Package ‘EWS’

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Type Package

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Description
The purpose of Early Warning Systems (EWS) is to detect accurately the occurrence of a crisis, which is represented by a binary variable which takes the value of one when the event occurs, and the value of zero otherwise. EWS are a toolbox for policymakers to prevent or attenuate the impact of economic downturns. Modern EWS are based on the econometric framework of Kauppi and Saikkonen (2008) <doi:10.1162/rest.90.4.777>. Specifically, this framework includes four dichotomous models, relying on a logit approach to model the relationship between yield spreads and future recessions, controlling for recession risk factors. These models can be estimated in a univariate or a balanced panel framework as in Candelon, Dumitrescu and Hurlin (2014) <doi:10.1016/j.ijforecast.2014.03.015>. This package provides both methods for estimating these models and a dataset covering 13 OECD countries over a period of 45 years. In addition, this package also provides methods for the analysis of the propagation mechanisms of an exogenous shock, as well as robust confidence intervals for these response functions using a block-bootstrap method as in Lajaunie (2021). This package constitutes a useful toolbox (data and functions) for scholars as well as policymakers.

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`BlockBootstrapp` *Block Bootstrapp*

Description

This function enables the estimation of the block size for resampling. The size of the blocks is computed as in Hall, Horowitz and Jing (1995). Then, the function returns in a matrix the new resampled input variables. These variables are then used to determine the confidence intervals of the response functions proposed by Lajaunie (2021).

Usage

```
BlockBootstrapp(Dicho_Y, Exp_X, Intercept, n_simul)
```

Arguments

`Dicho_Y`	Vector of the binary time series.
`Exp_X`	Vector or Matrix of explanatory time series.
`Intercept`	Boolean value: TRUE for an estimation with intercept, and FALSE otherwise.
`n_simul`	Numeric variable equal to the total number of replications.

Value

A matrix containing the replications of the new resampled input variables. The matrix contains $n \times S$ colomns, where n denotes the number of input variables, and S denotes the number of replications.

Author(s)

Jean-Baptiste Hasse and Quentin Lajaunie

References

Hall, Peter, Joel L. Horowitz, and Bing-Yi Jing. "On blocking rules for the bootstrap with dependent data." Biometrika 82.3 (1995): 561-574.

Lajaunie, Quentin. Generalized Impulse Response Function for Dichotomous Models. No. 2852. Orleans Economics Laboratory/Laboratoire d'Economie d'Orleans (LEO), University of Orleans, 2021.

Examples

```
# NOT RUN {

# Import data
data("data_USA")

# Data process
Var_Y <- as.vector(data_USA$NBER)
Var_X <- as.vector(data_USA$Spread)

# Resample
results <- BlockBootstrapp(Dicho_Y = Var_Y, Exp_X = Var_X, Intercept = TRUE, n_simul = 100)

# print results
results

#}
```

---

data_panel *Historical data for 13 OECD countries*

Description

data_USA contains: - OECD based Recession Indicators for 13 OECD countries from the Peak through the Trough from 1975:03 to 2019:05 - Yield Spread (10Years TB minus 3Months TB) for 13 OECD countries from 1975:03 to 2019:05

List of countries: Australia, Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, New Zealand, Sweden, Switzerland, the United Kinkdom, the United States.

Usage

```
data("data_panel")
```

Format

A data frame with 6903 observations on the following 4 variables.

`country` List of countries.

`Date` Vector of dates.

`YIESPR` historical yield spread for the 13 OECD countries.

`OECD` Historical binary variable related to historical recessions for the 13 OECD countries.

Source

https://fred.stlouisfed.org/

Examples

```
data("data_panel")
head("data_panel")
```

`data_USA` *Historical data for the United States*

Description

data_USA contains: - NBER based Recession Indicators for the United States from 1953:04 to 2020:01 - 10Years TB for the United States from 1953:04 to 2020:01 - 3Months TB for the United States from 1953:04 to 2020:01 - Yield Spread (10Years TB minus 3Months TB) for the United States from 1975:03 to 2019:05

Usage

```
data("data_USA")
```

Format

A data frame with 268 observations on the following 5 variables.

`Date` Vector of dates.

`X10Y` Historical 10 years Treasury bond.

`X3M` Historical 3 months Treasury bond.

`Spread` Historical yield spread.

`NBER` Historical binary variable related to historical recessions.

Source

https://fred.stlouisfed.org/

Examples

```
data("data_USA")
head("data_USA")
```

EWS_AM_Criterion — *AM Threshold - optimal cut-off*

Description

This function provides a method to compute the optimal AM (Accuracy Measure) criterion. As defined in Candelon, Dumitrescu and Hurlin (2012), this approach consists in aggregating the number of crisis and calm periods correctly identified by the EWS. The optimal cut-off maximizes the number of correctly identified periods.

Usage

```
EWS_AM_Criterion(Var_Proba, Dicho_Y, cutoff_interval)
```

Arguments

- `Var_Proba` — Vector containing the estimated probabilities obtained with the Logistic Estimation function.
- `Dicho_Y` — Vector of the binary time series.
- `cutoff_interval` — Numeric variable between 0 and 1.

Value

A numeric variable containing the optimal cut-off that maximizes the higher proportion of calm and crisis periods correctly identified.

Author(s)

Jean-Baptiste Hasse and Quentin Lajaunie

References

Candelon, Bertrand, Elena-Ivona Dumitrescu, and Christophe Hurlin. "How to evaluate an early-warning system: Toward a unified statistical framework for assessing financial crises forecasting methods." IMF Economic Review 60.1 (2012): 75-113.

Lajaunie, Quentin. Generalized Impulse Response Function for Dichotomous Models. No. 2852. Orleans Economics Laboratory/Laboratoire d'Economie d'Orleans (LEO), University of Orleans, 2021.

Examples

```
# NOT RUN {

# Import data
data("data_USA")
```

```
# Data process
Var_Y <- as.vector(data_USA$NBER)
Var_X <- as.vector(data_USA$Spread)

# Estimate the logit regression
Logistic_results <- Logistic_Estimation(Dicho_Y = Var_Y, Exp_X = Var_X, Intercept = TRUE,
                      Nb_Id = 1, Lag = 1, type_model = 4)

# Vector of probabilities
vector_proba <- as.vector(rep(0,length(Var_Y)-1))
vector_proba <- Logistic_results$prob

# Vector of binary variables
Lag <- 1
vector_binary <- as.vector(rep(0,length(Var_Y)-1))
vector_binary <- Var_Y[(1+Lag):length(Var_Y)]

# optimal cut-off that maximizes the AM criterion
results <- EWS_AM_Criterion(Var_Proba = vector_proba, Dicho_Y = vector_binary,
                      cutoff_interval = 0.0001)

# print results
results

#}
```

EWS_CSA_Criterion *CSA Threshold - optimal cut-off*

Description

This function provides a method to compute the optimal CSA (Credit-Scoring Approach) criterion. As defined in Candelon, Dumitrescu and Hurlin (2012), this approach consists of calculating the difference between the sensitivity and the specificity. Sensitivity represents the proportion of crisis periods correctly identified by the EWS. Specificity is the proportion of calm periods correctly identified by the EWS. The optimal cut-off minimizes the absolute value of this difference.

Usage

```
EWS_CSA_Criterion(Var_Proba, Dicho_Y, cutoff_interval)
```

Arguments

`Var_Proba`	Vector containing the estimated probabilities obtained with the Logistic Estimation function.
`Dicho_Y`	Vector of the binary time series.
`cutoff_interval`	Numeric variable between 0 and 1.

Value

A numeric variable containing the optimal cut-off that minimizes the absolute value of the difference between the sensitivity and the specificity.

Author(s)

Jean-Baptiste Hasse and Quentin Lajaunie

References

Basel Committee on Banking Supervision, 2005, "Studies on the Validation of Internal Rating Systems", working paper no.14, Bank for International Settlements.

Candelon, Bertrand, Elena-Ivona Dumitrescu, and Christophe Hurlin. "How to evaluate an early-warning system: Toward a unified statistical framework for assessing financial crises forecasting methods." IMF Economic Review 60.1 (2012): 75-113.

Examples

```
# NOT RUN {

# Import data
data("data_USA")

# Data process
Var_Y <- as.vector(data_USA$NBER)
Var_X <- as.vector(data_USA$Spread)

# Estimate the logit regression
Logistic_results <- Logistic_Estimation(Dicho_Y = Var_Y, Exp_X = Var_X, Intercept = TRUE,
                      Nb_Id = 1, Lag = 1, type_model = 4)

# Vector of probabilities
vector_proba <- as.vector(rep(0,length(Var_Y)-1))
vector_proba <- Logistic_results$prob

# Vector of binary variables
Lag <- 1
vector_binary <- as.vector(rep(0,length(Var_Y)-1))
vector_binary <- Var_Y[(1+Lag):length(Var_Y)]

# optimal cut-off that minimizes the CSA criterion
results <- EWS_CSA_Criterion(Var_Proba = vector_proba, Dicho_Y = vector_binary,
                      cutoff_interval = 0.0001)

# print results
results

#}
```

EWS_NSR_Criterion *NSR Threshold - optimal cut-off*

Description

This function provides a method to compute the optimal NSR (Noise to Signal Ratio) criterion proposed by Kaminsky, Lizondo and Reinhart (1998). As defined in Candelon, Dumitrescu and Hurlin (2012), the NSR represents the ratio of the false alarms (type II error) to the number of crises correctly identified by the EWS for a given cut-off. The optimal cut-off minimizes the NSR criterion.

Usage

```
EWS_NSR_Criterion(Var_Proba, Dicho_Y, cutoff_interval)
```

Arguments

- `Var_Proba` Vector containing the estimated probabilities obtained with the Logistic Estimation function.
- `Dicho_Y` Vector of the binary time series.
- `cutoff_interval` Numeric variable between 0 and 1.

Value

A numeric variable containing the optimal cut-off that minimizes the NSR criterion.

Author(s)

Jean-Baptiste Hasse and Quentin Lajaunie

References

Candelon, Bertrand, Elena-Ivona Dumitrescu, and Christophe Hurlin. "How to evaluate an early-warning system: Toward a unified statistical framework for assessing financial crises forecasting methods." IMF Economic Review 60.1 (2012): 75-113.

Kaminsky, Graciela, Saul Lizondo, and Carmen M. Reinhart. "Leading indicators of currency crises." IMF Staff Papers 45.1 (1998): 1-48.

Examples

```
# NOT RUN {

# Import data
data("data_USA")
```

```
# Data process
Var_Y <- as.vector(data_USA$NBER)
Var_X <- as.vector(data_USA$Spread)

# Estimate the logit regression
Logistic_results <- Logistic_Estimation(Dicho_Y = Var_Y, Exp_X = Var_X, Intercept = TRUE,
                      Nb_Id = 1, Lag = 1, type_model = 4)

# Vector of probabilities
vector_proba <- as.vector(rep(0,length(Var_Y)-1))
vector_proba <- Logistic_results$prob

# Vector of binary variables
Lag <- 1
vector_binary <- as.vector(rep(0,length(Var_Y)-1))
vector_binary <- Var_Y[(1+Lag):length(Var_Y)]

# optimal cut-off that minimizes the NSR criterion
results <- EWS_NSR_Criterion(Var_Proba = vector_proba, Dicho_Y = vector_binary,
                      cutoff_interval = 0.0001)

# print results
results

#}
```

GIRF_Dicho *GIRF for Dichotomous models*

Description

This function estimates the response functions of dichotomous models in a univariate framework using the method proposed by Lajaunie (2021). The response functions are based on the 4 specifications proposed by Kauppi & Saikkonen (2008).

Usage

```
GIRF_Dicho(Dicho_Y, Exp_X, Lag, Int, t_mod, horizon, shock_size, OC)
```

Arguments

`Dicho_Y`	Vector of the binary time series.
`Exp_X`	Vector or Matrix of explanatory time series.
`Lag`	Number of lags used for the estimation.
`Int`	Boolean value: TRUE for an estimation with intercept, and FALSE otherwise.
`t_mod`	Model number: 1, 2, 3 or 4. -> 1 for the static model:

$$P_{t-1}(Y_t) = F(\pi_t) = F(\alpha + \beta' X_t)$$

-> 2 for the dynamic model with lag binary variable:

$$P_{t-1}(Y_t) = F(\pi_t) = F(\alpha + \beta' X_t + \gamma Y_{t-l})$$

-> 3 for the dynamic model with lag index variable:

$$P_{t-1}(Y_t) = F(\pi_t) = F(\alpha + \beta' X_t + \eta \pi_{t-l})$$

-> 4 for the dynamic model with both lag binary variable and lag index variable:

$$P_{t-1}(Y_t) = F(\pi_t) = F(\alpha + \beta' X_t + \eta \pi_{t-l} + \gamma Y_{t-l})$$

`horizon` Numeric variable corresponding to the horizon target for the GIRF analysis.

`shock_size` Numeric variable equal to the size of the shock. It can be estimated with the Vector_Error function.

`OC` Numeric variable equal to the Optimal Cut-off (threshold). This threshold can be considered arbitrarily, with a value between 0 and 1, or it can be estimated with one of the functions EWS_AM_Criterion, EWS_CSA_Criterion, or EWS_NSR_Criterion.

Value

Matrix with 7 columns:

`column 1` horizon

`column 2` index

`column 3` index with shock

`column 4` probability associated to the index

`column 5` probability associated to the index with shock

`column 6` binary variable associated to the index

`column 7` binary variable associated to the index with shock

Author(s)

Jean-Baptiste Hasse and Quentin Lajaunie

References

Kauppi, Heikki, and Pentti Saikkonen. "Predicting US recessions with dynamic binary response models." The Review of Economics and Statistics 90.4 (2008): 777-791.

Lajaunie, Quentin. Generalized Impulse Response Function for Dichotomous Models. No. 2852. Orleans Economics Laboratory/Laboratoire d'Economie d'Orleans (LEO), University of Orleans, 2021.

Examples

```
# NOT RUN {

# Import data
data("data_USA")

# Data process
Var_Y <- as.vector(data_USA$NBER)
Var_X <- as.vector(data_USA$Spread)

# Estimate the logit regression
Logistic_results <- Logistic_Estimation(Dicho_Y = Var_Y, Exp_X = Var_X, Intercept = TRUE,
                      Nb_Id = 1, Lag = 1, type_model = 1)

# Vector of probabilities
vector_proba <- as.vector(rep(0,length(Var_Y)-1))
vector_proba <- Logistic_results$prob

# Vector of binary variables
Lag <- 1
vector_binary <- as.vector(rep(0,length(Var_Y)-1))
vector_binary <- Var_Y[(1+Lag):length(Var_Y)]

# optimal cut-off that maximizes the AM criterion
Threshold_AM <- EWS_AM_Criterion(Var_Proba = vector_proba, Dicho_Y = vector_binary,
                      cutoff_interval = 0.0001)

# Estimate the estimation errors
Residuals <- Vector_Error(Dicho_Y = Var_Y, Exp_X = Var_X, Intercept = TRUE,
                      Nb_Id = 1, Lag = 1, type_model = 1)

# Initialize the shock
size_shock <- quantile(Residuals,0.95)

# GIRF Analysis
results <- GIRF_Dicho(Dicho_Y = Var_Y, Exp_X = Var_X, Lag = 1, Int = TRUE, t_mod = 1,
                      horizon = 3, shock_size = size_shock, OC = Threshold_AM)

# print results
results

#}
```

GIRF_Index_CI *Confidence Intervals for the Index - GIRF Analysis*

Description

From the results of the Simulation_GIRF function, this function calculates the values of the upper and lower bounds of the confidence intervals, as well as the average of the different response functions for the index.

Usage

```
GIRF_Index_CI(results_simul_GIRF, CI_bounds, n_simul, horizon_forecast)
```

Arguments

`results_simul_GIRF`
: Matrix containing results of the Simulation_GIRF function.

`CI_bounds`
: Numeric variable between 0 and 1 for the size of the confidence intervals.

`n_simul`
: Numeric variable equal to the total number of replications.

`horizon_forecast`
: Numeric variable corresponding to the horizon target for the GIRF analysis.

Value

A list with:

`Simulation_CI`
: a matrix containing the set of simulations belonging to the confidence interval.

`values_CI`
: a matrix containing three columns: the lower bound of the CI, the average of the IRFs, and the upper bound of the CI.

Author(s)

Jean-Baptiste Hasse and Quentin Lajaunie

References

Lajaunie, Quentin. Generalized Impulse Response Function for Dichotomous Models. No. 2852. Orleans Economics Laboratory/Laboratoire d'Economie d'Orleans (LEO), University of Orleans, 2021.

Examples

```
# NOT RUN {

# Import data
data("data_USA")

# Data process
Var_Y <- as.vector(data_USA$NBER)
Var_X <- as.vector(data_USA$Spread)

# Simulation for the GIRF analysis
results_simulation <- Simul_GIRF(Var_Y, Var_X, TRUE, 1, 1, 2, 0.95, 3, "AM")

# Confidence intervals for the index
results <- GIRF_Index_CI(results_simulation, 0.95, 2, 3)
```

```
# print results
results

#}
```

`GIRF_Proba_CI` *Confidence Intervals for the Probability - GIRF Analysis*

Description

From the results of the Simulation_GIRF function, this function calculates the values of the upper and lower bounds of the confidence intervals, as well as the average of the different response functions for the probability.

Usage

```
GIRF_Proba_CI(results_simul_GIRF, CI_bounds, n_simul, horizon_forecast)
```

Arguments

`results_simul_GIRF`
: Matrix containing results of the Simulation_GIRF function.

`CI_bounds`
: Numeric variable between 0 and 1 for the size of the confidence intervals.

`n_simul`
: Numeric variable equal to the total number of replications.

`horizon_forecast`
: Numeric variable corresponding to the horizon target for the GIRF analysis.

Value

A list with:

`horizon`
: Numeric vector containing the horizon targer.

`Simulation_CI_proba_shock`
: a matrix containing the set of simulations of probabilities with shock belonging to the confidence interval.

`Simulation_CI_proba`
: a matrix containing the set of simulations of probabilities belonging to the confidence interval.

`CI_proba_shock`
: a matrix containing three columns: the lower bound of the CI, the average of the IRFs, and the upper bound of the CI for the probabilities with shock.

`CI_proba`
: a matrix containing three columns: the lower bound of the CI, the average of the IRFs, and the upper bound of the CI for the probabilities.

Author(s)

Jean-Baptiste Hasse and Quentin Lajaunie

References

Lajaunie, Quentin. Generalized Impulse Response Function for Dichotomous Models. No. 2852. Orleans Economics Laboratory/Laboratoire d'Economie d'Orleans (LEO), University of Orleans, 2021.

Examples

```
# NOT RUN {

# Import data
data("data_USA")

# Data process
Var_Y <- as.vector(data_USA$NBER)
Var_X <- as.vector(data_USA$Spread)

# Simulation for the GIRF analysis
results_simulation <- Simul_GIRF(Var_Y, Var_X, TRUE, 1, 1, 2, 0.95, 3, "AM")

# Confidence intervals for the index
results <- GIRF_Proba_CI(results_simulation, 0.95, 2, 3)

# print results
results

#}
```

`Logistic_Estimation` *Logistic Estimation for Dichotomous Analysis*

Description

This function provides methods for estimating the four dichotomous models as in Kauppi & Saikkonen (2008). Based on a logit approach, models are estimated in a univariate or a balanced panel framework as in Candelon, Dumitrescu and Hurlin (2014). This estimation has been used in recent papers such in Ben Naceur, Candelon and Lajaunie (2019) and Hasse and Lajaunie (2020).

Usage

```
Logistic_Estimation(Dicho_Y, Exp_X, Intercept, Nb_Id, Lag, type_model)
```

Arguments

`Dicho_Y`	Vector of the binary time series.
`Exp_X`	Vector or Matrix of explanatory time series.
`Intercept`	Boolean value: TRUE for an estimation with intercept, and FALSE otherwise.

`Nb_Id` Number of individuals studied for a panel approach. Nb_Id=1 in the univariate case.

`Lag` Number of lags used for the estimation.

`type_model` Model number: 1, 2, 3 or 4.
-> 1 for the static model:

$$P_{t-1}(Y_t) = F(\pi_t) = F(\alpha + \beta' X_t)$$

-> 2 for the dynamic model with lag binary variable:

$$P_{t-1}(Y_t) = F(\pi_t) = F(\alpha + \beta' X_t + \gamma Y_{t-l})$$

-> 3 for the dynamic model with lag index variable:

$$P_{t-1}(Y_t) = F(\pi_t) = F(\alpha + \beta' X_t + \eta \pi_{t-l})$$

-> 4 for the dynamic model with both lag binary variable and lag index variable:

$$P_{t-1}(Y_t) = F(\pi_t) = F(\alpha + \beta' X_t + \eta \pi_{t-l} + \gamma Y_{t-l})$$

Value

A list with:

`Estimation` a dataframe containing the coefficients of the logitic estimation, the Standard Error for each coefficient, the Z-score and the associated critical probability

`AIC` a numeric vector containing the Akaike information criterion

`BIC` a numeric vector containing the Bayesian information criterion

`R2` a numeric vector containing the Pseudo R Square

`index` a numeric vector containing the estimated index

`prob` a numeric vector containing the estimated probabilities

`LogLik` a numeric vector containing the Log likelihood value of the estimation

`VCM` a numeric matrix of the Variance Covariance of the estimation

Note

For the panel estimation, data must be stacked one after the other for each country or for each individual.

Author(s)

Jean-Baptiste Hasse and Quentin Lajaunie

References

Candelon, Bertrand, Elena-Ivona Dumitrescu, and Christophe Hurlin. "Currency crisis early warning systems: Why they should be dynamic." International Journal of Forecasting 30.4 (2014): 1016-1029.

Hasse, Jean-Baptiste, Lajaunie Quentin. "Does the Yield Curve Signal Recessions? New Evidence from an International Panel Data Analysis." (2020)

Kauppi, Heikki, and Pentti Saikkonen. "Predicting US recessions with dynamic binary response models." The Review of Economics and Statistics 90.4 (2008): 777-791.

Naceur, Sami Ben, Bertrand Candelon, and Quentin Lajaunie. "Taming financial development to reduce crises." Emerging Markets Review 40 (2019): 100618.

Examples

```
# NOT RUN {

# Import data
data("data_USA")

# Data process
Var_Y <- as.vector(data_USA$NBER)
Var_X <- as.vector(data_USA$Spread)

# Estimate the logit regression
results <- Logistic_Estimation(Dicho_Y = Var_Y, Exp_X = Var_X, Intercept = TRUE,
                      Nb_Id = 1, Lag = 1, type_model = 1)

# print results
results

# }
```

Matrix_lag *Matrix Lag - data processing*

Description

Compute a lagged version of a time series, shifting the time base back by a given number of observations defined by the user. The user must enter three parameters for this function: the matrix, the number of lags, and of boolean variable calls 'beginning'. If 'beginning'=TRUE, then the lag will be applied at the beginning of the matrix whereas if 'beginning'=FALSE, then the lag will be applied at the end of the matrix.

Usage

```
Matrix_lag(Matrix_target, Nb_lag, beginning)
```

Arguments

Matrix_target	Initial Matrix
Nb_lag	Number of lag
beginning	Boolean variable. If 'place'=TRUE, the lag is applied at the beginning of the matrix. If 'place'=FALSE, the lag is applied at the end of the matrix.

Value

A numeric Matrix.

Examples

```
# NOT RUN {

# Initialize the following matrix
Matrix_example <- matrix(data=(1:10), nrow=5, ncol=2)

# Use Matrix_lag
new_matrix <- Matrix_lag(Matrix_target = Matrix_example, Nb_lag = 1, beginning = TRUE)

new_matrix

# Results:
#> new_matrix
#     [,1] [,2]
#[1,]    2    7
#[2,]    3    8
#[3,]    4    9
#[4,]    5   10

#}
```

Simul_GIRF *GIRF Simulations*

Description

This function calls the BlockBootstrap function of the EWS package and then calculates response functions for each simulation. It then measures the confidence intervals as in Lajaunie (2021). The response functions are based on the 4 specifications proposed by Kauppi & Saikkonen (2008).

Usage

```
Simul_GIRF(Dicho_Y, Exp_X, Int, Lag, t_mod, n_simul, centile_shock, horizon, OC)
```

Arguments

`Dicho_Y`	Vector of the binary time series.
`Exp_X`	Vector or Matrix of explanatory time series.
`Int`	Boolean value: TRUE for an estimation with intercept, and FALSE otherwise.
`Lag`	Number of lags used for the estimation.
`t_mod`	Model number: 1, 2, 3 or 4.

-> 1 for the static model:

$$P_{t-1}(Y_t) = F(\pi_t) = F(\alpha + \beta' X_t)$$

-> 2 for the dynamic model with lag binary variable:

$$P_{t-1}(Y_t) = F(\pi_t) = F(\alpha + \beta' X_t + \gamma Y_{t-l})$$

-> 3 for the dynamic model with lag index variable:

$$P_{t-1}(Y_t) = F(\pi_t) = F(\alpha + \beta' X_t + \eta \pi_{t-l})$$

-> 4 for the dynamic model with both lag binary variable and lag index variable:

$$P_{t-1}(Y_t) = F(\pi_t) = F(\alpha + \beta' X_t + \eta \pi_{t-l} + \gamma Y_{t-l})$$

`n_simul`	Numeric variable equal to the total number of replications.
`centile_shock`	Numeric variable corresponding to the centile of the shock following Koop, Pesaran and Potter (1996).
`horizon`	Numeric variable corresponding to the horizon target for the GIRF analysis.
`OC`	Either a numeric variable equal to the optimal cut-off (threshold) or a character variable of the method chosen to calculate the optimal cut-off ("NSR", "CSA", "AM").

Value

A matrix containing the GIRF analysis for each replication. For each replication, the function returns 7 colomns with:

`column 1`	horizon
`column 2`	index
`column 3`	index with shock
`column 4`	probability associated to the index
`column 5`	probability associated to the index with shock
`column 6`	binary variable associated to the index
`column 7`	binary variable associated to the index with shock

The matrix contains $7 \times S$ colomns, where S denotes the number of replications.

Author(s)

Jean-Baptiste Hasse and Quentin Lajaunie

References

Kauppi, Heikki, and Pentti Saikkonen. "Predicting US recessions with dynamic binary response models." The Review of Economics and Statistics 90.4 (2008): 777-791.

Koop, Gary, M. Hashem Pesaran, and Simon M. Potter. "Impulse response analysis in nonlinear multivariate models." Journal of econometrics 74.1 (1996): 119-147.

Lajaunie, Quentin. Generalized Impulse Response Function for Dichotomous Models. No. 2852. Orleans Economics Laboratory/Laboratoire d'Economie d'Orleans (LEO), University of Orleans, 2021.

Examples

```
# NOT RUN {

# Import data
data("data_USA")

# Data process
Var_Y <- as.vector(data_USA$NBER)
Var_X <- as.vector(data_USA$Spread)

# Simulations
results <- Simul_GIRF(Dicho_Y = Var_Y, Exp_X = Var_X, Int = TRUE, Lag = 1, t_mod = 1 ,
                      n_simul = 2 , centile_shock = 0.95, horizon = 3, OC = "AM")

# print results
results

#}
```

`Vector_Error` *Vector of Errors*

Description

The function measures the estimation errors from the logistic estimation, and stores them in a vector. This function is used to initialize a shock in impulse response analysis as in Koop, Pesaran and Potter (1996).

Usage

```
Vector_Error(Dicho_Y, Exp_X, Intercept, Nb_Id, Lag, type_model)
```

Arguments

`Dicho_Y`	Vector of the binary time series.
`Exp_X`	Vector or Matrix of explanatory time series.
`Intercept`	Boolean value: TRUE for an estimation with intercept, and FALSE otherwise.
`Nb_Id`	Number of individuals studied for a panel approach. Nb_Id=1 in the univariate case.
`Lag`	Number of lags used for the estimation.
`type_model`	Model number: 1, 2, 3 or 4.

Value

A numeric vector containing estimation errors.

Author(s)

Jean-Baptiste Hasse and Quentin Lajaunie

References

Kauppi, Heikki, and Pentti Saikkonen. "Predicting US recessions with dynamic binary response models." The Review of Economics and Statistics 90.4 (2008): 777-791.

Koop, Gary, M. Hashem Pesaran, and Simon M. Potter. "Impulse response analysis in nonlinear multivariate models." Journal of econometrics 74.1 (1996): 119-147.

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Examples

```
# NOT RUN {

# Import data
data("data_USA")

# Data process
Var_Y <- as.vector(data_USA$NBER)
Var_X <- as.vector(data_USA$Spread)

# Estimate the estimation errors
results <- Vector_Error(Dicho_Y = Var_Y, Exp_X = Var_X, Intercept = TRUE,
                      Nb_Id = 1, Lag = 1, type_model = 4)

# print results
results

#}
```

`Vector_lag` *Vector lag - data processing*

Description

Compute a lagged version of a time series, shifting the time base back by a given number of observations defined by the user. The user must enter three parameters for this function: the vector, the number of lags, and a boolean variable named 'beginning'. If 'beginning'=TRUE, then the lag will be applied at the beginning of the vector whereas if 'beginning'=FALSE, then the lag will be applied at the end of the vector.

Usage

```
Vector_lag(Vector_target, Nb_lag, beginning)
```

Arguments

`Vector_target`	Initial vector
`Nb_lag`	Number of lag
`beginning`	Boolean variable. If 'beginning'=TRUE, the lag is applied at the beginning of the vector. If 'beginning'=FALSE, the lag is applied at the end of the vector.

Value

A numeric Vector.

Examples

```
# NOT RUN {

# Initialize the following vector
vector_example <- as.vector(1:10)

# Use Vector_lag
new_vector <- Vector_lag(Vector_target = vector_example, Nb_lag = 2, beginning = TRUE)

new_vector
# Results:
#> new_vector
#[1]  3  4  5  6  7  8  9 10

#}
```

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