Package ‘HDShOP’

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Title High-Dimensional Shrinkage Optimal Portfolios
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Description
Constructs shrinkage estimators of high-dimensional mean-variance portfolios and performs
high-dimensional tests on optimality of a given portfolio. The techniques developed in
are central to the package. They provide simple and feasible estimators and tests for optimal
portfolio weights, which are applicable for 'large p and large n' situations where p is the
portfolio dimension (number of stocks) and n is the sample size. The package also includes tools
for constructing portfolios based on shrinkage estimators of the mean vector and covariance matrix
as well as a new Bayesian estimator for the Markowitz efficient frontier recently developed by

License GPL-3
LazyData yes
Encoding UTF-8
Depends R (>= 3.5.0)
Imports Rdpack, lattice
Suggests ggplot2, testthat, EstimDiagnostics, MASS, corpcor, waldo
RdMacros Rdpack
RoxygenNote 7.3.1
NeedsCompilation no
Class MeanVar_portfolio

Description

Class MeanVar_portfolio is designed to construct mean-variance portfolios with provided estimators of the mean vector, covariance matrix, and inverse covariance matrix. It includes the following elements:

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</table>
CovarEstim

weights  portfolio weights
Port_Var  portfolio variance
Port_mean_return  expected portfolio return
Sharpe  portfolio Sharpe ratio

See Also

summary.MeanVar_portfolio summary method for the class, new_MeanVar_portfolio class constructor, validate_MeanVar_portfolio class validator, MeanVar_portfolio class helper.

CovarEstim Covariance matrix estimator

Description

It is a function dispatcher for covariance matrix estimation. One can choose between traditional and shrinkage-based estimators.

Usage

CovarEstim(x, type = c("trad", "BGP14", "LW20"), ...)

Arguments

x  a p by n matrix or a data frame of asset returns. Rows represent different assets, columns – observations.
type  a character. The estimation method to be used.
...  arguments to pass to estimators

Details

The available estimation methods are:

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<td>Ledoit &amp; Wolf 2020</td>
<td>LW20</td>
</tr>
</tbody>
</table>

Value

an object of class matrix
Examples

n<-3e2 # number of realizations
p<-.5*n # number of assets

x <- matrix(data = rnorm(n*p), nrow = p, ncol = n)

Mtrx_trad <- CovarEstim(x, type="trad")

TM <- matrix(0, p, p)
diag(TM) <- 1
Mtrx_bgp <- CovarEstim(x, type="BGP14", TM=TM)

Mtrx_lw <- CovarEstim(x, type="LW20")

Description

The optimal linear shrinkage estimator of the covariance matrix that minimizes the Frobenius norm:

\[ \hat{\Sigma}_{\text{OLSE}} = \hat{\alpha} S + \hat{\beta} \Sigma_0, \]

where \( \hat{\alpha} \) and \( \hat{\beta} \) are optimal shrinkage intensities given in Eq. (4.3) and (4.4) of Bodnar et al. (2014). \( S \) is the sample covariance matrix (SCM, see Sigma_sample_estimator) and \( \Sigma_0 \) is a positive definite symmetric matrix used as the target matrix (TM), for example, \( \frac{1}{p} I \).

Usage

CovShrinkBGP14(n, TM, SCM)

Arguments

n sample size.
TM the target matrix for the shrinkage estimator.
SCM sample covariance matrix.

Value

a list containing an object of class matrix (S) and the estimated shrinkage intensities \( \hat{\alpha} \) and \( \hat{\beta} \).

References

InvCovShrinkBGP16

Examples

# Parameter setting
n<-3e2
c<-0.7
p<-c*n
mu <- rep(0, p)
Sigma <- RandCovMtrx(p=p)

# Generating observations
X <- t(MASS::mvrnorm(n=n, mu=mu, Sigma=Sigma))

# Estimation
TM <- matrix(0, nrow=p, ncol=p)
diag(TM) <- 1/p
SCM <- Sigma_sample_estimator(X)
Sigma_shr <- CovShrinkBGP14(n=n, TM=TM, SCM=SCM)
Sigma_shr$S[1:6, 1:6]

Description

The optimal linear shrinkage estimator of the inverse covariance (precision) matrix that minimizes the Frobenius norm is given by:

\[ \hat{\Pi}_{OLSE} = \hat{\alpha} \hat{\Pi} + \hat{\beta} \Pi_0, \]

where \( \hat{\alpha} \) and \( \hat{\beta} \) are optimal shrinkage intensities given in Eq. (4.4) and (4.5) of Bodnar et al. (2016). \( \hat{\Pi} \) is the inverse of the sample covariance matrix (iSCM) and \( \Pi_0 \) is a positive definite symmetric matrix used as the target matrix (TM), for example, I.

Usage

InvCovShrinkBGP16(n, p, TM, iSCM)

Arguments

- **n**: the number of observations
- **p**: the number of variables (rows of the covariance matrix)
- **TM**: the target matrix for the shrinkage estimator
- **iSCM**: the inverse of the sample covariance matrix

Value

a list containing an object of class matrix (S) and the estimated shrinkage intensities \( \hat{\alpha} \) and \( \hat{\beta} \).
References

Examples
```r
# Parameter setting
n <- 3e2
c <- 0.7
p <- c*n
mu <- rep(0, p)
Sigma <- RandCovMtrx(p=p)

# Generating observations
X <- t(MASS::mvrnorm(n=n, mu=mu, Sigma=Sigma))

# Estimation
TM <- matrix(0, nrow=p, ncol=p)
diag(TM) <- 1
iSCM <- solve(Sigma_sample_estimator(X))
Sigma_shr <- InvCovShrinkBGP16(n=n, p=p, TM=TM, iSCM=iSCM)
Sigma_shr$S[1:6, 1:6]
```

MeanEstim

Mean vector estimator

Description
A user-friendly function for estimation of the mean vector. Essentially, it is a function dispatcher for estimation of the mean vector that chooses a method accordingly to the type argument.

Usage

```r
MeanEstim(x, type, ...)
```

Arguments

- `x` a p by n matrix or a data frame of asset returns. Rows represent different assets, columns – observations.
- `type` a character. The estimation method to be used.
- `...` arguments to pass to estimators

Details
The available estimation methods for the mean are:

<table>
<thead>
<tr>
<th>Function</th>
<th>Paper</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>.rowMeans</td>
<td></td>
<td>trad</td>
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</table>
**MeanVar_portfolio**

<table>
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<tr>
<th>mean_bs</th>
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<tr>
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</tr>
</tbody>
</table>

**Value**

a numeric vector—a value of the specified estimator of the mean vector.

**References**


**Examples**

```r
n<-3e2 # number of realizations
p<-.5*n # number of assets
x <- matrix(data = rnorm(n*p), nrow = p, ncol = n)
Mean_trad <- MeanEstim(x, type="trad")
mu_0 <- rep(1/p, p)
Mean_BOP <- MeanEstim(x, type="BOP19", mu_0=mu_0)
```

**MeanVar_portfolio**  
*A helper function for MeanVar_portfolio*

**Description**

A user-friendly function making mean-variance portfolios for assets with customly computed covariance matrix and mean returns. The weights are computed in accordance with the formula

\[ \hat{w}_{MV} = \frac{\hat{\Sigma}^{-1}11'}{1'\hat{\Sigma}^{-1}1} + \gamma^{-1}\hat{Q}\hat{\mu}, \]

where \(\hat{\Sigma}\) is an estimator for the covariance matrix, \(\hat{\mu}\) is an estimator for the mean vector, \(\gamma\) is the coefficient of risk aversion, and \(\hat{Q}\) is given by

\[ \hat{Q} = \hat{\Sigma}^{-1} - \frac{\hat{\Sigma}^{-1}11'\hat{\Sigma}^{-1}}{1'\hat{\Sigma}^{-1}1}. \]

The computation is made by `new_MeanVar_portfolio` and the result is validated by `validate_MeanVar_portfolio`. 
Usage

MeanVar_portfolio(mean_vec, cov_mtrx, gamma)

Arguments

mean_vec        mean vector of asset returns provided in the form of a vector or a list.
cov_mtrx        the covariance matrix of asset returns. It could be a matrix or a data frame.
gamma           a numeric variable. Coefficient of risk aversion.

Value

Mean-variance portfolio in the form of object of S3 class MeanVar_portfolio.

Examples

n<-3e2 # number of realizations
p<-.5*n # number of assets
gamma<-1

x <- matrix(data = rnorm(n*p), nrow = p, ncol = n)
# Simple MV portfolio
cov_mtrx <- Sigma_sample_estimator(x)
means <- rowMeans(x)
cust_port_simp <- MeanVar_portfolio(mean_vec=means, cov_mtrx=cov_mtrx, gamma=2)
str(cust_port_simp)


mean_bop19

BOP shrinkage estimator

Description

Shrinkage estimator of the high-dimensional mean vector as suggested in Bodnar et al. (2019). It uses the formula

\[ \hat{\mu}_{BOP} = \hat{\alpha} \bar{x} + \hat{\beta} \mu_0, \]

where \( \hat{\alpha} \) and \( \hat{\beta} \) are shrinkage coefficients given by Eq.(6) and Eq.(7) of Bodnar et al. (2019) that minimize weighted quadratic loss for a given target vector \( \mu_0 \) (shrinkage target). \( \bar{x} \) stands for the sample mean vector.

Usage

mean_bop19(x, mu_0 = rep(1, p))
mean_bs

Arguments

x  
a p by n matrix or a data frame of asset returns. Rows represent different assets, columns – observations.

mu_0  
a numeric vector. The target vector used in the construction of the shrinkage estimator.

Value

a numeric vector containing the shrinkage estimator of the mean vector

References


Examples

n<-7e2  # number of realizations
p<-.5*n  # number of assets
x <- matrix(data = rnorm(n*p), nrow = p, ncol = n)
mm <- mean_bop19(x=x, mu_0=rep(1,p))

mean_bs  
Bayes-Stein shrinkage estimator of the mean vector

Description

Bayes-Stein shrinkage estimator of the mean vector as suggested in Jorion (1986). The estimator is given by

$$\hat{\mu}_BS = (1 - \beta)\bar{x} + \beta Y_0 1,$$

where $\bar{x}$ is the sample mean vector, $\beta$ and $Y_0$ are derived using Bayesian approach (see Eq.(14) and Eq.(17) in Jorion (1986)).

Usage

mean_bs(x)

Arguments

x  
a p by n matrix or a data frame of asset returns. Rows represent different assets, columns – observations.

Value

a numeric vector containing the Bayes-Stein shrinkage estimator of the mean vector
References

Examples
```r
n <- 7e2  # number of realizations
p <- .5*n  # number of assets
x <- matrix(data = rnorm(n*p), nrow = p, ncol = n)
mm <- mean_bs(x=x)
```

### mean_js

*James-Stein shrinkage estimator of the mean vector*

**Description**

James-Stein shrinkage estimator of the mean vector as suggested in Jorion (1986). The estimator is given by

$$
\hat{\mu}_{JS} = (1 - \beta)\bar{x} + \beta Y_0 1,
$$

where $\bar{x}$ is the sample mean vector, $\beta$ is the shrinkage coefficient which minimizes a quadratic loss given by Eq.(11) in Jorion (1986). $Y_0$ is a prespecified value.

**Usage**

```r
mean_js(x, Y_0 = 1)
```

**Arguments**

- `x` a p by n matrix or a data frame of asset returns. Rows represent different assets, columns – observations.
- `Y_0` a numeric variable. Shrinkage target coefficient.

**Value**

a numeric vector containing the James-Stein shrinkage estimator of the mean vector.

**References**


**Examples**

```r
n<-7e2  # number of realizations
p<-.5*n  # number of assets
x <- matrix(data = rnorm(n*p), nrow = p, ncol = n)
mm <- mean_js(x=x, Y_0 = 1)
```
MVShrinkPortfolio

Description

The main function for mean-variance (also known as expected utility) portfolio construction. It is a dispatcher using methods according to argument type, values of gamma and dimensionality of matrix x.

Usage

MVShrinkPortfolio(x, gamma, type = c("shrinkage", "traditional"), ...)

Arguments

x a p by n matrix or a data frame of asset returns. Rows represent different assets, columns – observations.
gamma a numeric variable. Coefficient of risk aversion.
type a character. The type of methods to use to construct the portfolio.
... arguments to pass to portfolio constructors

Details

The sample estimator of the mean-variance portfolio weights, which results in a traditional mean-variance portfolio, is calculated by

\[
\hat{w}_{MV} = S^{-1}1 + \gamma^{-1}Q\bar{x},
\]

where \(S^{-1}\) and \(\bar{x}\) are the inverse of the sample covariance matrix and the sample mean vector of asset returns respectively, \(\gamma\) is the coefficient of risk aversion and \(Q\) is given by

\[
\hat{Q} = S^{-1} - \frac{S^{-1}11'S^{-1}}{1'S^{-1}1}.
\]

In the case when \(p > n\), \(S^{-1}\) becomes \(S^+\), Moore-Penrose inverse. The shrinkage estimator for the mean-variance portfolio weights in a high-dimensional setting is given by

\[
\hat{w}_{ShMV} = \hat{\alpha}\hat{w}_{MV} + (1 - \hat{\alpha})b,
\]

where \(\hat{\alpha}\) is the estimated shrinkage intensity and \(b\) is a target vector with the sum of the elements equal to one.

In the case \(\gamma \neq \infty\), \(\hat{\alpha}\) is computed following Eq. (2.22) of Bodnar et al. (2023) for \(c<1\) and following Eq. (2.29) of Bodnar et al. (2023) for \(c>1\).

The case of a fully risk averse investor (\(\gamma = \infty\)) leads to the traditional global minimum variance (GMV) portfolio with the weights given by

\[
\hat{w}_{GMV} = \frac{S^{-1}1}{1'S^{-1}1}.
\]
The shrinkage estimator for the GMV portfolio is then calculated by

$$\hat{w}_{\text{SHGMV}} = \hat{\alpha} \hat{w}_{\text{GMV}} + (1 - \hat{\alpha}) b,$$

with \( \hat{\alpha} \) given in Eq. (2.31) of Bodnar et al. (2018) for \( c<1 \) and in Eq. (2.33) of Bodnar et al. (2018) for \( c>1 \).

These estimation methods are available as separate functions employed by MVShrinkPortfolio accordingly to the following parameter configurations:

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<th>Paper</th>
<th>Type</th>
<th>gamma</th>
<th>p/n</th>
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<td>Bodnar et al. (2023)</td>
<td>shrinkage</td>
<td>&lt; Inf</td>
<td>&lt;1</td>
</tr>
<tr>
<td>new_MV_portfolio_weights_BDOPS21_pgn</td>
<td>Bodnar et al. (2023)</td>
<td>shrinkage</td>
<td>&lt; Inf</td>
<td>&gt;1</td>
</tr>
<tr>
<td>new_GMV_portfolio_weights_BDPS19</td>
<td>Bodnar et al. (2018)</td>
<td>shrinkage</td>
<td>Inf</td>
<td>&lt;1</td>
</tr>
<tr>
<td>new_GMV_portfolio_weights_BDPS19_pgn</td>
<td>Bodnar et al. (2018)</td>
<td>shrinkage</td>
<td>Inf</td>
<td>&gt;1</td>
</tr>
<tr>
<td>new_MV_portfolio_traditional</td>
<td>traditional</td>
<td>&gt; 0</td>
<td>&lt;1</td>
<td></td>
</tr>
<tr>
<td>new_MV_portfolio_traditional_pgn</td>
<td>traditional</td>
<td>&gt; 0</td>
<td>&gt;1</td>
<td></td>
</tr>
</tbody>
</table>

**Value**

A portfolio in the form of an object of class MeanVar_portfolio potentially with a subclass. See Class_MeanVar_portfolio for the details of the class.

**References**


**Examples**

```r
n<-3e2 # number of realizations
gamma<-1

# The case p<n
p<-.5*n # number of assets
b<-rep(1/p,p)
x <- matrix(data = rnorm(n*p), nrow = p, ncol = n)
test <- MVShrinkPortfolio(x=x, gamma=gamma, type='shrinkage', b=b, beta = 0.05)
str(test)

test <- MVShrinkPortfolio(x=x, gamma=Inf, type='shrinkage', b=b, beta = 0.05)
str(test)
```
```r
# The case p<n
p<-1.2*n  # Re-define the number of assets
b<-rep(1/p,p)
x <- matrix(data = rnorm(n*p), nrow = p, ncol = n)

test <- MVShrinkPortfolio(x=x, gamma=gamma, type='shrinkage',
                        b=b, beta = 0.05)
str(test)

test <- MVShrinkPortfolio(x=x, gamma=Inf, type='shrinkage',
                        b=b, beta = 0.05)
str(test)
```

---

### new_GMV_portfolio_weights_BDPS19

*Constructor of GMV portfolio object.*

**Description**

Constructor of global minimum variance portfolio. new_GMV_portfolio_weights_BDPS19 is for the case p<n, while new_GMV_portfolio_weights_BDPS19_pgn is for p>n, where p is the number of assets and n is the number of observations. For more details of the method, see `MVShrinkPortfolio`.

**Usage**

```r
new_GMV_portfolio_weights_BDPS19(x, b, beta)
new_GMV_portfolio_weights_BDPS19_pgn(x, b, beta)
```

**Arguments**

- **x**: a p by n matrix or a data frame of asset returns. Rows represent different assets, columns – observations.
- **b**: a numeric vector. 1-beta is the confidence level of the symmetric confidence interval, constructed for each weight.
- **beta**: a numeric variable. The confidence level for weight intervals.

**Value**

an object of class MeanVar_portfolio with subclass GMV_portfolio_weights_BDPS19.

<table>
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<tr>
<th>Element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
call the function call with which it was created
cov_mtrx the sample covariance matrix of the asset returns
inv_cov_mtrx the inverse of the sample covariance matrix
means sample mean vector estimate of the asset returns
w_GMVP sample estimator of portfolio weights
weights shrinkage estimator of portfolio weights
alpha shrinkage intensity for the weights
Port_Var portfolio variance
Port_mean_return expected portfolio return
Sharpe portfolio Sharpe ratio
weight_intervals A data frame, see details

weight_intervals contains a shrinkage estimator of portfolio weights, asymptotic confidence intervals for the true portfolio weights, the value of test statistic and the p-value of the test on the equality of the weight of each individual asset to zero (see Section 4.3 of Bodnar et al. 2023). weight_intervals is only computed when p<n.

References


Examples

```r
# c<1
n <- 3e2 # number of realizations
p <- .5*n # number of assets
b <- rep(1/p,p)

# Assets with a diagonal covariance matrix
x <- matrix(data = rnorm(n*p), nrow = p, ncol = n)
test <- new_GMV_portfolio_weights_BDPS19(x=x, b=b, beta=0.05)
str(test)

# Assets with a non-diagonal covariance matrix
Mtrx <- RandCovMtrx(p=p)
x <- t(MASS::mvrnorm(n=n , mu=rep(0,p), Sigma=Mtrx))
test <- new_GMV_portfolio_weights_BDPS19(x=x, b=b, beta=0.05)
```
summary(test)
# c>1

p <- 1.3*n # number of assets
b <- rep(1/p, p)

# Assets with a diagonal covariance matrix
x <- matrix(data = rnorm(n*p), nrow = p, ncol = n)
test <- new_GMV_portfolio_weights_BDPS19_pgn(x=x, b=b, beta=0.05)
str(test)

`new_MeanVar_portfolio`  
A constructor for class `MeanVar_portfolio`

**Description**

A light-weight constructor of objects of S3 class `MeanVar_portfolio`. This function is for development purposes. A helper function equipped with error messages and allowing more flexible input is `MeanVar_portfolio`.

**Usage**

```r
new_MeanVar_portfolio(mean_vec, cov_mtrx, gamma)
```

**Arguments**

- `mean_vec`: mean vector of asset returns
- `cov_mtrx`: the covariance matrix of asset returns

**Value**

Mean-variance portfolio in the form of object of S3 class `MeanVar_portfolio`.

**Examples**

```r
n<-3e2 # number of realizations
p<-.5*n # number of assets
gamma<-1

x <- matrix(data = rnorm(n*p), nrow = p, ncol = n)

# Simple MV portfolio
cov_mtrx <- Sigma_sample_estimator(x)
means <- rowMeans(x)
```
new_MV_portfolio_traditional

Traditional mean-variance portfolio

Description

Mean-variance portfolios with the traditional (sample) estimators for the mean vector and the covariance matrix of asset returns. For more details of the method, see MVShrinkPortfolio. new_MV_portfolio_traditional is for the case \( p < n \), while new_MV_portfolio_traditional_pgn is for \( p > n \), where \( p \) is the number of assets and \( n \) is the number of observations.

Usage

new_MV_portfolio_traditional(x, gamma)

new_MV_portfolio_traditional_pgn(x, gamma)

Arguments

x a \( p \) by \( n \) matrix or a data frame of asset returns. Rows represent different assets, columns – observations.

gamma a numeric variable. Coefficient of risk aversion.

Value

an object of class MeanVar_portfolio

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>call</td>
<td>the function call with which it was created</td>
</tr>
<tr>
<td>cov_mtrx</td>
<td>the sample covariance matrix of asset returns</td>
</tr>
<tr>
<td>inv_cov_mtrx</td>
<td>the inverse of the sample covariance matrix</td>
</tr>
<tr>
<td>means</td>
<td>sample mean estimator of the asset returns</td>
</tr>
<tr>
<td>W_mv_hat</td>
<td>sample estimator of portfolio weights</td>
</tr>
</tbody>
</table>
### Examples

```r
n <- 3e2  # number of realizations
p <- .5*n  # number of assets
gamma <- 1

x <- matrix(data = rnorm(n*p), nrow = p, ncol = n)

test <- new_MV_portfolio_traditional(x=x, gamma=gamma)
str(test)
```

### Description

Constructor of mean-variance shrinkage portfolios. `new_MV_portfolio_weights_BDOPS21` is for the case \(p < n\), while `new_MV_portfolio_weights_BDOPS21_pgn` is for \(p > n\), where \(p\) is the number of assets and \(n\) is the number of observations. For more details of the method, see [MVShrinkPortfolio](#).

### Usage

```r
new_MV_portfolio_weights_BDOPS21(x, gamma, b, beta)
new_MV_portfolio_weights_BDOPS21_pgn(x, gamma, b, beta)
```

### Arguments

- **x**: a \(p \times n\) matrix or a data frame of asset returns. Rows represent different assets, columns – observations.
- **gamma**: a numeric variable. Coefficient of risk aversion.
- **b**: a numeric variable. 1-\(\beta\) is the confidence level of the symmetric confidence interval, constructed for each weight.
- **beta**: a numeric variable. The confidence level for weight intervals.

### Value

an object of class `MeanVar_portfolio` with subclass `MV_portfolio_weights_BDOPS21`.

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>call</td>
<td>the function call with which it was created</td>
</tr>
</tbody>
</table>
weight_intervals contains a shrinkage estimator of portfolio weights, asymptotic confidence intervals for the true portfolio weights, value of the test statistic and the p-value of the test on the equality of the weight of each individual asset to zero (see Section 4.3 of Bodnar et al. 2023). weight_intervals is only computed when p<n.

References


Examples

```r
# c<1

# Assets with a diagonal covariance matrix
n <- 3e2 # number of realizations
p <- .5*n # number of assets
b <- rep(1/p, p)
gamma <- 1
x <- matrix(data = rnorm(n*p), nrow = p, ncol = n)
test <- new_MV_portfolio_weights_BDOPS21(x=x, gamma=gamma, b=b, beta=0.05)
summary(test)

# Assets with a non-diagonal covariance matrix
Mtrx <- RandCovMtrx(p=p)
x <- t(MASS::mvrnorm(n=n, mu=rep(0,p), Sigma=Mtrx))
test <- new_MV_portfolio_weights_BDOPS21(x=x, gamma=gamma, b=b, beta=0.05)
str(test)
```
nonlin_shrinkLW

# c>1

n <-2e2  # number of realizations
p <-1.2*n  # number of assets
b <-rep(1/p, p)
x <- matrix(data = rnorm(n*p), nrow = p, ncol = n)

# Assets with a non-diagonal covariance matrix

test <- new_MV_portfolio_weights_BDOPS21_pgn(x=x, gamma=gamma, 
b=b, beta=0.05)

summary(test)

nonlin_shrinkLW
nonlinear shrinkage estimator of the covariance matrix of Ledoit and Wolf (2020)

Description

The nonlinear shrinkage estimator of the covariance matrix, that minimizes the minimum variance loss functions as defined in Eq (2.1) of Ledoit and Wolf (2020).

Usage

nonlin_shrinkLW(x)

Arguments

x  a p by n matrix or a data frame of asset returns. Rows represent different assets, columns – observations.

Value

an object of class matrix

References


Examples

n<-3e2
c<-.7
p<-c*n
mu <- rep(0, p)
Sigma <- RandCovMtrx(p=p)
X <- t(MASS::mvrnorm(n=n, mu=mu, Sigma=Sigma))
Sigma_shr <- nonlin_shrinkLW(X)

plot_frontier

Plot the Bayesian efficient frontier (Bauder et al. 2021) and the provided portfolios.

Description

The plotted Bayesian efficient frontier is provided by Eq. (8) in Bauder et al. (2021). It is the set of optimal portfolios obtained by employing the posterior predictive distribution on the asset returns. This efficient frontier can be used to assess the mean-variance efficiency of various estimators of the portfolio weights. The standard deviation of the portfolio return is plotted in the $x$-axis and the mean portfolio return in the $y$-axis. The portfolios with the weights $w$ are added to the plot by computing $\sqrt{w'Sw}$ and $w'\bar{x}$.

Usage

plot_frontier(x, weights.eff = rep(1/nrow(x), length = nrow(x)))

Arguments

x
da p by n matrix or a data frame of asset returns. Rows represent different assets, columns – observations.

weights.eff
matrix of portfolio weights. Each column contains p values of the weights for a given portfolio. Default: equally weighted portfolio.

Value

a ggplot object

References


Examples

p <- 150
n <- 300
gamma <- 10
mu <- seq(0.2,-0.2, length.out=p)
Sigma <- RandCovMtrx(p=p)
x <- t(MASS::mvrnorm(n=n , mu=mu, Sigma=Sigma))
EW_port <- rep(1/p, length=p)
MV_shr_port <- new_MV_portfolio_weights_BDOPS21(x=x, gamma=gamma, b=EW_port, beta=0.05)$weights
GMV_shr_port <- new_MV_portfolio_weights_BDOPS21(x=x, gamma=Inf, b=EW_port, beta=0.05)$weights
MV_trad_port <- new_MV_portfolio_traditional(x=x, gamma=gamma)$weights
GMV_trad_port <- new_MV_portfolio_traditional(x=x, gamma=Inf)$weights

weights.eff <- cbind(EW_port, MV_shr_port, GMV_shr_port, MV_trad_port, GMV_trad_port)
colnames(weights.eff) <- c("EW", "MV_shr", "GMV_shr", "MV_trad", "GMV_trad")

Fplot <- plot_frontier(x, weights.eff)
Fplot

RandCovMtrx

Covariance matrix generator

Description
Generates a covariance matrix from Wishart distribution with given eigenvalues or with exponentially decreasing eigenvalues. Useful for examples and tests when an arbitrary covariance matrix is needed.

Usage
RandCovMtrx(p = 200, eigenvalues = 0.1 * exp(5 * seq_len(p)/p))

Arguments

p dimension of the covariance matrix
eigenvalues the vector of positive eigenvalues

Details
This function generates a symmetric positive definite covariance matrix with given eigenvalues. The eigenvalues can be specified explicitly. Or, by default, they are generated with exponential decay.

Value
covariance matrix

Examples

p<-1e1
# A non-diagonal covariance matrix
Mtrx <- RandCovMtrx(p=p)
Mtrx
**Sigma_sample_estimator**

*Sample covariance matrix*

**Description**

It computes the sample covariance of matrix $S$ as follows:

$$ S = \frac{1}{n-1} \sum_{j=1}^{n} (x_j - \bar{x})(x_j - \bar{x})', \quad \bar{x} = \frac{1}{n} \sum_{j=1}^{n} x_j, $$

where $x_j$ is the $j$-th column of the data matrix $x$.

**Usage**

`Sigma_sample_estimator(x)`

**Arguments**

x

- a p by n matrix or a data frame of asset returns. Rows represent different assets, columns – observations.

**Value**

Sample covariance estimation

**Examples**

```r
p<-5  # number of assets
n<-1e1  # number of realizations

x <-matrix(data = rnorm(n*p), nrow = p, ncol = n)
Sigma_sample_estimator(x)
```

---

**SP_daily_asset_returns**

*Daily log-returns of selected constituents S&P500.*

**Description**

Daily log-returns of selected constituents of S&P500 in percents. The data are sampled in business time, i.e., weekends and holidays are omitted.

**Usage**

`SP_daily_asset_returns`
**Format**

A matrix with the first column containing the data and company names as column labels.

**Source**

Yahoo finance

---

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>alpha_hat</td>
<td>the estimated shrinkage intensity</td>
</tr>
<tr>
<td>alpha_sd</td>
<td>the standard deviation of the shrinkage intensity</td>
</tr>
<tr>
<td>alpha_lower</td>
<td>the lower bound for the shrinkage intensity</td>
</tr>
<tr>
<td>alpha_upper</td>
<td>the upper bound for the shrinkage intensity</td>
</tr>
<tr>
<td>T_alpha</td>
<td>the value of the test statistic</td>
</tr>
<tr>
<td>p_value</td>
<td>the p-value for the test</td>
</tr>
</tbody>
</table>
validate_MeanVar_portfolio

A validator for objects of class MeanVar_portfolio

Description

A validator for objects of class MeanVar_portfolio

Usage

validate_MeanVar_portfolio(w)

Arguments

w Object of class MeanVar_portfolio.

Value

If the object passes all the checks, then w itself is returned, otherwise an error is thrown.

References


Examples

n<-3e2 # number of realizations
p<-.5*n # number of assets
b<-rep(1/p,p)
gamma<-1

x <- matrix(data = rnorm(n*p), nrow = p, ncol = n)

T_alpha <- test_MVSP(gamma=gamma, x=x, w_0=b, beta=0.05)
T_alpha

validate_MeanVar_portfolio

A validator for objects of class MeanVar_portfolio
Examples

n<-3e2 # number of realizations
p<-.5*n # number of assets
gamma<-1

x <- matrix(data = rnorm(n*p), nrow = p, ncol = n)

# Simple MV portfolio
cov_mtrx <- Sigma_sample_estimator(x)
means <- rowMeans(x)

cust_port_simp <- new_MeanVar_portfolio(mean_vec=means,
cov_mtrx=cov_mtrx, gamma=2)
str(validate_MeanVar_portfolio(cust_port_simp))
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