Package ‘GRS.test’

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Type Package

Title GRS Test for Portfolio Efficiency, Its Statistical Power Analysis, and Optimal Significance Level Calculation

Version 1.1

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Description Computational resources for test proposed by Gibbons, Ross, Shanken (1989)<DOI:10.2307/1913625>. It also has the functions for the power analysis and the choice of the optimal level of significance. The optimal level is determined by minimizing the expected loss from hypothesis testing.

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Description

Computational resources for test proposed by Gibbons, Ross, Shanken (1989)<DOI:10.2307/1913625>. It also has the functions for the power analysis and the choice of the optimal level of significance. The optimal level is determined by minimizing the expected loss from hypothesis testing.

Details

The DESCRIPTION file:

Package: GRS.test
Type: Package
Title: GRS Test for Portfolio Efficiency, Its Statistical Power Analysis, and Optimal Significance Level Calculation
Version: 1.1
Date: 2017-11-20
Author: Jae H. Kim <J.Kim@latrobe.edu.au>
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GRS Test Statistic and p-value based on Maximum Likelihood Estimator for Covariance matrix
Statistical Power of the GRS test
Power functions for the GRS test
Sample Size Selection for the GRS test
Optimal Level of Significance for the GRS test: Normality Assumption
Optimal Level of Significance for the GRS test: Bootstrapping
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GRS test and Model Estimation Results
GRS Test for Portfolio Efficiency, Its Statistical Power Analysis, and Optimal Significance Level Calculation
Fama-French Data: 25 size-B/M portfolio and risk factors, obtained from French's library
The package accompanies the working paper:

The function GRS.test returns the GRS test statistics with model estimation results.
The function GRS.MLtest provides an alternative test statistic with theta and theta* estimation results.
Additional functions for the power analysis and calculation of optimal level of significance are also included.

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References

See Also
The examples replicate the results reported in Fama and French (1993) and Kim and Shamsuddin (2016)

Examples
```r
data(data)
factor.mat = data[1:342,2:4]  # Fama-French 3-factor model
ret.mat = data[1:342,ncol(data)]  # 25 size-BM portfolio returns
GRS.test(ret.mat,factor.mat)$GRS.stat  # Table 9C of Fama-French (1993)
```

Description
Fama-French Data: 25 size-B/M portfolio and risk factors, obtained from French's library

Usage
```r
data("data")
```
**Format**

A data frame with 630 observations on the following 32 variables.

- **date** date
- **RM_RF** Market Excess Return
- **SMB** SMB
- **HML** HML
- **RMW** RMW
- **CMA** CMA
- **MOM** MOM
- **P11** Portfolio Returns
- **P12** Portfolio Returns
- **P13** Portfolio Returns
- **P14** Portfolio Returns
- **P15** Portfolio Returns
- **P21** Portfolio Returns
- **P22** Portfolio Returns
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**Details**

http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html
### Source

http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

Monthly from 1963 to 2015

### References


### Examples

```r
data(data)
y=ts(data[,2],frequency=12,start=c(1950,1))
plot.ts(y)
```

---

**GRS.MLtest**

**GRS Test Statistic and p-value based on Maximum Likelihood Estimator for Covariance matrix**

### Description


### Usage

`GRS.MLtest(ret.mat, factor.mat)`

### Arguments

- `ret.mat`: portfolio return matrix, T by N
- `factor.mat`: matrix of risk factors, T by K

### Details

T: sample size, N: number of portfolio returns, K: number of risk factors

### Value

- `GRS.stat`: GRS test statistic
- `GRS.pval`: its p-value
- `theta`: maximum Sharpe ratio of the K factor portfolios
- `thetas`: slope of the efficient frontier based on all assets
- `ratio`: theta/thetas, proportion of the potential efficiency
Note

Applicable to CAPM as well as a multi-factor model

Author(s)

Jae H. Kim

References


See Also


Examples

data(data)
factor.mat = data[1:342,2:4] # Fama-French 3-factor model
ret.mat = data[1:342,8:ncol(data)] # 25 size-BM portfolio returns
GRS.MLtest(ret.mat,factor.mat) # See column (iv), Table 9C of Fama-French (1993)

---

GRS.optimal

Optimal Level of Significance for the GRS test: Normality Assumption

Description

The optimal level is calculated by minimizing expected loss from hypothesis testing

The F-distributions are used to calculate the power, under the normality assumption

Usage

GRS.optimal(T, N, K, theta, ratio, p = 0.5, k = 1, Graph = TRUE)

Arguments

T sample size
N the number of portfolio returns
K the number of risk factors
theta maximum Sharpe ratio of the K factor portfolios
ratio theta/thetas, proportion of the potential efficiency
GRS.optimal

- \( p \) prior probability for \( H_0 \), default is \( p = 0.5 \)
- \( k \) relative loss, \( k = L_2/L_1 \), default is \( k = 1 \)
- Graph show graph if TRUE. No graph otherwise

**Details**

Based on the power calculation of the GRS test, as in GRS (1989) <DOI:10.2307/1913625>.

The blue square in the plot is the point where the expected loss is minimized.

The red horizontal line in the plot indicates the point of the conventional level of significance (alpha = 0.05).

**Value**

- \( \text{opt.sig} \) Optimal level of significance
- \( \text{opt.crit} \) Critical value corresponding to \( \text{opt.sig} \)
- \( \text{opt.beta} \) Type II error probability corresponding to \( \text{opt.sig} \)

**Note**

\[ \text{ratio} = \theta / \text{thetas} \]

\[ \text{thetas} = \text{maximum Sharpe ratio of the K factor portfolios: GRS (1989) <DOI:10.2307/1913625>} \]

**Author(s)**

Jae H. Kim

**References**


**See Also**

Kim and Choi, 2017, Choosing the Level of Significance: A Decision-theoretic Approach

**Examples**

GRS.optimal(T=90, N=25, K=3, theta=0.25, ratio=0.4) # Figure 3 of Kim and Shamsuddin (2017)
GRS.optimalboot

**Optimal Level of Significance for the GRS test: Bootstrapping**

**Description**

The optimal level is calculated by minimizing expected loss from hypothesis testing.

The bootstrap is used to calculate the power.

The power is calculated at the estimated values (unrestricted) of parameters under H1.

**Usage**

```r
GRS.optimalboot(ret.mat, factor.mat, p=0.5, k=1, nboot=3000, wild=FALSE, Graph=TRUE)
```

**Arguments**

- `ret.mat`: portfolio return matrix, T by N
- `factor.mat`: matrix of risk factors, T by K
- `p`: prior probability for H0, default is p = 0.5
- `k`: relative loss, k = L2/L1, default is k = 1
- `nboot`: the number of bootstrap iterations, the default is 3000
- `wild`: if TRUE, wild bootstrap is conducted; if FALSE (default), bootstrap is based on iid residual resampling
- `Graph`: show graph if TRUE (default). No graph otherwise

**Details**

The blue square in the plot is the point where the expected loss is minimized.

The red horizontal line in the plot indicates the point of the conventional level of significance (alpha = 0.05).

The function also returns the density functions under H0 and H1 (black and red curves, with vertical line the critical value at the optimal level).

**Value**

- `opt.sig`: Optimal level of significance
- `opt.crit`: Critical value corresponding to opt.sig
- `opt.beta`: Type II error probability corresponding to opt.sig

**Note**

The example below sets `nboot`=500 for faster execution, but a higher number is recommended.

**Author(s)**

Jae H. Kim
GRS.optimalbootweight

References


See Also

Kim and Choi, 2017, Choosing the Level of Significance: A Decision-theoretic Approach

Examples

data(data)

n=60; m1=nrow(data)-n+1; m2=nrow(data)  # Choose the last n observations from the data set
factor.mat = data[m1:m2,2:6]  # Fama-French 5-factors
ret.mat = data[m1:m2,8:ncol(data)]  # 25 size-BM portfolio returns
GRS.optimalboot(ret.mat,factor.mat,p=0.5,k=1,nboot=500,wild=TRUE,Graph=TRUE)

GRS.optimalbootweight  Weighted Optimal Level of Significance for the GRS test: Bootstrapping

Description

The optimal level is calculated by minimizing expected loss from hypothesis testing

The bootstrap is used to calculate the power.

The non-centrality parameter is estimated and its bootstrap distribution is obtained.

9 percentiles from this distribution is used to calculate the power and the optimal level.

These optimal levels are weighted using the weights from the density of the bootstrap distribution of lambda.

Usage

GRS.optimalbootweight(ret.mat,factor.mat,p=0.5,k=1,nboot=3000,wild=FALSE,Graph=TRUE)
GRS.optimalbootweight

**Arguments**

- `ret.mat` portfolio return matrix, T by N
- `factor.mat` matrix of risk factors, T by K
- `p` prior probability for H0, default is p = 0.5
- `k` relative loss, k = L2/L1, default is k = 1
- `nboot` the number of bootstrap iterations, the default is 3000
- `wild` if TRUE, wild bootstrap is conducted; if FALSE (default), bootstrap is based on iid residual resampling
- `Graph` show graph if TRUE (default). No graph otherwise

**Details**

Power is calculated based on the bootstrap

The plot shows the bootstrap distribution of lambda (non-centrality parameter)

See Kim and Choi, 2017, Choosing the Level of Significance: A Decision-theoretic Approach

**Value**

- `opt.sig` Optimal level of significance
- `opt.crit` Critical value corresponding to `opt.sig`

**Note**

The example below sets `nboot`=500 for faster execution, but a higher number is recommended.

**Author(s)**

Jae H. Kim

**References**


**See Also**

Kim and Choi, 2017, Choosing the Level of Significance: A Decision-theoretic Approach
Examples

```r
data(data)
m=60; m1=nrow(data)-n+1; m2=nrow(data)  # Choose the last n observations from the data set
factor.mat = data[m1:m2,2:6]  # Fama-French 5-factors
ret.mat = data[m1:m2,8:ncol(data)]  # 25 size-BM portfolio returns
GRS.optimalboot(ret.mat,factor.mat,p=0.5,k=1,nboot=500,wild=TRUE,Graph=TRUE)
```

---

**Description**

The optimal level is calculated by minimizing expected loss from hypothesis testing.

*The F-distributions are used to calculate the power, under the normality assumption.*

The power is calculated using a range of non-centrality parameters (lambda), following a folded-normal distribution.

The weights are obtained from the density function of folded-normal distribution.


**Usage**

```r
GRS.optimalweight(T, N, K, theta, ratio, delta = 3, p = 0.5, k = 1, Graph = TRUE)
```

**Arguments**

- `T` sample size
- `N` the number of portfolio returns
- `K` the number of risk factors
- `theta` maximum Sharpe ratio of the K factor portfolios
- `ratio` theta/thetas, proportion of the potential efficiency
- `delta` the standard deviation of the folded-normal distribution, default is 3
- `p` prior probability for H0, default is p = 0.5
- `k` relative loss, k = L2/L1, default is k = 1
- `Graph` show graph if TRUE. No graph otherwise

**Details**

Based on the power calculation of the GRS test, as in GRS (1989) <DOI:10.2307/1913625>.

The plot shows the folded-normal distribution.
Value

- opt.sig: Optimal level of significance
- opt.crit: Critical value corresponding to opt.sig

Note

- ratio = theta/thetas

Author(s)

Jae H. Kim

References


See Also

- Kim and Choi, 2017, Choosing the Level of Significance: A Decision-theoretic Approach

Examples

GRS.optimalweight(T=90, N=25, K=3, theta=0.25, ratio=0.4)

Description

Calculates the power of the GRS test with density functions under H0 and H1

Usage

GRS.Power(T, N, K, theta, ratio, alpha = 0.05, xmax = 10, Graph = "TRUE")
Arguments

T  sample size
N  the number of portfolio returns
K  the number of risk factors
theta  maximum Sharpe ratio of the K factor portfolios
ratio  theta/thetas, proportion of the potential efficiency
alpha  the level of significance, default is 0.05
xmax  the support of the density is from 0 to xmax, default is 10
Graph  show graph if TRUE. No graph otherwise

Details

Calculate the power following GRS (1989) <DOI:10.2307/1913625>
The distribution under H1 is based on the value of theta and ratio
Under H0: ratio = 1; under H1: ratio < 1

Value

Power  power of the test
Critical.value  critical value at alpha

Note

The graph option plots the density functions of the GRS test under H0 and H1.
The blue vertical line represents the critical value at alpha level of significance
The black density function is the one under H0, and the gray-shaded area is level of significance.
The red one is the one under H1, and the red-shaded area is the power.

Author(s)

Jae H. Kim

References


See Also


Examples

GRS.Power(T=120, N=25, K=3, theta=0.3, ratio=0.5)  # Figure 1 of Kim and Shamsuddin (2016)
GRS.Powerfunc

**Power functions for the GRS test**

**Description**

The function plots the power functions for a range of sample size (T), given the other parameter values.

**Usage**

```r
GRS.Powerfunc(Tvec, N, K, theta, alpha = 0.05)
```

**Arguments**

- `Tvec`: a vector of sample sizes
- `N`: the number of portfolio returns
- `K`: the number of risk factors
- `theta`: maximum Sharpe ratio of the K factor portfolios
- `alpha`: the level of significance, default is 0.05

**Details**

The power is plotted against the ratio=theta/thetas, the proportion of potential efficiency.

**Value**

Power: Matrix of power values plotted

**Note**

Under H0: ratio = 1, so the power = alpha when ratio = 1.

The power increases as the ratio declines from 1.

The power increases with sample size, so the upper power function is associated with larger sample size.

**Author(s)**

Jae H. Kim

**References**


**See Also**

**Examples**

```r
grsPowerfunc(Tvec=c(60,120),N=25, K=3, theta=0.3) # Figure 2 of Kim and Shamsuddin (2016)
```

---

**GRS.T**  
*Sample Size Selection for the GRS test*

**Description**

Given the desired level of Type I and II error probabilities, the function returns the sample size required.

**Usage**

```r
GRS.T(N, K, theta, ratio, alpha, beta, Tmax = 10000)
```

**Arguments**

- `N` the number of portfolio returns
- `K` the number of risk factors
- `theta` maximum Sharpe ratio of the K factor portfolios
- `ratio` theta/thetas, proportion of the potential efficiency
- `alpha` the desired level of significance, or Type I error probability
- `beta` the desired level of Type II error probability
- `Tmax` the maximum number of sample size, default is 10000

**Details**

the desired level of power = 1 - beta

**Value**

- `Required.T` required sample size
- `Critical.value` the corresponding critical value

**Note**

Critical.value is from the F-distribution with df1=N and df2=Required.T-N-K degrees of freedom, at the alpha level of significance.

**Author(s)**

Jae H. Kim

**References**

See Also


Examples

GRS.T(N=25,K=3,theta=0.25,ratio=0.4,alpha=0.05, beta=0.05, Tmax=5000)

GRS.test 

GRS test and Model Estimation Results

Description

Wu statistic given in (5) of GRS (1989) <DOI:10.2307/1913625>

The function also provide estimation results for asset pricing models

Usage

GRS.test(ret.mat, factor.mat)

Arguments

ret.mat portfolio return matrix, T by N
factor.mat matrix of risk factors, T by K

Details

T: sample size, N: number of portfolio returns, K: number of risk factors

Value

GRS.stat GRS test statistic
GRS.pval its p-value
coef matrix of coefficient estimates from N equations, N by (K+1)
resid matrix of residuals from N equations, T by N
tstat matrix of t-statistics for coefficients, N by (K+1)
se matrix of standard errors for coefficients, N by (K+1)
R2 matrix of R-squares for N equations, N by 1

Note

Applicable to CAPM as well as a multi-factor model

Author(s)

Jae H. Kim
References


See Also


Examples

```r
data(data)
factor.mat = data[1:342,2:4]  # Fama-French 3-factor model
ret.mat = data[1:342,ncol(data)]  # 25 size-BM portfolio returns
GRS.test(ret.mat,factor.mat)$GRS.stat  # See Table 9C of Fama-French (1993)
```
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