Package ‘mvecr’

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Type Package

Title Multivariate Error Components Regression

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Description An implementation of multivariate error components regression in R. It converts individual level data to 'stacked form' panel data, which facilitates the multivariate error components regression.
The dependent variable as well as the independent variables are assumed to be multivariate. The error structure is assumed to consist of multiple (usually two or three) independent multivariate error components. This structure enables breaking down the variance matrices into matrices of much smaller dimensions.

References Ikefuji, M., Laeven, R. J., Magnus, J. R., & Yue, Y. (2020). Earthquake risk embedded in property prices: Evidence from five Japanese cities.

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Depends R (>= 3.6)

Imports dplyr (>= 1.0.0)

Encoding UTF-8

LazyData true

RoxygenNote 7.1.0

R topics documented:

`ec_reg` *Maximum likelihood estimation of the multivariate error components model*

Description

This function implements the maximum likelihood estimation procedure for the regression model with multivariate error components.

Usage

```
ec_reg(
  data.X,
  data.y,
  data.H,
  colName.i,
  colName.t,
  colName.p,
  district,
  time,
  type,
  var,
  par.include = rep(1, 18),
  par.init = rep(0.5, 18)
)
```

Arguments

`data.X`	A matrix containing independent variables.
`data.y`	A vector of dependent variables.
`data.H`	A vector of the number of observations in each t-i-p combination.
`colName.i`	Name of the column in data.X that contains "district" information.
`colName.t`	Name of the column in data.X that contains "time" information.
`colName.p`	Name of the column in data.X that contains "type" information.
`district`	A vector of the unique names of districts.
`time`	A vector of the unique time periods in the data.
`type`	A vector of the unique names of types in the data.
`var`	A vector of the names of the columns in data.X to be included as regressors in the regression.
`par.include`	A vector of logical values indicating whether or not to include a certain error parameter in the regression. If FALSE, the parameter is constrained to be 0. The error parameters are the non-zero elements of the Cholesky decomposition of the variance-covariance matrices of each error component. The dimension of each error matrix will be $p \times p$, corresponding to $p * (p + 1)/2$ parameters. Default value of par.include is $rep(1, 18)$ for a three error component model with $p = 3$, where p is the number of distinct types (the length of vector in each t-i combination). The first $p * (p + 1)/2$ parameters correspond to the error

matrix Σ_ζ (district specific error component), the second $p*(p+1)/2$ parameters correspond to the error matrix Σ_η (time specific error component), and the last $p*(p+1)/2$ parameters correspond to the error matrix Σ_ϵ (individual specific error component).

`par.init` A vector of initial values of the parameters. Default value is 0.5 for each parameter. The number of parameters is $3*p*(p+1)/2$, where p is the number of types and 3 is the number of error components in the full model. Note that the parameters corresponding to the elements of "par.include" being FALSE are constrained to be 0, so even if initial parameters are specified for these parameters, they will not be used.

Value

results, a dataframe containing parameter estimates and t statistics.

References

Ikefuji, M., Laeven, R. J., Magnus, J. R., & Yue, Y. (2020). Earthquake risk embedded in property prices: Evidence from five Japanese cities.

Examples

```
## Not run:
vars_include <- c("constant_LandBldg", "constant_LandOnly", "constant_Condo",
"distance.num", "area.m2.num", "total.floor.area.m2.num", "building.age",
"LandBldg_RC", "LandBldg_S", "LandBldg_W", "built.1981_2000", "built.after2000",
"Urban_Control", "max.building.coverage.ratio", "max.floor.area.ratio",
"City_Fukuoka", "City_Nagoya", "City_Osaka", "City_Sapporo", "log.nGDP", "log.CPI",
"PctImmi", "Ncrime", "PctUnemploy", "PctExec", "JSHIS_I45_55", "JSHIS_I55")
data_vec <- vectorize(data = individual_data_sample,
colName.i = "Area.Ward.City",
colName.t = "t", colName.p = "Type",
colName.y = "log.price",
colName.X = vars_include)
results <- ec_reg(data.X = data_vec$X, data.y = data_vec$y, data.H = data_vec$H,
colName.i = "Area.Ward.City", colName.t = "t",  colName.p = "Type",
district = data_vec$district, time = data_vec$time, type = data_vec$type,
var = vars_include,
par.include = c(rep(1, 6), rep(0,6), rep(1,6)))

## End(Not run)
```

`gradient` *Gradient of the loglikelihood function of the multivariate error component model*

Description

This function is the gradient function of the multivariate error component model.

Usage

```
gradient(par, include, N, Tn, HX, Hy, p)
```

Arguments

`par` A vector of parameters corresponding to the Cholesky decomposition of the error matrices, that is, $\Sigma = LL'$ where L is a lower triangular matrix with positive diagonal elements). This vector is of length $3 * p * (p+1)/2$, where 3 comes from the three error components. However, note that only the parameters corresponding to include=TRUE are included in the models while others are constrained to be 0. The first $p * (p+1)/2$ parameters correspond to the error matrix Σ_ζ (district specific error component), the second $p*(p+1)/2$ parameters correspond to the error matrix Σ_η (time specific error component), and the last $p * (p+1)/2$ parameters correspond to the error matrix Σ_ϵ (individual specific error component).

`include` A vector of logical values with the same dimension as par, indicating whether the parameter should be included as one of the values to optimize on. If a certain element corresponds to include=FALSE, that parameter is constrained to be 0. Hence, for a "full" three error component model, set include=rep(1, $3 * p * (p+1)/2$); for a two error component model with only district specific and individual specific errors, set include=c(rep(1, $p * (p+1)/2$), rep(0, $p * (p+1)/2$), rep(1, $p * (p+1)/2$)).

`N` A numeric scalar, number of districts.

`Tn` A numeric scalar, number of time periods.

`HX` A numeric matrix of independent variables, with dimension $N * Tn * p \times k_1$ where k_1 is the number of regressors.

`Hy` A numeric vector of dependent variables, with dimension $N * Tn * p \times 1$.

`p` A numeric scalar, number of types.

Value

A vector of the gradient of the multivariate error component model.

References

Ikefuji, M., Laeven, R. J., Magnus, J. R., & Yue, Y. (2020). Earthquake risk embedded in property prices: Evidence from five Japanese cities.

`individual_data_sample` *A sample of housing transaction data with macroeconomic variables, demographic characterics and earthquake risk probabilities*

Description

A dataset containing the prices and other attributes of housing transaction records.

Usage

```
individual_data_sample
```

Format

A data frame of 92478 rows and 32 variables:

log.price natural logarithm of housing transaction price, in Japanese Yen

Area.Ward.City name of the district (area), ward, and city that the property is located in

t transaction time, in quarters, e.g. "2020 Q3"

Type type of the property, which can be of value "Residential Land(Land Only)", "Residential Land(Land and Building)", or "Pre-owned Condominiums, etc."

constant_LandBldg a dummy variable indicating whether the property type is "Residential Land(Land and Building)"

constant_LandOnly a dummy variable indicating whether the property type is "Residential Land(Land Only)"

constant_Condo a dummy variable indicating whether the property type is "Pre-owned Condominiums, etc."

distance.num distance to the nearest station, in terms of minutes in walking

area.m2.num area of the property, in square meters

total.floor.area.m2.num total floor area of the property, in square meters

building.age age of the building

LandBldg_RC dummy variable indicating whether the property is of type "Residential Land(Land and Building)" and building structure is primarily Reinforced Concrete

LandBldg_S dummy variable indicating whether the property is of type "Residential Land(Land and Building)" and building structure is primarily Steel

LandBldg_W dummy variable indicating whether the property is of type "Residential Land(Land and Building)" and building structure is primarily Wood

built.1981_2000 dummy variable indicating whether the property is built between 1981 and 2000

built.after2000 dummy variable indicating whether the property is built after 2000

Urban_Control dummy variable indicating whether the property is in an "Urban Control" area

max.building.coverage.ratio maximum allowed building coverage ratio (BCR)

max.floor.area.ratio maximum allowed floor area ratio (FAR)

City_Fukuoka dummy variable indicating whether the property is located in the city of Fukuoka

City_Nagoya dummy variable indicating whether the property is located in the city of Nagoya

City_Osaka dummy variable indicating whether the property is located in the city of Osaka

City_Sapporo dummy variable indicating whether the property is located in the city of Sapporo

log.nGDP natural logarithm of nominal GDP of the year of transaction

log.CPI natural logarithm of the CPI of the year of transaction

PctImmi average percentage of immigrants in the ward where the property is located in

Ncrime average number of crimes in the ward where the property is located in

PctUnemploy average percentage of unemployed in the ward where the property is located in

PctExec average percentage of executives in the ward where the property is located in

JSHIS_I45_55 long run earthquake probabilities that an earthquake of intensity between "5 lower" and "6 lower" occurs within the next 30 years

JSHIS_I55 long run earthquake probabilities that an earthquake of intensity above "6 lower" occurs within the next 30 years

Xpsi_obj short run "objective" earthquake probabilities

Source

See references.

References

Ikefuji, M., Laeven, R. J., Magnus, J. R., & Yue, Y. (2020). Earthquake risk embedded in property prices: Evidence from five Japanese cities - Data documentation.

`negloglik` *Negative loglikelihood function*

Description

This function is the negative loglikelihood function of the multivariate error component model.

Usage

```
negloglik(par, include, N, Tn, HX, Hy, p)
```

Arguments

`par`	A vector of parameters corresponding to the Cholesky decomposition of the error matrices, that is, $\Sigma = LL'$ where L is a lower triangular matrix with positive diagonal elements). This vector is of length $3 * p * (p + 1)/2$, where 3 comes from the three error components. However, note that only the parameters corresponding to include=TRUE are included in the models while others are constrained to be 0. The first $p * (p + 1)/2$ parameters correspond to the error matrix Σ_ζ (district specific error component), the second $p*(p+1)/2$ parameters correspond to the error matrix Σ_η (time specific error component), and the last $p * (p + 1)/2$ parameters correspond to the error matrix Σ_ϵ (individual specific error component).
`include`	A vector of logical values with the same dimension as par, indicating whether the parameter should be included as one of the values to optimize on. If a certain element corresponds to include=FALSE, that parameter is constrained to be 0. Hence, for a "full" three error component model, set include=rep(1, $3 * p * (p + 1)/2$); for a two error component model with only district specific and individual specific errors, set include=c(rep(1, $p * (p + 1)/2$), rep(0, $p * (p + 1)/2$), rep(1, $p * (p + 1)/2$)).
`N`	A numeric scalar, number of districts.
`Tn`	A numeric scalar, number of time periods.
`HX`	A numeric matrix of independent variables, with dimension $N * Tn * p \times k_1$ where k_1 is the number of regressors.
`Hy`	A numeric vector of dependent variables, with dimension $N * Tn * p \times 1$.
`p`	A numeric scalar, number of types.

Value

A numeric scalar of the negative loglikelihood of the multivariate error component model.

References

Ikefuji, M., Laeven, R. J., Magnus, J. R., & Yue, Y. (2020). Earthquake risk embedded in property prices: Evidence from five Japanese cities.

---

opt_psi *Optimization of the psi parameter used in the transformation of regressor in the multivariate error components model*

Description

Given a list of psi parameter values, this function finds the psi that maximizes loglikelihood by implementing a grid search.

Usage

```
opt_psi(
  data.X,
  data.y,
  data.H,
  colName.i,
  colName.t,
  colName.p,
  colName.Xpsi,
  list.psi = 1,
  transform.func,
  transform.gradient,
  district,
  time,
  type,
  var,
  par.include = rep(1, 18),
  par.init = rep(0.5, 18)
)
```

Arguments

`data.X`	Matrix of independent variables.
`data.y`	Vector of dependent variables.
`data.H`	Vector of number of observations in each i-t-p combination.
`colName.i`	Column name in data that contains district information.
`colName.t`	Column name in data that contains time information.
`colName.p`	Column name in data that contains type information.
`colName.Xpsi`	Name of the column x to be transformed by transform.func.
`list.psi`	A numeric vector of the psi parameter.
`transform.func`	A function of form $f(x, \psi)$ which is used to transform the vector $data.X[, colName.Xpsi]$.
`transform.gradient`	A function of form $g(x, \psi)$. This is the gradient of transform.func w.r.t. ψ and evaluated at p.

`district` Unique name of districts.

`time` Unique time periods in the data.

`type` Unique names of the type in the data.

`var` Vector of names of the columns in data.X to include in the regression.

`par.include` A vector of logical values indicating whether or not to include a certain error parameter in the regression. If FALSE, the parameter is constrained to be 0. The error parameters are the non-zero elements of the Cholesky decomposition of the variance-covariance matrices of each error component. The dimension of each error matrix will be $p \times p$, corresponding to $p * (p + 1)/2$ parameters. Default value of par.include is $rep(1, 18)$ for a three error component model with $p = 3$, where p is the number of distinct types (the length of vector in each t-i combination). The first $p * (p + 1)/2$ parameters correspond to the error matrix Σ_ζ (district specific error component), the second $p*(p+1)/2$ parameters correspond to the error matrix Σ_η (time specific error component), and the last $p * (p + 1)/2$ parameters correspond to the error matrix Σ_ϵ (individual specific error component).

`par.init` A vector of initial values of the parameters. Default value is 0.5 for each parameter. The number of parameters is $3 * p * (p + 1)/2$, where p is the number of types and 3 is the number of error components in the full model. Note that the parameters corresponding to the elements of "par.include" being FALSE are constrained to be 0, so even if initial parameters are specified for these parameters, they will not be used.

Value

Numeric value of the psi parameter that maximizes loglikelihood.

References

Ikefuji, M., Laeven, R. J., Magnus, J. R., & Yue, Y. (2020). Earthquake risk embedded in property prices: Evidence from five Japanese cities.

Examples

```
## Not run:
vars_include <- c("constant_LandBldg", "constant_LandOnly", "constant_Condo",
"distance.num", "area.m2.num", "total.floor.area.m2.num", "building.age",
"LandBldg_RC", "LandBldg_S", "LandBldg_W", "built.1981_2000", "built.after2000",
"Urban_Control", "max.building.coverage.ratio", "max.floor.area.ratio",
"City_Fukuoka", "City_Nagoya", "City_Osaka", "City_Sapporo", "log.nGDP", "log.CPI",
"PctImmi", "Ncrime", "PctUnemploy", "PctExec", "JSHIS_I45_55", "JSHIS_I55", "Xpsi_obj")
data_vec <- vectorize(data = individual_data_sample, colName.i = "Area.Ward.City",
colName.t = "t", colName.p = "Type",
colName.y = "log.price",
colName.X = vars_include)
list_results <- opt_psi(data.X = data_vec$X, data.y = data_vec$y, data.H = data_vec$H,
colName.i = "Area.Ward.City", colName.t = "t", colName.p = "Type", colName.Xpsi = "Xpsi_obj",
list.psi = c(3, 3.5, 4), transform.func = prelec, transform.gradient = Z_prelec,
district = data_vec$district, time = data_vec$time, type = data_vec$type,
var = gsub("Xpsi_obj", "Xpsi", vars_include),
par.include = c(rep(1, 6), rep(0,6), rep(1,6)))

## End(Not run)
```

prelec *"Prelec" probability weighting function*

Description

A function that converts probability into weighted probability using the functional form introduced in Prelec (1998).

Usage

```
prelec(p, psi, psi2 = 1)
```

Arguments

p	Original probability, numeric value between 0 and 1.
psi	Parameter of the function (single parameter form).
psi2	Optional, second parameter of the function (two parameter form). Default value is 1 in which case the function degenerates into a single parameter form.

Value

Weighted probability, numeric value between 0 and 1.

References

Prelec, D. (1998). The probability weighting function. Econometrica, 497-527.

Examples

```
prelec(0.2, 0.5)
prelec(0.2, 5)
```

reg_gamma_psi *Maximum likelihood estimation of the multivariate error components model, when two or more of the regressors are transformed by two single-parameter functions with parameters gamma and psi*

Description

When two or more of the regressors depend on parameters (ψ and γ), adjust the corresponding variance of the regression coefficients and calculate the t statistic of ψ and γ.

Usage

```
reg_gamma_psi(
  data.X,
  data.y,
  data.H,
  colName.i,
  colName.t,
  colName.p,
  gamma = 1,
  psi = 1,
  method_1 = "p",
  method_2 = "p",
  district,
  time,
  type,
  var,
  par.include = rep(1, 18),
  par.init = rep(0.5, 18)
)
```

Arguments

`data.X`	Matrix of independent variables.
`data.y`	Vector of dependent variables.
`data.H`	Vector of number of observations in each i-t-p combination.
`colName.i`	Column name in data that contains district information.
`colName.t`	Column name in data that contains time information.
`colName.p`	Column name in data that contains type information.
`gamma`	A numeric scalar of the γ parameter.
`psi`	A numeric scalar of the ψ parameter.
`method_1`	The transformation method of the long run probabilities with parameter γ. A method of "p" means the Prelec transformation function and a method of "t" means the Tversky and Kahneman function.
`method_2`	The transformation method of the long run probabilities with parameter ψ. A method of "p" means the Prelec transformation function and a method of "t" means the Tversky and Kahneman function.
`district`	Unique name of districts.
`time`	Unique time periods in the data.
`type`	Unique names of the type in the data.
`var`	Vector of names of the columns in data.X to include in the regression.
`par.include`	A vector of logical values indicating whether or not to include a certain error parameter in the regression. If FALSE, the parameter is constrained to be 0. The error parameters are the non-zero elements of the Cholesky decomposition of the variance-covariance matrices of each error component. The dimension of each error matrix will be $p \times p$, corresponding to $p * (p + 1)/2$ parameters. Default value of par.include is $rep(1, 18)$ for a three error component model with $p = 3$, where p is the number of distinct types (the length of vector in each t-i combination). The first $p * (p + 1)/2$ parameters correspond to the error

matrix Σ_ζ (district specific error component), the second $p*(p+1)/2$ parameters correspond to the error matrix Σ_η (time specific error component), and the last $p*(p+1)/2$ parameters correspond to the error matrix Σ_ϵ (individual specific error component).

`par.init` A vector of initial values of the parameters. Default value is 0.5 for each parameter. The number of parameters is $3*p*(p+1)/2$, where p is the number of types and 3 is the number of error components in the full model. Note that the parameters corresponding to the elements of "par.include" being FALSE are constrained to be 0, so even if initial parameters are specified for these parameters, they will not be used.

Value

A data frame containing parameter estimates, t statistics, loglikelihood value, value of gamma, psi, and the t-statistic w.r.t. gamma and psi.

References

Ikefuji, M., Laeven, R. J., Magnus, J. R., & Yue, Y. (2020). Earthquake risk embedded in property prices: Evidence from five Japanese cities.

`reg_psi` *Maximum likelihood estimation of the multivariate error components model, when one of the regressors is transformed by a single parameter function*

Description

When one of the regressors depends on a parameter (ψ), adjust the corresponding variance of the regression coefficients and calculate the t statistic of ψ. Here we assume $f(x, \psi)$ is a differentiable function of x with parameter ψ. The transformation function and its gradient should be provided as input parameters.

Usage

```
reg_psi(
  data.X,
  data.y,
  data.H,
  colName.i,
  colName.t,
  colName.p,
  colName.Xpsi,
  psi = 1,
  transform.func,
  transform.gradient,
  district,
  time,
  type,
  var,
  par.include = rep(1, 18),
  par.init = rep(0.5, 18)
)
```

Arguments

`data.X`	Matrix of independent variables.
`data.y`	Vector of dependent variables.
`data.H`	Vector of number of observations in each t-i-p combination.
`colName.i`	Column name in data that contains "district" information.
`colName.t`	Column name in data that contains "time" information.
`colName.p`	Column name in data that contains "type" information.
`colName.Xpsi`	Name of the column x to be transformed by transform.func.
`psi`	A numeric scalar of the ψ parameter.
`transform.func`	A function of form $f(x, \psi)$ which is used to transform the vector $data.X[, colName.Xpsi]$.
`transform.gradient`	A function of form $g(x, \psi)$. This is the gradient of transform.func w.r.t. ψ and evaluated at p.
`district`	Unique name of districts.
`time`	Unique time periods in the data.
`type`	Unique names of the type in the data.
`var`	Vector of names of the columns in data.X to include in the regression.
`par.include`	A vector of logical values indicating whether or not to include a certain error parameter in the regression. If FALSE, the parameter is constrained to be 0. The error parameters are the non-zero elements of the Cholesky decomposition of the variance-covariance matrices of each error component. The dimension of each error matrix will be $p \times p$, corresponding to $p * (p + 1)/2$ parameters. Default value of par.include is $rep(1, 18)$ for a three error component model with $p = 3$, where p is the number of distinct types (the length of vector in each t-i combination). The first $p * (p+1)/2$ parameters correspond to the error matrix Σ_ζ (district specific error component), the second $p*(p+1)/2$ parameters correspond to the error matrix Σ_η (time specific error component), and the last $p * (p + 1)/2$ parameters correspond to the error matrix Σ_ϵ (individual specific error component).
`par.init`	A vector of initial values of the parameters. Default value is 0.5 for each parameter. The number of parameters is $3 * p * (p + 1)/2$, where p is the number of types and 3 is the number of error components in the full model. Note that the parameters corresponding to the elements of "par.include" being FALSE are constrained to be 0, so even if initial parameters are specified for these parameters, they will not be used.

Value

A data frame containing parameter estimates, t statistics, loglikelihood value, value of psi (given as input), and the t-statistic w.r.t. psi.

References

Ikefuji, M., Laeven, R. J., Magnus, J. R., & Yue, Y. (2020). Earthquake risk embedded in property prices: Evidence from five Japanese cities.

Examples

```
## Not run:
vars_include <- c("constant_LandBldg", "constant_LandOnly", "constant_Condo",
"distance.num", "area.m2.num", "total.floor.area.m2.num", "building.age",
"LandBldg_RC", "LandBldg_S", "LandBldg_W", "built.1981_2000", "built.after2000",
"Urban_Control", "max.building.coverage.ratio", "max.floor.area.ratio",
"City_Fukuoka", "City_Nagoya", "City_Osaka", "City_Sapporo", "log.nGDP", "log.CPI",
"PctImmi", "Ncrime", "PctUnemploy", "PctExec", "JSHIS_I45_55", "JSHIS_I55", "Xpsi_obj")
data_vec <- vectorize(data = individual_data_sample, colName.i = "Area.Ward.City",
colName.t = "t", colName.p = "Type",
colName.y = "log.price",
colName.X = vars_include)
results <- reg_psi(data.X = data_vec$X, data.y = data_vec$y, data.H = data_vec$H,
colName.i = "Area.Ward.City", colName.t = "t", colName.p = "Type", colName.Xpsi = "Xpsi_obj",
psi = 1, transform.func = prelec, transform.gradient = Z_prelec,
district = data_vec$district, time = data_vec$time, type = data_vec$type,
var = gsub("Xpsi_obj", "Xpsi", vars_include),
par.include = c(rep(1, 6), rep(0,6), rep(1,6)))

## End(Not run)
```

`tversky` *"Tversky and Kahneman" probability weighting function*

Description

A function that converts probability into weighted probability using the functional form introduced in Tversky and Kahneman (1992).

Usage

```
tversky(p, psi = 1)
```

Arguments

p	Original probability, numeric value between 0 and 1.
psi	Parameter of the function (single parameter form). Default value is 1 in which case the function degenerates into identity function $w(p) = p$.

Value

Weighted probability, numeric value between 0 and 1.

References

Tversky, A., & Kahneman, D. (1992). Advances in prospect theory: Cumulative representation of uncertainty. Journal of Risk and Uncertainty, 5(4), 297-323.

Examples

```
tversky(0.2, 0.5)
tversky(0.2, 5)
```

`vectorize` *Function for the transformation of individual records into stacked form*

Description

This function reads the data frames containing y, X, and information for i(district), t(time period) and p(type), takes the average over each t-i-p combination, and stacks the averages into a vectorized form.

Usage

```
vectorize(data, colName.i, colName.t, colName.p, colName.y, colName.X)
```

Arguments

`data`	Input data frame. All data should be numericals except for the columns containing i, t and p.
`colName.i`	Column name in data that contains "district" information.
`colName.t`	Column name in data that contains "time" information.
`colName.p`	Column name in data that contains "type" information.
`colName.y`	Column name in data that contains the dependent variable.
`colName.X`	Column name in data that contains the independent variables.

Value

A list containing: "district": unique names of districts, "time": unique time periods, "type": unique type names, "H": number of observations for each t-i-p combination, "y": average of the dependent variable for each t-i-p combination, "X": average of the independent variables for each t-i-p combination.

References

Ikefuji, M., Laeven, R. J., Magnus, J. R., & Yue, Y. (2020). Earthquake risk embedded in property prices: Evidence from five Japanese cities.

Examples

```
## Not run:
vars_include <- c("constant_LandBldg", "constant_LandOnly", "constant_Condo",
"distance.num", "area.m2.num", "total.floor.area.m2.num", "building.age",
"LandBldg_RC", "LandBldg_S", "LandBldg_W", "built.1981_2000", "built.after2000",
"Urban_Control", "max.building.coverage.ratio", "max.floor.area.ratio",
"City_Fukuoka", "City_Nagoya", "City_Osaka", "City_Sapporo", "log.nGDP", "log.CPI",
"PctImmi", "Ncrime", "PctUnemploy", "PctExec", "JSHIS_I45_55", "JSHIS_I55", "Xpsi_obj")
data_vec <- vectorize(data = data_sample, colName.i = "Area.Ward.City",
colName.t = "t", colName.p = "Type",
colName.y = "log.price",
colName.X = vars_include)

## End(Not run)
```

`X_invOmega_Y` *Function to calculate matrix multiplications in the form of $X'\Omega\hat{}-1Y$*

Description

This function is an internal function needed by $negloglik$ and $gradient$. It calculates matrix multiplications in the form of $X'\Omega^{-1}Y$, where Ω is the error matrix $Var(u)$ of the multivariate three error components model.

Usage

```
X_invOmega_Y(X, Y, N, Tn, p, O1inv, O2inv, O3inv, O4inv)
```

Arguments

`X`	Matrix or vector of dimension $N * Tn * p \times k_1$.
`Y`	Matrix or vector of dimension $N * Tn * p \times k_2$.
`N`	A numeric scalar, number of districts.
`Tn`	A numeric scalar, number of time periods.
`p`	A numeric scalar, number of types.
`O1inv`	A matrix of dimension $p \times p$, inverse of the Δ_1 matrix, where $\Delta_1 = \Sigma_\epsilon + Tn * \Sigma_\zeta + N * \Sigma_\eta$.
`O2inv`	A matrix of dimension $p \times p$, inverse of the Δ_2 matrix, where $\Delta_2 = \Sigma_\epsilon + Tn * \Sigma_\zeta$.
`O3inv`	A matrix of dimension $p \times p$, inverse of the Δ_3 matrix, where $\Delta_3 = \Sigma_\epsilon + N * \Sigma_\eta$.
`O4inv`	A matrix of dimension $p \times p$, inverse of the Δ_4 matrix, where $\Delta_4 = \Sigma_\epsilon$.

Value

$X'\Omega^{-1}Y$, a matrix or vector of dimension $k_1 \times k_2$.

References

Ikefuji, M., Laeven, R. J., Magnus, J. R., & Yue, Y. (2020). Earthquake risk embedded in property prices: Evidence from five Japanese cities.

`Z_prelec` *Derivative of the "Prelec" probability weighting function*

Description

A function that calculates the first derivative of the probability weighting function w.r.t. its parameter.

Usage

```
Z_prelec(p, psi, log = FALSE)
```

Arguments

p	Original probability, numeric value between 0 and 1.
psi	Parameter of the function (single parameter form).
log	Logical value indicating whether the weighted probability is taken natural logarithm. Default value is FALSE.

Value

Derivative of the "Prelec" function w.r.t. psi evaluated at p, a numeric value.

Examples

```
Z_prelec(0.5,3)
Z_prelec(0.5, 0.5, log = TRUE)
```

Z_tversky *Derivative of the "Tversky and Kahneman" probability weighting function*

Description

A function that calculates the first derivative of the probability weighting function w.r.t. its parameter.

Usage

```
Z_tversky(p, psi, log = FALSE)
```

Arguments

p	Original probability, numeric value between 0 and 1.
psi	Parameter of the function (single parameter form).
log	Logical value indicating whether the weighted probability is taken natural logarithm. Default value is FALSE.

Value

Derivative of the "Tversky and Kahneman" function w.r.t. psi evaluated at p, a numeric value.

Examples

```
Z_tversky(0.5,3)
Z_tversky(0.5, 0.5, log = TRUE)
```

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