EARTHQUAKE

CATASTROPHIC

Pricing

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What

THE PROJECT IS ABOUT

Creating an interactive earthquake insurance pricing model

Why

DO THIS PROJECT

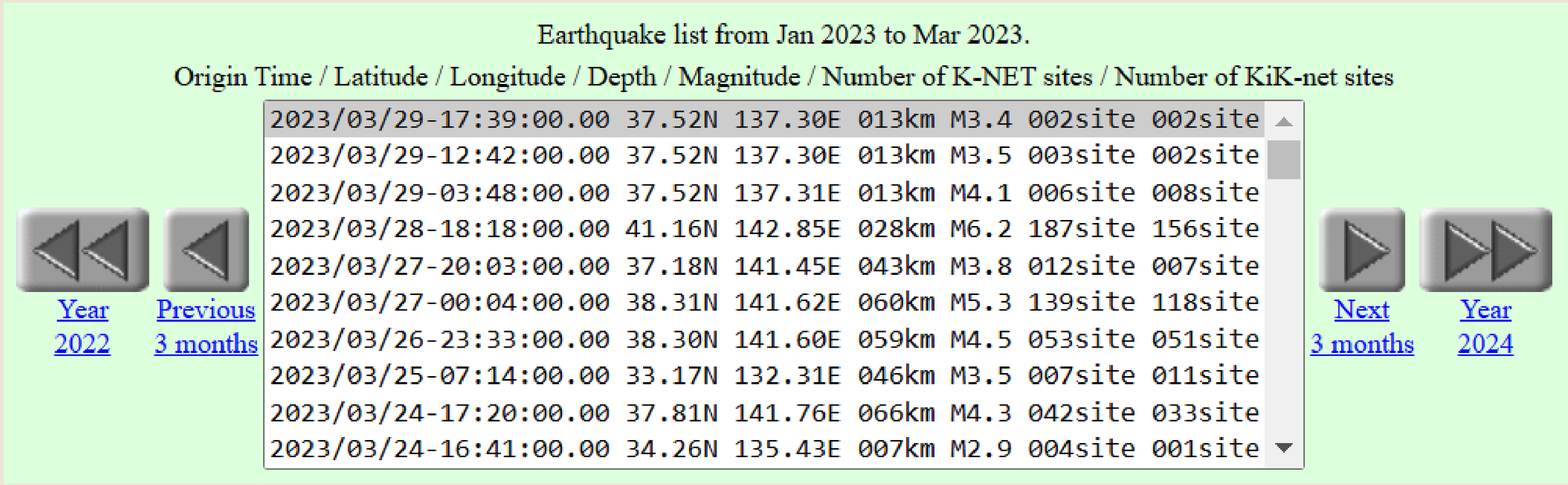
To promote fairness and transparency in insurance pricing

CHAPTERS TO *Apply*

- Interactive Visualization (chapter 3)
- Probabilistic Modelling (chapter 4)

DATA USED

Data is from the National Research Institute for Earth Science and Disaster Resilience (NIED)



Earthquake list from Jan 2023 to Mar 2023.

Origin Time / Latitude / Longitude / Depth / Magnitude / Number of K-NET sites / Number of KiK-net sites

2023/03/29-17:39:00.00 37.52N 137.30E 013km M3.4 002site 002site
2023/03/29-12:42:00.00 37.52N 137.30E 013km M3.5 003site 002site
2023/03/29-03:48:00.00 37.52N 137.31E 013km M4.1 006site 008site
2023/03/28-18:18:00.00 41.16N 142.85E 028km M6.2 187site 156site
2023/03/27-20:03:00.00 37.18N 141.45E 043km M3.8 012site 007site
2023/03/27-00:04:00.00 38.31N 141.62E 060km M5.3 139site 118site
2023/03/26-23:33:00.00 38.30N 141.60E 059km M4.5 053site 051site
2023/03/25-07:14:00.00 33.17N 132.31E 046km M3.5 007site 011site
2023/03/24-17:20:00.00 37.81N 141.76E 066km M4.3 042site 033site
2023/03/24-16:41:00.00 34.26N 135.43E 007km M2.9 004site 001site

Year 2022 | Previous 3 months | Next 3 months | Year 2024

https://www.kyoshin.bosai.go.jp/kyoshin/quick/index_en.html

METHODOLOGY

Find the distribution of Magnitude and Its Frequency

Magnitude

Normally Distributed with $\mu=4.30784$ and $\sigma 2=1.54993$

Frequency

Exponentially Distributed with $\lambda = 0.04842$

METHODOLOGY

Use Cramer-Lundberg Theory

To calculate the risk of insolvency (ruin) in the context of claims and premium income.

$$R(t) = u + ct - \sum_{i=1}^{N(t)} S_i$$

- R(t): reserve of the insurer
- u: initial reserve of the insurer
- c: premium rate per unit of time.
- N(t): Number of claims up to time (modeled as a Poisson process)
- Si: Size of the i-th claim

METHODOLOGY

Expected Claim Size

So the insurer can predict the average cost of claims and set premiums that ensure they collect enough to cover payouts.

$$\mathbb{E}[S] = \int_{-\infty}^{\infty} S(x) \cdot f(x)\, dx$$

- S(x): The claim size function
- f(x): The probability density function (PDF) of the claim size S

METHODOLOGY

Expected Loss

To ensures that the collected premiums are at fair price and sufficient to cover claims.

$$E[Loss] = E[S] \times \lambda \times t$$

- E[S]: Expected claim size
- λ: Number of claims per unit time.
- t: Number of years

METHODOLOGY

Premium Calculation

To ensures that the collected premiums are at fair price and sufficient to cover claims.

$$\text{Premium} = (1 + \text{safetyLoading}) \times E[\text{Loss}]$$

- E[Loss]: Expected loss
- Safety Loading: Additional amount added to the expected loss or premium to ensure that the insurer can cover unexpected variations in claims

METHODOLOGY

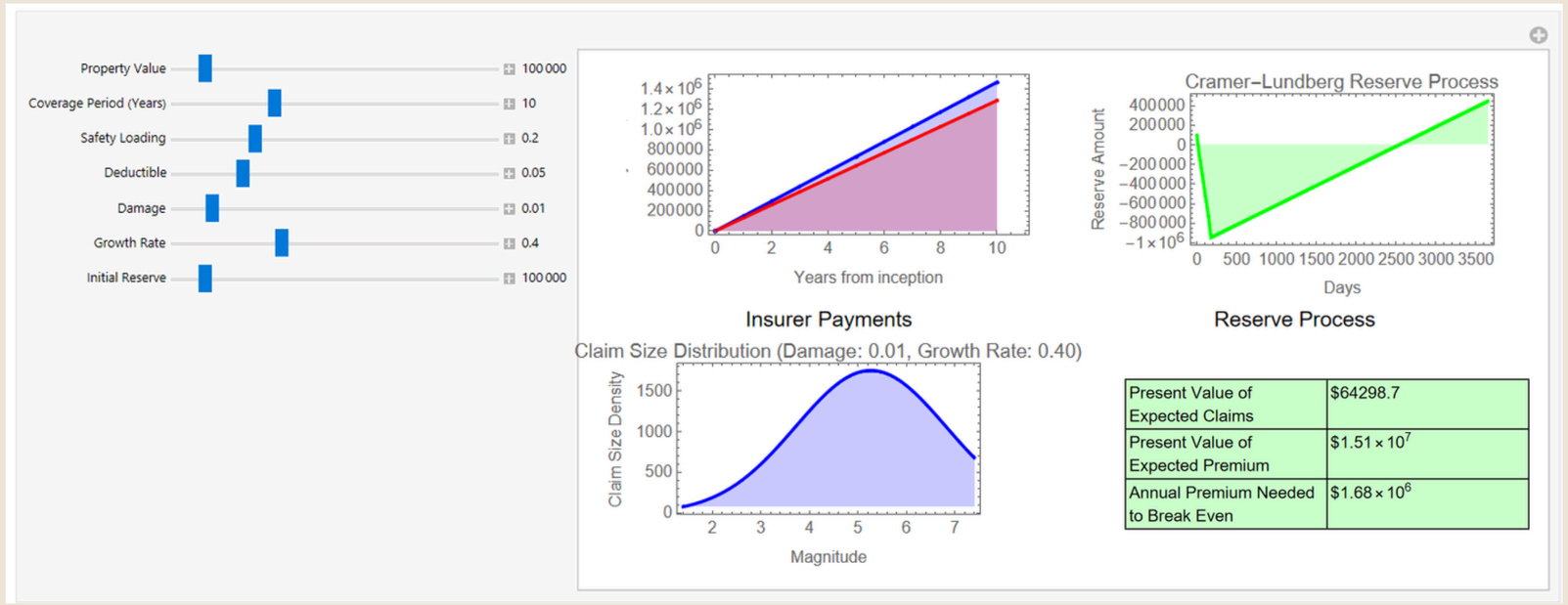
Assess Ruin Probability

Measures the likelihood that their financial reserves will be exhausted due to excessive claims.

```
ruinProbability = Probability[reserve[t] < 0,
    {t, 0, Infinity}, Method → "MonteCarlo"];
```

METHODOLOGY

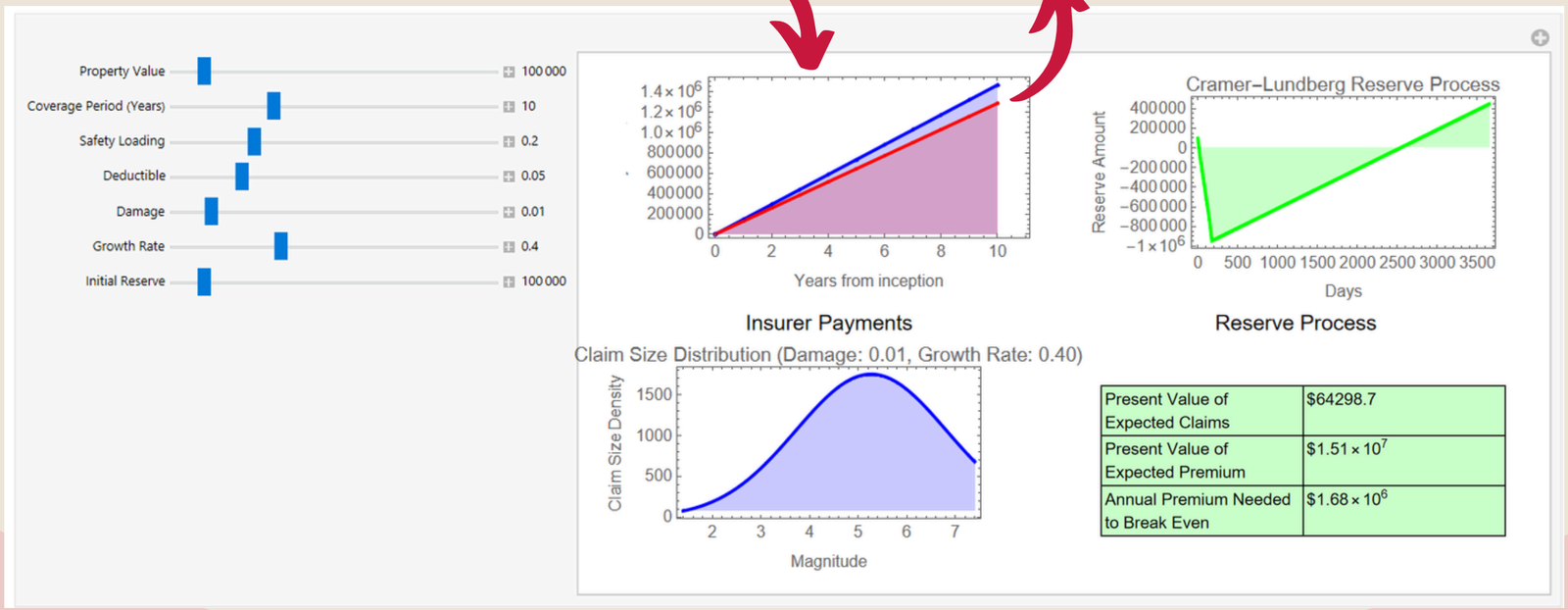
Interactive Visualization



KEY *Findings*

the blue line (premium) will always be greater than the red line (payout)

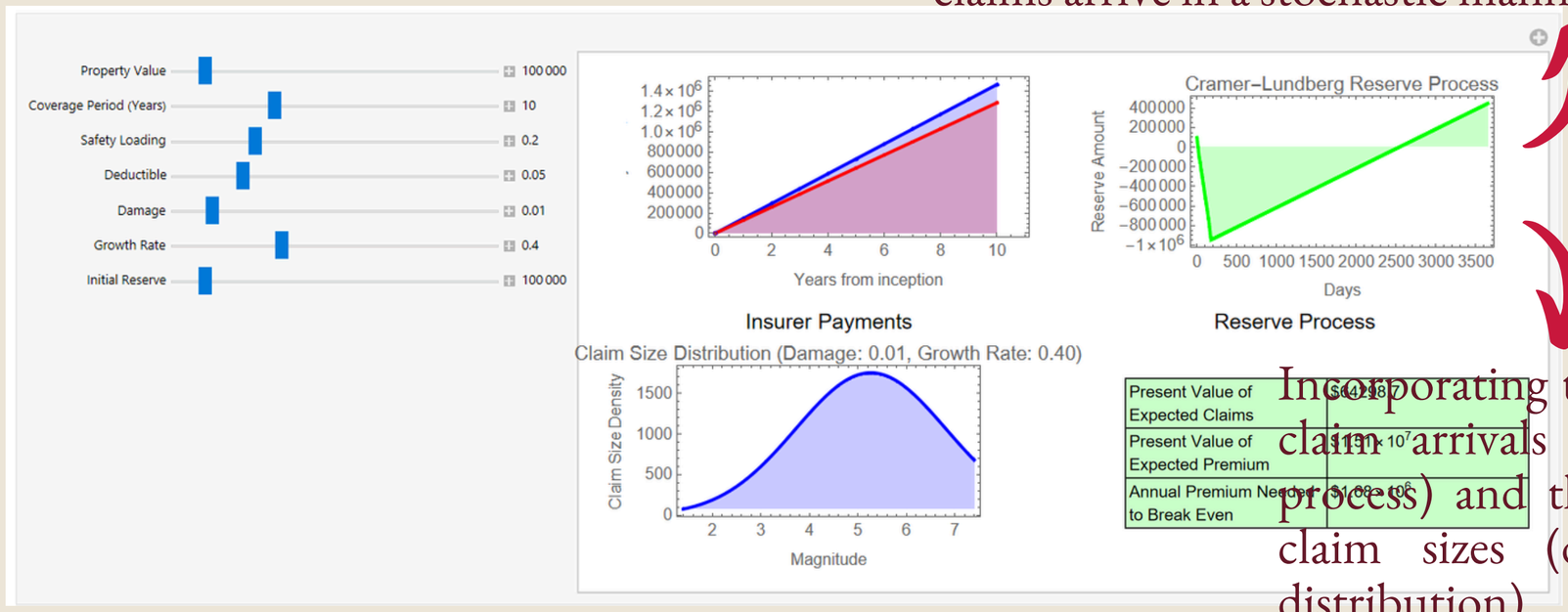
the area between the line is the profit for the insurer



the higher the Safety Loading, the higher the red line (payout)

KEY *Findings*

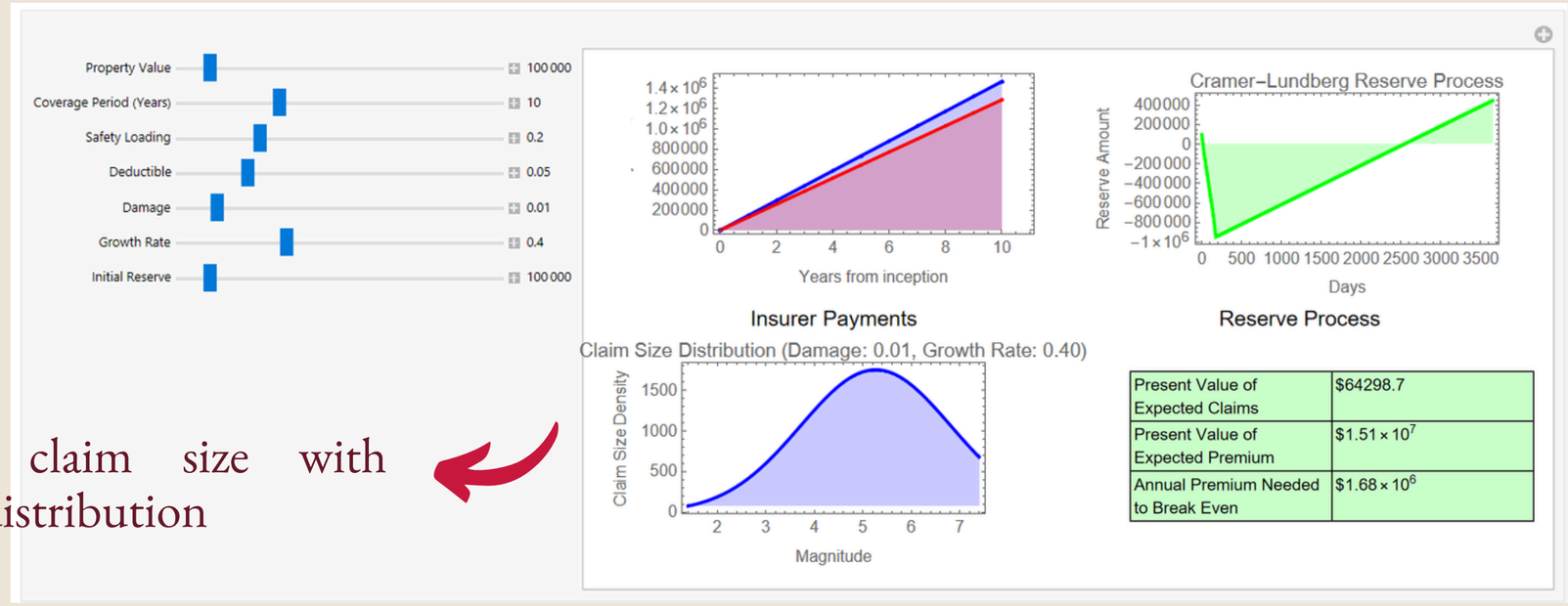
The reserve amount changes dynamically as claims arrive in a stochastic manner



Incorporating the randomness of claim arrivals (using a Poisson process) and the randomness of claim sizes (drawn from the distribution).

The shaded area represents the time during which the reserves are negative, indicating insolvency risk

KEY *Findings*



Model the claim size with exponential distribution

Increased damage alone, increases all claims proportionally, while increasing the rate of growth creates a compounding effect where larger claims dominate the tail of the distribution.

THANK *You*