Financial Impairment Prediction Among Life and Health Insurers

Brought to you by the Industry Partnership Program

Undergraduate Students: Kelly Skogheim, Accident Fund Holdings Inc. & Cindy (Xi) Wu, Stanford University

University of Michigan Professors: Ed Ionides, Statistics & Kristen Moore, Actuarial Mathematics

M Financial Actuaries: Hans Avery, FSA & Ted Schleismen, FSA
We gratefully acknowledge the support of a Center of Actuarial Excellence (CAE) Education Grant from the Society of Actuaries.
The Vision

• Innovative capstone experience for students
• Facilitate collaboration between the academic and practitioner communities, and faculty and students across the disciplines.
Background

- Around 1% of life and health insurers become impaired each year.
- Any exposure to insurer failure could cause drastic financial setbacks.
- Using statutory financial data, we set out to determine key predictors of an impairment in the life and health insurance industry.
Our Industry Partner

• Carrier Relationships: M partners with a number of other insurance carriers to provide their clients with the best product available.

• Reinsurance Relationships: As in common practice, M cedes a portion of losses to reinsurance companies.
Previous Literature

- Ambrose and Carroll:
  Method: Logistic Regression
- Xue:
  Data: 2006-2008 Life Insurance
  Method: Logistic Regression
- Karasheva and Traskin:
  Data: 1993-2000 Property & Casualty Insurance
  Method: Random Forest
- Additional systemic risk studies:
  “Systemic Risk and Interconnectedness Between Banks and Insurers: An Econometric Analysis” – Hua Chen, J. David Cummins, Krupa S. Viswanthan, Mary A. Weiss
  “Networks Financial Institute at Indiana State University” – Martin F. Grace
Project Overview

- **Data**: AM Best’s Impairment Review and Statement Files for life and health insurers from 2004 to 2012.
- **Method**: Random Forest Classification
- **Results**: Competitive classification of impaired companies. Selection of important variables for prediction. Industry applications.
Impairments

U.S. Life/Health – Financially Impaired Companies (1969-2012)

Source: A.M. Best data & research
Eighty-eight explanatory variables were used in our model.

The predictors considered can be categorized into 4 main types:
- Calculated Variables
- Regulatory Ratios
- Trend Variables
- Indicator Variables
Random Forest

- Makes good predictions even with highly imbalanced data.
- Can be used with a large set of explanatory variables.
- Can handle a mixture of categorical and continuous variables.
- Can recognize the non-monotone relationships between individual predictors and the dependent variable.
Decision Trees

Single Tree

RBC ratio >= 2.818

unimpaired
1360/22

Net change in capital and surplus >= 52.5

unimpaired
1325/12

RBC ratio >= 18.15

unimpaired
33/6

Non-admitted to admitted assets < 0.5

unimpaired
35/10

Change in net premium to reserves >= -0.07327

unimpaired
19/0

unimpaired
14/6

unimpaired
9/0

impaired
5/6
Random Forest
<table>
<thead>
<tr>
<th>Impaired Company Name</th>
<th>Unimpaired</th>
<th>Impaired</th>
<th>Rank</th>
<th>Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employers Life Insurance Corporation</td>
<td>0.1551</td>
<td>0.8449</td>
<td>3</td>
<td>0.2171</td>
</tr>
<tr>
<td>American Community Mutual Insurance Company</td>
<td>0.1649</td>
<td>0.8351</td>
<td>4</td>
<td>0.2894</td>
</tr>
<tr>
<td>Benicorp Insurance Company</td>
<td>0.1725</td>
<td>0.8275</td>
<td>5</td>
<td>0.3618</td>
</tr>
<tr>
<td>Continental Life Insurance Company of South Carolina</td>
<td>0.1955</td>
<td>0.8045</td>
<td>7</td>
<td>0.5065</td>
</tr>
<tr>
<td>Municipal Insurance Company of America</td>
<td>0.2148</td>
<td>0.7852</td>
<td>9</td>
<td>0.6512</td>
</tr>
<tr>
<td>Great Republic Life Insurance Company</td>
<td>0.2437</td>
<td>0.7563</td>
<td>13</td>
<td>0.9407</td>
</tr>
<tr>
<td>Atlanta Life Insurance Company</td>
<td>0.2763</td>
<td>0.7237</td>
<td>15</td>
<td>1.0854</td>
</tr>
<tr>
<td>Republic American Life Insurance Company</td>
<td>0.2916</td>
<td>0.7084</td>
<td>17</td>
<td>1.2301</td>
</tr>
<tr>
<td>Life of America Insurance Company</td>
<td>0.2996</td>
<td>0.7004</td>
<td>21</td>
<td>1.5195</td>
</tr>
<tr>
<td>Golden State Mutual Life Insurance Company</td>
<td>0.3317</td>
<td>0.6683</td>
<td>29</td>
<td>2.0984</td>
</tr>
<tr>
<td>United Security Life and Health Insurance Company</td>
<td>0.3517</td>
<td>0.6483</td>
<td>35</td>
<td>2.5326</td>
</tr>
<tr>
<td>Booker T Washington Insurance Company</td>
<td>0.3649</td>
<td>0.6351</td>
<td>44</td>
<td>3.1838</td>
</tr>
<tr>
<td>Penn Treaty Network America Insurance Company</td>
<td>0.3938</td>
<td>0.6062</td>
<td>58</td>
<td>4.1968</td>
</tr>
<tr>
<td>Scottish Reinsurance (U.S.), Inc.</td>
<td>0.4292</td>
<td>0.5708</td>
<td>78</td>
<td>5.6440</td>
</tr>
<tr>
<td>Citizens National Life Insurance Company</td>
<td>0.4495</td>
<td>0.5505</td>
<td>100</td>
<td>7.2359</td>
</tr>
<tr>
<td>American Network Insurance Company</td>
<td>0.4992</td>
<td>0.5008</td>
<td>152</td>
<td>10.9986</td>
</tr>
<tr>
<td>National States Insurance Company</td>
<td>0.5004</td>
<td>0.4996</td>
<td>156</td>
<td>11.2880</td>
</tr>
<tr>
<td>Universal Life Insurance Company</td>
<td>0.5244</td>
<td>0.4756</td>
<td>188</td>
<td>13.6035</td>
</tr>
<tr>
<td>Standard Life Insurance Company of Indiana</td>
<td>0.5653</td>
<td>0.4347</td>
<td>259</td>
<td>18.7410</td>
</tr>
<tr>
<td>Medical Savings Insurance Company</td>
<td>0.5661</td>
<td>0.4339</td>
<td>261</td>
<td>18.8857</td>
</tr>
<tr>
<td>Ability Insurance Company</td>
<td>0.7414</td>
<td>0.2586</td>
<td>736</td>
<td>53.2562</td>
</tr>
<tr>
<td>Shenandoah Life Insurance Company</td>
<td>0.7480</td>
<td>0.2520</td>
<td>767</td>
<td>55.4993</td>
</tr>
</tbody>
</table>
# Error Rates

<table>
<thead>
<tr>
<th>Method</th>
<th>Variables</th>
<th>Total Error</th>
<th>True Positives</th>
<th>False Positives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive Prediction</td>
<td>0</td>
<td>1.6%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Random Forest</td>
<td>88</td>
<td>10%</td>
<td>73%</td>
<td>10%</td>
</tr>
<tr>
<td>RF - Variable Selection</td>
<td>6</td>
<td>14%</td>
<td>76%</td>
<td>13%</td>
</tr>
<tr>
<td>AM Best</td>
<td></td>
<td>55%</td>
<td>90%</td>
<td>55%</td>
</tr>
<tr>
<td>RF – Adjusted Standard</td>
<td>88</td>
<td>18%</td>
<td>90%</td>
<td>18%</td>
</tr>
</tbody>
</table>
Important Variables

- Change in RBC ratio
- Change in current liquidity
- RBC ratio
- Net change in capital and surplus
- Non-admitted to admitted assets
- Change in premium
- Net income to total assets
- Change in net premium to net income
- Change in quick liquidity
- Gross change in capital and surplus
- Net income to total income
- Change in product mix
- Change in surplus relief
- Change in net income to total income
- Net income to total income
- Total annuities affiliated investments to capital and surplus
- Change in reserves
- Change in adequacy of investment income
- Change in total lapse rate
- Current liquidity
- Change in net income to total assets
- Adequacy of investment income
- Indicator supplemental
- Change in log total assets
- Surplus relief
- Change in premiums
- Change in asset mix
- Total lapse rate
- Net premium to reserves
- Change in net premium to reserves
Variable Selection

- Iterative Feature Elimination
- We can achieve competitive accuracy with only 6 predictors:
  - Change in ratio of net income to total income
  - Change in RBC ratio
  - Current liquidity
  - Change in premium
  - Net income to total income
  - Quick liquidity
Applications

- In the Industry:
  - Monitor reinsurers, fronting arrangements, mergers and acquisitions
  - Self monitoring

- Regulatory and Rating:
  - Consider using random forest methodology for rating
  - Evaluate statutory data requirements

"The most that can be expected from any model is that it can supply a useful approximation to reality: All models are wrong; some models are useful"

-George E. P. Box
Final Highlights

Using the Random Forest Classification algorithm we,

• Accurately predicted a large percentage of impairments while maintaining a low false positive rate

• Identified the most important predictors

• Ranked companies by probability of impairment, which gives a qualitative sense of the relative financial strength of companies

• Determined that our client’s carrier firms are all financially healthy

• Provided our client with a tool with which they can monitor carriers and reinsurers in the future
References

- **R packages:** *randomForest* and *varSelRF*

- **AM Best Sources:**
  - Noonan, Brendan (2013). “L/H Impairments Hold at Half-Century Low; Accident & Health Remains Trouble Spot”. *Best's Special Report*
  - Statement file products available for purchase at: [www.ambest.com/sales/statementproducts](http://www.ambest.com/sales/statementproducts)

- **Impairment Prediction Papers:**
  - Xue, Xiaolei (2011). “A Logistic Regression Analysis for Potentially Insolvent Status of Life Insurers in the United States”. (Master's thesis). The University of Texas at Austin, Austin, TX.

- **Methodology Resources:**

- **Related Papers:**
  - Martin F. Grace (2006). “Networks Financial Institute at Indiana State University.” *Networks Financial Institute at Indiana State University*