Quant Task

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Portfolio Optimization & Backtesting Challenge

Google Drive link: Quant Club - Quant Task

1. Initial Capital & Stock Universe

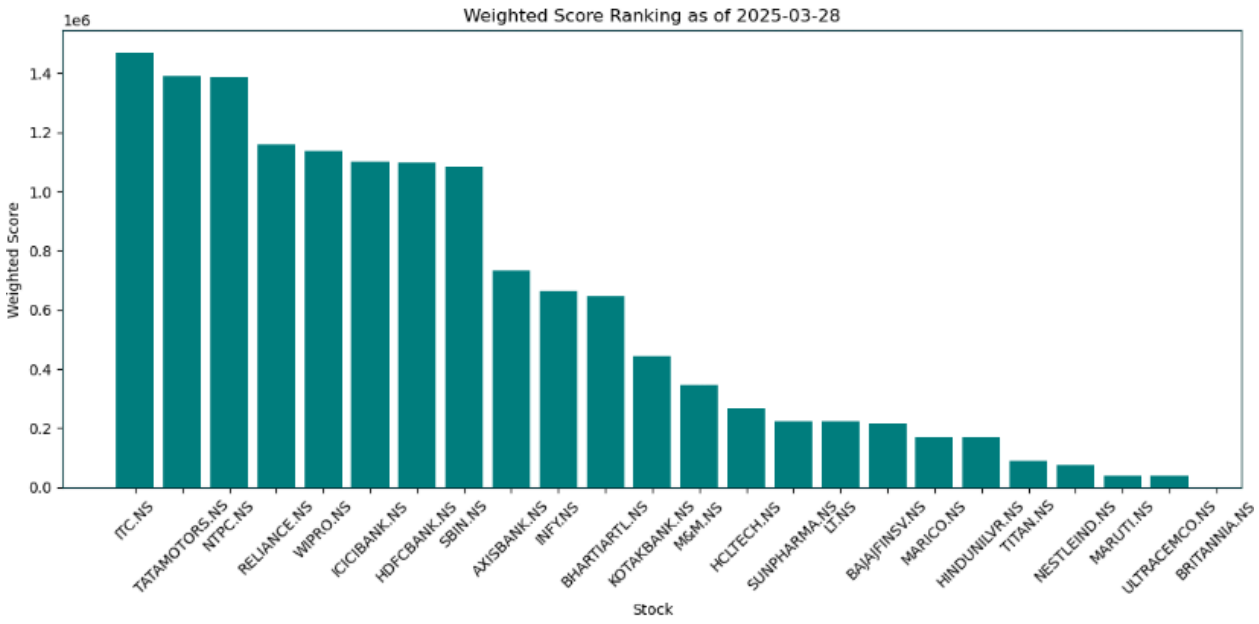
- First we took top 26 components of NIFITY 50(^NSEI)

  'HDFCBANK.NS', 'ICICIBANK.NS', 'RELIANCE.NS', 'INFY.NS', 'BHARTIARTL.NS', 'LT.NS', 'ITC.NS', 'AXISBANK.NS', 'KOTAKBANK.NS', 'MARICO.NS', 'SBIN.NS', 'BAJAJFINSV.NS', 'M&M.NS', 'HINDUNILVR.NS', 'SUNPHARMA.NS', 'HCLTECH.NS', 'MARUTI.NS', 'TITAN.NS', 'NTPC.NS', 'TATAMOTORS.NS', 'SHRIRAMFIN.NS', 'NESTLEIND.NS', 'BRITANNIA.NS', 'ULTRACEMCO.NS', 'HDFCLIFE.NS', 'WIPRO.NS'

- Then we calculated momentum, volatility, liquidity, ESG_SCORE for the given trackable universe

- Then calculated a weighted score that is:
  Weighted Score = 0.5 * Momentum + 0.3 * Volatility + 0.1 * ESG_Score + 0.1 * Liquidity (DEFINED BY ME)

- Then rank the companies based on weighted scores
- Then generate a portfolio with top 10 stocks



	Momentum	Volatility	Liquidity	ESG
AXISBANK.NS	-0.134430	0.205052	7.328812e+06	24.17
BAJAJFINSV.NS	-0.001666	0.273662	2.161619e+06	26.53
BHARTIARTL.NS	-0.000692	0.240777	6.460408e+06	19.48
BRITANNIA.NS	-0.212465	0.181138	5.248901e+05	NaN
HCLTECH.NS	-0.110641	0.260415	2.669787e+06	12.92
HDFCBANK.NS	0.043106	0.172491	1.096888e+07	30.61
HDFCLIFE.NS	-0.060942	0.245635	2.808363e+06	NaN
HINDUNILVR.NS	-0.235451	0.187126	1.679014e+06	23.40
ICICIBANK.NS	0.031953	0.165388	1.101784e+07	23.96
INFY.NS	-0.166889	0.252495	6.648509e+06	13.08
ITC.NS	-0.203716	0.213833	1.471139e+07	28.03
KOTAKBANK.NS	0.159550	0.255877	4.436835e+06	19.09
LT.NS	-0.057574	0.252407	2.219803e+06	34.08
M&M.NS	-0.162659	0.314341	3.448548e+06	27.81
MARICO.NS	-0.053916	0.241339	1.689862e+06	26.21
MARUTI.NS	-0.146229	0.213752	3.996830e+05	25.80
NESTLEIND.NS	-0.175014	0.188961	7.580943e+05	28.28
NTPC.NS	-0.170042	0.290664	1.387426e+07	39.43
RELIANCE.NS	-0.164513	0.202764	1.160913e+07	41.04
SBIN.NS	-0.038809	0.211241	1.084303e+07	27.05
SHRIRAMFIN.NS	-0.083633	0.377225	7.129937e+06	NaN
SUNPHARMA.NS	-0.104452	0.212898	2.222144e+06	31.60
TATAMOTORS.NS	-0.320796	0.318924	1.391588e+07	27.50
TITAN.NS	-0.197383	0.229859	9.092538e+05	16.04
ULTRACEMCO.NS	-0.037043	0.274188	3.832941e+05	32.87
WIPRO.NS	-0.012694	0.296504	1.138538e+07	13.18

- Final companies in portfolio:
- `['ITC.NS',`

- 'TATAMOTORS.NS',
- 'NTPC.NS',
- 'RELIANCE.NS',
- 'WIPRO.NS',
- 'ICICIBANK.NS',
- 'HDFCBANK.NS',
- 'SBIN.NS',
- 'AXISBANK.NS',
- 'INFY.NS']

2. Strategy For weight allocation

Here we will be using Eigen portfolio strategy and Minimum variance portfolio (MVP)

Eigen Portfolio strategy

Eigen Portfolios (PCA-driven weights from covariance matrix)
These portfolios are orthogonal and uncorrelated to the market in general thus yielding high reward and alpha. However, since they are uncorrelated to the market, they can also provide great risk.

Covariance Matrix

- Compute the covariance matrix Σ of asset returns:

$$\Sigma = \text{Cov}(R_i, R_j)$$

where R_i and R_j are returns of assets i and j.

Eigenvalue Decomposition

Decompose Σ into eigenvalues and eigenvectors:

$$\Sigma = Q\Lambda Q^T$$

- Λ: Diagonal matrix of eigenvalues ($\lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_n$)
- Q: Orthogonal matrix of eigenvectors (columns)

Principal Components (PCs)

- Eigenvectors (Q) represent **orthogonal directions of maximum variance**.
- The largest eigenvalue λ_1 corresponds to the eigenvector explaining the most variance (often interpreted as the "market factor").

Portfolio Construction

- Use eigenvectors as portfolio weights:

$$w = \frac{q_i}{\sum q_i} \quad \text{(normalized)}$$

where q_i is the i-th eigenvector.

Intuition already discussed

Future Works

Multi-Factor Eigen Portfolios
Combine top k eigenvectors: w = ∑ i = 1 k α i q i
where α i scales by eigenvalue magnitude.

Robust PCA
Use sparse PCA to handle outliers

Minimum Variance Portfolio

The Minimum Variance Strategy is a portfolio construction approach rooted in Modern Portfolio Theory (MPT) that aims to minimize the overall risk (variance) of a portfolio.

- **Efficient Frontier**: The set of portfolios offering the highest return for a given risk. The Minimum Variance Portfolio (MVP) is the **leftmost point** on this frontier.
- **Covariance Matrix**: Captures the interdependencies (correlations) between asset returns. Accurate estimation is critical.

- **Portfolio Variance**:

$$\sigma_p^2 = \mathbf{w}^T \Sigma \mathbf{w}$$

where:

  - $\mathbf{w}$ = Vector of asset weights
  - Σ = Covariance matrix of asset returns

- **Optimization Problem**:

$$\min_{\mathbf{w}} \mathbf{w}^T \Sigma \mathbf{w}$$

Subject to:

$$\sum_{i=1}^{n} w_i = 1 \quad \text{(fully invested)}$$

Additional constraints (e.g., $w_i \geq 0$ for no short selling).

Output

For Eigen Portfolio Strategy

```
Portfolio Weights (Normalize):
ITC.NS:  0.0990
```

```
TATAMOTORS.NS:  0.0741
NTPC.NS:  0.0776
RELIANCE.NS:  0.0675
WIPRO.NS:  0.0509
ICICIBANK.NS:  0.1591
HDFCBANK.NS:  0.1005
SBIN.NS:  0.1375
AXISBANK.NS:  0.1286
INFY.NS:  0.1052
```

For Minimum variance strategy

```
Portfolio Weights:
ITC.NS: 0.0348
TATAMOTORS.NS: 0.1967
NTPC.NS: 0.2073
RELIANCE.NS: 0.1610
WIPRO.NS: 0.2744
ICICIBANK.NS: -0.0096
HDFCBANK.NS: 0.1002
SBIN.NS: -0.0248
AXISBANK.NS: 0.0647
INFY.NS: -0.0047
```

3. Backtesting

For this backtesting we will be using Eigen Portfolio Strategy for weights allocations

I have backtested the portfolio only for eigen portfolio strategy because it is a risky strategy (unlike MVP that is a low risk and low reward but a consistent strategy)

you can change few lines of code if you want to backtest using MVP

there are few things i haven't done:

firstly you can scale the benchmark value to 10000 (which is currently at its original price in the graphs)

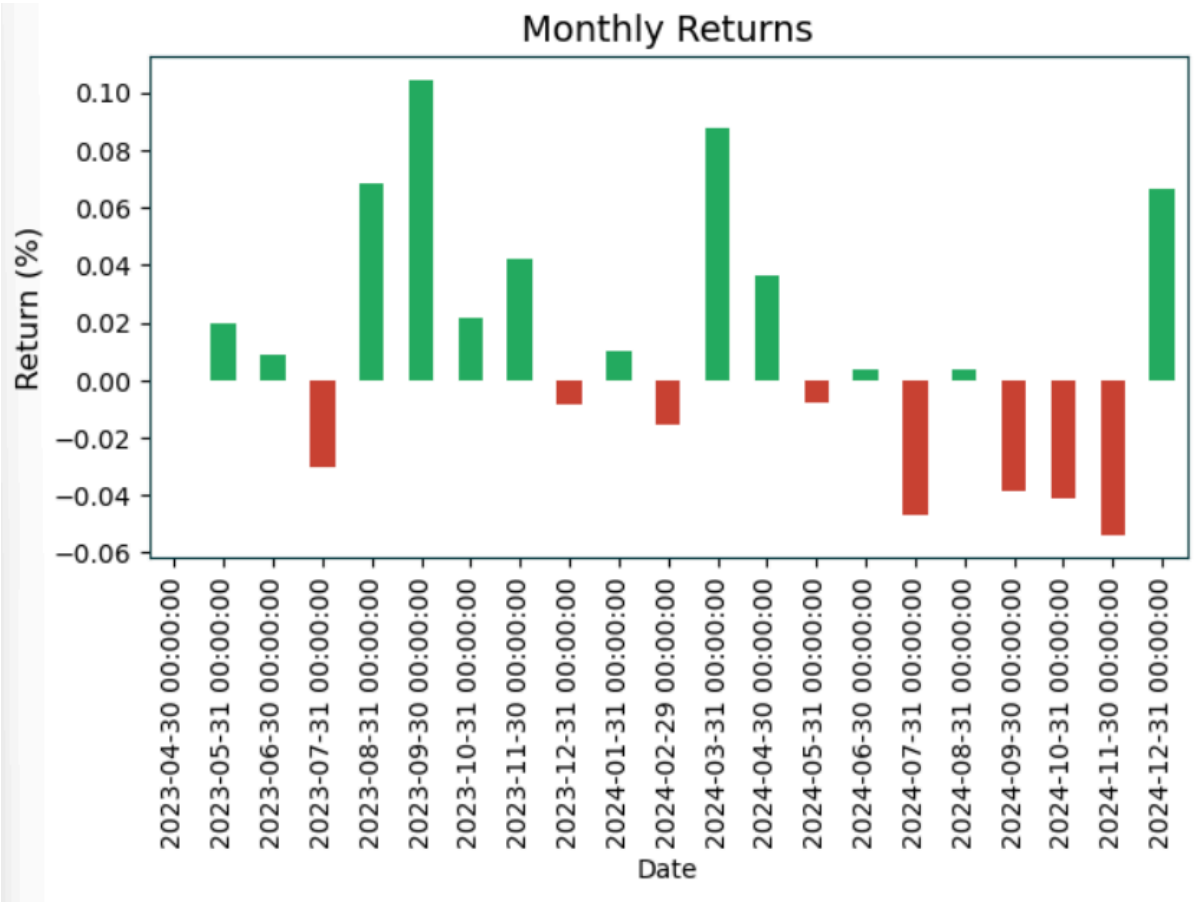
secondly you can Rebalance the portfolio at a regular frequency for quarterly i have done it only for monthly and then you can get more results (since the scope of the task in my opinion was not to tackle every possible scenario and do the analysis but to focus on a particular parameter and get results for it which i have done sorry if i interpreted it wrongly)

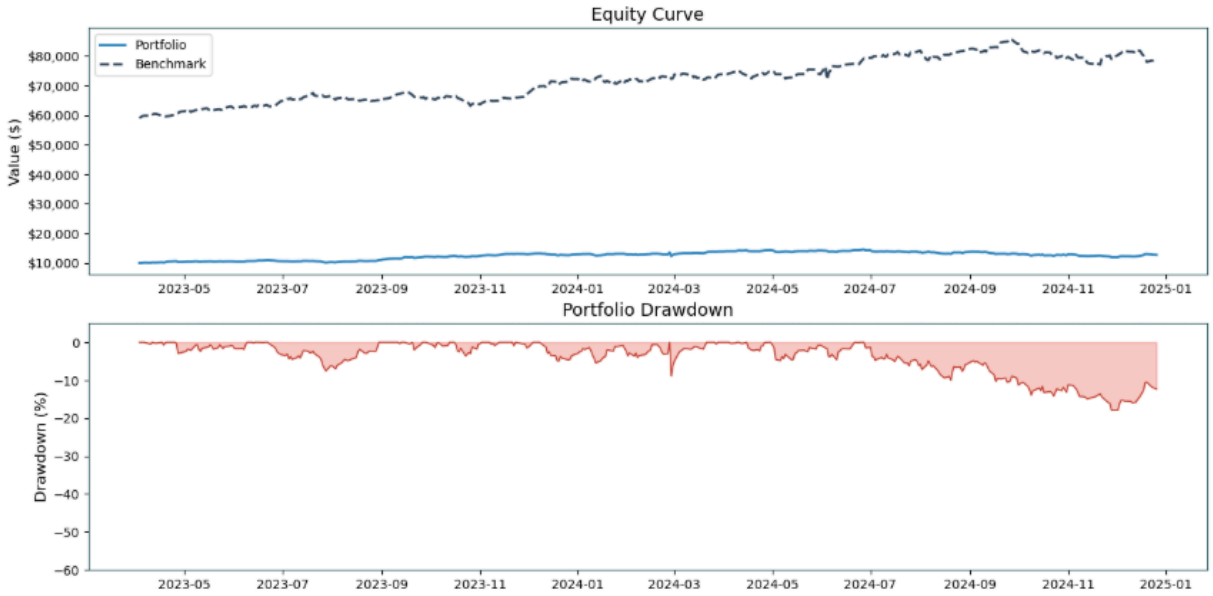
I have mentioned about the metrics/ parameters used in detailed in the notebook

Also i have plotted 3 curves Equity curve (explained in notebook), Portfolio Drawdown, Returns for each months

4. Results

Sharpe Ratio: 0.96
Max Drawdown: -17.96%
Total Return: 26.90%
Sortino Ratio: 1.18
Value at Risk (VaR): -0.01%
Omega Ratio: 1.19
Conditional VaR (CVaR): -0.02%


Monthly Returns
Return (%)
0.10
0.08
0.06
0.04
0.02
0.00
−0.02
−0.04
−0.06
2023-04-30 00:00:00
2023-05-31 00:00:00
2023-06-30 00:00:00
2023-07-31 00:00:00
2023-08-31 00:00:00
2023-09-30 00:00:00
2023-10-31 00:00:00
2023-11-30 00:00:00
2023-12-31 00:00:00
2024-01-31 00:00:00
2024-02-29 00:00:00
2024-03-31 00:00:00
2024-04-30 00:00:00
2024-05-31 00:00:00
2024-06-30 00:00:00
2024-07-31 00:00:00
2024-08-31 00:00:00
2024-09-30 00:00:00
2024-10-31 00:00:00
2024-11-30 00:00:00
2024-12-31 00:00:00
Date


Equity Curve
Portfolio
Benchmark
Value ($)
$80,000
$70,000
$60,000
$50,000
$40,000
$30,000
$20,000
$10,000
2023-05
2023-07
2023-09
2023-11
2024-01
2024-03
2024-05
2024-07
2024-09
2024-11
2025-01
Portfolio Drawdown
Drawdown (%)
0
−10
−20
−30
−40
−50
−60
2023-05
2023-07
2023-09
2023-11
2024-01
2024-03
2024-05
2024-07
2024-09
2024-11
2025-01