Risky Business - How Operational Changes Impact Surety Risk

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**MIT MANAGEMENT SLOAN SCHOOL**

Liberty Mutual INSURANCE

Project Background & Context

Objective & Surety at Liberty Mutual

Project goal: Develop a **comprehensive, quantifiable understanding** of how changes to underlying **contractor's business operations affect surety bond risks**.

- **Surety bonds:** provide a **guarantee** that specific **contracted tasks will be fulfilled**
- **Large construction projects** throughout the world depend on Surety bonds
- **Liberty Mutual** is the **number one surety provider both** in the US and the world
- Customers in 60 countries, projects up to $750M and **$1.7B exposure limit**

Surety
Obligee — Surety Bond — Principal
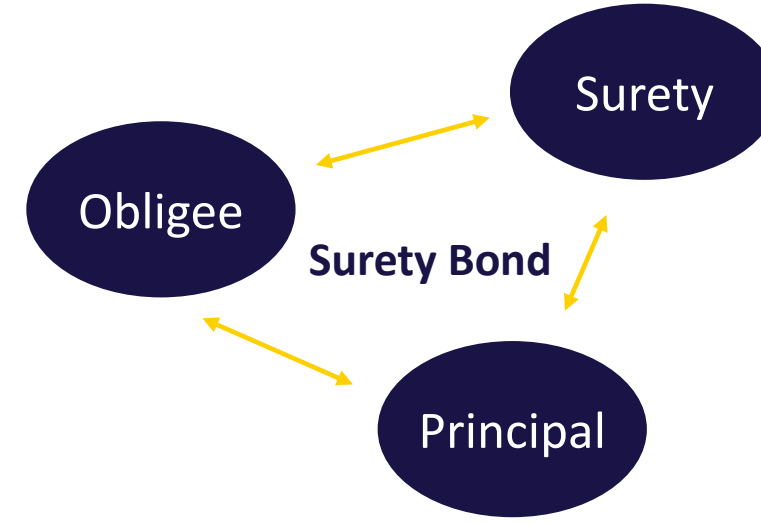
Why Operational Data?

- Liberty Mutual currently assesses contractor risk using their financial statements, work history, reputation and their relationship to underwriters
- This is the **first attempt to enrich this data with operational changes**
- **Supporting underwriters** in this process with **more accurate** and **earlier** indications of risk
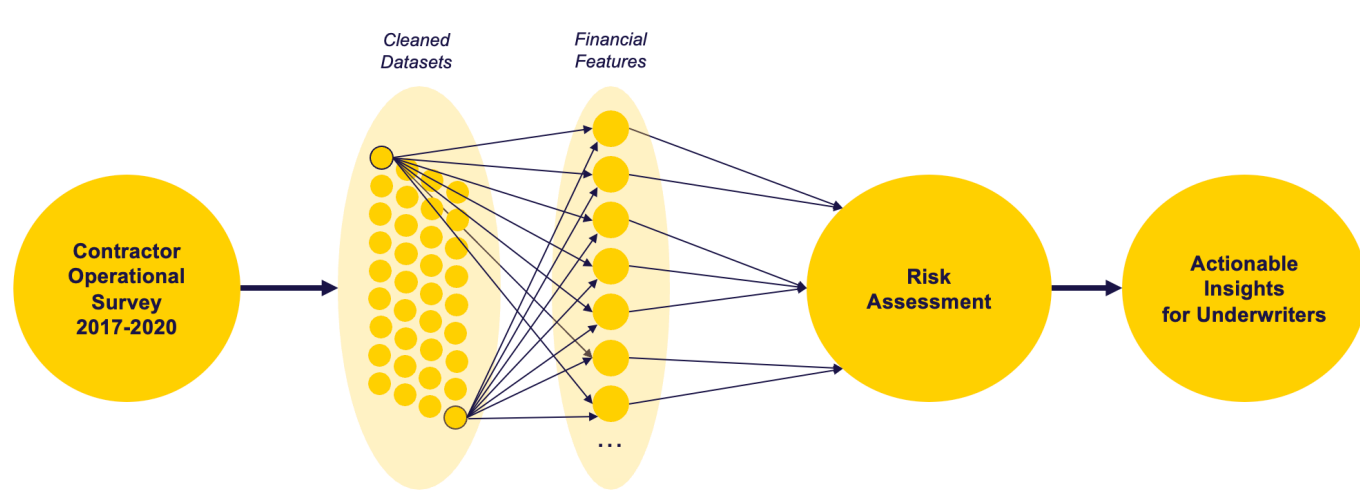
Data

Data Exploration

4

4 Years of survey results for contractor accounts

7

7 Questions related to categories of operational risk

Data Handling

Cleaned Datasets — Financial Features

Contractor Operational Survey 2017-2020 → Risk Assessment → Actionable Insights for Underwriters
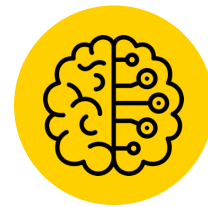
Large degree of freedom problem: many possibilities to format our dataset e.g. temporal lags and handling of multi-tiered categorical variables
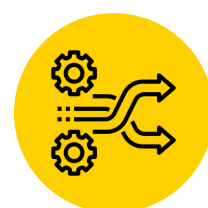
Challenges: Data inconsistencies, statistical outliers and low incidence variables
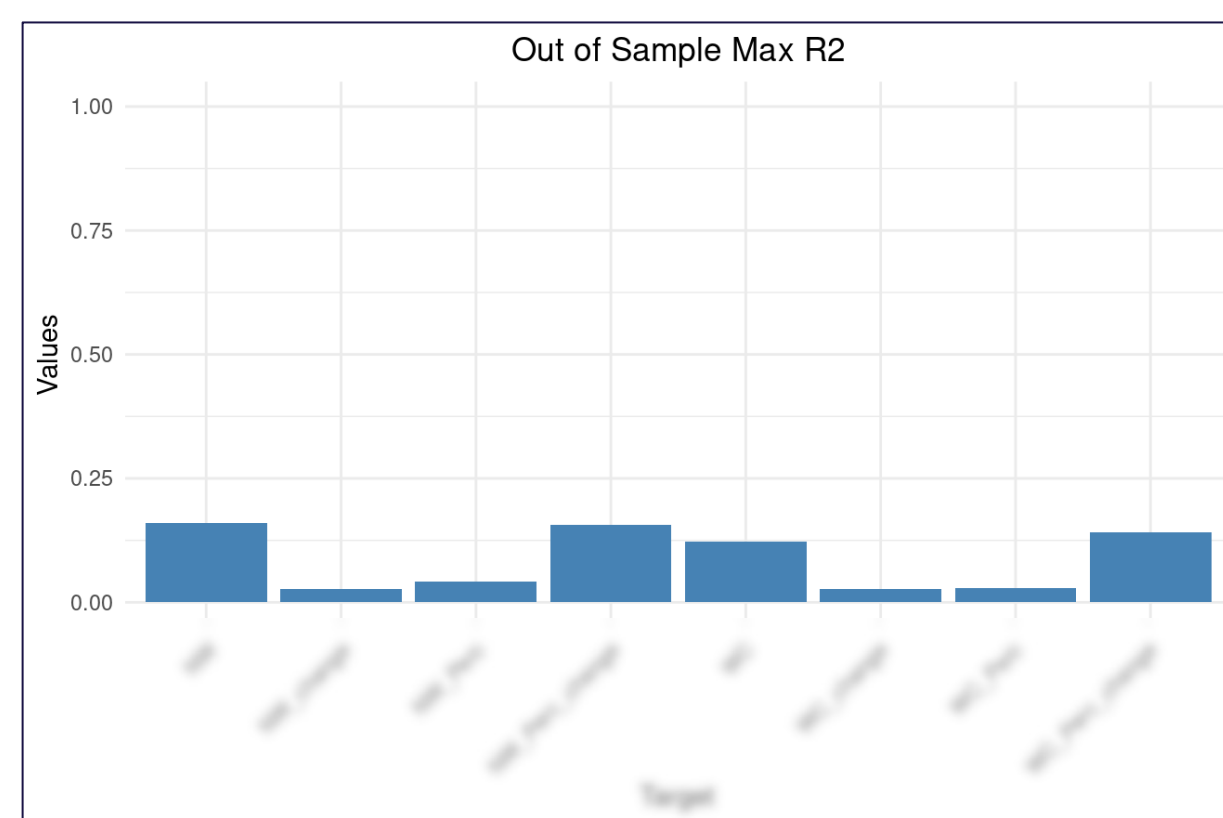
Supervised Learning

Regression & Trees

Models: OLS, LASSO, Ridge, CART, Ensemble Models

Transformations: Temporal Lags, Log Transforms, Outlier Filtering, YoY % Change, Change Absolute Values, Binarized Targets, Disaggregation by account type

Out of Sample Max R2

Novel business insights generated despite limited predictive performance in R2

Optimization

If an operational change happens today, in how many years will that be reflected in financial features?

Optimization-based multi-objective-regression

$$\min_{\beta_1,\beta_2,z,s} \quad ||y_1 - \overline{X}\beta_1||_2^2 + ||y_2 - \overline{X}\beta_2||_2^2 + \lambda||\beta_1||_2^2 + \lambda||\beta_2||_2^2$$

$$s.t. \quad ||\beta_1 - \beta_2||_2^2 \le \delta$$
$$|\beta_{1jt}| \le M \cdot z_{jt} \qquad \forall j,t$$
$$|\beta_{2jt}| \le M \cdot z_{jt} \qquad \forall j,t$$
$$s_{gt} \ge z_{jt} \qquad \forall j \in G_g$$
$$\sum_t s_{gt} = 1 \qquad \forall g$$
$$z_{jt} \in \{0,1\}, \qquad \forall j,t$$
$$s_{gt} \in \{0,1\}, \qquad \forall g,t$$

*The motivation was to Identify the **optimal temporal lags** for different **groups** of operational changes*
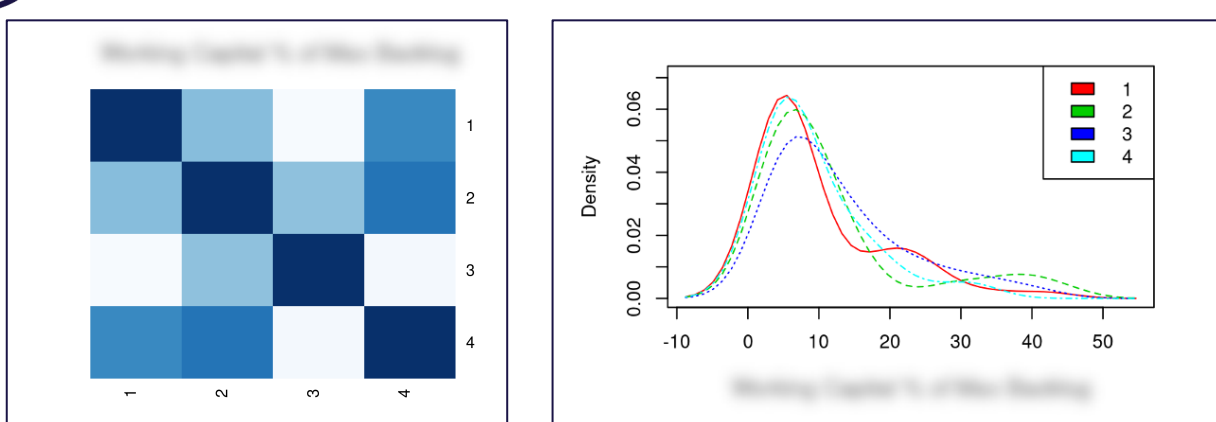

Out of Sample R2
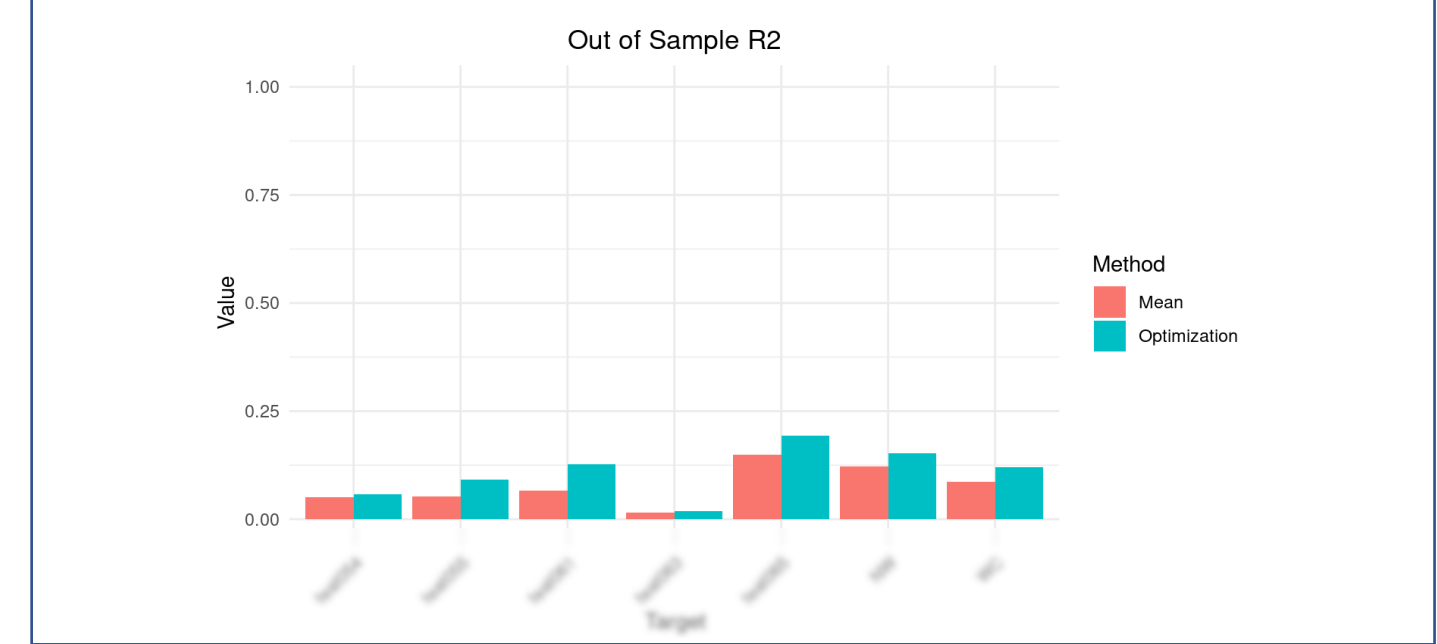
Unsupervised Learning

Clustering

① **Methodology**:

Clustering on Operational Features
↓
Analysis of Financial Distribution within Clusters
↓
Evaluation using Kologorov Smirnoff and Lepage Tests

② **Sample Outcome:**

③ **Insights:**
- **Changes in variance within clusters are** equally relevant to describe risk as mean
- **Statistically significant correlations** identified and hypotheses confirmed

Low Level Insights into High Level Actions

Univariate Relationship Analysis & OCA Dashboard for Underwriters

To **support Liberty Mutual underwriters** in risk assessment, we **developed an interactive Shiny dashboard** including the most **significant correlations** between specific operational and financial variables found over the 4 years and all accounts
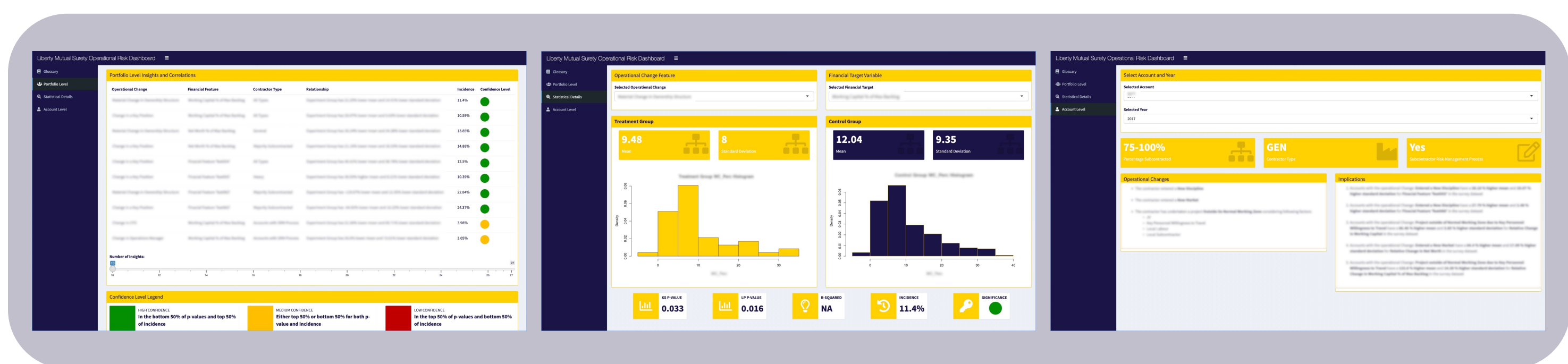
Glossary and context to educate user and **abstract** technical **complexity**

Portfolio level strongest **correlations** presented with 2 levels of granularity

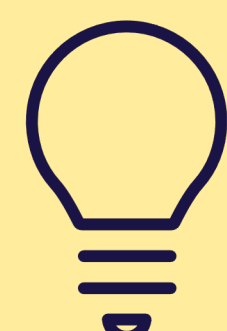**Actionable insights** on the **account level** based on operational changes

Parts of dashboard blurred for confidentiality reasons
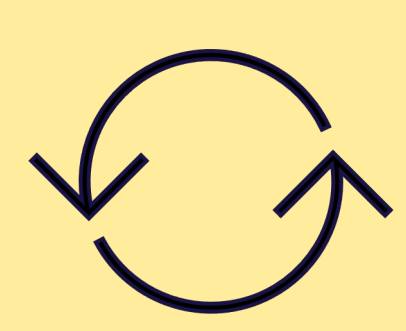
Business Impact & Results

First time that operational data has been **integrated** into surety **risk assessment** at Liberty Mutual

Identified **statistically significant correlations** between operational changes and financial risk

Fully responsive, easily interpretable **dashboard for underwriter support** in daily work

Repeatable process and pipeline set up to populate for coming years as survey signal increases