AGENT BASED MODELING FOR PREDICTING PROPERTY AND CASUALTY UNDERWRITING CYCLES

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Sponsor: UCONN Goldenson Research for Actuarial Center

7/16/2014

Overview

- About this research

- Underwriting Cycle

- Agent Based Modeling

- Prototype Model for Workers Compensation

About this research

- Sponsored by UCONN Goldenson Center for Actuarial Research

- Presented at UCONN Student Research Conference 2014

- Positive feedback and interest from industry

What is Underwriting Cycle

- Hard market – Hard to buy, good business
  - Periods when premiums are increasing, profits are rising and loss ratios are decreasing
  - Competition diminishes, restrict coverage, tighten underwriting standards,
  - Buyers have difficulty finding coverage

- Soft market
  - Periods when premiums are decreasing, profits are decreasing and loss ratios are increasing
  - Competition is intense, expand coverage, relax underwriting standards

- Underwriting Cycle can be demonstrated by modeling the Combined Loss Ratio cycle
  - Rising prices ⇔ Decreasing combined loss ratios

Why underwriting cycle is important?

Soft Market

Hard Market

Workers Compensation Historical Combined Ratio
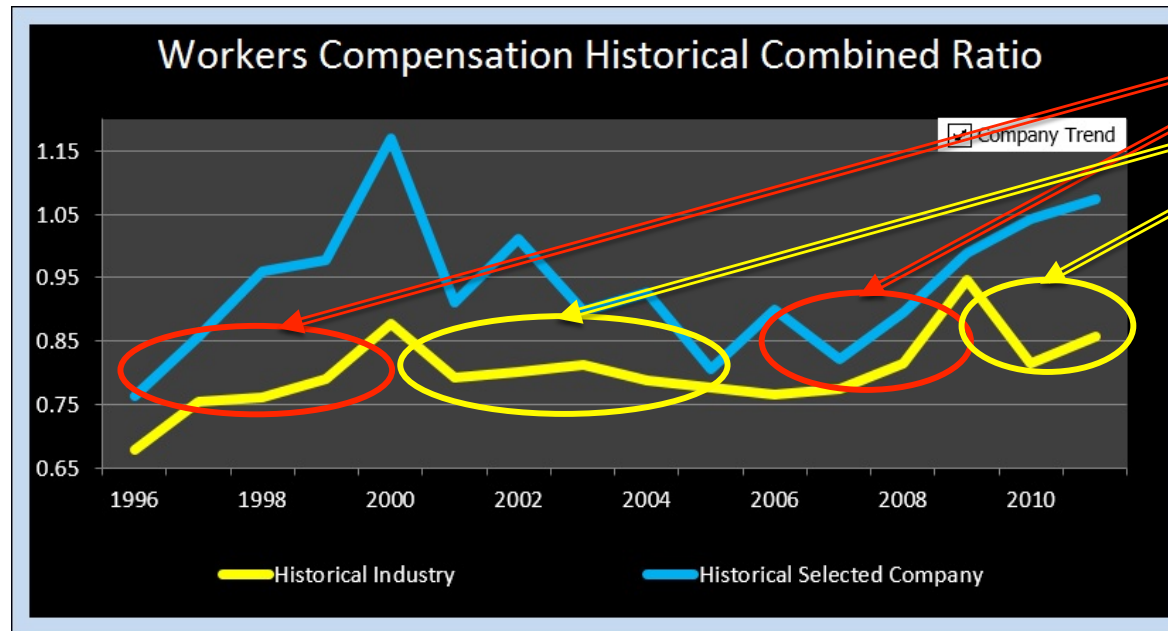
Company could make better pricing decisions in terms of timing and magnitude

Why there is a cycle?

- Theory of Supply and Demand

- Demand – inelastic
  1. Not much alternatives
  2. Regulation

- Supply
  1. Herd mentality
  2. Individual Companies Financial Status
  3. Company Risk Appetite

What is Agent Based Modeling?

- Bottom Up Approach
    - Agents or decision makers have to be defined
    - Logical agent decision rules have to be developed
    - Interactions between agents and external factors have to be modeled

- Dynamic

- Consistent with other forecasting approaches

Agent Based Modeling(ABM) vs Generalized Linear Model(GLM)

- Generalized Linear Model (GLM) uses quantitative and categorical predictive variables to estimate the combined ratio so that historical combined ratios are closely reproduced.
  - ➢ Y ~ X1, X2, .. X1 * X2, ..

- Agent Based Modeling (ABM) estimates industry and individual company combined ratios.
  - ➢ Uses individual company decision rules reflective of historical financial decisions.
  - ➢ Captures relationship between individual company decisions and industry patterns.
  - ➢ Richer and more realistic approach.
  - ➢ Decision rules can also be calibrated to repeat the past, but are flexible enough to model the future using different but logical decisions.

Agent Based Modeling(ABM) vs Generalized Linear Model(GLM)

Sensitivity Test

- GLM Sensitivity changes variables
  - ➢ Add or remove more variables
  - ➢ Add interactions

- ABM Sensitivity changes decision rules
  - ➢ Add new decision rules
 - ➢ Change parameters of current decision rules

Prototype Model for Workers Compensation

- High level Data Description

- Model Mechanics

- Selected Variable Description

- Agent Definition

- Outputs

High Level Data Description

- Data are extracted from SNL Database
  - SNL is a sector-focused financial information firm.
  - The firm covers data of more than 6,500 public companies and over 50,000 private companies including P&C insurance companies

- Top 200 P&C companies with largest workers compensation premiums selected for the ABM model

- 17 years of historical data extracted from SNL for each company

- 20 years of financial projections modeled for each company using an ABM approach
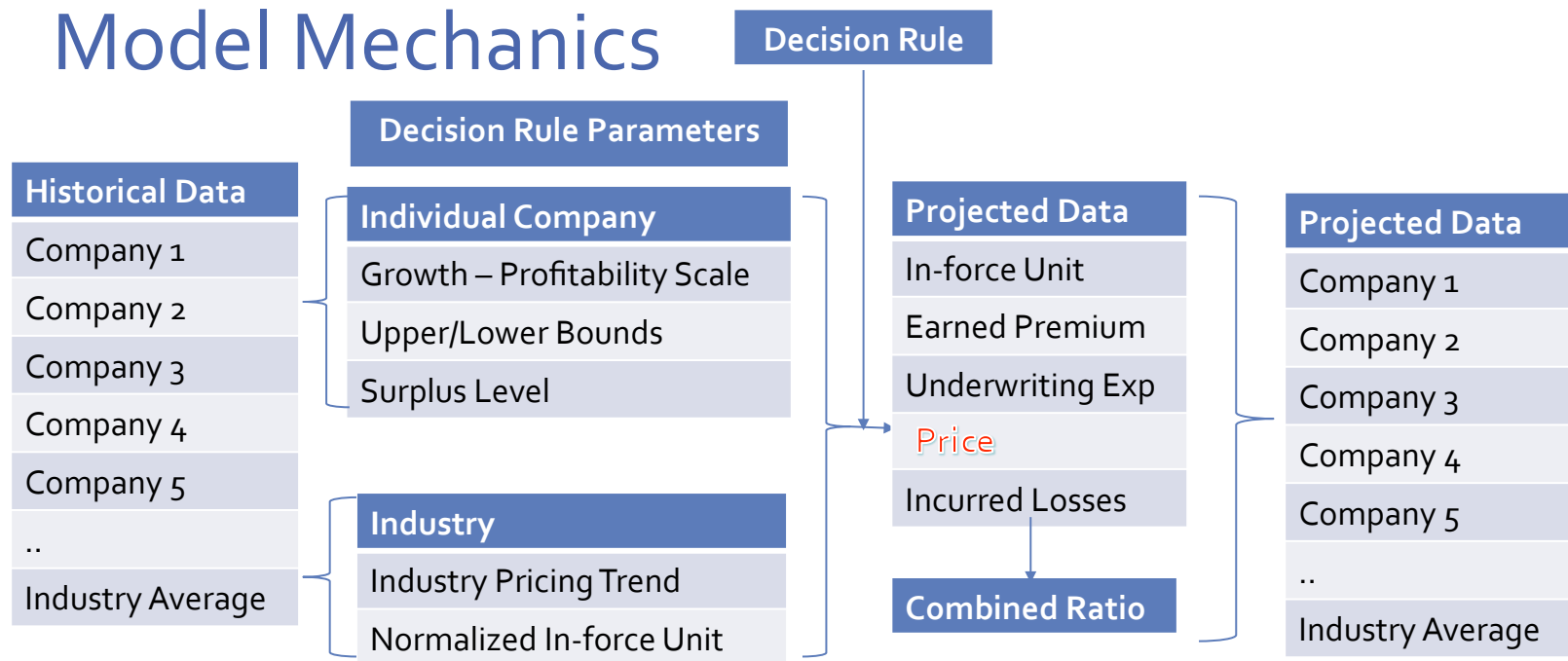
Selected Parameter Description

- Growth – Profitability Scale – Company's Risk Appetite

- Upper and Lower Bounds of Combined Ratio – Company's Risk Appetite

- In-force Unit – Market Share

- Price – Individual Companies Financial Status, Herd Mentality

Drivers of pricing decision
- ➤ **Company's Risk Appetite**
- ➤ **Herd Mentality**
- ➤ **Individual Company's Financial Status**

Selected Variable Description

- Growth – Profitability Scale

- 1 represents profit driven companies, 10 represents growth driven companies

- Scale assigned based on percentiles of 2012 combined ratios

- High Combined Ratio ⇔ High Growth-Profitability Scale

- Low Combined Ratio ⇔ Low Growth-Profitability Scale

Selected Variable Description
## -Upper and Lower Bounds of Combined Ratio

- Capped at 130% and 50% respectively

- Individual company's combined ratio bounds
  - Determined by historical mean and standard deviation of a company's combined ratio
  - Further modified by company's GPScale.

- The upper and lower bound formulas generate the highest (Upper Bound – Mean) interval for a GPScale of 10, and the highest (Mean – Lower Bound) for a GPScale of 1.

Selected Variable Description
-In-force Units

- Total industry in-force units set to 1,000,000.
  - Model distributes the initial in-force units to each company by 2012 written premium volume.

- Intermediate projected in-force units
  - Are negatively correlated with the projected price increase

- Final projected in-force units
  - Normalize the intermediate projected in-force units to equal the industry total of 1,000,000 units

- Price increase for an individual company could result in an increase in market share if it is relatively lower than the rest of industry

Selected Variable Description
-Pricing
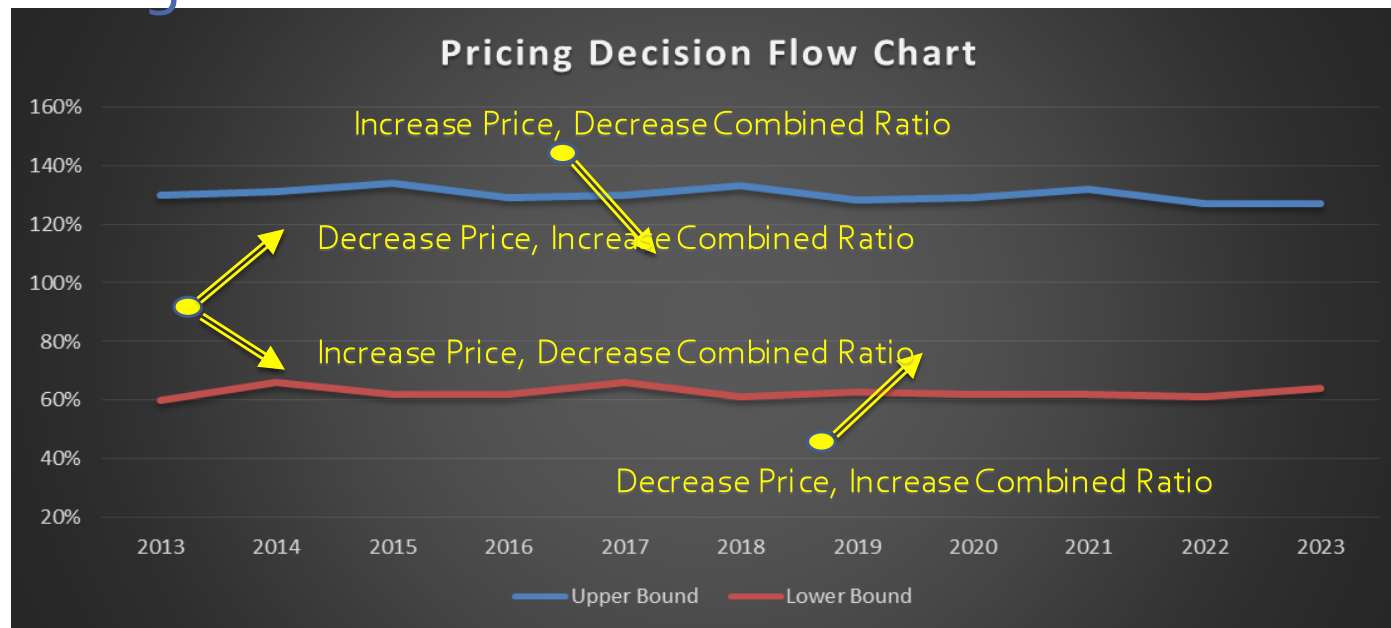
Agent Attributes

Avoid GIGO

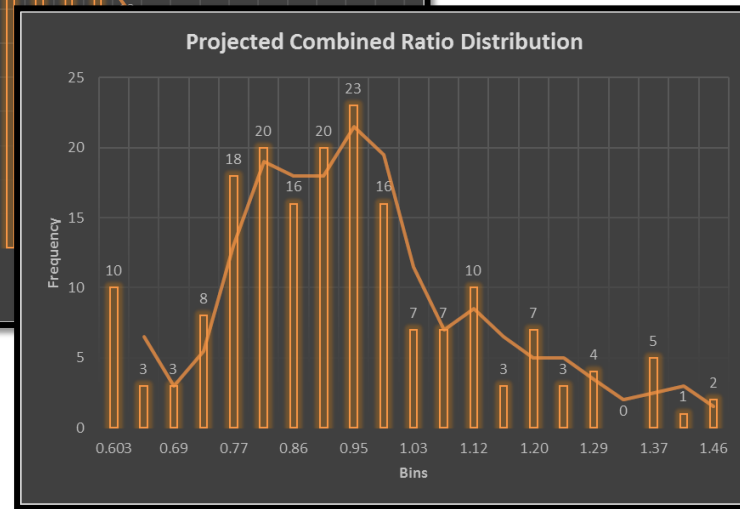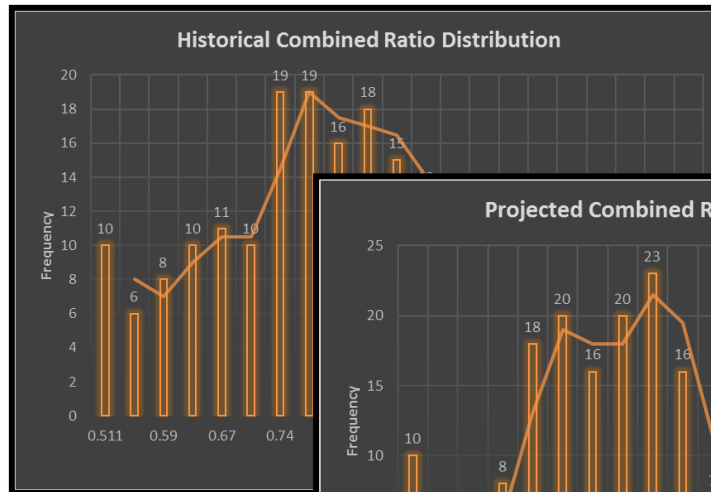## Balance Sheet   Income Statement   Key Financial Metrics

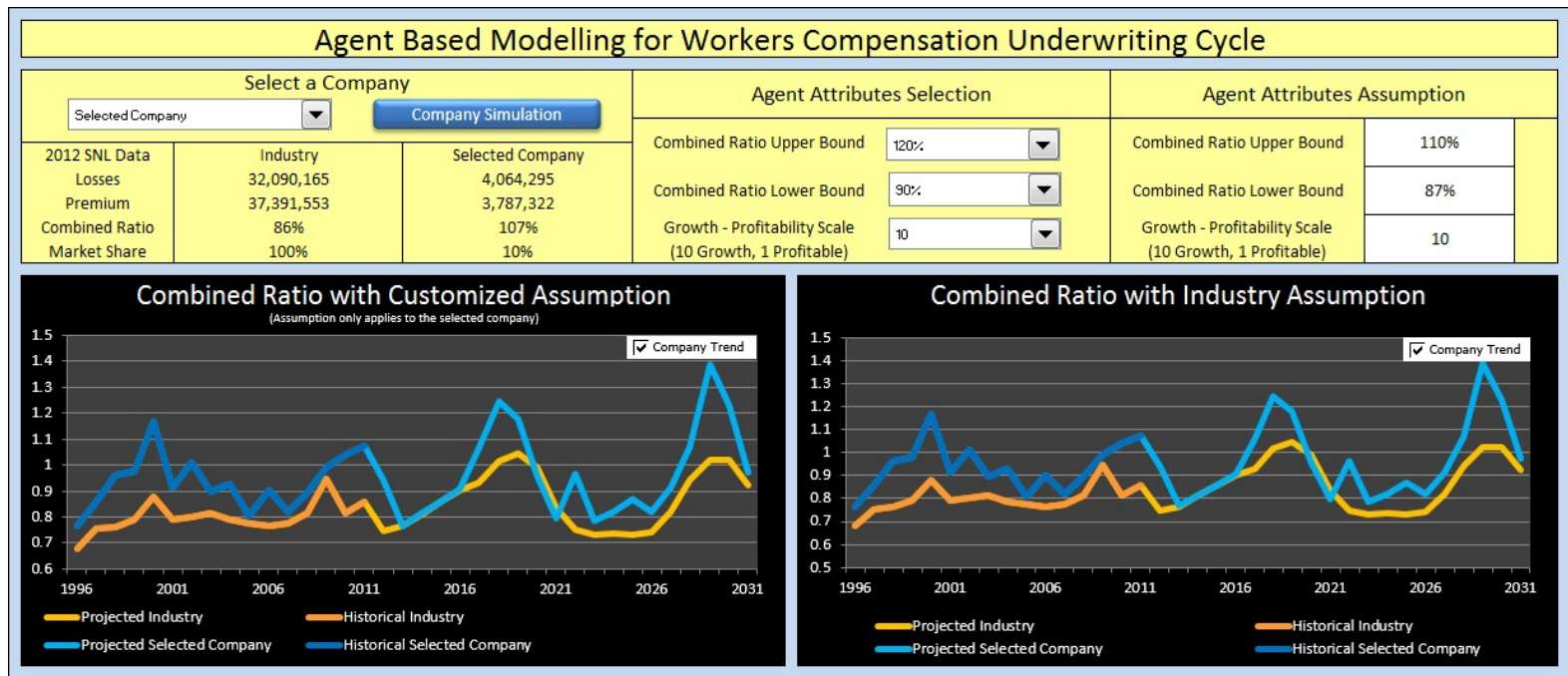|	2010	2011	2012	2013	2014	2015
B Key Metrics						
Adjusting Expense Ratio (E)	8%	10%	10%	10%	10%	10%
Prior Year Loss + DCC Ratio (E)	63%	67%	73%	54%	44%	21%
Current Year Loss + DCC Ratio (E)	16%	16%	14%	15%	12%	6%
Loss and LAE Ratio	87%	93%	96%	79%	66%	37%
Underwriting Expense Ratio (W)	30%	30%	31%	31%	31%	31%
Combined Ratio	117%	123%	127%	110%	97%	68%
Reserve Development	18%	19%	20%	16%	15%	10%
Return on Mean Surplus	3%	0%	-3%	3%	9%	24%
Capital Ratio	209%	193%	195%	213%	251%	430%

Output

- Full Individual Company financials for each year
  - Historical
  - Projected

- Full Industry financials for each year
  - Historical
  - Projected

- Distribution of financial results and key financial metrics for each year
  - By Individual Company
  - By Industry

Sample Output - Continued

Sample Output

Questions?