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EXAMINING LOSS TRENDS USING STATISTICAL MODELING: A BEGINNER'S PERSPECTIVE

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EXAMINING LOSS TRENDS USING STATISTICAL MODELING: A BEGINNER'S PERSPECTIVE

Discussion Outline

1. Introduction

2. Modeling
   - Approach
   - Model Fit
   - Data

3. Examples
   - Profitability Analysis
   - Loss Reserving

Introduction

How Did I Get Here???

Introduction

- A Word on Statistical Packages
  - JMP/SAS
  - R
  - Others?

Modeling

- **Approach**
  - **Start with first principles**
  - **Linear Models vs. Generalized Linear Models**

Modeling – How Well Does the Model Fit?

- $R^2 = 1 - \frac{\text{Sum of Squares (errors)}}{\text{Sum of Squares (total)}}$

- Measures amount of variability explained by the model relative to the total variability
- Useful for aggregated data, not so much when looking at granular data

Modeling – How Well Does the Model Fit?

- **Bayesian Information Criterion (BIC) =**
  k * ln(n) – 2 * ln(L)

  where:
  L = maximum of likelihood function of the model
  k = number of parameters including intercept
  n = number of observations

Modeling – How Well Does the Model Fit?

- **Akaike Information Criterion (AIC) =**
  $2 * k - 2 * \ln(L)$

  where:
  L = maximum of likelihood function of the model
  k = number of parameters including intercept

Modeling – How Well Does the Model Fit?

- BIC and AIC do not tell you if model is a good fit in the absolute but do tell you tradeoff between fit and complexity
- Both penalize for using too many parameters
- Want lowest value out of a set of models

Modeling – How Well Does the Model Fit?

- **Deviance =**
  $-2 * [\ \ln(p(y|\widehat{\theta}_o)) - \ln(p(y|\widehat{\theta}_s))\ ]$

  ↑ Tested Model ↑ Perfect Model

  - **Want lowest value here as well**

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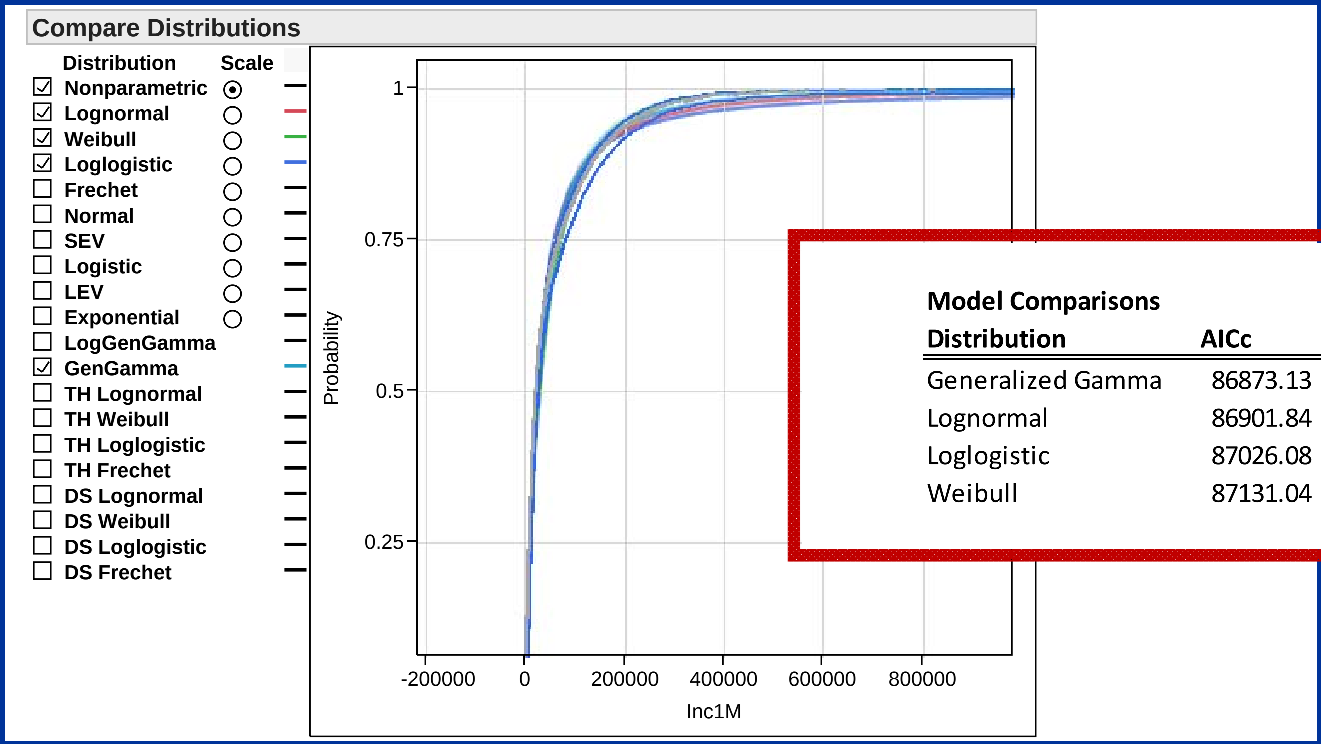
- Example: Reported Indemnity Severity Limited to $1M



Model Comparisons

Distribution	AICc	-2Loglikelihood	BIC
Generalized Gamma	86873.13	86867.122	86891.76
Lognormal	86901.84	86897.834	86914.26
Loglogistic	87026.08	87022.075	87038.5
Weibull	87131.04	87127.039	87143.46

Modeling – Data Considerations

- Exclude $0 claims
- Consider whether to cap losses
- Granularity likely provides too much detail, e.g.
  - Age at time of accident
  - Injured body part
  - Nature of injury

Modeling – Data Considerations

- **Example: Workers Compensation Injured Body Part**

Original categories	Grouped category
Head: Brain Head: Skull Head: Multiple Injuries	Head: Brain/Skull
Head: Eyes Head: Ears Head: Nose Head: Mouth Head: Teeth Head: Soft Tissue	Head: Other

Modeling – Data Considerations

- **Example: Workers Compensation Nature of Injury**

Silicosis Cancer Respiratory Disorder	Occupational Disease
Asphyxiation Rupture Hernia	Other
Sprain	Strain/Sprain

Examples – Profitability Analysis

- The Scenario:
  - Fairly new commercial lines writer experiencing rapid growth
  - Company trying to determine "true" profitability of commercial auto trucking exposure

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Examples – Profitability Analysis

- The Challenge:
  - Limited data

↓

- The Response:
  - Management information to help strategic decisions about the book

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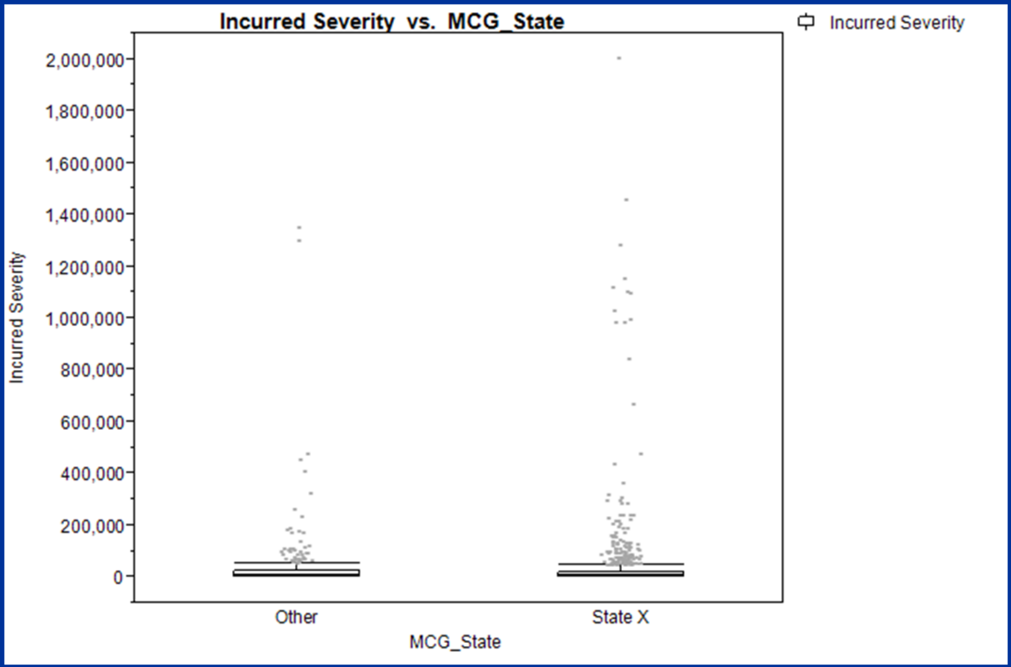
Examples – Profitability Analysis

- Ability to link policy and claims run data
- Define model to predict loss ratio based on individual characteristics → none were good fits
- Examine impact of characteristics to provide at least high level information on the book

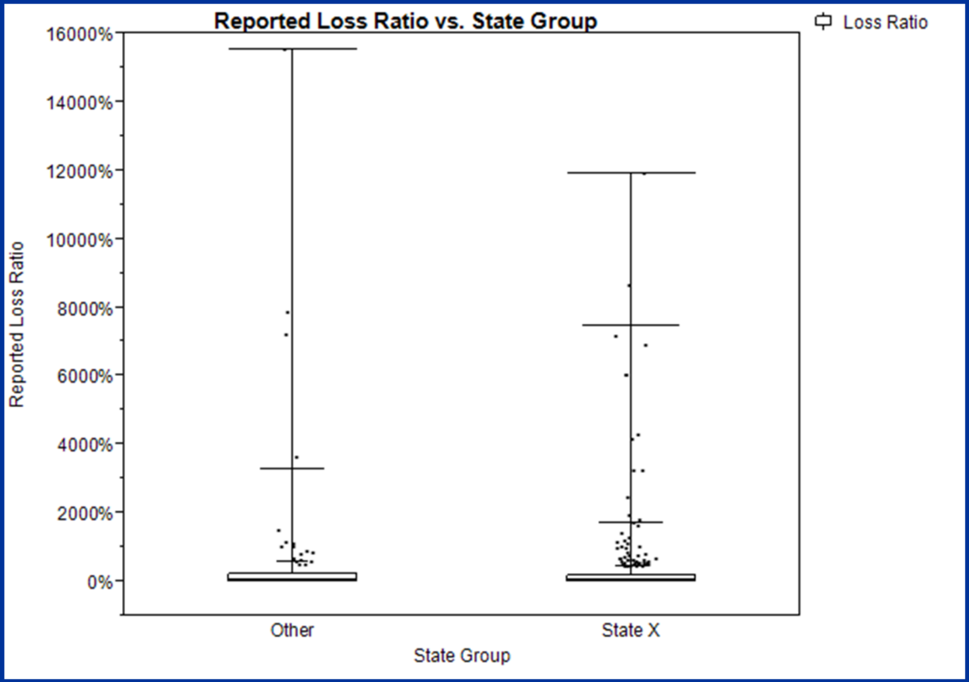
Examples – Profitability Analysis

- **Average severity relative to state grouping**



Examples – Profitability Analysis

- Reported loss ratio relative to state grouping



Although State X severities are more variable, pricing appears to be better (if still not so good).

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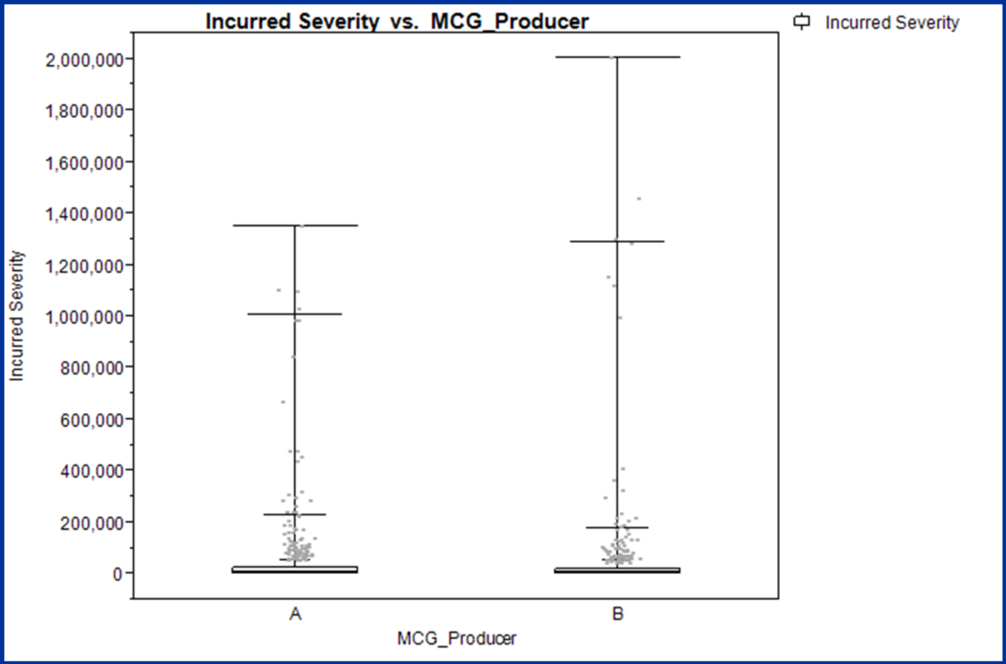
Examples – Profitability Analysis

- Average severity relative to producer grouping



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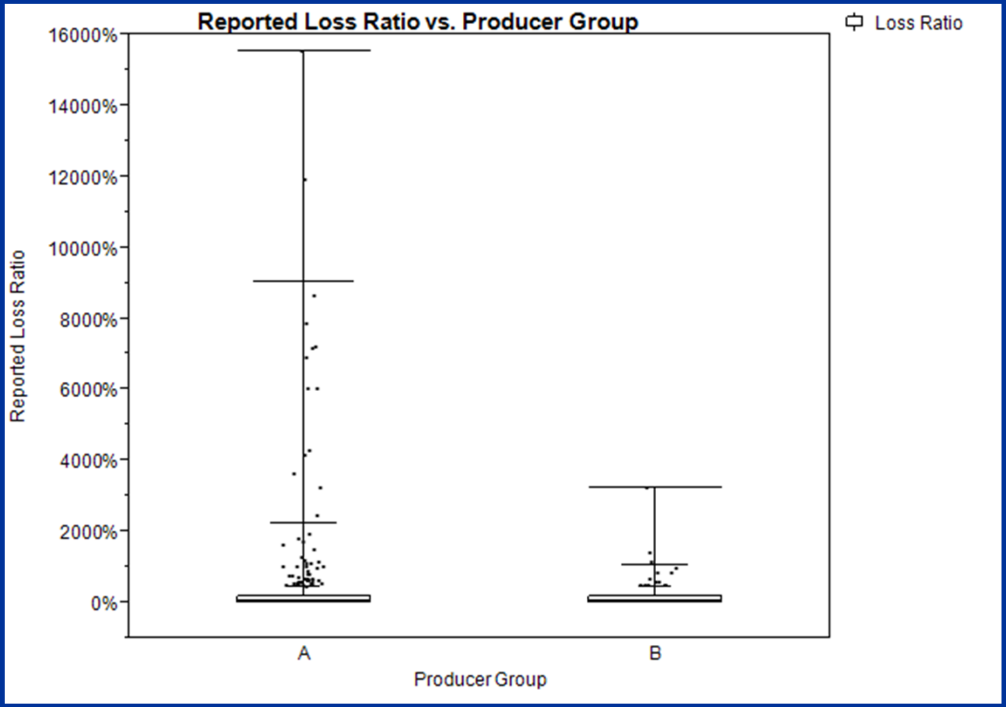
Examples – Profitability Analysis

- Reported loss ratio relative to producer grouping



Producer B group (smaller producers) have much more stable results.

Examples – Profitability Analysis

- **Observations:**
  - **Poor model fits may be due to not having appropriate / enough claims characteristics**
  - **High level information on state and producer groupings could be compiled without use of statistical packages, but software provides efficiencies and a means for communicating the results.**

Examples – Loss Reserving

- The Scenario:
  - Workers compensation writer, recently expanding in new states
  - Historically very strong case reserving
  - Numerous operational changes in last few years → changing case reserve adequacy and settlement rates?

Examples – Loss Reserving

- The Challenge:
  - Divergent methodology results
  - Berquist-Sherman applications relatively high

↓

- The Response:
  - A "new" perspective on Frequency/Severity

Examples – Loss Reserving

- Based on individual claims runs, define a model to predict claim severity based on the historical claims characteristics
- Indemnity only, non-$0 claims

Industry

Age at Injury

Gender

Body Part

Accident Year

Nature of Injury

State

Injury Code

Examples – Loss Reserving

- **Final Model: GLM Gamma with log link function**

log(Expected Severity) = $\boldsymbol{\alpha} + (\boldsymbol{\beta}_1$ *** Acc. Year)** $+ \boldsymbol{\beta}_2 + \boldsymbol{\beta}_3 + \boldsymbol{\beta}_4 + \boldsymbol{\beta}_5 + \boldsymbol{\beta}_6 + \boldsymbol{\beta}_7$

where:

α **= intercept**

β **= parameters for each claims characteristic**

Accident Year, Injury Code, Nature of Injury, Body Part, Age, Gender, Industry

Examples – Loss Reserving

Sample Output from R

Coefficients:

	Estimate	Std. Error	t value	Pr(> |t|)
Intercept	-76.916310	15.667280	-4.909	9.46E-07
AY	0.044366	0.007802	5.687	1.38E-08
InjCdPP	-0.495832	0.323430	-1.533	0.125337
InjCdPTD	2.165105	1.131679	1.913	0.055789
InjCdTT	-0.909945	0.303503	-2.998	0.002731
NatureBurn	-0.854137	0.410225	-2.082	0.037389
NatureFracture	-0.939986	0.302350	-3.109	0.001889
⋮	⋮	⋮	⋮	⋮
NatureStrain/Sprain	-1.531418	0.301480	-5.080	3.94E-07
PartHead_Brain/Skull	1.997440	0.267083	7.479	8.99E-14
⋮	⋮	⋮	⋮	⋮
PartMultiple	1.189996	0.121157	9.822	< 2E-16
AgeMid2	0.137531	0.052541	2.618	0.008885
AgeOld	-0.465194	0.229164	-2.030	0.042420
AgeYoung	-0.458560	0.073918	-6.204	6.02E-10

Examples – Loss Reserving

- **Observations:**
  - **Multiple models tested**
  - **State was not considered significant**
  - **Gender and Industry were added in subsequently to improve results**
  - **Method = sum of predicted severities for known claims + IBNR provision using average predicted severity**
  - **Method result validated Berquist-Sherman results**

Discussion / Questions

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Thank You!

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