Asset return oments

INTERMEDIATE PORTFOLIO ANALYSIS IN R

Ross Bennett
Instructor

datacamp

Optimization Inputs

Portfolio optimization problem inputs:

- Assets
- Constraints
- Objectives
- Moments of asset returns

Asset return moments

- First Moment: expected returns vector
- Second Moment: variance-covariance matrix
- Third Moment: coskewness matrix
- Fourth Moment: cokurtosis matrix

Asset return moments

Moments to estimate are determined by objectives and constraints:

- Mean - Variance
  - Expected returns vector
  - Covariance matrix
- Minimum Variance
  - Covariance matrix

Asset return moment estimates

Ledoit and Wolf (2003): *"The central message of this paper is that nobody should be using the sample covariance matrix for the purpose of portfolio optimization."*

***20 Asset Portfolio*:**

Method	Sample	k = 3 factors
# of parameters	210	86

- Methods:
  - Sample
  - Shrinkage estimators
  - Factor model
  - Expressing views
  - Robust statistics

Calculating moments in PortfolioAnalytics

```
set.portfolio.moments(R,
                      portfolio,
                      method = c("sample", "boudt", "black_litterman", "meucci"),
                      ...)
```

`set.portfolio.moments()` supports several methods:

- Sample
- Boudt
- Black-Litterman
- Meucci

Example: moments in PortfolioAnalytics

```
# Sample vs Boudt
sample_moments <- set.portfolio.moments(R = asset_returns,
                                        portfolio = port_spec)

boudt_moments <- set.portfolio.moments(R = asset_returns,
                                       portfolio = port_spec,
                                       method = "boudt",
                                       k = 1)
```

Example: moments in PortfolioAnalytics

```
round(sample_moments$sigma, 6)
```

```
          [,1]      [,2]      [,3]  ...
[1,]  0.000402 -0.000034  0.000262  ...
[2,] -0.000034  0.000632 -0.000037  ...
[3,]  0.000262 -0.000037  0.000337  ...
[4,]  0.000429 -0.000010  0.000568  ...
```

```
round(boudt_moments$sigma, 6)
```

```
          [,1]      [,2]      [,3]  ...
[1,]  0.000403 -0.000016  0.000224  ...
[2,] -0.000016  0.000636 -0.000019  ...
[3,]  0.000224 -0.000019  0.000337  ...
[4,]  0.000523 -0.000044  0.000614  ...
```

Let's practice!

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Custom moment functions

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Custom moment functions

A custom moment function is a user defined function

- Arguments:
  - `R` for asset returns
  - `portfolio` for the portfolio specification object
- Return a named list where the elements represent the moments
  - `mu` : Expected returns vector
  - `sigma` : Variance-covariance matrix
  - `m3` : Coskewness matrix
  - `m4` : Cokurtosis matrix

Example: custom moment function

```
library(MASS)

custom_fun <- function(R, portfolio, rob_method = "mcd"){
    out <- list()
    out$sigma <- cov.rob(R, method = rob_method)
    return(out)
```

```
# Passing the rob_method argument to custom_fun
optimize.portfolio(R, portfolio, momentFUN = custom_fun,
                   rob_method = "mcd")
optimize.portfolio(R, portfolio, momentFUN = custom_fun,
                   rob_method = "mve")
```

Let's practice!

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Objective functions

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Objective functions

Objective functions compute the objective value. In `PortfolioAnalytics` , objective functions can be any valid R function.

- Common portfolio risk measures
  - standard deviation, expected shortfall, value at risk, component contribution to risk, maximum drawdown, Sharpe Ratio
- Common benchmark relative performance measures
  - information ratio, tracking error, excess return, maximum relative drawdown

Custom objective functions

User defined functions as objective functions

- Argument naming:
  - `R` for asset returns
  - `weights` for the portfolio weights
  - `mu`, `sigma`, `m3`, `m4` for the moments
- Returns a single value

```
# Annualized sharpe ratio
sr_annualized <- function(R, weights, sigma, scale, rfr){

    # Geometric annualized return
    r <- Return.annualized(Return.portfolio(R, weights), scale = scale)
    # Annual excess return
    re <- r - rfr

    # Annualized portfolio standard deviation
    pasd <- sqrt(as.numeric(t(weights) %*%
                  sigma %*% weights)) * sqrt(scale)

    return(re / pasd)
}
```

```
data(edhec)
asset_returns <- edhec[,1:4]
# Setup spec and add constraints
port_spec <- portfolio.spec(assets = colnames(asset_returns))
port_spec <- add.constraint(portfolio = port_spec,
                            type = "full_investment")
port_spec <- add.constraint(portfolio = port_spec,
                            type = "long_only")
# Add custom objective function
port_spec <- add.objective(portfolio = port_spec,
                           type = "return", name = "sr_annualized",
                           arguments = list(scale = 12, rfr = 0.02))
```

Let's practice!

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