Robust Optimization in Portfolio Management

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Executive Summary

- Robust portfolio management that achieves target return and minimizes risk simultaneously
- Formulation with ellipsoidal uncertainty set
- More resilient to noises and changes in market such as a Black Swan event

Problem Statement

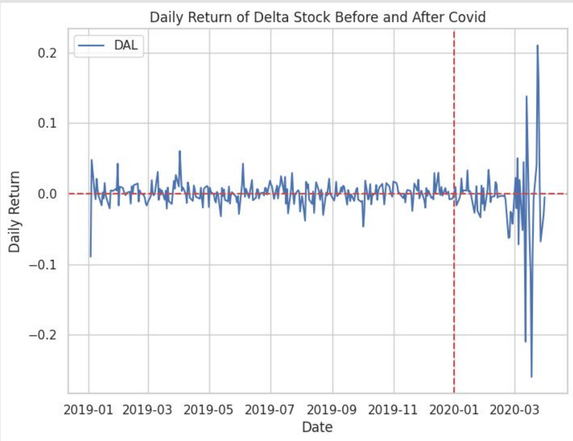
Notable drawbacks of mean-variance framework:

- Difficulty in obtaining accurate input estimates
- Sensitivity of the optimal portfolio to inputs
- Single factor to drive returns (i.e. market factor)

Data Description

We selected 10 stocks from 5 different sectors defined by The Global Industry Classification Standard (GICS®)

- Healthcare, Financials, Industrials, Technology, Consumer Discretionary



Formulation

Objective: Minimize variance (risk) of portfolio
Decision Variable: Weight (percentage) of each stock
Constraint:

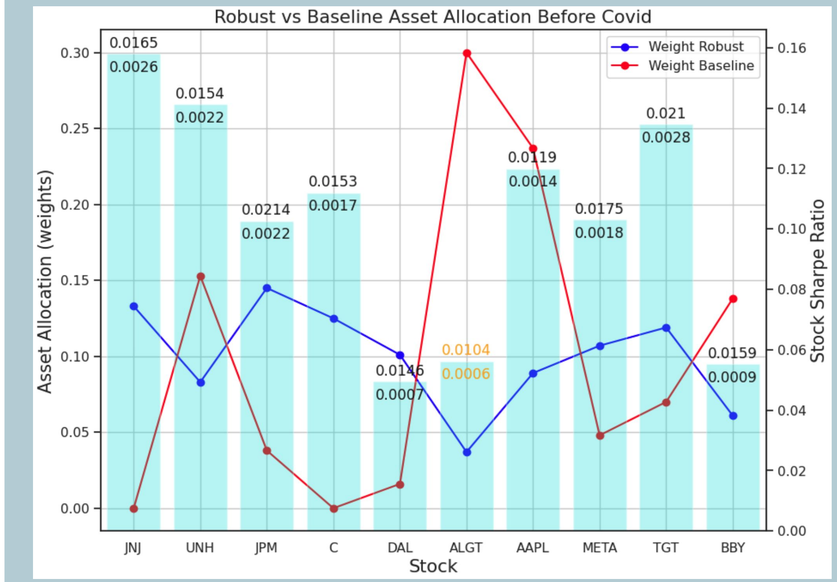
- Target return is met (0.04% daily return)
- Long only
- Limited weight in single position and sums to 1

Assumptions:

- Covariance of any pair of stock is static

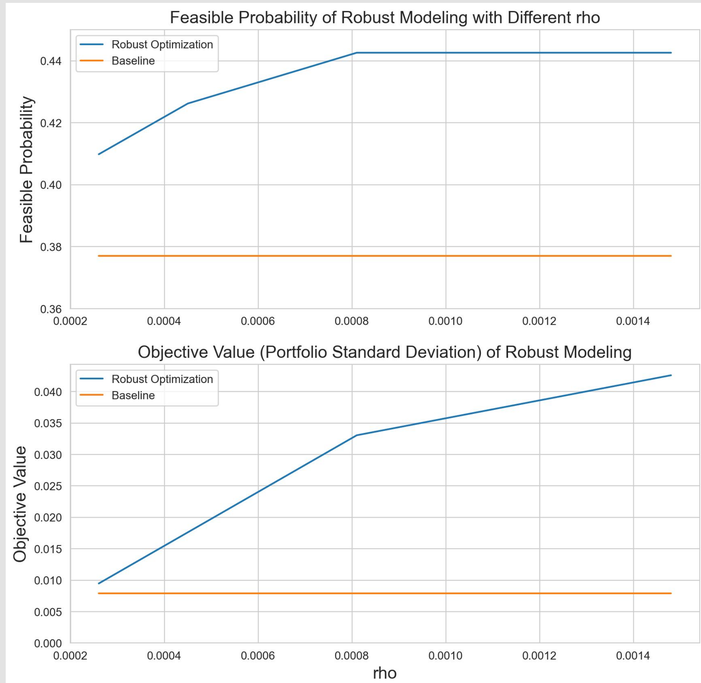
$$
\begin{aligned}
&min \quad w^T \Sigma w \\
&s.t. \quad \bar{r}^T w + \rho \|(\Sigma^{-\frac{1}{2}})^T w\|_2 \geq \beta \\
&\quad w_i \leq t, \ \forall i = 1, \ldots, n \\
&\quad \sum w_i = 1 \\
&\quad w_1, \ldots, w_n \geq 0
\end{aligned}
$$

Key Findings



- Robust model invests wiser following Sharpe Ratio
- Baseline model cares more about lowering risk

Impact



- For same target return, robust model gives less portfolio turnover with slightly higher risk, as the perturbations in market increase
- In particular, though feeding on data at "good" years, robust model can better survive crisis

Future Work

- Utilize factor model to forecast financial return and interpret allocation at broad factor level
- Expand to more asset classes
- Other considerations: liquidity, turnover, transaction cost, short position