**Package ‘PDMIF’**

March 30, 2021

**Title** Heterogeneous panel data models with interactive effects

**Version** 0.0.0.9

**Date** December 4th 2021

**Description** Fits heterogeneous panel data models with interactive effects for linear regression, logit, poisson, probit, quantile, and clustering. For more information, visit the PDMIF homepage <https://------->.

**URL** <https://github.com/>------

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**Date/Publication** December 4th 2021

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HOMTEST *Testing homogeneity of panel data models with interactive effects*

# Description

This function tests homogeneity of the regression coefficients in heterogeneous panel data models with interactive effects.

# Usage

HOMTEST (X, Y, Nfactors, Maxit=100, tol=0.001)

# Arguments

X The (NT) times p design matrix, without an intercept where N=number of individuals, T=length of time series, p=number of explanatory variables.

Y The T times N panel of response where N=number of individuals, T=length of time series.

Nfactors A pre-specified number of common factors.

Maxit A maximum number of iterations in optimization. Default is 100.

tol Tolerance level of convergence. Default is 0.001.

# Details

Under a pre-specified number of common factors, this function tests homogeneity of the regression coefficients.

# Value

**Coefficients** The estimated heterogeneous coefficients.

**Factors** The estimated common factors across groups.

**Loadings** The estimated factor loadings for the common factors.

**p-value** Thep-value of the homogeneity test.

# References

Ando, T. and Bai, J. (2015) A simple new test for slope homogeneity in panel data models with interactive effects. *Economics Letters*, 136, 112-117.

# Example

N <- 100

P <- 200

R <- 2

p <- 2

LAM <- matrix(rnorm(P\*R,0,1),nrow=P,ncol=R)

FAC <- matrix(rnorm(N\*R,0,1),nrow=N,ncol=R)

AY <- FAC%\*%t(LAM)+matrix(rnorm(N\*P,0,1),nrow=N,ncol=P)

AX <- matrix(0,nrow=N\*P,ncol=p)

for(j in 1:P){

AX[(N\*(j-1)+1):(N\*j),1] <- 0.2+0.3\*AY[,j]+matrix(rnorm(N,0,1),nrow=N)

AX[(N\*(j-1)+1):(N\*j),2] <- 0.5+0.5\*AY[,j]+matrix(rnorm(N,0,1),nrow=N)

}

B <- (1:p)/2-1

AB <- B%\*%t(rep(1,len=P))

for(j in 1:P){AY[,j] <- AY[,j]+AX[(N\*(j-1)+1):(N\*j),]%\*%AB[,j]}

fit <- HOMTEST(AX,AY,2)

HYPTEST *Hypothesis testing for coefficients of panel data models*

# Description

This function undergoes hypothesis testing for regression coefficients obtained from the various functions in the package.

# Usage

HYPTEST (B, B0, Se, test ="two", individuals=seq(1,ncol(B)), variables=seq(1,nrow(B)))

# Arguments

B A dataframe of Coefficients as obtained in the output of any function in the package.

B0 A dataframe of hypothetical coefficients to be evaluated in the test. (nrows should match number of variables and ncols should match number of individuals

Se A dataframe of Standard Errors as obtained in the output of any function in the package.

test A string to determine what kind of test to run (“two” for two-tailed, “right” for right-tailed and “left for left-tailed).

individuals A list of individuals whose coefficients are to be tested. Default is all individuals in the B dataframe.

variables A list of variables whose coefficients are to be tested. Default is all variables in the B dataframe.

# Details

Under a pre-specified hypothetical beta, this function tests whether the hypothesis is to be rejected or not based on the model’s estimate

# Value

**pVal** A dataframe of p-values resulting from each individual test.

# Example

N <- 400

P <- 300

R <- 3

p <- 3

LAM <- matrix(rnorm(P\*R,0,1),nrow=P,ncol=R)

FAC <- matrix(rnorm(N\*R,0,1),nrow=N,ncol=R)

AY <- FAC%\*%t(LAM)

AX <- matrix(rnorm(p\*P\*N,0,1),nrow=P\*N)

for(j in 1:P){

AX[(N\*(j-1)+1):(N\*j),1] <- AX[(N\*(j-1)+1):(N\*j),1]+0.15\*AY[,j]

AX[(N\*(j-1)+1):(N\*j),3] <- AX[(N\*(j-1)+1):(N\*j),3]-0.21\*AY[,j]

}

B <- c(-1,2,-1)

AB <- B%\*%t(rep(1,len=P))+matrix(0.1\*runif(p\*P,-1,1),p,P)

for(j in 1:P){

AY[,j] <- AY[,j]+(AX[(N\*(j-1)+1):(N\*j),])%\*%AB[,j]

}

PROB <- exp(AY)/(1+exp(AY))

AY <- trunc(matrix(runif(N\*P,0,1),ncol=P)+PROB)

fit <- PDMIFLOGIT(AX,AY,R)

HYPTEST(fit$Coefficients,data.frame(c(0,1),c(-1,2)),fit$Se, "two",c(1,2),c(1,3))

PDMIFCLUST *Clustering individuals with panel data models with interactive effects*

# Description

Cluster individuals by heterogeneous panel data models with interactive effects.

# Usage

PDMIFCLUST(X, Y, NGfactors, NLfactors, Maxit=100, tol=0.001)

# Arguments

X The (NT) times p design matrix, without an intercept where N=number of individuals, T=length of time series, p=number of explanatory variables.

Y The T times N panel of response where N=number of individuals, T=length of time series.

NGfactors A pre-specified number of common factors across groups (see example).

NLfactors A pre-specified number of factors in each groups (see example).

Maxit A maximum number of iterations in optimization. Default is 100.

tol Tolerance level of convergence. Default is 0.001

# Details

Under a pre-specified number of groups and the number of common factors, this function implements clustering for N individuals in the panels. Each of individuals in the group are subject to the group-specific unobserved common factors.

# Value

**Label** The estimated group membership for each of individuals.

**Coefficients** The estimated heterogeneous coefficients.

**Lower05** Lower end (5%) of the 90% confidence interval of the regression coefficients.

**Upper95** Upper end (95%) of the 90% confidence interval of the regression coefficients.

**GlobalFactors** The estimated common factors across groups.

**GroupLoadings** The estimated factor loadings for each group.

**GroupFactors** The estimated group-specific factors.

**GlobalLoadings** The estimated factor loadings for the common factors.

**pval** p-value for testing hypothesis on heterogeneous coefficients.

**Se** Standard error of the estimated regression coefficients.

# References

Ando, T. and Bai, J. (2016) Panel data models with grouped factor structure under unknown group membership *Journal of Applied Econometrics*, 31, 163-191.

Ando, T. and Bai, J. (2017) Clustering huge number of financial time series: A panel data approach with high-dimensional predictors and factor structures. *Journal of the American Statistical Association*, 112, 1182-1198.

# Examples

N <- 200

NGroup <- 3

Rs <- rep(2,len=NGroup)

PP <- rep(200,len=NGroup)

P <- sum(PP)

p <- 3

R <- 2

AY <- matrix(0,nrow=N,ncol=P)

LAM <- matrix(rnorm(P\*R,0,1),nrow=P,ncol=R)

FAC <- matrix(rnorm(N\*R,0,1),nrow=N,ncol=R)

XG <- FAC%\*%t(LAM)

XL <- matrix(0,ncol=P,nrow=N)

for(i in 1:NGroup){

LAM <- matrix(rnorm(PP[i]\*Rs[i],1,1),nrow=PP[i],ncol=Rs[i])

FAC <- matrix(rnorm(N\*Rs[i],0,1),nrow=N,ncol=Rs[i])

X <- FAC%\*%t(LAM)

XL[,(PP[i]\*(i-1)+1):(PP[i]\*i)] <- X

}

ERR <- matrix(rnorm(N\*P,0,1),nrow=N,ncol=P)

AY <- XG+XL+ERR

AX <- matrix(runif(p\*P\*N,-2,2),nrow=P\*N)

AB <- matrix(rnorm(p\*P,4,2),ncol=P)

for(j in 1:P){AY[,j] <- AY[,j]+AX[(N\*(j-1)+1):(N\*j),]%\*%AB[,j]}

PDMIFCLUST(AX,AY,R,Rs)

PDMIFCOUNT *Heterogeneous panel data models with interactive effects for count data*

# Description

Estimate heterogeneous poisson panel data models with interactive effects.

# Usage

PDMIFCOUNT(X, Y, Nfactors, Maxit=100, tol=0.001)

# Arguments

X The (NT) times p design matrix, without an intercept where N=number of individuals, T=length of time series, p=number of explanatory variables.

Y The T times N panel of response where N=number of individuals, T=length of time series.

Nfactors A pre-specified number of common factors.

maxite A maximum number of iterations in optimization. Default is 100.

tol Tolerance level of convergence. Default is 0.001

# Details

This function estimates heterogeneous poisson panel data models with interactive effects.

# Value

**Coefficients** The estimated heterogeneous coefficients.

**Lower05** Lower end (5%) of the 90% confidence interval of the regression coefficients.

**Upper95** Upper end (95%) of the 90% confidence interval of the regression coefficients.

**Factors** The estimated common factors across groups.

**Loadings** The estimated factor loadings for the common factors.

**Predict** The conditional expectation of response variable

**pval** p-value for testing hypothesis on heterogeneous coefficients.

**Se** Standard error of the estimated regression coefficients.

# References

Ando, T., Bai, J. and Li, K. (2021) Bayesian and maximum likelihood analysis of large-scale panel choice models with unobserved heterogeneity, *Journal of Econometrics*.

# Examples

N <- 400

P <- 300

R <- 3

p <- 3

LAM <- matrix(runif(P\*R,0,1),nrow=P,ncol=R)

FAC <- matrix(runif(N\*R,0,1),nrow=N,ncol=R)

AY <- FAC%\*%t(LAM)

AX <- matrix(runif(p\*P\*N,0,1),nrow=P\*N)

for(j in 1:P){

AX[(N\*(j-1)+1):(N\*j),1] <- AX[(N\*(j-1)+1):(N\*j),1]+0.01\*AY[,j]

AX[(N\*(j-1)+1):(N\*j),3] <- AX[(N\*(j-1)+1):(N\*j),3]-0.01\*AY[,j]

}

B <- c(-1,2,-1)

AB <- B%\*%t(rep(1,len=P))

for(j in 1:P){

AY[,j] <- AY[,j]+(AX[(N\*(j-1)+1):(N\*j),])%\*%AB[,j]

}

MM <- exp(AY)

for(i in 1:N){

for(j in 1:P){

AY[i,j] <- rpois(1,lambda=MM[i,j])

}}

fit <- PDMIFCOUNT(AX,AY,R)

PDMIFGLM *Heterogeneous panel data models with interactive effects for generalized linear models*

# Description

Estimate generalized linear heterogeneous panel data models with interactive effects.

# Usage

PDMIFGLM(X, Y, FAMILY, Nfactors, Maxit=100, tol=0.001)

# Arguments

X The (NT) times p design matrix, without an intercept where N=number of individuals, T=length of time series, p=number of explanatory variables.

Y The T times N panel of response where N=number of individuals, T=length of time series.

FAMILY A description of the error distribution and link function to be used in the model just like in glm functions.

Nfactors A pre-specified number of common factors.

maxite A maximum number of iterations in optimization. Default is 100.

tol Tolerance level of convergence. Default is 0.001

# Details

This function estimates heterogeneous panel data models with interactive effects using generalized linear models.

# Value

**Coefficients** The estimated heterogeneous coefficients.

**Lower05** Lower end (5%) of the 90% confidence interval of the regression coefficients.

**Upper95** Upper end (95%) of the 90% confidence interval of the regression coefficients.

**Factors** The estimated common factors across groups.

**Loadings** The estimated factor loadings for the common factors.

**Predict** The conditional expectation of response variable**.**

**pval** p-value for testing hypothesis on heterogeneous coefficients.

**Se** Standard error of the estimated regression coefficients.

# References

Ando, T., Bai, J. and Li, K. (2021) Bayesian and maximum likelihood analysis of large-scale panel choice models with unobserved heterogeneity, *Journal of Econometrics*.

# Examples

N <- 400

P <- 300

R <- 3

p <- 3

LAM <- matrix(rnorm(P\*R,0,1),nrow=P,ncol=R)

FAC <- matrix(rnorm(N\*R,0,1),nrow=N,ncol=R)

AY <- FAC%\*%t(LAM)

AX <- matrix(rnorm(p\*P\*N,0,1),nrow=P\*N)

for(j in 1:P){

AX[(N\*(j-1)+1):(N\*j),1] <- AX[(N\*(j-1)+1):(N\*j),1]+0.15\*AY[,j]

AX[(N\*(j-1)+1):(N\*j),3] <- AX[(N\*(j-1)+1):(N\*j),3]-0.21\*AY[,j]

}

B <- c(-1,2,-1)

AB <- B%\*%t(rep(1,len=P))+matrix(0.1\*runif(p\*P,-1,1),p,P)

for(j in 1:P){

AY[,j] <- AY[,j]+(AX[(N\*(j-1)+1):(N\*j),])%\*%AB[,j]

}

PROB <- exp(AY)/(1+exp(AY))

AY <- trunc(matrix(runif(N\*P,0,1),ncol=P)+PROB)

fit <- PDMIFGLM(AX,AY,binomial(link=logit),R)

PDMIFLIN *Heterogeneous panel data models with interactive effects*

# Description

Estimate heterogeneous panel data models with interactive effects.

# Usage

PDMIFLIN(X, Y, Nfactors, Maxit=100, tol=0.001)

# Arguments

X The (NT) times p design matrix, without an intercept where N=number of individuals, T=length of time series, p=number of explanatory variables.

Y The T times N panel of response where N=number of individuals, T=length of time series.

Nfactors A pre-specified number of common factors.

maxite A maximum number of iterations in optimization. Default is 100.

tol Tolerance level of convergence. Default is 0.001

# Details

This function estimates heterogeneous panel data models with interactive effects. This function is similar version of PDMIFLING which accommodates a group structure.

# Value

**Coefficients** The estimated heterogeneous coefficients.

**Lower05** Lower end (5%) of the 90% confidence interval of the regression coefficients.

**Upper95** Upper end (95%) of the 90% confidence interval of the regression coefficients.

**Factors** The estimated common factors across groups.

**Loadings** The estimated factor loadings for the common factors.

**Predict** The conditional expectation of response variable**.**

**pval** p-value for testing hypothesis on heterogeneous coefficients.

**Se** Standard error of the estimated regression coefficients.

# References

Ando, T. and Bai, J. (2015) Asset Pricing with a General Multifactor Structure *Journal of Financial Econometrics*, 13, 556-604.

# Example

N <- 100

P <- 200

R <- 2

p <- 2

LAM <- matrix(rnorm(P\*R,0,1),nrow=P,ncol=R)

FAC <- matrix(rnorm(N\*R,0,1),nrow=N,ncol=R)

AY <- FAC%\*%t(LAM)+matrix(rnorm(N\*P,0,1),nrow=N,ncol=P)

AX <- matrix(0,nrow=N\*P,ncol=p)

for(j in 1:P){

AX[(N\*(j-1)+1):(N\*j),1] <- 0.2+0.3\*AY[,j]+matrix(rnorm(N,0,1),nrow=N)

AX[(N\*(j-1)+1):(N\*j),2] <- 0.5+0.5\*AY[,j]+matrix(rnorm(N,0,1),nrow=N)

}

B <- (1:p)/2-1

AB <- B%\*%t(rep(1,len=P))

for(j in 1:P){

AY[,j] <- AY[,j]+AX[(N\*(j-1)+1):(N\*j),]%\*%AB[,j]

}

fit <- PDMIFLIN(AX,AY,2)

PDMIFLING *Heterogeneous panel data models with interactive effects under known group membership*

# Description

Estimate heterogeneous panel data models with interactive effects under known group membership.

# Usage

PDMIFLING(X, Y, Membership, NGfactors ,NLfactors, Maxit=100, tol=0.001)

# Arguments

X The (NT) times p design matrix, without an intercept where N=number of individuals, T=length of time series, p=number of explanatory variables.

Y The T times N panel of response where N=number of individuals, T=length of time series.

Membership A pre-specified group membership.

NGfactors A pre-specified number of common factors across groups (see example).

NLfactors A pre-specified number of factors in each groups (see example).

Maxit A maximum number of iterations in optimization. Default is 100.

tol Tolerance level of convergence. Default is 0.001

# Details

Under a known group membership, this function estimates heterogeneous panel data models with interactive effects. Together with the regression coefficients, this function estimates the unobserved common factor structures both for across/within groups.

# Value

**Coefficients** The estimated heterogeneous coefficients.

**Lower05** Lower end (5%) of the 90% confidence interval of the regression coefficients.

**Upper95** Upper end (95%) of the 90% confidence interval of the regression coefficients.

**GlobalFactors** The estimated common factors across groups.

**GlobalLoadings** The estimated factor loadings for the common factors.

**GroupFactors** The estimated group-specific factors.

**GroupLoadings** The estimated factor loadings for each group.

**pval** p-value for testing hypothesis on heterogeneous coefficients.

**Se** Standard error of the estimated regression coefficients.

# References

Ando, T. and Bai, J. (2015) Asset Pricing with a General Multifactor Structure *Journal of Financial Econometrics*, 13, 556-604.

# Example

N <- 200

NGroup <- 3

Rs <- rep(2,len=NGroup)

PP <- rep(200,len=NGroup)

P <- sum(PP)

p <- 3

R <- 2

AY <- matrix(0,nrow=N,ncol=P)

LAB <- sort(rep(1:NGroup,len=P))

LAM <- matrix(rnorm(P\*R,0,1),nrow=P,ncol=R)

FAC <- matrix(rnorm(N\*R,0,1),nrow=N,ncol=R)

XG <- FAC%\*%t(LAM)

XL <- matrix(0,ncol=P,nrow=N)

for(i in 1:NGroup){

LAM <- matrix(rnorm(PP[i]\*Rs[i],1,1),nrow=PP[i],ncol=Rs[i])

FAC <- matrix(rnorm(N\*Rs[i],0,1),nrow=N,ncol=Rs[i])

X <- FAC%\*%t(LAM)

XL[,(PP[i]\*(i-1)+1):(PP[i]\*i)] <- X

}

ERR <- matrix(rnorm(N\*P,0,1),nrow=N,ncol=P)

AY <- XG+XL+ERR

AX <- matrix(runif(p\*P\*N,-2,2),nrow=P\*N)

AB <- matrix(rnorm(p\*P,4,2),ncol=P)

for(j in 1:P){AY[,j] <- AY[,j]+AX[(N\*(j-1)+1):(N\*j),]%\*%AB[,j]}

PDMIFLING(AX,AY,LAB,R,Rs)

PDMIFLOGIT *Heterogeneous logistic panel data models with interactive effects*

# Description

Estimate heterogeneous logistic panel data models with interactive effects.

# Usage

PDMIFLOGIT(X, Y, Nfactors, Maxit=100, tol=0.001)

# Arguments

X The (NT) times p design matrix, without an intercept where N=number of individuals, T=length of time series, p=number of explanatory variables.

Y The T times N panel of response where N=number of individuals, T=length of time series.

Nfactors A pre-specified number of common factors.

Maxit A maximum number of iterations in optimization. Default is 100.

tol Tolerance level of convergence. Default is 0.001

# Details

This function estimates heterogeneous loigistic panel data models with interactive effects.

# Value

**Coefficients** The estimated heterogeneous coefficients.

**Lower05** Lower end (5%) of the 90% confidence interval of the regression coefficients.

**Upper95** Upper end (95%) of the 90% confidence interval of the regression coefficients.

**Factors** The estimated common factors across groups.

**Loadings** The estimated factor loadings for the common factors.

**Predict** Conditional expectation of response variable**.**

**pval** p-value for testing hypothesis on heterogeneous coefficients.

**Se** Standard error of the estimated regression coefficients.

# References

Ando, T., Bai, J. and Li, K. (2021) Bayesian and maximum likelihood analysis of large-scale panel choice models with unobserved heterogeneity, *Journal of Econometrics*.

# Example

N <- 400

P <- 300

R <- 3

p <- 3

LAM <- matrix(rnorm(P\*R,0,1),nrow=P,ncol=R)

FAC <- matrix(rnorm(N\*R,0,1),nrow=N,ncol=R)

AY <- FAC%\*%t(LAM)

AX <- matrix(rnorm(p\*P\*N,0,1),nrow=P\*N)

for(j in 1:P){

AX[(N\*(j-1)+1):(N\*j),1] <- AX[(N\*(j-1)+1):(N\*j),1]+0.15\*AY[,j]

AX[(N\*(j-1)+1):(N\*j),3] <- AX[(N\*(j-1)+1):(N\*j),3]-0.21\*AY[,j]

}

B <- c(-1,2,-1)

AB <- B%\*%t(rep(1,len=P))+matrix(0.1\*runif(p\*P,-1,1),p,P)

for(j in 1:P){

AY[,j] <- AY[,j]+(AX[(N\*(j-1)+1):(N\*j),])%\*%AB[,j]

}

PROB <- exp(AY)/(1+exp(AY))

AY <- trunc(matrix(runif(N\*P,0,1),ncol=P)+PROB)

fit <- PDMIFLOGIT(AX,AY,R)

PDMIFPROBIT *Heterogeneous probit panel data models with interactive effects*

# Description

Estimate heterogeneous probit panel data models with interactive effects.

# Usage

PDMIFPROBIT(X, Y, Nfactors, Maxit=100, tol=0.001)

# Arguments

X The (NT) times p design matrix, without an intercept where N=number of individuals, T=length of time series, p=number of explanatory variables.

Y The T times N panel of response where N=number of individuals, T=length of time series.

Nfactors A pre-specified number of common factors.

Maxit A maximum number of iterations in optimization. Default is 100.

tol Tolerance level of convergence. Default is 0.001

# Details

This function estimates heterogeneous probit panel data models with interactive effects.

# Value

**Coefficients** The estimated heterogeneous coefficients.

**Lower05** Lower end (5%) of the 90% confidence interval of the regression coefficients.

**Upper95** Upper end (95%) of the 90% confidence interval of the regression coefficients.

**Factors** The estimated common factors across groups.

**Loadings** The estimated factor loadings for the common factors.

**Predict** Conditional expectation of response variable**.**

**pval** p-value for testing hypothesis on heterogeneous coefficients.

**Se** Standard error of the estimated regression coefficients.

# References

Ando, T., Bai, J. and Li, K. (2021) Bayesian and maximum likelihood analysis of large-scale panel choice models with unobserved heterogeneity, *Journal of Econometrics*.

# Example

N <- 1000

P <- 500

R <- 2

p <- 3

LAM <- matrix(rnorm(P\*R,0,1),nrow=P,ncol=R)

FAC <- matrix(rnorm(N\*R,0,1),nrow=N,ncol=R)

AY <- FAC%\*%t(LAM)

AX <- matrix(rnorm(p\*P\*N,0,1),nrow=P\*N)

for(j in 1:P){

AX[(N\*(j-1)+1):(N\*j),1] <- AX[(N\*(j-1)+1):(N\*j),1]+0.05\*AY[,j]

AX[(N\*(j-1)+1):(N\*j),3] <- AX[(N\*(j-1)+1):(N\*j),3]-0.01\*AY[,j]

}

B <- c(1,2,-2)

AB <- B%\*%t(rep(1,len=P))+matrix(0.2\*runif(p\*P,-1,1),p,P)

for(j in 1:P){

AY[,j] <- AY[,j]+(AX[(N\*(j-1)+1):(N\*j),])%\*%AB[,j]

}

PROB <- exp(AY)/(1+exp(AY))

AY <- trunc(matrix(runif(N\*P,0,1),ncol=P)+PROB)

fit <- PDMIFPROBIT(AX,AY,R)

PDMIFQUANTILE *Heterogeneous quantile panel data models with interactive effects*

# Description

Estimate heterogeneous quantile panel data models with interactive effects.

# Usage

PDMIFQUANTILE(X, Y, TAU, Nfactors, Maxit=100, tol=0.001)

# Arguments

X The (NT) times p design matrix, without an intercept where N=number of individuals, T=length of time series, p=number of explanatory variables.

Y The T times N panel of response where N=number of individuals, T=length of time series.

TAU A pre-specified quantile point.

Nfactors A pre-specified number of common factors.

Maxit A maximum number of iterations in optimization. Default is 100.

tol Tolerance level of convergence. Default is 0.001

# Details

This function estimates heterogeneous quantile panel data models with interactive effects.

# Value

**Coefficients** The estimated heterogeneous coefficients.

**Lower05** Lower end (5%) of the 90% confidence interval of the regression coefficients.

**Upper95** Upper end (95%) of the 90% confidence interval of the regression coefficients.

**Factors** The estimated common factors across groups.

**Loadings** The estimated factor loadings for the common factors.

**Predict** Estimated quantile point under a given tau.

**pval** p-value for testing hypothesis on heterogeneous coefficients.

**Se** Standard error of the estimated regression coefficients.

# References

Ando, T. and Bai, J. (2020) Quantile co-movement in financial markets *Journal of the American Statistical Association*.

# Example

N <- 300

P <- 300

R <- 5

p <- 8

TAU <- 0.95

U <- matrix(runif(N\*P,0,1),nrow=N,ncol=P)

LAM <- matrix(runif(P\*R,-1,1),nrow=P,ncol=R)

FAC <- matrix(runif(N\*R,0,2),nrow=N,ncol=R)

FL <- matrix(0,nrow=N,ncol=P)

for(i in 1:N){

for(j in 1:P){

B <- LAM[j,]+0.1\*U[i,j]

if(U[i,j]<=0.2){FL[i,j] <- FAC[i,1:3]%\*%B[1:3]}

if(0.2<=U[i,j] && U[i,j]<=0.8){FL[i,j] <- FAC[i,1:4]%\*%B[1:4]}

if(0.8<=U[i,j]){FL[i,j] <- FAC[i,1:5]%\*%B[1:5]}

}

}

AX <- matrix(runif(p\*P\*N,0,2),nrow=P\*N)

for(j in 1:P){

AX[(N\*(j-1)+1):(N\*j),1] <- AX[(N\*(j-1)+1):(N\*j),1]+0.01\*FL[,j]

AX[(N\*(j-1)+1):(N\*j),3] <- AX[(N\*(j-1)+1):(N\*j),3]-0.01\*FL[,j]

AX[(N\*(j-1)+1):(N\*j),5] <- AX[(N\*(j-1)+1):(N\*j),5]+0.02\*FL[,j]

AX[(N\*(j-1)+1):(N\*j),6] <- AX[(N\*(j-1)+1):(N\*j),6]-0.02\*FL[,j]

}

XB <- matrix(0,nrow=N,ncol=P)

for(i in 1:N){

for(j in 1:P){

X <- AX[(N\*(j-1)+1):(N\*j),]

B <- c(-1,1,1,-1,rep(1,len=p-4))+0.1\*j/N+0.1\*U[i,j]

if(U[i,j]<=0.2){XB[i,j] <- X[i,1:p]%\*%B[1:p]}

if(0.2<=U[i,j] && U[i,j]<=0.8){XB[i,j] <- X[i,1:p]%\*%B[1:p]}

if(0.8<=U[i,j]){XB[i,j] <- X[i,1:p]%\*%B[1:p]}

}

}

AY <- XB+FL+qnorm(U,0,1)

fit <- PDMIFQUANTILE(AX,AY,TAU,R)