

# Riskfolio-Lib

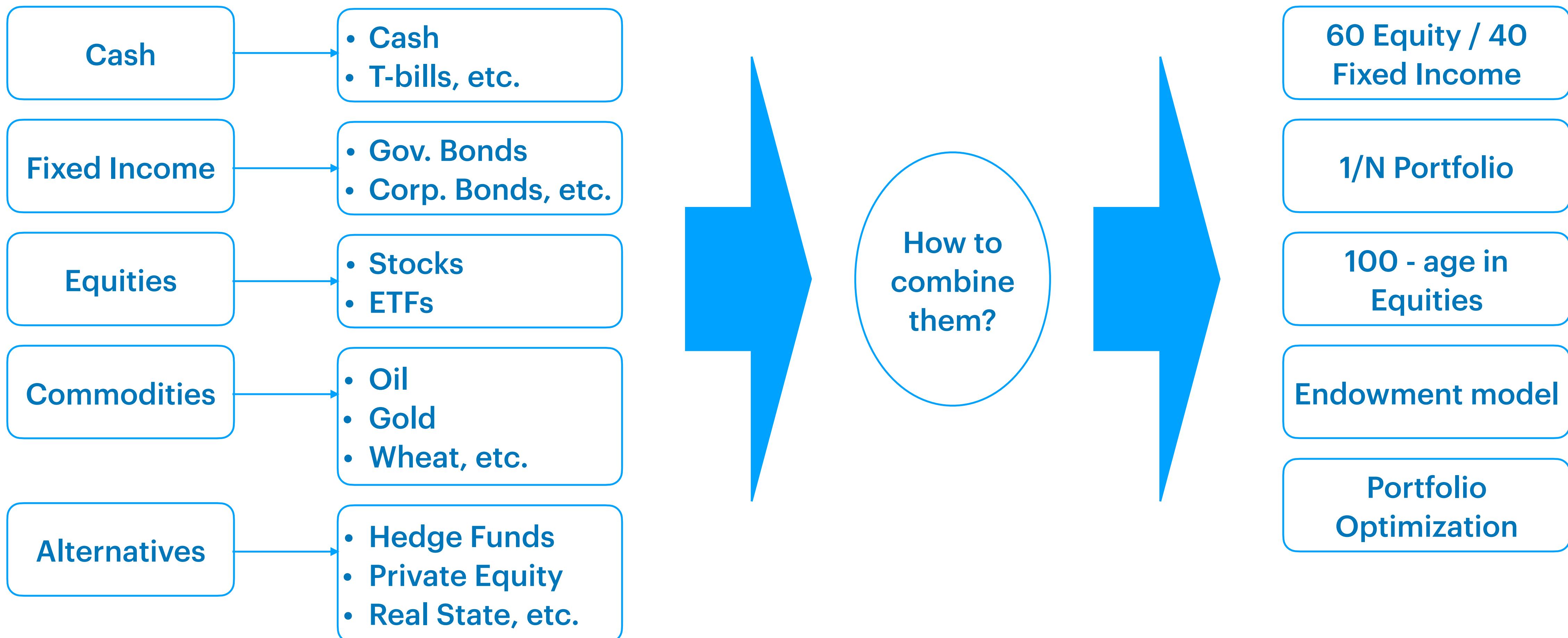
Quantitative Strategic Asset Allocation  
with Python

Dany Cajas - April 2023

Sleeping Beauty - Tingo Maria - Peru

# How asset managers build a Portfolio?

Asset managers have a wide universe of assets, asset classes and models to choose:



# What is Portfolio Optimization?

Portfolio optimization is the process to select the best possible combination of asset according to a set of desired objectives and constraints using mathematical techniques.

Advantages	Disadvantages
Diversification, reduce of idiosyncratic risk.	Risk of over-diversification, too many assets increase cost of rebalancing.
Lead to more efficient portfolios in a risk return relationship.	More appropriate for frictionless markets and liquid assets.
Allows to build custom portfolios designed to meet investor needs.	Complex mathematical models. Some models are hard to implement and solve.

# Riskfolio-Lib

Riskfolio-Lib is a library for portfolio optimization in Python made in Peru . It is built on top of CVXPY and closely integrated with Pandas data structures. It allows users to solve two kinds of portfolio optimization models:

Convex Portfolio Optimization	Machine Learning Portfolio Optimization
Risk-Return Trade off	Hierarchical Risk Parity
Risk Parity Risk Budgeting Approach	Hierarchical Equal Risk Contribution
Risk Parity Least Squares Approach	Nested Clustered Optimization
Worst Case Optimization	

# Convex Portfolio Optimization

## Risk-Return Trade Off

**Risk Minimization**

$$\begin{aligned} \min_x \quad & \phi_0(x) \\ \text{s.t.} \quad & Ax \geq B \\ & \mu'x \geq \bar{\mu} \\ & \phi_i(x) \leq \bar{\phi}_i, \quad i = 1, \dots, m \end{aligned}$$

**Return Maximization**

$$\begin{aligned} \max_x \quad & \mu'x \\ \text{s.t.} \quad & Ax \geq B \\ & \phi_i(x) \leq \bar{\phi}_i, \quad i = 0, \dots, m \end{aligned}$$

**Utility Maximization**

$$\begin{aligned} \max_x \quad & \mu'x - \lambda\phi_0(x) \\ \text{s.t.} \quad & Ax \geq B \\ & \phi_i(x) \leq \bar{\phi}_i, \quad i = 1, \dots, m \end{aligned}$$

**Return/Risk Maximization**

$$\begin{aligned} \max_x \quad & \frac{\mu'x}{\phi_0(x)} \\ \text{s.t.} \quad & Ax \geq B \\ & \phi_i(x) \leq \bar{\phi}_i, \quad i = 1, \dots, m \end{aligned}$$

## Risk Parity Least Squares

$$\begin{aligned} \min_x \quad & \sum_{i=1}^N \left( \frac{x_i(\Sigma x)_i}{x^T \Sigma x} - b_i \right)^2 \\ \text{s.t.} \quad & \mathbf{1}'x = 1 \\ & x \geq 0 \end{aligned}$$

## Risk Parity Risk Budgeting

$$\begin{aligned} \min_{y,t} \quad & \phi(y) \\ \text{s.t.} \quad & b' \ln(y) \geq c \\ & \mathbf{1}'y = t \\ & y, t \geq 0 \\ & x = \frac{y}{t} \end{aligned}$$

**Robust Variance Minimization**

**Robust Return Maximization**

**Robust Utility Maximization**

**Robust Return/Standard Deviation Maximization**

## Worst Case Optimization

$$\begin{aligned} \min_x \quad & \max_{\Sigma \in U_\Sigma} x^T \Sigma x \\ \text{s.t.} \quad & Ax \geq b \end{aligned}$$

$$\begin{aligned} \max_x \quad & \min_{\mu \in U_\mu} \mu x \\ \text{s.t.} \quad & Ax \geq b \end{aligned}$$

$$\begin{aligned} \max_x \quad & \min_{\mu \in U_\mu} \mu x - \lambda \max_{\Sigma \in U_\Sigma} x^T \Sigma x \\ \text{s.t.} \quad & Ax \geq b \end{aligned}$$

$$\begin{aligned} \max_x \quad & \frac{\min_{\mu \in U_\mu} \mu x - r_f}{\max_{\Sigma \in U_\Sigma} \sqrt{x^T \Sigma x}} \\ \text{s.t.} \quad & Ax \geq b \end{aligned}$$

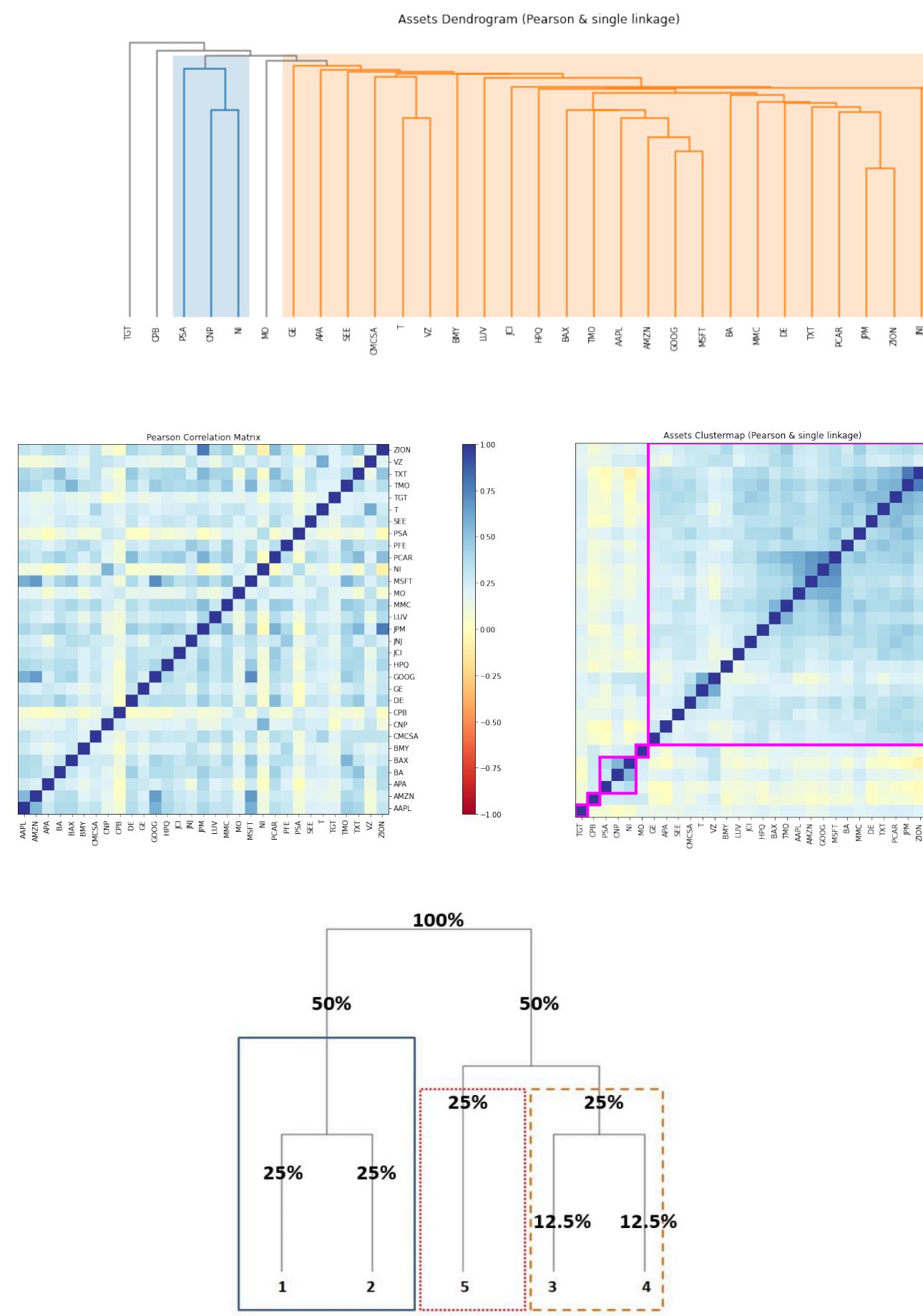
# Convex Portfolio Optimization

It is the traditional approach for portfolio optimization. Using convex optimization techniques we can create portfolios that meets investor's needs like:

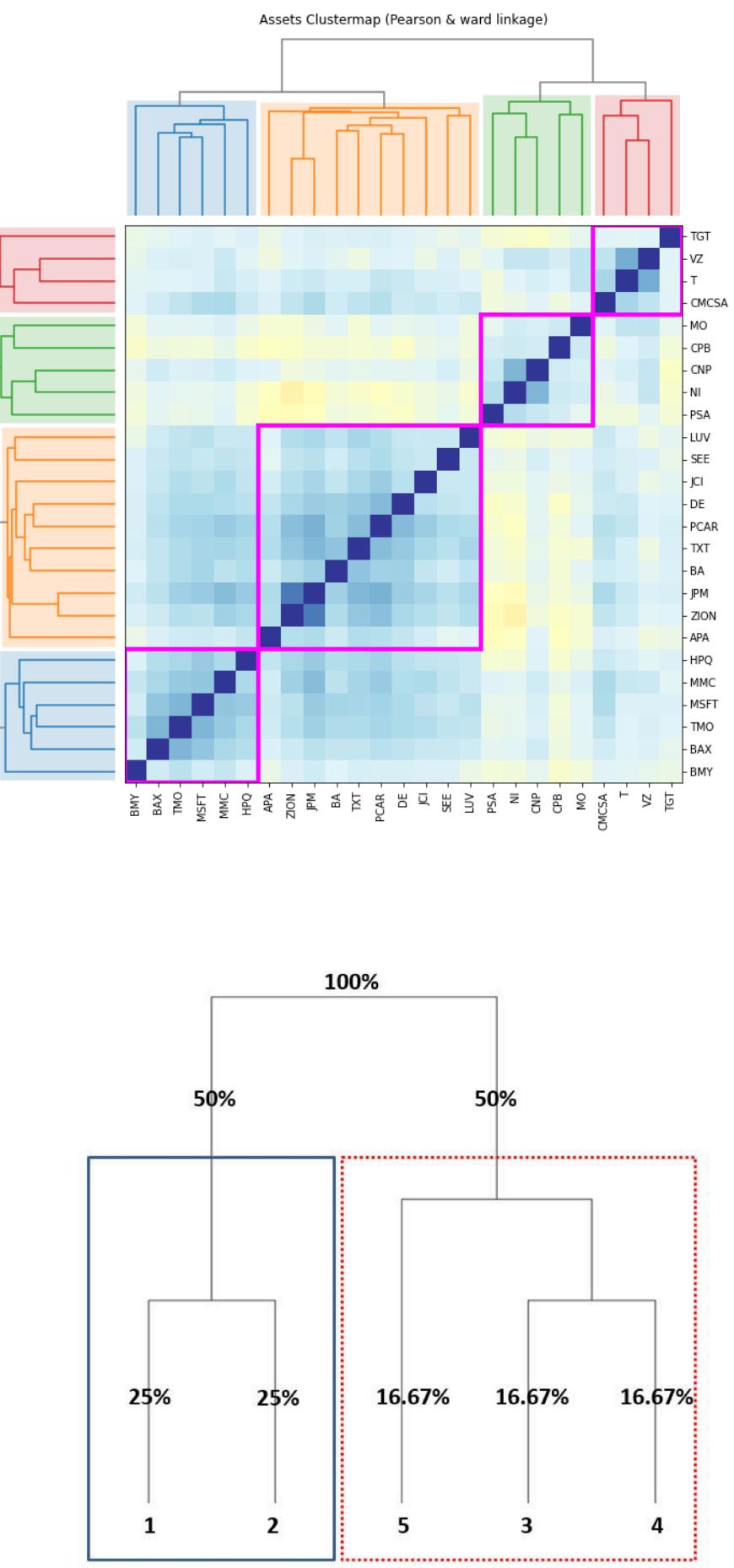
- Minimize the risk of a portfolio.
- Create constraints on asset classes.
- Create tracking error constraints.
- Create long-short portfolios.
- Constraints on risk measures, among other investor's needs.

# Machine Learning Portfolio Optimization

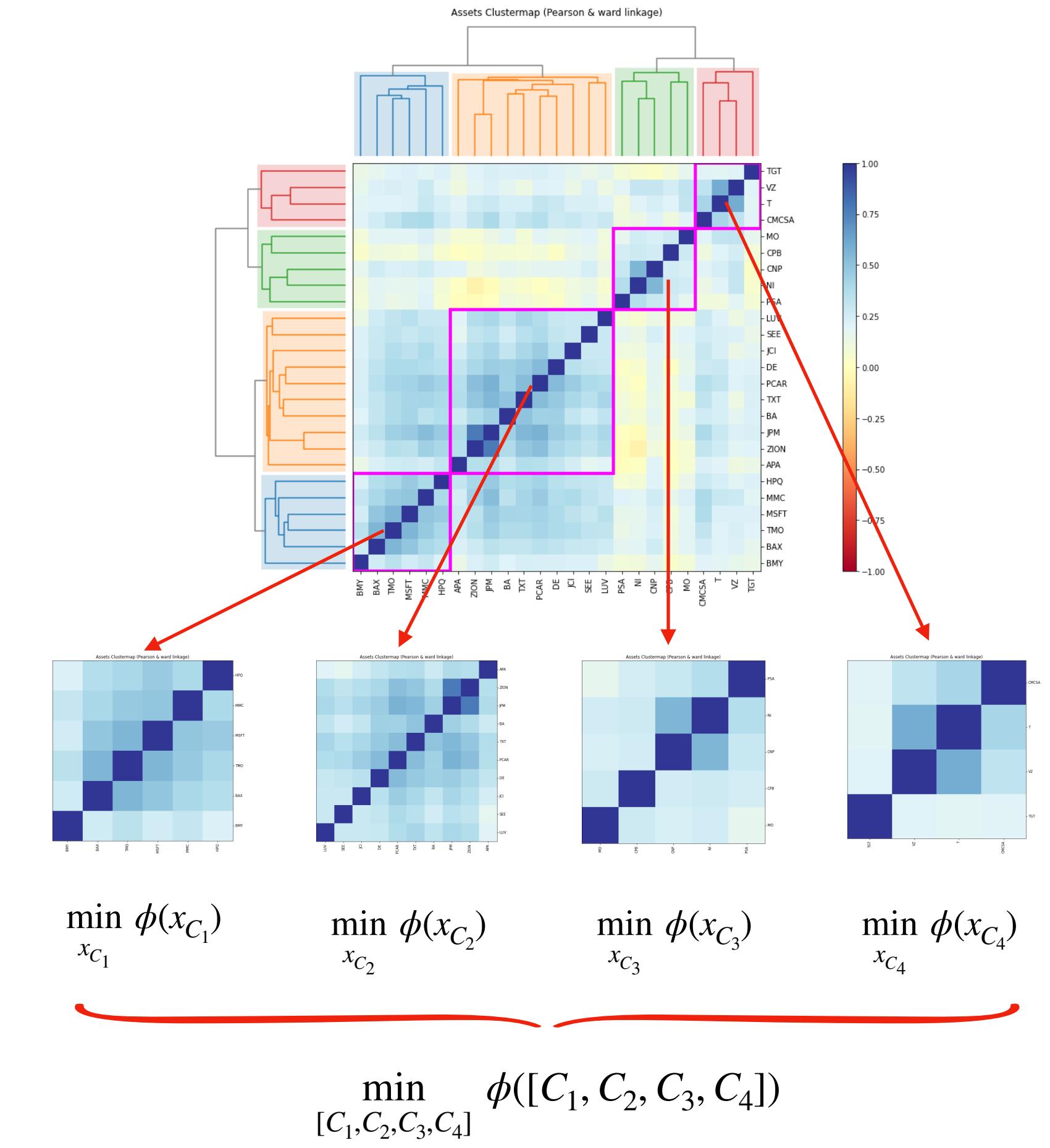
Hierarchical Risk Parity



Hierarchical Equal Risk Contribution

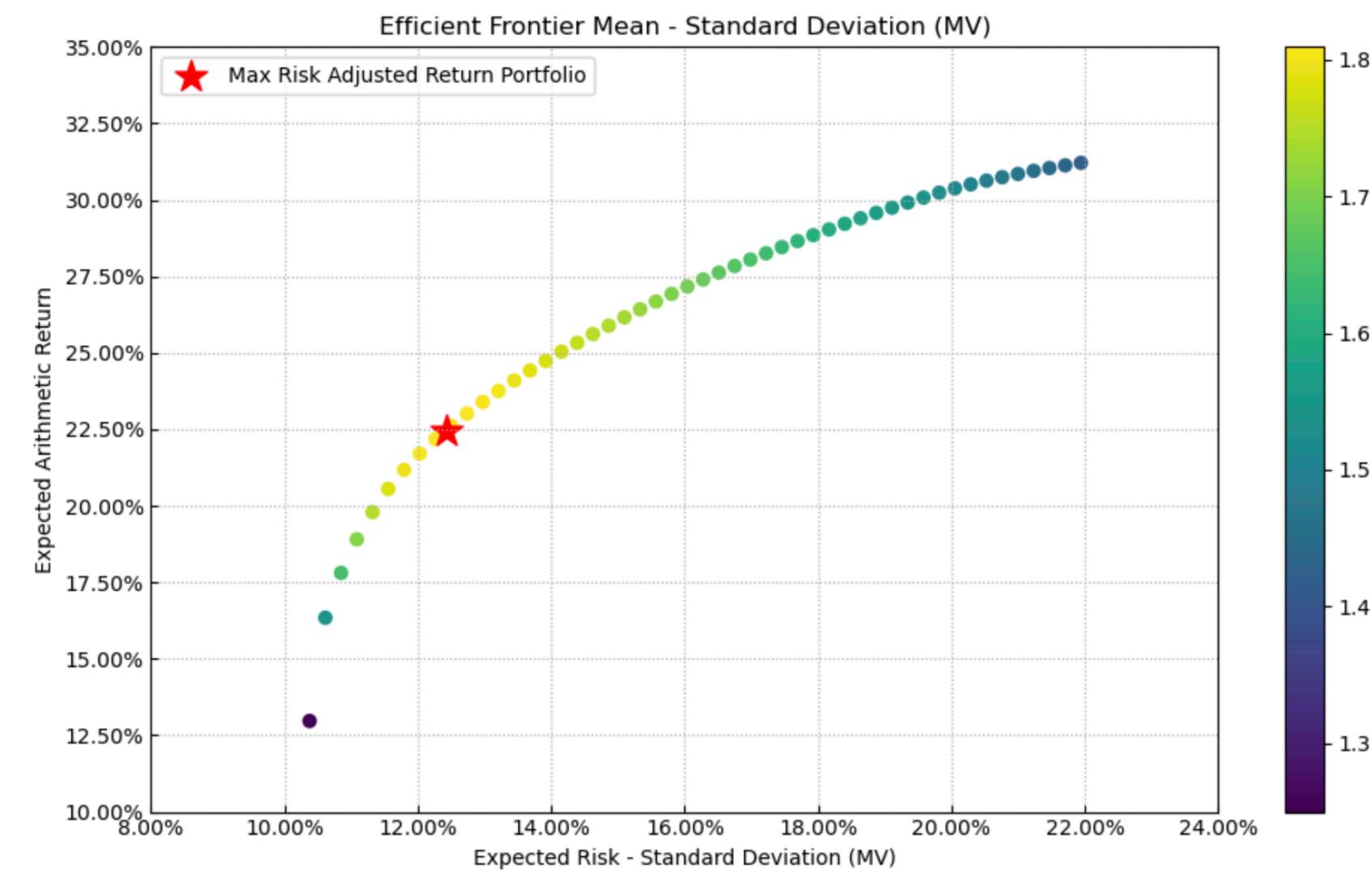


Nested Clustered Optimization

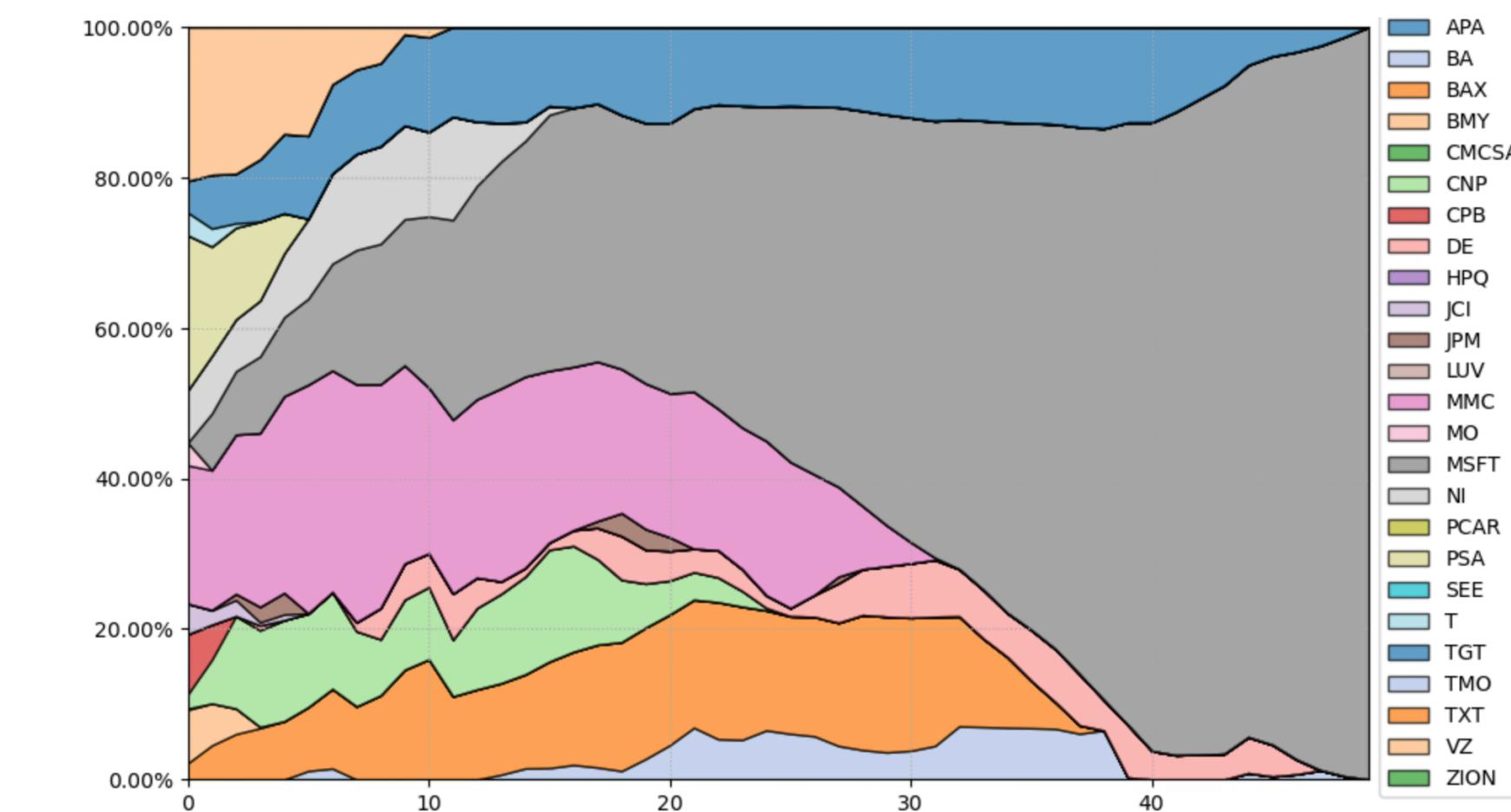
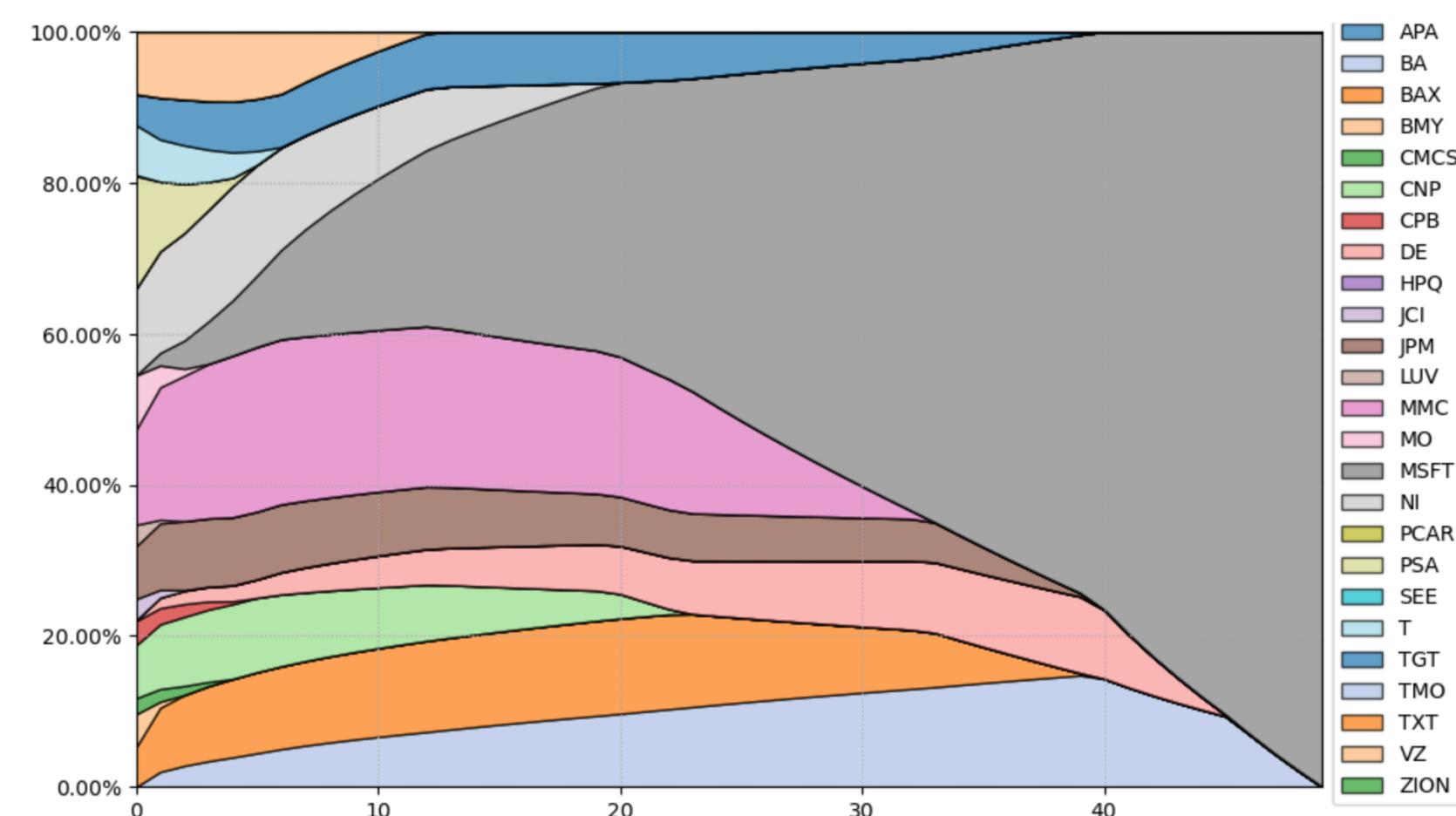
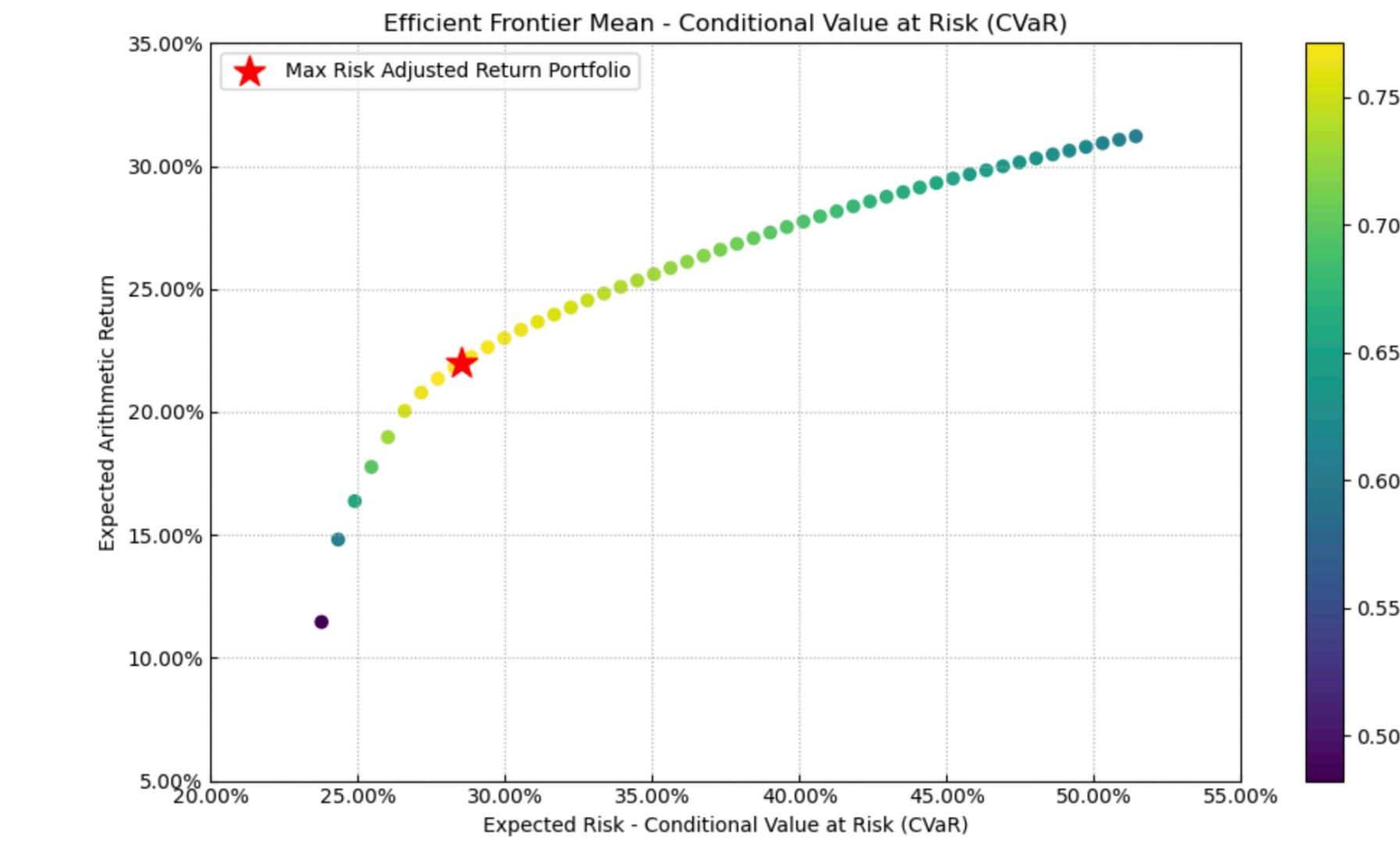


# More Riskfolio-Lib Features

## Efficient Frontier Mean-Standard Deviation

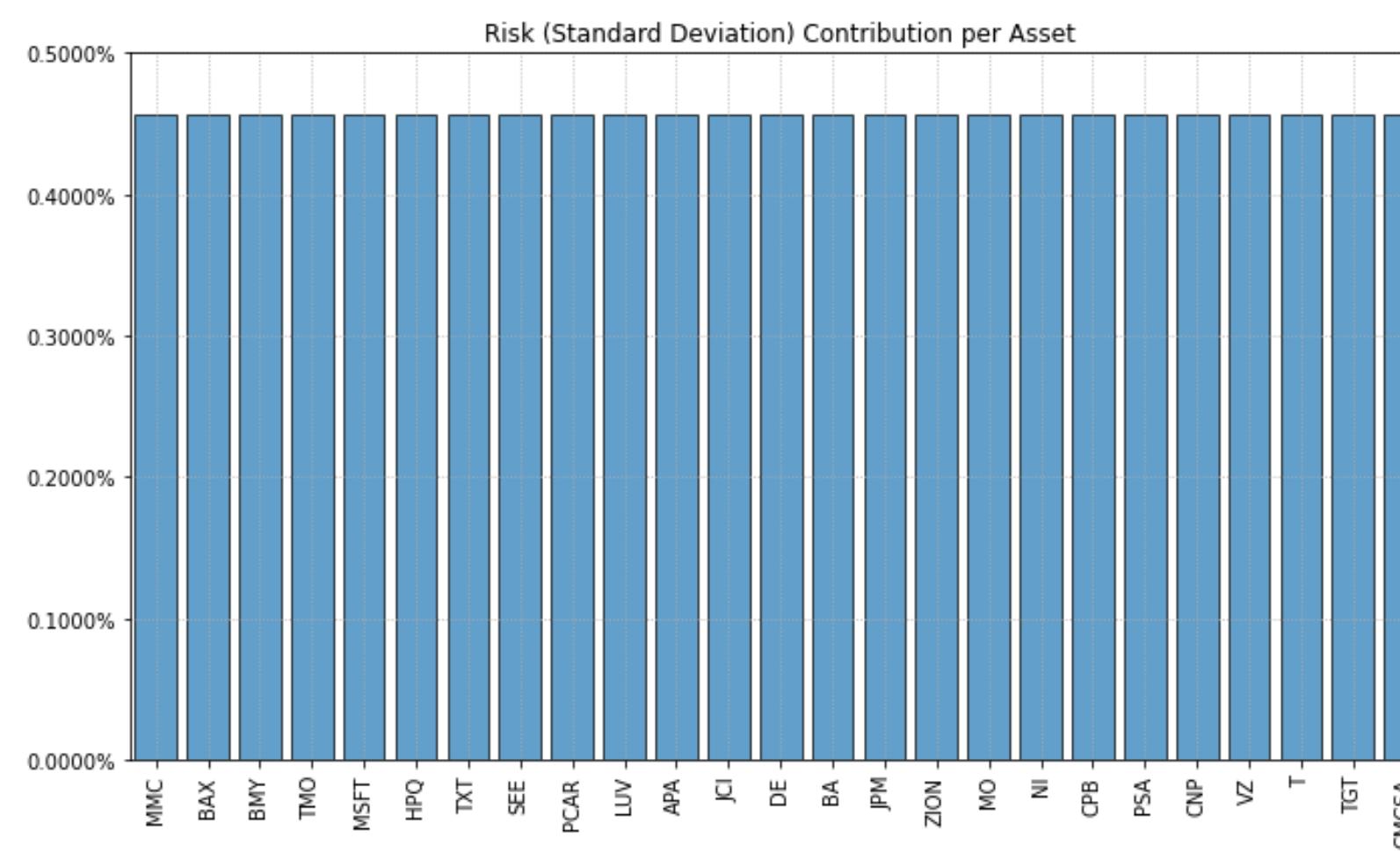


## Efficient Frontier Mean-CVaR

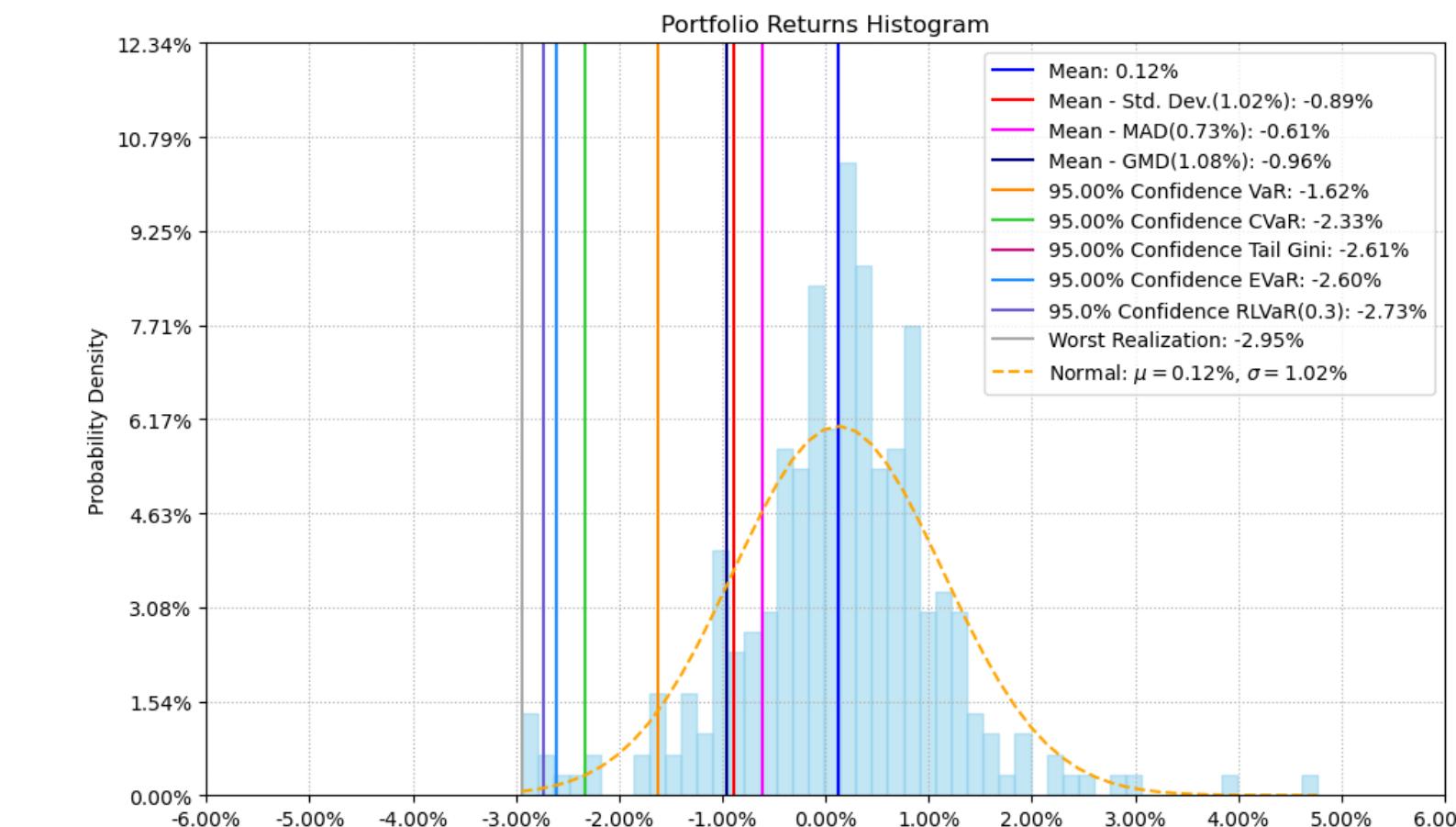


# More Riskfolio-Lib Features

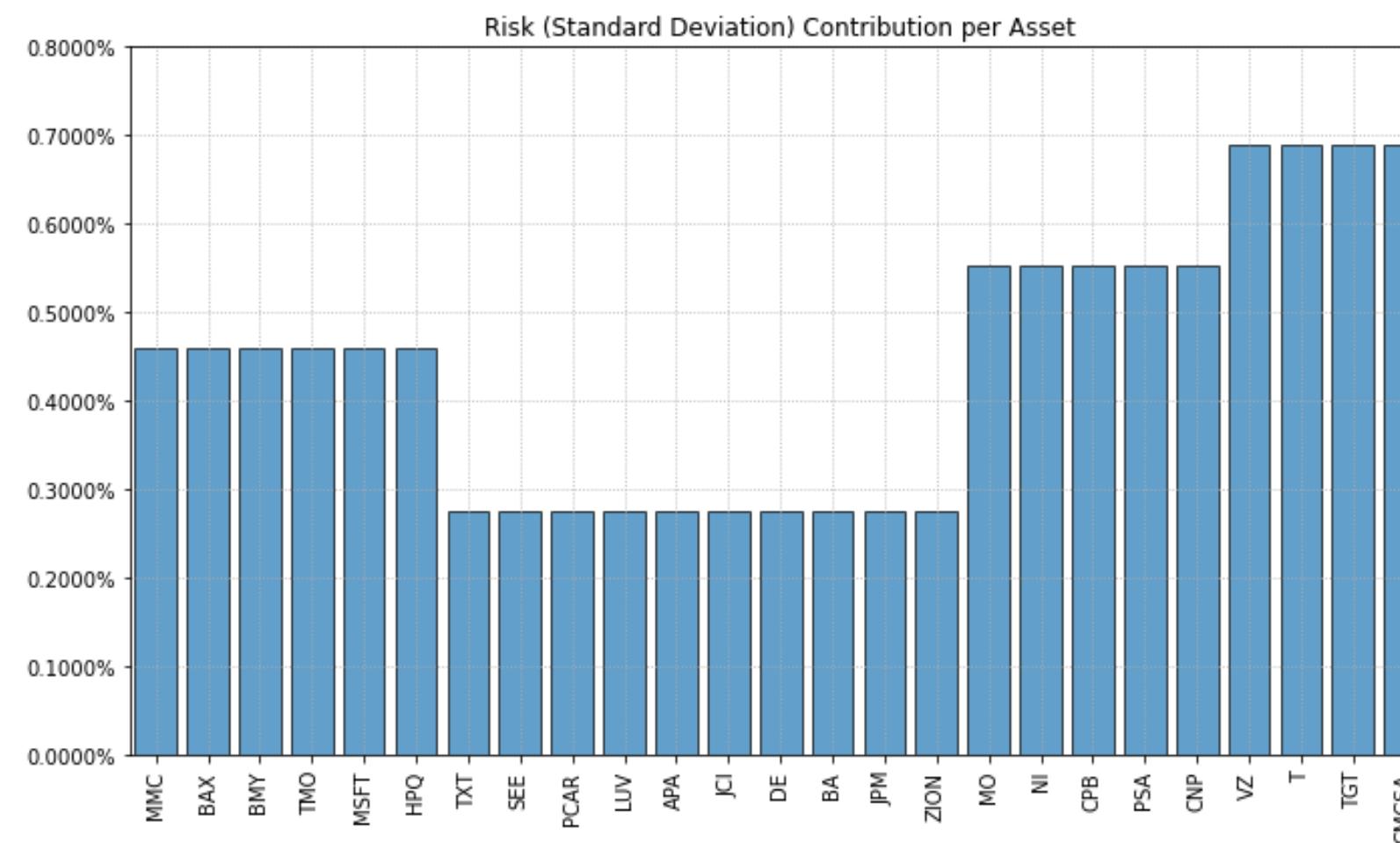
**Risk Parity - Equal Risk Contribution**



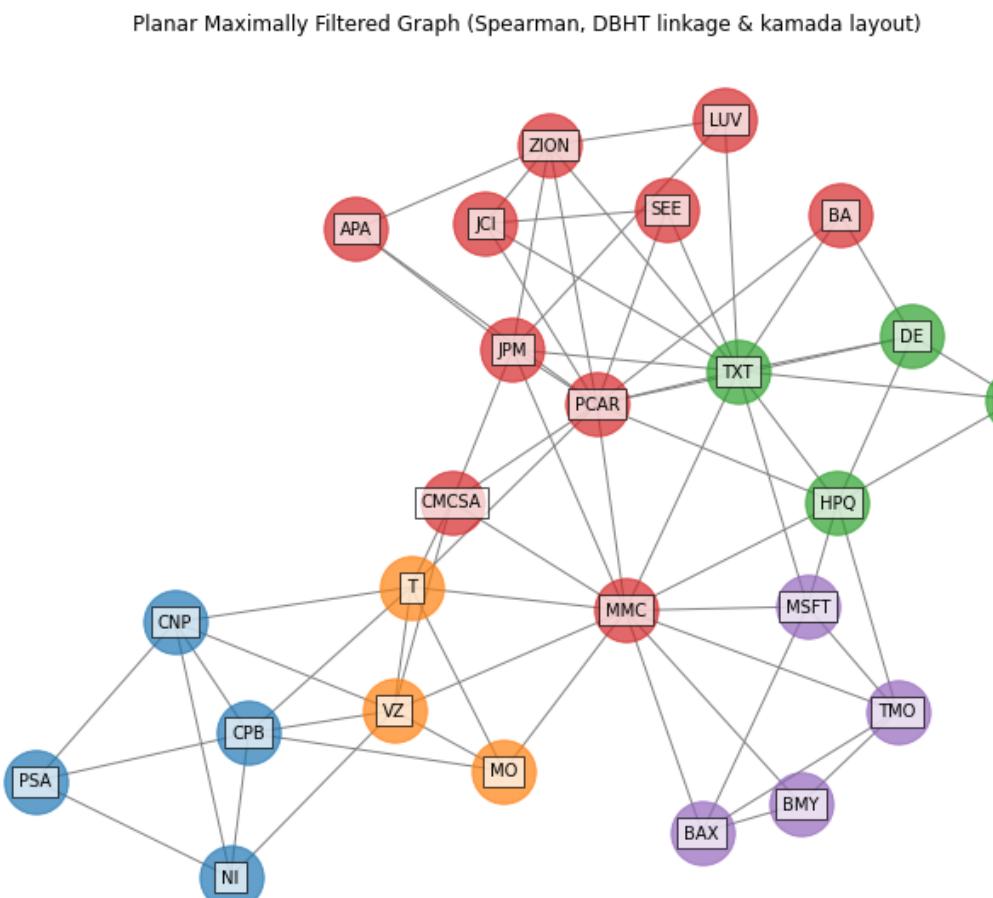
**Portfolio Return's Histogram**



**Risk Parity - Equal Risk Contribution per Asset Class**



**Assets Cluster's Network**



# Riskfolio-Lib Links

- Source code is available in <https://github.com/dcajasn/Riskfolio-Lib>
- Documentation is available in <https://riskfolio-lib.readthedocs.io/>
- Examples are available in <https://riskfolio-lib.readthedocs.io/en/latest/examples.html>
- PyPi page for installation is available in <https://pypi.org/project/Riskfolio-Lib/>
- Support this project (Donations):
  - <https://github.com/sponsors/dcajasn>
  - <https://ko-fi.com/riskfolio>

# Riskfolio-Lib Tutorial

## Riskfolio-Lib Tutorial:

[Financionerioncios](#)  
[Orenji](#)  
[Riskfolio-Lib](#)  
[Dany Cajas](#)



## Mean Risk Optimization

### 1. Downloading the data:

```
In [1]: import numpy as np
import pandas as pd
import yfinance as yf
import warnings

warnings.filterwarnings("ignore")
pd.options.display.float_format = '{:.4%}'.format

# Date range
start = '2016-01-01'
end = '2019-12-30'

# Tickers of assets
assets = ['JCI', 'TGT', 'CMCSA', 'CPB', 'MO', 'APA', 'MMC', 'JPM',
          'ZION', 'PSA', 'BAX', 'BMY', 'LUV', 'PCAR', 'TXT', 'TMO',
          'DE', 'MSFT', 'HPQ', 'SEE', 'VZ', 'CNP', 'NI', 'T', 'BA']
assets.sort()

# Downloading data
data = yf.download(assets, start = start, end = end)
data = data.loc[:,('Adj Close', slice(None))]
data.columns = assets
```

# Selected Questions

- About advanced mathematical portfolio construction models beyond mean-variance theory under ESG context.
- How stable the most recent Machine Learning allocation optimization methods are, compare to more traditional ones ?
- How would you account for tail risk in portfolio optimization programs?
- What is your favorite feature?

# Selected Questions

- Does speaker have any experience in integrating Riskfolio-lib with another open-source data aggregation tool OpenBB?
- What is the necessary programming background to build portfolios?
- Recommended mathematics to study?
- Highlight practical differences between RIVaR, EVaR, CVaR and cases where each one where should be over the others?



Thanks

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