Package 'ffpqr'

May 11, 2024

Type Package

Title Function-on-function partial quantile regression

Version 1.0

Depends R (>= 3.5.0), fda, MASS, quantreg

Imports expm, cvTools

LazyLoad yes

ByteCompile TRUE

Encoding UTF-8

Maintainer Muge Mutis <muge.mutis@yildiz.edu.tr>

Description Functions for implementing methods for function-on-function linear quantile regression.

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dgp *Generate a dataset for the function-on-function regression model*

Description

This function can be used to generate a dataset for the function-on-function regression model

$$Y(u) = \int X(v)\beta(u,v)dv + \epsilon(u),$$

where $Y(u)$ denotes the functional response, $X(v)$ denotes the functional predictor, $\beta(u,v)$ denotes the bivariate regression coefficient function, and $\epsilon(u)$ is the error function.

Usage

```
dgp(n, nphi, gpy, gpx, err.dist, out.p)
```

Arguments

n	An integer, specifying the number of observations for each variable to be generated.
nphi	An integer, specifying the number of sub-random variables used in the generation of functional predictor. Default value is 10.
gpy	A vector, denoting the grid points of the functional response variable $Y(u)$.
gpx	A vector, denoting the grid points of the functional predictor variable $X(v)$.
err.dist	Distribution of the error term. Possibilities are "normal","t","chisq", "cn".
out.p	An integer between 0 and 1, denoting the outlier percentage in the generated data when the error distribution is contaminated normel, that is, "cn".

Details

When generating the data for the function-on-function regression model, first, the functional predictor is generated using the following process:

$$X_i(v) = \sum_{k=1}^{10} \frac{1}{k^2}\{\zeta_{i1,k}\sqrt{2}\sin(k\pi v)\zeta_{i2,k}\sqrt{2}\cos(k\pi v)\}$$

where $\zeta_{i1,k}$ and $\zeta_{i2,k}$ for $k = 1, \ldots, 10$ are independent random variables generated from the standard normal distribution. The true intercept and bivariate regression parameter functions are generated as $\alpha(u) = 2e^{\{} - (u-1)^2\}$ and $\beta(v,u) = 4\cos(2\pi u)\sin(\pi v)$, respectively, Then, the elements of the functional response are generated as follows:

$$Y_i(u) = \alpha(u) + \int X_i(v)\beta(v,u)dv + \varepsilon_i(u),$$

where $\varepsilon_i(u)$ are generated from one of the following distributions:

When err.dist is "normal", then the error terms are generated from the standard normal distribution.

When err.dist is "t", then the error terms are generated from the t distribution with five degrees of freedom.

When err.dist is "chisq", then the error terms are generated from the chi-square distribution with one degree of freedom.

When err.dist is "cn", then the error terms are generated from the contaminated normal distribution.

Value

x	A matrix containing the observations of simulated functional predictor variable.
y	A matrix containing the observations of simulated functional response variable.
x.true	A matrix containing the observations of simulated functional predictor variable without measurement error.

y.true	A matrix containing the observations of simulated functional response variable without measurement error.
coef.a	A vector containing the intercept function.
coef.b	A matrix containing the bivariate regression coefficient vector.

Author(s)

Muge Mutis, Ufuk Beyaztas, Filiz Karaman, and Han Lin Shang

References

C. Xiong, X. Liugen, and C. Jiguo (2021), "Robust penalized M-estimation for function-on-function linear regression"", *Stat*, **10**(1), e390.

Examples

```
gpx <- (1:50)/50
gpy <- (1:60)/60
data <- dgp(n = 250, gpy = gpy, gpx = gpx, err.dist = "normal")
y <- data$y
x <- data$x
```

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fpqr *Function-on-function partial quantile regression*

Description

This function is used to perform function-on-function linear quantile regression model

$$Q_\tau[Y(u)|X(v)] = \int X(v)\beta_\tau(u,v)dv$$

based on the functional partial quantile regression.

Usage

```
fpqr(y, x, h, tau, nby, nbx, gpy, gpx, qc.type = c("dodge","choi","li"),
hs, nbys, nbxs, nfold, CV)
```

Arguments

y	An matrix containing the observations of function response $Y(u)$.
x	A matrix containing the observations of functional predictor $X(v)$.
h	A numeric value denoting the number of functional partial quantile regression components to be computed.
tau	Quantile level.

nby	A numeric value denoting the number of B-spline basis expansion functions to be used to approximate the functional response variable.
nbx	A numeric value denoting the number of B-spline basis expansion functions to be used to approximate the functional predictor variable.
gpy	A vector containing the grid points of the functional response $Y(u)$.
gpx	A vector containing the grid points of the functional predictor $X(v)$.
qc.type	Method type used to estimate the quantile covariance. Possibilities are "dodge", "choi", and "li".
hs	A vector containing the candidate elements for the h.
nbys	A vector containing the candidate elements for the nby.
nbxs	A vector containing the candidate elements for the nbx.
nfold	An integer denoting the number of folds used in the k-fold cross validation. Default value is 5.
CV	Logical. If TRUE, then nfold cross-validation is used to find optimum values of h, nby, and nbx. If FALSE, then the specified h, nby, and nbx values are used in the model.

Details

If qc.type = "dodge", then, the quantile covariance proposed by Dodge and Whittaker (2009) is used in the functional partial quantile regression decomposition.

If qc.type = "choi", then, the quantile covariance proposed by Choi and Shin (2018) is used in the functional partial quantile regression decomposition.

If qc.type = "li", then, the quantile covariance proposed by Li et al. (2015) is used in the functional partial quantile regression decomposition.

Value

fitted.values	An matrix containing the fitted values of the functional response.
b0.hat	A vector containing the estimate of intersecp parameter.
b.hat	A matrix containing the estimate of bivariate regression coefficient coducted between the functional response and functional predictor.
mdts	A numeric value containing the estimated intercept parameter.
pqr.coefs	A vector containing the estimated regression parameter for the regression problem of scalar response on the partial quantile regression components.
V	A matrix whose rows are the eigenvectors
model.details	A list object containing model details, such as number of basis functions, number of partial quantile components, and grid points used for the functional variables.

Author(s)

Muge Mutis, Ufuk Beyaztas, Filiz Karaman, and Han Lin Shang

References

Y. Dodge and J. Whittaker (2009), "Partial quantile regression", *Metrika*, **70**(1), 35–57. J. E.. Choi and D. W. Shin (2018), "Quantile correlation coefficient: A new tail dependence measure", *Statistical Papers*, **63**, 1075–1104. G. Li and Y. Li and C. L. Tsai (2015), "Quantile correlations and quantile autoregressive modeling" *Journal of American Statistical Association*, **110**(509), 246–261.

Examples

```
gpx <- (1:50)/50
gpy <- (1:60)/60
data <- dgp(n = 100, gpy = gpy, gpx = gpx, err.dist = "normal")
y <- data$y
x <- data$x

fpqr.model.dodge <- fpqr(y=y, x=x, tau = 0.5, gpx = gpx, gpy = gpy,
                         qc.type = "dodge")

fpqr.model.choi <- fpqr(y=y, x=x, tau = 0.5, gpx = gpx, gpy = gpy,
                        qc.type = "choi")

fpqr.model.li <- fpqr(y=y, x=x, tau = 0.5, gpx = gpx, gpy = gpy,
                      qc.type = "li")
```

`predict_fpqr` *Prediction for a function-on-function linear quantile regression model based on functional partial quantile regression*

Description

This function is used to make prediction for a new set of functional predictors based upon a fitted function-on-function linear quantile regression model in the output of `fpqr`.

Usage

```
predict_fpqr(object, xnew)
```

Arguments

`object`	An output object obtained from `fpqr`.
`xnew`	A matricx consisting of the new observations of functional predictor. The argument `xnew` must have the same length and the same structure as the input `x` of `fpqr`.

Value

A matrix of predicted values of the functional response variable for the given set of new functional predictor `xnew`.

Author(s)

Muge Mutis, Ufuk Beyaztas, Filiz Karaman, and Han Lin Shang

Examples

```
gpx <- (1:50)/50
gpy <- (1:60)/60
data <- dgp(n = 100, gpy = gpy, gpx = gpx, err.dist = "normal")
y <- data$y
x <- data$x

data.test <- dgp(n = 100, gpy = gpy, gpx = gpx, err.dist = "normal")
x.test <- data.test$x
y.test <- data.test$y.true

fpqr.model.li <- fpqr(y=y, x=x, tau = 0.5, gpx = gpx, gpy = gpy,
                      qc.type = "li")

predictions <- predict_fpqr(object = fpqr.model.li, xnew = x.test)
```

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