GLM I:

An Introduction to Generalized Linear Models

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Overview of Presentation

- ØPreparing the Data for Analysis
- ØPreliminary Analysis of the Data
- ØSampling the Data
- ØRunning a GLM

Preparing the Data for Analysis

How Much Data is Needed?

- In summary … as much as possible
  - Ø Large datasets can always be sampled or made smaller
  - Ø If more data is needed, consider pulling more years
    - Assumes additional years are readily available
    - Assumes older years contain valid information in data fields
- Preferred threshold is a minimum of 5,000 claims
  - Ø Depends on current level of sophistication & volatility of data
    - Analysis Y began with 120,000 records & 4,000 claims
    - Still produced meaningful results on a volatile line of business

Placing Data in Proper Platform

- Format of the Data being Retrieved / Received
  - Ø Text (.txt) or Flat (.dat) Files
    - Fixed length – each record is a pre-defined length
    - Delimited (tab, comma, etc.) – each variable is separated by a common character
  - Ø Other Database Files: Excel, Access, SQL, etc.
- Statistical Software / Platform
  - Ø SAS is widely used & easy to understand
  - Ø Others include S, S+, and R

Understanding the Data

- Initial Data Check
  - Ø Ask for control totals & documentation of variables
- How was the Data Compiled?
  - Ø Raw data dump vs. Combination of multiple files
- Secondary Data Check
  - Ø Match totals in your dataset to control totals
  - Ø Did you receive a complete dataset?
  - Ø Frequency distributions of key fields
    - Years, States, Companies, etc.

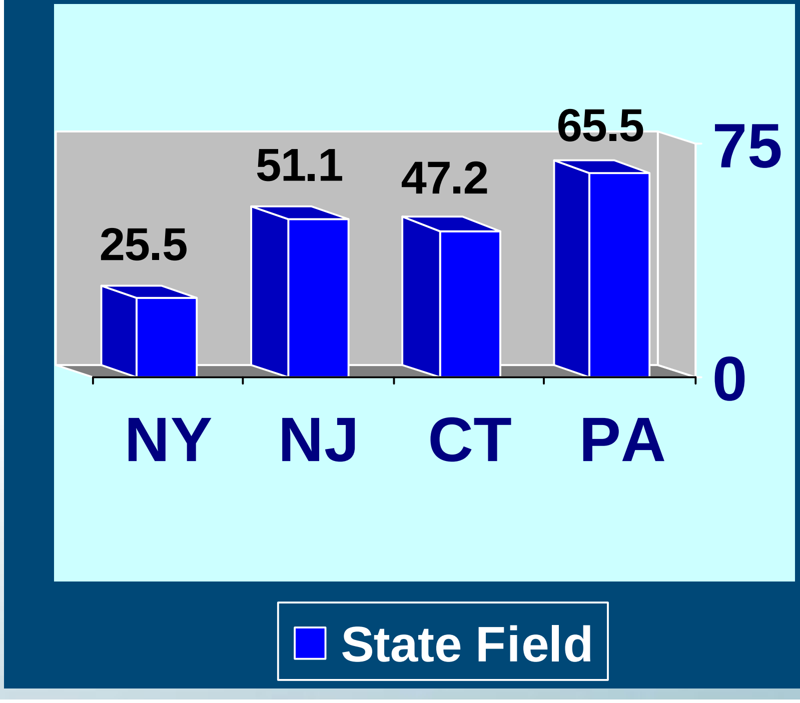
Understanding the Data (cont.)

- Review Data Fields Provided
  - Ø Did you receive all the needed fields?
  - Ø Expected values within each field
  - Ø Completeness of data within each field
    - Are any data fields missing for 100% of records?
  - Ø Unique Identifiers
  - Ø Linking Variables
  - Ø Defined Variables vs. Derived Variables

Understanding the Data (cont.)

Distribution of State Field

WC Claims in Thousands



Distribution of Variable X

(Number of Records)

	Freq	%	Cum. Freq	Cum. %
1	14,251	8.2	14,251	8.2
2	11,251	6.5	25,502	14.7
3	11,549	6.6	37,051	21.3
4	55,642	32.0	92,693	53.3
5	44,654	25.7	137,347	78.9
6	22,111	12.7	159,458	92.6
AA	14,541	8.4	173,999	100.0

Missing = 25,000

Examples of Data Problems

- Problem 1: Duplicate Records
  - Ø Definition of Problem:
    - Multiple records for the same policy, usually with different information applying to each record
  - Ø How to Identify Problem:
    - First “dot”/Last “dot”
  - Ø Solution:
    - Nodupkey
    - Last “dot”

Examples of Data Problems (cont.)

- Problem 2: Missing Records (Incomplete Data)
  - Ø Definition of Problem:
    - Missing some or all of data expected
  - Ø How to Identify Problem:
    - Frequency distributions and control totals
  - Ø Solution:
    - Request data resubmission from data source

Examples of Data Problems (cont.)

- Problem 3: Fields with Missing Values
  - Ø Definition of Problem:
    - A field has missing values for all or most records
  - Ø How to Identify Problem:
    - Frequency distributions and/or univariate analysis
  - Ø Solution:
    - Confirm whether field is rarely used or if this indicates a larger data issue
    - May require resubmission from data source
    - Eliminate field from dataset as it will not be useful in the modeling process

Other Possible Data Problems

- Unexpected values reported for a field
- Error in data compilation (usually when combining multiple data sources)
- Extraneous data provided
  - Not a problem, just reminder to check for and eliminate unnecessary data as early in the process as possible.

Preliminary Analysis of the Data

Identification of Key Components

- Define Modeling Variable (i.e. Loss Ratio)
- Develop the list of “Contenders”
  - Ø What fields might you want to model?
- Compile Base Variables (Premium, Losses)

Univariate Analysis:

A Preliminary Step in Analyzing the Data

- Continues process of reducing the list of contenders
  - Ø File size is dependent on number of variables
  - Ø The sooner you can eliminate variables from the analysis, the more manageable your data becomes.
- Further checks fields and values for data issues
  - Ø i.e. low loss ratio might indicate incorrect compilation of losses and/or premiums
- Identifies potential groupings within variables

Sample Univariate Analysis

Flag 1	# of Policies	Premium (Millions)	Losses (Millions)	Avg. Prem	Prem Rel.	Loss Ratio	LR Rel.
Y	355,585	$210	$99	$591	0.92	0.471	1.17
N	55,546	$55	$8	$990	1.54	0.145	0.36

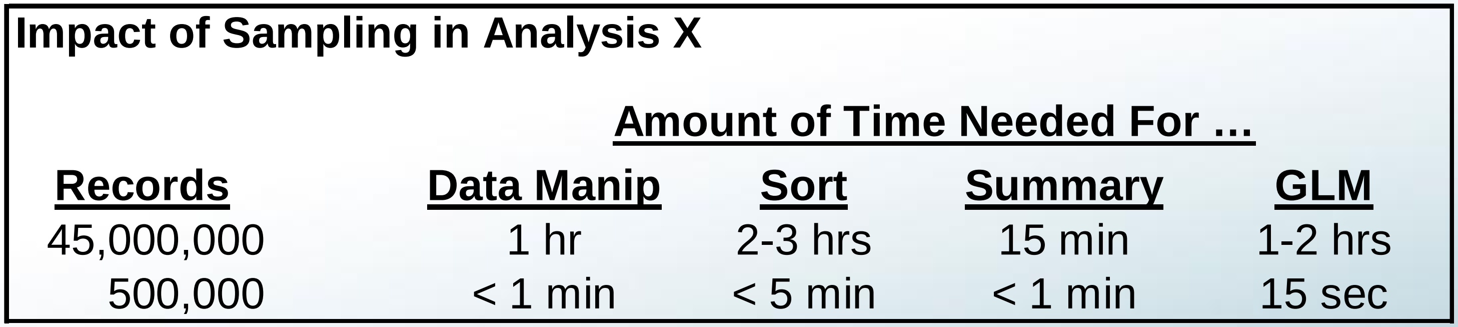
What we observe:

- Since Flag 1 = “N”, with a loss ratio relativity of 0.36, differs significantly from Flag 1 = “Y” and from an average relativity of 1.00, this field would be considered as a potential contender in the model

Sampling the Data

Reasons to Sample the Data

1. Reduce the size of the overall database
   - Large databases are preferred for predictive modeling, but it is possible to be too big
   - Improves efficiency of programs and productivity of analyst



Impact of Sampling in Analysis X

	Amount of Time Needed For ...			
Records	**Data Manip**	**Sort**	**Summary**	**GLM**
45,000,000	1 hr	2-3 hrs	15 min	1-2 hrs
500,000	< 1 min	< 5 min	< 1 min	15 sec

2. Validate the model being built
   - Otherwise, modeling process simply explains history and may not be the best predictor of the future

Sampling Methods in Predictive Modeling

- Random Sampling
  - Ø Assign a random number to each record and divide these random numbers into groups
  - Ø Each record has an equal probability of being selected
  - Ø Goal is to represent the population
- Systematic Sampling
  - Ø Selecting a subset of the data using specified criteria
    - Every 10th record
    - Policy numbers ending in “X”
  - Ø Easy to implement & efficient, but assumes database is already random

Sampling Methods (cont.)

- Sampling for Purposes of Validation
  1. Sampling
     - Sample created & set aside (20-40% of total data)
     - Model built on remaining data (variables selected & preliminary parameter estimates)
     - Validate that model works on sample or use sample to choose between several alternative models
     - Finalize model using all data (final parameter estimates)

Sampling Methods (cont.)

- Sampling for Purposes of Validation (cont.)

  2. Resampling
     - Used for smaller databases
     - Similar to Sampling, but repeated N times using N different samples
     - Variables are selected that are most robust and remain predictive across all (or most) of the N iterations
     - After N iterations of modeling, finalize model using all data
  3. Partitioning
     - Alternative method for smaller databases
     - Similar to Resampling, but data divided into N partitions
     - 1st partition set aside, model built & validated against 1st partition
     - Process repeated for other N-1 partitions
     - Finalize model using all data

Running a GLM

Data Needed for a GLM

In summary … as much detail as possible

- Ø Level of detail depends on the goal of the analysis
- Ø One record per policy, per year
  - Useful for Pricing, Ratemaking, or Underwriting analyses
- Ø One record per claim, possibly per evaluation period
  - Useful for Claim-related analyses
- Ø One record per agent, per year
  - Useful for Sales-related analyses
- Ø Each record should contain data related to the dependent variable being modeled & as many independent variables as possible

What Can be Modeled With a GLM?

Anything that we try to predict or estimate:

- Ø Pure Premiums
- Ø Loss Ratios
  - Can be complex due to historical changes in class plan
- Ø Claim Frequencies
- Ø Claim Severities
  - Unlimited or capped
- Ø Retention Ratios / Termination Ratios
- Ø Close Ratios
- Ø Claim Settlement Patterns
- Ø Relativities of any of the above

Inputs & Outputs of a GLM

Inputs:

- Ø Database at the appropriate level of detail
  - Data/Records have been “cleaned up”, filtered, tested, & sampled

Outputs:

- Ø Listing of values for each variable being modeled
  - Parameter estimate
  - 3-4 statistical measures to help identify confidence in each estimate
  - Note: Last value within each variable is usually the base class (i.e. factor = 1.00)

Selecting a Final Model

- Consider reduction in residual (error) vs. added complexity of an another variable
- Balance between predictive and explanatory
    - Ø Overall mean is predictive
    - Ø Individuality is explanatory

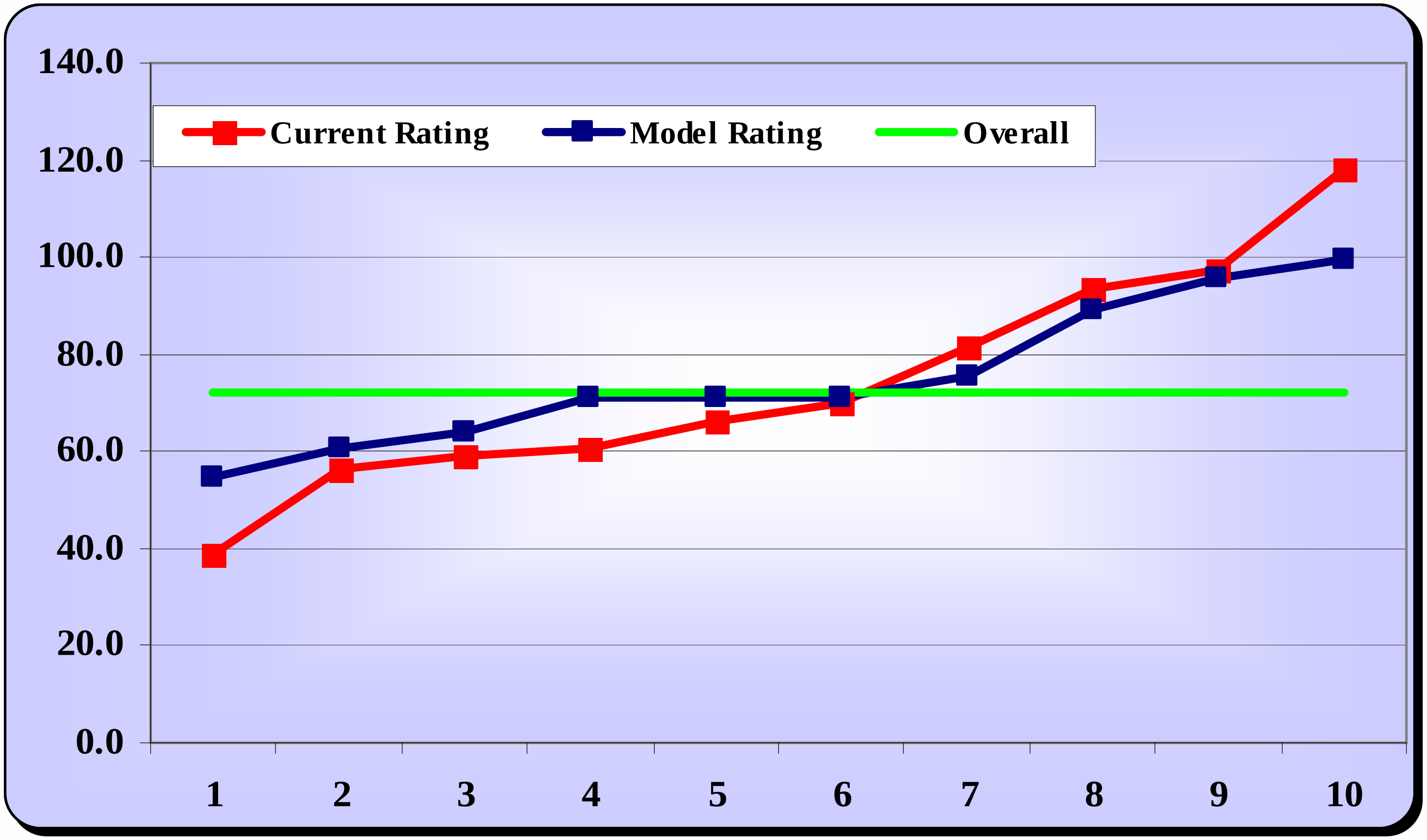
Sample table showing process of monitoring results:

	Run 1	Run 2	Run 3	Run 4	Run 5
Log Likelihood	-3,041	-3,025	-3,017	-3,010	-3,002
Degrees of Freedom	4	7	9	14	25
-2 x (Chng in Log Likelihood)		30	17	13	16
ChiSq = Pr(Improvement NOT Signif)		0.00%	0.02%	2.11%	15.08%

Validating the Results

- Goal of validation is to ensure that parameter estimates in selected model truly are good predictors

Sample loss ratio chart shows reduced subsidy by decile


Current Rating
Model Rating
Overall