Master's title: Banking and Insurance Finance

Modul: Actuarial Mathematics

Required prior knowledge:

Financial mathematics

Mathematical statistics

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Chapter 01

The actuarial study

The actuarial study is a specialized field that combines mathematics, statistics, and economics to assess and manage future financial risks. Actuaries use mathematical and statistical tools to estimate the potential financial impacts of future events, such as death, illness, or accidents, on institutions like insurance companies and pension funds.

1. The Basic Concept of Actuarial Study:

The actuarial study aims to assess and manage the risks associated with uncertain future events that can affect the financial obligations of companies or institutions. Actuaries rely on mathematical models to estimate the cost of future risks and provide suitable financial solutions to handle them.

2. The Core principal of actuarial studies

A. Risk and Uncertainty:

One of the fundamental principles of actuarial studies is dealing with risks. Actuaries identify the types of potential risks and how they may affect financial obligations.

Example:

If an insurance company deals with life insurance, the risks include early death of employees or changes in mortality rates.

B. Mathematical Modeling:

Mathematical models are used to estimate the probabilities associated with different events. These models are based on historical data.

Example:

A statistical model can be used to estimate mortality rates based on different age groups.

C. Risk Management:

This principle involves developing strategies to reduce the impact of risks.

Example:

Insurance companies create reinsurance strategies to reduce financial risk.

D. Time Value of Money:

This principle recognizes that the value of money changes over time due to inflation and interest, which must be accounted for when evaluating long-term financial obligations.

Example:

If there's an obligation to pay $100,000 in 10 years, its present value is less than $100,000 because of interest.

3. Basic Assumptions in Actuarial Studies:

A. Continuity:

It is assumed that historical trends will continue in the future. Example: If the accident rate in previous years was 4 accidents per 1,000 drivers, it is assumed that this rate will continue into the future.

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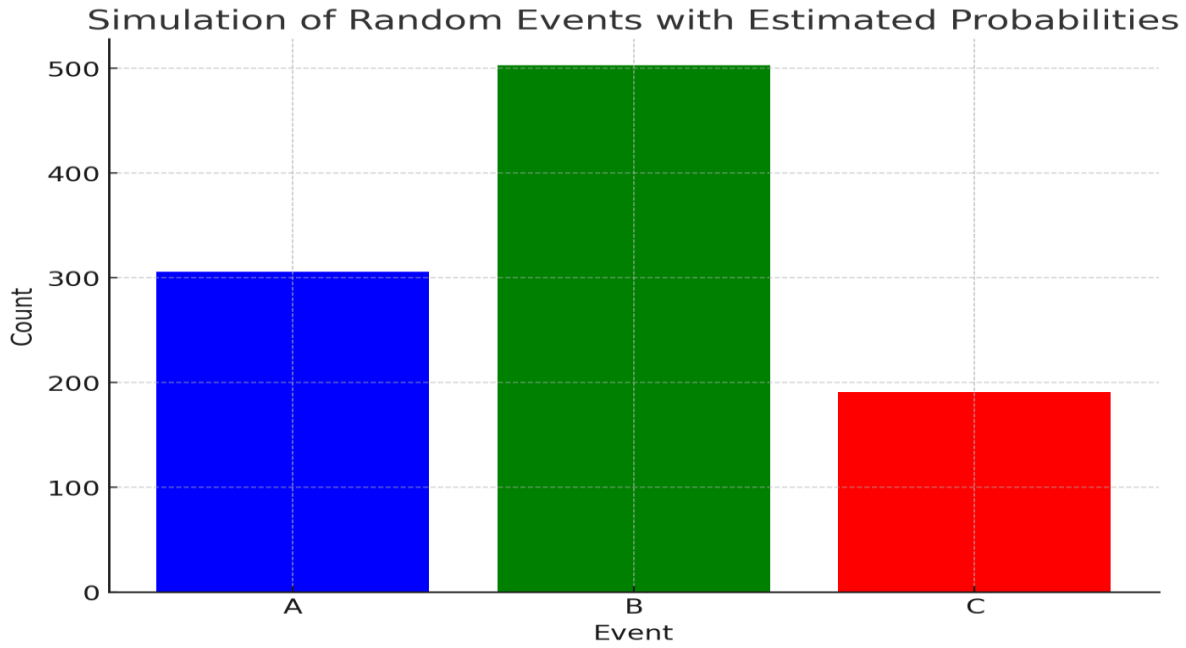
If the accident rate in previous years was 4 accidents per 1,000 drivers, it is assumed that this rate will continue into the future.

B. Randomness:

It is assumed that some events occur randomly, but their probability can be estimated.



Here is the graph showing the simulation of random events (A, B, and C) based on their estimated probabilities (30%, 50%, and 20%). The bars represent the number of times each event occurred over 1,000 simulations. You can see how the events were distributed according to the given probabilities.

Example:

The number of accidents in a group of drivers can be predicted based on the average historical accident rate.

C. Financial Stability:

It is generally assumed that the institution conducting the actuarial study will remain financially stable without drastic changes that could affect the data.

Example:

It is assumed that the market and economic conditions will not change drastically during the evaluation period.

To simulate financial stability for an actuarial study, we can model the financial health of an insurance company or pension fund over time. Actuaries often assess the ability of these entities to meet their obligations under different economic conditions. A key concept is maintaining adequate reserves to cover future liabilities (claims or payouts).

Financial Stability for an Insurance Company

In this example, let's simulate the financial position of an insurance company over time, considering:

1. **Assets:** The company earns returns on investments.
2. **Liabilities:** The company pays claims.
3. **Reserves:** The company must maintain a certain level of reserves to stay solvent.

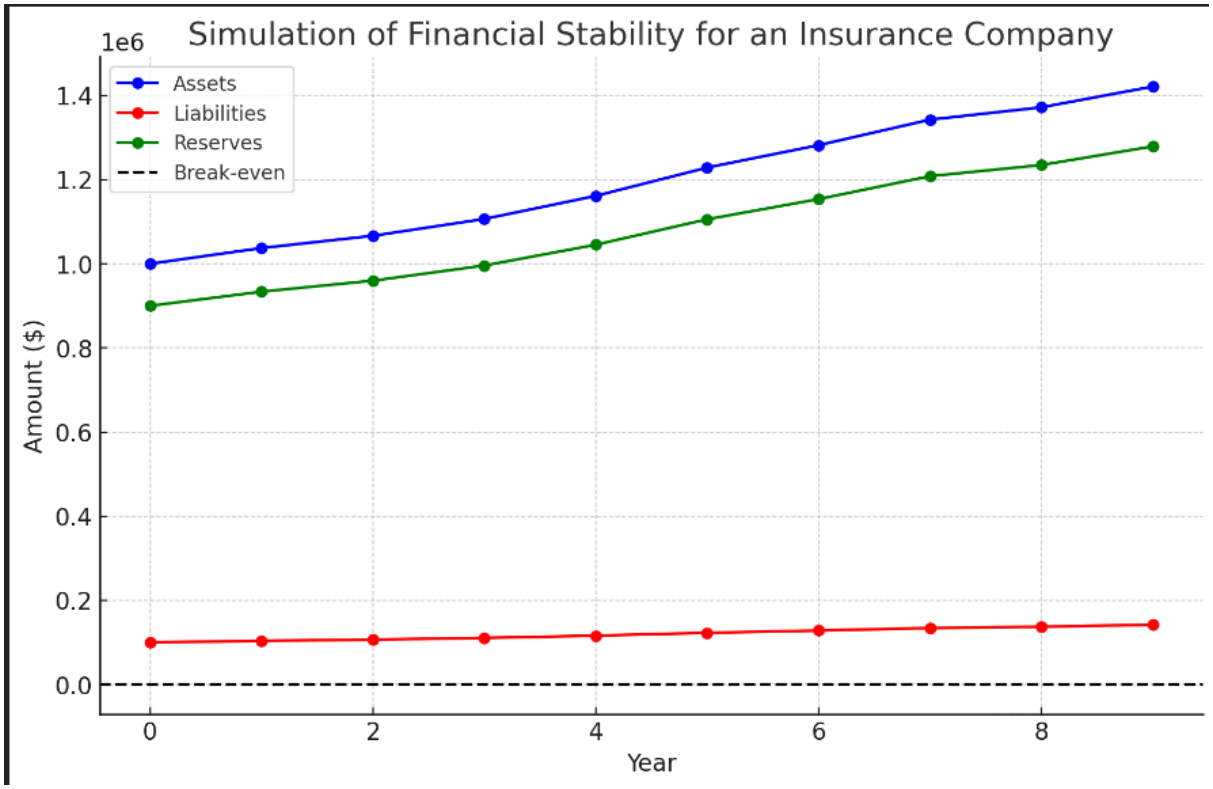
Key Variables:

- **Investment Return Rate:** The annual rate at which the company's assets grow (e.g., 5% per year).
- **Claim Rate:** The average amount paid in claims each year (e.g., 10% of assets).
- **Reserves Requirement:** A threshold to determine the solvency of the company (e.g., reserves must be at least 20% of liabilities).

Steps:

1. **Simulate Investment Returns:** Randomly generate returns for each year.
2. **Simulate Claims:** Estimate the claims paid out each year.
3. **Track Reserves:** Calculate the company's financial position each year, comparing assets to liabilities.

I'll simulate this scenario over 10 years and plot the financial trajectory (assets vs. liabilities). Let's proceed with the simulation.



Here is a graph showing the simulation of financial stability for an insurance company over 10 years:

- **Blue Line (Assets):** Represents the company's total assets, which grow each year based on random investment returns.
- **Red Line (Liabilities):** Shows the liabilities or claims the company has to pay, which is a percentage of the assets.
- **Green Line (Reserves):** Indicates the reserves remaining after liabilities are deducted from assets.

This gives an idea of how the company's financial health changes over time, depending on investment returns and claims paid.

4. Main Objectives of Actuarial Studies:

A. Identifying Risks:

Actuarial studies help institutions identify the risks they may face in the future.

Example:

An insurance company uses actuarial studies to identify the risk of accidents or deaths in a specific group of customers.

B. Estimating Financial Reserves:

Actuarial studies help estimate the reserves needed to cover future financial obligations.

Example:

A pension fund needs to estimate the amount required to pay out retirement benefits to retirees in the coming years.

C. Policy Setting:

The results of actuarial studies guide financial decisions and help set appropriate policies.

Example:

An insurance company might use these results to determine the appropriate premium to charge its customers.

A. Scenario Forecasting:

Actuaries create multiple scenarios to assess the potential impact of risks.

Example:

Actuaries might develop scenarios for mortality rates in case of a pandemic.