Estimation of Aggregate Earthquake Insurance Claim Using an Actuarial Risk Model

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Abstract

This independent study examines the estimation of expected aggregate claim for a Thai insurance company following the earthquake on March 28, 2025. The study utilizes data spanning from March 29 to September 30, 2025, and employs stochastic models for aggregate claim estimation by considering the homogeneous compound Poisson process and the nonhomogeneous compound Poisson process. The claim size is assumed to follow a Pareto distribution. Then, We compare and choose the best model for calculating the company's surplus.

Introduction

Following the earthquake of March 28, 2025, which was highly severe and caused widespread damage to property and the economy in the region, particularly the severe damage to Mandalay International Airport, the collapse of the air traffic control tower in Naypyidaw, and significant disruption to public utilities, and in Thailand, the reported fatalities from the collapse of the new office building of the Office of the Auditor General of Thailand during construction, the authors recognize the critical importance of insurance and risk management through the application of actuarial models to estimate total claims. These models are essential tools for enhancing financial stability and reducing risk for insurance companies.

Objectives

1. To estimate the aggregate claims using actuarial models.
2. To compare stochastic models for estimating aggregate claims, where the claim frequency is determined by Homogeneous and Nonhomogeneous Compound Poisson processes.
3. To calculate the net premium reserves for insurance companies.

Methodology

1. Process data using Relative Difference (RD) and perform preliminary statistical analysis.

$$Relative\ difference\ (RD) = \frac{Estimated\ claims - Actual\ claims\ paid}{Estimated\ claims}$$

$$Actual\ claims\ paid = Estimated\ claims \times (1 - RD)$$

2. Investigate stochastic models suitable for earthquake events to estimate claim frequency.

Model	Parameter	Intensity Function
Poisson	λ	λ
NHPP-Exponential	β_0 β_1	$exp(\beta_0 + \beta_1 t)$
NHPP-Weibull	γ δ	$\gamma\delta t^{\delta-1}$

3. Selecting the optimal stochastic model based on AIC and BIC criteria, and determining the expected values for both the selected frequency model and the Pareto distribution for claim severity.

4. Estimate the aggregate claims using the Collective risk model.

$$E[S(t)] = E[X_1]E[N(t)]$$

5. Calculate the insurer's surplus using the Classical risk model.

$$E[U(t)] = u + ct - E[S(t)]$$

Preliminaries

Classical risk model

The insurance company's surplus at time t, denoted as U(t), is defined by the following equation :

$$U(t) = u + ct - S(t)$$

where $U(t)$: the insurer's surplus at time t
u : the initial surplus.
$S(t)$: the aggregate claim amount incurred over the interval $(0,t]$
c : the net premium rate per unit of time

$$c = (1 + \rho)\lambda E[X_i]$$

where ρ : safety loading
λ : expected number of claims per unit time

collective risk model

$$S(t) = \sum_{i=1}^{N(t)} X_i$$

where X_i : the individual claim amount for the$i$claim, where$X_i$are assumed to be independent and identically distributed (i.i.d.) and independent of the claim number process, $N(t)$
$N(t)$: the number of claims reported in the interval $(0, t]$, where t is measured in months. The time horizon considered is March to September

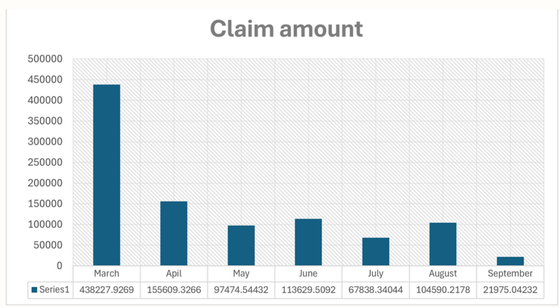
Expectation of $S(t)$

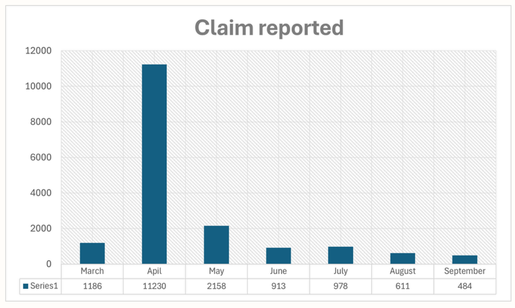
$$E[S(t)] = E[X_i]E[N(t)]$$

Expectation of Stochastic processes and Pareto distribution

	Homo-Poisson	NHP-Expo	NHP-Weibull	Pareto
Expectation	λ	$\frac{e^{\beta_0}}{\beta_1}(e^{\beta_1 t} - 1)$	γt^{δ}	$\frac{\alpha\theta}{(\alpha - 1)}$

Main results





1. The Pareto distribution is the most suitable model for describing claim severity data, yielding an estimated monthly claim amount of 144,663,708 Baht.

2. The Nonhomogeneous Poisson process (NHPP) utilizing an exponential intensity function demonstrated the highest efficiency in estimating claim frequency, with a total of 21,495 claims over a seven-month period.

3. According to the calculations, the estimated aggregate claim amount is approximately 3,109,608,170.677 Baht.

4. Given that ρ takes values of 5, 10, 15, and 20 percent respectively, and an initial surplus of u = 3,989,625,202 baht, the calculation results are presented in the following table.

Safety loading (ρ)	The net premium rate/time (c)	The expected surplus ($E[U(t)]$)
5 %	466, 441, 225.601	4, 145, 105, 610.530
10 %	488, 647, 212.534	4, 300, 547, 519.061
15 %	510, 864, 199.468	4, 456, 066, 427.599
20 %	533, 075, 686.401	4, 611, 546, 836.130

Conclusion

The results of the study indicate that the Pareto distribution for estimating claim severity, together with the Nonhomogeneous Poisson Process (NHPP) for estimating the number of expected claims, is sufficiently effective for estimating the aggregate claim amount and the reserve of an insurance company. This approach can support financial risk management for insurance companies, particularly in situations involving large-scale catastrophic events.