Underwriting Risk Estimation

Capstone Sponsor: *Frederick Alves* | MIT Advisor: *Rodrigo Verdi* | *Marian Huot & Badiss Ben Abdallah*

MIT Sloan MANAGEMENT

Problem Statement and Challenge

Itaú Unibanco, Latin America's largest financial institution, manages a diverse insurance portfolio. The current **SUSEP** (*Superintendência de Seguros Privados*) standard formula overestimates capital needs by ignoring Itaú's specific risk profile. Under **ORSA** (Own Risk and Solvency Assessment), insurers must assess solvency based on internal risk. Itaú's challenge is to develop a transparent internal model that accurately quantifies underwriting risk and improves capital efficiency.

Business Impact

- ✓ ***Comply with ORSA regulation***
- ✓ ***Estimation of required capital for each insurance product***
- ✓ ***Optimization of reinsurance policy***

Possibly unlocking up to **$100 million** for investments

* ***Upon internal model validation by regulators***

Portfolio Overview and Risk Modeling

PROPERTY | HOMEOWNER | TRAVEL | CARDS | LIFE & PENSION

5 products

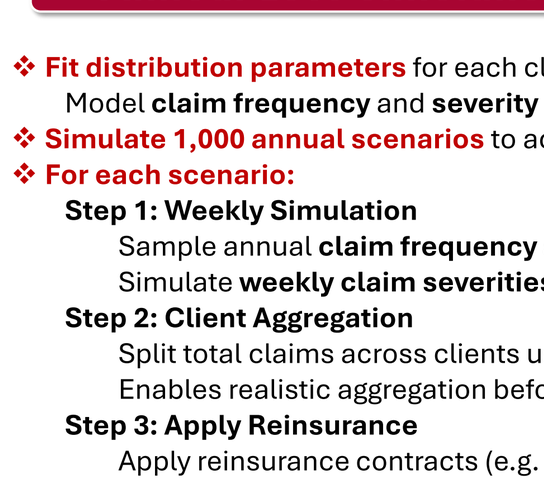
What Are We Trying to Model?

We are modeling **underwriting risk**, specifically the **total annual claims cost** across multiple insurance products. This involves understanding both:

- **How often** claims occur (**Frequency**)
- **How large** each claim tends to be (**Severity**)

These two components are **modeled separately** and then **combined via Monte Carlo simulation** to estimate annual losses, which feed into capital requirement calculations.

Clustering



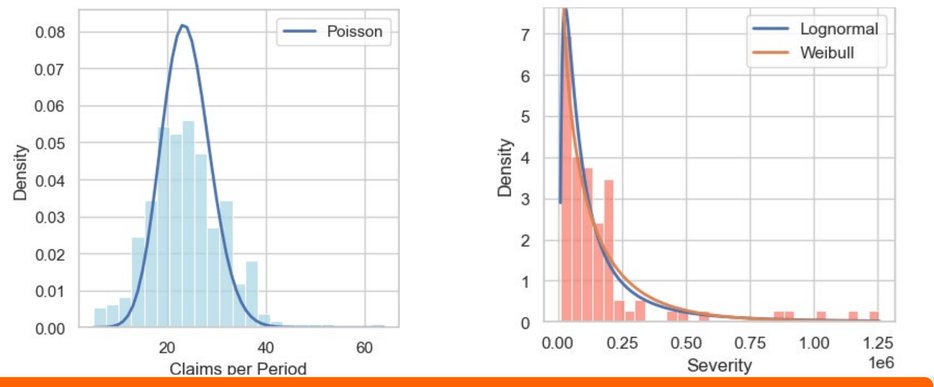
Why Clustering ?

- **Different coverages** exhibit heterogeneous claim patterns (e.g., fire vs. theft).
- **Clustering** allows risk pooling across coverages with similar statistical behavior, improving model robustness.

How We Clustered ?

- Used **tail-sensitive k-means** on statistical features of each coverage:
  - **Mean & variance of frequency**
  - **Mean & variance of severity**
- Grouped coverages into **homogeneous risk segments** for joint modeling.
- **Enabled cluster-specific** frequency (Poisson) and severity (Lognormal/Weibull) fitting.

Risk Simulation Pipeline



Fit distributions of claim frequency and severity

We assess how closely the simulation matches real-world data using **Relative Quantile Error (RQE):**

$$RQE = \frac{1}{|Q|}\sum_{q\in Q}\left|\frac{Q_q^{sim} - Q_q^{emp}}{Q_q^{emp}}\right|$$

Selected quantiles:

- **25%, 50%, 75%** → Represent **typical losses**
- **90%** → Captures **extreme tail risk** — critical for regulatory capital

Lower RQE = better match between simulation and historical losses

Why it matters:

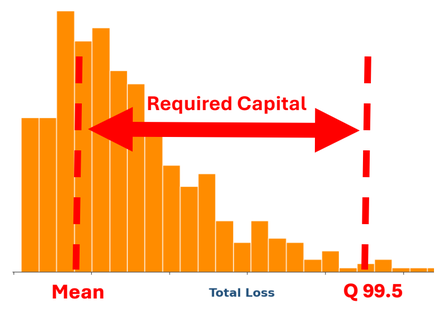
High-tail accuracy ensures the model realistically reflects **worst-case scenarios**, strengthening capital planning and ORSA compliance

How Do We Evaluate the Fit Accuracy ?

Annual Loss Simulation with Reinsurance

- ❖ **Fit distribution parameters** for each cluster:
  Model **claim frequency** and **severity** separately.
- ❖ **Simulate 1,000 annual scenarios** to account for variability in claims.
- ❖ **For each scenario:**
  - **Step 1: Weekly Simulation**
    Sample annual **claim frequency** and distribute across 52 weeks.
    Simulate **weekly claim severities** independently.
  - **Step 2: Client Aggregation**
    Split total claims across clients using a **claim-to-client ratio**.
    Enables realistic aggregation before applying reinsurance.
  - **Step 3: Apply Reinsurance**
    Apply reinsurance contracts (e.g. per-client or aggregate retention).

- ❖ **After all scenarios: Capital Requirement**
  - Plot the distribution of annual losses **with and without reinsurance**.
  - Compute **key quantiles** (e.g., 99.5%) for capital estimation.
  - Validate the model by comparing to **historical test losses**.



Results and Key Takeaways

Products	Refined Clustering	Per-Coverage Model	1-Cluster Baseline
Property	**21.34%**	102.45%	28.99%
Homeowner	**9.18%**	10.42%	10.02%
Travel	**34.66%**	101.83%	39.47%
Card	**20.78%**	22.89%	20.93%
Life & Pension	**4.87%**	23.92%	10.72%

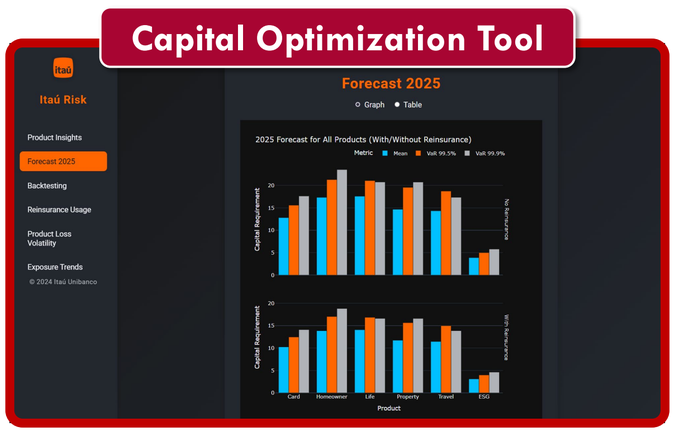
Refined Clustering RQE

- The SUSEP standard formula **significantly overestimates** underwriting risk by ignoring portfolio structure and diversification.
- A **cluster-based internal model** enables more granular, data-driven segmentation, improving model accuracy and interpretability.
- **Capital requirements can be reduced** by **tuning reinsurance thresholds:** allowing for earlier reinsurance activation and more efficient risk transfer.
- **Backtesting with quantile errors** confirms the model's robustness and alignment with historical outcomes.
- The final model is **ready for ORSA deployment**, supported by a **Capital Optimization Dashboard** that enables data-driven decision-making and stress testing.

Practical applications

- **ORSA Reporting**: Aligns with regulatory expectations for internal model validation.
- **Capital Optimization**: Quantifies impact of reinsurance structures and tuning priority thresholds.
- **Portfolio Steering**: Identifies high-risk clusters to support product repricing or underwriting actions.
- **Scenario Testing**: Enables simulation under stressed environments to support risk planning.

Capital Optimization Tool



Team members

Marian Huot

Badiss Ben Abdallah