CS 524: Introduction to Optimization Fall 2020

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CVaR Portfolio Optimization with Sector Caps – Project Specs

1. What is the issue being addressed?

Many simple portfolio optimization projects focus only on average returns, ignoring significant downside losses. In problem three of homework five, we had to find the best combination of investments given specific constraints, but we only considered expected return, not risk. This project will build an equity portfolio that controls tail risk using Conditional Value-at-Risk (CVaR). The scope of the project will remain realistic, with basic position and sector limits. The decision is the allocation weight for each stock, and the goal is to find the weights that achieve a chosen return while minimizing the expected loss on the worst days.

2. Where does the data come from, and how will it be obtained?

I will pull three years of daily adjusted close prices for an initial small sample of stocks. Starting with ten popular stocks to ensure the model's correctness, then expanding to 30 or more. The data for this will be pulled from the Yahoo Finance API (yfinance), then, using Python, the relevant data will be calculated. I will save the data into two CSV files: prices.csv and returns.csv, containing the prices and converted log returns, respectively. I'll clean and verify the data to check for null or odd values, and perform a brief exploratory data analysis to set the project's background.

3. What is the optimization problem underlying this project?

I will solve a scenario-based linear program to determine portfolio weights that control tail risk. This is based on the Rockafellar and Uryasev CVaR model. The model minimizes the CVaR at level α subject to a simple expected return target and diversification limits. A possible extension to this model would be to convert it into an MIP, as was done in problem three of homework five, including indicator variables.

4. What are the deliverables?

A GAMSPy notebook that reads the CSVs, builds the scenario matrix for daily returns, and solves the CVaR LP for the chosen setting. A small helper function that lets a user supply any ticker list (stocks), regenerates prices and returns, and re-runs the model for reproducibility. Figures that include a return versus CVaR curve from a short sweep, a bar chart of weights grouped by sector, and a simple backtest versus an equal-weight benchmark. A brief write-up that reports the chosen α, position, and sector bounds, the optimal weights, expected return, VaR, and CVaR, plus which constraints bind.

5. Other points for me to consider when evaluating?

For now, I am most concerned with the computational cost of this problem and ensuring I correctly collect and calculate my data. If runtime ever becomes an issue, I will shorten the lookback window, keep the model long only, and avoid optional integer features such as cardinality.

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[1] https://sites.math.washington.edu/~rtr/papers/rtr179-CVaR1.pdf

[2] https://www2.mathematik.hu-berlin.de/~romisch/SP01/Uryasev.pdf

[3] https://finance.yahoo.com/sectors/financial-services/financial-data-stock-exchanges