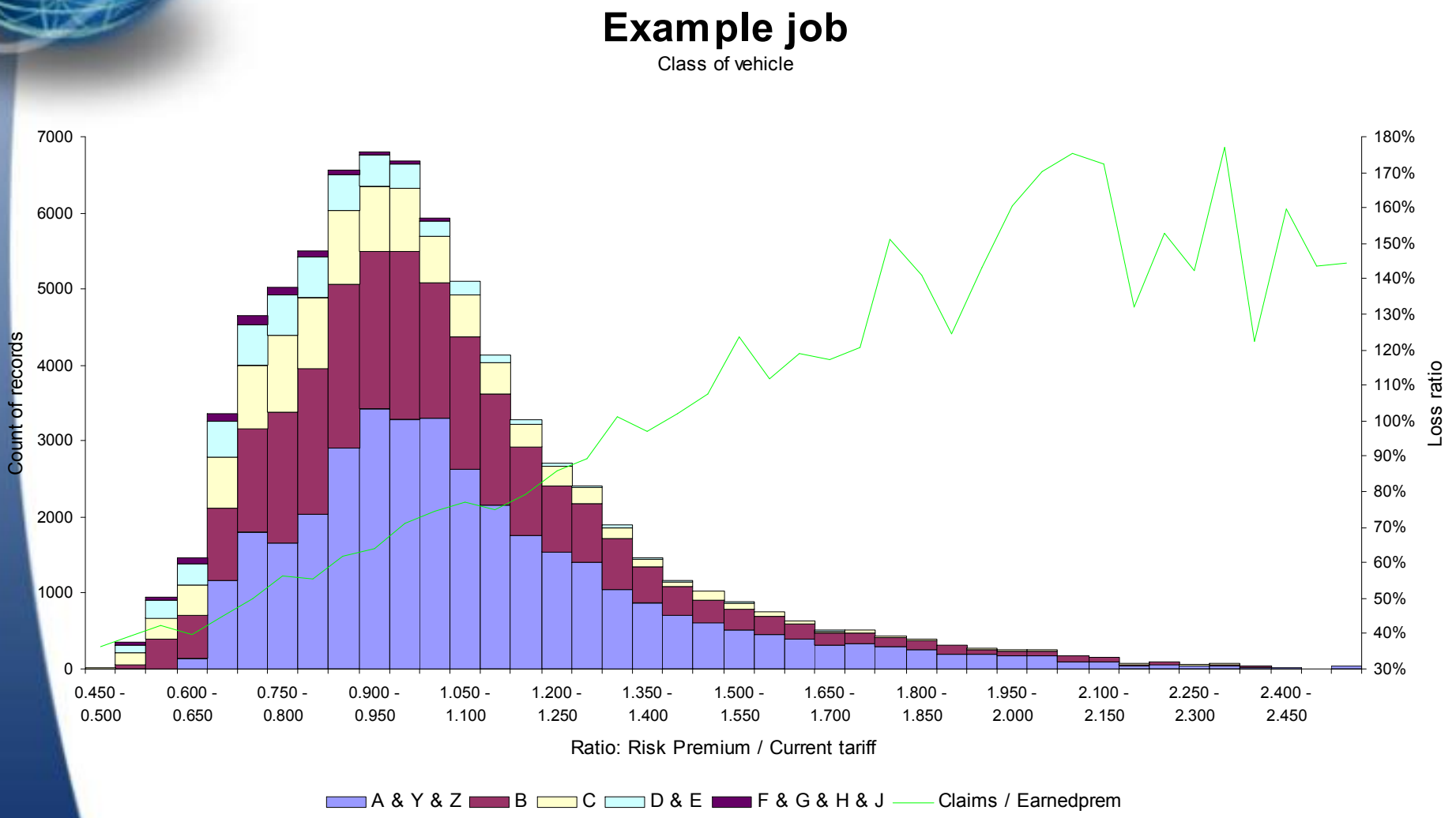

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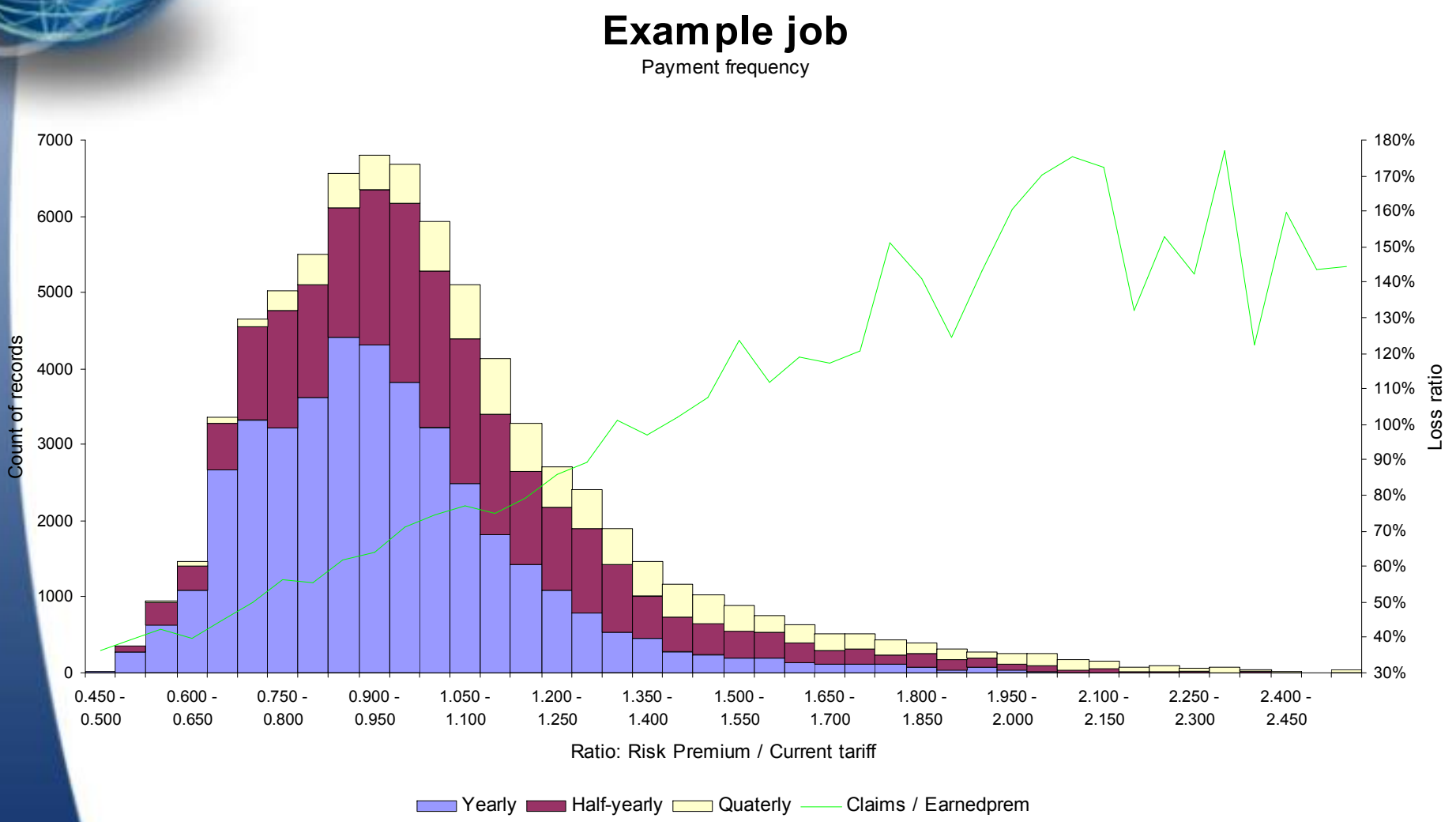
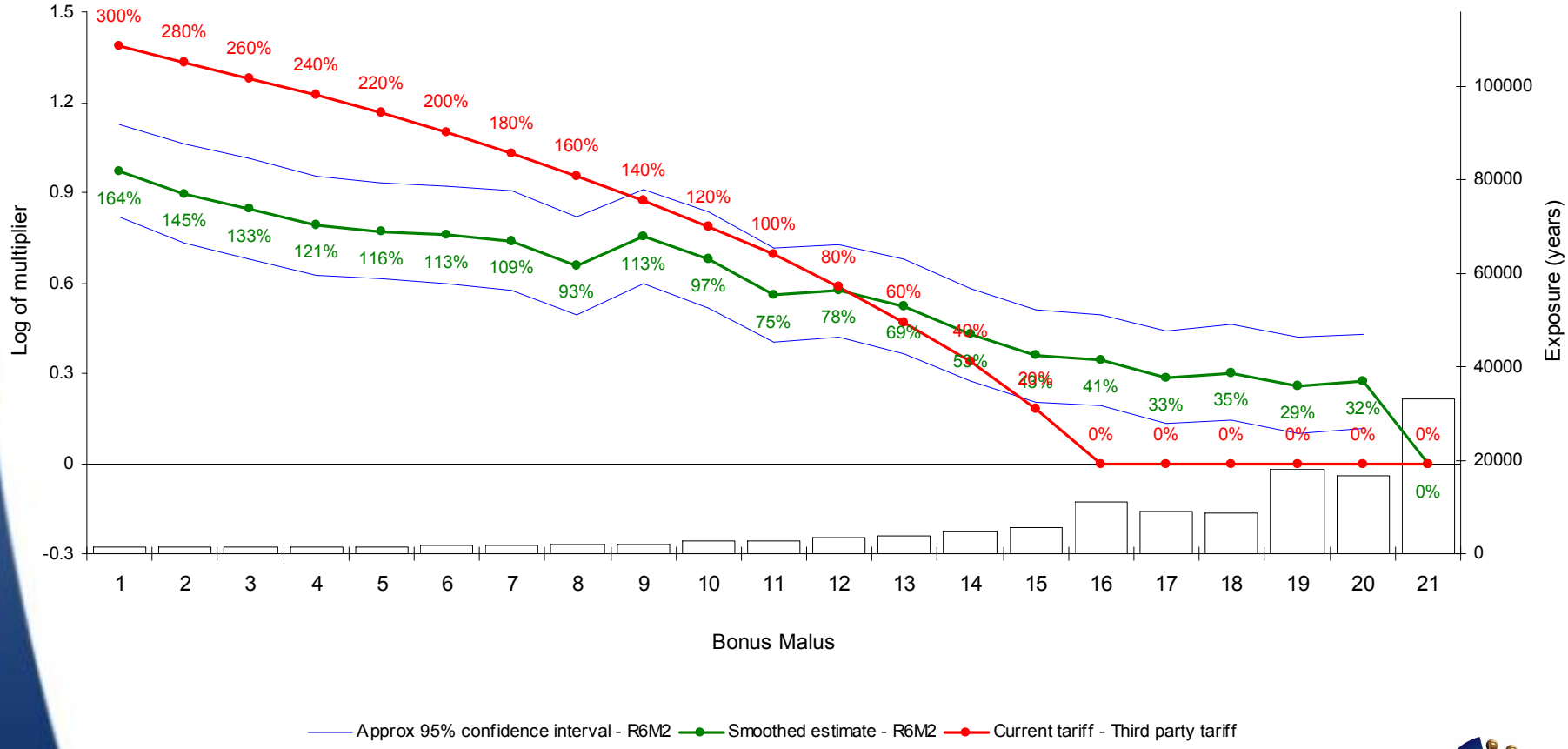


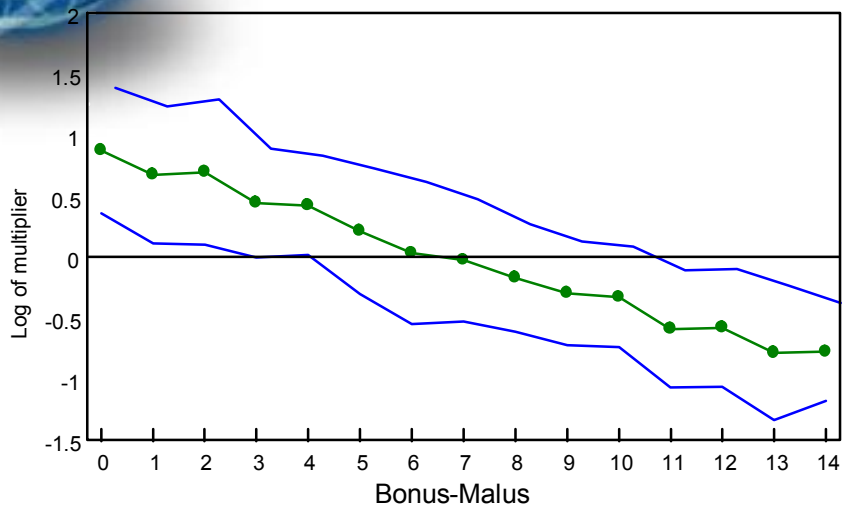
Bonus-Malus

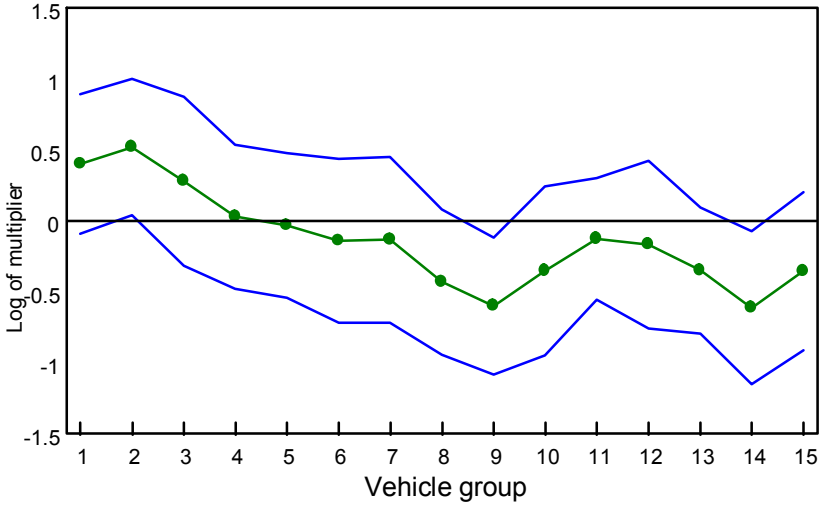
Comparison of current and theoretical Bonus Malus

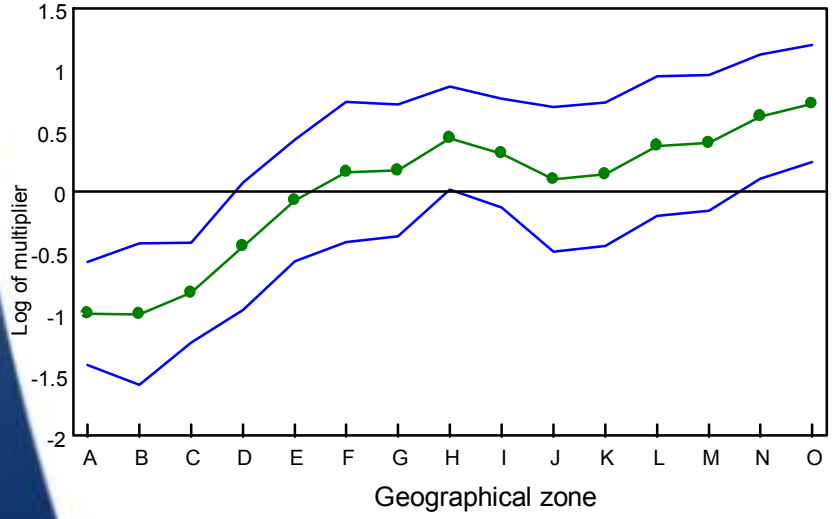
Run 6 Model 2 - Unrestricted standard risk premium run - Unsmoothed standard risk premium model

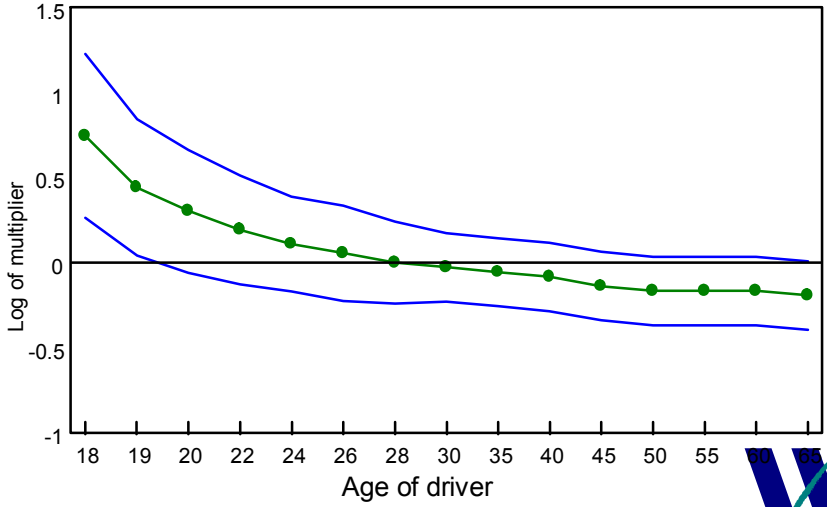


Restricted models

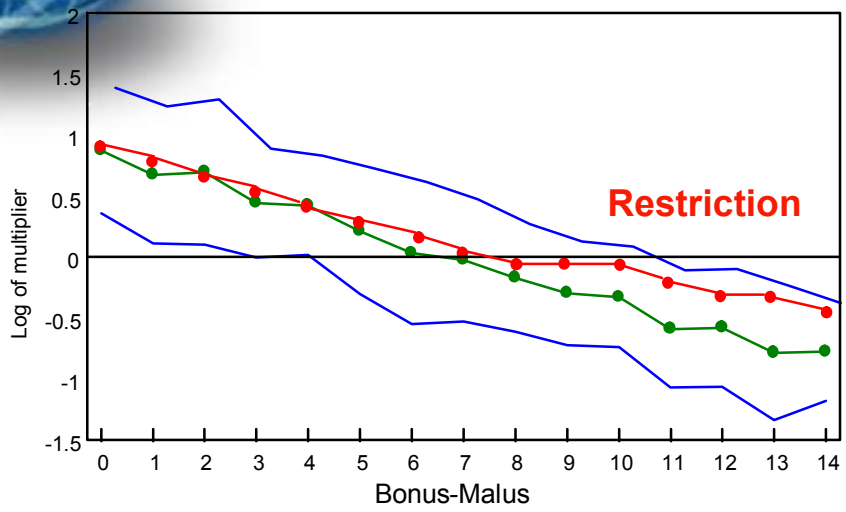


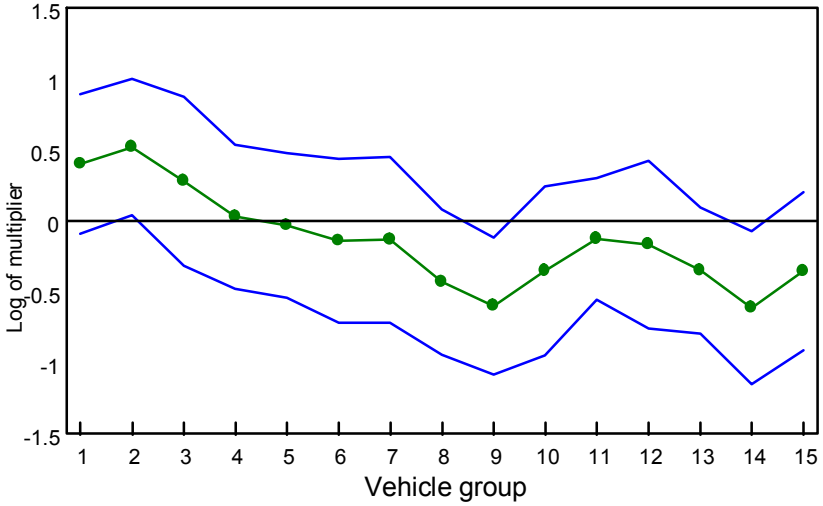


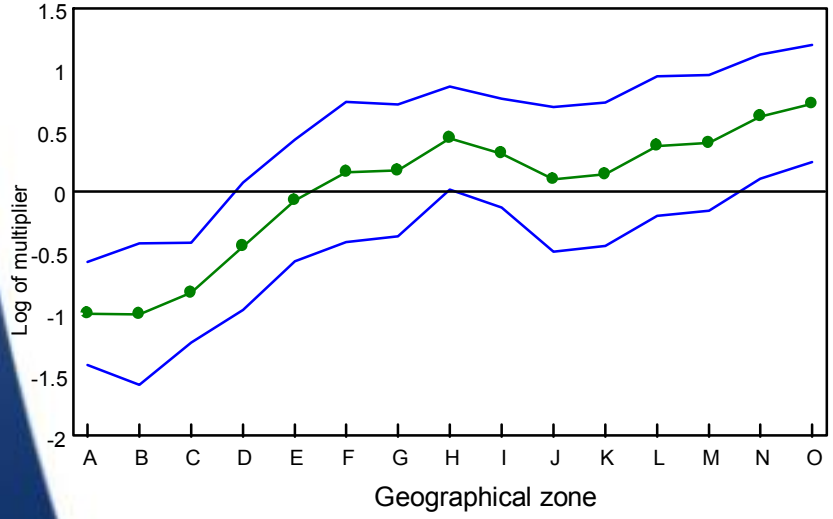


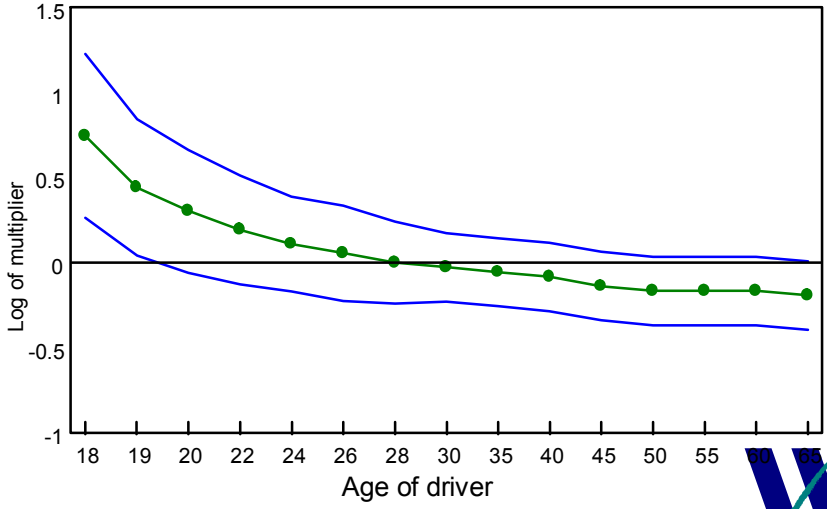


Restricted models

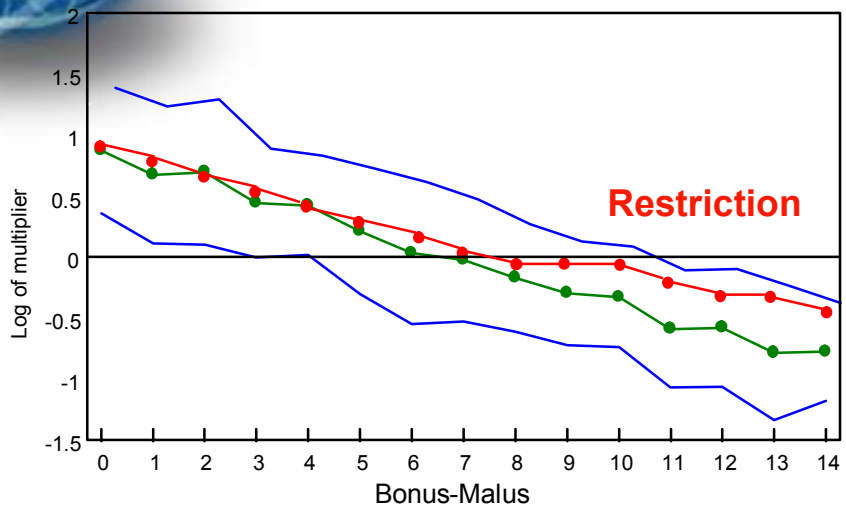


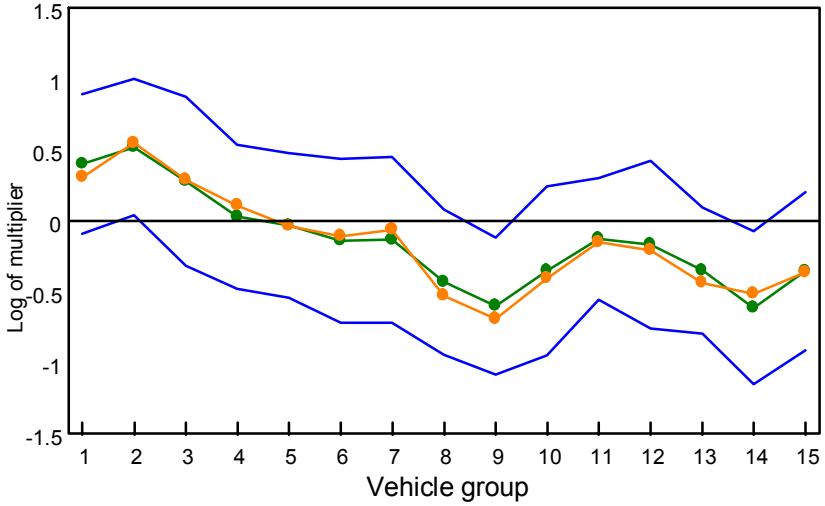


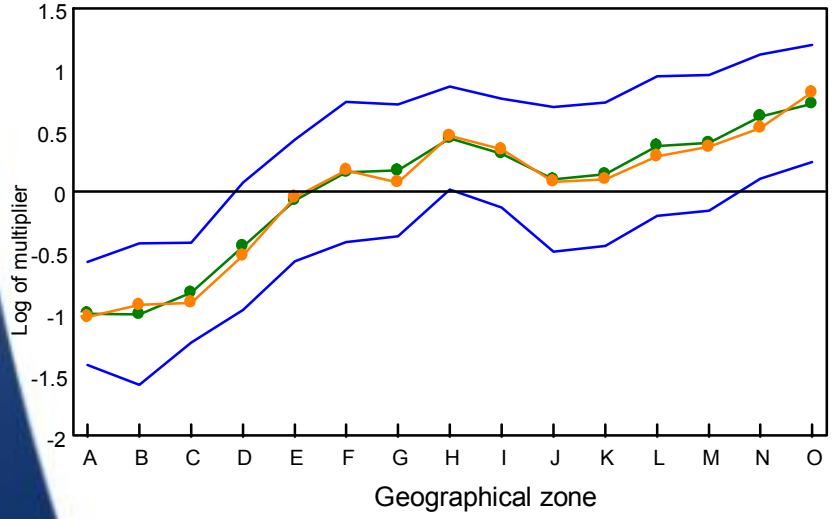


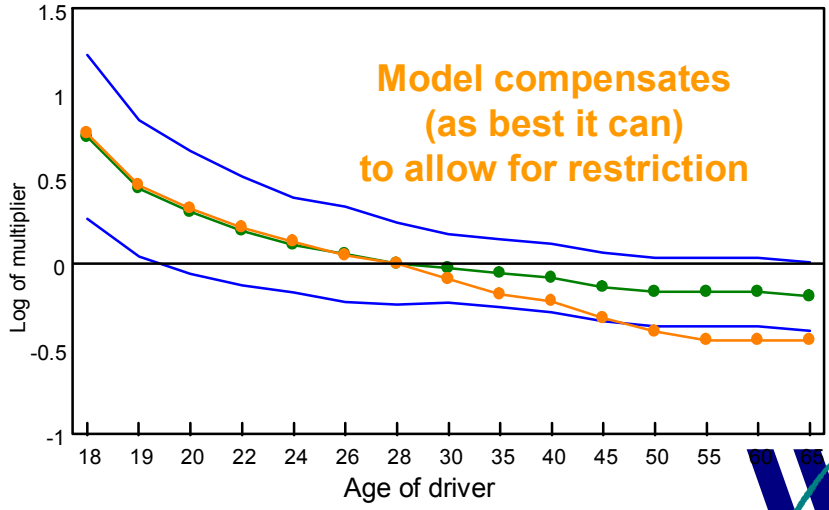


Restricted models

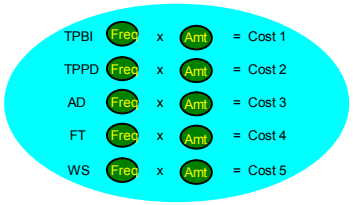








The premium rating process



Current Tariff

Rate level adjustment

Expense loadings

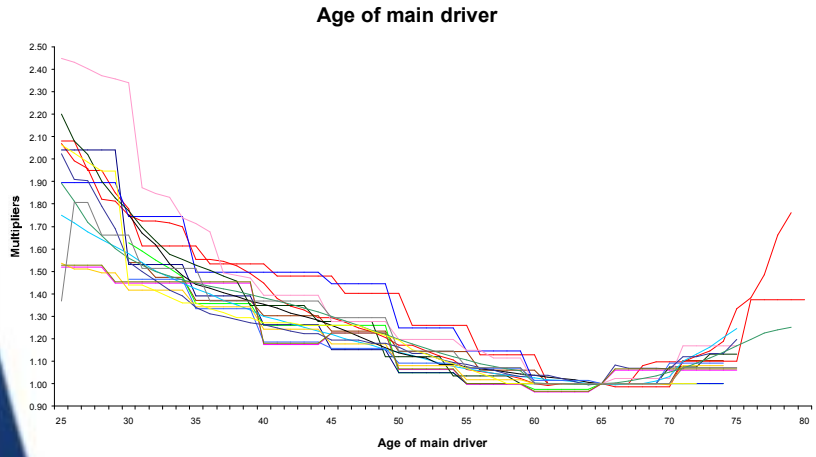
Risk Model

Compare

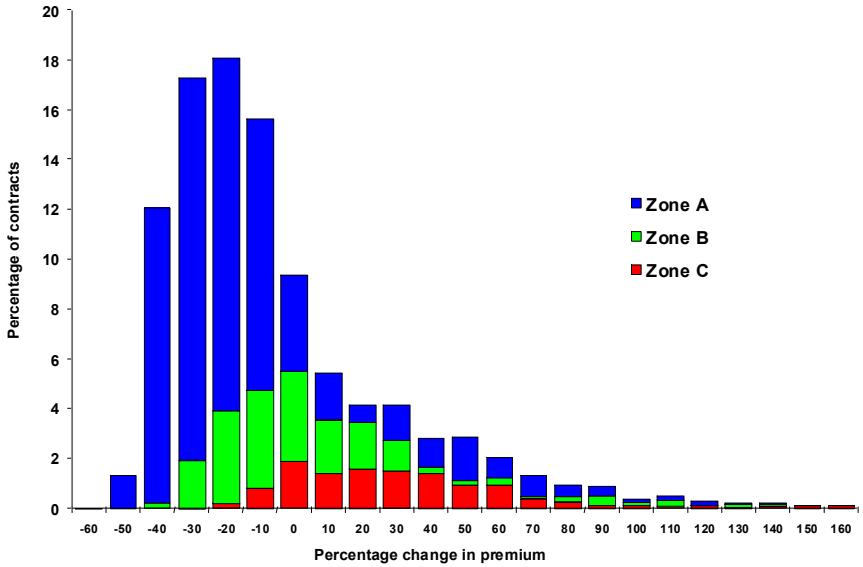
New Tariff

Competitive position

- Survey market
  - broker quotation systems
  - question policyholder
  - mystery shopping
- Investigate competitors' structures



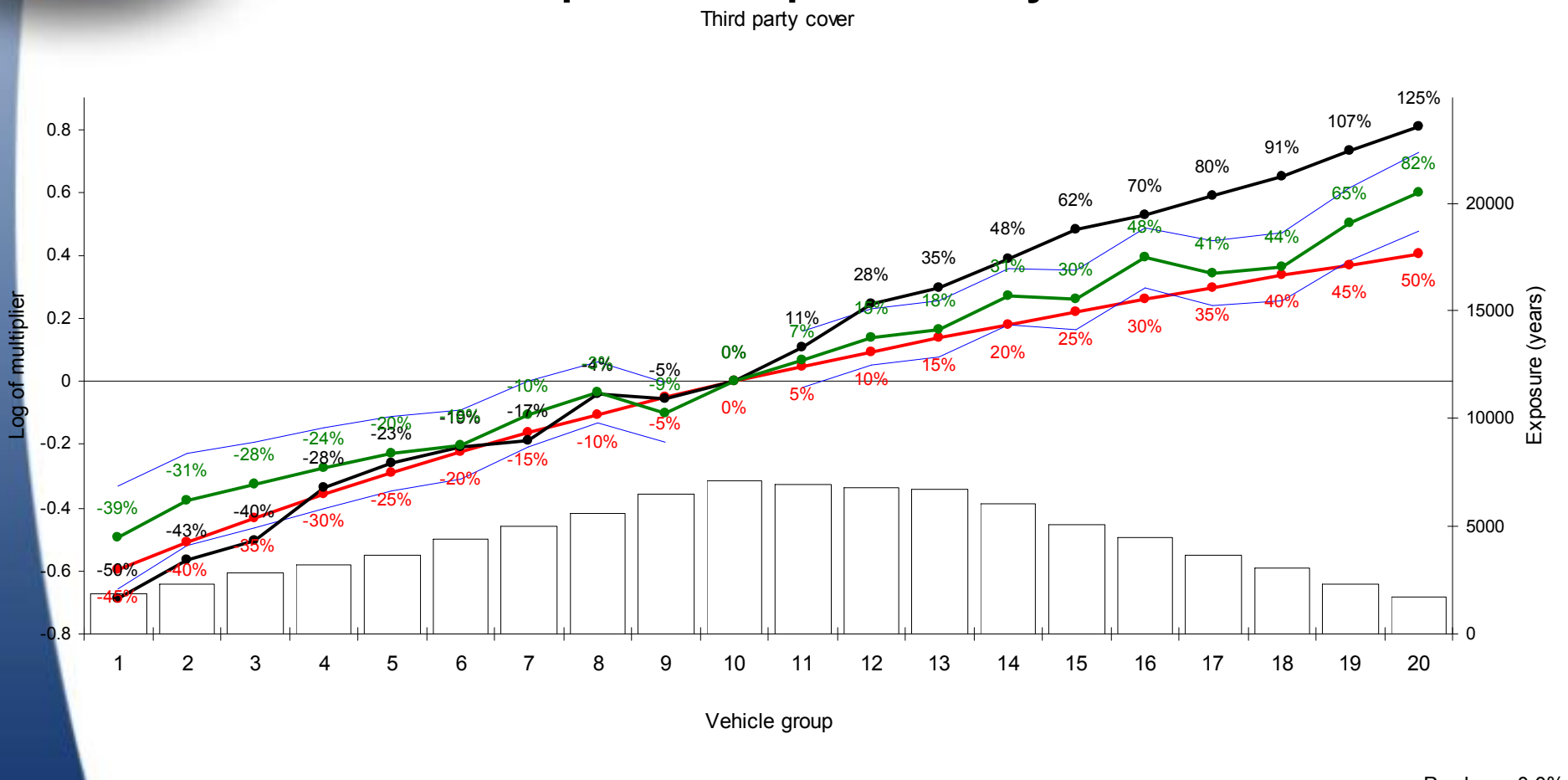
- Apply "cheapest" tariff to own portfolio



- Use in retention / new business model

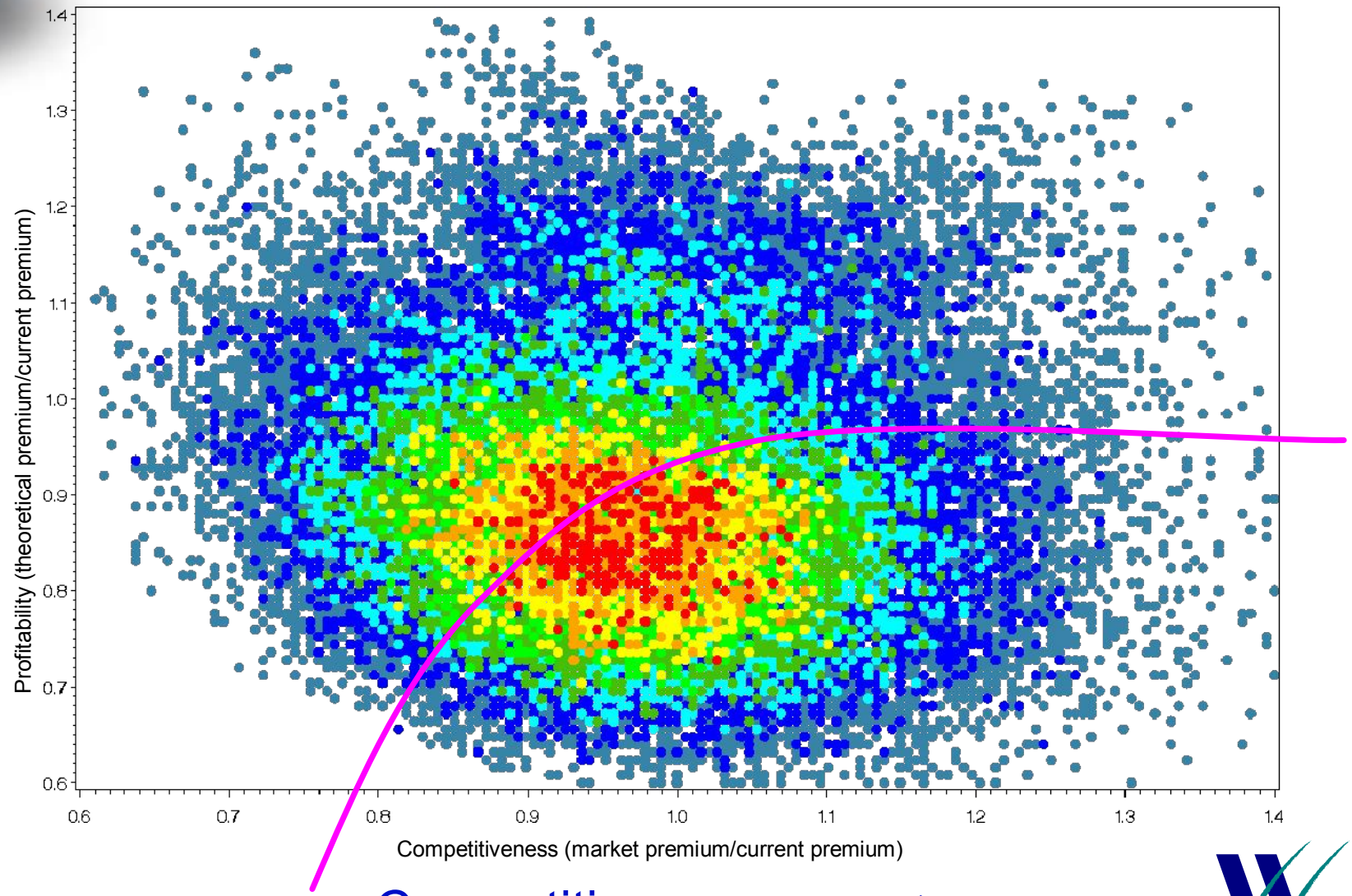
Considering the competitive position

Example of competitor analysis

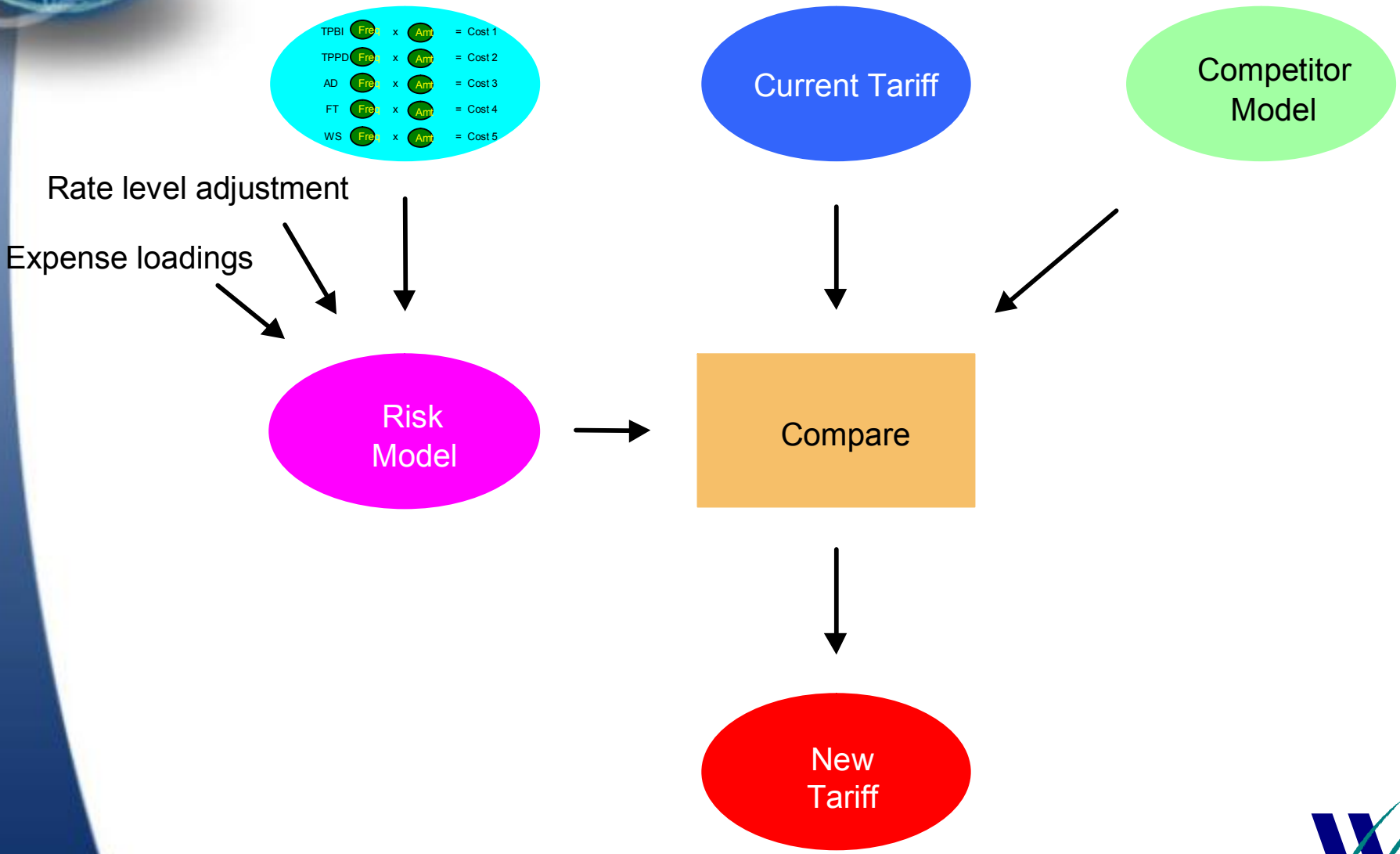


P value = 0.0%
Rank 9/11

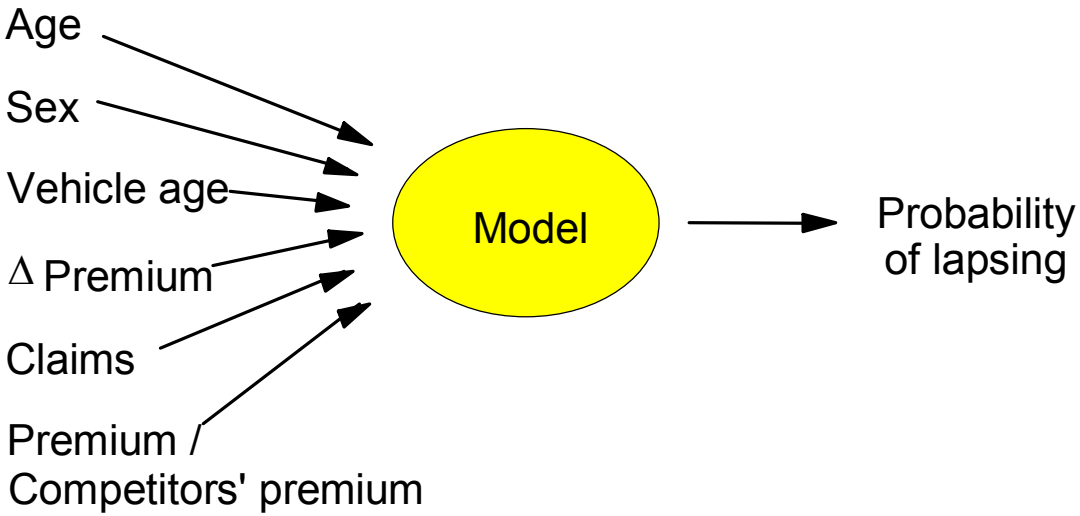
Considering the competitive position



The premium rating process



Modelling retention

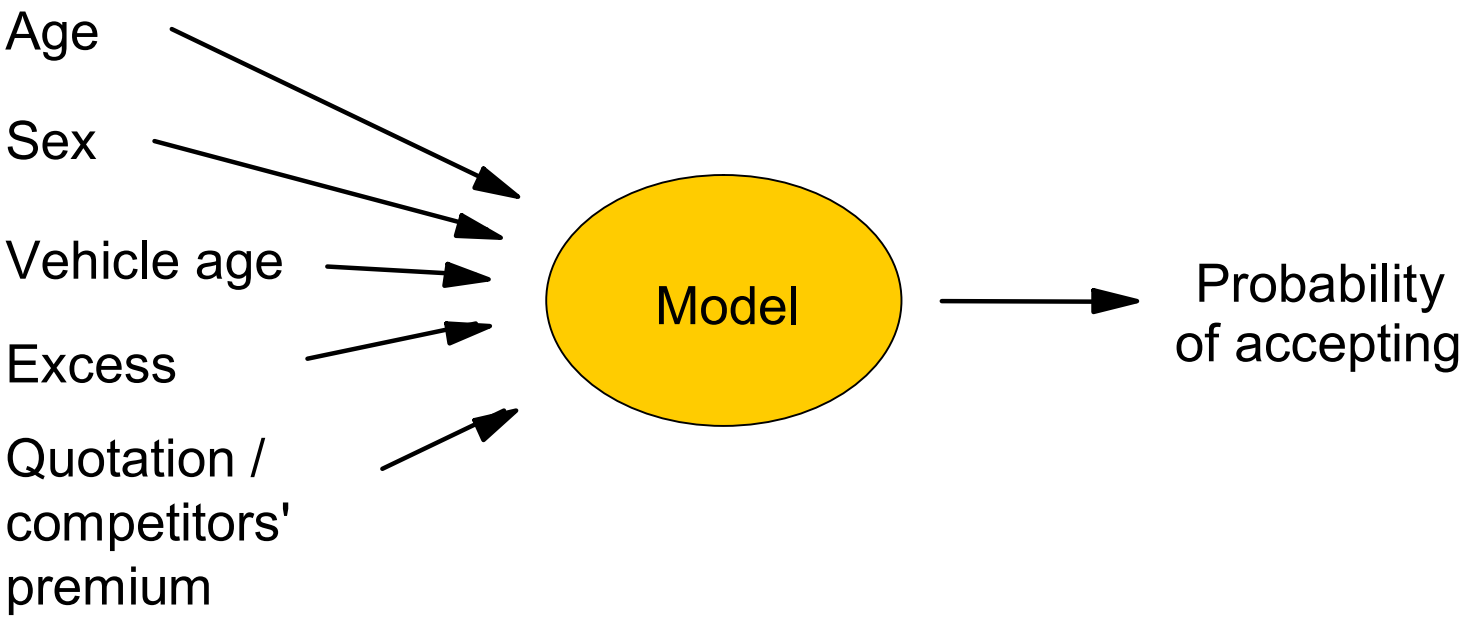


- Model
  - normal factors
  - payment method
  - Bonus-Malus expectation
  - source
  - claims history
  - other products held
  - change in cover

  plus…
  - change in premium
  - competitiveness

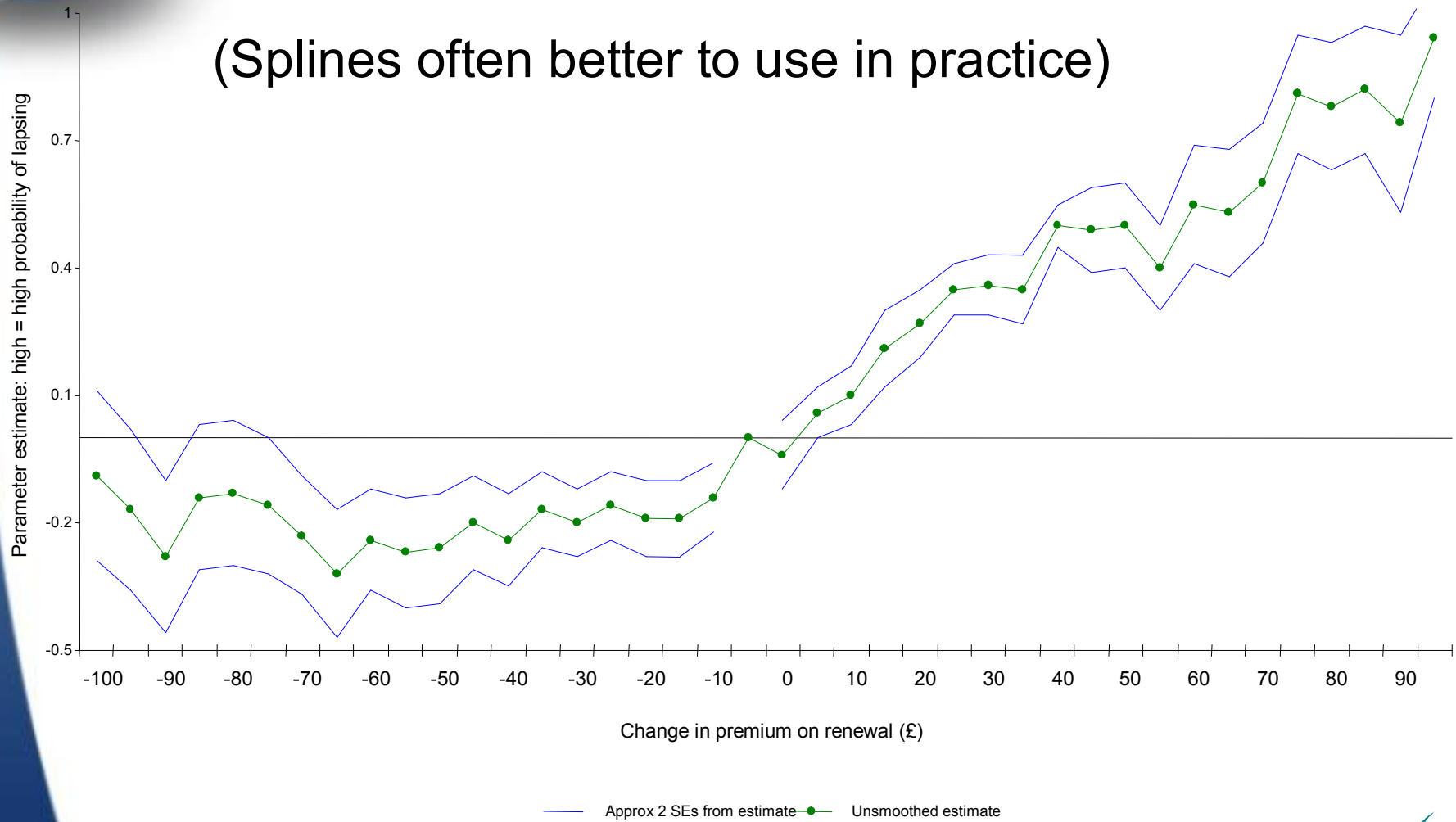
Modelling new business rates

- If details of individual quotes known, can be modelled in similar way
- Otherwise approximations required

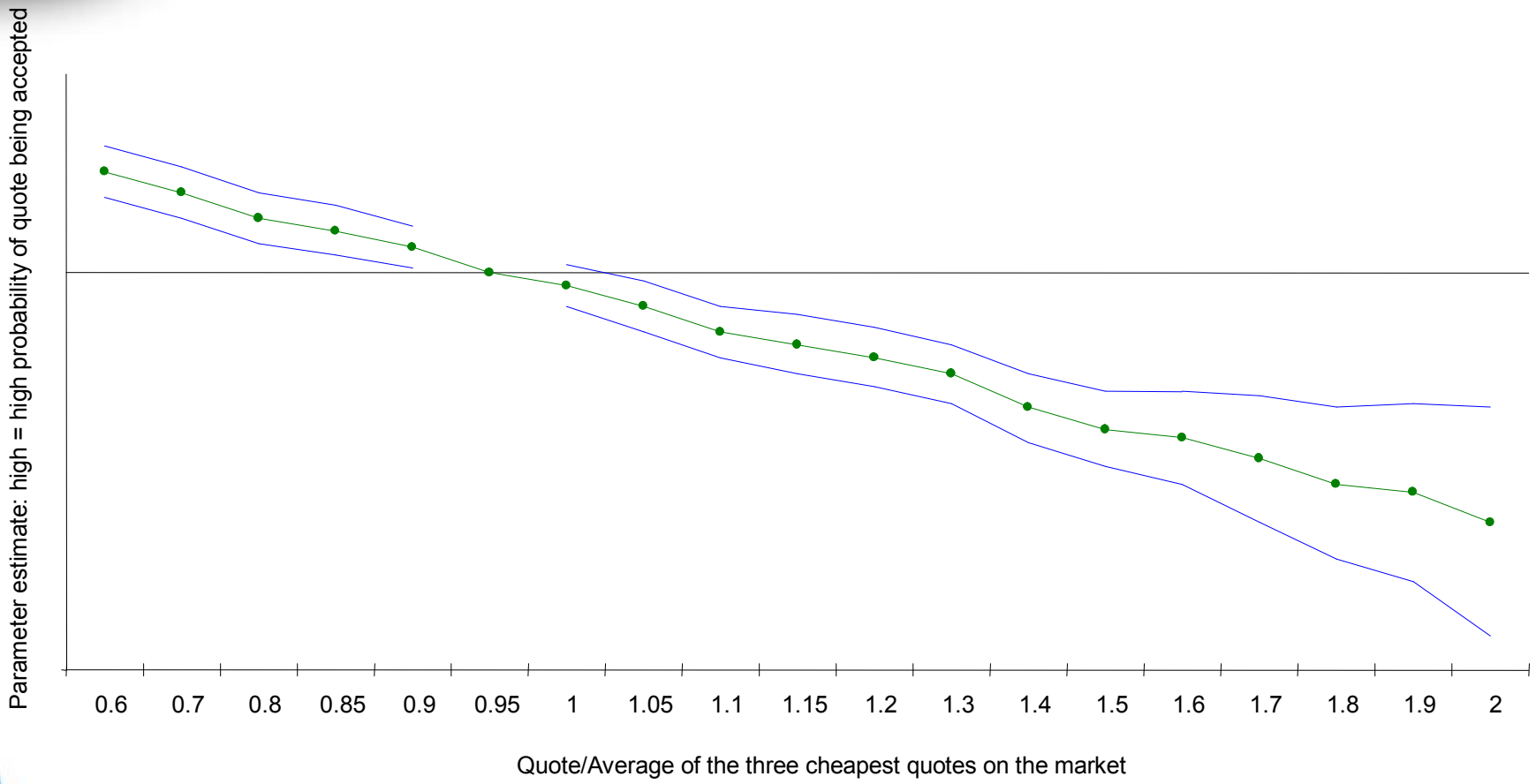


Effect of premium change on lapses

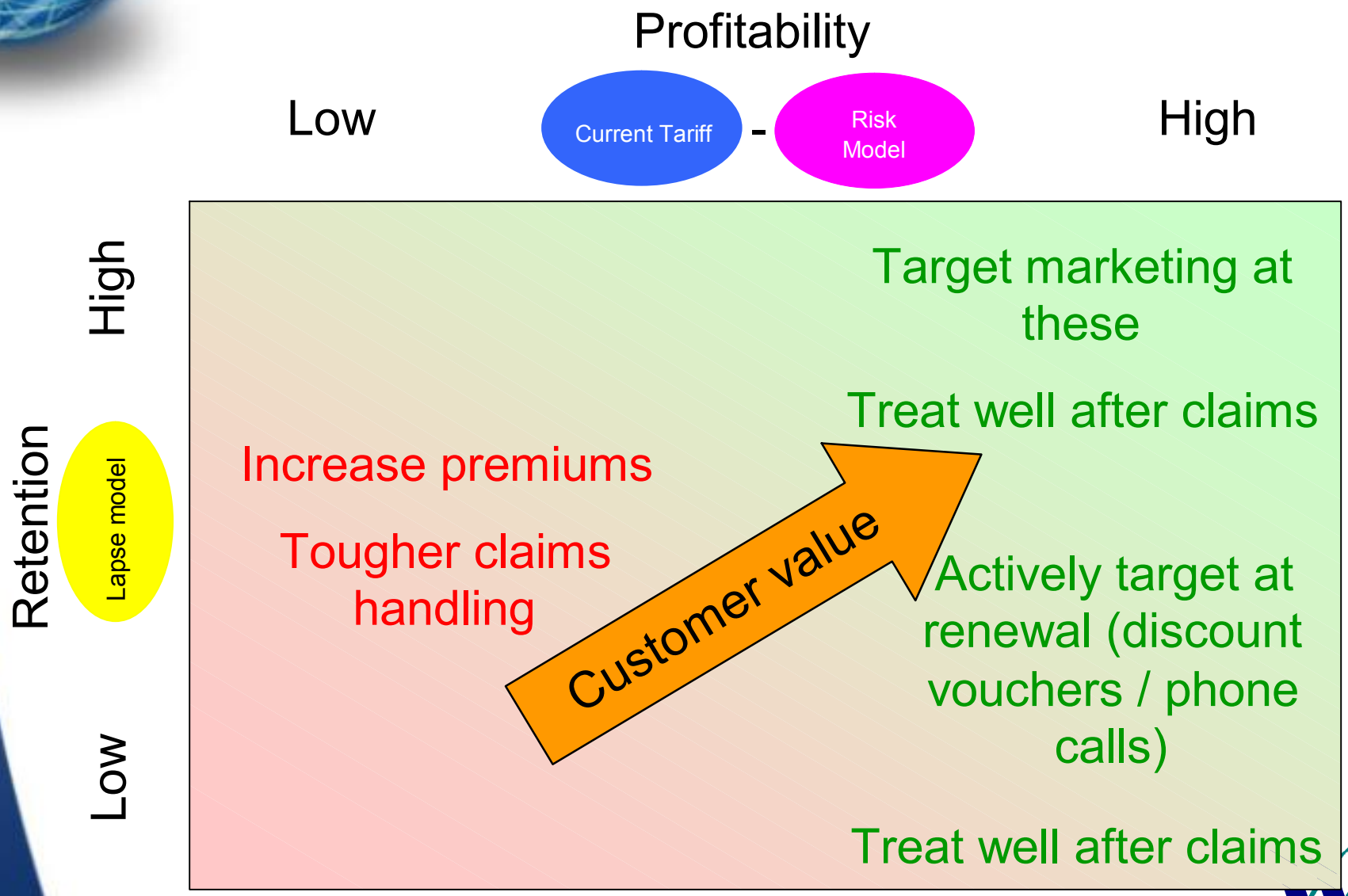
(Splines often better to use in practice)



Effect of competitiveness on new business



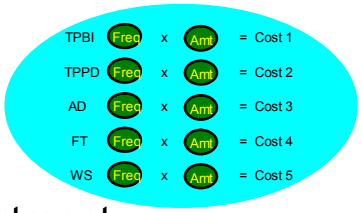
Customer value



Lifetime loadings

- Expenses per policy
  - acquisition 100
  - renewal 30
- Expected lifetime
  - young 2 years
  - old 5 years
- Lifetime expense loadings
  - young (100 + 1 * 30) / 2 = 65
  - old (100 + 4 * 30) / 5 = 44

The premium rating process



Rate level adjustment

Expense loadings

Current Tariff

Competitor Model

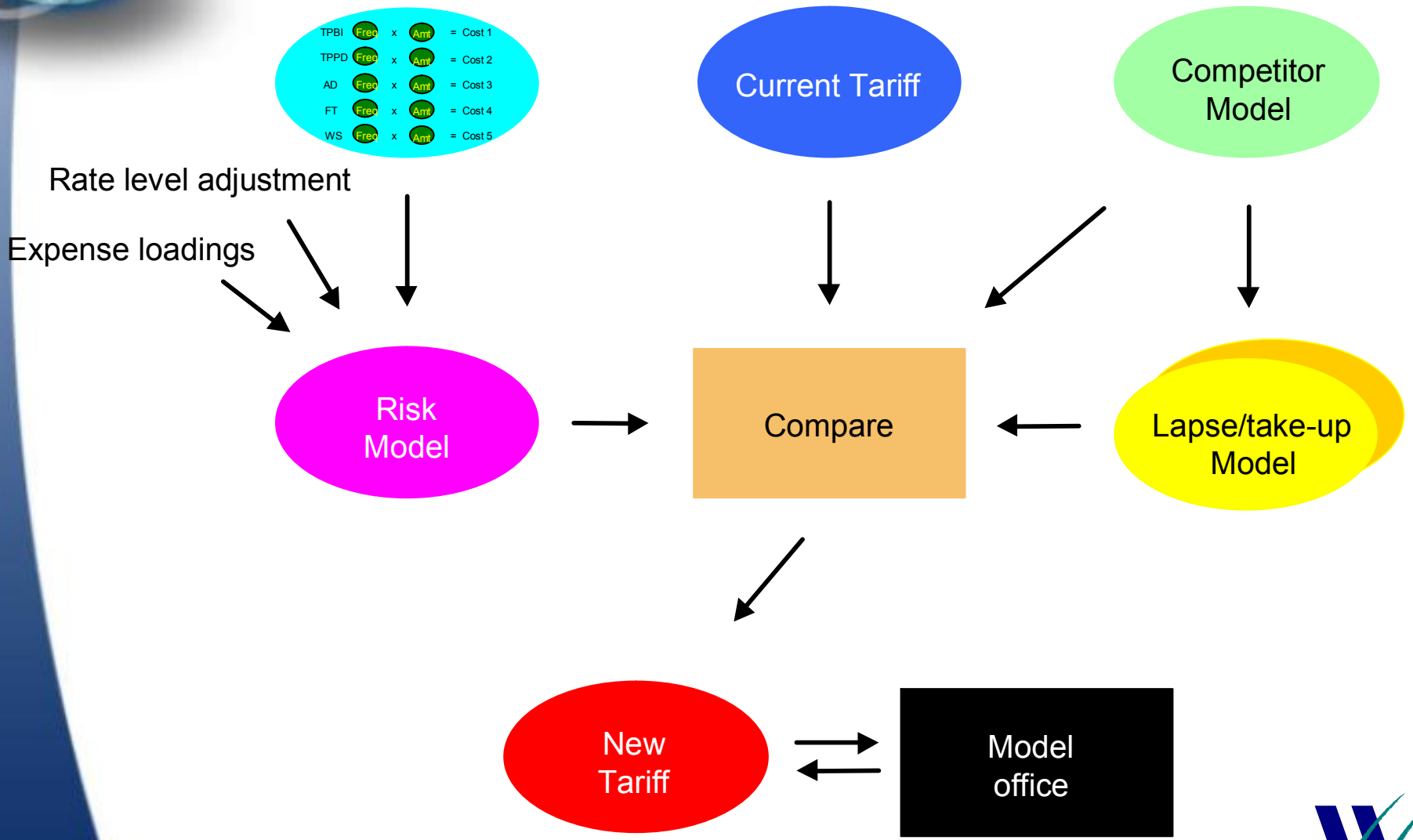
Risk Model

Compare

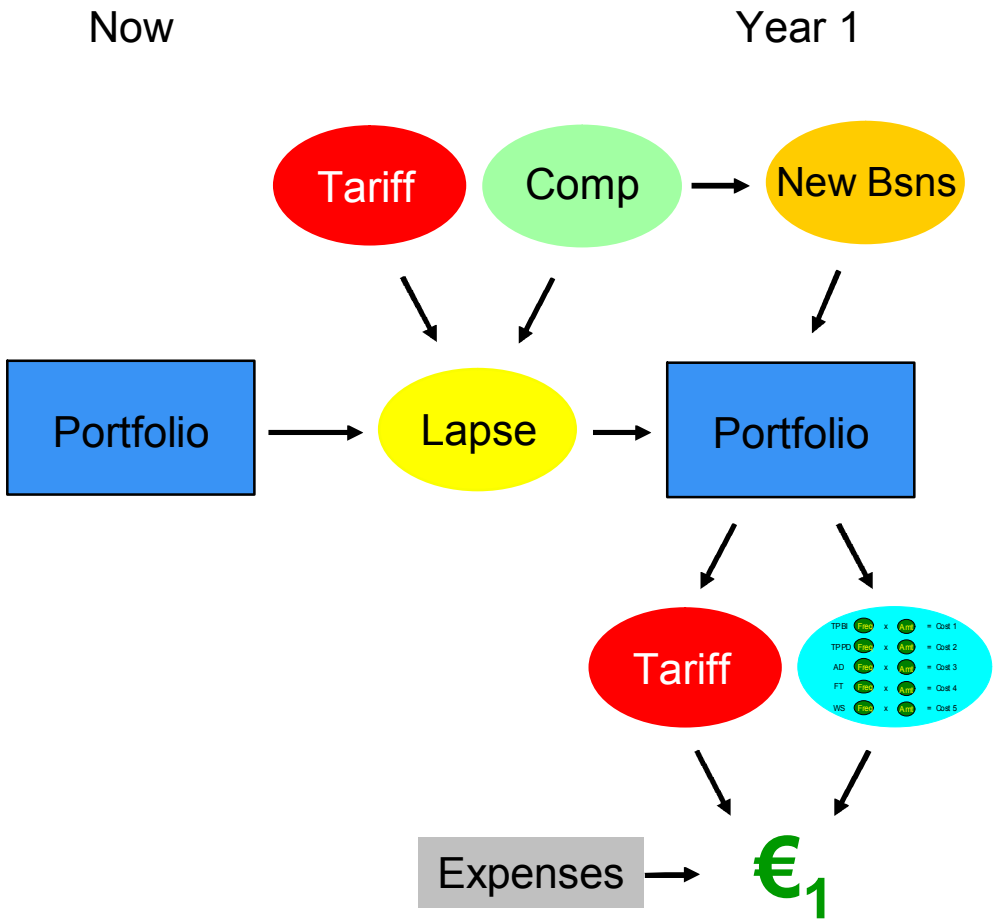
Lapse/take-up Model

New Tariff

The premium rating process



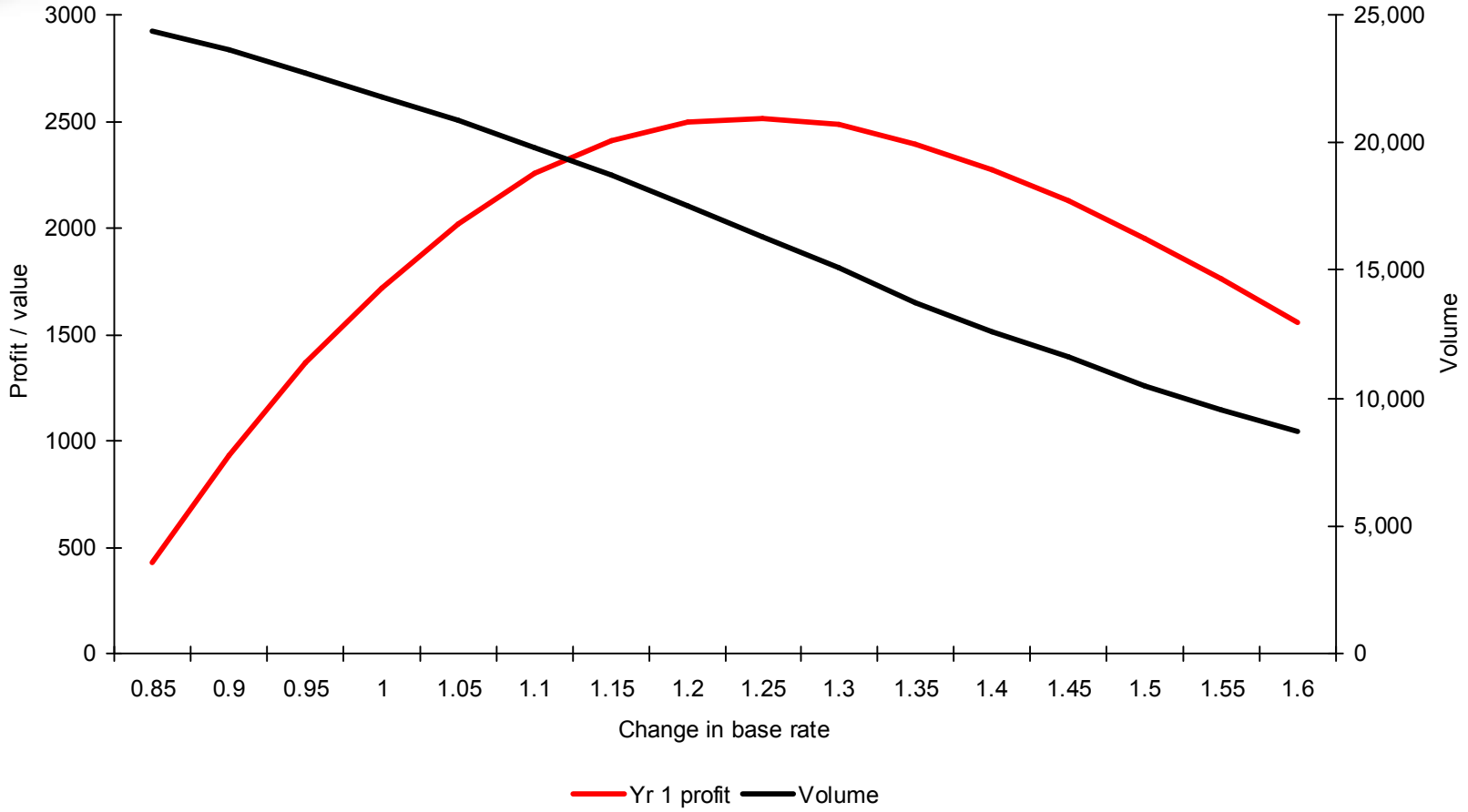
Scenario testing



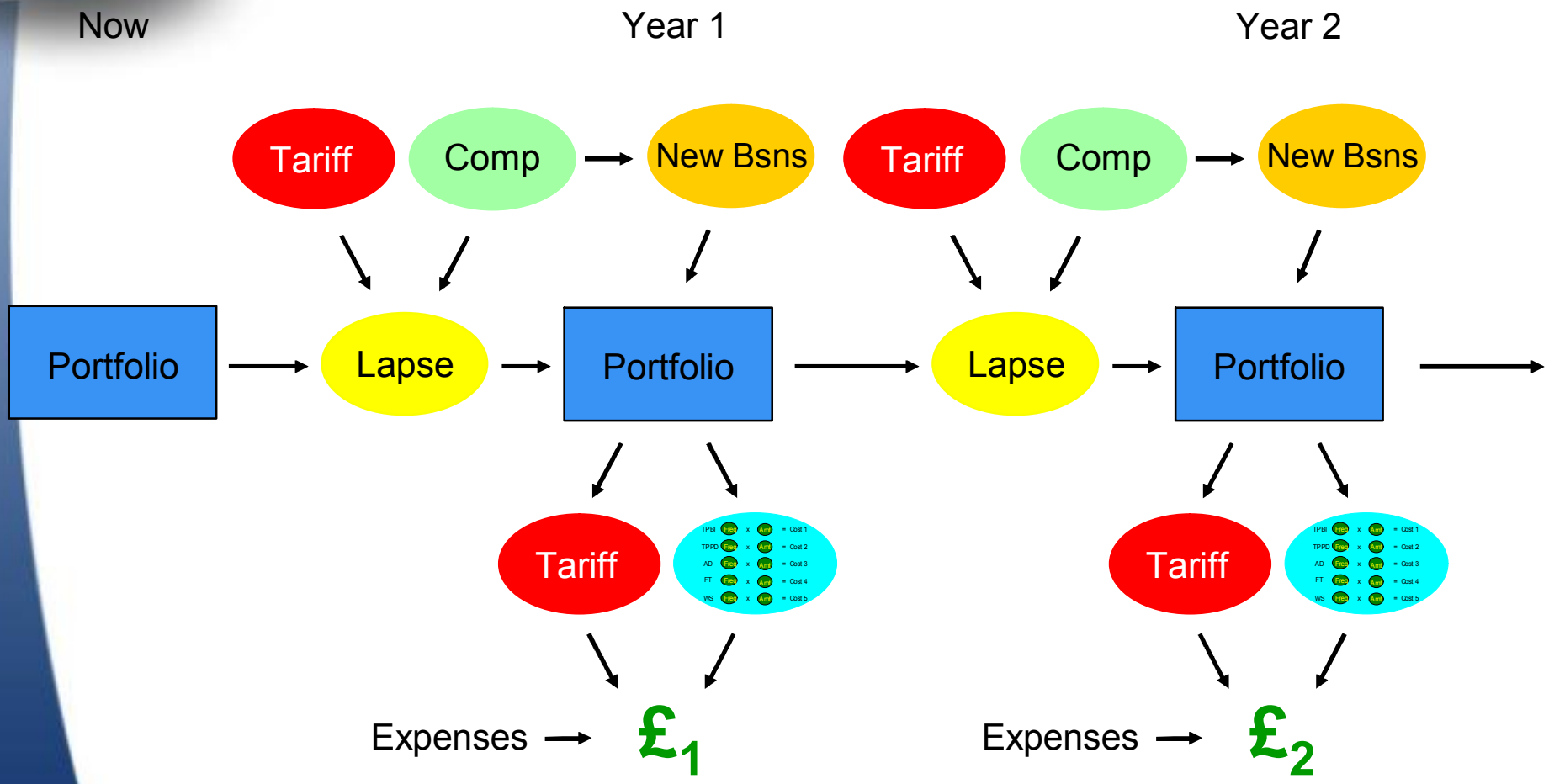
Problems (1)

- What will the competition do?
- Things change
  - age of policyholder
  - age of vehicle
  - vehicle
  - address
  - NCD / Bonus-Malus
- Inputs to some models are outputs from others

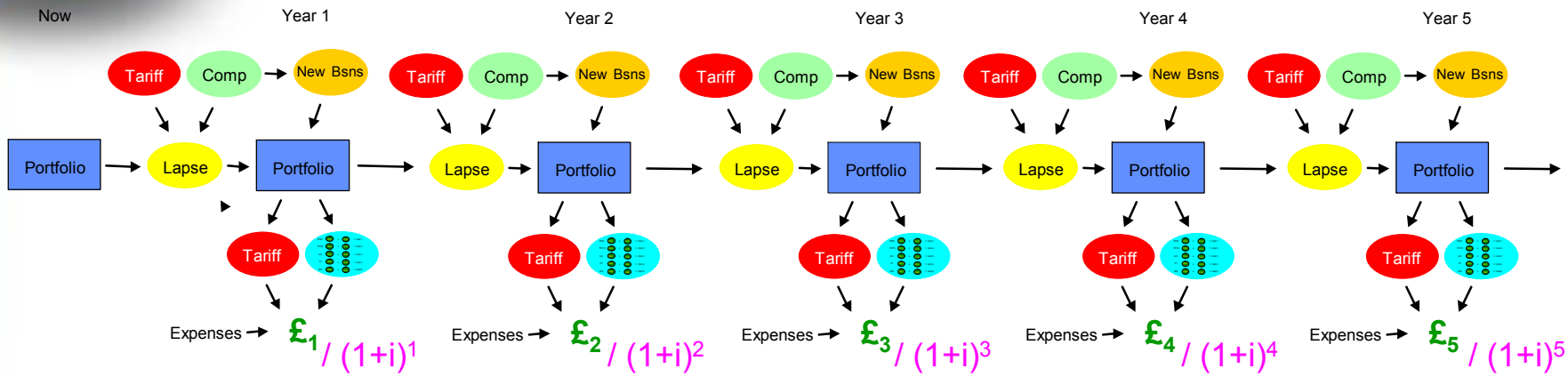
Period of projection



Multiple year projections

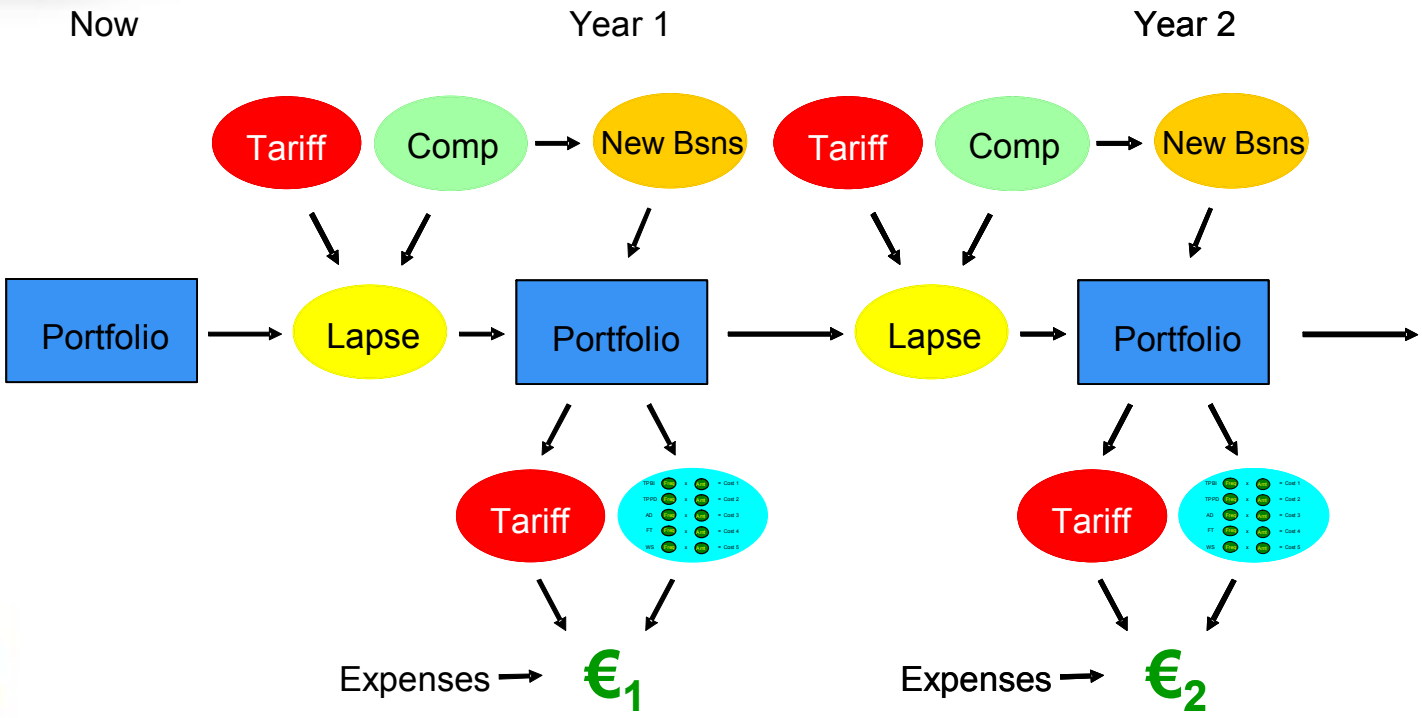


Multiple year projections



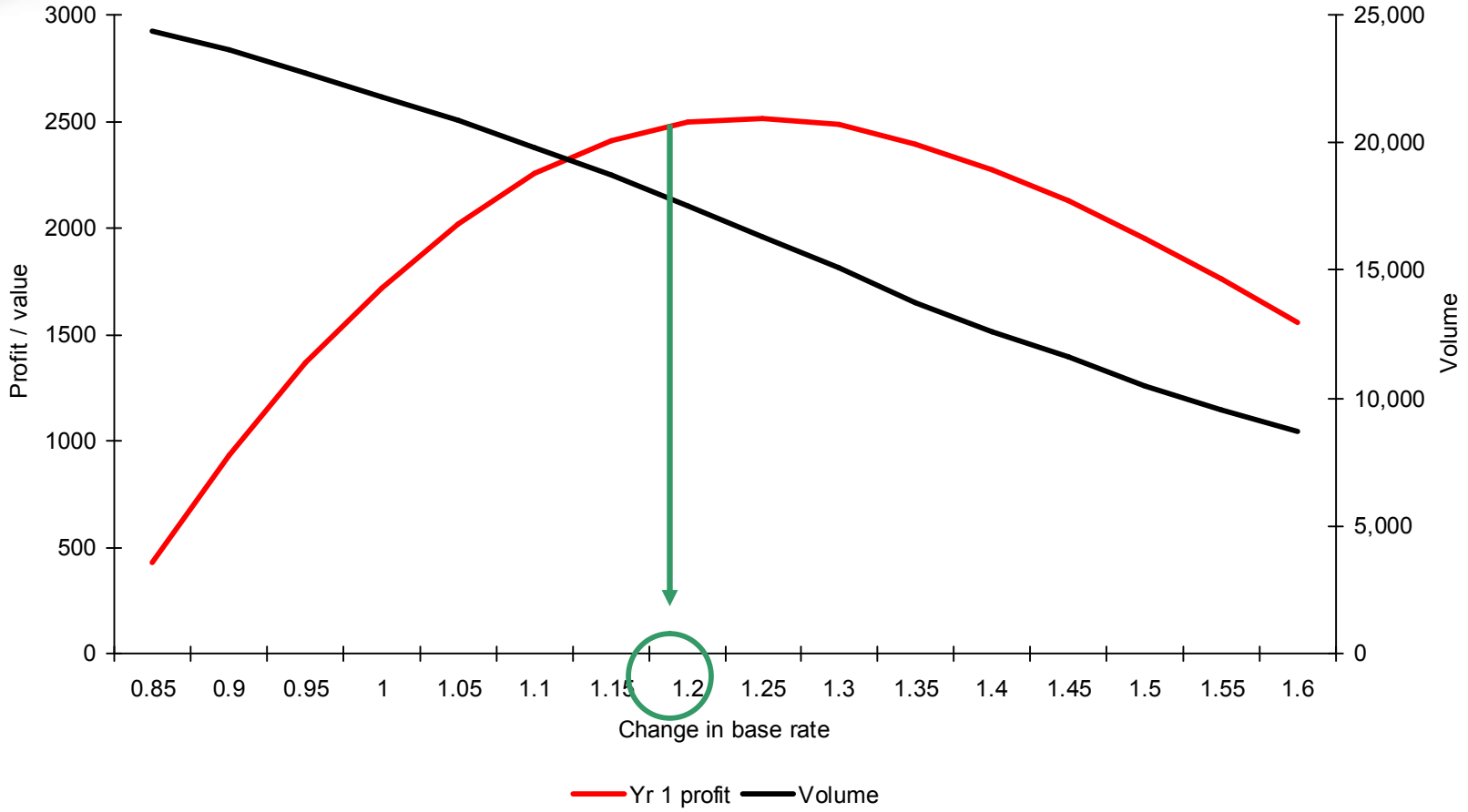
- In theory project many years
- In practice assumptions become too uncertain and model becomes too complex

A pragmatic compromise

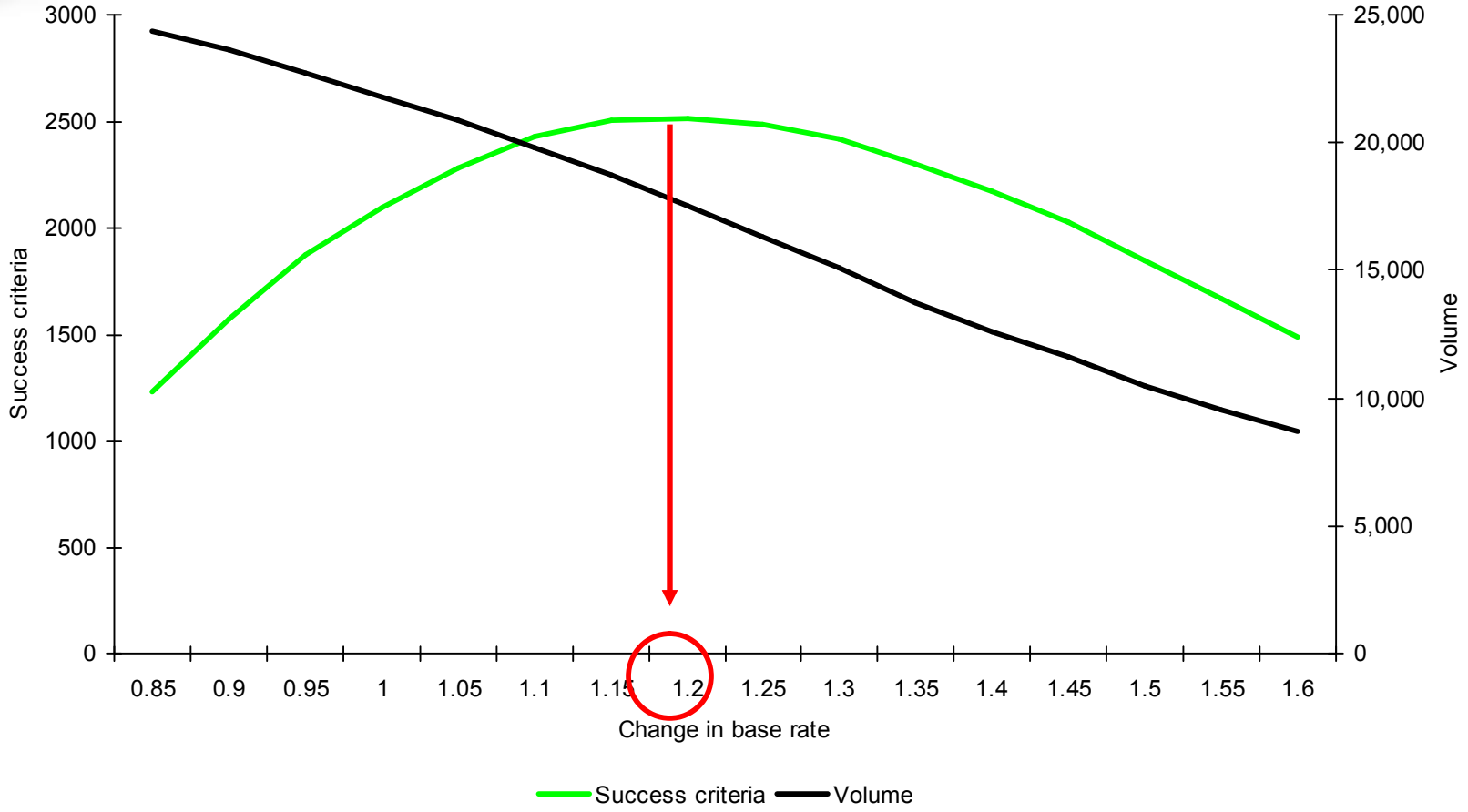


+ €X per policy in force, perhaps modified to make some allowance for lifetime value

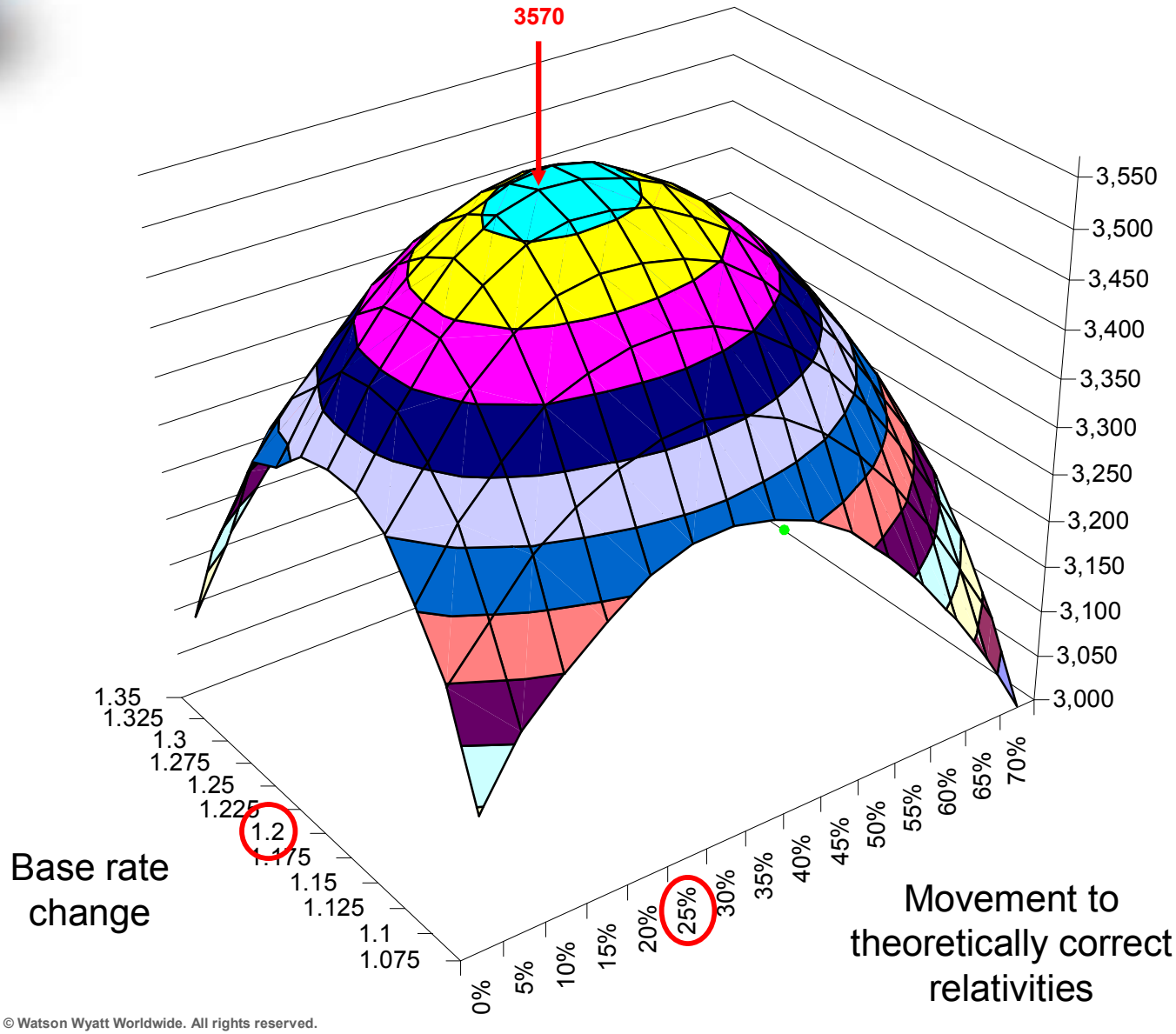
Base rate change - consider profit vs volume



Base rate change - single success criteria



Base rate change with simple relativity change



Base rate change

Movement to theoretically correct relativities

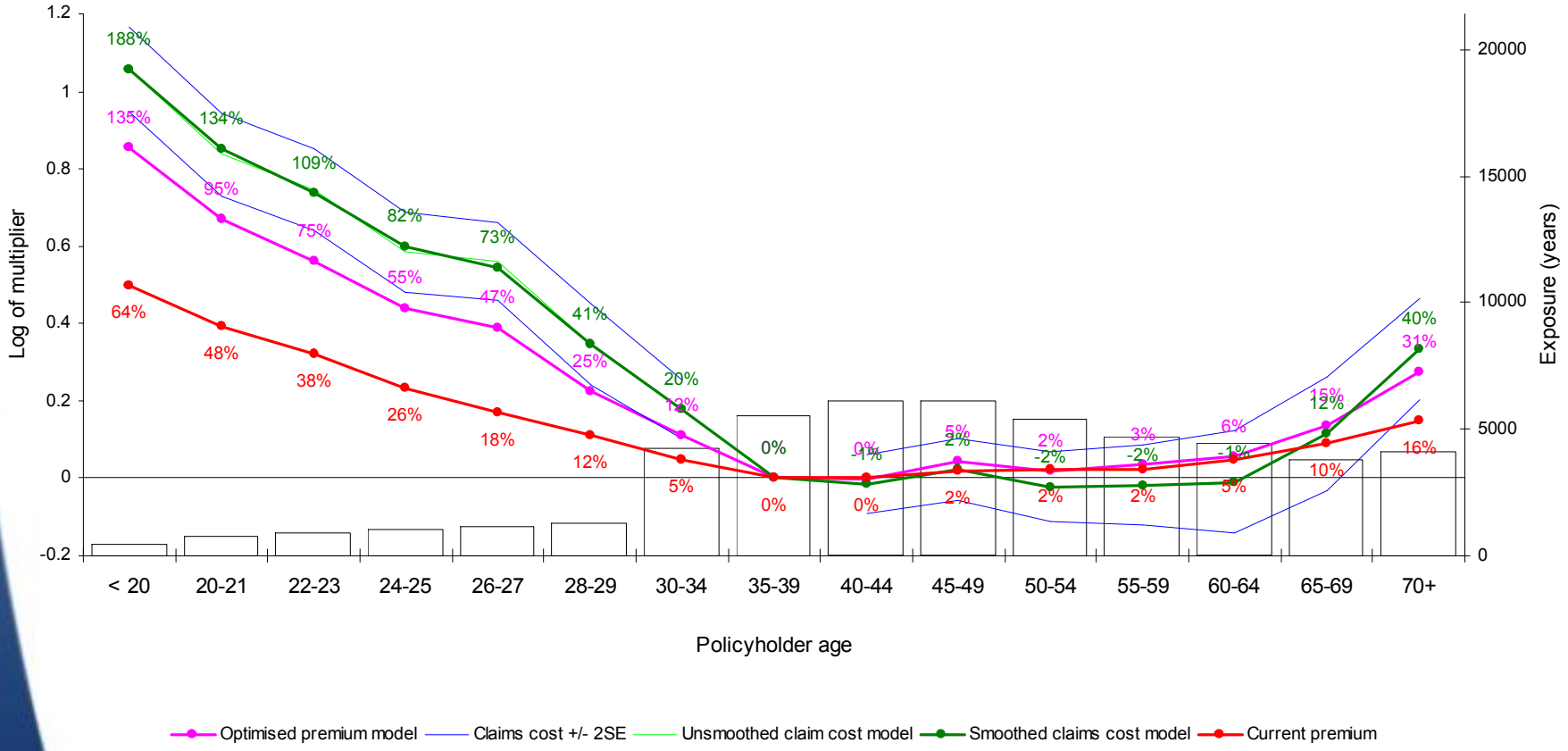
Optimisation

- Methods exist which allow optimal rating structure (considering all parameters) to be derived

Optimised rating structure

Optimised premium

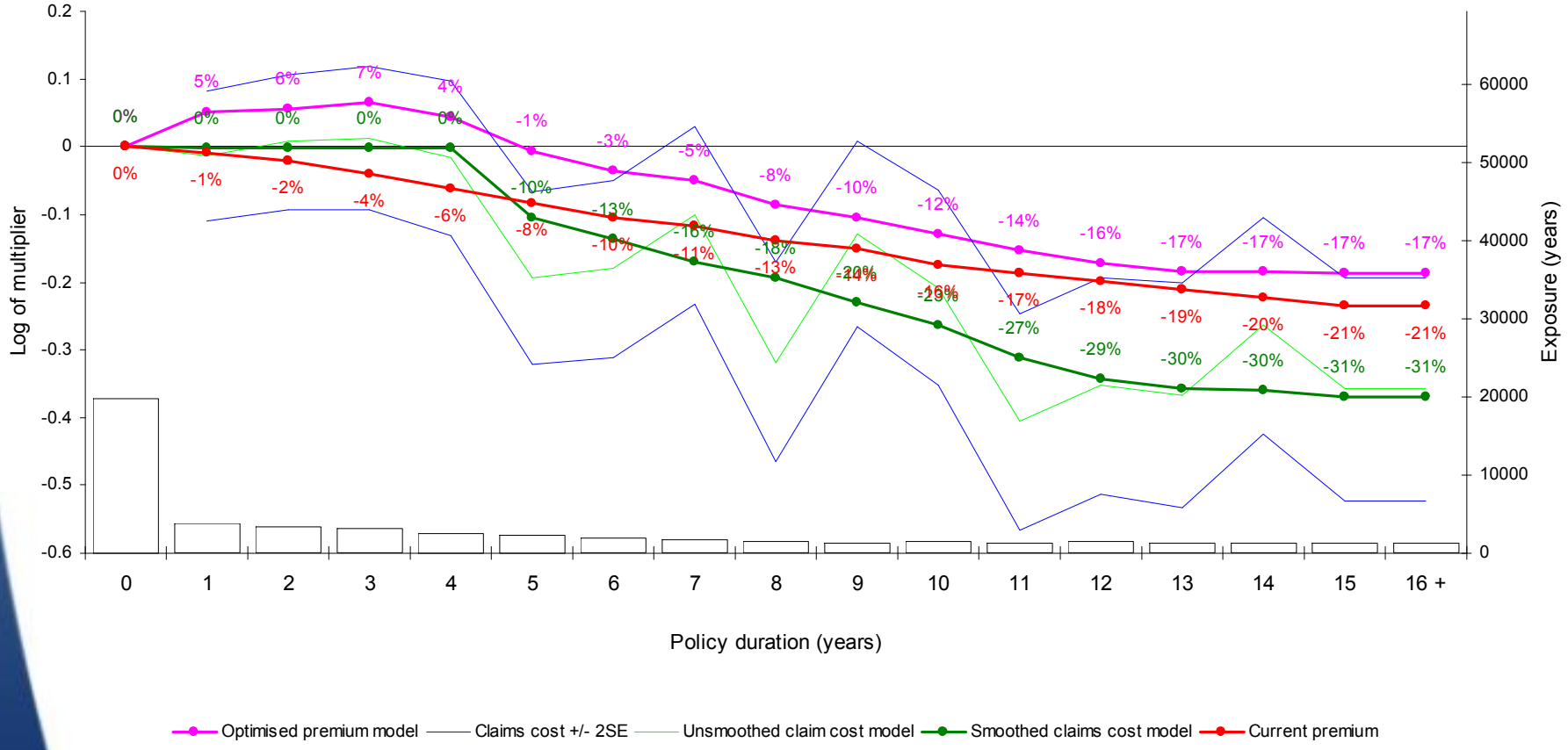
Comparison with claims model and current premium



Optimised rating structure

Optimised premium

Comparison with claims model and current premium

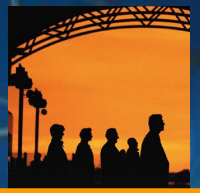


Modern methods in personal lines pricing

CAE/DAV Meeting

Berlin

29 April 2005



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