INTERMEDIATE PORTFOLIO ANALYSIS IN R

Welcome to Intermediate Portfolio Analysis in R

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What you will learn:

- Build on fundamental concepts from "Introduction to Portfolio Analysis in R"
- Explore advanced concepts in the portfolio optimization process
- Use the R package `PortfolioAnalytics` to solve portfolio optimization problems that mirror real world problems

Modern Portfolio Theory

Modern Portfolio Theory (MPT) was introduced by Harry Markowitz in 1952.

MPT states that an investor's objective is to maximize **portfolio expected return** for a given amount of **risk**.

Common Objectives:

- Maximize a measure of gain per unit measure of risk
- Minimize a measure of risk

Mean - Standard Deviation Example: Setup

```
> library(PortfolioAnalytics)
> data(edhec)
> data <- edhec[,1:8]

# Create the portfolio specification
> port_spec <- portfolio.spec(colnames(data))

> port_spec <- add.constraint(portfolio = port_spec,
                              type = "full_investment")
> port_spec <- add.constraint(portfolio = port_spec,
                              type = "long_only")

> port_spec <- add.objective(portfolio = port_spec,
                             type = "return",
                             name = "mean")
> port_spec <- add.objective(portfolio = port_spec,
                             type = "risk",
                             name = "StdDev")
```

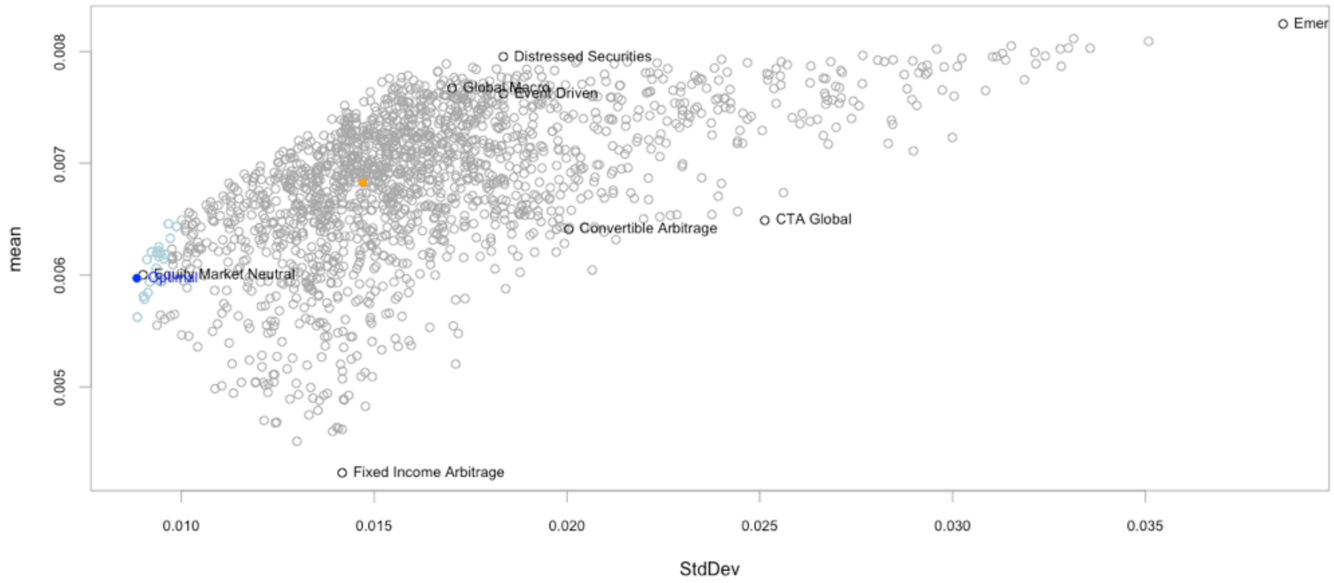
Mean - Standard Deviation Example: Output

```
> print(port_spec)
***************************************************
PortfolioAnalytics Portfolio Specification
***************************************************
Call:
portfolio.spec(assets = colnames(data))

Number of assets: 8
Asset Names
[1] "Convertible Arbitrage"  "CTA Global"              "Distressed Securities"
[4] "Emerging Markets"       "Equity Market Neutral"   "Event Driven"
[7] "Fixed Income Arbitrage" "Global Macro"

Constraints
Enabled constraint types
     - full_investment
     - long_only

Objectives:
Enabled objective names
     - mean
     - StdDev
```

Mean - Standard Deviation Example: Optimize

```
# Run optimization and chart results in risk-reward space
> opt <- optimize.portfolio(data, portfolio = port_spec,
                            optimize_method = "random",
                            trace = TRUE)
```

```
> chart.RiskReward(opt, risk.col = "StdDev", return.col = "mean",
                   chart.assets = TRUE)
```



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Let’s practice!

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Challenges of Portfolio Optimization

Challenges:

- Many solvers are not specific to portfolio optimization
- Understanding the capabilities and limits of solvers to select the appropriate solver for the problem **or** formulate the problem to fit the solver
- Difficult to switch between solvers
- Closed-Form solver (eg. quadratic programming)
- Global solver (eg. differential evolution optimization)

Quadratic Utility

Maximize: $w^T * \mu - \lambda * w^T * \Sigma * w$

Subject To:

- $w_i >= 0$
- $\sum_{i=1}^{n} w_i = 1$

Where:

- w is the weight vector
- μ is the expected return vector
- λ is the risk aversion parameter
- Σ is the variance - covariance matrix

Quadratic Programming Solver

Use the R package `quadprog` to solve the quadratic utility optimization problem.

`solve.QP()` solves quadratic programming problems of the form:

- $min(-d^T b + \frac{1}{2} b^T D b)$

Subject to the constraint:

- $A^T b >= b_0$

Quadratic Utility Optimization

```
# Load quadprog
> library(quadprog)
> data(edhec)
> dat <- edhec[,1:4]

# Create the constraint matrix
> Amat <- cbind(1, diag(ncol(dat)), -diag(ncol(dat)))

# Create the constraint vector
> bvec <- c(1, rep(0, ncol(dat)), -rep(1, ncol(dat)))

# Create the objective matrix
> Dmat <- 10 * cov(dat)

# Create the objective vector
> dvec <- colMeans(dat)

# Specify the number of equality constraints
> meq <- 1

# Solve the optimization problem
> opt <- solve.QP(Dmat, dvec, Amat, bvec, meq)
```

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Introduction to PortfolioAnalytics

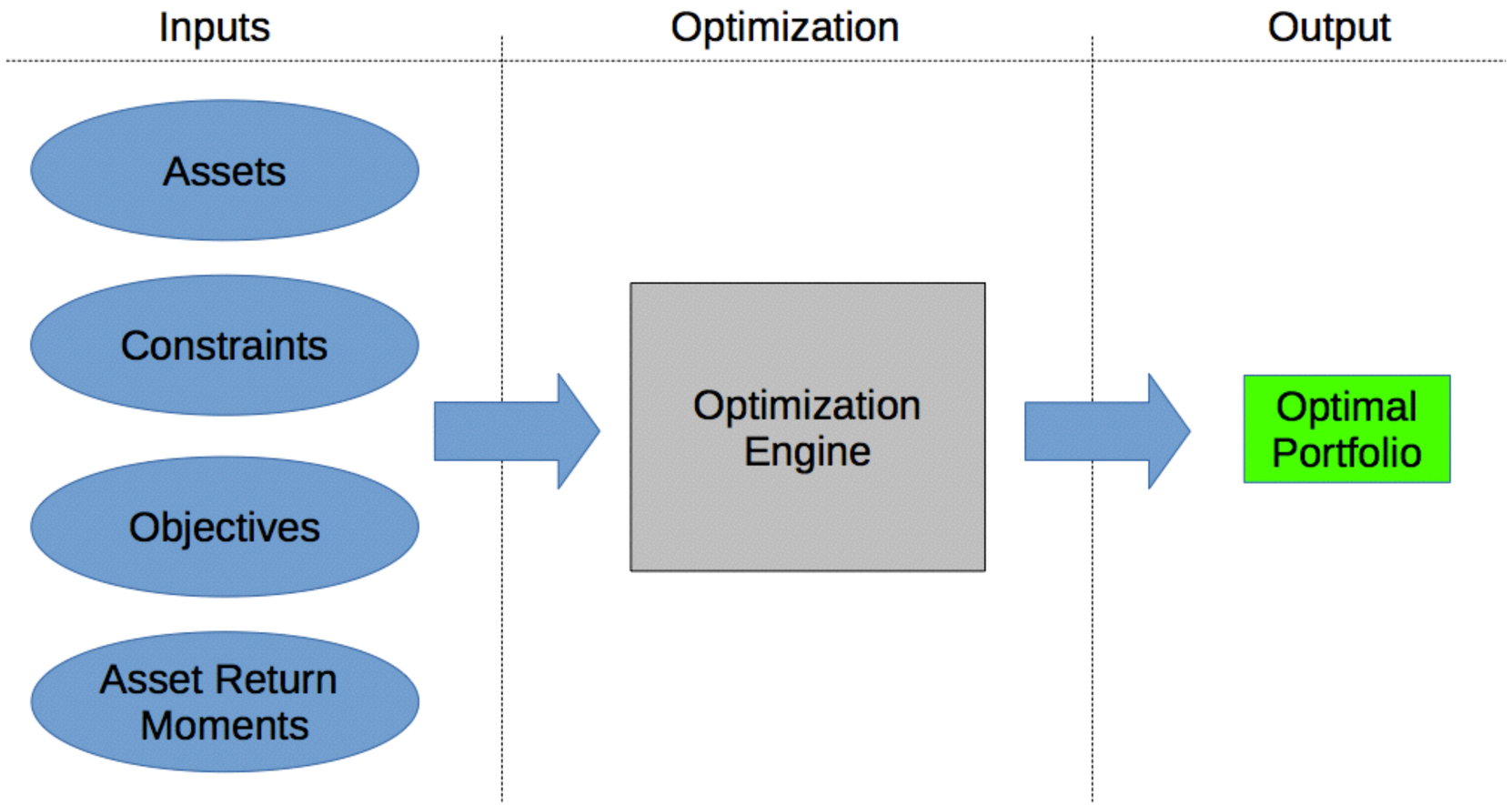
PortfolioAnalytics

`PortfolioAnalytics` is designed to provide numerical solutions and visualizations for portfolio optimization problems with complex constraints and objectives.

Supports:

- Multiple and modular constraint and objective types
- An objective function can be any valid R function
- User defined moment functions (covariance matrix, return projections)
- Visualizations
- Solver agnostic
- Parallel computing

PortfolioAnalytics Framework



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