Robo-Advisor App with Sentiment Analysis

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Table of contents

Why Robo-advising?

Reduce Cost

Instead of paying expensive fee to traditional advisory, robo-advisor charges on usage in a much lower price.

Reduce Human Biases

Robo-advising eases the biases on Disposition Effect (selling), Trend Chasing (buying), and Rank Effect.

Markowitz Mean-Variance Analysis

Maximizing Utility Function

- Risk and Return are Considered
  - converts “consumption” and “satisfaction”
  - **non-decreasing** and **concave**
- 100 Days Lookback Period
  - **time-consistent** optimal strategy
- Conventional Investment Wisdom in Long Term
  - invest more money in risky assets: **leverage**
  - prefer long than short: **short threshold**, **long-short threshold**

Return Risk

$$\text{maximize} \quad \omega \cdot \mu - \frac{\gamma^2}{2}\sigma^2$$

$$\text{subject to} \quad \omega_i \geq \theta_s \qquad \text{Short Threshold}$$

$$\omega_i \leq \theta_l \qquad \text{Long Threshold}$$

$$\sum_i \omega_i \geq \kappa \qquad \text{Long-Short Ratio}$$

$$\sum_i |\omega_i| \leq \lambda \qquad \text{Leverage}$$

$$\sqrt{\sigma^2} \leq \rho \qquad \text{Risk Level}$$

$$\frac{|w_T - w_t|}{2} \leq \phi \qquad \text{Turnover}$$

Backtesting Setup

Simulation Period:

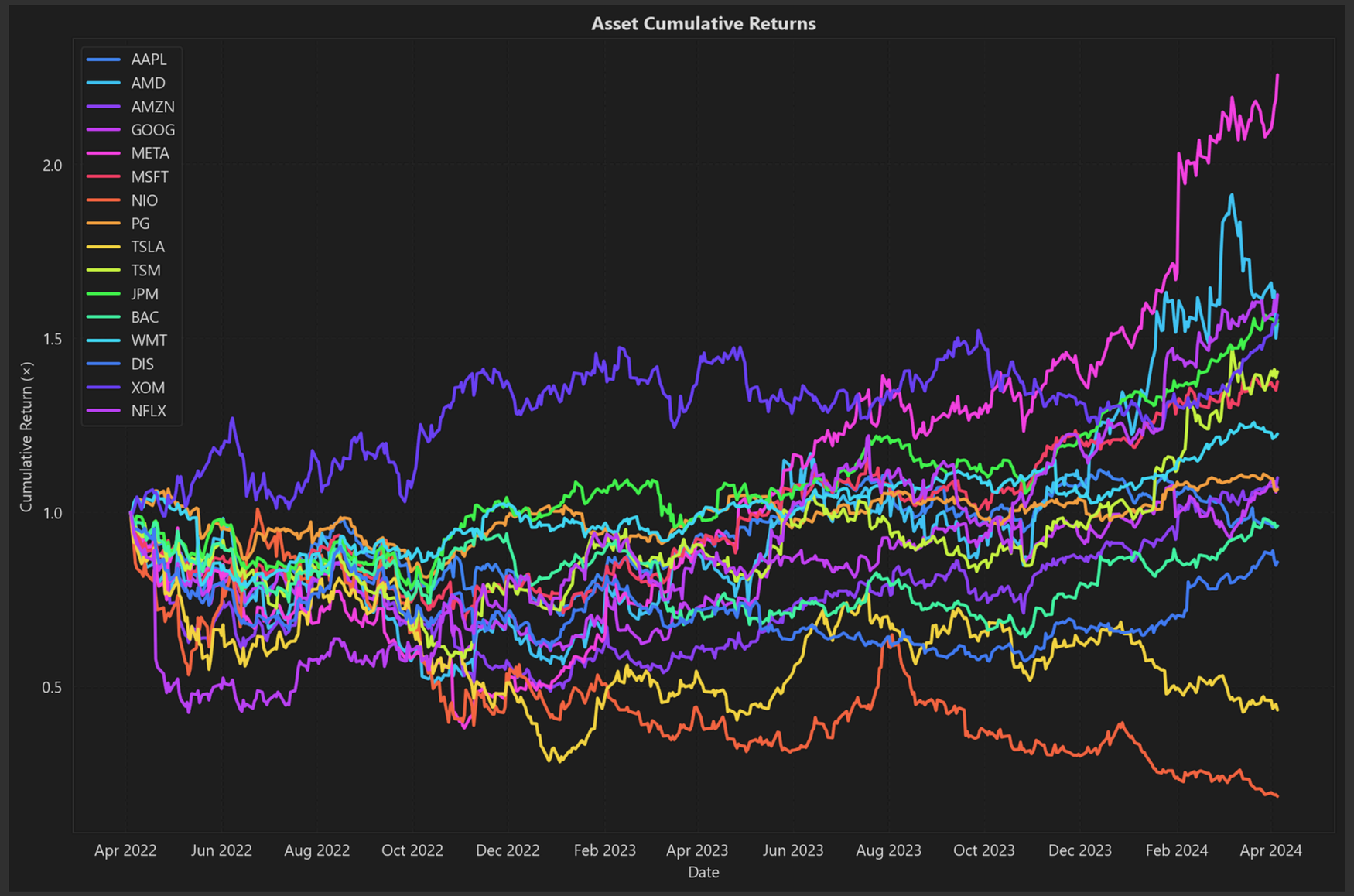
Apr 2022 - Apr 2024

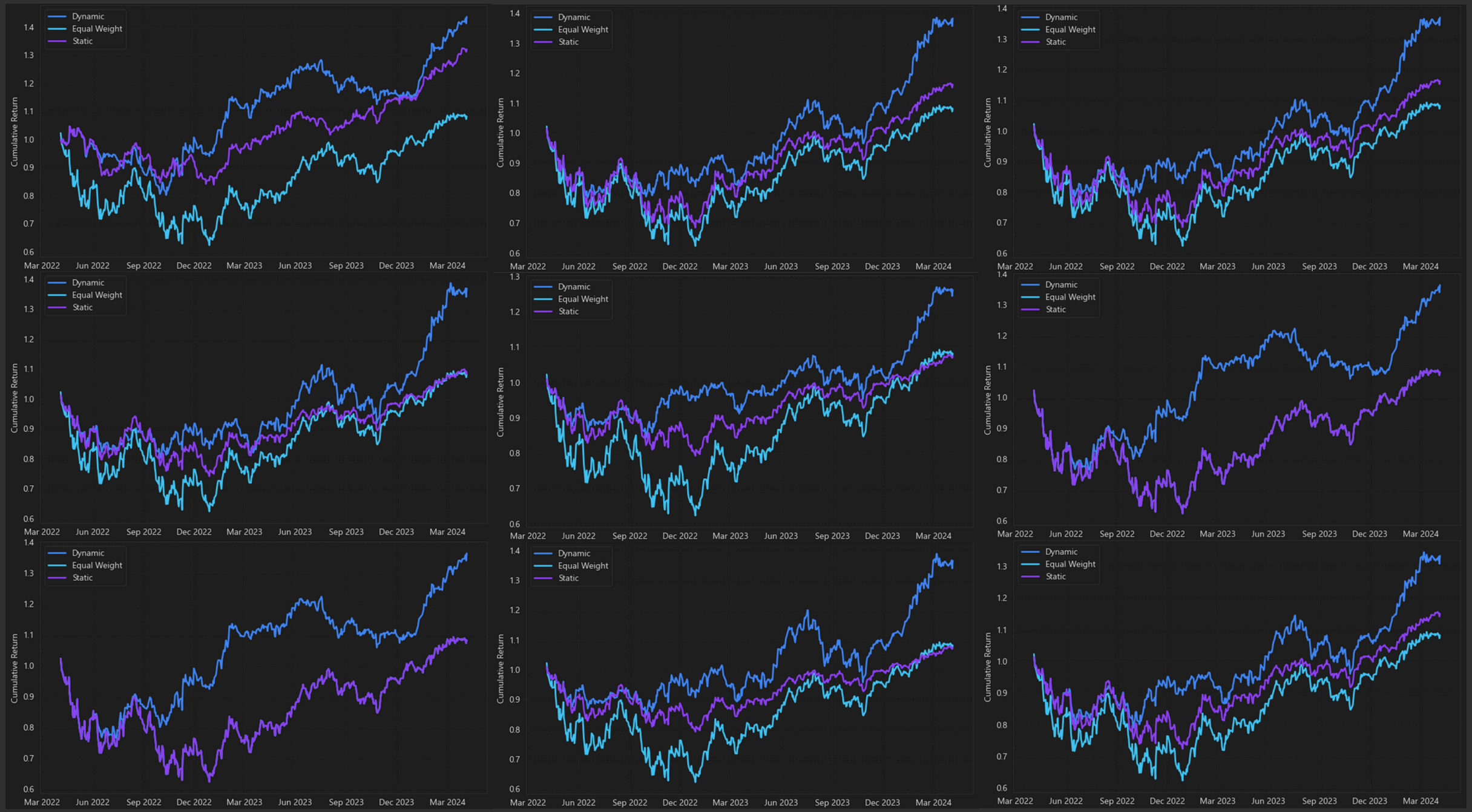
Stocks:

as shown in label

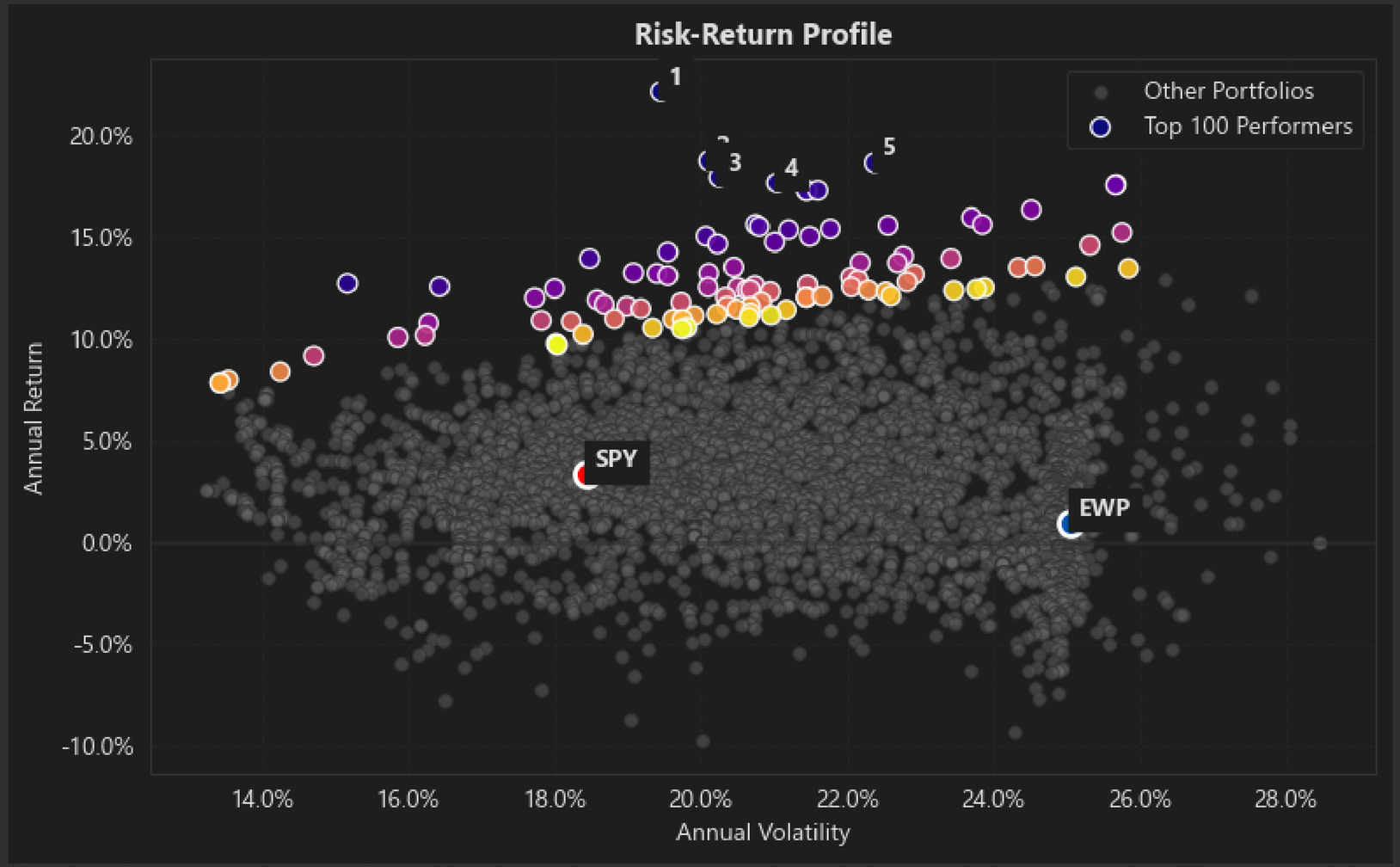
Parameters:

τ	Rebalance Period
γ	Gamma
θ_{short}	Short Threshold
θ_{long}	Long Threshold
κ	Long-Short Ratio
λ	Leverage
ρ	Risk Level
ϕ	Turnover

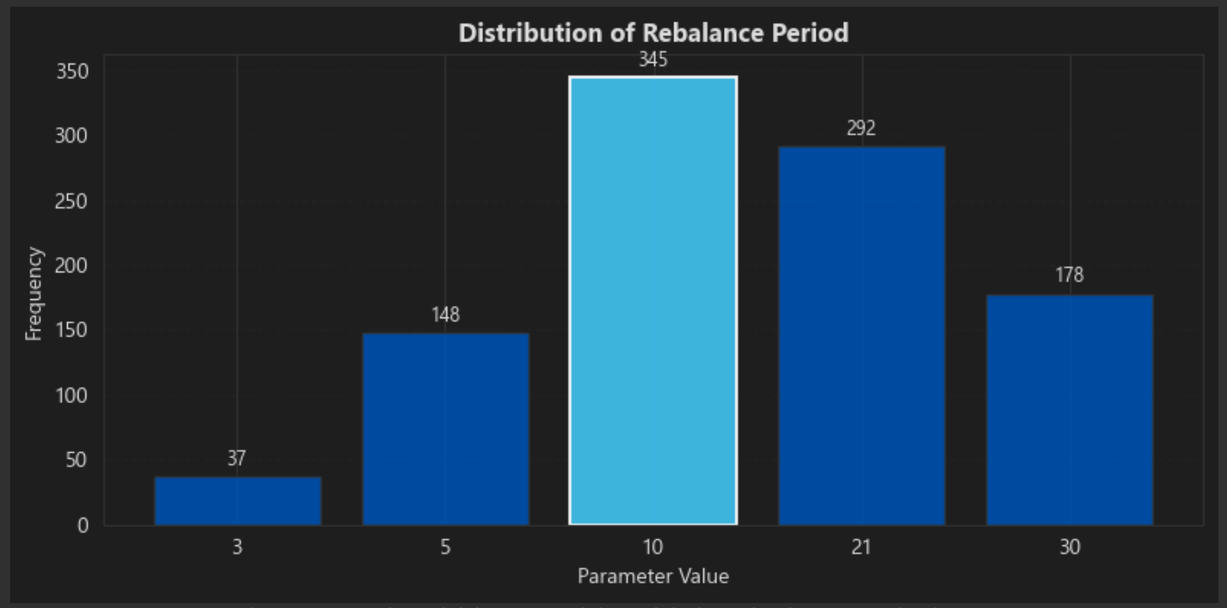



Dynamic
Equal Weight
Static
Cumulative Return
Mar 2022
Jun 2022
Sep 2022
Dec 2022
Mar 2023
Jun 2023
Sep 2023
Dec 2023
Mar 2024

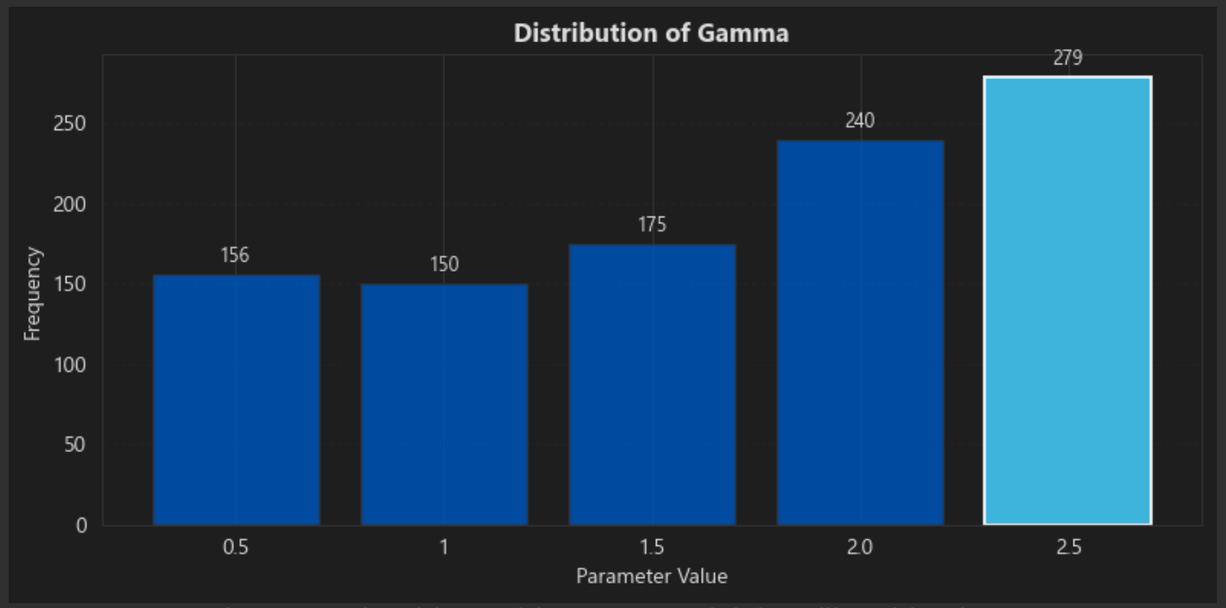
How should we set our parameters for long term investment?



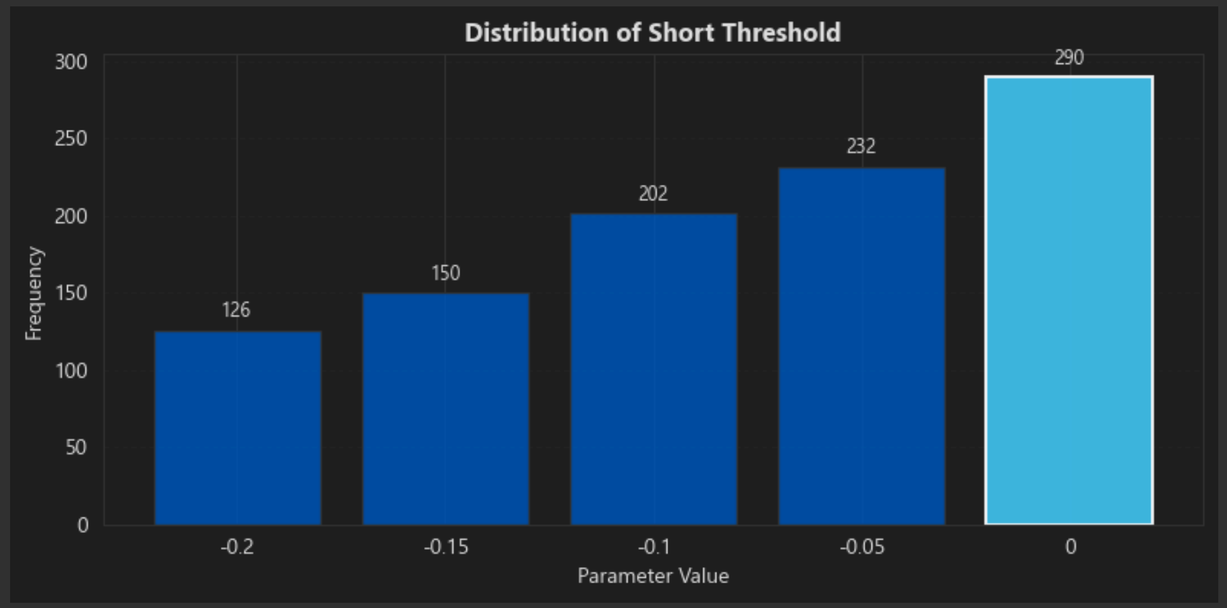
Simulate 5,000 out of 390,625 combinations of parameters and get their cumulative returns for different portfolios.
Locate the top 100 performers in term of annualized Sharpe Ratio (return/risk).



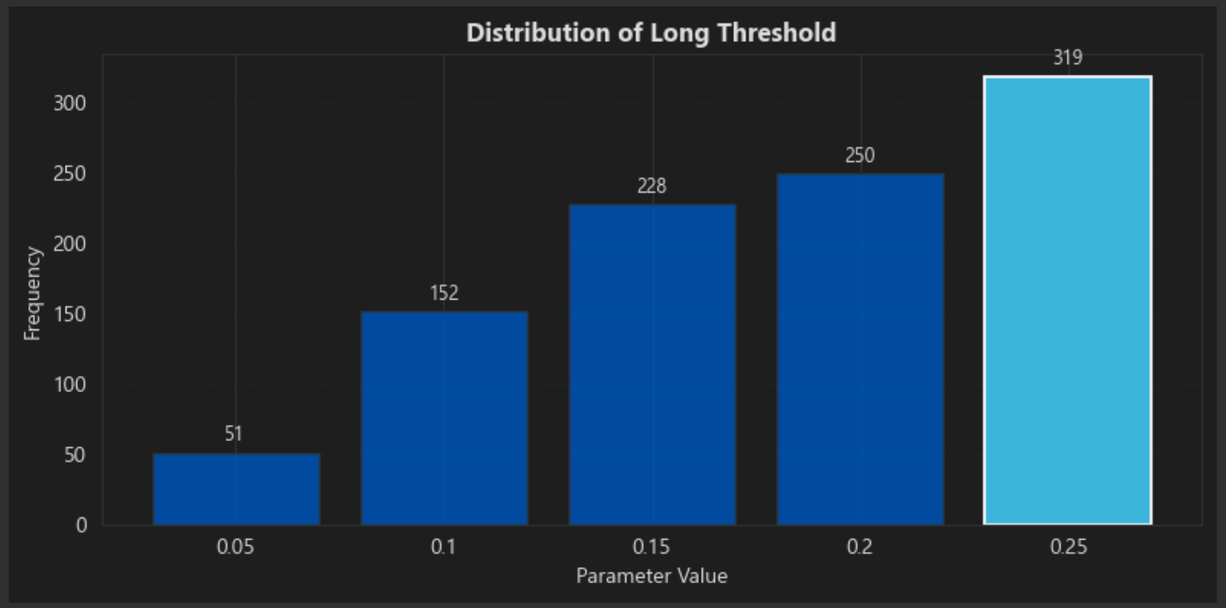
investor should have mid-to-high rebalance window



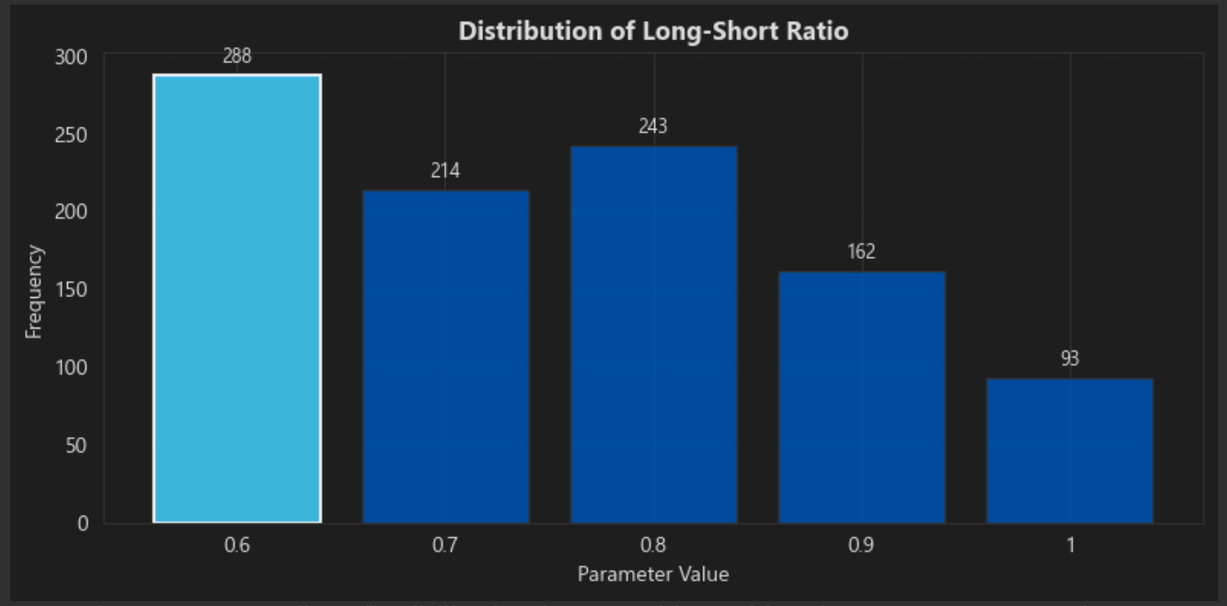
investor should consider more at risk in utility objective



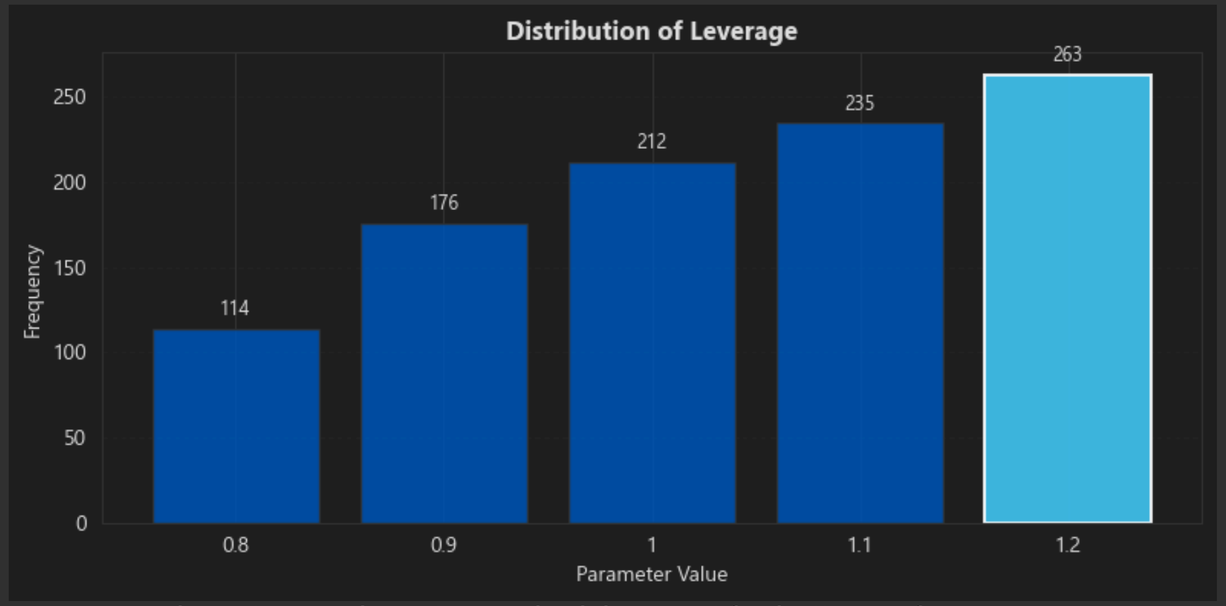
investor should not invest too much in short selling



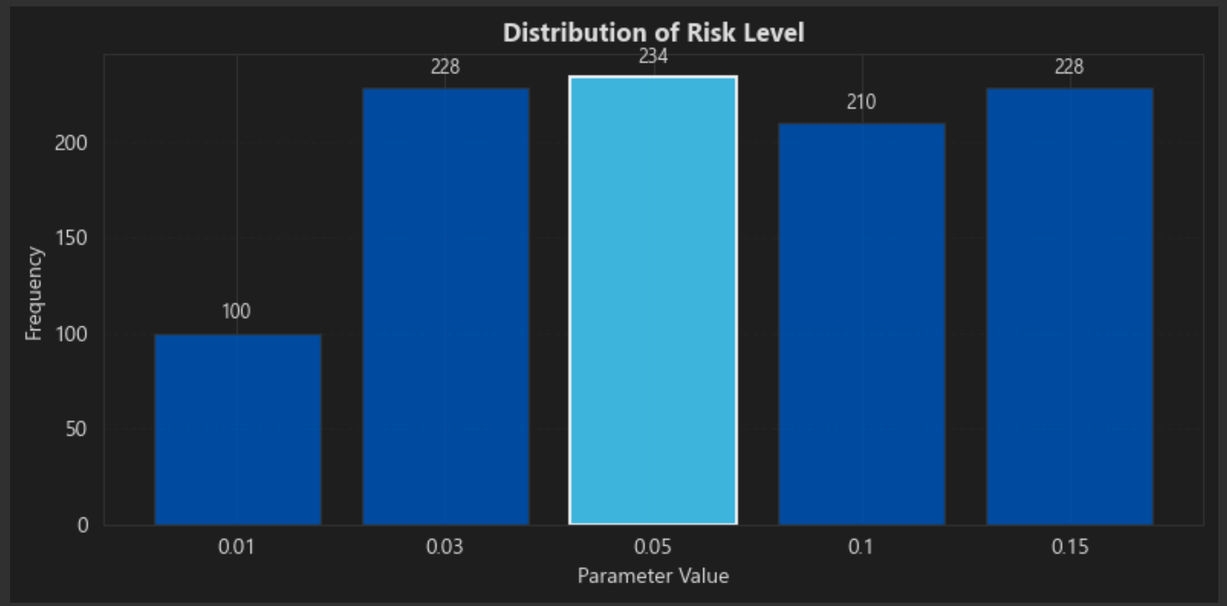
investor can allow slightly higher weight for individual stock



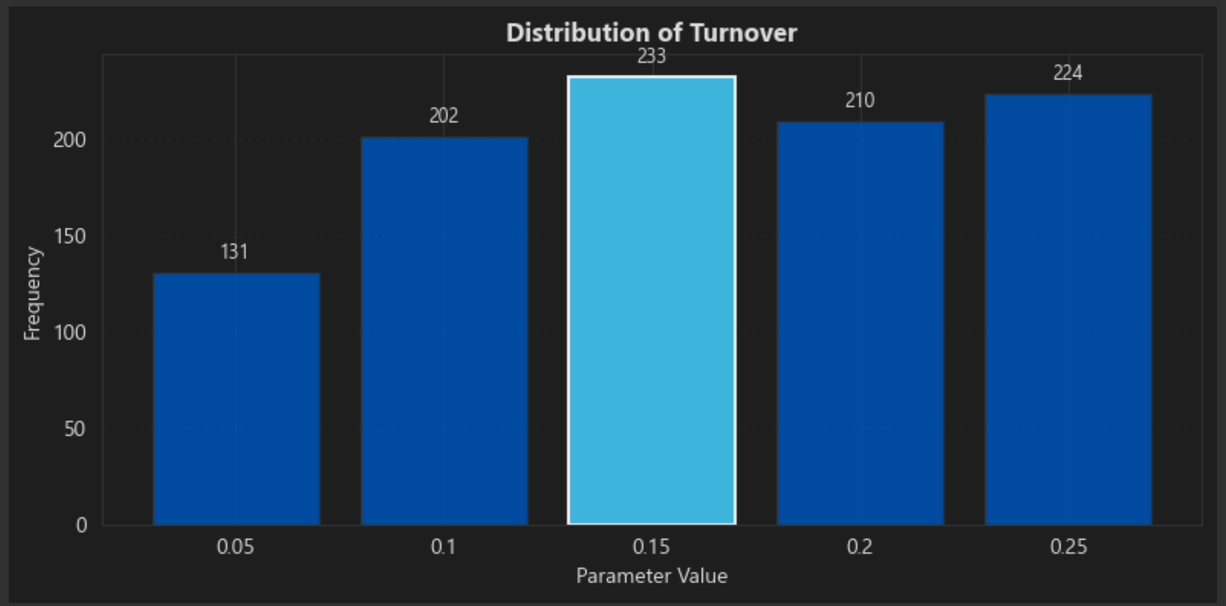
investor can allow flexibility in short position with other proper constraints



investor can invest more in risky asset for better performance



investor should consider risk level as supplement of gamma



investor can allow higher turnover for flexibility

Gathering User Preferences

Behavior Assessment

High-level Questions:

- Personal Goal
- Risk Tolerance
- Financial Situation
- Investment Preference

Technical Parameters

- Parameters are initialized according to the response
- Further customizations are allowed

Parameter/Index	0	1	2	3	4
Rebalance Period	3	5	10	21	30
Gamma	0.5	1	1.5	2.0	2.5
Short Threshold	-0.2	-0.15	-0.1	-0.05	0
Long Threshold	0.05	0.1	0.15	0.2	0.25
Long-Short Ratio	1	0.9	0.8	0.7	0.6
Leverage	0.8	0.9	1	1.1	1.2
Risk Level	0.01	0.03	0.05	0.1	0.15
Turnover	0.05	0.1	0.15	0.2	0.25

Options/Parameters	Short Threshold	Long Threshold	Leverage	Gamma	Risk Level
Growth	4 (0)	3 (0.2)	3 (1.1)	2 (1.5)	3 (0.1)
Income	4 (0)	1 (0.1)	1 (0.9)	3 (2)	1 (0.03)
Capital Preservation	4 (0)	0 (0.05)	0 (0.8)	4 (2.5)	0 (0.01)
Balanced Growth & Income	4 (0)	2 (0.15)	2 (1)	3 (1.5)	2 (0.05)

Options/Parameters	Rebalance Period	Long-Short Ratio	Turnover
A few months to 1 year	0 (3)	2 (0.8)	3 (0.2)
2 to 3 years	1 (5)	2 (0.8)	3 (0.2)
4 to 5 years	2 (10)	2 (0.8)	2 (0.15)
Over 5 years	3 (21)	0 (1)	1 (0.1)

Options/Parameters	Gamma	Risk Level
Very Low	[i] -> [i+1]	[i] -> [i-1]
Low		
Moderate		
High		
Very High	[i] -> [i-1]	[i] -> [i+1]

Options/Parameters	Gamma	Risk Level	Turnover
Sell everything	[i] -> [i+1]	[i] -> [i-1]	[i] ->[i+1]
Sell some			
Hold			
Buy more	[i] -> [i-1]	[i] -> [i+1]	[i] ->[i+1]

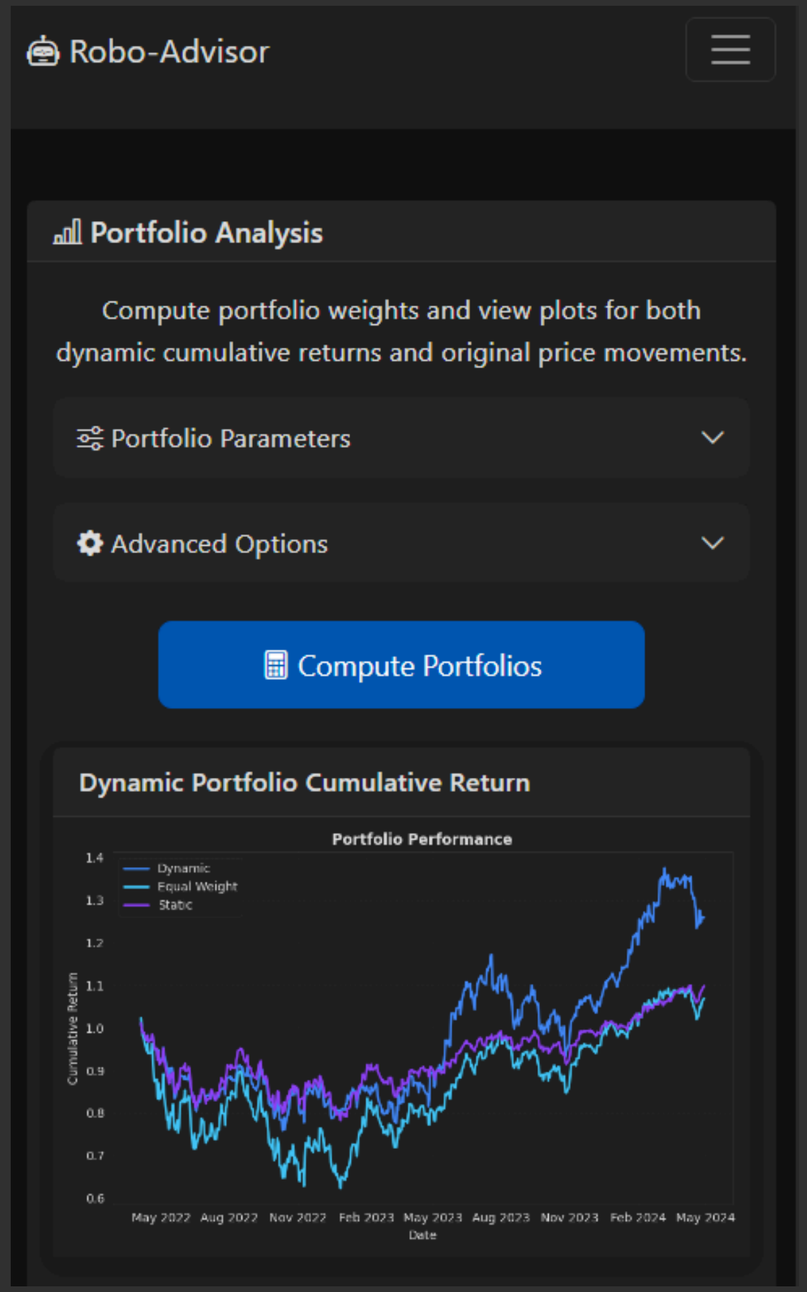
Options/Parameters	Short Threshold	Leverage
Under $50,000		[i] -> [i-1]
50 to 100k		
100 to 200k	[i] -> [i-1]	
Over $200,000	[i] -> [i-1]	[i] -> [i+1]

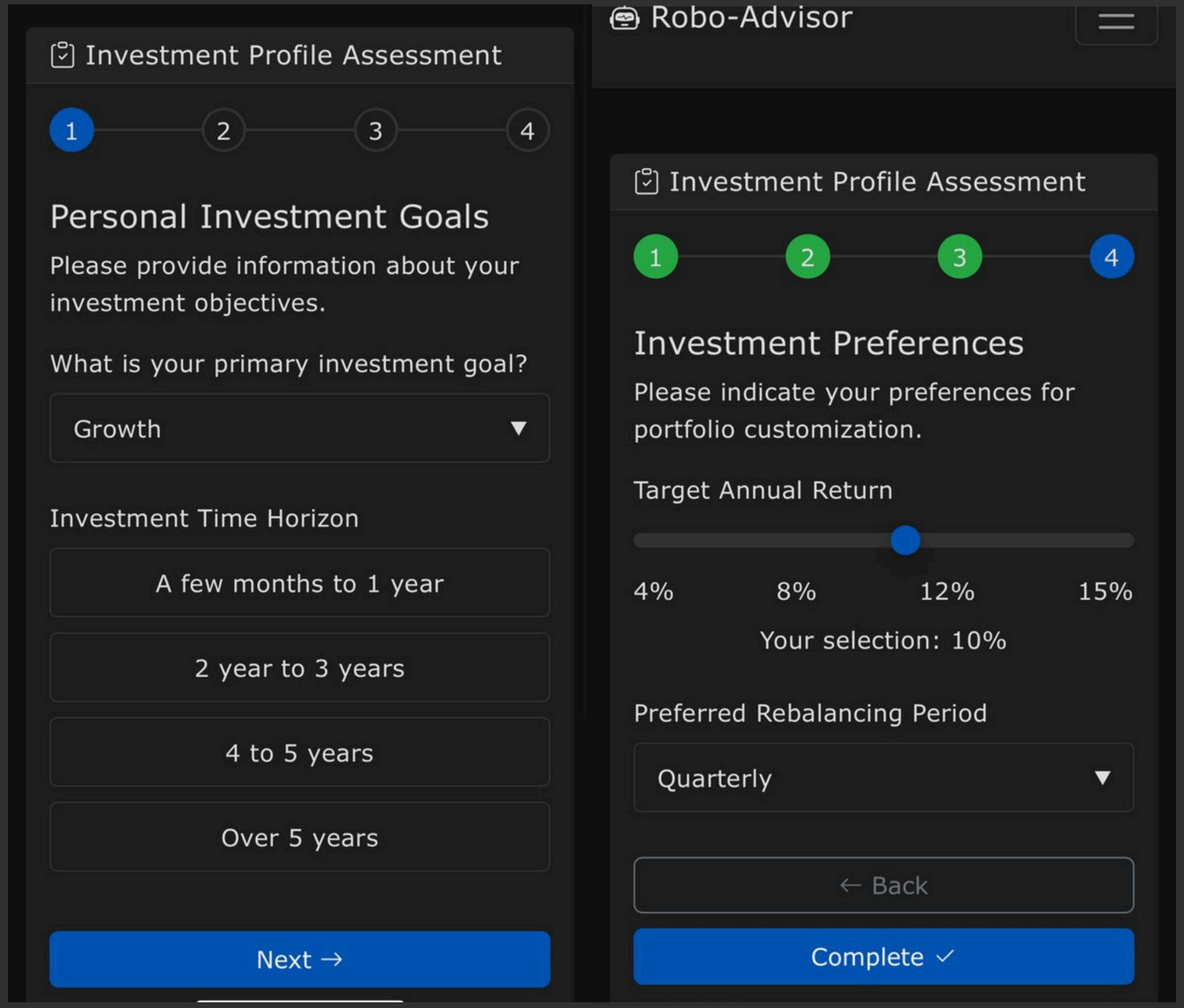
Options/Parameters	Long Threshold	Leverage	Turnover
Under $50,000		max([i] -> [i-1], 1)	
$50,000 - $100,000			
$100,000 - $200,000	min([i] -> [i+1], 3)	[i] -> [i+1]	max([i] -> [i-1], 2)
Over $200,000	[i] -> [i+2]	[i] -> [i+1]	max([i] -> [i-2], 1)

Options/Parameters	Gamma	Risk Level
4%	[i] -> [i+2]	[i] -> [i-2]
6%		
10%	max([i] -> [i-1], 1)	min([i] -> [i+1], 3)
12%	[i] -> [i-2]	[i] -> [i+2]

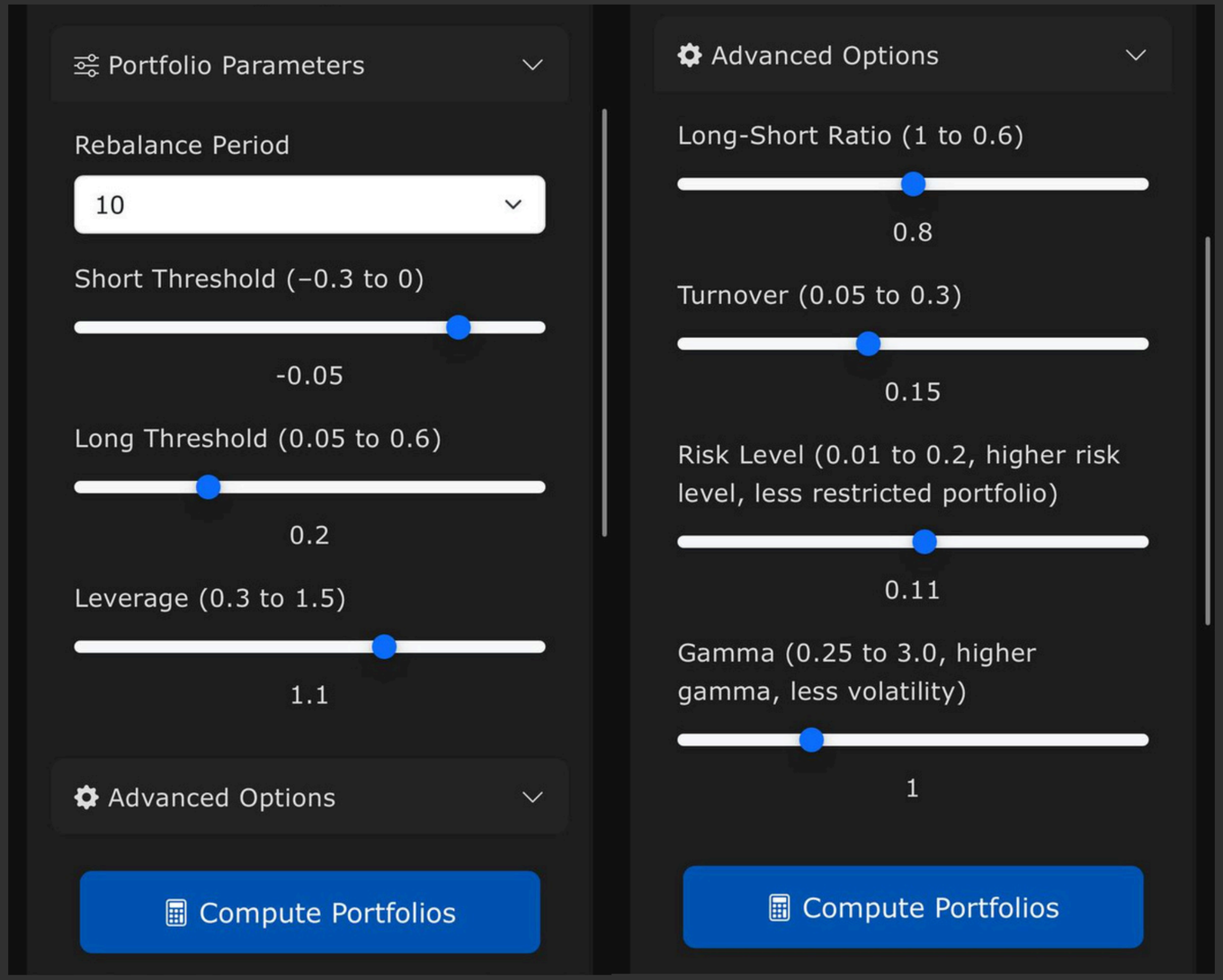
Options/Parameters	Rebalance Period	Turnover
Monthly	[i] -> [i-1]	[i] -> [i+1]
Quarterly		
Bi-annually	[i] -> [i+1]	
Annually	[i] -> [i+2]	

Robo-Advisor App





complete the assessment to get your portfolio preferences



further adjust the parameters to customize your portfolio

Dynamic Portfolio Cumulative Return

Dynamic Portfolio Cumulative Return

	Dynamic	Equal Weight	Static
rn	4.63%	0.27%	8.89%
lity	22.19%	24.87%	16.86%
io	0.3148	0.1352	0.5892
turn	9.80%	0.56%	19.20%
wn	-24.16%	-35.73%	-21.90%

Portfolio Weights

AAPL	AMD	AMZN	GOOG	META
6.25%	6.25%	6.25%	6.25%	3.75%
6.25%	-5.00%	6.25%	6.25%	0.00%
6.25%	-5.00%	0.00%	6.25%	0.00%
13.40%	-3.40%	0.00%	6.25%	-1.61%
13.40%	0.00%	0.00%	3.74%	-5.00%
15.00%	0.00%	0.00%	0.00%	-5.00%

get the portfolio returns, evaluation and weights in rebalance period

Sentiment as Feature Setup

Objectives

Discover **potential profit opportunity** for **short-frequent trading**.

Use **sentiment analysis** as one of the features for **price movement prediction**.

Adjust portfolio according to the prediction results (up or down).

Methodology

Set a set of parameters to optimize the MVO portfolio as **baseline performance**.

Gather stock tweets from Kaggle and convert selected stocks to sentiment feature.

Use classification result to determine the trend with **majority vote method**.

Prediction Accruacy

Feature Set 1:

	LR	RF	AB	LR_PCA	RF_PCA	AB_PCA
AAPL	0.391304	0.565217	0.521739	0.391304	0.608696	0.608696
AMD	0.565217	0.217391	0.217391	0.782609	0.217391	0.782609
AMZN	0.391304	0.565217	0.608696	0.521739	0.521739	0.521739
GOOG	0.608696	0.347826	0.304348	0.652174	0.652174	0.347826
META	0.565217	0.434783	0.347826	0.565217	0.565217	0.565217
MSFT	0.478261	0.391304	0.347826	0.391304	0.391304	0.391304
NIO	0.434783	0.521739	0.739130	0.521739	0.521739	0.521739
PG	0.391304	0.478261	0.434783	0.391304	0.608696	0.608696
TSLA	0.608696	0.478261	0.521739	0.478261	0.478261	0.478261
TSM	0.565217	0.608696	0.434783	0.304348	0.304348	0.695652
Model Mean	0.500000	0.460870	0.447826	0.500000	0.486957	0.552174

Stock Data, Sentiment Score, Log Return, Moving Average (7 and 14 days)

Feature Set 2:

	LR	RF	AB	LR_PCA	RF_PCA	AB_PCA
AAPL	0.391304	0.608696	0.608696	0.391304	0.391304	0.608696
AMD	0.565217	0.217391	0.347826	0.782609	0.782609	0.782609
AMZN	0.391304	0.608696	0.695652	0.521739	0.521739	0.521739
GOOG	0.608696	0.347826	0.347826	0.652174	0.565217	0.565217
META	0.565217	0.434783	0.434783	0.565217	0.565217	0.565217
MSFT	0.478261	0.478261	0.521739	0.391304	0.391304	0.391304
NIO	0.434783	0.652174	0.608696	0.521739	0.521739	0.521739
PG	0.391304	0.434783	0.478261	0.391304	0.608696	0.608696
TSLA	0.608696	0.478261	0.608696	0.478261	0.521739	0.478261
TSM	0.565217	0.478261	0.391304	0.304348	0.304348	0.304348
Model Mean	0.500000	0.473913	0.504348	0.500000	0.517391	0.534783

Feature Set 1, MACD, 14SD, Upper/Lower Band, Log Momentum

Baseline Performance

maximize $\omega \cdot \mu - 0.1\sigma^2$

subject to $\omega_i \geq -0.2$

$\omega_i \leq 0.2$

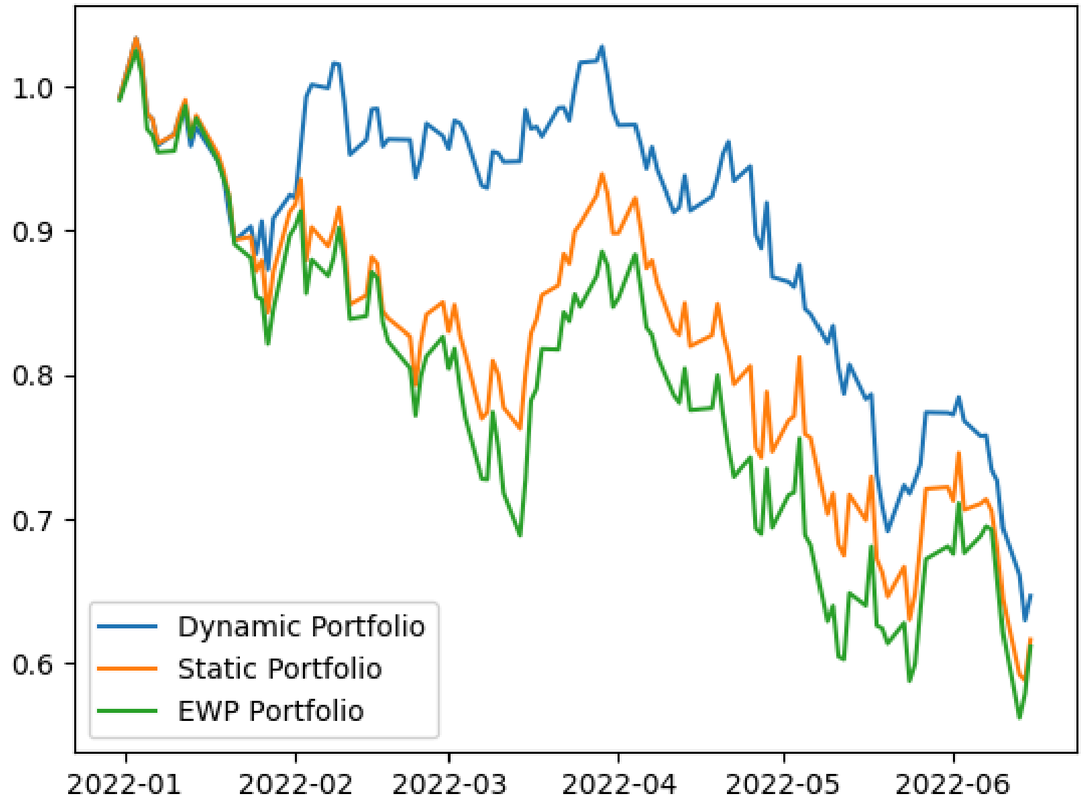
$\sum_i \omega_i = 1$

$\sum_i |\omega_i| \leq 1.4$

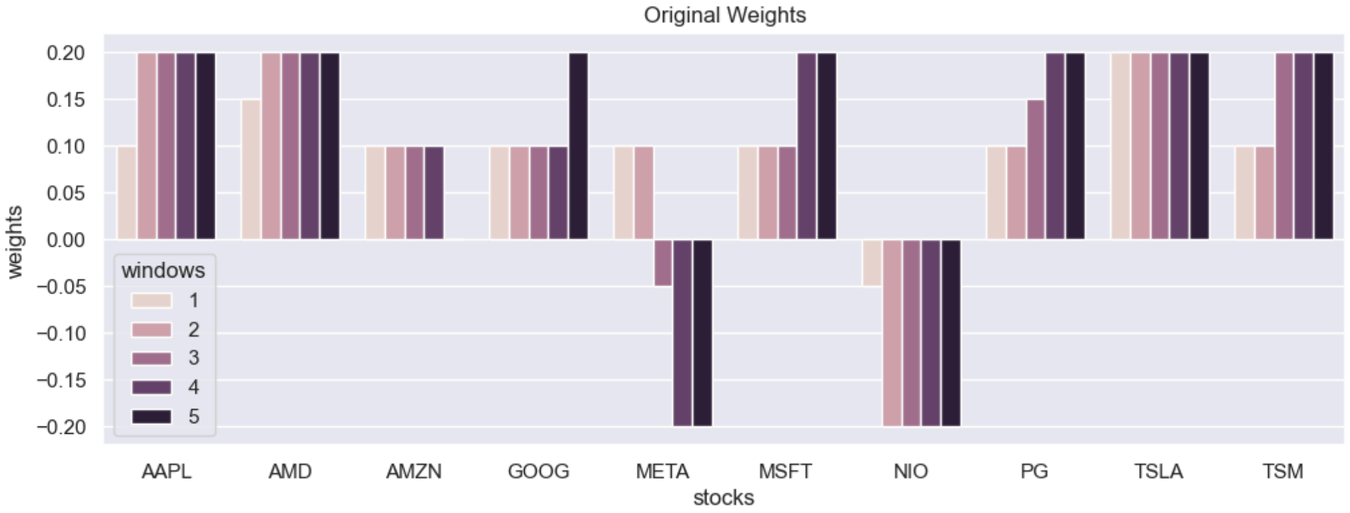
$\sqrt{\sigma^2} \leq 0.1$

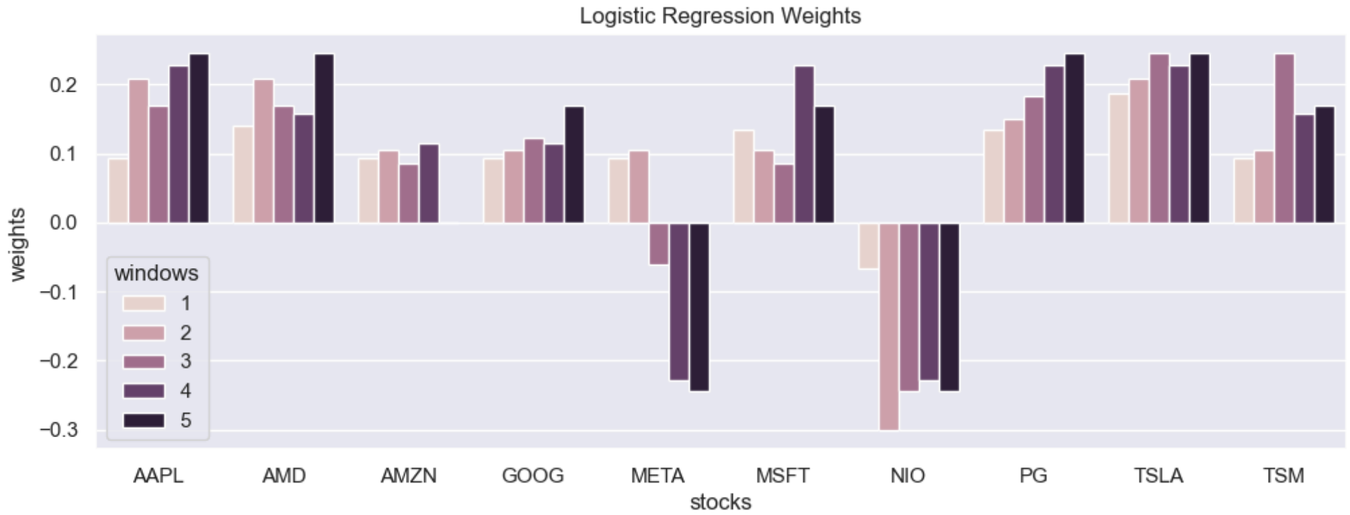
$\frac{|w_T - w_t|}{2} \leq 0.15$

	Dynamic Portfolio	Static Portfolio	EWP Portfolio
Annual Return	-0.5637	-0.6033	-0.6112
Annual Volatility	0.3263	0.4061	0.4296
Sharpe Ratio	-2.3753	-2.0702	-1.9814
Cumulative Return	0.6463	0.6163	0.6116
Max Drawdown	-0.3474	-0.3823	-0.3958

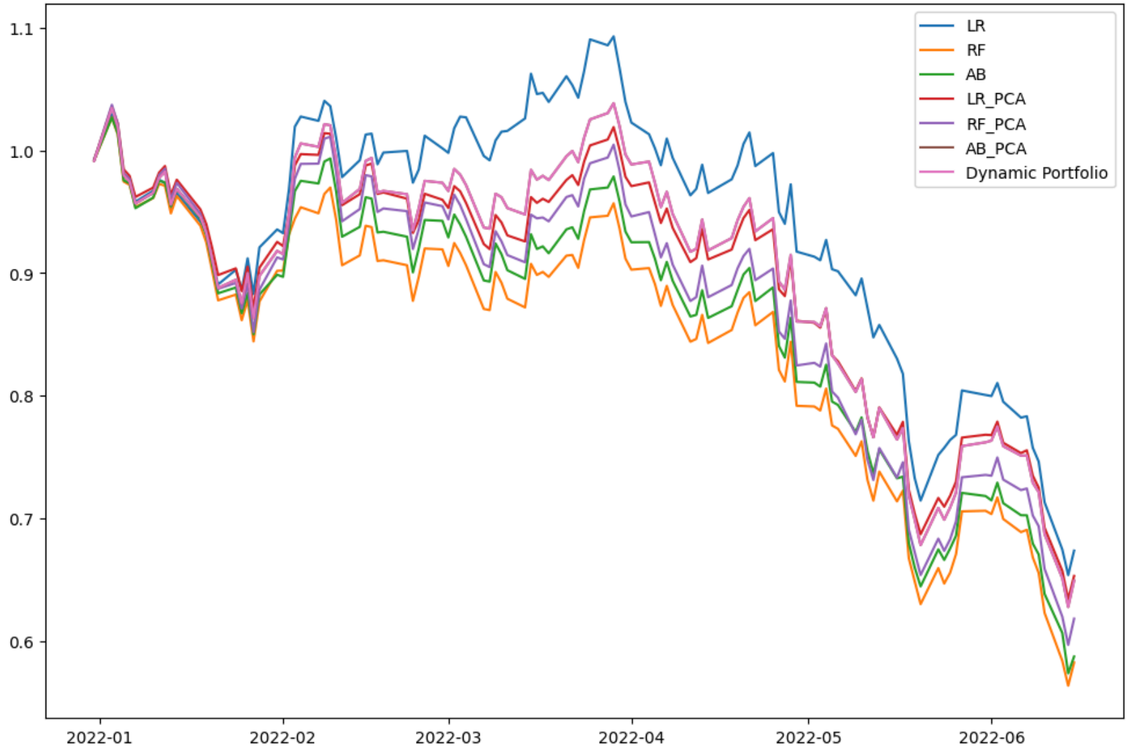


Weight Adjustment for MVO



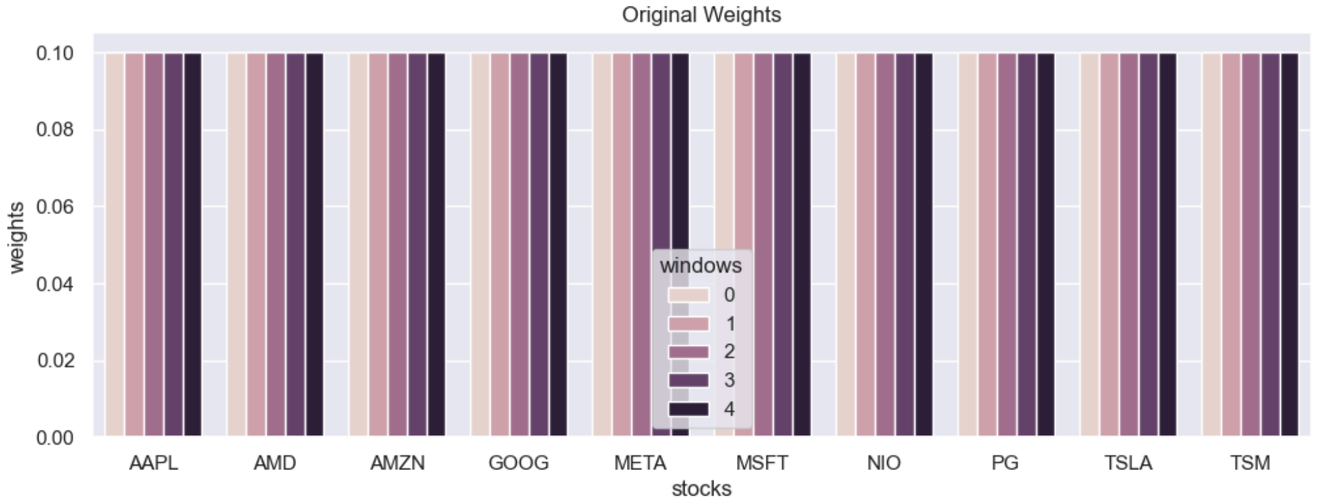


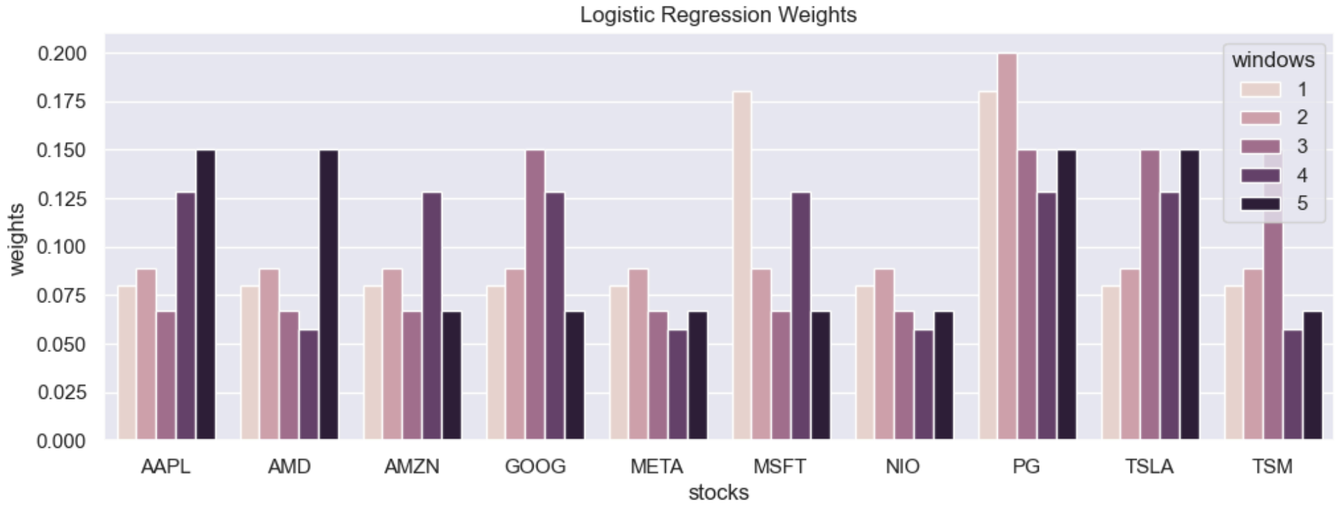
stocks with matching direction (long + up, short + down) are weighted by 1.2



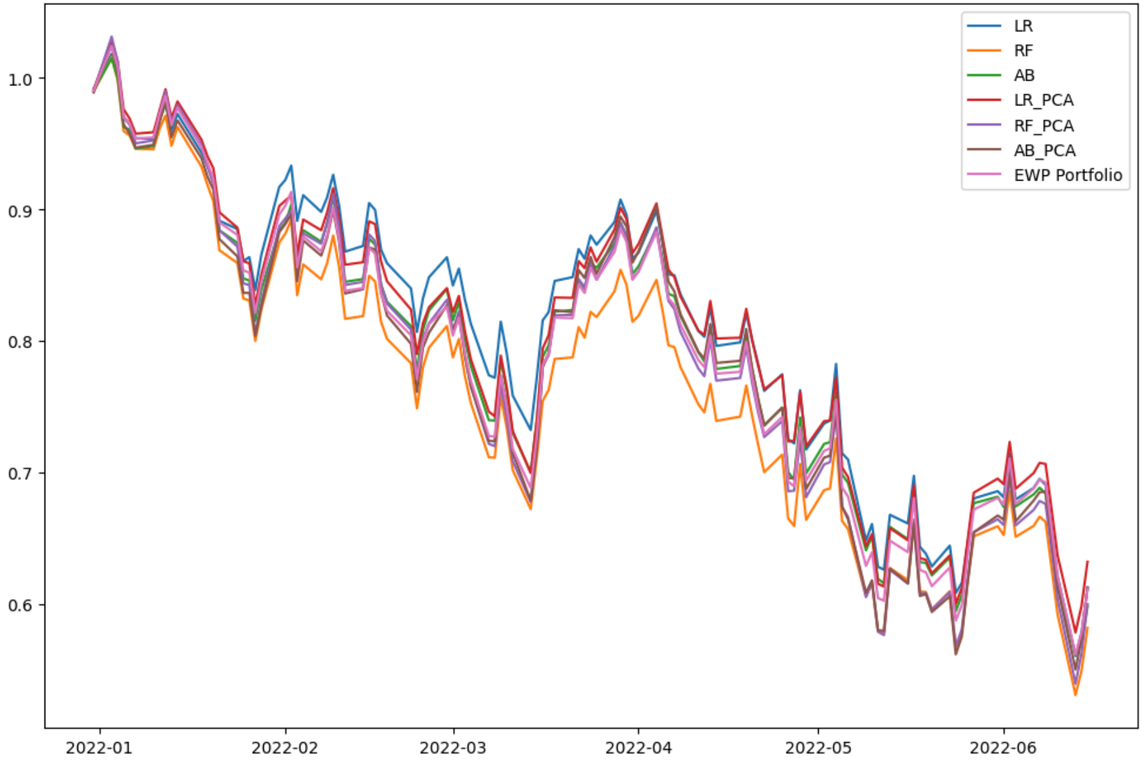
	LR	RF	AB	LR_PCA	RF_PCA	AB_PCA
Annual Return	-0.5377	-0.6204	-0.6164	-0.5564	-0.5925	-0.5626
Annual Volatility	0.3342	0.3236	0.3244	0.3217	0.3462	0.339
Sharpe Ratio	-2.139	-2.8268	-2.7867	-2.3629	-2.4156	-2.2658
Cumulative Return	0.6738	0.5826	0.5875	0.6532	0.6183	0.6494
Max Drawdown	-0.3643	-0.3855	-0.3794	-0.3458	-0.3731	-0.351

Weight Adjustment for EWP





stocks with matching direction (long + up, short + down) are weighted by 1.5



	LR	RF	AB	LR_PCA	RF_PCA	AB_PCA
Annual Return	-0.6077	-0.6353	-0.6199	-0.5917	-0.626	-0.6151
Annual Volatility	0.41	0.427	0.4131	0.4216	0.4597	0.4582
Sharpe Ratio	-2.0733	-2.145	-2.1312	-1.9113	-1.9067	-1.8515
Cumulative Return	0.6121	0.582	0.5982	0.6323	0.6	0.6128
Max Drawdown	-0.3908	-0.4093	-0.3888	-0.3871	-0.4166	-0.4066

Improvement Plan

Robo Advisor

Sensitivity Analysis

Grid-search alone won’t reveal each parameter’s impact; sensitivity analysis pinpoints the drivers of performance.

Assessment Evaluation

Many parameter sets underperform; implement adaptive tuning or heuristics to filter out weak configurations.

Sentiment Analysis

Model Accuracy

Traditional ML misses temporal patterns; switch to sequence models (e.g. LSTM or transformer architectures).

Integration

Tweet data doesn’t cover all robo advisor stocks; build an integration method into the app feature.

Thank You