Axis Brokerage LLC

Executive Summary

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Overview

In this project, our goal is to analyze the loss profile of Montgomery Realty, which consists of damages incurred to assets primarily due to poor fire safety engineering, along with Named Windstorms (NWS) and Earthquakes (EQ). We are tasked with the challenge of developing a cost-effective Commercial Property policy using the provided loss profile to simulate and create an exhibit of Montgomery's annual aggregate fire loss. In addition, we are asked to incorporate data from external Catastrophe models and compare the results to determine the optimal policy which balances Montgomery's internal objectives and cost-effectiveness.

Historical Data

We were given a 15-year loss profile of Montgomery Realty's assets dating from 2010 to 2024. There were a total of 259 claims within this period, each labeled with an ultimate loss amount, trended ultimate loss, location (Tampa, San Francisco, Chicago) and type of loss (NWS, EQ, and fire).

Assumptions

It was brought to the team's attention that a competitor of Montgomery Realty recently experienced a $150M fire loss to an asset. However, our team decided against incorporating this loss into our data. While it is important to analyze the competitor's portfolio similarities, we determined that the loss is an outlier due to the fact that fire losses do not exceed $10M based on Montgomery's loss profile. Furthermore, it is unknown whether the competitor's assets have similar levels of risk exposure as Montgomery Realty's assets do, further deeming the competitor's fire loss as extraneous data.

For simulating fire losses during the renewal period, we assumed Poisson claims with an average rate of occurrence equal to 15.

For simulating NWS and EQ losses, we assumed the probabilities of occurrence and severity mean/CV values given by the CAT models for the two claim types. In addition, we assumed that fire, NWS, and EQ losses were all independent of one another, and that frequency and severity were independent.

Distribution Analysis

The first step in working towards simulating Montgomery Realty's fire losses is selecting candidate distributions that could accurately fit the company's annual aggregate fire losses. The three our team decided to investigate were the lognormal, Pareto, and Burr distributions, as these are common distributions for a severity curve. The lognormal distribution holds advantages in its ability to handle right-skewed data well, and its ability to handle very wide ranges of data (particularly when most losses are small, but occasional large losses occur). Parameters of the lognormal distribution consist of the shape, location, and scale. Pareto distributions are commonly used for modeling extreme values and heavy-tailed distributions, as they capture the occurrence of rare but severe losses effectively. Parameters consist of shape and scale, which influence the tail thickness and central tendency. Finally, Burr distributions exhibit flexibility, as they can adjust to a wide range of data characteristics.

We measured the goodness of fit upon the fire loss data of each chosen distribution using three metrics: the Akaike Information Criterion (AIC), Kolmogorov-Smirnov (KS) Statistic, and Cramér-von Mises (CvM). The AIC is favorable for balancing fit and complexity, as it rewards models that fit the data while penalizing overly complex models. The KS is non-parametric, which assures that it is very flexible and does not rely on assumptions about the distribution of the fire loss data, such as its skewness or normality. Finally, the CvM was chosen for its holistic approach in measuring fit over the entire distribution, as well as its effectiveness with heavy-tailed distributions. These tests were run on the three distributions in Python. A lower AIC suggests a better balance between fit and complexity, while a higher p-value of the KS and CvM statistic indicates a higher likelihood that the model is accurate. Based on the results, the lognormal distribution was found to best fit the fire loss data using maximum likelihood estimation (MLE).

Monte Carlo Simulation

The last step for simulating the annual aggregate fire loss of the company was to run the Monte Carlo Simulation itself. Given the extreme losses present in the data, as well as desire for high percentile statistics, we ran 100,000 trials. We employed a lognormal distribution to simulate the fire claim severity, while the claim frequency was modeled by a Poisson distribution ($\lambda = 15$). The results of the simulation captured the volatility of Montgomery's annual aggregate fire loss.

Incorporating Catastrophe Modeling

Reliance on CAT models is key for modeling NWSs and EQs for Montgomery especially due to the limited historical data available on the company's loss profile (only 18 NWS claims and one EQ claim in 15 years). CAT models also incorporate the expertise of several different disciplines, taking into account historical, geophysical, and meteorological data to assess the risk of occurrence and potential severity of NWS and EQ claims. While individual loss profiles undoubtedly provide credible statistics, reliance on past information alone can result in inaccurate estimations about future events, thereby resulting in erroneous loss predictions. As such, incorporating probabilistic distributions from CAT models in addition to utilization of historical data widens the range of relevant overall data, thereby providing greater insight into potential catastrophic events. This significantly increases accuracy in assessing future losses, resulting in a greater efficiency of risk mitigation in the long run.

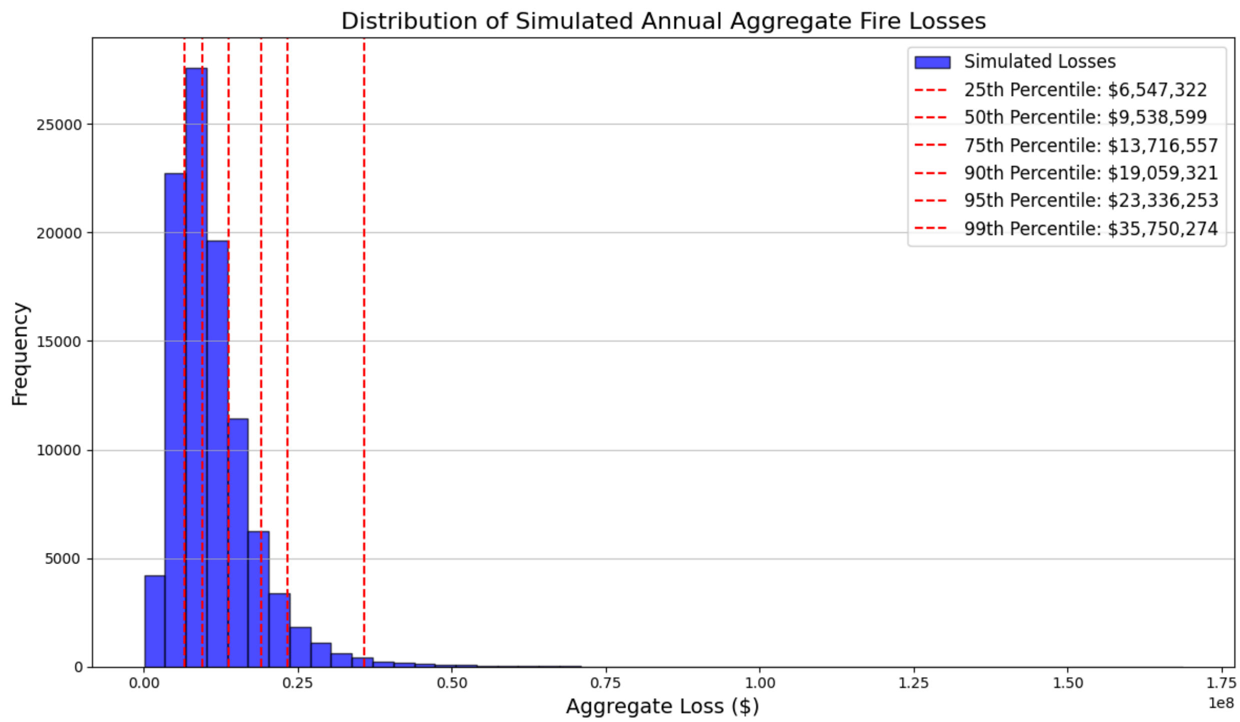
With all this said, we used the CAT models given to simulate Montgomery's annual aggregate NWS and EQ losses in addition to the already simulated fire losses.

Results

Based on the simulation results, we were yielded a range of statistics (mean; 25th, 50th, 75th, 90th, 95th, 99th, 99.9th percentiles) for the projected annual aggregate loss for each fire, NWS, and EQ claims. We can conclude what a typical year would look like versus the extent to which an extreme year could cause damage to the company. For instance, on an average year (50th percentile) Montgomery would experience around $9.5 million in damages to assets from fires. Looking at somewhat of a worst case scenario (99.9th percentile), the damages could amount to $61 million. Further data for all loss types can be observed in the appendix. This data will be used in guiding Montgomery Realty on choosing the most effective and appropriate insurance policy for their needs.

Appendix

Graph 1: Histogram of Simulated Annual Aggregate Fire Losses



Graph 2: Histogram of Simulated Annual Aggregate Total Losses

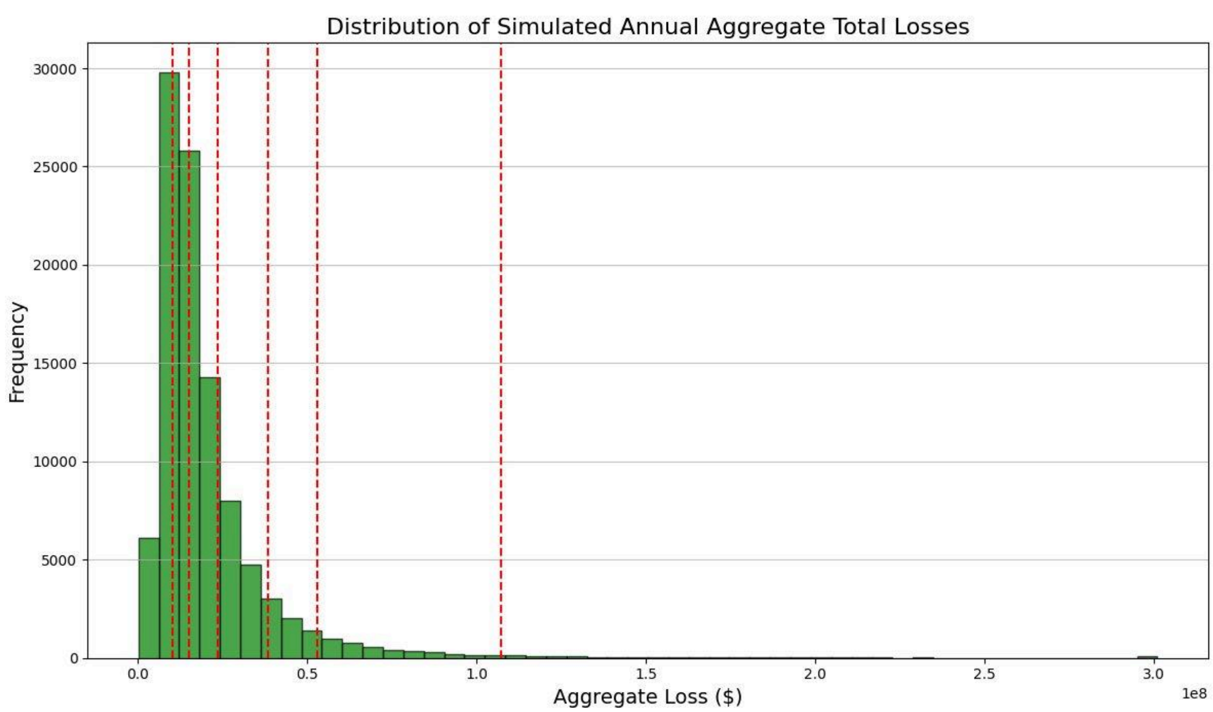


Table 1: Distribution Comparison

Distribution	KS Statistic	KS p-value	AIC	CvM Statistic	CvM p-value
Lognormal	0.055820	4.276823e-01	6879.612453	0.125419	4.742740e-01
Pareto	0.292841	9.939137e-19	7096.074301	7.015034	2.017878e-10
Burr	0.313680	1.746532e-21	7044.746771	9.373146	5.700062e-10

Table 2: Simulated Annual Aggregate Loss Statistics

	Loss Type			
Statistic	Aggregate Fire Loss	Aggregate NWS Loss	Aggregate EQ Loss	**Total Aggregate Loss**
Mean	$11,065,030	$2,536,374	$7,469,352	$21,070,756
25th Percentile	$6,547,322	$841,862	$0	$10,159,731
50th Percentile	$9,538,599	$1,666,987	$0	$15,097,680
75th Percentile	$13,716,560	$3,074,466	$6,019,336	$23,618,575
90th Percentile	$19,059,320	$5,258,738	$21,040,590	$38,290,477
95th Percentile	$23,336,250	$7,229,981	$36,065,950	$53,264,845
99th Percentile	$35,750,270	$14,471,180	$89,913,280	$105,842,398
99.9th Percentile	$60,999,760	$40,013,190	$284,058,300	$298,219,177