

## Background

You are an associate actuary at Axis Brokerage LLC, a multinational commercial insurance brokerage offering brokerage services to large Fortune 500 companies. Your primary duty is to provide quantitative advice to clients on their risk management decisions. A typical project involves running simulations based on the client's loss profile and using the simulation results to stress test the insurance options your brokers have procured. As an associate, you will work with a lead consultant who will peer-review your analysis and overall approach.

The broking team has been working on placing a Commercial Property program for a large Real Estate investment client, Montgomery Realty, with assets all over the US. Montgomery's portfolio is heavily concentrated in three areas: Tampa (FL), San Francisco (CA), and Chicago (IL). With assets in Tampa and San Francisco, Montgomery is concerned with destructions caused by Named Windstorms ("NWS" aka hurricanes) and Earthquakes ("EQ"). Furthermore, due to poor fire safety engineering, the company also routinely experiences fires at its assets.

The brokers are marketing for a Commercial Property policy that will cover three specific perils: NWS, EQ, and Fire. They are seeking various combinations of retentions/limits to ensure that Montgomery is presented with the best terms. *The risk manager has requested the assistance of an actuary to help pick the "optimal" program – balancing company internal objectives with cost-effectiveness.*

### Task 1: Fire Modeling (30%)

The data file "Loss Run 20241231.xlsx" contains all losses (Fire, NWS, and EQ) valued as of 12/31/2024. All loss values are fully developed and fully trended to reflect their ultimate losses as well as cost levels for the renewal policy period. After consulting with your lead consultant, you have decided to assume Poisson ( $\lambda = 15$ ) claims for the renewal period and separately fit a severity distribution(s) to the company Fire losses.

1. What are some common distributions for a severity curve? List at least 3.
2. The Risk Manager commented that a competitor recently experienced a \$150M fire loss to an asset. Discuss considerations for incorporating this external data, if at all.
3. Identify at least 3 fitting statistics that can be used to compare fitting of losses to a theoretical distribution. Perform a severity fit<sup>1</sup> and justify severity distribution(s) best representative of Montgomery's annual aggregate Fire loss.
4. Run a Monte Carlo simulation<sup>2</sup> and create an exhibit that captures the volatility of Montgomery's annual aggregate Fire loss.

### Task 2: Incorporating Catastrophe Modeling (10%)

Upon hearing that you are involved in modeling losses for Montgomery, the Catastrophe ("CAT") modeling team at your brokerage reached out to share the following output from Montgomery's CAT modeling run:

<u>Named Windstorm</u>	<u>Earthquake</u>
<i>Frequency</i> 40% chance of 2 claims, 20% chance of 3 claims, 20% chance of 4 claims, 20% chance of 5 claims	<i>Frequency</i> 60% chance of no claims, 20% chance of 1 claim, 10% chance of 2 claims, 10% chance of 3 claims
<i>Severity</i> Pareto with mean = \$794K and CV = 3.7	<i>Severity</i> Pareto with mean = \$10.67M and CV = 34.5

<sup>1</sup> Refer to Appendix A for suggested resources.

<sup>2</sup> Refer to Appendix B for suggested resources.

1. Provide reasoning to your lead consultant on why reliance on external CAT models is necessary when modeling Property losses.
2. Run a combined Monte Carlo simulation and update the exhibit in Task 1.4 with: Annual Aggregate NWS Loss, Annual Aggregate EQ Loss, and Annual Aggregate Total Loss. State all assumptions.

### **Task 3: Program Stress Testing (20%)**

The brokers have procured three different program structures for Montgomery Realty to consider. For Insurer 1 and Insurer 3, NWS limits are also subject to an aggregate limit. Fire limits are excess of the retention, and there is no retention on NWS or EQ Losses. Refer to glossary for definition of insurance terms.

1. Given the loss profile of Montgomery, compare the performance of three insurance programs below.

	Insurer 1	Insurer 2	Insurer 3
Retention	\$10M per occurrence	\$10M per occurrence	\$1M per occurrence
Fire Limits	\$1B per occurrence	\$1B per occurrence	\$1B per occurrence, with 30% co-insurance
NWS Limits	\$100M per occurrence / \$100M aggregate	\$100M per occurrence	\$100M per occurrence / \$100M aggregate
EQ Limits	\$500M per occurrence	\$1B per occurrence	\$1B per occurrence
Quoted premium	\$51,270,000	\$54,095,800	\$59,411,000

### **Task 4: Advisory (40%)**

Leading up to the presentation, you were informed that the CFO will be in attendance. Due to other financial constraints at Montgomery, the CFO's goal is to free up as much cash as possible by selecting lowest premium option. The risk manager is more risk averse and wants to go with the option that has the lowest Total Retained amount at the 50<sup>th</sup> percentile, regardless of premium. The broker thinks Montgomery should go with the option that provides lowest average Total Cost of Risk ("TCOR").

1. Propose one additional metric<sup>3</sup>, beyond the three listed above, Montgomery should consider. Be careful to balance both the client's internal objectives and cost-effectiveness.
2. From the three currently quoted options, select and justify the option you would recommend.
3. Later, you discover that the risk manager is not keen on having an aggregate limit on NWS. At a follow-up meeting with Insurer 1, the underwriter indicated that they would be willing to remove the aggregate on the NWS limit for "the right price". Recommend and justify a price (i.e., revised premium), rounded to the nearest \$0.1 million, you believe to be most appropriate.

<sup>3</sup> Refer to Appendix C for suggested resources

## Deliverables

1. Summary report to be shared with your lead consultant. This report should address Tasks 1 & 2. Pay extra attention to documenting your findings and justifying your selections.
2. Client presentation to address Tasks 3-4. Volatility exhibits created for Task 1.4 and Task 2.2 should be included.
  - a. Any additional items from Tasks 1 & 2 should be included only to the extent that it supports the conversation with client. Keep in mind that while the clients appreciate the mathematical rigor of your work, they have limited knowledge in advanced actuarial or statistics concepts.

Note that while only #2 will be presented during the final round, the judging panel reserves the right to ask questions from #1 during the final round. Both deliverables will be made available to the judging panel and the final score will be based on the quality of both.

## Provided Materials

1. Loss Run 20241231.xlsx
2. Monte Carlo example.R

## Glossary

Aggregate Limit	Consider a policy with \$5M per occurrence limit and \$10M aggregate limit. If 3 \$7M claims occurred, only \$10M claims would be insured (\$5M from the first claim, \$5M from the second claim, and nothing from the third claim would be insured since the aggregate has been fully eroded).
Retention	A \$50M per occurrence limit on top of a \$5M per occurrence retention means that a \$55M loss is fully insured. For a \$150M loss, the first \$5M would be retained under the retention, the second \$50M would be covered by the insurer, and the remaining \$95M would be considered “excess of limits” and also retained by the policyholder.
Coinsurance	A 10% co-insurance means that 10% of the loss in the insured layer is covered by the policyholder. Co-insurance would apply after any per-occurrence or aggregate limit has been applied. Amounts covered by the policyholder can be considered as either additional retention or additional limits exceedance.
Total Retained	In this context, this is the sum of the losses retained by the policyholder in the retention layer, and the losses excess of insurance limits. In the \$150M loss example above, the total retained amount is $\$5M + \$95M = \$100M$ .
Total Cost of Risk (TCOR)	Total Retained + Premium  Expected Total Cost of Risk = $E[\text{Total Retained} + \text{Premium}]$ = $E[\text{Total Retained}] + \text{Premium}$ = $E[\text{Retained in Retention}] + E[\text{Excess of Limits}] + \text{Premium}$ .
Loss Ratio	Total loss covered by the insurance policy, divided by the premium.

## **Appendix**

### **Appendix A: Suggested fitting tools**

1. Overview of the [fitdistrplus](#) package
2. Overview of the [scipy.stats](#) package
3. Daniel, J.W., “[Poisson processes \(and mixture distributions\)](#).” CAS Study Note, June 2008.

### **Appendix B: Suggested Monte Carlo reference**

1. KV, “[Aggregate Loss Distribution – Monte Carlo Simulation](#).” RPubS by RStudio, September 2017.
2. Dutang, C., Goulet, V., Pigeon, M., Pouliot, “L., “[Simulation of insurance data with actuar](#).” Cran.r-project.org, November 2011.

### **Appendix C: Risk measures**

1. Hardy, “[An Introduction to Risk Measures for Actuarial Applications](#).” University of Waterloo, 2006.
2. Enterprise Risk Management Committee, “[Overview of Enterprise Risk Management](#).” Casualty Actuarial Society, May 2003.