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PM-2: Conversion and Retention Modeling

CAS RPM Seminar

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Watson Wyatt Worldwide

Agenda

- Model forms
- GLM choices
- Modelling price change

Elasticity models

- UK Actuarial profession's 2008 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?

Agenda

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Model form:
Linear versus non-linear

- Varying views:
  - Simplistic
  - Complex linear
  - Non-linear
- Consider relative competitiveness for retention as an example
  - Our price / market price

Simplistic

- Treat as variate, assume linear

$$\mu = g^{-1}(\Sigma X_j \beta_j + c(p/m))$$

- Assumes “same” price sensitivity everywhere
  - Logit link => Central probabilities more sensitive, extremes less sensitive
- No-one does this, but helpful to understand issues

Complex linear

- Use a continuous function of competitiveness

$$\mu = g^{-1}(\Sigma X_j \beta_j + c_k.f_k(p/m))$$

- Function is polynomial or spline
- Can interact with other variables to achieve range of shapes
- Simple to apply with existing tools

Non-linear

- Linear in competitiveness, gradient varies by segment

$$\mu = g^{-1}(\Sigma X_j \beta_j + (p/m).\exp(\Sigma Z_j \gamma_j))$$

- Similar issues to simplistic, but locally OK
- Hard to fit due to co-linearity of parameters

What is best approach?

- Working party did not look at non-linear models
- Splines and interactions with splines give wide range of shapes
- Significant evidence that price sensitivity is not “constant”
  - Asymmetric utility curve
- GLM complex linear practical and effective

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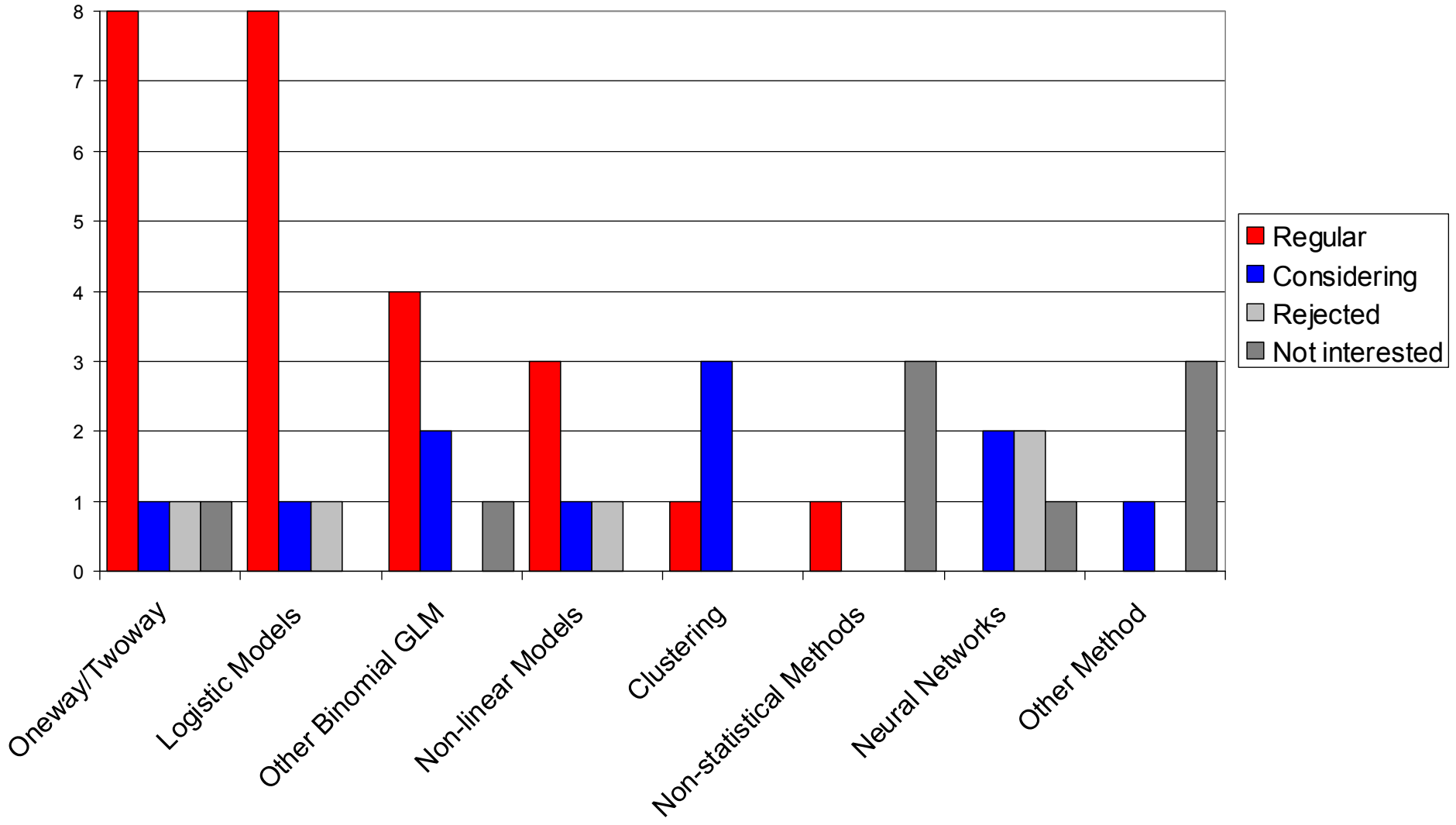
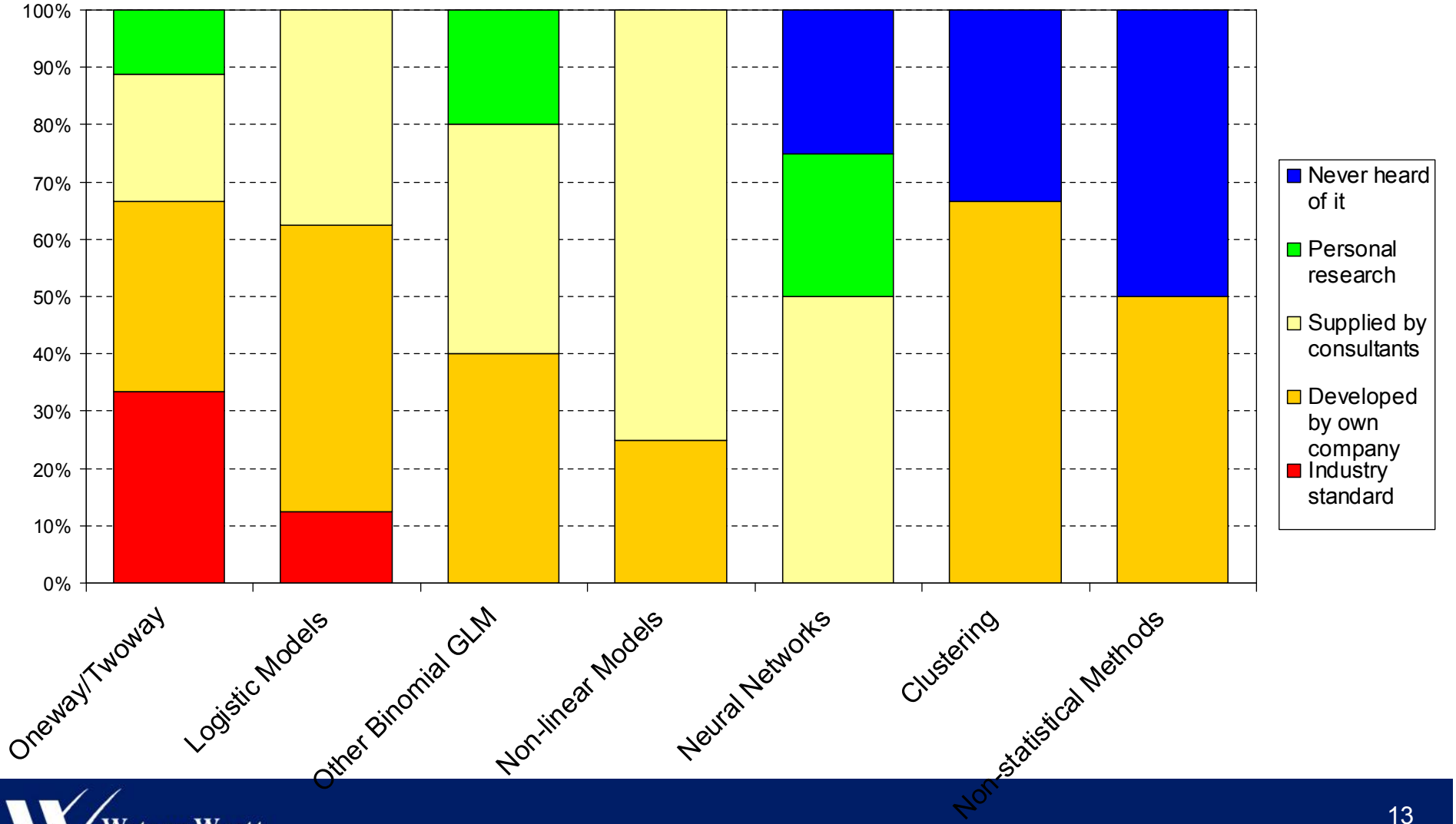
Survey

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

Methods in use



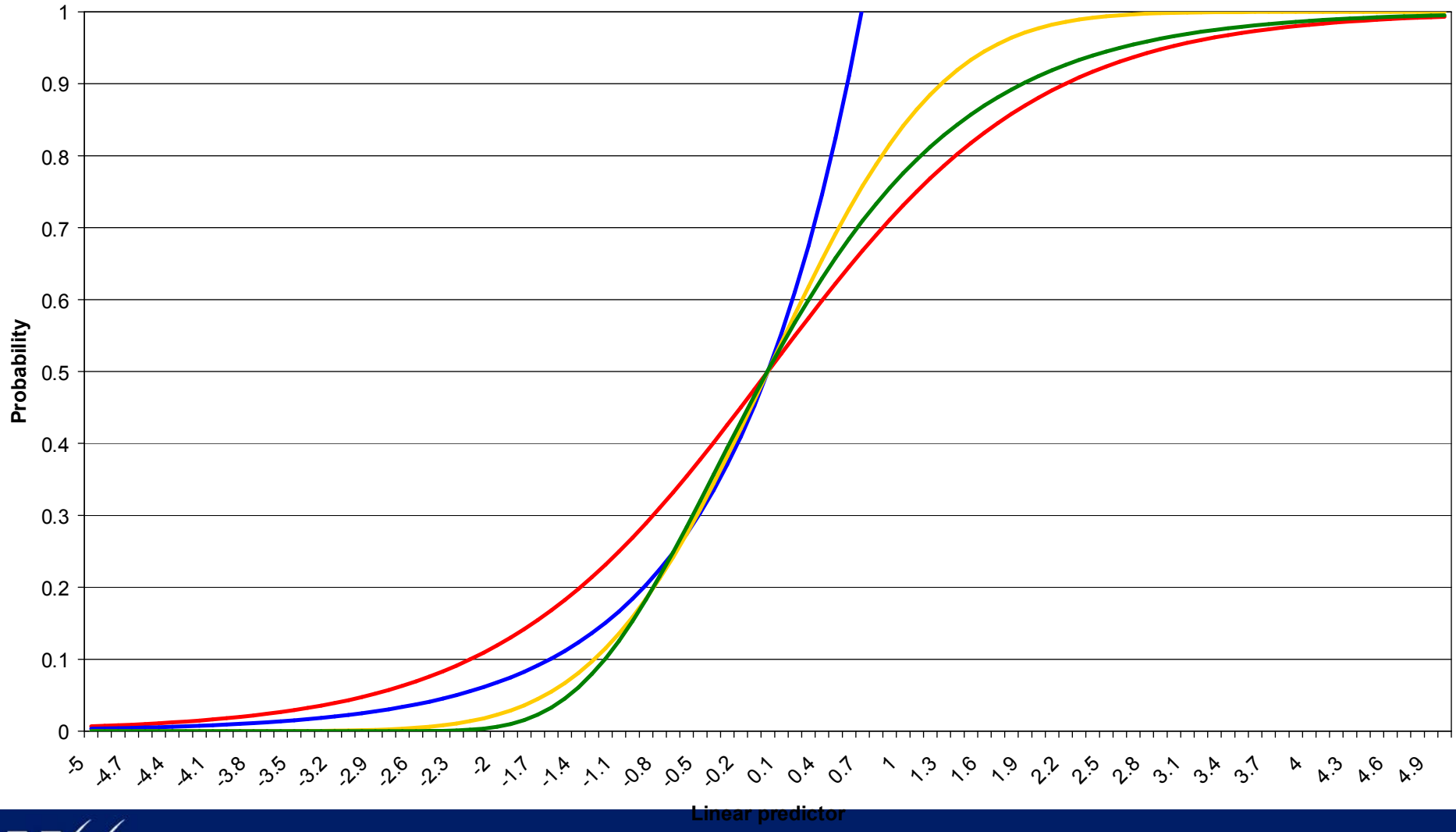
Source of models



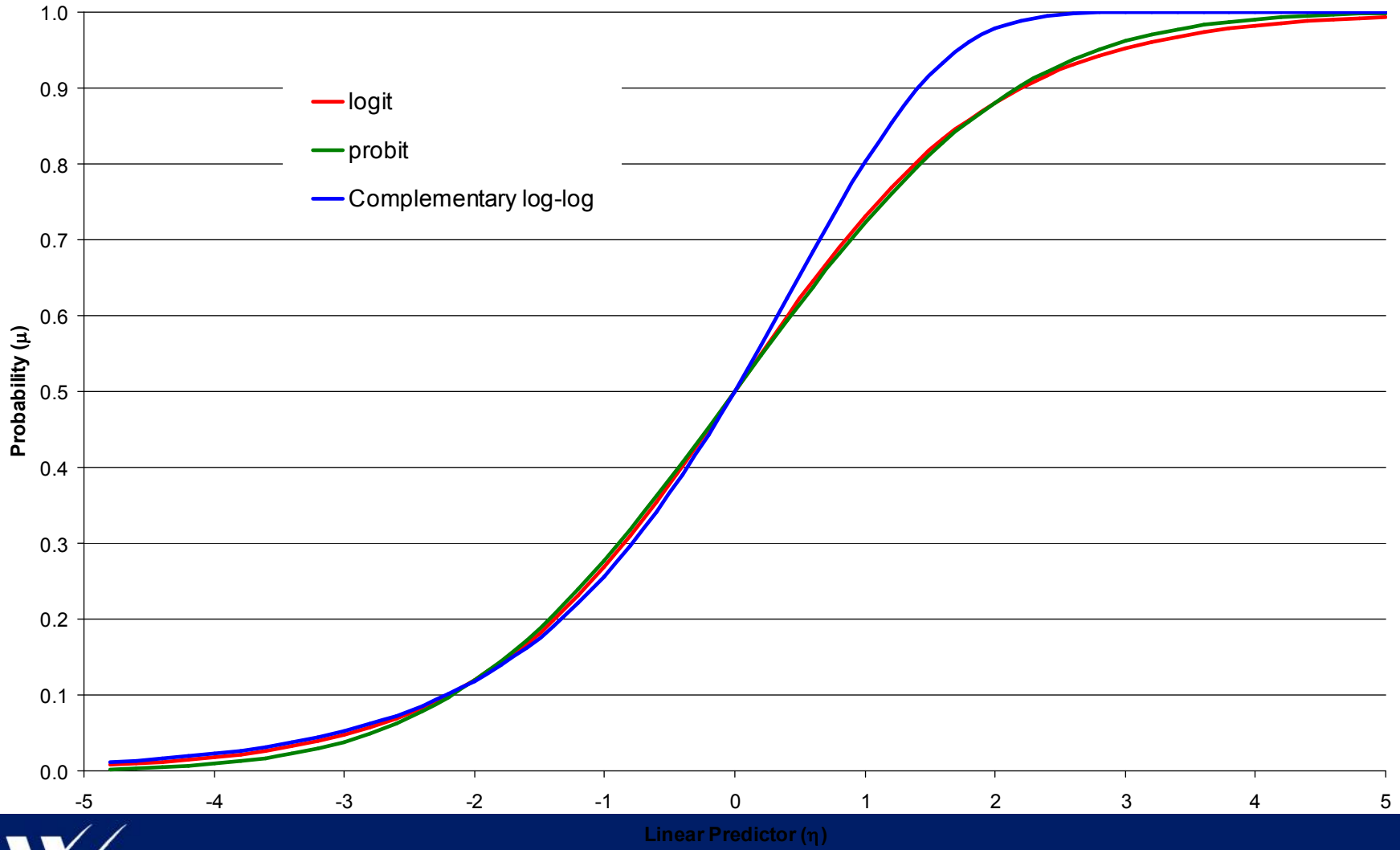
GLM choices

- Could try:
  - log link
  - probit link
  - complementary log-log link

Link functions
Rescaled so 0 => 0.5



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



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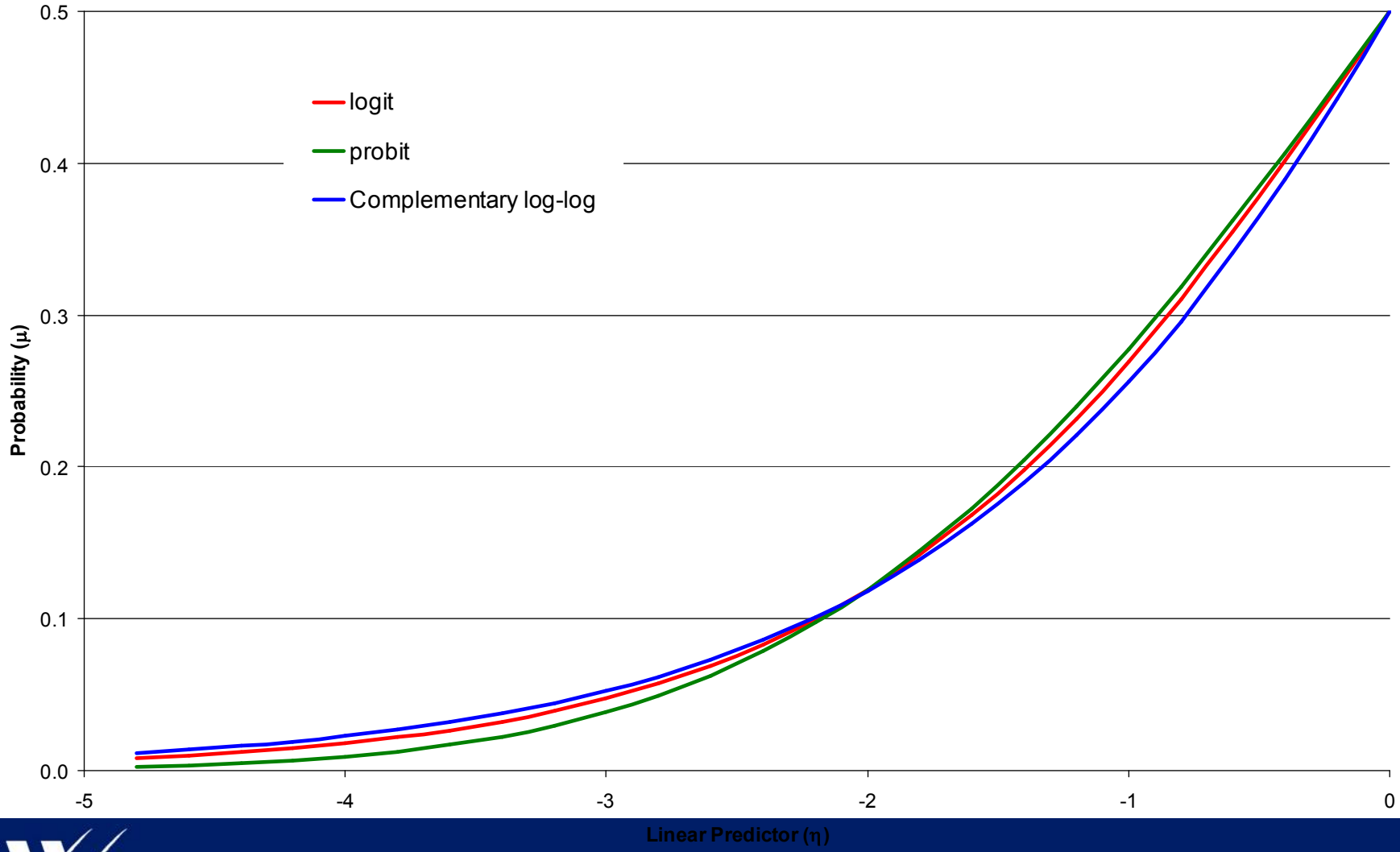
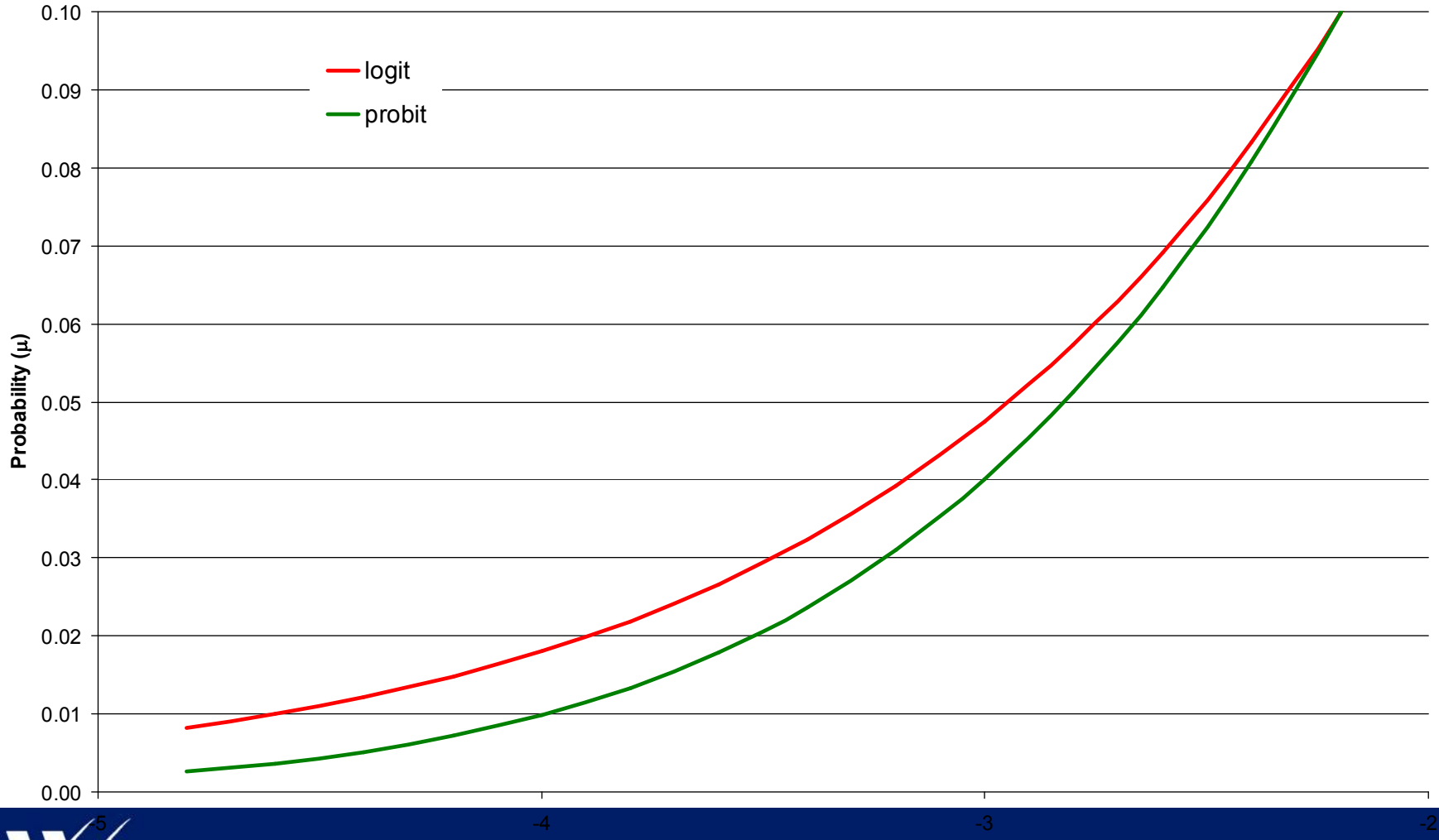


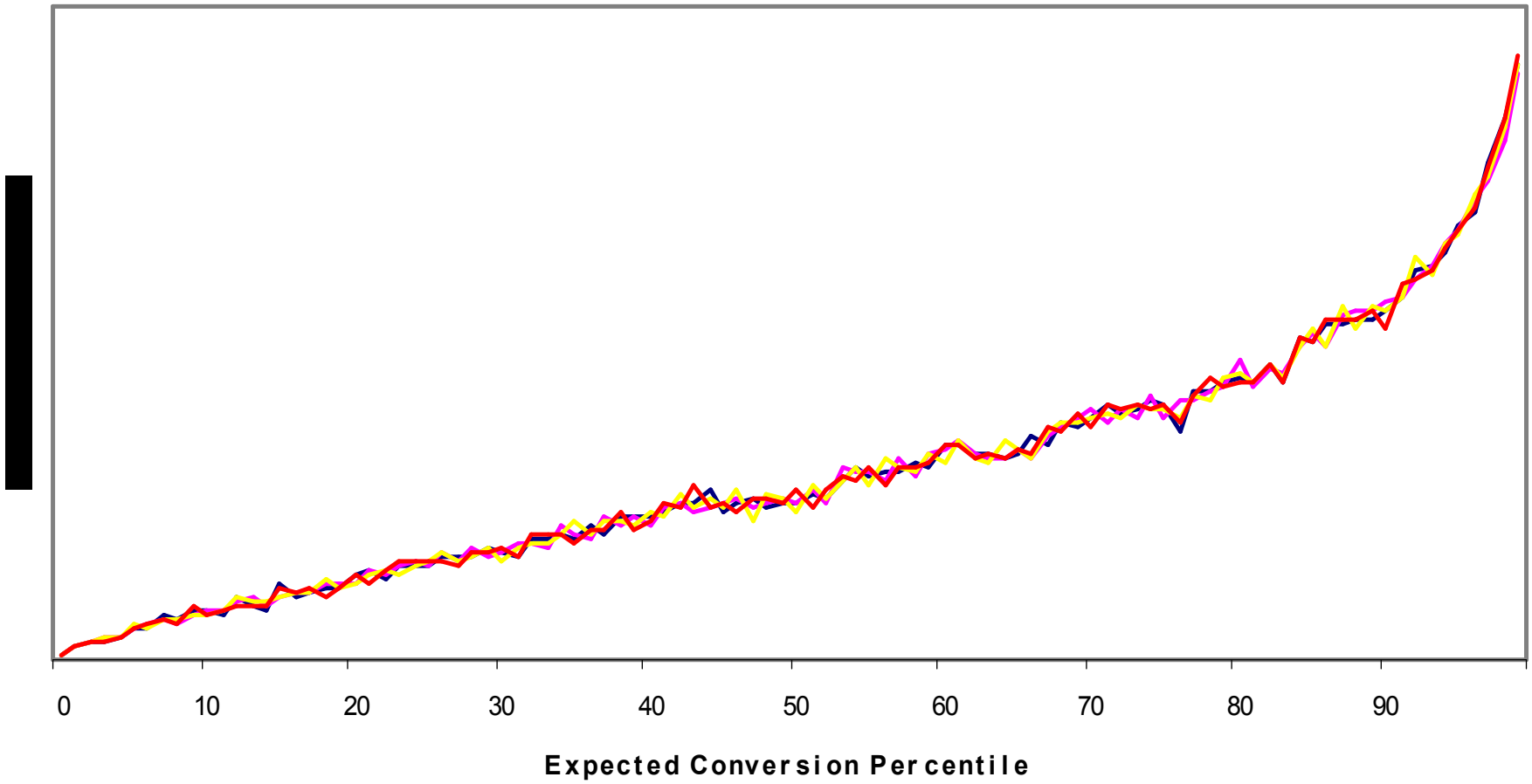
Link functions
Rescaled to be the same at p=0.1



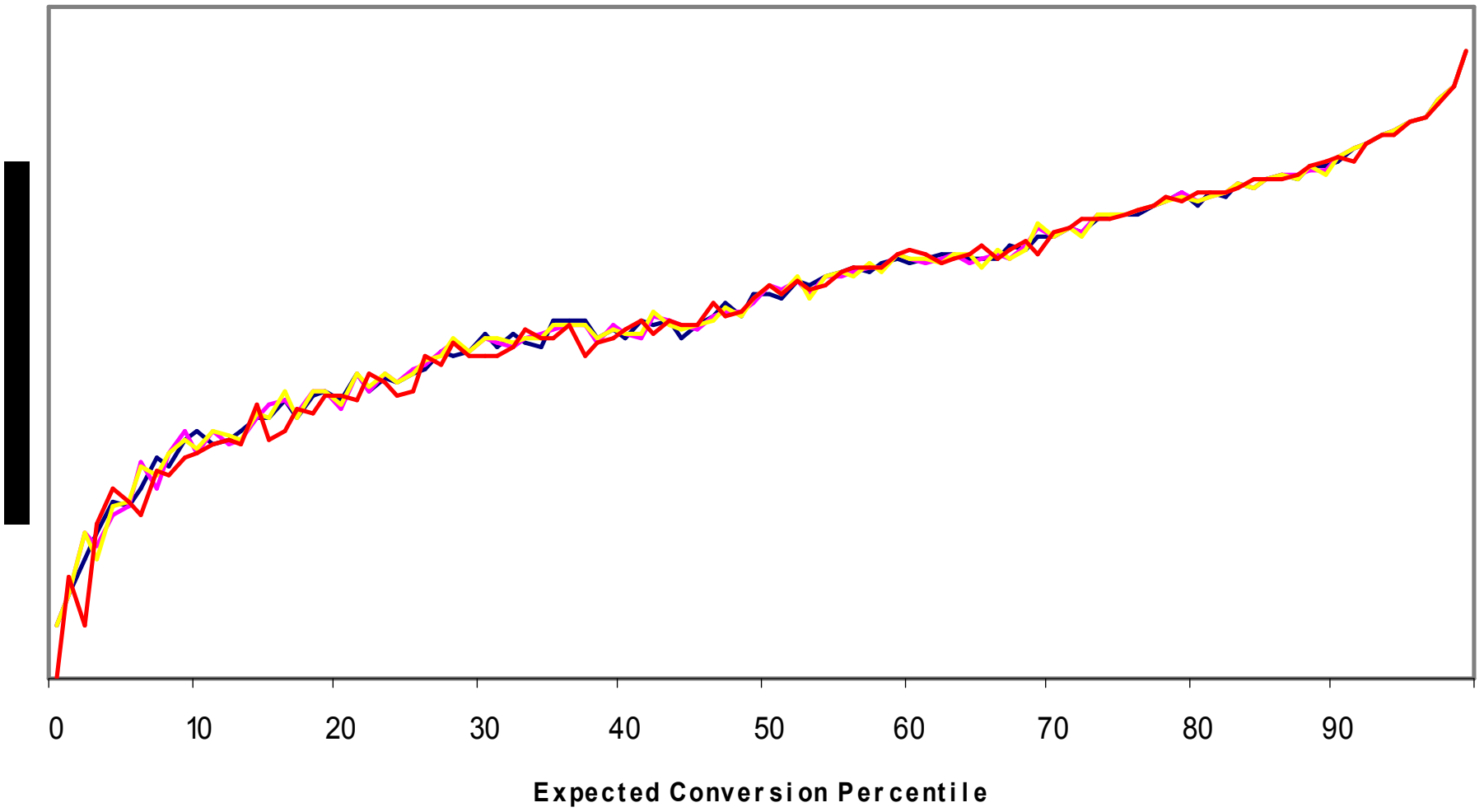
Data analysis

- 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



Lift Curve - Low Conversion Data Set



Note: Y-axis on log scale

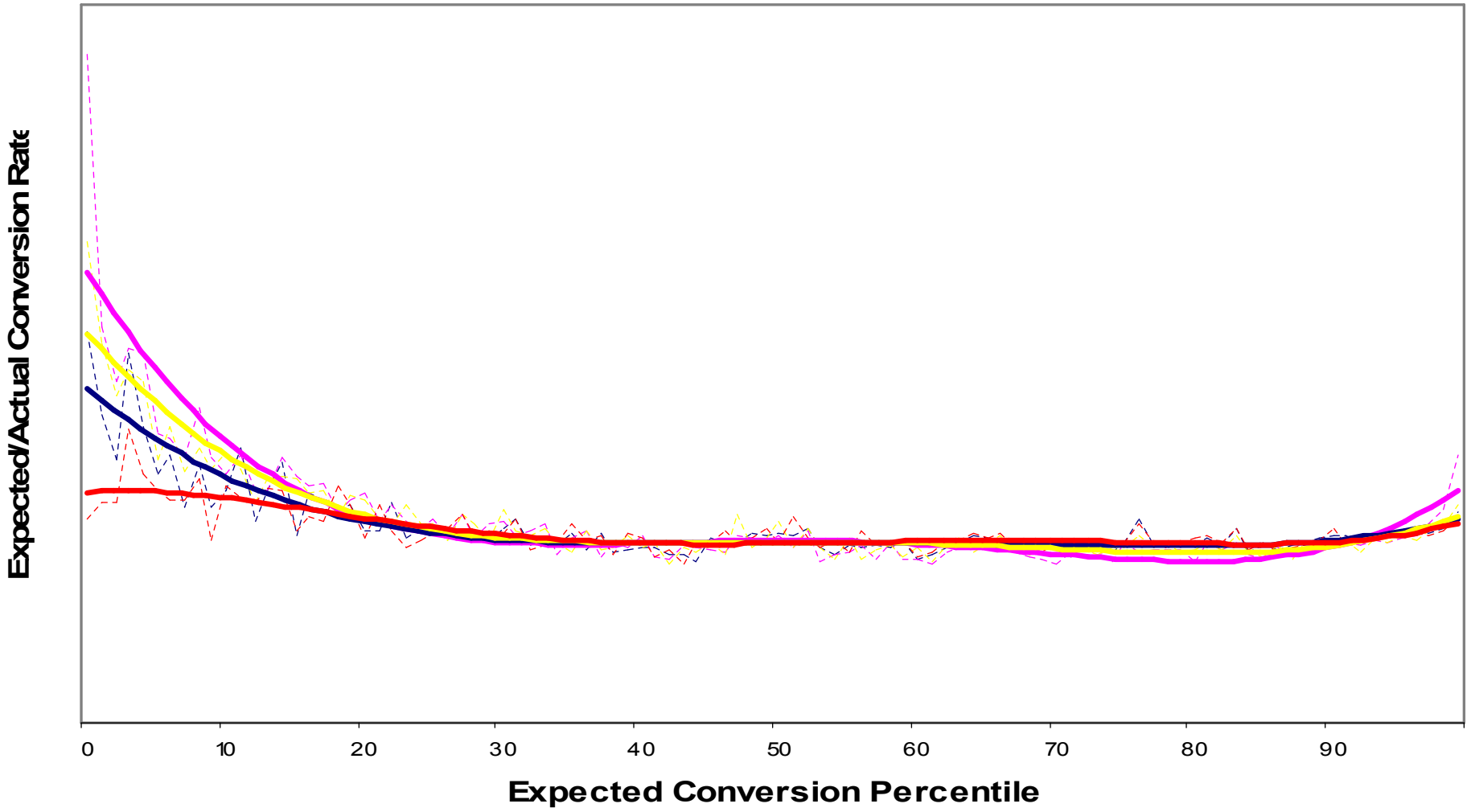
Lift curves: Conclusions

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

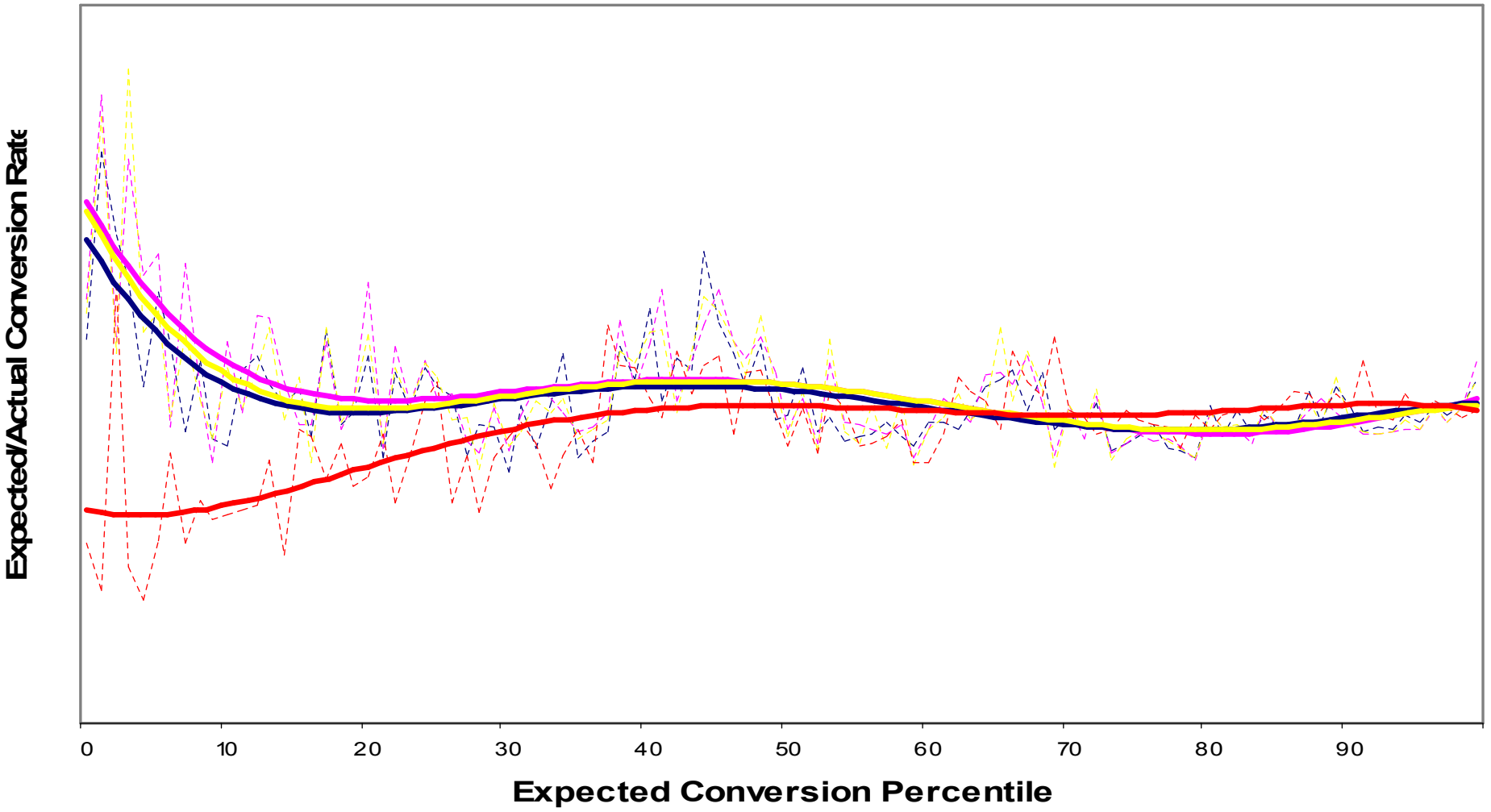
Actual versus Expected: Definition

- Take out of sample data and add fitted values
- Sort data according to expected value
- Create 100 pots of equal exposure
- Calculate Expected / Actual in each pot and plot on graph
- Key points:
  - A flat line is equally good (or bad) everywhere
  - Systematic over or under estimation revealed by departure from y=1 line (not shown)

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

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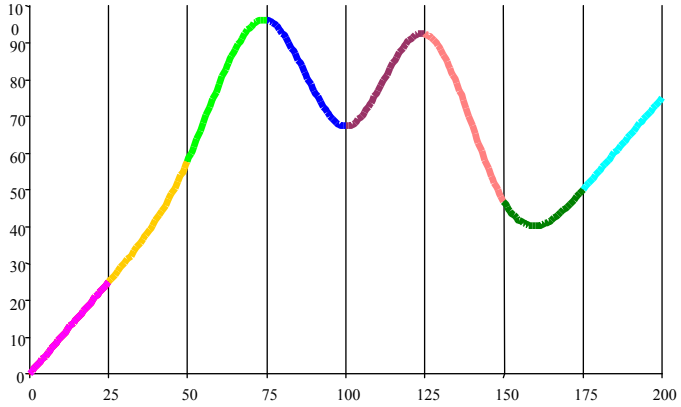
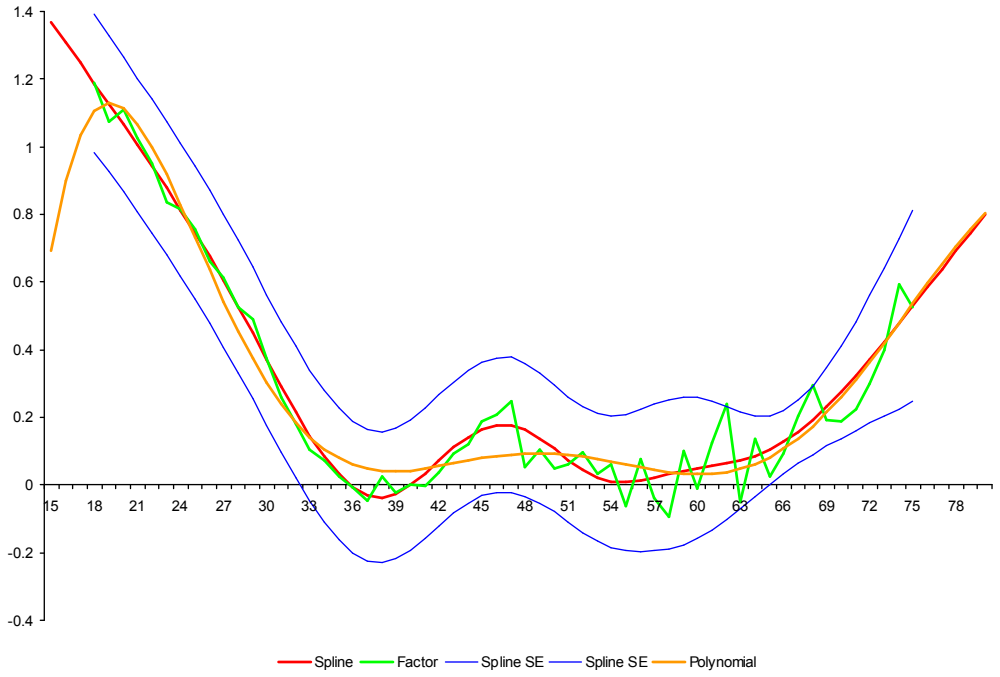
Explanatory variables

- Treat as standard analysis
- Price change best treated continuously
- Care is needed not to over fit

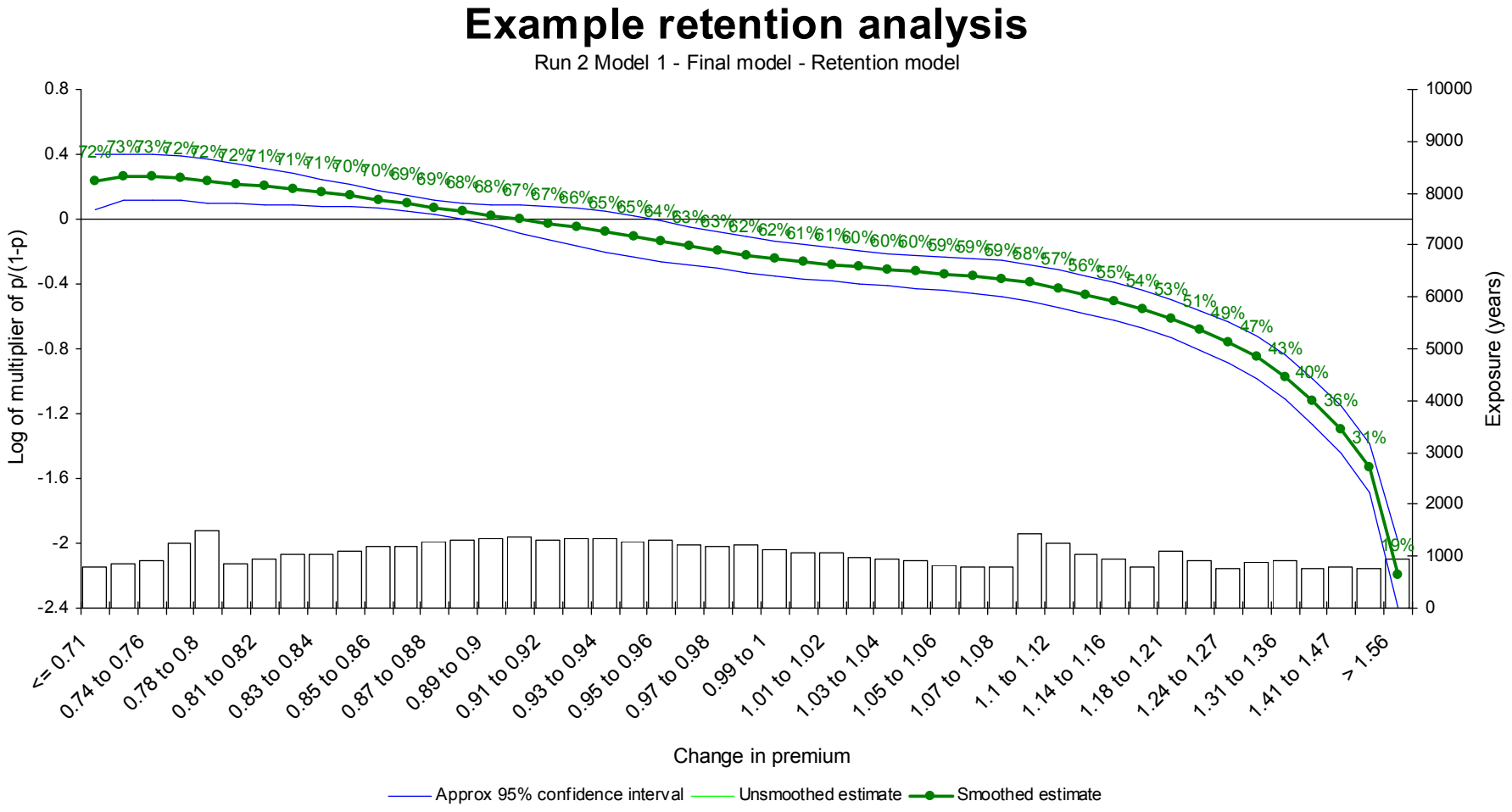
Spline definition

- Regression splines important when modelling elasticity in optimisation context

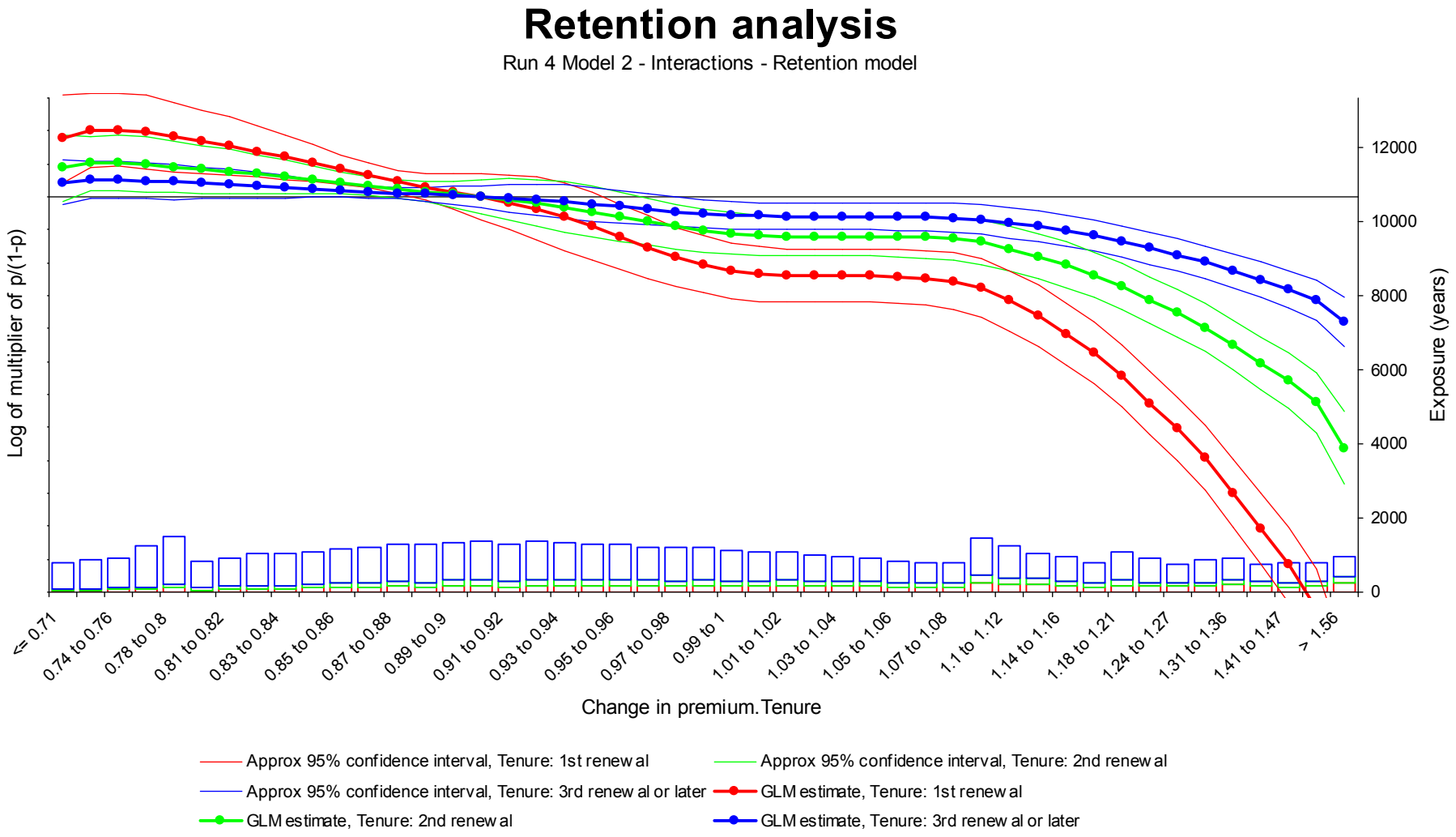




Example retention elasticity curve



Example retention elasticity curve



Negative elasticity

- Interaction curves may not be monotonic
- Negative elasticity can be local or global
- May be:
  - Noise: Reduce number of knots or smooth
  - Genuine effect: Look for consistency and understand segment
- Don’t throw the baby out with the bath water

Missing values

- Missing values in a variate cause entire record to be ignored
  - Replace missing values with zeros
- Care is needed to differentiate "real" zeros and "missing" zeros
  - Create a missing flag and include in all models involving variate
  - Remember spline basis functions transform zero to some other (non-zero) value (extrapolation)

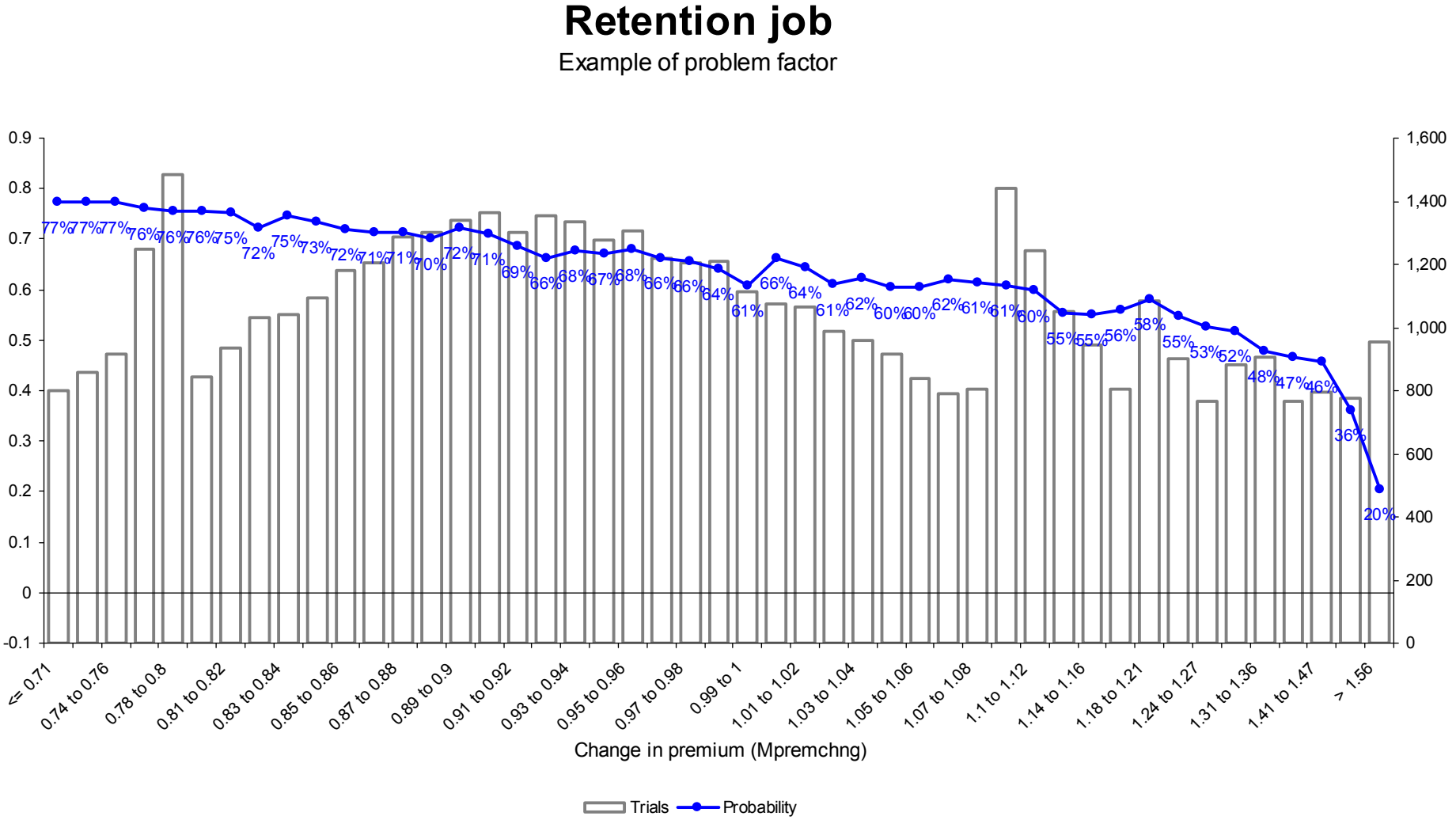
Edge effects

- One or two records with extreme variate values can have a disproportionate effect on the model
  - Look at leverage or Cook's distance
  - Understand your data
  - Consider limiting range of variate
  - Be careful when extrapolating

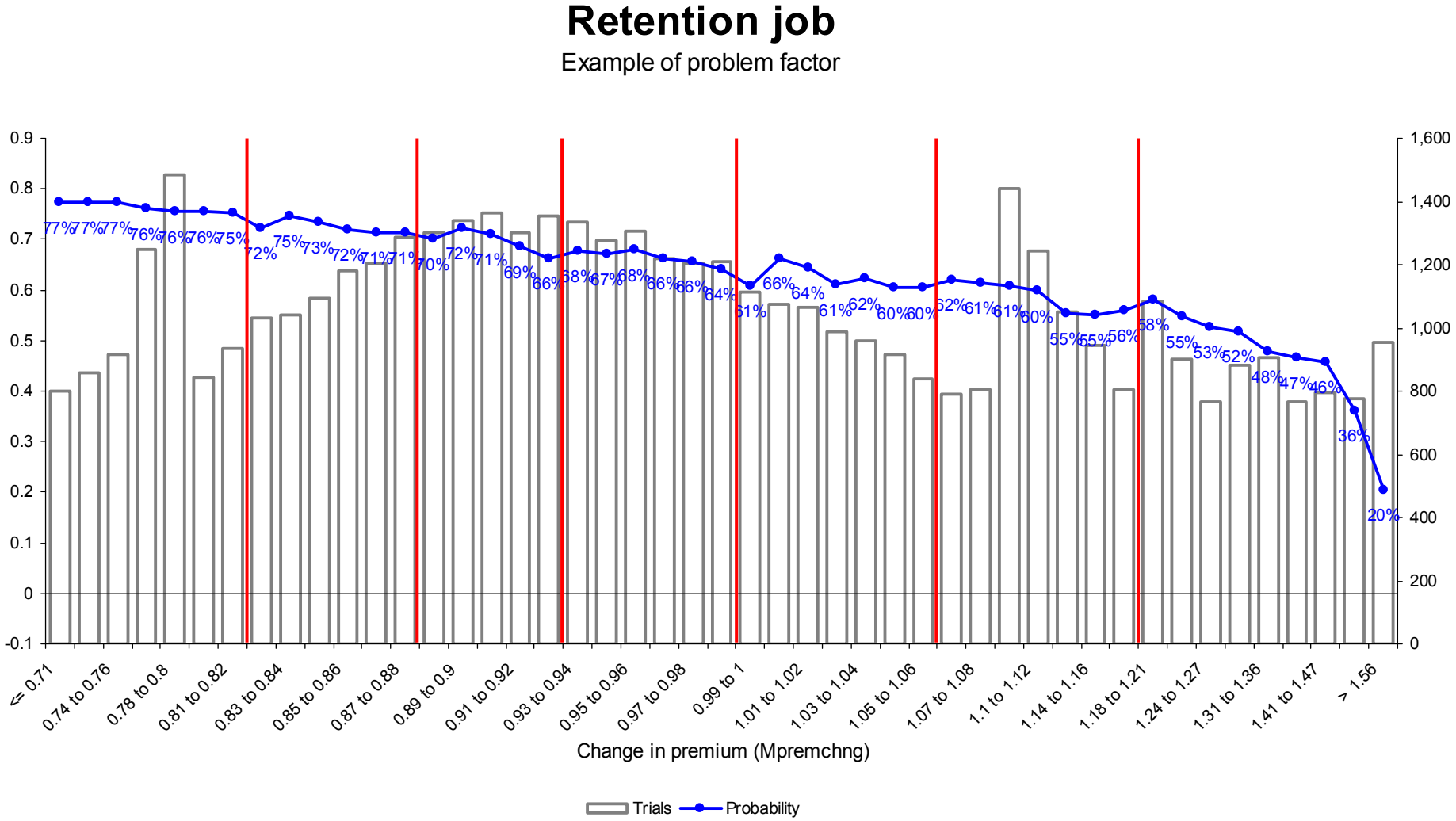
Cautionary example

- Artificial data, loosely based on actual naive analysis
- Retention analysis containing three records with incorrect premium change, all of which renewed
- Problems:
  - Overfitting to edges
  - Knot placement

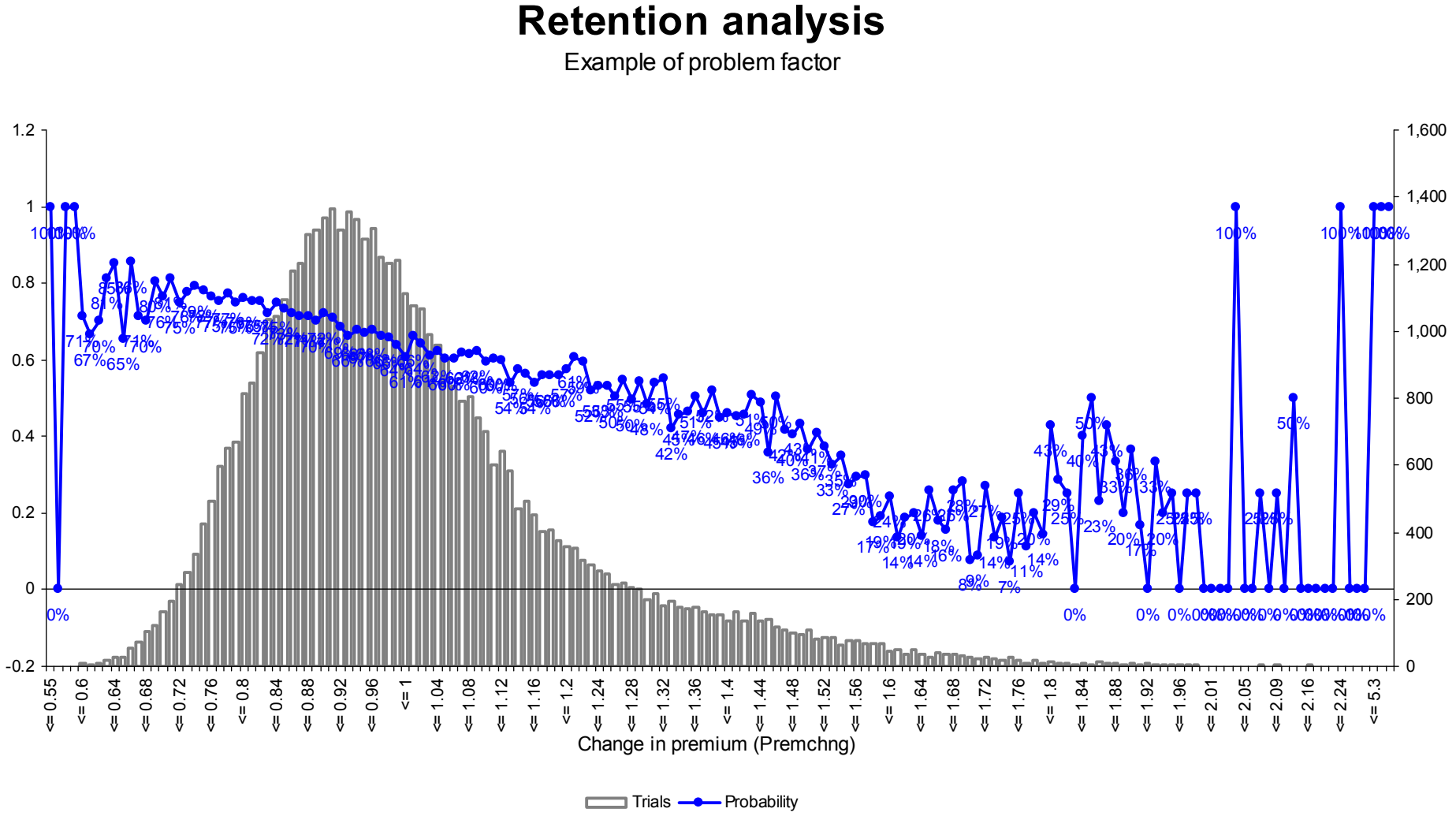
Simple grouped oneway



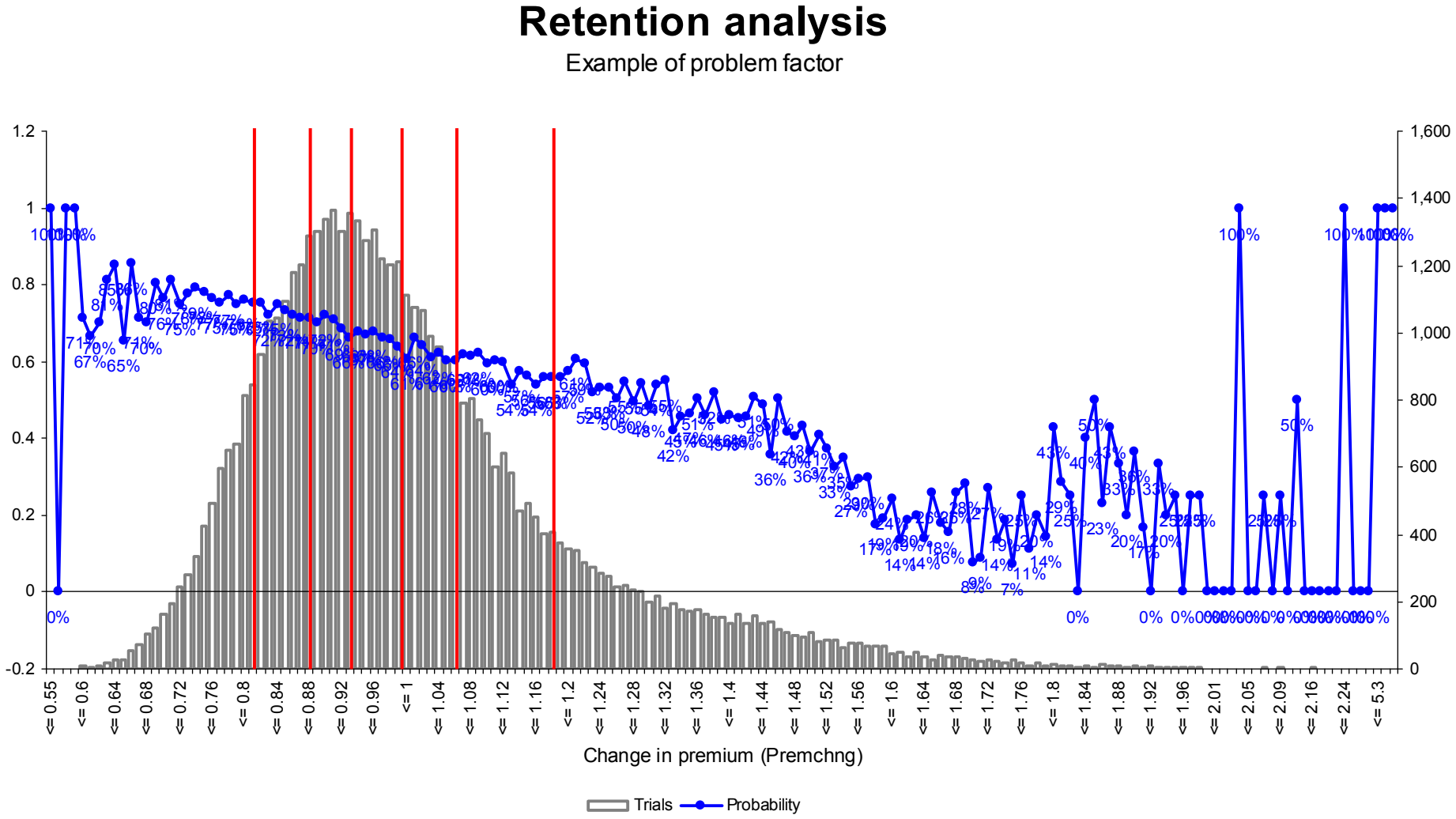
Simple grouped oneway



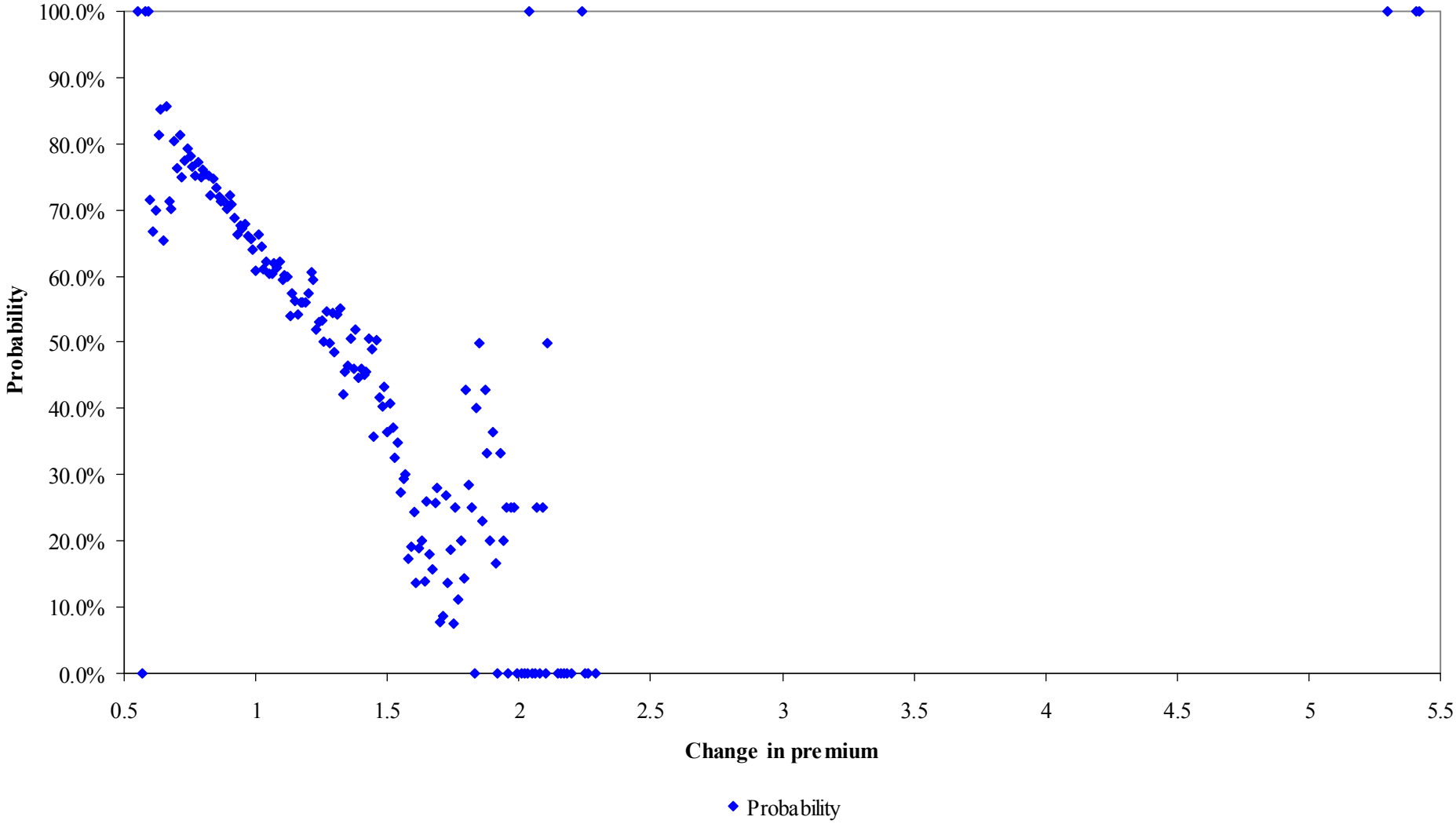
Detailed oneway



Detailed oneway



X-Y plot



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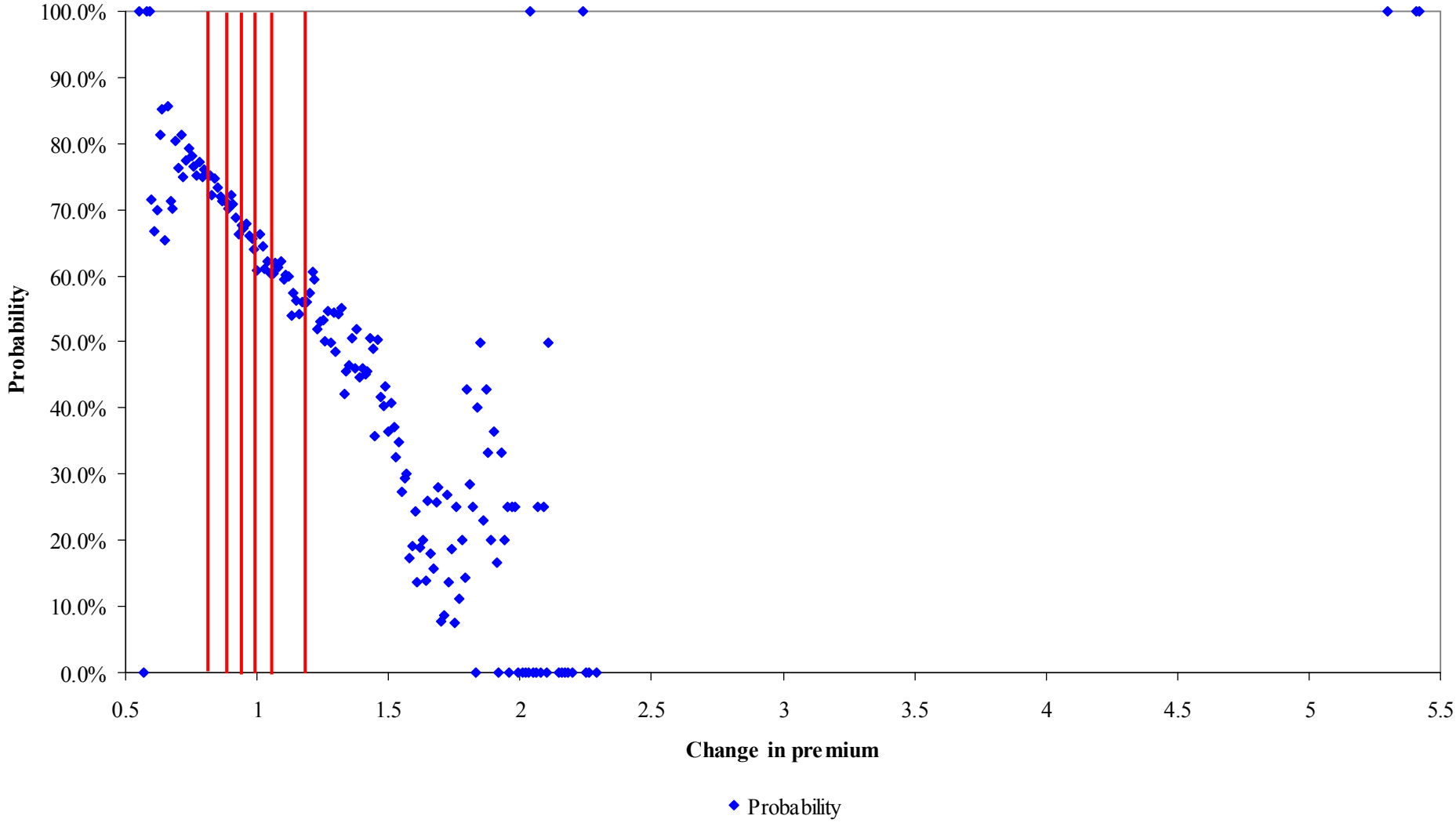
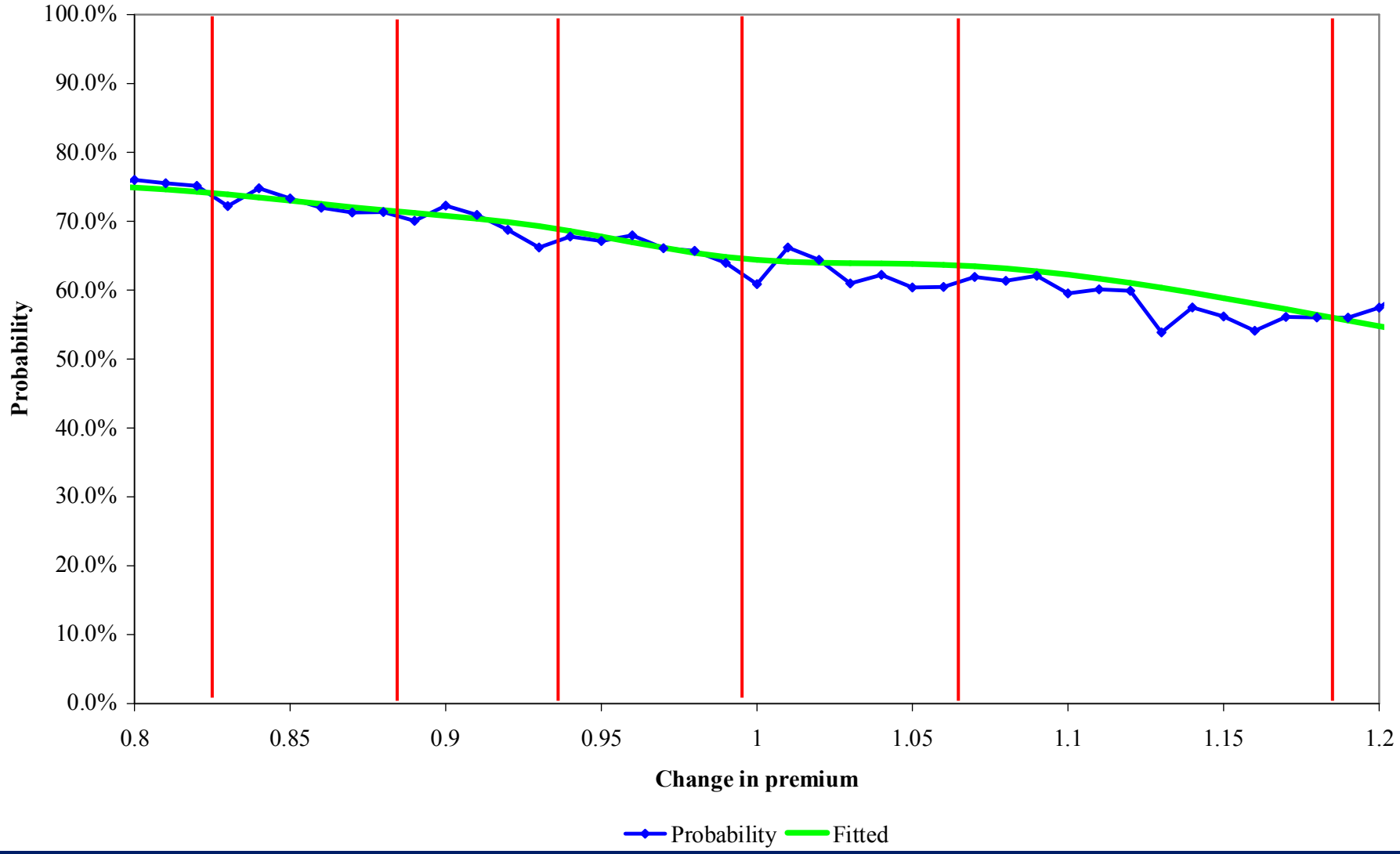


Model results



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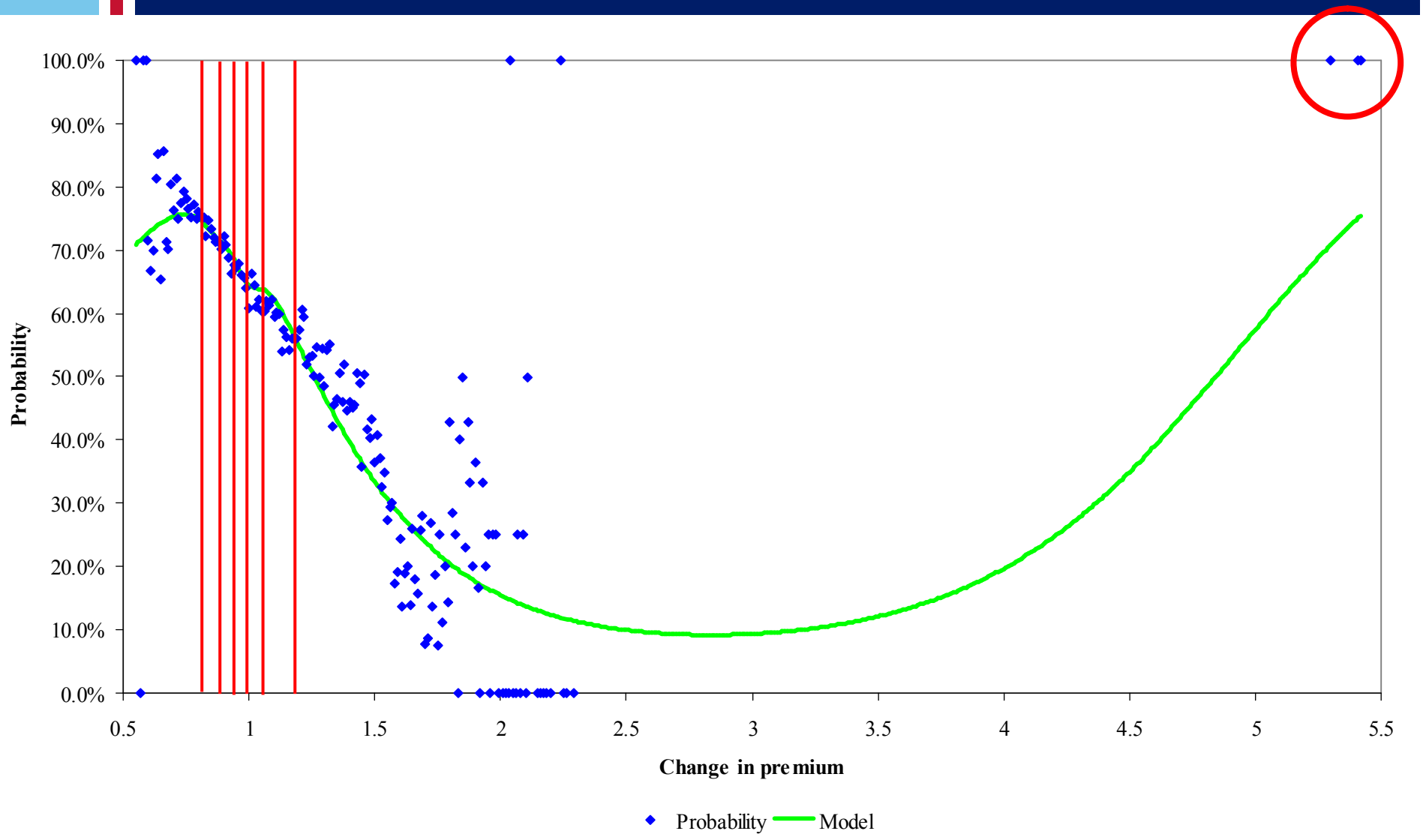

Solutions

- Cap and collar price changes in data
- Understand your data and results
  - Thought needed
- Take care in extrapolation

Questions?

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