Dependencies

Diversification Benefit – Understanding drivers and building trust in the numbers\(^1\)

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\(^1\)Based on a booklet produced for the Institute of Risk Managers Internal Model Industry Forum of the same name
Overview

• Dependencies:
  – Are difficult to implement, calibrate, validate and communicate
  – Can have material impact on the capital result
  – Lack of data (and probably always will be)

• But all is not lost!
  – The issues with dependencies are a reflection of reality
  – Shift the focus:
    • From getting the “right” number to getting a “reasonable” number
    • Improving insight and understanding by going through the process
  – It will take time: multi-year process

• Thesis: By having a model which focuses on systemic drivers of risk we are able to meaningfully, design, calibrate and validate model dependency structures
Introduction

• Start with collection of all available knowledge on aggregation of risk which exists within the business:
  – Stress and Scenario tests
  – Board and Risk Committee discussions
  – Price monitoring exercises which articulate causes for trends in experience
  – Claims departments reports which track leading indicators of risk
  – Independent assessments from CRO, Actuaries and Underwriters

• Designing a dependency structure should reflect key drivers and incorporate qualitative and quantitative information

• Models can incorporate structural or statistical dependencies
An example: Dependencies between classes

- Commercial Property — US
- Commercial Property — UK
- Homeowners — US
- Auto — US
An example: Dependencies between classes

Factors affecting frequency of claims

Factor:

Natural Catastrophes

Explanation:

A cat will cause aggregation of risk across classes of business in the same geographic region as they are exposed to the same systemic risk.
An example: Dependencies between classes

Factors affecting frequency of claims

- US Wind
  - Commercial Property – US
  - Commercial Property – UK
  - Homeowners – US
  - Auto – US
An example: Dependencies between classes

Factors affecting severity of claims

Factor:
Inflation

Explanation:
Increases in claims severity, if caused by inflation, can be a systemic risk factor affecting multiple classes of business and across time periods.
An example: Dependencies between classes

Factors affecting frequency and/or severity of claims

Factor:

Pricing Workbooks

Explanation:

Common pricing techniques and prior year assumptions can lead to systemic rate deviations.
An example: Dependencies between classes

Factors affecting frequency and/or severity of claims

Factor:

- Common underwriting

Explanation:

Behavioural factors and company incentives can cause correlation in extreme circumstances. Examples: incentive to write riskier business to meet profit targets.
Themes from the example

• Some dependencies amenable to causal modelling
  – Models & data available (Cat, ESGs)
  – Market practice
  – Materiality / Model Runtime / Parameterisation time / Stability

• Others difficult to explicitly model
  – Worth having the conversation
  – But there may be enough to give a residual correlation
Copula Calibration Pass 1: Determine the form and rank the strength

- Perform for each copula-based dependency in the model:
  - Aiming to rank the strength of correlation between pairs/groups
  - Aiming to match copula types
    - Zero, positive, negative correlation
    - Tail dependencies (and in which quadrant)
- **Graph technologies** can help visualise and compute strengths between nodes
  - Milliman’s use Dacord in booklet
  - Neo4j (open source)
Copula Calibration Pass 2: Estimate the strength

• Remove trends, beware of time series
  – Sample correlations should generally be calculated from ‘Actual less Expected’ data

• Correlation measures

• Record uncertainty in estimates
  – 10 data pts: inter-quartile range up to ±25%
  – 20 data pts: inter-quartile range up to ±15%
  – Use Fisher’s z-transformation / look up tables

• Ensure results consistent with ‘Pass 1’: a good first pass cuts down the range of values available
# Validation Tests

<table>
<thead>
<tr>
<th>Validation Test</th>
<th>Pitfalls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independent assessment</td>
<td>Beware of biases in opinion and those that are not</td>
</tr>
<tr>
<td></td>
<td>mathematically possible</td>
</tr>
<tr>
<td>Back-testing and <strong>aggregation testing</strong> using</td>
<td>Experience can change in time.</td>
</tr>
<tr>
<td>company’s own data</td>
<td>Beware of noise in the data</td>
</tr>
<tr>
<td>Benchmarking - reports from Lloyd’s, brokers or</td>
<td>Every company will deviate from the average, eg geographic</td>
</tr>
<tr>
<td>consultancies</td>
<td>diversification</td>
</tr>
<tr>
<td>Sensitivity testing</td>
<td>Helps to prioritize but does not give a final answer</td>
</tr>
<tr>
<td>Conditional probability testing focusing on the tail</td>
<td>Limited historical data to measure extreme outcomes</td>
</tr>
<tr>
<td>Risk ranking to judge appropriateness of relativities</td>
<td>Based on expert judgement</td>
</tr>
<tr>
<td>Profit and loss attribution</td>
<td>Will not identify underlying drivers</td>
</tr>
</tbody>
</table>
Conclusion

• Have a healthy model development and validation cycle, as findings year on year create a feedback loop
  – Uses, risk management processes, model testing all help to enhance the quality of the model
  – New experience and data helps to expand knowledge base
  – Keep investing in analytical techniques and follow an evidence based approach

• Conclusion
  – Yes it’s difficult & will take time but don’t stop trying / make a start
  – Internal models not internal formulae
Appendix: Further Links

• IRM Booklet (along with other IMIF booklets)

• Classic actuarial paper on dependencies

• Github for downloadable resources discussed in this presentation

• Dacord: https://www.dacord.co.uk/

• Neo4j: https://neo4j.com/