**Core Analytical Functionality Specification Document**

**I. Executive Summary:**

In this document, we synthesize all of the aforementioned ideas and technical specifications we discussed so far regarding the core analytical function of ReSolve’s FinTech App. We start by presenting the main interface of this financial analysis app and closely introduce how each functional tab in the main interface help users to achieve their desired analytical outcome.

**II. Conceptual Design Overview:**

The Main interface of the app is succinct in design and contains the following five tabs and some miscellaneous things.

Miscellaneous things could be ads from other third-party financial companies & institutions, or it can be some important news & information from ReSolve that we want our users to know. This could be a window for us to demonstrate our company values, ideas, thoughts, comments regarding markets,etc. to the users.

The five tabs provide the major functions of this app. They include: **Discovery, Portfolio Construction , Analysis, My Account(Data Management),** and **About Us***.*

1. **Discovery** tab leads user to a tutorial teaching them the functions of the App in detail.
2. **Portfolio Construction:** 
   1. ***Time-series import and Basic Inquiry:*** Import time-series from Tiingo and ReSolve’s proprietary database via API keys. There will be a sourcing of end-of-day proprietary data for futures and indices from ReSolve’s SQL database as well as sourcing end-of-day data for securities, mutual funds and ETFs from Tiingo.Users can inquiry the relavant information regarding the market data (E.g. the High,Low,Volume,Volatility,etc. of a single stock).
   2. **Portfolio construction:** Using these data to create portfolios out of given scope of assets by i) specifying target weights by user themselves, ii) Find target weights via optimization by using ***Portfolio optimization*** function under **Analysis** tab.
   3. **Plots and tables:** Produce plots and tables of the portfolios assuming static target weights through time using ***Performance examining*** and ***Visualization*** functions under **Analysis** tab. Once users have registered, all of the plots, tables and charts can be easily saved in their personal account and are easily exportable in appropriate format with customable specifications.
3. **Analysis** tab allow users to conduct professional analysis of their portfolio, including the following functions:
   1. ***Portfolio optimization:*** given a universe of assets and a target time horizon, solve for the optimal portfolio using full in-sample covariance matrix and either full in-sample average returns (if required by the target optimization) or user specified expected returns under constraints like long-only and/or sum-to-1 constraints.

***RMK for a.:***

* **Libraries**

1, Riskfolio-Lib:

<https://github.com/dcajasn/Riskfolio-Lib>

2, PyPortfolioOpt: <https://pyportfolioopt.readthedocs.io/en/latest/index.html>

* **Optimization methods:** a series of optimization methods that users can choose from, including:

**1, *Equal Weight \****

***2, Inverse volatility weighting \****

**3, *Inverse variance weights \****

**4, *Hierarchical Risk Parity weighting(HRP):***

*Intro:* HRP achieves portfolio optimization by prioritizing risk diversification across different levels of the investment hierarchy. It begins by clustering assets based on their pairwise correlations, forming a hierarchical tree structure. HRP then allocates weights to assets considering both the risk contribution of each asset within its cluster and the correlation between clusters. By balancing risk contributions at multiple levels of the hierarchy, HRP effectively minimizes portfolio volatility while maximizing diversification benefits. This approach ensures that the portfolio is resilient to fluctuations in individual asset prices and provides a more stable risk-adjusted return profile compared to traditional optimization methods.

*Procedures:* *1. Downloading the data; 2 Calculating the HRP portfolio; 3, Plotting portfolio composition; 4, Plotting Risk Contribution; 5, Calculate Optimal HRP Portfolios for Several Risk Measures*

*Demo1 :<https://pyportfolioopt.readthedocs.io/en/latest/OtherOptimizers.html#hierarchical-risk-parity-hrp>;*

*Demo2:* [*https://github.com/dcajasn/Riskfolio-Lib/blob/master/examples/Tutorial%2024%20-%20Hierarchical%20Risk%20Parity%20(HRP)%20Portfolio%20Optimization.ipynb*](https://github.com/dcajasn/Riskfolio-Lib/blob/master/examples/Tutorial%2024%20-%20Hierarchical%20Risk%20Parity%20(HRP)%20Portfolio%20Optimization.ipynb)

**5, *Equal Risk Contribution weighting(ERC):***

*Intro:* ERC weighting achieves portfolio optimization by assigning weights to assets in a way that each asset contributes equally to the total portfolio risk. It achieves this by iteratively adjusting the weights until the contribution of each asset's risk, as measured by its covariance with the portfolio, is equal. ERC ensures diversification across assets, as it allocates more weight to assets with lower correlations to each other. This strategy minimizes concentration risk and enhances portfolio stability, providing a balanced risk-return profile. By prioritizing risk equalization, ERC weighting aims to achieve robustness and resilience in various market conditions, leading to more consistent performance over time.

*Procedures:* *1, Downloading the data; 2, Estimating HERC Portfolio; 3, Calculating the HERC portfolio; 4, Plotting portfolio composition; 5, Plotting Risk Contribution; 6, Calculate Optimal HERC Portfolios for Several Risk*

*Demo:* [*https://nbviewer.org/github/dcajasn/Riskfolio-Lib/blob/master/examples/Tutorial%2025%20-%20Hierarchical%20Equal%20Risk%20Contribution%20(HERC)%20Portfolio%20Optimization.ipynb*](https://nbviewer.org/github/dcajasn/Riskfolio-Lib/blob/master/examples/Tutorial%2025%20-%20Hierarchical%20Equal%20Risk%20Contribution%20(HERC)%20Portfolio%20Optimization.ipynb)

***6, Maximum diversification weighting \****

***7, Maximum decorrelation weighting \****

***8, Maximum Sharpe ratio weighting \****

***9, Mean-variance given Target return or Target volatility:***

*Structure & Demo:* [*https://pyportfolioopt.readthedocs.io/en/latest/MeanVariance.html*](https://pyportfolioopt.readthedocs.io/en/latest/MeanVariance.html)

***10, Mean Ulcer Index Portfolio Optimization(MUI):***

*Intro:* MUI Optimization achieves portfolio optimization by focusing on downside risk and drawdowns rather than traditional risk measures like volatility. The Ulcer Index measures the depth and duration of drawdowns in a portfolio, providing a more comprehensive view of downside risk. MUI optimization aims to minimize the mean Ulcer Index, indicating a strategy that not only seeks to maximize returns but also prioritizes the protection of capital during market downturns. By emphasizing downside protection, MUI optimization aims to deliver smoother and more consistent returns over time, making it suitable for risk-averse investors or those with specific capital preservation objectives.

*Procedures:1. Downloading the data; 2, Calculating the portfolio that maximizes Ulcer Performance Index (UPI) ratio; 3, Plotting portfolio composition; 4, Calculate efficient frontier; 5, Estimating Risk Parity Portfolios for Ulcer Index; 6, Calculating the risk parity portfolio for Ulcer Index; 7, Plotting portfolio composition; 8, Plotting Risk Composition.*

*Demo:* <https://nbviewer.org/github/dcajasn/Riskfolio-Lib/blob/master/examples/Tutorial%2014%20-%20Mean%20Ulcer%20Index%20Portfolio%20Optimization.ipynb>

***11. Mean Entropic Value at Risk (EVaR) Optimization:***

*Intro:* MEVaR achieves portfolio optimization by incorporating both the expected return and the uncertainty associated with the returns distribution. It employs the concept of entropy, which measures the uncertainty or randomness in a probability distribution, to quantify the risk in the portfolio. MEVaR optimization aims to minimize the entropy of the portfolio returns while ensuring that the expected return meets a specified threshold. By considering both risk and return in a unified framework, MEVaR optimization provides a balanced approach to portfolio management, allowing investors to make informed decisions that account for both the upside potential and downside risk.

*Procedures:1. Downloading the data; 2, Calculating the portfolio that optimize EVaR ratio; 3, Plotting portfolio composition; 4, Calculate efficient frontier; 5, Estimating Risk Parity Portfolios for EVaR; 6, Calculating the risk parity portfolio for EVaR; 7, Plotting portfolio composition; 8, Plotting Risk Composition*

*Demo*: <https://nbviewer.org/github/dcajasn/Riskfolio-Lib/blob/master/examples/Tutorial%2015%20-%20Mean%20Entropic%20Value%20at%20Risk%20(EVaR)%20Optimization.ipynb>

***12, OWA Portfolio Optimization:***

*Intro:* OWA Optimization achieves portfolio optimization by allowing investors to customize their risk preferences through the use of ordered weighted averaging operators. OWA operators enable the aggregation of asset returns based on their ranking or order, allowing investors to prioritize certain assets over others according to their risk-return preferences. By adjusting the weights assigned to each asset based on its position in the ordered list, OWA optimization offers a flexible and intuitive approach to portfolio construction. This method enables investors to tailor their portfolios to specific risk-return profiles, providing a more personalized and adaptive investment strategy.

*Procedures: 1. Downloading the data; 2, Estimating OWA Portfolios; 3, Comparing Classical formulations vs OWA formulations.*

*Demo:* <https://nbviewer.org/github/dcajasn/Riskfolio-Lib/blob/master/examples/Tutorial%2037%20-%20OWA%20Portfolio%20Optimization.ipynb>; <https://github.com/dcajasn/Riskfolio-Lib/blob/master/examples/Tutorial%2037%20-%20OWA%20Portfolio%20Optimization.ipynb>

*\* Note:*

For optimization methods 1,2,3,6,7,8, we completed the theoretical research, and the following are the mathematical setups: <https://github.com/AndrewCeon328/ReSolve-FinTech-App/blob/main/Mathematical%20setup%20for%20Optimization%20Method%201%2C2%2C3%2C6%2C7%2C8.pdf>

For the above methods, since there’s no appropriate libraries we can readily use, we are still working on generating demo/prototype codes.

* 1. ***Performance examining:*** Examing the performance of the portfolio by reporting to users with various financial ratios and performance evaluators and output the result into table and charts.

***RMK for b.:***

* Performance evaluators are functions *like* ***“***Block Bootstrapping”. Block Bootstrapping for ranges of expected performance statistics, and a log-cone of expected range of performance trajectories, and then producing the graph showing the visualization of the result.
* Risk Measures: <https://github.com/dcajasn/Riskfolio-Lib/tree/master> (Description Section)
  1. Dispersion Risk Measures: Standard Deviation, Gini Mean Difference (GMD), Range;
  2. Downside Risk Measures: Conditional Value at Risk (CVaR), Entropic Value at Risk (EVaR), Relativistic Value at Risk (RLVaR);
  3. Drawdown Risk Measures: Ulcer Index for uncompounded cumulative returns.
  4. ***Returns based style analysis \*\*:*** given a benchmark and explanatory assets, find the closest tracking portfolio by using ElasticNet regression with cross-validated norm parameters, including options for long-only and/or sum-to-1 constraints.

\*\* Note:

For ElasticNet regression with cross-validated norm parameters, we did a through mathematical study and summed up the mathematical setups, including LASSO, Ridge Method, and how they are combined as ElasticNet method.

<https://github.com/AndrewCeon328/ReSolve-FinTech-App/blob/main/ElasticNet%20Regression%20Method%20Math%20Set-up.pdf>

We’re still working on generating prototype codes.

* 1. ***Visualization***: ploting the performance of constructed portfolios and other assets & indicies, allowing users to compare their constructed portfolios with various other financial assets. The plots are produced assuming static target weights through time, with portfolios rebalanced back to target weights at fixed intervals (i.e. monthly to be specified by user).

***RMK for d.:*** We roughly browsed through the complexity and practicality of the Panel and Lets-Plot, we generally agree to stick with Panel as it generates graphs that are more convenient and appropriate for financial data visualization.

* Graphing and plotting with “Panel” under “Holoviz”:

Holoviz: <https://holoviz.org/>

Panel: <https://panel.holoviz.org/>

* Demos for how to install/ use Panel: <https://panel.holoviz.org/getting_started/build_app.html>
* Graphing and Plotting with “Lets-Plot”: <https://github.com/JetBrains/lets-plot/blob/master/README.md>   
  1. ***Backtesting:*** Backtest users’ strategies, recomputing target weights according to a target optimization at each rebalance period. This function allows Registered Advisors to use ReSolve’s internal backtests methods to check and modify their portfolio accordingly.

***RMK for e.:***

**1, Multi Assets Algorithmic Trading Backtesting with Backtrader:**

*Intro. & Demo*: <https://nbviewer.org/github/dcajasn/Riskfolio-Lib/blob/master/examples/Tutorial%205%20-%20Multi%20Assets%20Algorithmic%20Trading%20Backtesting%20with%20Backtrader.ipynb> )

**2, Multi Assets Algorithmic Trading Backtesting with Vectorbt:** *Intro. & Demo*: <https://nbviewer.org/github/dcajasn/Riskfolio-Lib/blob/master/examples/Tutorial%2018%20-%20Multi%20Assets%20Algorithmic%20Trading%20Backtesting%20with%20Vectorbt.ipynb>

* 1. **My Account (aka Data Management)** tab allows Registered Advisors to save i) portfolio as synthetic assets (E.g. they might save a portfolio of 100% stocks + 100% 10-year Treasury bond futures as a “Returned Stacked Stock+Bonds” strategy); ii) any series they create in the Analysis tab. It should also allow users to manage their customized data series, including reviewing and modifying their saved historical portfolios and adjustments, etc.

**RMK:**

* Different types of users will have access to different types and different scopes of data. E.g. Internal ReSolver employees will have access to all backtests and simulation data whereas the external users can not. Registered Advisors will have access to a mix of internal and external data with some limitation on internal data.

1. **About Us** tab will provide some introduction to ReSolve, which could directly lead user to the official website of ReSolve.

In closing, this document serves as a blueprint for the core analytical functionality of ReSolve’s FinTech App adhering to the demands of financial professionals. The desiging idea is subject to change based on further comments and feedbacks.