Welcome to the course!

INTERMEDIATE PORTFOLIO ANALYSIS IN R

Ross Bennett
Instructor

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")
```

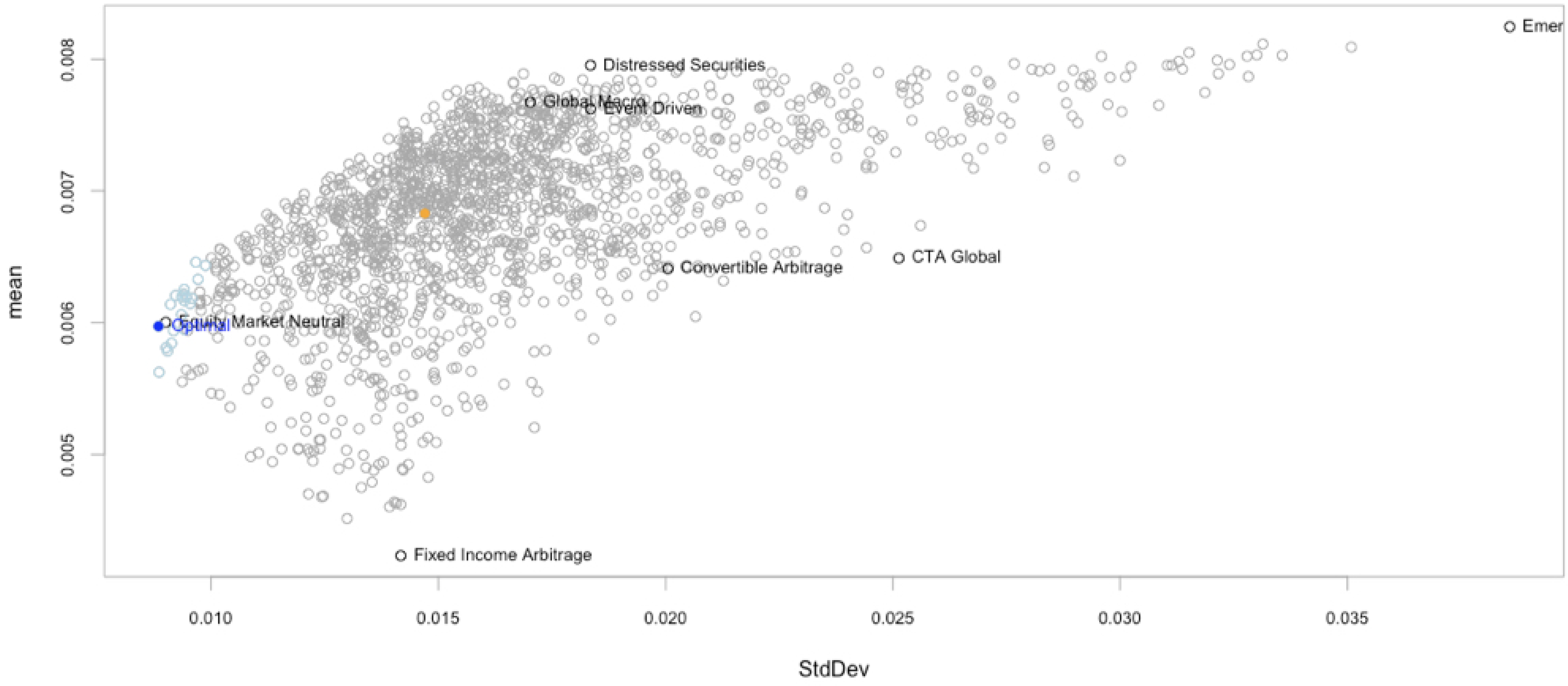
```
**************************************************
PortfolioAnalytics Portfolio Specification
**************************************************
Call:
portfolio.spec(assets = colnames(data))

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)
```

Mean - Standard Deviation Example: Optimize



Let's practice!

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Challenges of portfolio optimization

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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 (e.g., quadratic programming)
- Global solver (e.g., differential evolution optimization)

Quadratic utility

- Maximize: $\omega^T * \mu - \lambda * \omega^T * \Sigma * \omega$
- Subject to:

$$\omega_i >= 0$$

$$\sum_{i=1}^{n} \omega_i = 1$$

- ω 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:

$$A^T b >= b_0$$

```r
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 number of equality constraints
meq <- 1

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

Let's practice!

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Introduction to PortfolioAnalytics

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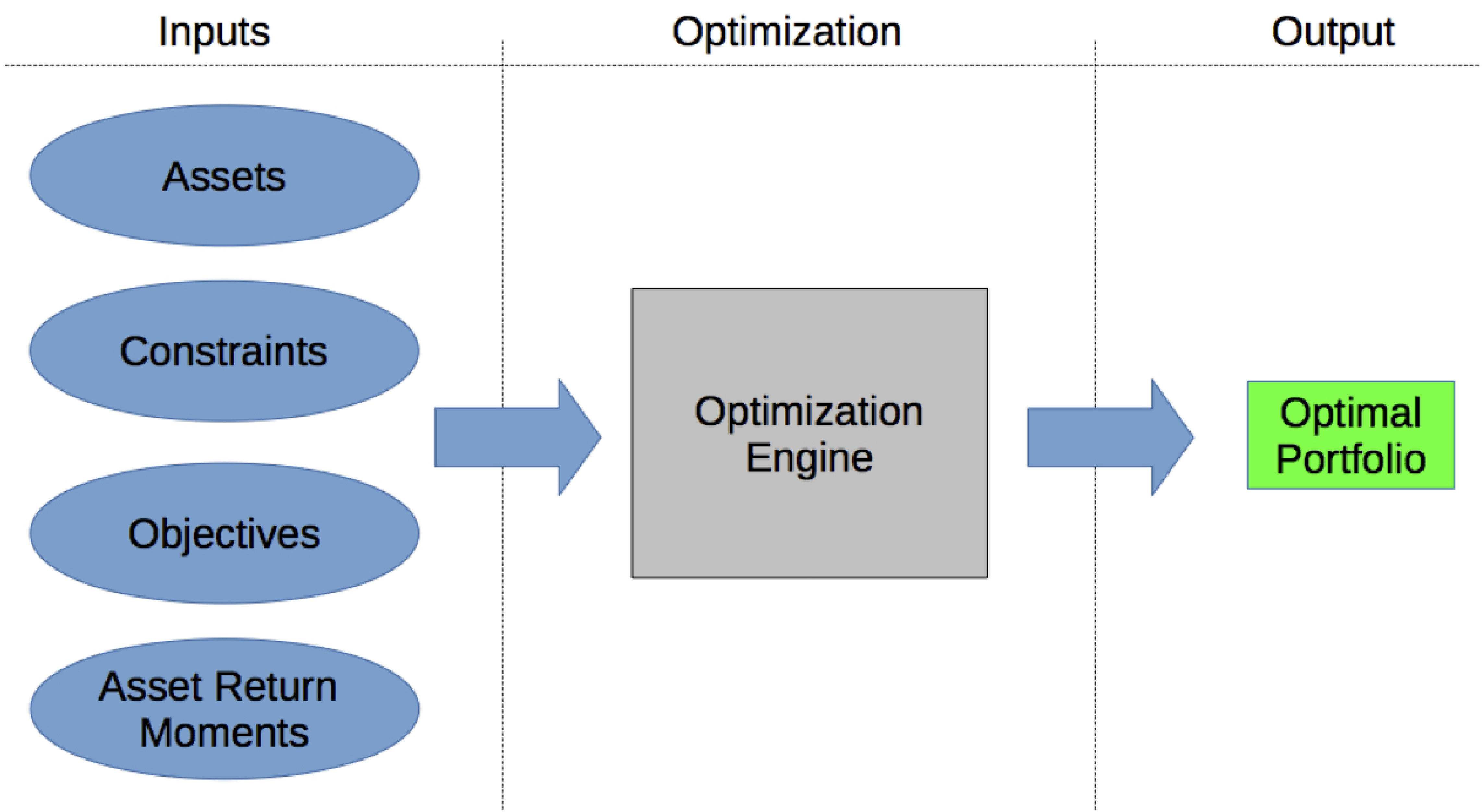
PortfolioAnalytics

`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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