Package ‘skewMLRM’

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choose2

Select a distribution in the MSMN, MSSMN, MSMSN or/and MSMSNC
classes and perform covariates selection.

Description

choose2 select a model inside the multivariate scale mixtures of normal (MSMN), the multivariate
scale mixtures of skew-normal (MSMSN), the multivariate skew scale mixtures of normal
(MSSMN) or/and the multivariate scale mixtures of skew-normal-Cauchy (MSMSNC) classes.
See details for supported distributions within each class. Then, implement the covariates selection
based on the significance, the Akaike’s information criteria (AIC) or Schwartz’s information
criteria (BIC).

Usage

choose2(y, X = NULL, max.iter = 1000, prec = 1e-04, class = "MSMN",
est.var = TRUE, criteria = "AIC", criteria.cov = "AIC",
significance = 0.05, cluster = FALSE)

Arguments

y The multivariate vector of responses. The univariate case also is supported.
X The regressor matrix.
max.iter The maximum number of iterations.
prec The convergence tolerance for parameters.
class class in which will be performed a distribution: MSMN (default), MSSMN,
MSMSN, MSMSNC or ALL (which consider all the mentioned classes). See
details.
est.var Logical. If TRUE the standard errors are estimated.
criteria criteria to perform the selection model: AIC (default) or BIC.
criteria.cov criteria to perform the covariates selection: AIC (default), BIC or significance.
significance the level of significance to perform the covariate selection. Only used if criteria.cov="significance". By default is 0.05.
cluster logical. If TRUE, parallel computing is used. FALSE is the default value.
Details

Supported models are:

In MSMN class: multivariate normal (MN), multivariate Student t (MT), multivariate slash (MSL), multivariate contaminated normal (MCN). See Lange and Sinsheimer (1993) for details.


In MSSMN class: MSN, multivariate skew-t-normal (MSTN), multivariate skew-slash normal (MSSL), multivariate skew-contaminated normal (MSCN). See Louredo, Zeller and Ferreira (2021) for details.

In MSMSNC class: multivariate skew-normal-Cauchy (MSNC), multivariate skew-t-Expected-Cauchy (MSTEC), multivariate skew-slash-Expected-Cauchy (MSSLEC), multivariate skew-contaminated-Expected-Cauchy (MSCEC). See Kahrari et al. (2020) for details.

Note: the MSN distribution belongs to both, MSMSN and MSSMN classes.

Value

an object of class "skewMLRM" is returned. The object returned for this functions is a list containing the following components:

coefficients  A named vector of coefficients
se            A named vector of the standard errors for the estimated coefficients. Valid if est.var is TRUE and the hessian matrix is invertible.
logLik        The log-likelihood function evaluated in the estimated parameters for the selected model
AIC           Akaike's Information Criterion for the selected model
BIC           Bayesian's Information Criterion for the selected model
iterations    the number of iterations until convergence (if attached)
conv          An integer code for the selected model. 0 indicates successful completion. 1 otherwise.
dist          The distribution for which was performed the estimation.
class         The class for which was performed the estimation.
function      a string with the name of the used function.
choose.crit   the specified criteria to choose the distribution.
choose.crit.cov the specified criteria to choose the covariates.
y             The multivariate vector of responses. The univariate case also is supported.
X              The regressor matrix (in a list form).
fitted.models A vector with the fitted models
selected.model Selected model based on the specified criteria.
fitted.class  Selected class based on the specified criteria.
comment       A comment indicating how many coefficients were eliminated
Author(s)

Clecio Ferreira, Diego Gallardo and Camila Zeller

References


Examples

data(ais, package="sn") ##Australian Institute of Sport data set
attach(ais)
##It is considered a bivariate regression model
##with Hg and SSF as response variables and
##Hc, Fe, Bfat and LBM as covariates
y<-cbind(Hg,SSF)
n<-nrow(y); m<-ncol(y)
X.aux=model.matrix(~Hc+Fe+Bfat+LBM)
p<-ncol(X.aux)
X<-array(0,dim=c(2*p,m,n))
for(i in 1:n) {
  X[1:p,1,i]=X.aux[i,,drop=FALSE]
  X[p+1:p,2,i]=X.aux[i,,drop=FALSE]
}
##See the covariate matrix X
##X

##Select a distribution within the MSMN class. Then, perform covariate
##selection based on the significance
fit.MSMN=choose2(y, X, class="MSMN")
summary(fit.MSMN)
##Identical process within the MSSMN class.
##may take some time on some systems
fit.MSSMN=choose2(y, X, class="MSSMN")
summary(fit.MSSMN)
Choose a distribution in the MSMN, MSMSN, MSSMN and/or MSMSNC classes

Description

choose.xxx select a model inside the xxx class, where xxx is the multivariate scale mixtures of normal (MSMN), the multivariate scale mixtures of skew-normal (MSMSN), the multivariate skew scale mixtures of normal (MSSMN) or the multivariate scale mixtures of skew-normal-Cauchy (MSMSNC) classes. See details for supported distributions within each class. choose.models select a model among the MSMN, MSMSN, MSSMN and MSMSNC classes.

Usage

choose.MSMN(y, X = NULL, max.iter = 1000, prec = 1e-4, est.var = TRUE, criteria = "AIC", cluster = FALSE)
choose.MSSSN(y, X = NULL, max.iter = 1000, prec = 1e-4, est.var = TRUE, criteria = "AIC", cluster = FALSE)
choose.MSSMN(y, X = NULL, max.iter = 1000, prec = 1e-4, est.var = TRUE, criteria = "AIC", cluster = FALSE)
choose.MMSNC(y, X = NULL, max.iter = 1000, prec = 1e-4, est.var = TRUE, criteria = "AIC", cluster = FALSE)
choose.models(y, X = NULL, max.iter = 1000, prec = 1e-4, est.var = TRUE, criteria = "AIC", cluster = FALSE)

Arguments

y The multivariate vector of responses. The univariate case also is supported.
X The regressor matrix.
max.iter The maximum number of iterations.
prec The convergence tolerance for parameters.
est.var Logical. If TRUE the standard errors are estimated.
criteria criteria to perform the selection model: AIC (default) or BIC.
cluster logical. If TRUE, parallel computing is used. FALSE is the default value.

Details

Supported models are:

In MSMN class: multivariate normal (MN), multivariate Student t (MT), multivariate slash (MSL), multivariate contaminated normal (MCN). See Lange and Sinsheimer (1993) for details.

In MSSMN class: MSN, multivariate skew-t-normal (MSTN), multivariate skew-slash normal (MSSL), multivariate skew-contaminated normal (MSCN). See Louredo, Zeller and Ferreira (2021) for details.

In MSMSNC class: multivariate skew-normal-Cauchy (MSNC), multivariate skew-t-Expected-Cauchy (MSTEC), multivariate skew-slash-Expected-Cauchy (MSSLEC), multivariate skew-contaminated-Expected-Cauchy (MSCEC). See Kahrari et al. (2020) for details.

Note: the MSN distribution belongs to both, MSMSN and MSSMN classes.

Value

an object of class "skewMLRM" is returned. The object returned for this functions is a list containing the following components:

- **coefficients**: A named vector of coefficients
- **se**: A named vector of the standard errors for the estimated coefficients. Valid if est.var is TRUE and the hessian matrix is invertible.
- **logLik**: The log-likelihood function evaluated in the estimated parameters for the selected model
- **AIC**: Akaike’s Information Criterion for the selected model
- **BIC**: Bayesian’s Information Criterion for the selected model
- **iterations**: the number of iterations until convergence (if attached)
- **conv**: An integer code for the selected model. 0 indicates successful completion. 1 otherwise.
- **dist**: The distribution for which was performed the estimation.
- **class**: The class for which was performed the estimation.
- **function**: a string with the name of the used function.
- **choose.crit**: the specified criteria to choose the distribution.
- **y**: The multivariate vector of responses. The univariate case also is supported.
- **X**: The regressor matrix (in a list form).
- **fitted.models**: A vector with the fitted models
- **selected.model**: Selected model based on the specified criteria.
- **comment**: A comment indicating how many coefficients were eliminated

Note

This function does not consider selection of covariates.

Author(s)

Clecio Ferreira, Diego Gallardo and Camila Zeller
References


Examples

```r
data(ais, package="sn") ##Australian Institute of Sport data set
attach(ais)
##It is considered a bivariate regression model
##with Hg and SSF as response variables and
##Hc, Fe, Bfat and LBM as covariates
y<-cbind(Hg,SSF)
n<-nrow(y); m<-ncol(y)
X.aux=model.matrix(~Hc+Fe+Bfat+LBM)
p<-ncol(X.aux)
X<-array(0,dim=c(2*p,m,n))
for(i in 1:n) {
  X[1:p,1,i]=X.aux[i,,drop=FALSE]
  X[p+1:p,2,i]=X.aux[i,,drop=FALSE]
}
##See the covariate matrix X
##X
##Select a distribution within the MSMN class.
fit.MSMN=choose.MSMN(y,X)
summary(fit.MSMN)
##Identical process within the MSSMN class.
##may take some time on some systems
fit.MSSMN=choose.MSSMN(y,X)
summary(fit.MSSMN)
```

distMahal

Mahalanobis distance for fitted models in the MSMN, MSMSN, MSSMN and MSMSNC classes
Description

Compute and plot the Mahalanobis distance for any supported model in the multivariate scale mixtures of normal (MSMN), multivariate scale mixtures of skew-normal (MSMSN), multivariate skew scale mixtures of normal (MSSMN) or multivariate scale mixtures of skew-normal-Cauchy (MSMSNC) classes. See details for supported distributions.

Usage

distMahal(object, alpha = 0.95, ...)

Arguments

object an object of class "skewMLRM" returned by one of the following functions: estimate.xxx, choose.yyy, choose2, mbackcrit or mbacksign. See details for supported distributions.

alpha significance level (0.05 by default).

... aditional graphical parameters

Details

Supported models are:

In MSMN class: multivariate normal (MN), multivariate Student t (MT), multivariate slash (MSL), multivariate contaminated normal (MCN). See Lange and Sinsheimer (1993) for details.


In MSSMN class: MSN, multivariate skew-t-normal (MSTN), multivariate skew-slash normal (MSSL), multivariate skew-contaminated normal (MSCN). See Louredo, Zeller and Ferreira (2021) for details.

In MSMSNC class: multivariate skew-normal-Cauchy (MSNC), multivariate skew-t-Expected-Cauchy (MSTEC), multivariate skew-slash-Expected-Cauchy (MSSLEC), multivariate skew-contaminated-Expected-Cauchy (MSCEC). See Kahrahi et al. (2020) for details.

Note: the MSN distribution belongs to both, MSMSN and MSSMN classes.

Value

distMahal provides an object of class skewMLRM related to compute the Mahalanobis distance for all the observations and a cut-off to detect possible influent observations based on the specified significance (0.05 by default).

an object of class "skewMLRM" is returned. The object returned for this functions is a list containing the following components:

Mahal the Mahalanobis distance for all the observations
function a string with the name of the used function.
dist The distribution for which was performed the estimation.
class The class for which was performed the estimation.
alpha  specified level of significance (0.05 by default).
cut  the cut-off to detect possible influent observations based on the specified signif-
icance.
y  The multivariate vector of responses. The univariate case also is supported.
X  The regressor matrix (in a list form).

Author(s)

Clecio Ferreira, Diego Gallardo and Camila Zeller

References


Examples

```r
set.seed(2020)
n=200  # length of the sample
nv<-3  # number of explanatory variables
p<-nv+1  # nv + intercept
m<-4  # dimension of Y
q0<p*m
X<-array(0,c(q0,m,n))
for(i in 1:n) {
  aux=rep(1,p)
  aux[2:p]<-rMN(1,mu=rnorm(nv),Sigma=diag(nv))  ##simulating covariates
  mi=matrix(0,q0,m)
  for (j in 1:m) mi[((j-1)*p+1):(j*p),j]=aux
  X[,i]<-mi
}
  ##X is the simulated regressor matrix
betas<-matrix(rnorm(q0),ncol=1)  #True betas
Sigmas <- clusterGeneration::genPositiveDefMat(m,rangeVar=c(1,3),
  lambdaLow=1, ratioLambda=3)$Sigma  #True Sigma
y=matrix(0,n,m)
for(i in 1:n) {
  mui<-t(X[,i])%*%betas
  y[i,]<-rMN(n=1,c(mui),Sigmas)  ## simulating the response vector
}
fit.MN=estimate.MN(y,X)  #fit the MN model
mahal.MN=distMahal(fit.MN)  #compute the Mahalanobis distances for MN model
```
estimateM

Fitting a model in the MSMN, MSMSN, MSSMN and MSMSNC classes

Description

estimate.Mxxx computes the maximum likelihood estimates for the distribution xxx, where xxx is any supported model in the multivariate scale mixtures of normal (MSMN), multivariate scale mixtures of skew-normal (MSMSN), multivariate skew scale mixtures of normal (MSSMN) or multivariate scale mixtures of skew-normal-Cauchy (MSMSNC) classes. See details for supported distributions.

Usage

estimate.MN(y, X, max.iter = 1000, prec = 1e-04, est.var = TRUE)
estimate.MT(y, X, max.iter = 1000, prec = 1e-04, est.var = TRUE, nu.min = 2.0001)
estimate.MSL(y, X, max.iter = 1000, prec = 1e-04, est.var = TRUE, nu.min = 2.0001)
estimate.MCN(y, X, max.iter = 1000, prec = 1e-04, est.var = TRUE)
estimate.MSN(y, X, max.iter = 1000, prec = 1e-04, est.var = TRUE)
estimate.MSTN(y, X, max.iter = 1000, prec = 1e-04, est.var = TRUE, nu.min = 2.0001)
estimate.MSSL(y, X, max.iter = 1000, prec = 1e-04, est.var = TRUE, nu.min = 2.0001)
estimate.MSSL2(y, X, max.iter = 1000, prec = 1e-04, est.var = TRUE, nu.fixed = 3, nu.min = 2.0001)
estimate.MSCN(y, X, max.iter = 1000, prec = 1e-04, est.var = TRUE)
estimate.MSTT(y, X, max.iter = 1000, prec = 1e-04, est.var = TRUE, nu.fixed = 3, nu.min = 2.0001)
estimate.MSNC(y, X, max.iter = 1000, prec = 1e-04, est.var = TRUE, nu.fixed = 0.5, gamma.fixed = 0.5)
estimate.MSTEC(y, X, max.iter = 1000, prec = 1e-04, est.var = TRUE, nu.fixed = 3, nu.min = 2.0001)
estimate.MSSLEC(y, X, max.iter = 1000, prec = 1e-04, est.var = TRUE, nu.fixed = 3, nu.min = 2.0001)
estimate.MSCN2(y, X, max.iter = 1000, prec = 1e-04, est.var = TRUE, nu.fixed = 0.5, gamma.fixed = 0.5)

Arguments

y The multivariate vector of responses. The univariate case also is supported.
x The regressor matrix.
max.iter The maximum number of iterations.
estimateM

prec The convergence tolerance for parameters.
est.var Logical. If TRUE the standard errors are estimated.
nu.fixed If a numerical value is provided, the estimation consider nu as fixed. To estimate nu, use nu.fixed=FALSE. Available for MSTT, MSSL2, MSCN2, MSTEC, MSSLEC and MSCEC distributions. For MSTT, MSSL2, MSTEC and MSSLEC, the default value is 3 and nu should be greater than 1. For MSCN2 and MSCEC, the default value is 0.5 and nu should be in the (0,1) interval.
gamma.fixed If a numerical value is provided, the estimation consider gamma as fixed. To estimate gamma, use gamma.fixed=FALSE. Available for MSCN2 and MSCEC distributions. For MSCN2 and MSCEC, the default value is 0.5 and gamma should be in the (0,1) interval.
nu.min Lower value to perform the maximization for nu. For MSTT, MSSL2, MSTEC and MSSLEC is used only when nu.fixed=FALSE.

Details

Supported models are:

In MSMN class: multivariate normal (MN), multivariate Student t (MT), multivariate slash (MSL), multivariate contaminated normal (MCN). See Lange and Sinsheimer (1993) for details.


In MSSMN class: MSN, multivariate skew-t-normal (MSTN), multivariate skew-slash normal (MSSL), multivariate skew-contaminated normal (MSCN). See Louredo, Zeller and Ferreira (2021) for details.

In MSMSNC class: multivariate skew-normal-Cauchy (MSNC), multivariate skew-t-Expected-Cauchy (MSTEC), multivariate skew-slash-Expected-Cauchy (MSSLEC), multivariate skew-contaminated-Expected-Cauchy (MSCEC). See Kahrari et al. (2020) for details.

Note: the MSN distribution belongs to both, MSMSN and MSSMN classes.

Value

an object of class "skewMLRM" is returned. The object returned for this functions is a list containing the following components:

coefficients A named vector of coefficients
se A named vector of the standard errors for the estimated coefficients. Valid if est.var is TRUE and the hessian matrix is invertible.
nu The estimated or fixed nu (only for MSTT, MSSL2, MSCN2, MSTEC, MSSLEC and MSCEC models)
gamma The estimated or fixed gamma (only for MSCN2 and MSCEC models)
logLik The log-likelihood function evaluated in the estimated parameters
AIC Akaike’s Information Criterion
BIC Bayesian’s Information Criterion
iterations the number of iterations until convergence (if attached)
time execution time in seconds
conv An integer code. 0 indicates successful completion. 1 otherwise.
dist The distribution for which was performed the estimation.
class The class for which was performed the estimation.
n The sample size
y The multivariate vector of responses. The univariate case also is supported.
X The regressor matrix (in a list form).
function a string with the name of the used function.

Note
In MT, MSL, MSTN, MSSL2, MSTT, MSSL and MSSLEC distributions, nu>2 guarantees that the mean and variance exist, nu>1 guarantees the existence only for the mean and for nu<=1, the mean and variance of the distribution is not finite.

Author(s)
Clecio Ferreira, Diego Gallardo and Camila Zeller

References

Examples
data(ais, package="sn") ##Australian Institute of Sport data set
attach(ais)
##It is considered a bivariate regression model
##with Hg and SSF as response variables and
##Hc, Fe, Bfat and LBM as covariates
y<-cbind(Hg,SSF)
n<-nrow(y); m<-ncol(y)
X.aux=model.matrix(~Hc+Fe+Bfat+LBM)
p<-ncol(X.aux)
X<-array(0,dim=c(2*p,m,n))
for(i in 1:n) {
    X[1:p,1,i]=X.aux[i,,drop=FALSE]
X[p+1:p,2,i]=X.aux[i,,drop=FALSE]
}
##See the covariate matrix X
fit.MN=estimate.MN(y, X) ##Estimate the parameters for the MN regression model
summary(fit.MN)
fit.MT=estimate.MT(y, X) ##Estimate the parameters for the MT regression model
summary(fit.MT)
##may take some time on some systems
fit.MSSL=estimate.MSSL(y, X) ##Estimate the parameters for the MSSL regression model
summary(fit.MSSL)
fit.MSTT=estimate.MSTT(y, X) ##Estimate the parameters for the MSTT regression model
summary(fit.MSTT)
fit.MSNC=estimate.MSNC(y, X) ##Estimate the parameters for the MSNC regression model
summary(fit.MSNC)
fit.MSCEC=estimate.MSCEC(y, X) ##Estimate the parameters for the MSCEC regression model
summary(fit.MSCEC)

FIM

Observed Fisher information matrix for distributions in the MSMN, MSMSN, MSSMN and MSMSNC classes.

Description

FIM.xxx computes the observed Fisher information (FI) matrix for the distribution xxx, where xxx is any supported model in the multivariate scale mixtures of normal (MSMN), multivariate scale mixtures of skew-normal (MSMSN), multivariate skew scale mixtures of normal (MSSMN) or multivariate scale mixtures of skew-normal-Cauchy (MSMSNC) classes. See details for supported distributions.

Usage

FIM.MN(P, y, X)
FIM.MT(P, y, X)
FIM.MSL(P, y, X)
FIM.MCN(P, y, X)
FIM.MSN(P, y, X)
FIM.MSTN(P, y, X)
FIM.MSSL(P, y, X)
FIM.MSCN(P, y, X)
FIM.MSTT(P, y, X, nu)
FIM.MSSL2(P, y, X, nu)
FIM.MSCN2(P, y, X, nu, gamma)
FIM.MSNC(P, y, X)
FIM.MSTEC(P, y, X, nu)
FIM.MSSLEC(P, y, X, nu)
FIM.MSCEC(P, y, X, nu, gamma)
Arguments

\( P \)  
the estimated parameters returned by a function of the form estimate.xxx, where xxx is a supported distribution.

\( y \)  
The multivariate vector of responses. The univariate case also is supported.

\( X \)  
The regressor matrix.

\( \nu \)  
\( \nu \) parameter. Only for MSTT, MSSL2, MSTEC, MSSLEC and MSCEC distributions.

\( \gamma \)  
\( \gamma \) parameter. Only for MSCN2 and MSCEC distributions.

Details

Supported models are:

In MSMN class: multivariate normal (MN), multivariate Student t (MT), multivariate slash (MSL), multivariate contaminated normal (MCN). See Lange and Sinsheimer (1993) for details.


In MSSMN class: MSN, multivariate skew-t-normal (MSTN), multivariate skew-slash normal (MSSL), multivariate skew-contaminated normal (MSCN). See Louredo, Zeller and Ferreira (2021) for details.

In MSMSNC class: multivariate skew-normal-Cauchy (MSNC), multivariate skew-t-Expected-Cauchy (MSTEC), multivariate skew-slash-Expected-Cauchy (MSSLEC), multivariate skew-contaminated-Expected-Cauchy (MSCEC). See Kahrari et al. (2020) for details.

Note: the MSN distribution belongs to both, MSMSN and MSSMN classes.

Value

A matrix with the observed FI matrix for the specified model.

Note

For MSTEC and MSSLEC distributions, \( \nu > 0 \) is considered as fixed. For MSCEC distribution, \( 0 < \nu < 1 \) and \( 0 < \gamma < 1 \) are considered as fixed.

Author(s)

Clecio Ferreira, Diego Gallardo and Camila Zeller.

References


Examples

```r
set.seed(2020)
n=200  # length of the sample
nv<-3  # number of explanatory variables
p<-nv+1 # nv + intercept
m<-4   # dimension of Y
q0=p*m
X<-array(0,c(q0,m,n))
for(i in 1:n) {
  aux=rep(1,p)
  aux[2:p]<-rMN(1,mu=rnorm(nv),Sigma=diag(nv))
  mi=matrix(0,q0,m)
  for (j in 1:m) mi[((j-1)*p+1):(j*p),j]=aux
  X[,,i]<-mi
}
# Simulated matrix covariates
betas<-matrix(rnorm(q0),ncol=1) ## True betas
Sigmas <- clusterGeneration::genPositiveDefMat(m,rangeVar=c(1,3),
  lambdaLow=1, ratioLambda=3)$Sigma ## True Sigma
lambda<-rnorm(m) ## True lambda
y=matrix(0,n,m)
for(i in 1:n) {
  mui<-t(X[,,i])%*%betas
  y[i,]<-rMSN(n=1,c(mui),Sigmas,lambda)}

fit.MSN=estimate.MSN(y,X) ## Estimate parameters for MSN model
fit.MSN ## Output of estimate.MSN
summary(fit.MSN)
fit.MSN$se ## Estimated standard errors by the estimate.MSN function
# Estimated standard errors by minus the square root of
# the diagonal from the observed FI matrix of the MSN model
sqrt(diag(solve(-FI.MSN(fit.MSN$coefficients, y, X))))
```

---

**matrix.sqrt**

Square root of a matrix

**Description**

Compute the square root of a matrix

**Usage**

```r
matrix.sqrt(A)
```
Arguments

A a symmetric semi-definite positive matrix

Value

A symmetric matrix, say B, such as B^t*B=A

Note

For internal use.

Author(s)

Clecio Ferreira, Diego Gallardo and Camila Zeller.

Examples

A<-matrix(c(1,2,2,5),nrow=2)
B<-matrix.sqrt(A)
##Recovering A
t(B)%*%B
A

mbackcrit Multivariate backward based on the AIC or BIC criteria

Description

mbackcrit implements the covariates selection based on backward and the Akaike's information criteria (AIC) or Schwartz's information criteria (BIC) in a specified multivariate model in the multivariate scale mixtures of normal (MSMN), multivariate scale mixtures of skew-normal (MSMSN), multivariate skew scale mixtures of normal (MSSMN) or multivariate scale mixtures of skew-normal-Cauchy (MSMSNC) classes. See details for available distributions.

Usage

mbackcrit(y, X = NULL, max.iter = 1000, prec = 1e-04, dist = "MN", criteria = "AIC", est.var=TRUE, cluster = FALSE, ...)

Arguments

y The multivariate vector of responses. The univariate case also is supported.
X The regressor matrix. It should include intercept term for all the variates.
max.iter The maximum number of iterations.
prec The convergence tolerance for parameters.
dist the multivariate distribution in which the covariates selection will be implemented.
criteria criteria used to perform the covariates selection. AIC (default) and BIC available.
est.var Logical. If TRUE the standard errors are estimated.
ccluster logical. If TRUE, parallel computing is used. FALSE is the default value.

Details

Supported models are:

In **MSMN** class: multivariate normal (MN), multivariate Student t (MT), multivariate slash (MSL), multivariate contaminated normal (MCN). See Lange and Sinsheimer (1993) for details.


In **MSSMN** class: MSN, multivariate skew-t-normal (MSTN), multivariate skew-slash normal (MSSL), multivariate skew-contaminated normal (MSCN). See Louredo, Zeller and Ferreira (2021) for details.

In **MSMSNC** class: multivariate skew-normal-Cauchy (MSNC), multivariate skew-t-Expected-Cauchy (MSTEC), multivariate skew-slash-Expected-Cauchy (MSSLEC), multivariate skew-contaminated-Expected-Cauchy (MSCEC). See Kahrari et al. (2020) for details.

Note: the MSN distribution belongs to both, MSMSN and MSSMN classes.

Value

an object of class "skewMLRM" is returned. The object returned for this functions is a list containing the following components:

coefficients A named vector of coefficients
se A named vector of the standard errors for the estimated coefficients. Valid if est.var is TRUE and the hessian matrix is invertible.
logLik The log-likelihood function evaluated in the estimated parameters for the selected model
AIC Akaike’s Information Criterion for the selected model
BIC Bayesian’s Information Criterion for the selected model
iterations the number of iterations until convergence (if attached)
conv An integer code for the selected model. 0 indicates successful completion. 1 otherwise.
dist The distribution for which was performed the estimation.
class The class for which was performed the estimation.
choose.crit the specified criteria to choose the distribution.
comment A comment indicating how many coefficients were eliminated
The multivariate vector of responses. The univariate case also is supported.

X
The regressor matrix (in a list form).

function
a string with the name of the used function.

Author(s)

Clecio Ferreira, Diego Gallardo and Camila Zeller.

References


Examples

data(ais, package="sn") ##Australian Institute of Sport data set
attach(ais)
##It is considered a bivariate regression model
##with Hg and SSF as response variables and
##Hc, Fe, Bfat and LBM as covariates
y<-cbind(Hg,SSF)
m<-nrow(y); p<-ncol(y)
X.aux=model.matrix(~Hc+Fe+Bfat+LBM)
X<-array(0,dim=c(2*p,m,n))
for(i in 1:n) {
  X[1:p,1,i]=X.aux[i,,drop=FALSE]
  X[p+1:p,2,i]=X.aux[i,,drop=FALSE]
}
##See the regressor matrix X
##
##Perform covariates selection in the MN distribution
##based on the AIC criteria
##may take some time on some systems
fit.MN=mbackcrit(y, X, dist="MN")
summary(fit.MN)
##Identical process for MT distribution
fit.MT=mbackcrit(y, X, dist="MT")
summary(fit.MT)
##and for MSN distribution
fit.MSN=mbackcrit(y, X, dist="MSN")
mbacksing

summary(fit.MSN)

mbacksing  Multivariate Backward Based on Significance

Description

mbacksing implements the covariates selection based on the significance of the covariates in a specified multivariate model in the multivariate scale mixtures of normal (MSMN), multivariate scale mixtures of skew-normal (MSMSN), multivariate skew scale mixtures of normal (MSSMN) or multivariate scale mixtures of skew-normal-Cauchy (MSMSNC) classes. See details for available distributions.

Usage

mbacksing(y, X = NULL, max.iter = 1000, prec = 1e-04, dist = "MN", significance = 0.05, ...)

Arguments

y  The multivariate vector of responses. The univariate case also is supported.
X  The regressor matrix. It should include intercept term for all the variates.
max.iter  The maximum number of iterations.
prec  The convergence tolerance for parameters.
dist  the multivariate distribution in which the covariates selection will be implemented.
significance  the level of significance to perform the covariate selection. By default is 0.05.
...  Possible additional arguments. For instance, for MSTT, MSSL2, MSTEC and MSSLEC distributions should be added nu.min and nu.fixed related to specifications for the nu parameter.

Details

Supported models are:

In MSMN class: multivariate normal (MN), multivariate Student t (MT), multivariate slash (MSL), multivariate contaminated normal (MCN). See Lange and Sinsheimer (1993) for details.


In MSSMN class: MSN, multivariate skew-t-normal (MSTN), multivariate skew-slash normal (MSSL), multivariate skew-contaminated normal (MSCN). See Louredo, Zeller and Ferreira (2021) for details.

In MSMSNC class: multivariate skew-normal-Cauchy (MSNC), multivariate skew-t-Expected-Cauchy (MSTEC), multivariate skew-slash-Expected-Cauchy (MSSLEC), multivariate skew-contaminated-Expected-Cauchy (MSCEC). See Kahrari et al. (2020) for details.

Note: the MSN distribution belongs to both, MSMSN and MSSMN classes.
Value

An object of class "skewMLRM" is returned. The object returned for this functions is a list containing the following components:

- **coefficients**: A named vector of coefficients
- **se**: A named vector of the standard errors for the estimated coefficients. Valid if est.var is TRUE and the hessian matrix is invertible.
- **logLik**: The log-likelihood function evaluated in the estimated parameters for the selected model
- **AIC**: Akaike’s Information Criterion for the selected model
- **BIC**: Bayesian’s Information Criterion for the selected model
- **iterations**: the number of iterations until convergence (if attached)
- **conv**: An integer code for the selected model. 0 indicates successful completion. 1 otherwise.
- **dist**: The distribution for which was performed the estimation.
- **class**: The class for which was performed the estimation.
- **choose.crit**: the specified criteria to choose the distribution.
- **comment**: A comment indicating how many coefficients were eliminated
- **eliminated**: An string vector with the eliminated betas (in order of elimination).
- **y**: The multivariate vector of responses. The univariate case also is supported.
- **X**: The regressor matrix (in a list form).
- **significance**: The specified level of significance (0.05 by default).
- **function**: a string with the name of the used function.

Author(s)

Clecio Ferreira, Diego Gallardo and Camila Zeller.

References


Examples

data(ais, package="sn")  ##Australian Institute of Sport data set
attach(ais)
##It is considered a bivariate regression model
##with Hg and SSF as response variables and
##Hc, Fe, Bfat and LBM as covariates
y<-cbind(Hg,SSF)
n<-nrow(y);  m<-ncol(y)
X.aux=model.matrix(~Hc+Fe+Bfat+LBM)
p<-ncol(X.aux)
X<-array(0,dim=c(2*p,m,n))
for(i in 1:n) {
  X[1:p,1,i]=X.aux[i,,drop=FALSE]
  X[p+1:p,2,i]=X.aux[i,,drop=FALSE]
}
##See the regressor matrix X
##X
##Perform covariates selection in the MN distribution
##based on a significance level of 1%, 5% and 10%

##may take some time on some systems
fit.MN.01=mbacksign(y, X, dist="MN", sign=0.01)
fit.MN.05=mbacksign(y, X, dist="MN", sign=0.05)
fit.MN.10=mbacksign(y, X, dist="MN", sign=0.10)
summary(fit.MN.01)
summary(fit.MN.05)
summary(fit.MN.10)
##identical process in the MCN model with
##significance level of 5%
fit.MCN=mbacksign(y, X, dist="MCN")
summary(fit.MCN)
##for MSSL model
fit.MSSL=mbacksign(y, X, dist="MSSL")
summary(fit.MSSL)
##for MSNC model
fit.MSNC=mbacksign(y, X, dist="MSNC")
summary(fit.MSNC)

plot.skewMLRM

Plot an object of the "skewMLRM" class produced with the function
distMahal.

Description

Plot the Mahalanobis distance for a object of the class "skewMLRM" produced by the function
distMahal.
Usage

```r
## S3 method for class 'skewMLRM'
plot(x, ...)
```

Arguments

- `x`: an object of the class "skewMLRM" produced by the function `distMahal`.
- `...`: for graphical extra arguments

Details

Supported models are:

- In `MSMN` class: multivariate normal (MN), multivariate Student t (MT), multivariate slash (MSL), multivariate contaminated normal (MCN). See Lange and Sinsheimer (1993) for details.
- In `MSSMN` class: MSN, multivariate skew-t-normal (MSTN), multivariate skew-slash normal (MSSL), multivariate skew-contaminated normal (MSCN). See Louredo, Zeller and Ferreira (2021) for details.

Note: the MSN distribution belongs to both, `MSMSN` and `MSSMN` classes.

The functions which generate an object of the class "skewMLRM" are:

- `estimate.xxx`: where `xxx` can be MN, MT, MSL, MCN, MSN, MSTN, MSSL, MSCN, MSTT, MSSL2, MSCN2, MSNC, MSTEC, MSSLEC or MSCEC.
- `choose.yyy`: where `yyy` can be MSMN, MSSMN, MSMSN, MSMSNC or models.
- `chose2`, `mbackcrit` and `mbacksign`.

Value

A complete summary for the coefficients extracted from a skewMLRM object.

Author(s)

Clecio Ferreira, Diego Gallardo and Camila Zeller

References


Examples

```r
data(ais, package="sn")  ##Australian Institute of Sport data set
attach(ais)
##It is considered a bivariate regression model
##with Hg and SSF as response variables and
##Hc, Fe, Bfat and LBM as covariates
y<-cbind(Hg,SSF)
n<-nrow(y); m<-ncol(y)
X.aux=model.matrix(~Hc+Fe+Bfat+LBM)
p<-ncol(X.aux)
X<-array(0,dim=c(2*p,m,n))
for(i in 1:n) {
  X[1:p,1,i]=X.aux[i,,drop=FALSE]
  X[p+1:p,2,i]=X.aux[i,,drop=FALSE]
}
##See the covariate matrix X
##X
fit.MN=estimate.MN(y, X) #Fit the MN distribution
res.MN=distMahal(fit.MN) #Compute the Mahalanobis distances
plot(res.MN) #Plot the Mahalanobis distances
# fit.MSN=estimate.MSN(y, X) #Fit the MSN distribution
res.MSN=distMahal(fit.MSN) #Compute the Mahalanobis distances
plot(res.MSN) #Plot the Mahalanobis distances
```

**Description**

`rM` generates random values for the distribution `xxx`, where `xxx` is any supported model in the multivariate scale mixtures of normal (MSMN), multivariate scale mixtures of skew-normal (MSMSN), multivariate skew scale mixtures of normal (MSSMN) or multivariate scale mixtures of skew-normal-Cauchy (MSMSNC) classes. See details for supported distributions.

**Usage**

```r
rMN(n, mu, Sigma)
rMT(n, mu, Sigma, nu = 1)
```
rMSL(n, mu, Sigma, nu = 1)
rMCN(n, mu, Sigma, nu = 0.5, gamma = 0.5)
rMSN(n, mu, Sigma, lambda)
rMSTN(n, mu, Sigma, lambda, nu = 1)
rMSSL(n, mu, Sigma, lambda, nu = 1)
rMSCN(n, mu, Sigma, lambda, nu = 0.5, gamma = 0.5)
rMSTT(n, mu, Sigma, lambda, nu = 1)
rMSSL2(n, mu, Sigma, lambda, nu = 1)
rMSCN2(n, mu, Sigma, lambda, nu = 0.5, gamma = 0.5)
rMSNC(n, mu, Sigma, lambda)
rMSTEC(n, mu, Sigma, lambda, nu = 1)
rMSSLEC(n, mu, Sigma, lambda, nu = 1)
rMSCEC(n, mu, Sigma, lambda, nu = 0.5, gamma = 0.5)

Arguments

n           number of observations to be generated.
mu          vector of location parameters.
Sigma       covariance matrix (a positive definite matrix).
lambda      vector of shape parameters.
u           nu parameter. A positive scalar for MT, MSL, MSTN, MSSL, MSTT, MSSL2,
            MSTEC and MSSLEC models. A value in the interval (0,1) for MCN, MSCN,
            MSCN2 and MSCEC models.
gamma       gamma parameter. A value in the interval (0,1) for MCN, MSCN, MSCN2 and
            MSCEC models.

Details

Supported models are:

In MSMN class: multivariate normal (MN), multivariate Student t (MT), multivariate slash (MSL),
multivariate contaminated normal (MCN). See Lange and Sinsheimer (1993) for details.

In MSMSN class: multivariate skew-normal (MSN), multivariate skew-T (MSTT), multivariate
skew-slash (MSSL2), multivariate skew-contaminated normal (MSCN2). See Zeller, Lachos and
Vilca-Labra (2011) for details.

In MSSMN class: MN, multivariate skew-t-normal (MSTN), multivariate skew-slash normal
(MSSL), multivariate skew-contaminated normal (MSCN). See Louredo, Zeller and Ferreira (2021)
for details.

In MSMSNC class: multivariate skew-normal-Cauchy (MSNC), multivariate skew-t-Expected-
Cauchi (MSTEC), multivariate skew-slash-Expected-Cauchy (MSSLEC), multivariate skew-contaminated-
Expected-Cauchy (MSCEC). See Kahrari et al. (2020) for details.

Note: the MSN distribution belongs to both, MSMSN and MSSMN classes.

MN used mvrnorm. For MT, MSL and MCN, the generation is based on the MSMN class. See
Lange and Sinsheimer (1993) for details. For MSTN, MSSL and MSCN, the generation is based
on the MSSMN class. See Ferreira, Lachos and Bolfarine (2016) for details. For MSTT, MSSL2
and MSCN2, the generation is based on the multivariate scale mixtures of skew-normal (MSMSN)
Value

A matrix with the generated data.

Author(s)

Clecio Ferreira, Diego Gallardo and Camila Zeller.

References


Examples

rMSN(10, mu=c(0,0), Sigma=diag(2), lambda=c(1,-1)) ##bivariate MSN model
rMSNC(10, mu=0, Sigma=2, lambda=1) ##univariate MSNC model
rMSNC(10, mu=1:3, Sigma=2*diag(3), lambda=c(1,-1,0)) ##trivariate MSN model

---

solve2

Computes the inverse of a matrix

Description

Computes the inverse of a matrix using the LU decomposition.

Usage

solve2(A)

Arguments

A an invertible square matrix.
Use the LU decomposition to compute the inverse of a matrix. In some cases, solve produces error to invert a matrix whereas this decomposition provide a valid solution.

Value
A square matrix corresponding to the inverse of A.

Author(s)
Clecio Ferreira, Diego Gallardo and Camila Zeller

References


Examples
```
A=matrix(c(1,2,5,6),ncol=2)
solve2(A)
```

summary.skewMLRM

Print a summary for a object estimate.xxx

Description
Summarizes the results for a object of the class "skewMLRM".

Usage
```
## S3 method for class 'skewMLRM'
summary(object, ...)
```

Arguments
```
object       an object of the class "skewMLRM". See details for supported models.
...           for extra arguments
```
Details

Supported models are:

In MSMN class: multivariate normal (MN), multivariate Student t (MT), multivariate slash (MSL), multivariate contaminated normal (MCN). See Lange and Sinsheimer (1993) for details.


In MSSMN class: MSN, multivariate skew-t-normal (MSTN), multivariate skew-slash normal (MSSL), multivariate skew-contaminated normal (MSCN). See Louredo, Zeller and Ferreira (2021) for details.

In MSMSNC class: multivariate skew-normal-Cauchy (MSNC), multivariate skew-t-Expected-Cauchy (MSTEC), multivariate skew-slash-Expected-Cauchy (MSSLEC), multivariate skew-contaminated-Expected-Cauchy (MSCEC). See Kahrari et al. (2020) for details.

Note: the MSN distribution belongs to both, MSMSN and MSSMN classes.

The functions which generate an object of the class "skewMLRM" are

estimate.xxx: where xxx can be MN, MT, MSL, MCN, MN, MSTN, MSSL, MSCN, MSTT, MSSL2, MSCN2, MSNC, MSTEC, MSSLEC or MSCEC.

choose.yyy: where yyy can be MSMN, MSSMN, MSMSN, MSMSNC or models.

choose2, mbackcrit, mbacksign and distMahal.

Value

A complete summary for the coefficients extracted from a skewMLRM object. If the object was generated by function distMahal, the summary is related to the Mahalanobis distances.

Author(s)

Clecio Ferreira, Diego Gallardo and Camila Zeller

References


Examples

```r
data(ais, package="sn") ##Australian Institute of Sport data set
attach(ais)
##It is considered a bivariate regression model
##with Hg and SSF as response variables and
##Hc, Fe, Bfat and LBM as covariates
y<-cbind(Hg,SSF)
n<-nrow(y); m<-ncol(y)
X.aux=model.matrix(~Hc+Fe+Bfat+LBM)
p<-ncol(X.aux)
X<-array(0,dim=c(2*p,m,n))
for(i in 1:n) {
  X[1:p,1,i]=X.aux[i,,drop=FALSE]
  X[p+1:p,2,i]=X.aux[i,,drop=FALSE]
}
##See the covariate matrix X
##X
```

```r
fit.MN=estimate.MN(y, X) #fit the MN distribution
summary(fit.MN) #summary for the fit
#
fit.MSN=estimate.MSN(y, X) #fit the MSN distribution
summary(fit.MSN) #summary for the fit
```

---

**tgamma**

*Truncated gamma distribution*

**Description**

Compute the probability density and quantile functions for the truncated gamma distribution with shape and scale parameters, restricted to the interval (a,b).

**Usage**

```r
dtgamma(x, shape, scale = 1, a = 0, b = Inf)
qtgamma(p, shape, scale = 1, a = 0, b = Inf)
```

**Arguments**

- `x`: vector of quantiles
- `p`: vector of probabilities
- `shape`: shape parameter
- `scale`: scale parameter
- `a`: lower limit of range
- `b`: upper limit of range
Value

dtgamma gives the density function for the truncated gamma distribution. qtgamma gives the quantile function for the truncated gamma distribution.

Note

Auxiliary function to compute the E step for the Slash and Skew-slash models.

Author(s)

Clecio Ferreira, Diego Gallardo and Camila Zeller

Examples

## probability density and quantile function of the truncated gamma
## model with shape and scale parameters equal to 1
## evaluated in 2 and 0.75, respectively
dtgamma(2, shape=1, a=1)
qtgamma(0.75, shape=1, a=1)
## standard gamma distribution with shape parameter 2 evaluated in 1
dtgamma(1, shape=2)
dgamma(1, shape=2)

v cov. skewMLRM

Calculate Variance-Covariance Matrix for a Fitted Model Object

Description

Returns the variance-covariance matrix of the parameters of a fitted model object of the class "skewMLRM".

Usage

## S3 method for class 'skewMLRM'
v cov(object, ...)

Arguments

object an object of the class "skewMLRM". See details for supported models.
... for extra arguments
Details

Supported models are:

In MSMN class: multivariate normal (MN), multivariate Student t (MT), multivariate slash (MSL), multivariate contaminated normal (MCN). See Lange and Sinsheimer (1993) for details.


In MSSMN class: MN, multivariate skew-t-normal (MSTN), multivariate skew-slash normal (MSSL), multivariate skew-contaminated normal (MSCN). See Louredo, Zeller and Ferreira (2021) for details.

In MSMSNC class: multivariate skew-normal-Cauchy (MSNC), multivariate skew-t-Expected-Cauchy (MSTEC), multivariate skew-slash-Expected-Cauchy (MSSLEC), multivariate skew-contaminated-Expected-Cauchy (MSCEC). See Kahrari et al. (2020) for details.

Note: the MSN distribution belongs to both, MSMSN and MSSMN classes.

The functions which generate an object of the class "skewMLRM" compatible with vcov are

- estimate.xxx: where xxx can be MN, MT, MSL, MCN, MSN, MSTN, MSSL, MSCN, MSTT, MSSL2, MSCN2, MSNC, MSTEC, MSSLEC or MSCEC.
- choose.yyy: where yyy can be MSMN, MSSMN, MSMSN, MSMSNC or models.
- choose2, mbackcrit and mbacksing.

Value

A matrix of the estimated covariances between the parameter estimates in the linear or non-linear predictor of the model. This should have row and column names corresponding to the parameter names given by the coef method.

Author(s)

Clecio Ferreira, Diego Gallardo and Camila Zeller

References


Examples

data(ais, package="sn") ##Australian Institute of Sport data set
attach(ais)
##It is considered a bivariate regression model
##with Hg and SSF as response variables and
##Hc, Fe, Bfat and LBM as covariates
y<-cbind(Hg,SSF)
n<-nrow(y); m<-ncol(y)
X.aux=model.matrix(~Hc+Fe+Bfat+LBM)
p<-ncol(X.aux)
X<-array(0,dim=c(2*p,m,n))
for(i in 1:n) {
  X[1:p,1,i]=X.aux[i,,drop=FALSE]
  X[p+1:p,2,i]=X.aux[i,,drop=FALSE]
}
##See the covariate matrix X
##X

fit.MN=estimate.MN(y, X) #fit the MN distribution
vcov(fit.MN) #variance-covariance matrix
fit.MSN=estimate.MSN(y, X) #fit the MSN distribution
vcov(fit.MSN) #variance-covariance matrix

---

**vech**  
*Vectorize a symmetric matrix*

**Description**

vech takes the upper diagonal from a symmetric matrix and vectorizes it.

**Usage**

```r
vech(x)
```

**Arguments**

- `x` a symmetric matrix.

**Value**

A vector with the components of the upper diagonal from the matrix, listed by row.

**Note**

For internal use.

**Author(s)**

Clecio Ferreira, Diego Gallardo and Camila Zeller.
Examples

```r
A <- matrix(c(1, 2, 2, 5), nrow=2)
## vectorized A matrix
B <- vech(A)
B
## reconstitute matrix A using B
xpnd(B, 2)
```

---

**xpnd**

Reconstitute a symmetric matrix from a vector.

**Description**

`xpnd` reconstitutes a symmetric matrix from a vector obtained with the `vech` function.

**Usage**

```r
xpnd(x, nrow = NULL)
```

**Arguments**

- `x` vector with the components of the upper diagonal of the matrix
- `nrow` dimension of the matrix to be reconstitute.

**Value**

A symmetric matrix.

**Note**

For internal use.

**Author(s)**

Clecio Ferreira, Diego Gallardo and Camila Zeller.

**Examples**

```r
A <- matrix(c(1, 2, 2, 5), nrow=2)
## vectorized A matrix
B <- vech(A)
B
## reconstitute matrix A using B
xpnd(B, 2)
```
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