Package ‘OCA’

May 30, 2020

Type Package

Title Optimal Capital Allocations

Version 0.2

Date 2020-05-30

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Description Computes optimal capital allocations based on some standard principles such as Haircut, Overbeck type II and the Covariance Allocation Principle. It also provides some shortcuts for obtaining the Value at Risk and the Expectation Shortfall, using both the normal and the t-student distribution, see Urbina and Guillén (2014)<doi:10.1016/j.eswa.2014.05.017> and Urbina (2013)<http://hdl.handle.net/2099.1/19443>.

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Encoding UTF-8

NeedsCompilation no

Repository CRAN

Date/Publication 2020-05-30 12:50:11 UTC

R topics documented:

`OCA-package` *Optimal Capital Allocation Principles*

Description

`OCA` computes optimal capital allocation based on some standard principles such as Haircut, Overbeck type II and the Covariance Allocation Principle. Also it provides some shortcuts for obtaining the Value at Risk and the Expectation Shortfall, using both the normal and the t-student distribution.

Details

Package:	OCA
Type:	Package
Version:	0.1
Date:	2017-02-07
License:	GPL-2

Author(s)

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References

Dhaene J., Tsanakas A., Valdez E. and Vanduffel S. (2011). *Optimal capital allocation principles*. The Journal of Risk and Insurance. 79(1):1-28.

McNeil, A. J.; Frey, R. and Embrechts, P. *Quantitative risk management: concepts, techniques and tools*. Princeton University Press, 2005

Urbina, J. (2013) *Quantifying Optimal Capital Allocation Principles based on Risk Measures.* Master Thesis, Universitat Politècnica de Catalunya. http://hdl.handle.net/2099.1/19443.

Urbina, J. and Guillén, M. (2014). *An application of capital allocation principles to operational risk and the cost of fraud*. Expert Systems with Applications. 41(16):7023-7031.

`cap` *Covariance Allocation Principle*

Description

This function implements the covariance allocation principle for optimal capital allocation.

Usage

```
cap(Loss, Capital)
```

Arguments

`Loss`	A matrix containing the individual losses in each column
`Capital`	A scalar representing the capital to be allocated to each loss.

Details

The Covariance Allocation Principle correspond to the following expression:

$$K_i = \frac{K}{Var[S]} Cov(X_i, S), \quad i = 1, \ldots, n,$$

where K_i is the capital to be allocated to the *ith* loss, *K* is the total capital to be allocated, X_i is the individual unit loss and *S* is the total (aggretate) loss, this comes from $\sum_i X_i$. $Cov(X_i, S)$ is the covariance between the individual loss X_i and the aggregate loss *S*; and $Var(S)$ is the variance of the aggregate loss.

Value

A $n \times 1$ matrix containing each asset and the corresponding capital allocation. If `Capital=1`, then the returned value will be the proportions of capital required by each loss to be faced.

Author(s)

Jilber Urbina

References

Dhaene J., Tsanakas A., Valdez E. and Vanduffel S. (2011). *Optimal Capital Allocation Principles*. The Journal of Risk and Insurance. Vol. 00, No. 0, 1-28.

Urbina, J. (2013) *Quantifying Optimal Capital Allocation Principles based on Risk Measures.* Master Thesis, Universitat Politècnica de Catalunya.

Urbina, J. and Guillén, M. (2014). *An application of capital allocation principles to operational risk and the cost of fraud*. Expert Systems with Applications. 41(16):7023-7031.

See Also

`Overbeck2`, `hap`

Examples

```
data(dat1, dat2)
Loss <- cbind(Loss1=dat1[1:400, ], Loss2=unname(dat2))
# Proportions of capital to be allocated to each bussines unit
cap(Loss, Capital=1)
```

```
# Capital allocation,
# capital is determined as the empirical VaR of the losses at 99%
K <- quantile(rowSums(Loss),  probs = 0.99)
cap(Loss, Capital=K)
```

---

dat1 *Public data risk no. 1*

Description

Dataset named Public data risk no. 1 consisting in 1000 of simulated data.

Usage

```
data(dat1)
```

Format

A data frame with 1000 observations on the following variable.

`y` a numeric vector

References

Bolance, C.; Guillen, M.; Gustafsson, J. & Nielsen, J. P. Quantitative Operational Risk Models Chapman & Hall/CRC, 2012

Examples

```
data(dat1)
```

---

dat2 *Public data risk no. 2*

Description

Dataset named Public data risk no. 1 consisting in 400 of simulated data.

Usage

```
data(dat2)
```

Format

A data frame with 400 observations on the following variable.

`y` a numeric vector

References

Bolance, C.; Guillen, M.; Gustafsson, J. & Nielsen, J. P. Quantitative Operational Risk Models Chapman & Hall/CRC, 2012

Examples

```
data(dat2)
```

ES *Expected Shortfall*

Description

Computes the Expected Shortfall of a given amount of loss.

Usage

```
ES(Loss, varcov, alpha = 0.95, weights = NULL,
   model = c("normal", "t-student", "both"),
   df = NULL)
```

Arguments

`Loss`	Either a single-numeric value or a vector representing the mean loss(es) to which the ES is to be calculated.
`varcov`	If `Loss` is a single-numeric value, then `varcov` must be a scalar denoting the variance of the loss, otherwise, if `Loss` is a vector of *N* elements, then `varcov` must be a variance-covariance matrix of dimension $N \times N$.
`alpha`	A numeric value (either a single one or a vector) consisting of the significance level at which ES has to be computed, it can either be a single numeric value or a vector of numeric values.
`weights`	A vector of weights of size *N* for computing both the mean and the variance of the vector of Losses, it is applicable only when `Loss` is a vector. When `weights=NULL` mean and variaces used to compute ES are the original values supplied to `Losses` and `varcov`.
`model`	A character string indicating which distribution is to be used for computing the ES, the default value is the `normal` distribution, the other alternative is `t-student` distribution with υ degrees of freedom. When `model='both'` `'normal'` as well as `'t-student'` are used when computing the ES, see examples.
`df`	An integer indicating the degrees of freedom for the t-student distribution when setting `model='t-student'` and `model='both'`. `df` must be greater than 2.

Details

`ES` computes the Expected Shortfall (ES) of a certaing amount of loss based upon the following general formulation:

$$ES_\alpha = \frac{1}{(1-\alpha)} \int_\alpha^1 VaR_u(X)du = E[X|X > F_X^{-1}(\alpha)].$$

where α is the significance level, $VaR_u(X)$ is the Value-at-Risk of X.

`ES` for the normal case is based on the following expression:

$$ES_\alpha = \mu + \sigma \frac{\phi(\Phi^{-1}(\alpha))}{1-\alpha}$$

Meanwhile, `ES` for the t-student distribution takes comes from:

$$ES_\alpha(\tilde{X}) = \frac{g_\upsilon(t_\upsilon^{-1}(\alpha))}{1-\alpha} \left(\frac{\upsilon + (t_\upsilon^{-1}(\alpha))^2}{\upsilon - 1} \right)$$

Value

A `data.frame` containing the ES for each significance level specified.

Author(s)

Jilber Urbina

References

Dhaene J., Tsanakas A., Valdez E. and Vanduffel S. (2011). *Optimal Capital Allocation Principles*. The Journal of Risk and Insurance. Vol. 00, No. 0, 1-28.

McNeil, A. J.; Frey, R. & Embrechts, P. *Quantitative risk management: concepts, techniques and tools*. Princeton University Press, 2005

Urbina, J. (2013) *Quantifying Optimal Capital Allocation Principles based on Risk Measures.* Master Thesis, Universitat Politècnica de Catalunya.

Urbina, J. and Guillén, M. (2014). *An application of capital allocation principles to operational risk and the cost of fraud*. Expert Systems with Applications. 41(16):7023-7031.

See Also

`VaR`, `Risk`

Examples

```
# Exercise 2.21, page 46 in McNeil et al (2005)
alpha <- c(.90, .95, .975, .99, .995)
(ES(Loss=1, varcov=(0.2/sqrt(250))^2, alpha=alpha, model='normal')-1)*10000
(ES(Loss=1, varcov=(0.2/sqrt(250))^2, alpha=alpha, model='t-student', df=4)-1)*10000
```

```
# Both type of models at once.
(ES(Loss=1, varcov=(0.2/sqrt(250))^2, alpha=alpha, model='both', df=4)-1)*10000

# A vector of losses
L <- c(10,40)                         # a vector of two (mean) losses
varcov <- matrix(c(100,150,150,900), 2) # covariance matrix
w <- c(0.5, 0.5)                      # a vector weights
ES(Loss=L, varcov=varcov, weights=w, alpha=0.95)
```

---

hap *Haircut Allocation Principle*

Description

Capital allocation based on the Haircut Allocation Principle.

Usage

```
hap(Loss, Capital, alpha = 0.95,
     model = "normal", df = NULL)
```

Arguments

`Loss`	Either a scalar or a vector of size *N* containing the mean losses.
`Capital`	A scalar representing the capital to be allocated to each loss.
`alpha`	A numeric value (either a single one or a vector) consisting of the significance level at which ES has to be computed, it can either be a single numeric value or a vector of numeric values.
`model`	A character string indicating which distribution is to be used for computing the VaR underlying the Haircut Allocation Principle (HAP), the default value is the `normal` distribution, the other alternative is `t-student` distribution with v degrees of freedom. When `model='both'` `'normal'` as well as `'t-student'` are used when computing the HAP, see examples.
`df`	An integer indicating the degrees of freedom for the t-student distribution when setting `model='t-student'` and `model='both'`. `df` must be greater than 2.

Details

This function computes the capital allocation based on the so-called Haircut Allocation Principle whose expression is as follows:

$$K_i = \frac{K}{\sum_{j=1}^{n} F_{X_j}^{-1}(p)} F_{X_i}^{-1}(p)$$

For $i = 1, \ldots, n$, where K_i represents the optimal capital to be allocated to each individual loss for the *i*-th business unit, *K* is the total capital to be allocated, $F_{X_i}^{-1}(p)$ is the quantile function (VaR) for the *i*-th loss.

Value

A real-valued $n \times 1$ matrix containing the optimal capital allocation, if `Capital` is set to 1, then the returned matrix will consist of the proportions of capital each individual loss needs to be optimally faced.

Author(s)

Jilber Urbina

References

Dhaene J., Tsanakas A., Valdez E. and Vanduffel S. (2011). *Optimal Capital Allocation Principles*. The Journal of Risk and Insurance. Vol. 00, No. 0, 1-28.

McNeil, A. J.; Frey, R. & Embrechts, P. *Quantitative risk management: concepts, techniques and tools*. Princeton University Press, 2005

Urbina, J. (2013) *Quantifying Optimal Capital Allocation Principles based on Risk Measures.* Master Thesis, Universitat Politècnica de Catalunya.

Urbina, J. and Guillén, M. (2014). *An application of capital allocation principles to operational risk and the cost of fraud*. Expert Systems with Applications. 41(16):7023-7031.

See Also

`Overbeck2`, `cap`

Examples

```
data(dat1, dat2)
Loss <- cbind(Loss1=dat1[1:400, ], Loss2=unname(dat2))
# Proportions of capital to be allocated to each bussines unit
hap(Loss, Capital=1)

# Capital allocation,
# capital is determined as the empirical VaR of the losses at 99%
K <- quantile(rowSums(Loss),  probs = 0.99)
hap(Loss, Capital=K)
```

`Overbeck2` *Overbeck type II Allocation Principle*

Description

This function implements the Overbeck type II allocation principle for optimal capital allocation.

Usage

```
Overbeck2(Loss, Capital, alpha = 0.95,
          model = c("normal", "t-student", "both"), df = NULL)
```

Arguments

`Loss`	Either a scalar or a vector of size *N* containing the mean losses.
`Capital`	A scalar representing the capital to be allocated to each loss.
`alpha`	A numeric value (either a single one or a vector) consisting of the significance level at which the allocation has to be computed, it can either be a single numeric value or a vector of numeric values.
`model`	A character string indicating which distribution is to be used for computing the VaR underlying the Overbeck type II principle, the default value is the `normal` distribution, the other alternative is `t-student` distribution with v degrees of freedom. When `model='both'` `'normal'` as well as `'t-student'` are used when computing the allocations, see examples.
`df`	An integer indicating the degrees of freedom for the t-student distribution when setting `model='t-student'` and `model='both'`. `df` must be greater than 2.

Details

`Overbeck2` computes the capital allocation based on the following formulation:

$$K_i = \frac{K}{CTE_p[S]} E\left[X_i | S > F_{X_S}^{-1}(p)\right], \quad i = 1, \ldots, n.$$

Where

$$K$$

is the aggregate capital to be allocated, $CTE_p[S]$ is the Conditional Tail Expectation of the aggregate loss at level *p*,

$$X_i$$

is the individual loss, *S* is the aggregate loss and $F_X^{-1}(p)$ is the quantile function of

$$X$$

at level *p*

Value

A real-valued $n \times 1$ matrix containing the optimal capital allocation, if `Capital` is set to 1, then the returned matrix will consist of the proportions of capital each individual loss needs to be optimally faced.

Author(s)

Jilber Urbina

References

Dhaene J., Tsanakas A., Valdez E. and Vanduffel S. (2011). *Optimal Capital Allocation Principles*. The Journal of Risk and Insurance. Vol. 00, No. 0, 1-28.

Urbina, J. (2013) *Quantifying Optimal Capital Allocation Principles based on Risk Measures.* Master Thesis, Universitat Politècnica de Catalunya.

Urbina, J. and Guillén, M. (2014). *An application of capital allocation principles to operational risk and the cost of fraud*. Expert Systems with Applications. 41(16):7023-7031.

See Also

hap, cap

Examples

```
data(dat1, dat2)
Loss <- cbind(Loss1=dat1[1:400, ], Loss2=unname(dat2))
# Proportions of capital to be allocated to each bussines unit
Overbeck2(Loss, Capital=1)

# Capital allocation,
# capital is determined as the empirical VaR of the losses at 99%
K <- quantile(rowSums(Loss),  probs = 0.99)
Overbeck2(Loss, Capital=K)
```

Risk — *Risk measures suchs as Value at Risk (VaR) and Expected Shortfall (ES) with normal and t-student distributions.*

Description

Standard risk measures such VaR and ES are provided by `Risk`. Both VaR and ES can be computed using either the normal or t-student distribution.

Usage

```
Risk(Loss, varcov, alpha = 0.95,
     measure = c("VaR", "ES", "both"),
     weights = NULL,
     model = c("normal", "t-student", "both"),
     df = NULL)
```

Arguments

`Loss`	It could be either a scalar or a $m x 1$ matrix containing the mean losses.
`varcov`	A scalar corresponding to the variance of the loss, if `Loss` is a $m x 1$ matrix, then `varcov` must be a $m x m$ matrix containing the variances and covariances of the losses.

alpha — The confidence level at which either the VaR or the ES will be computed, by default `alpha` is set to 0.95.

measure — An optional character string giving a measure for computing the risk. `"VaR"` stands for Value at Risk, `"ES"` stands for Expected Shortfall, and if both is chosen, then the function returns both the VaR and the ES as a result. By default `measure` is set to be `"VaR"`.

weights — A vector cointaining the weights. It is only needed if `Loss` is a matrix, if it is not then `weights` is set to 1.

model — A character string indicating which probability model has to be used for computing the risk measures, it could only be a normal distribution or a t-student distribution with v degrees of freedom. The normal distibution is the default model for this funcion. `model` also allows the user to set `'both'` if she wishes both normal and t-student VaR or ES depending on what she choses in `measure`. See example below.

df — An integer (df>2) denoting the degrees of freedom, only required if `model='t-student'`. Otherwise it has to be `NULL`.

Value

A `data.frame` containing each risk measure at its corresponding confidence level.

Author(s)

Jilber Urbina.

References

McNeal A., Frey R. and Embrechts P (2005). Quantitative Risk Management: Concepts, Techniques and Tools. Princeton Series of Finance. ISBN 0-691-12255-5

Urbina, J. (2013) *Quantifying Optimal Capital Allocation Principles based on Risk Measures.* Master Thesis, Universitat Politècnica de Catalunya.

Urbina, J. and Guillén, M. (2014). *An application of capital allocation principles to operational risk and the cost of fraud*. Expert Systems with Applications. 41(16):7023-7031.

See Also

VaR

Examples

```
# Reproducing Table 2.1 in page 47 of
# McNeal A., Frey R. and Embrechts P (2005).
 alpha <- c(.90, .95, .975, .99, .995)
 (Risk(Loss=1, varcov=(0.2/sqrt(250))^2, alpha=alpha,
       measure='both', model='both', df=4)-1)*10000

 # only VaR results
```

```
(Risk(Loss=1, varcov=(0.2/sqrt(250))^2, alpha=alpha,
      measure='VaR', model='both', df=4)-1)*10000

# only normal VaR results
(Risk(Loss=1, varcov=(0.2/sqrt(250))^2, alpha=alpha)-1)*10000

# only SE based on a 4 degrees t-student.
(Risk(Loss=1, varcov=(0.2/sqrt(250))^2, alpha=alpha,
      measure='ES', model='t-student', df=4)-1)*10000
```

VaR *Value at Risk*

Description

Computes Value at Risk based on both normal and t-student distribution.

Usage

```
VaR(Loss, varcov, alpha = 0.95, weights = NULL,
    model = c("normal", "t-student", "both"),
    df = NULL)
```

Arguments

Loss	It could be either a scalar or a $m x 1$ matrix containing the mean losses.
varcov	A scalar corresponding to the variance of the loss, if `Loss` is a $m x1$ matrix, then `varcov` must be a $m xm$ matrix containing the variances and covariances of the losses.
alpha	The confidence level at which either the VaR or the ES will be computed, by default `alpha` is set to 0.95.
weights	A vector of weights of size *N* for computing both the mean and the variance of the vector of Losses, it is applicable only when `Loss` is a vector. When `weights=NULL` mean and variaces used to compute ES are the original values supplied to `Losses` and `varcov`.
model	A character string indicating which probability model has to be used for computing the risk measures, it could only be a normal distribution or a t-student distribution with v degrees of freedom. The normal distibution is the default model for this funcion. `model` also allows the user to set `'both'` if she wishes both normal and t-student VaR or ES depending on what she choses in `measure`. See example below.
df	An integer (df>2) denoting the degrees of freedom, only required if `model='t-student'`. Otherwise it has to be `NULL`.

Value

A `data.frame` containing each risk measure at its corresponding confidence level

Author(s)

Jilber Urbina.

References

McNeal A., Frey R. and Embrechts P (2005). Quantitative Risk Management: Concepts, Techniques and Tools. Princeton Series of Finance. ISBN 0-691-12255-5

Urbina, J. (2013) *Quantifying Optimal Capital Allocation Principles based on Risk Measures.* Master Thesis, Universitat Politècnica de Catalunya.

Urbina, J. and Guillén, M. (2014). *An application of capital allocation principles to operational risk and the cost of fraud*. Expert Systems with Applications. 41(16):7023-7031.

See Also

Risk

Examples

```
# Reproducing VaR from Table 2.1 in page 47 of
# McNeal A., Frey R. and Embrechts P (2005).

alpha <- c(.90, .95, .975, .99, .995)
VaR(Loss=0, varcov=(10000*0.2/sqrt(250))^2, alpha=alpha, model='both', df=4)

 # only normal VaR results
VaR(Loss=0, varcov=(10000*0.2/sqrt(250))^2, alpha=alpha)
```

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