Package 'MultiATSM'

October 12, 2022

Type Package

Title Multicountry Term Structure of Interest Rates Models

Version 0.2.4

Date 2022-10-03

Author Rubens Moura

Maintainer Rubens Moura <rubens.gtmoura@gmail.com>

Description Estimation routines for several classes of affine term structure of interest rates models. All the models are based on the single-country unspanned macroeconomic risk framework from Joslin, Priebsch, and Singleton (2014) <doi:10.1111/jofi.12131>. Multicountry extensions such as the ones of Jotikasthira, Le, and Lundblad (2015) <doi:10.1016/j.jfineco.2014.09.004> and Candelon and Moura (2021) <http://hdl.handle.net/2078.1/249985> are also available.

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Encoding UTF-8

RoxygenNote 7.1.1

Imports zoo, pracma, wrapr, hablar, ggplot2

Suggests readxl, readr, magic, Jmisc, functional, cowplot, powerplus, reshape2, sjmisc, stringr, knitr, rmarkdown, bookdown, kableExtra, neldermead, magrittr

Depends R (>= 3.5.0)

VignetteBuilder knitr

NeedsCompilation no

Repository CRAN

Date/Publication 2022-10-03 10:00:02 UTC

R topics documented:

`A0N_MLEdensity_WOE__jointQ_Bootstrap`

Compute the maximum likelihood function (joint Q models) - Bootstrap version

---

Description

Compute the maximum likelihood function (joint Q models) - Bootstrap version

Usage

```
A0N_MLEdensity_WOE__jointQ_Bootstrap(
  K1XQ,
  r0,
  SSZ,
  K0Z,
  K1Z,
  se,
  Gy.0,
  mat,
  Y,
  Z,
  P,
  Wpca,
  We,
  WpcaFull,
  dt,
  Economies,
  FactorLabels,
  ModelType,
  residBS,
  MaxEigen,
  GVARinputs,
  JLLinputs,
  nargout
)
```

Arguments

K1XQ	risk-neutral feedback matrix (NxN)
r0	long-run interest rate (scalar)
SSZ	variance-covariance matrix (KxK)
K0Z	intercept from the P-dynamics (Kx1)
K1Z	feedback matrix from the P-dynamics (KxK)
se	Variance of the portfolio of yields observed with error (scalar)
Gy.0	matrix of contemporaneous terms from the P-dynamics (KxK)
mat	vector of maturities (in years) of yields used in estimation (J x 1)
Y	matrix of yields used in estimation (J x T)
Z	complete set of spanned and unspanned factors (KxT)
P	complete set of spanned factors (NxT)
Wpca	matrix of weights of the portfolios observed without errors (NxJ)
We	matrix of weights of the portfolios observed with errors ((J-N)xJ)
WpcaFull	composite matrix of weights the portfolios observed with and without errors

dt	time interval unit of the model (scalar). For instance, if data is (i) monthly, dt <- 12; (ii) quarterly, dt <- 4; (iii) yearly, dt <- 1.
Economies	a string-vector containing the names of the economies which are part of the economic system
FactorLabels	string-list based which contains the labels of all the variables present in the model
ModelType	feasible options are (i) "VAR jointQ", (ii) "GVAR jointQ" or (iii) "JLL jointSigma"
residBS	index of the re-ordered bootstrap residuals
MaxEigen	largest eigenvalue under the P-dynamics
GVARinputs	if the model chosen is the "GVAR sepQ", "GVARinputs" should be specified (see "GVAR" function)
JLLinputs	if the model chosen is the "JLL jointSigma". "JLLinputs" should be specified (see "JLL" function)
nargout	if nargout== 1: provides only the values of the likelihood; if nargout== 2: complete ATSM outputs

References

This function is modified version of the "A0N_MLEdensity_WOE" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at: https://cepr.org/40029

`A0N_MLEdensity_WOE__jointQ_sepSigma_Bootstrap`

Compute the maximum likelihood function ("joint Q" models for separate Sigma estimation) - Bootstrap version

---

Description

Compute the maximum likelihood function ("joint Q" models for separate Sigma estimation) - Bootstrap version

Usage

```
A0N_MLEdensity_WOE__jointQ_sepSigma_Bootstrap(
  K1XQ,
  r0,
  SSZ,
  K0Z,
  K1Z,
  se,
  Gy.0,
  mat,
```

```
  Y,
  Z,
  P,
  Wpca,
  We,
  WpcaFull,
  dt,
  Economies,
  FactorLabels,
  ModelType,
  residBS,
  MaxEigen,
  GVARinputs,
  JLLinputs,
  nargout
)
```

Arguments

K1XQ	risk-neutral feedback matrix (NxN)
r0	long-run interest rate (scalar)
SSZ	variance-covariance matrix (KxK)
K0Z	intercept from the P-dynamics (Kx1)
K1Z	feedback matrix from the P-dynamics (KxK)
se	Variance of the portfolio of yields observed with error (scalar)
Gy.0	matrix of contemporaneous terms from the P-dynamics (KxK)
mat	vector of maturities (in years) of yields used in estimation (J x 1)
Y	matrix of yields used in estimation (J x T)
Z	complete set of spanned and unspanned factors (KxT)
P	complete set of spanned factors (NxT)
Wpca	matrix of weights of the portfolios observed without errors (NxJ)
We	matrix of weights of the portfolios observed with errors ((J-N)xJ)
WpcaFull	composite matrix of weights the portfolios observed with and without errors
dt	time interval unit of the model (scalar). For instance, if data is (i) monthly, dt <- 12; (ii) quarterly, dt <- 4; (iii) yearly, dt <- 1.
Economies	a string-vector containing the names of the economies which are part of the economic system
FactorLabels	string-list based which contains the labels of all the variables present in the model
ModelType	feasile options are (i) "JLL original" or (ii) "JLL NoDomUnit"
residBS	indexes of the re-ordered bootstrap residuals
MaxEigen	largest eigenvalue under the P-dynamics

GVARinputs	if the model chosen is the "GVAR sepQ", "GVARinputs" must be specified (see "GVAR" function)
JLLinputs	if the model chosen is the "JLL jointSigma", "JLLinputs" must be specified (see "JLL" function)
nargout	if nargout== 1: provides only the values of the likelihood; if nargout== 2: complete ATSM outputs

References

This function is modified version of the "A0N_MLEdensity_WOE" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at: https://cepr.org/40029

`A0N_MLEdensity_WOE__sepQ_Bootstrap`

Compute the maximum likelihood function ("sep Q" models) - Bootstrap version

---

Description

Compute the maximum likelihood function ("sep Q" models) - Bootstrap version

Usage

```
A0N_MLEdensity_WOE__sepQ_Bootstrap(
  K1XQ,
  r0,
  SSZ,
  K0Z,
  K1Z,
  se,
  Gy.0,
  mat,
  Y,
  Z,
  P,
  Wpca,
  We,
  WpcaFull,
  dt,
  Economy,
  FactorLabels,
  ModelType,
  residBS,
```

```
  MaxEigen,
  GVARinputs,
  nargout
)
```

Arguments

K1XQ	risk-neutral feedback matrix (NxN)
r0	long-run interest rate (scalar)
SSZ	variance-covariance matrix (KxK)
K0Z	intercept from the P-dynamics (Kx1)
K1Z	feedback matrix from the P-dynamics (KxK)
se	Variance of the portfolio of yields observed with error (scalar)
Gy.0	matrix of contemporaneous terms from the P-dynamics (KxK)
mat	vector of maturities (in years) of yields used in estimation (J x 1)
Y	matrix of yields used in estimation (J x T)
Z	complete set of spanned and unspanned factors (KxT)
P	complete set of spanned factors (NxT)
Wpca	matrix of weights of the portfolios observed without errors (NxJ)
We	matrix of weights of the portfolios observed with errors ((J-N)xJ)
WpcaFull	composite matrix of weights the portfolios observed with and without errors
dt	time interval unit of the model (scalar). For instance, if data is (i) monthly, dt <- 12; (ii) quarterly, dt <- 4; (iii) yearly, dt <- 1.
Economy	Name of the economies under study
FactorLabels	string-list based which contains the labels of all the variables present in the model
ModelType	Feasible options are: (i) "JPS", (ii) "JPS jointP" or (iii) "GVAR sepQ"
residBS	index of the re-ordered bootstrap residuals
MaxEigen	largest eigenvalue under the P-dynamics
GVARinputs	if the model chosen is the "GVAR sepQ", "GVARinputs" should be specified (see "GVAR" function)
nargout	if nargout== 1: provides only the values of the likelihood; if nargout== 2: complete ATSM outputs

References

This function is modified version of the "A0N_MLEdensity_WOE" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at: https://cepr.org/40029

`A0N__computeBnAn_jointQ` *Compute the cross-section loadings of yields of a canonical A0_N model ("joint Q" models)*

Description

Compute the cross-section loadings of yields of a canonical A0_N model ("joint Q" models)

Usage

```
A0N__computeBnAn_jointQ(mat, K1XQ, dx, r0, SSX, Economies)
```

Arguments

`mat`	vector of maturities (J x 1). Maturities are in multiples of the discrete interval used in the model
`K1XQ`	risk neutral feedback matrix (N x N)
`dx`	state loadings for the one-period rate (1xN). Default is a vector of ones
`r0`	the long run risk neutral mean of the short rate (scalar)
`SSX`	the covariance matrix of the errors (N x N)
`Economies`	Set of economies that are part of the economic system (vector of text)

Value

List containing:

- Intercept (Jx1)
- slope (JxN)
- the betan (JX1, part of the intercepts unrelated to the long run risk neutral mean r0) coefficients of a canonical A_0(N).

References

This function is an extended version of the "A0N__computeBnAn" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at: https://cepr.org/40029

`A0N__computeBnAn_sepQ` *Compute the cross-section loadings of yields of a canonical A0_N model ("sep Q" models)*

Description

Compute the cross-section loadings of yields of a canonical A0_N model ("sep Q" models)

Usage

```
A0N__computeBnAn_sepQ(mat, K1XQ, dx, r0, SSX)
```

Arguments

`mat`	vector of maturities (J x 1). Maturities are in multiples of the discrete interval used in the model
`K1XQ`	risk neutral feedback matrix (N x N)
`dx`	state loadings for the one-period rate (1xN). Default is a vector of ones
`r0`	the long run risk neutral mean of the short rate (scalar)
`SSX`	the covariance matrix of the errors (N x N)

Value

List containing:

- Intercept (Jx1)
- slope (JxN)
- the betan (JX1, part of the intercepts unrelated to the long run risk neutral mean r0) coefficients of a canonical A_0(N).

References

- This function is based on the "A0N__computeBnAn" function by Le and Singleton (2018). "A Small Package of Matlab Routines for the Estimation of Some Term Structure Models." (Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at: https://cepr.org/40029
- Dai and Singleton (2000). "Specification Analysis of Affine Term Structure Models" (The Journal of Finance)

`aux2true` *Map auxiliary (unconstrained) parameters a to constrained parameters b*

Description

Map auxiliary (unconstrained) parameters a to constrained parameters b

Usage

```
aux2true(
  a,
  ctype,
  lb,
  ub,
  FactorLabels,
  Economies,
  JLLinputs = NULL,
  GVARinputs = NULL,
  nargout
)
```

Arguments

`a`	unconstrained auxiliary parameter
`ctype`	One of the following options: • 'Jordan' • 'Jordan; stationary' • 'Jordan MultiCountry' • 'Jordan MultiCountry; stationary' • 'psd'; • 'BlockDiag' • 'bounded' • 'diag' • 'JLLstructure'
`lb`	lower bounds of b (if option 'bounded' is chosen)
`ub`	upper bounds of b (if option 'bounded' is chosen)
`FactorLabels`	string-list based which contains the labels of all the variables present in the model
`Economies`	string-vector containing the names of the economies which are part of the economic system
`JLLinputs`	Inputs used in the estimation of the JLL-based models
`GVARinputs`	Inputs used in the estimation of the GVAR-based models
`nargout`	"nargout <- 1" returns a constrained scalar or matrix "nargout <- 2" returns a list of parameters

References

This function is a modified version of the "aux2true" function by Le and Singleton (2018). "A Small Package of Matlab Routines for the Estimation of Some Term Structure Models." (Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at: https://cepr.org/40029

`Bootstrap` *Generates the bootstrap-related outputs*

Description

Generates the bootstrap-related outputs

Usage

```
Bootstrap(
  ModelType,
  ModelParaPE,
  NumOutPE,
  mat,
  Economies,
  InputsForOutputs,
  FactorLabels,
  DataFrequency,
  vararginPE,
  JLLinputs = NULL,
  GVARinputs = NULL
)
```

Arguments

`ModelType`	string-vector containing the label of the model to be estimated
`ModelParaPE`	point estimate from the model parameters (see the outputs of the "Optimization" function)
`NumOutPE`	point estimate from the numerical outputs (see the outputs of the "NumOutputs" function)
`mat`	vector of maturities (in years) used in the estimation
`Economies`	string-vector containing the names of the economies which are part of the economic system
`InputsForOutputs`	list containing the desired inputs for the construction of IRFs, GIRFs, FEVDs, and GFEVDs.
`FactorLabels`	string-list based which contains the labels of all the variables present in the model

DataFrequency	character-based vector: "Daily All Days", "Daily Business Days", "Weekly", "Monthly", "Quarterly", "Annually"
vararginPE	list containg starting values and constraints (see arguments of the "Optimization" function)
JLLinputs	list of necessary inputs for the estimation of JLL-based models (see "JLL" function)
GVARinputs	list of necessary inputs for the estimation of GVAR-based models (see "GVAR" function)

Value

list containing the following elements:

- list of model parameters for one each one the draws;
- list of numerical outputs (IRFs, GIRFs, FEVDs, GFEVDs) for each one of the draws;
- Confidence bands for the chosen level of significance.

References

This function is a modified and extended version of the "VARirbound" function from "A toolbox for VAR analysis" by Ambrogio Cesa-Bianchi (https://github.com/ambropo/VAR-Toolbox)

Examples

```
# See examples in the vignette file of this package (Section 4).
```

BootstrapBoundsSet *Builds the confidence bounds and graphs (Bootstrap set)*

Description

Builds the confidence bounds and graphs (Bootstrap set)

Usage

```
BootstrapBoundsSet(
  ModelType,
  ModelBootstrap,
  NumOutPE,
  InputsForOutputs,
  Economies
)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelBootstrap	list containing the complete set of model parameters after the bootstrap estimation procedure
NumOutPE	point estimate from the numerical outputs (see the outputs of the "NumOutputs" function)
InputsForOutputs	list conataining the desired inputs for the construction of IRFs, GIRFs, FEVDs, and GFEVDs
Economies	string-vector containing the names of the economies which are part of the economic system

---

bound2x — *Transform a number bounded between a lower bound and upper bound to x by:*

Description

Transform a number bounded between a lower bound and upper bound to x by:

Usage

```
bound2x(y, lb, ub)
```

Arguments

y	Number to be transformed (scalar)
lb	lower bound (scalar)
ub	upper bound (scalar)

References

This function is based on the "bound2x" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at: https://cepr.org/40029

BR_jps_out *Replications of the JPS (2014) outputs by Bauer and Rudebusch (2017)*

Description

Unspanned macro risk model outputs by Bauer and Rudebusch (2017)

Usage

```
data("BR_jps_gro_R3")
```

Format

Unspanned macro risk model outputs by Bauer and Rudebusch (2017)

est.llk summary list of log-likelihood estimations

M.o time series of unspanned factors

pars additional summary list of log-likelihood estimations

W Weight matrix that results from principal components analysis

Y time series of bond yields

N total number of risk factor of the model (spanned and unspanned)

R total number of spanned factor of the model

References

Bauer, M. and Rudebusch, G. "Resolving the Spanning Puzzle in Macro-Finance Term Structure Models"

BUnspannedAdapJoint *Transform B_spanned into B_unspanned for jointQ models*

Description

Transform B_spanned into B_unspanned for jointQ models

Usage

```
BUnspannedAdapJoint(G, M, N, C, J, BSpanned)
```

Arguments

G	number of global unspanned factors
M	number of domestic unspanned factors
N	number of domestic spanned factors
C	number of economies of the economic system
J	number of country-specific observed bond yields
BSpanned	B that accomodates only the map to the spanned factors only

---

BUnspannedAdapSep *Transform B_spanned into B_unspanned for sepQ models*

Description

Transform B_spanned into B_unspanned for sepQ models

Usage

```
BUnspannedAdapSep(G, M, ModelPara, Economies, Economy, ModelType)
```

Arguments

G	number of global unspanned factors
M	number of domestic unspanned factors per country
ModelPara	list of model parameter estimates (See the "Optimization" function)
Economies	complet set of economies of the economic system
Economy	specific economy under study
ModelType	a string-vector containing the label of the model to be estimated

---

BUnspannedAdapSep_BS *Obtain the full form of B unspanned for "sep Q" models within the bootstrap setting*

Description

Obtain the full form of B unspanned for "sep Q" models within the bootstrap setting

Usage

```
BUnspannedAdapSep_BS(G, M, ModelParaBoot, Economies, Economy, ModelType, tt)
```

Arguments

G	number of global unspanned factors
M	number of country-specific domestic unspanned factors
ModelParaBoot	list of model parameter estimates (see the "Optimization" function) after a bootstrap draw
Economies	string-vector containing the names of the economies which are part of the economic system
Economy	string-vector containing the names of the economy under study
ModelType	string-vector containing the label of the model to be estimated
tt	number of the bootstrap draw

---

contain *Check whether one element is a subset of another element*

Description

Check whether one element is a subset of another element

Usage

```
contain(s1, s2)
```

Arguments

s1	smaller subset
s2	complete set

References

This function is based on the "contain" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at: https://cepr.org/40029

`DatabasePrep` *Prepare the GVARFactors database*

Description

Prepare the GVARFactors database

Usage

```
DatabasePrep(
  t_First,
  t_Last,
  Economies,
  N,
  FactorLabels,
  ModelType,
  Wgvar = NULL,
  DataPathMacro = NULL,
  DataPathYields = NULL
)
```

Arguments

`t_First`	sample starting date (yyyy-mm-dd)
`t_Last`	sample last date (yyyy-mm-dd)
`Economies`	string-vector containing the names of the economies which are part of the economic system
`N`	number of country-specific spanned factor (scalar)
`FactorLabels`	list containing the factor labels
`ModelType`	string-vector containing the label of the model to be estimated
`Wgvar`	GVAR transition matrix (CxC), if GVAR type model is chosen; default is set to NULL.
`DataPathMacro`	path of the Excel file containing the macroeconomic data (if any). The default is linked to the Excel file available in the package.
`DataPathYields`	path of the Excel file containing the yields data (if any). The default is linked to the Excel file available in the package.

Value

List of the risk factor set used in the estimation of the GVAR model

List containing the risk factor set used in the estimation of the GVAR-based models

Examples

```
DomVar <- c("Eco_Act", "Inflation")
GlobalVar <- c("GBC", "CPI_OECD")
t0 <- "2006-09-01"
tF <-  "2019-01-01"
Economies <- c("China", "Brazil", "Mexico", "Uruguay", "Russia")
N <- 3
ModelType <- "JPS jointQ"
FactorLabels <-  LabFac(N, DomVar, GlobalVar, Economies, ModelType)

GVARFactors <- DatabasePrep(t0, tF, Economies, N, FactorLabels, ModelType)
```

DataForEstimation *Retrieve data from Excel and build the database used in the model estimation*

Description

Retrieve data from Excel and build the database used in the model estimation

Usage

```
DataForEstimation(
  t0,
  tF,
  Economies,
  N,
  FactorLabels,
  ModelType,
  DataFrequency,
  DataPathMacro = NULL,
  DataPathYields = NULL,
  Wgvar = NULL
)
```

Arguments

t0	Sample starting date (yyyy-mm-dd)
tF	Sample last date (yyyy-mm-dd)
Economies	string-vector containing the names of the economies which are part of the economic system
N	Number of country-specific spanned factor (scalar)
FactorLabels	String-list based which contains the labels of all the variables present in the model

ModelType	String-vector containing the label of the model to be estimated
DataFrequency	Character-based-vector. Avaialable options are: "Daily All Days", "Daily Business Days", "Weekly", "Monthly", "Quarterly", "Annually"
DataPathMacro	Path of the Excel file conating the macroeconomic data (if any). The default is linked to the excel file present in the package.
DataPathYields	Path of the Excel file conating the yields data (if any). The default is linked to the excel file present in the package.
Wgvar	GVAR transition matrix, if GVAR type model is chosen; default is set to NULL.

Value

A list containing the

1. time series of the complete set of bond yields (matrix, JxT or CJxT);
2. time series of the complete set risk factors (matrix, KxT);
3. 'GVARFactors': list of all variables that are used in the estimation of the VARX (see e.g. 'CM_Factors_GVAR' file). If the estimated model type is not GVAR-based, then returns NULL.

Examples

```
DomVar <- c("Eco_Act", "Inflation")
GlobalVar <- c("GBC", "CPI_OECD")
t0 <- "2006-09-01"
tF <-  "2019-01-01"
Economies <- c("China", "Brazil", "Mexico", "Uruguay", "Russia")
N <- 2
ModelType <- "JPS"
FactorLabels <-  LabFac(N, DomVar, GlobalVar, Economies, ModelType)
DataFrequency <- "Monthly"


DataModel <- DataForEstimation(t0, tF, Economies, N, FactorLabels, ModelType, DataFrequency)
```

DataSet_BS *Prepare the factor set for GVAR models (Bootstrap version)*

Description

Prepare the factor set for GVAR models (Bootstrap version)

Usage

```
DataSet_BS(ModelType, RiskFactors, Wgvar, Economies, FactorLabels)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
RiskFactors	Complete set of risk factors (KxT)
Wgvar	transition matrix from GVAR models (CxC)
Economies	string-vector containing the names of the economies which are part of the economic system
FactorLabels	string-list based which contains the labels of all the variables present in the model

---

df__dx *Computes numerical first order derivative of f(x)*

Description

Computes numerical first order derivative of f(x)

Usage

```
df__dx(f, x)
```

Arguments

f	function which contains vector (J x T) valued function handle
x	parameter values

Value

transformed matrix (MN x JT)

References

This function is based on the "df__dx" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at: https://cepr.org/40029

FactorsGVAR *Data: Risk Factors for the GVAR - Candelon and Moura (2021)*

Description

Risk factors data used in the GVAR models - Candelon and Moura (2021)

Usage

```
data("CM_Factors_GVAR")
```

Format

list containing the variables used in the GVAR models

References

Candelon, B. and Moura, R. "A Multi-Country Model of the Term Structures of Interest Rates with a GVAR".

FEVDandGFEVDbs_jointQ *Creates the confidence bounds and the graphs of FEVDs and GFEVDs after bootstrap ("joint Q" models)*

Description

Creates the confidence bounds and the graphs of FEVDs and GFEVDs after bootstrap ("joint Q" models)

Usage

```
FEVDandGFEVDbs_jointQ(
  ModelType,
  ModelBootstrap,
  NumOutPE,
  InputsForOutputs,
  Economies,
  PathsGraphs
)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelBootstrap	list containing the complete set of model parameters after bootstrap estimation procedure
NumOutPE	list of model parameter point estimates
InputsForOutputs	list conataining the desired inputs for the construction of the outputs of interest
Economies	string-vector containing the names of the economies which are part of the economic system
PathsGraphs	path of the folder in which the graphs will be saved

---

FEVDandGFEVDbs_jointQ_Ortho

Creates the confidence bounds and the graphs of FEVDs and GFEVDs after bootstrap (JLL-based models)

Description

Creates the confidence bounds and the graphs of FEVDs and GFEVDs after bootstrap (JLL-based models)

Usage

```
FEVDandGFEVDbs_jointQ_Ortho(
  ModelType,
  ModelBootstrap,
  NumOutPE,
  InputsForOutputs,
  Economies,
  PathsGraphs
)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelBootstrap	list containing the complete set of model parameters after bootstrap estimation procedure
NumOutPE	list of model parameter point estimates
InputsForOutputs	list conataining the desired inputs for the construction of the outputs of interest
Economies	a string-vector containing the names of the economies which are part of the economic system
PathsGraphs	path of the folder in which the graphs will be saved

FEVDandGFEVDbs_sepQ *Creates the confidence bounds and the graphs of FEVDs and GFEVDs after bootstrap ("sep Q" models)*

Description

Creates the confidence bounds and the graphs of FEVDs and GFEVDs after bootstrap ("sep Q" models)

Usage

```
FEVDandGFEVDbs_sepQ(
  ModelType,
  ModelBootstrap,
  NumOutPE,
  InputsForOutputs,
  Economies,
  PathsGraphs
)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelBootstrap	list containing the complete set of model parameters after bootstrap estimation procedure
NumOutPE	list of model parameter point estimates
InputsForOutputs	list conataining the desired inputs for the construction of the outputs of interest
Economies	string-vector containing the names of the economies which are part of the economic system
PathsGraphs	path of the folder in which the graphs will be saved

FEVDgraphsJLLOrtho *FEVDs graphs for orthogonalized risk factors of JLL-based models*

Description

FEVDs graphs for orthogonalized risk factors of JLL-based models

Usage

```
FEVDgraphsJLLOrtho(
  ModelType,
  NumOut,
  WishPdynamicsgraphs,
  WishYieldsgraphs,
  FEVDhoriz,
  PathsGraphs
)
```

Arguments

ModelType	a string-vector containing the label of the model to be estimated
NumOut	list of computed outputs containing the model fit, IRFs, FEVDs, GIRFs, and GFEVDs
WishPdynamicsgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
WishYieldsgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
FEVDhoriz	single numerical vector conataining the desired horizon of analysis for the FEVDs
PathsGraphs	Path of the folder in which the graphs will be saved

---

FEVDgraphsJoint *FEVDs graphs for ("joint Q" models)*

Description

FEVDs graphs for ("joint Q" models)

Usage

```
FEVDgraphsJoint(
  ModelType,
  NumOut,
  WishPdynamicsgraphs,
  WishYieldsgraphs,
  FEVDhoriz,
  PathsGraphs
)
```

Arguments

ModelType	a string-vector containing the label of the model to be estimated
NumOut	list of computed outputs containing the model fit, IRFs, FEVDs, GIRFs, and GFEVDs
WishPdynamicsgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
WishYieldsgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
FEVDhoriz	single numerical vector conataining the desired horizon of analysis for the FEVDs
PathsGraphs	Path of the folder in which the graphs will be saved

---

FEVDgraphsSep *FEVDs graphs for ("sep Q" models)*

Description

FEVDs graphs for ("sep Q" models)

Usage

```
FEVDgraphsSep(
  ModelType,
  NumOut,
  WishPdynamicsgraphs,
  WishYieldsgraphs,
  FEVDhoriz,
  PathsGraphs,
  Economies
)
```

Arguments

ModelType	a string-vector containing the label of the model to be estimated
NumOut	list of computed outputs containing the model fit, IRFs, FEVDs, GIRFs, and GFEVDs
WishPdynamicsgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
WishYieldsgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
FEVDhoriz	single numerical vector conataining the desired horizon of analysis for the FEVDs
PathsGraphs	Path of the folder in which the graphs will be saved
Economies	a string-vector containing the names of the economies which are part of the economic system

FEVDjoint *FEVDs for "joint Q" models*

Description

FEVDs for "joint Q" models

Usage

```
FEVDjoint(ModelType, ModelPara, FEVDhoriz, FactorLabels, Economies)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelPara	list of model parameter estimates (see the "Optimization" function)
FEVDhoriz	single numerical vector conataining the desired horizon of analysis for the FEVDs
FactorLabels	string-list based which contains all the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

Details

Structural shocks are identified via Cholesky decomposition

FEVDjointOrthogoJLL *Orthogonalized FEVDs for JLL models*

Description

Orthogonalized FEVDs for JLL models

Usage

```
FEVDjointOrthogoJLL(ModelType, ModelPara, FEVDhoriz, FactorLabels, Economies)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelPara	list of model parameter estimates (see the "Optimization" function)
FEVDhoriz	single numerical vector conataining the desired horizon of analysis for the FEVDs
FactorLabels	string-list based which contains all the labels of all the variables present in the model
Economies	a string-vector containing the names of the economies which are part of the economic system

Details

Structural shocks are identified via Cholesky decomposition

`FEVDjointOrthogoJLL_BS` *FEVDs after bootstrap for JLL-based models*

Description

FEVDs after bootstrap for JLL-based models

Usage

```
FEVDjointOrthogoJLL_BS(
  ModelType,
  ModelParaBoot,
  FEVDhoriz,
  FactorLabels,
  Economies
)
```

Arguments

`ModelType`	string-vector containing the label of the model to be estimated
`ModelParaBoot`	list of model parameter estimates (see the "Optimization" function) after a bootstrap draw
`FEVDhoriz`	single numerical vector conataining the desired horizon of analysis for the FEVDs
`FactorLabels`	string-list based which contains all the labels of all the variables present in the model
`Economies`	string-vector containing the names of the economies which are part of the economic system

---

`FEVDjoint_BS` *FEVDs after bootstrap for "joint Q" models*

Description

FEVDs after bootstrap for "joint Q" models

Usage

```
FEVDjoint_BS(ModelType, ModelParaBoot, FEVDhoriz, FactorLabels, Economies)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelParaBoot	list of model parameter estimates (see the "Optimization" function) after a bootstrap draw
FEVDhoriz	single numerical vector conataining the desired horizon of analysis for the FEVDs
FactorLabels	string-list based which contains all the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

---

FEVDsep *FEVDs for "sep Q" models*

Description

FEVDs for "sep Q" models

Usage

```
FEVDsep(ModelType, ModelPara, FEVDhoriz, FactorLabels, Economies)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelPara	list of model parameter estimates (see the "Optimization" function)
FEVDhoriz	single numerical vector conataining the desired horizon of analysis for the FEVDs
FactorLabels	string-list based which contains all the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

Details

Structural shocks are identified via Cholesky decomposition

FEVDsep_BS *FEVDs after bootstrap for "sep Q" models*

Description

FEVDs after bootstrap for "sep Q" models

Usage

```
FEVDsep_BS(ModelType, ModelParaBoot, FEVDhoriz, FactorLabels, Economies)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelParaBoot	list of model parameter estimates (see the "Optimization" function) after a bootstrap draw
FEVDhoriz	single numerical vector conataining the desired horizon of analysis for the FEVDs
FactorLabels	string-list based which contains all the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

FitgraphsJoint *Model fit graphs for ("joint Q" models)*

Description

Model fit graphs for ("joint Q" models)

Usage

```
FitgraphsJoint(
  ModelType,
  WishFitgraphs,
  ModelPara,
  NumOut,
  Economies,
  PathsGraphs
)
```

Arguments

ModelType	a string-vector containing the label of the model to be estimated
WishFitgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
ModelPara	List of model parameter estimates (See the "Optimization" function)
NumOut	list of computed outputs containing the model fit, IRFs, FEVDs, GIRFs, and GFEVDs
Economies	a string-vector containing the names of the economies which are part of the economic system
PathsGraphs	Path of the folder in which the graphs will be saved

---

FitgraphsSep *Model fit graphs for ("sep Q" models)*

Description

Model fit graphs for ("sep Q" models)

Usage

```
FitgraphsSep(
  ModelType,
  WishFitgraphs,
  ModelPara,
  NumOut,
  Economies,
  PathsGraphs
)
```

Arguments

ModelType	a string-vector containing the label of the model to be estimated
WishFitgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
ModelPara	List of model parameter estimates (See the "Optimization" function)
NumOut	list of computed outputs containing the model fit, IRFs, FEVDs, GIRFs, and GFEVDs
Economies	a string-vector containing the names of the economies which are part of the economic system
PathsGraphs	Path of the folder in which the graphs will be saved

FMN__Rotate *Performs state rotations*

Description

Performs state rotations

Usage

```
FMN__Rotate(y0, U1, U0)
```

Arguments

y0	list of model parameters as described below
U1	matrix (N x N)
U0	vector (N x 1). Optional. Default: vector of zeros.

Details

This function performs a rotation from a model with Z as states to one with S = U0 + U1*Z as states.
Specifically, each model is characterized by the following inputs organized in a list of variables:
(i) K0: intercepts (N x 1);
(ii) K1: feedback matrix (N x N*p);
(iii) SS: volatility matrices (N x N*(M+1))
More specifically, the state Z follows the dynamics:
Z_t = N(K0 + K1 [Z_{t-1}; Z_{t-2}; ...], SSi[, , 1] + sum_{i=1}^M SSi[, ,i+1] where SSi <- array(SS, c(N, N, M+1))

Value

y1 - list of outputs after the transformation, the structure parallels that of y0

References

#' This function is modified version of the "FMN__Rotate" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at: https://cepr.org/40029

`ForecastYields` *Gather bond yields forecasts for all the model types*

Description

Gather bond yields forecasts for all the model types

Usage

```
ForecastYields(
  ModelType,
  ModelPara,
  InputsForOutputs,
  FactorLabels,
  Economies,
  DataFrequency,
  JLLinputs,
  GVARinputs
)
```

Arguments

`ModelType`	a string-vector containing the label of the model to be estimated
`ModelPara`	List of model parameter estimates (See the "Optimization" function)
`InputsForOutputs`	list conataining the desired horizon of analysis for the IRFs, GIRFs, FEVDs, and GFEVDs
`FactorLabels`	a string-list based which contains all the labels of all the variables present in the model
`Economies`	string-vector containing the names of the economies which are part of the economic system
`DataFrequency`	text: "Daily All Days", "Daily Business Days", "Weekly", "Monthly", "Quarterly", "Annually"
`JLLinputs`	list of necessary inputs for the estimation of JLL-based models (see "JLL" function)
`GVARinputs`	list of necessary inputs for the estimation of GVAR-based models (see "GVAR" function)

Value

List containg the following elements

1. Out-of-sample forecasts of bond yields per forecast horizon
2. Out-of-sample forecast errors of bond yields per forecast horizon
3. Root mean square errors per forecast horizon

Examples

```
# See examples in the vignette file of this package (Section 4).
```

`ForecastYieldsJointQ` *Bond yields forecasts ("joint Q" models)*

Description

Bond yields forecasts ("joint Q" models)

Usage

```
ForecastYieldsJointQ(
  ModelType,
  ModelPara,
  InputsForOutputs,
  FactorLabels,
  Economies,
  DataFrequency,
  JLLinputs,
  GVARinputs
)
```

Arguments

`ModelType`	a string-vector containing the label of the model to be estimated
`ModelPara`	List of model parameter estimates (See the "Optimization" function)
`InputsForOutputs`	list conataining the desired horizon of analysis for the IRFs, GIRFs, FEVDs, and GFEVDs
`FactorLabels`	a string-list based which contains all the labels of all the variables present in the model
`Economies`	string-vector containing the names of the economies which are part of the economic system
`DataFrequency`	character-based vector: "Daily All Days", "Daily Business Days", "Weekly", "Monthly", "Quarterly", "Annually"
`JLLinputs`	list of necessary inputs for the estimation of JLL-based models (see "JLL" function)
`GVARinputs`	list of necessary inputs for the estimation of GVAR-based models (see "GVAR" function)

`ForecastYieldsSepQ` *Bond yields forecasts ("sep Q" models)*

Description

Bond yields forecasts ("sep Q" models)

Usage

```
ForecastYieldsSepQ(
  ModelType,
  ModelPara,
  InputsForOutputs,
  FactorLabels,
  Economies,
  DataFrequency,
  JLLinputs,
  GVARinputs
)
```

Arguments

`ModelType`	a string-vector containing the label of the model to be estimated
`ModelPara`	List of model parameter estimates (See the "Optimization" function)
`InputsForOutputs`	list conataining the desired horizon of analysis for the IRFs, GIRFs, FEVDs, and GFEVDs
`FactorLabels`	a string-list based which contains all the labels of all the variables present in the model
`Economies`	string-vector containing the names of the economies which are part of the economic system
`DataFrequency`	character-based vector: "Daily All Days", "Daily Business Days", "Weekly", "Monthly", "Quarterly", "Annually"
`JLLinputs`	list of necessary inputs for the estimation of JLL-based models (see "JLL" function)
`GVARinputs`	list of necessary inputs for the estimation of GVAR-based models (see "GVAR" function)

Functionf *Set up the vector-valued objective function (Point estimate)*

Description

Set up the vector-valued objective function (Point estimate)

Usage

```
Functionf(MLEinputs, Economies, mat, DataFrequency, FactorLabels, ModelType)
```

Arguments

MLEinputs	Set of inputs that are necessary to the log-likelihood function
Economies	string-vector containing the names of the economies which are part of the economic system
mat	vector of maturities (in years) of yields used in estimation (J x 1)
DataFrequency	character-based vector: "Daily All Days", "Daily Business Days", "Weekly", "Monthly", "Quarterly", "Annually"
FactorLabels	string-list based which contains the labels of all the variables present in the model
ModelType	string-vector containing the label of the model to be estimated

Value

objective function

Examples

```
# See examples in the vignette file of this package (Section 4).
```

Functionf_Boot *Set up the vector-valued objective function (Bootstrap)*

Description

Set up the vector-valued objective function (Bootstrap)

Usage

```
Functionf_Boot(
  ModelType,
  MLEinputsBS,
  Economies,
  mat,
  dt,
  FactorLabels,
  residBS,
  MaxEigen,
  JLLinputs,
  GVARinputs
)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
MLEinputsBS	Set of inputs that are necessary to the log-likelihood function
Economies	string-vector containing the names of the economies which are part of the economic system
mat	vector of maturities (in years) of yields used in estimation (J x 1)
dt	adjusted yearly frequency of the data
FactorLabels	string-list based which contains the labels of all the variables present in the model
residBS	indexes of the re-ordered bootstrap residuals
MaxEigen	largest eigenvalue under the P-dynamics
JLLinputs	necessary inputs for the estimation of JLL-based models
GVARinputs	necessary inputs for the estimation of GVAR-based models

---

f_with_vectorized_parameters

Use function f to generate the outputs from a ATSM

Description

Use function f to generate the outputs from a ATSM

Usage

```
f_with_vectorized_parameters(
  x,
  sizex,
  f,
  con,
```

```
  varargin,
  ModelType,
  FactorLabels,
  Economies,
  JLLinputs,
  GVARinputs,
  nargout
)
```

Arguments

x	vector containing all the vectorized auxiliary parameters
sizex	matrix (6x2) containing the size information of all parameters
f	vector-valued objective function (function)
con	if con = 'concentration', then set the value of the parameter whose name contains @ to empty
varargin	variable inputs used in the optimization (see inputs from "optimization" function)
ModelType	string-vector containing the label of the model to be estimated
FactorLabels	string-list based which contains the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system
JLLinputs	Set of necessary inputs used in the estimation of the JLL-based models (see "JLL" function)
GVARinputs	Set of necessary inputs used in the estimation of the GVAR-based models (see "GVAR" function)
nargout	if nargout <- 1, returns only the values of the likelihood function. If nargout <- 2, generates the entire set of outputs

References

This function is modified version of the "f_with_vectorized_parameters" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at: https://cepr.org/40029

GaussianDensity *computes the density function of a gaussian process*

Description

computes the density function of a gaussian process

Usage

```
GaussianDensity(res, SS, invSS, logabsdetSS)
```

Arguments

res	matrix of residuals (N x T)
SS	covariance matrice or array of covariance matrices (If dim(SS) > 3, then the model has a stochastic volatility) (N x N) or (N x N x T)
invSS	Inverse of SS (N x N) or (N x N x T) - optional input
logabsdetSS	log(abs(|SS|)) (1 x T) - optional input

Value

y - vector of density (1 x T)

References

This function is based on the "Gaussian" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at: https://cepr.org/40029

getpara *Extract the parameter values from varargin*

Description

Extract the parameter values from varargin

Usage

```
getpara(varargin)
```

Arguments

varargin	All parameter features

References

This function is modified version of the "getpara" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at: https://cepr.org/40029

`getx` *Obtain the auxiliary values corresponding to each parameter, its size and its name*

Description

Obtain the auxiliary values corresponding to each parameter, its size and its name

Usage

```
getx(con, varargin, Economies, FactorLabels, JLLinputs = NULL)
```

Arguments

`con`	If con = 'concentration' and a parameter's name contains '@', then its auxiliary value is set to empty
`varargin`	variable inputs used in the optimization (see "optimization" function)
`Economies`	string-vector containing the names of the economies which are part of the economic system
`FactorLabels`	list of necessary inputs for the estimation of JLL-based models (see "JLL" function)
`JLLinputs`	Necessary inputs for the estimation of the JLL-based models

References

This function is a modified version of the "getx" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling).

GFEVDgraphsJLLOrtho *GFEVDs graphs for orthogonalized risk factors of JLL-based models*

Description

GFEVDs graphs for orthogonalized risk factors of JLL-based models

Usage

```
GFEVDgraphsJLLOrtho(
  ModelType,
  NumOut,
  WishPdynamicsgraphs,
  WishYieldsgraphs,
  GFEVDhoriz,
  PathsGraphs
)
```

Arguments

ModelType	a string-vector containing the label of the model to be estimated
NumOut	list of computed outputs containing the model fit, IRFs, FEVDs, GIRFs, and GFEVDs
WishPdynamicsgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
WishYieldsgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
GFEVDhoriz	single numerical vector conataining the desired horizon of analysis for the GFEVDs
PathsGraphs	Path of the folder in which the graphs will be saved

GFEVDgraphsJoint *GFEVDs graphs for ("joint Q" models)*

Description

GFEVDs graphs for ("joint Q" models)

Usage

```
GFEVDgraphsJoint(
  ModelType,
  NumOut,
  WishPdynamicsgraphs,
  WishYieldsgraphs,
  GFEVDhoriz,
  PathsGraphs
)
```

Arguments

ModelType	a string-vector containing the label of the model to be estimated
NumOut	list of computed outputs containing the model fit, IRFs, FEVDs, GIRFs, and GFEVDs
WishPdynamicsgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
WishYieldsgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
GFEVDhoriz	single numerical vector conataining the desired horizon of analysis for the GFEVDs
PathsGraphs	Path of the folder in which the graphs will be saved

---

GFEVDgraphsSep *GFEVDs graphs for ("sep Q" models)*

Description

GFEVDs graphs for ("sep Q" models)

Usage

```
GFEVDgraphsSep(
  ModelType,
  NumOut,
  WishPdynamicsgraphs,
  WishYieldsgraphs,
  GFEVDhoriz,
  PathsGraphs,
  Economies
)
```

Arguments

ModelType	a string-vector containing the label of the model to be estimated
NumOut	list of computed outputs containing the model fit, IRFs, FEVDs, GIRFs, and GFEVDs
WishPdynamicsgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
WishYieldsgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
GFEVDhoriz	single numerical vector conataining the desired horizon of analysis for the GFEVDs
PathsGraphs	Path of the folder in which the graphs will be saved
Economies	a string-vector containing the names of the economies which are part of the economic system

---

GFEVDjoint *GFEVDs for "joint Q" models*

Description

GFEVDs for "joint Q" models

Usage

```
GFEVDjoint(ModelType, ModelPara, GFEVDhoriz, FactorLabels, Economies)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelPara	list of model parameter estimates (see the "Optimization" function)
GFEVDhoriz	single numerical vector conataining the desired horizon of analysis for the GFEVDs
FactorLabels	string-list based which contains all the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

References

- This function is a modified and extended version of the "fevd" function from Smith, L.V. and A. Galesi (2014). GVAR Toolbox 2.0, available at https://sites.google.com/site/gvarmodelling/gvar-toolbox.
- Pesaran and Shin, 1998. "Generalized impulse response analysis in linear multivariate models" (Economics Letters)

GFEVDjointOrthoJLL *Orthogonalized GFEVDs for JLL models*

Description

Orthogonalized GFEVDs for JLL models

Usage

```
GFEVDjointOrthoJLL(ModelType, ModelPara, GFEVDhoriz, FactorLabels, Economies)
```

Arguments

ModelType	a string-vector containing the label of the model to be estimated
ModelPara	List of model parameter estimates (See the "Optimization" function)
GFEVDhoriz	single numerical vector conataining the desired horizon of analysis for the GFEVDs
FactorLabels	a string-list based which contains all the labels of all the variables present in the model
Economies	a string-vector containing the names of the economies which are part of the economic system

References

- This function is a modified and extended version of the "fevd" function from Smith, L.V. and A. Galesi (2014). GVAR Toolbox 2.0, available at https://sites.google.com/site/gvarmodelling/gvar-toolbox.
- Pesaran and Shin, 1998. "Generalized impulse response analysis in linear multivariate models" (Economics Letters)

GFEVDjointOrthoJLL_BS *GFEVDs after bootstrap for JLL-based models*

Description

GFEVDs after bootstrap for JLL-based models

Usage

```
GFEVDjointOrthoJLL_BS(
  ModelType,
  ModelParaBoot,
  GFEVDhoriz,
  FactorLabels,
  Economies
)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelParaBoot	list of model parameter estimates (see the "Optimization" function) after a bootstrap draw
GFEVDhoriz	single numerical vector conataining the desired horizon of analysis for the GFEVDs
FactorLabels	string-list based which contains all the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

References

- This function is a modified and extended version of the "fevd" function from Smith, L.V. and A. Galesi (2014). GVAR Toolbox 2.0, available at https://sites.google.com/site/gvarmodelling/gvar-toolbox.
- Pesaran and Shin, 1998. "Generalized impulse response analysis in linear multivariate models" (Economics Letters)

GFEVDjoint_BS *GFEVDs after bootstrap for "joint Q" models*

Description

GFEVDs after bootstrap for "joint Q" models

Usage

```
GFEVDjoint_BS(ModelType, ModelParaBoot, GFEVDhoriz, FactorLabels, Economies)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelParaBoot	List of model parameter estimates (See the "Optimization" function) after a bootstrap draw
GFEVDhoriz	single numerical vector conataining the desired horizon of analysis for the GFEVDs
FactorLabels	string-list based which contains all the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

References

- This function is a modified and extended version of the "fevd" function from Smith, L.V. and A. Galesi (2014). GVAR Toolbox 2.0, available at https://sites.google.com/site/gvarmodelling/gvar-toolbox.
- Pesaran and Shin, 1998. "Generalized impulse response analysis in linear multivariate models" (Economics Letters)

`GFEVDsep` *GFEVDs for "sep Q" models*

Description

GFEVDs for "sep Q" models

Usage

```
GFEVDsep(ModelType, ModelPara, GFEVDhoriz, FactorLabels, Economies)
```

Arguments

`ModelType`	string-vector containing the label of the model to be estimated
`ModelPara`	list of model parameter estimates (see the "Optimization" function)
`GFEVDhoriz`	single numerical vector conataining the desired horizon of analysis for the GFEVDs
`FactorLabels`	string-list based which contains all the labels of all the variables present in the model
`Economies`	string-vector containing the names of the economies which are part of the economic system

References

- This function is a modified and extended version of the "fevd" function from Smith, L.V. and A. Galesi (2014). GVAR Toolbox 2.0, available at https://sites.google.com/site/gvarmodelling/gvar-toolbox.
- Pesaran and Shin, 1998. "Generalized impulse response analysis in linear multivariate models" (Economics Letters)

GFEVDsep_BS *GFEVDs after bootstrap for "sep Q" models*

Description

GFEVDs after bootstrap for "sep Q" models

Usage

```
GFEVDsep_BS(ModelType, ModelParaBoot, GFEVDhoriz, FactorLabels, Economies)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelParaBoot	list of model parameter estimates (see the "Optimization" function) after a bootstrap draw
GFEVDhoriz	single numerical vector conataining the desired horizon of analysis for the GFEVDs
FactorLabels	string-list based which contains all the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

References

- This function is a modified and extended version of the "fevd" function from Smith, L.V. and A. Galesi (2014). GVAR Toolbox 2.0, available at https://sites.google.com/site/gvarmodelling/gvar-toolbox.
- Pesaran and Shin, 1998. "Generalized impulse response analysis in linear multivariate models" (Economics Letters)

GIRFgraphsJLLOrtho *GIRFs graphs for orthogonalized risk factors of JLL-based models*

Description

GIRFs graphs for orthogonalized risk factors of JLL-based models

Usage

```
GIRFgraphsJLLOrtho(
  ModelType,
  NumOut,
  WishPdynamicsgraphs,
  WishYieldsgraphs,
  GIRFhoriz,
  PathsGraphs
)
```

Arguments

ModelType	a string-vector containing the label of the model to be estimated
NumOut	list of computed outputs containing the model fit, IRFs, FEVDs, GIRFs, and GFEVDs
WishPdynamicsgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
WishYieldsgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
GIRFhoriz	single numerical vector conataining the desired horizon of analysis for the GIRFs
PathsGraphs	Path of the folder in which the graphs will be saved

---

GIRFgraphsJoint *GIRFs graphs for ("joint Q" models)*

Description

GIRFs graphs for ("joint Q" models)

Usage

```
GIRFgraphsJoint(
  ModelType,
  NumOut,
  WishPdynamicsgraphs,
  WishYieldsgraphs,
  GIRFhoriz,
  PathsGraphs
)
```

Arguments

ModelType	a string-vector containing the label of the model to be estimated
NumOut	list of computed outputs containing the model fit, IRFs, FEVDs, GIRFs, and GFEVDs
WishPdynamicsgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
WishYieldsgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
GIRFhoriz	single numerical vector conataining the desired horizon of analysis for the GIRFs
PathsGraphs	Path of the folder in which the graphs will be saved

GIRFgraphsSep *GIRFs graphs for ("sep Q" models)*

Description

GIRFs graphs for ("sep Q" models)

Usage

```
GIRFgraphsSep(
  ModelType,
  NumOut,
  WishPdynamicsgraphs,
  WishYieldsgraphs,
  GIRFhoriz,
  PathsGraphs,
  Economies
)
```

Arguments

ModelType	a string-vector containing the label of the model to be estimated
NumOut	list of computed outputs containing the model fit, IRFs, FEVDs, GIRFs, and GFEVDs
WishPdynamicsgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
WishYieldsgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
GIRFhoriz	single numerical vector conataining the desired horizon of analysis for the GIRFs
PathsGraphs	Path of the folder in which the graphs will be saved
Economies	a string-vector containing the names of the economies which are part of the economic system

GIRFjoint *GIRFs for "joint Q" models*

Description

GIRFs for "joint Q" models

Usage

```
GIRFjoint(ModelType, ModelPara, GIRFhoriz, FactorLabels, Economies)
```

Arguments

ModelType	a string-vector containing the label of the model to be estimated
ModelPara	List of model parameter estimates (See the "Optimization" function)
GIRFhoriz	single numerical vector conataining the desired horizon of analysis for the GIRFs
FactorLabels	a string-list based which contains all the labels of all the variables present in the model
Economies	a string-vector containing the names of the economies which are part of the economic system

References

- This function is a modified and extended version of the "irf" function from Smith, L.V. and A. Galesi (2014). GVAR Toolbox 2.0, available at https://sites.google.com/site/gvarmodelling/gvar-toolbox.
- Pesaran and Shin, 1998. "Generalized impulse response analysis in linear multivariate models" (Economics Letters)

GIRFjointOrthoJLL *Orthogonalized GIRFs for JLL models*

Description

Orthogonalized GIRFs for JLL models

Usage

```
GIRFjointOrthoJLL(ModelType, ModelPara, GIRFhoriz, FactorLabels, Economies)
```

Arguments

ModelType	a string-vector containing the label of the model to be estimated
ModelPara	List of model parameter estimates (See the "Optimization" function)
GIRFhoriz	single numerical vector conataining the desired horizon of analysis for the GIRFs
FactorLabels	a string-list based which contains all the labels of all the variables present in the model
Economies	a string-vector containing the names of the economies which are part of the economic system

References

- This function is a modified and extended version of the "irf" function from Smith, L.V. and A. Galesi (2014). GVAR Toolbox 2.0, available at https://sites.google.com/site/gvarmodelling/gvar-toolbox.
- Pesaran and Shin, 1998. "Generalized impulse response analysis in linear multivariate models" (Economics Letters)

GIRFjointOrthoJLL_BS *GIRFs after bootstrap for JLL-based models*

Description

GIRFs after bootstrap for JLL-based models

Usage

```
GIRFjointOrthoJLL_BS(
  ModelType,
  ModelParaBoot,
  GIRFhoriz,
  FactorLabels,
  Economies
)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelParaBoot	list of model parameter estimates (see the "Optimization" function) after a bootstrap draw
GIRFhoriz	single numerical vector conataining the desired horizon of analysis for the GIRFs
FactorLabels	string-list based which contains the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

References

- This function is a modified and extended version of the "irf" function from Smith, L.V. and A. Galesi (2014). GVAR Toolbox 2.0, available at https://sites.google.com/site/gvarmodelling/gvar-toolbox.
- Pesaran and Shin, 1998. "Generalized impulse response analysis in linear multivariate models" (Economics Letters)

GIRFjoint_BS *GIRFs after bootstrap for "joint Q" models*

Description

GIRFs after bootstrap for "joint Q" models

Usage

```
GIRFjoint_BS(ModelType, ModelParaBoot, GIRFhoriz, FactorLabels, Economies)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelParaBoot	list of model parameter estimates (see the "Optimization" function) after a bootstrap draw
GIRFhoriz	single numerical vector conataining the desired horizon of analysis for the GIRFs
FactorLabels	string-list based which contains all the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

References

- This function is a modified and extended version of the "irf" function from Smith, L.V. and A. Galesi (2014). GVAR Toolbox 2.0, available at https://sites.google.com/site/gvarmodelling/gvar-toolbox.
- Pesaran and Shin, 1998. "Generalized impulse response analysis in linear multivariate models" (Economics Letters)

GIRFSep *GIRFs for "sep Q" models*

Description

GIRFs for "sep Q" models

Usage

```
GIRFSep(ModelType, ModelPara, GIRFhoriz, FactorLabels, Economies)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelPara	list of model parameter estimates (see the "Optimization" function)
GIRFhoriz	single numerical vector conataining the desired horizon of analysis for the GIRFs
FactorLabels	string-list based which contains all the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

References

- This function is a modified and extended version of the "irf" function from Smith, L.V. and A. Galesi (2014). GVAR Toolbox 2.0, available at https://sites.google.com/site/gvarmodelling/gvar-toolbox.
- Pesaran and Shin, 1998. "Generalized impulse response analysis in linear multivariate models" (Economics Letters)

GIRFSep_BS *GIRFs after bootstrap for "sep Q" models*

Description

GIRFs after bootstrap for "sep Q" models

Usage

```
GIRFSep_BS(ModelType, ModelParaBoot, GIRFhoriz, FactorLabels, Economies)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelParaBoot	list of model parameter estimates (see the "Optimization" function) after a bootstrap draw
GIRFhoriz	single numerical vector conataining the desired horizon of analysis for the GIRFs
FactorLabels	string-list based which contains all the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

References

- This function is a modified and extended version of the "irf" function from Smith, L.V. and A. Galesi (2014). GVAR Toolbox 2.0, available at https://sites.google.com/site/gvarmodelling/gvar-toolbox.
- Pesaran and Shin, 1998. "Generalized impulse response analysis in linear multivariate models" (Economics Letters)

GraphicalOutputs *Generate the graphical outputs for the selected models (Point estimate)*

Description

Generate the graphical outputs for the selected models (Point estimate)

Usage

```
GraphicalOutputs(
  ModelType,
  ModelPara,
  NumOut,
  InputsForOutputs,
  Economies,
  FactorLabels
)
```

Arguments

ModelType	a string-vector containing the label of the model to be estimated
ModelPara	List of model parameter estimates (See the "Optimization" function)
NumOut	list of computed outputs containing the model fit, IRFs, FEVDs, GIRFs, and GFEVDs
InputsForOutputs	list containing the desired inputs for the construction of the desired output
Economies	string-vector containing the names of the economies which are part of the economic system
FactorLabels	string-list based which contains the labels of all the variables present in the model

GVAR *Estimate a GVAR(1) and a VARX(1,1,1)*

Description

Estimate a GVAR(1) and a VARX(1,1,1)

Usage

```
GVAR(GVARinputs, N)
```

Arguments

`GVARinputs` List containing the following necessary inputs for the estimation of the GVAR:

1. Economies: string-vector containing the names of the economies which are part of the economic system
2. 'GVARFactors': list of all variables that are used in the estimation of the VARX
   (see e.g. 'CM_Factors_GVAR' file);
3. 'VARXtype': character-vector containing two possibilities:
   - 'unconstrained': model is estimated without any constrained (each equation is estimated individually by OLS);
   - 'constrained: Spanned Factors': model is estimated taking into account the fact that foreign-pricing-factors do NOT impirge on (i) domestic economic variables and (ii) domestic pricing factors. (equations are estimated by restricted least squares)
   - 'constrained: ' extended by the name of the risk factor: model is estimated taking into account the fact that the restricted factor is only affected by its own lagged values and the lagged values of its own star variables. (equations are estimated by restricted least squares)
4. 'Wgvar': GVAR transition matrix (C x C) - see the output from 'Transition_Matrix' function

`N` number of country-specific spanned factors (scalar)

Value

A list containing

1. parameters of the country-specific VARX(1,1,1)
   - intercept (M+Nx1);
   - phi_1 (M+N x M+N);
   - phi_1^star (M+N x M+N);
   - phi_g (M+N x M+N);
   - Sigma (M+N x G)
2. parameters of the GVAR.
   - F0 (F X 1);
   - F1 (F x F);
   - Sigma_y (F x F)

References

Chudik and Pesaran, (2016). "Theory and Practice of GVAR modelling" (Journal of Economic Surveys)

Examples

```
data(CM_Factors_GVAR)

N <- 3

GVARinputs <- list()
GVARinputs$Economies <- c("China", "Brazil", "Mexico", "Uruguay")
GVARinputs$GVARFactors <- FactorsGVAR
GVARinputs$VARXtype <- "unconstrained"
GVARinputs$Wgvar <- matrix( c(0, 0.83, 0.86, 0.38,
                              0.65, 0, 0.13, 0.55,
                              0.32, 0.12, 0, 0.07,
                              0.03, 0.05, 0.01, 0), nrow = 4, ncol = 4)

GVAR(GVARinputs, N)
```

IdxAllSpanned *Find the indexes of the spanned factors*

Description

Find the indexes of the spanned factors

Usage

```
IdxAllSpanned(ModelType, FactorLabels, Economies)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
FactorLabels	string-list based which contains the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

---

IdxSpanned *Extract the indexes related to the spanned factors in the variance-covariance matrix*

Description

Extract the indexes related to the spanned factors in the variance-covariance matrix

Usage

```
IdxSpanned(G, M, N, C)
```

Arguments

G	number of global unspanned factors (scalar)
M	number of domestic unspanned factors per country (scalar)
N	number of domestic spanned factors per country (scalar)
C	number of countries of the economic system (scalar)

`InputsForMLEdensity` *Generates several inputs that are necessary to build the likelihood function*

Description

Generates several inputs that are necessary to build the likelihood function

Usage

```
InputsForMLEdensity(
  ModelType,
  Yields,
  PdynamicsFactors,
  FactorLabels,
  mat,
  Economies,
  DataFrequency,
  JLLinputs = NULL,
  GVARinputs = NULL
)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
Yields	time series of yields (JxT or CJ x T)
PdynamicsFactors	time series of the risk factors (K x T)
FactorLabels	string-list based which contains the labels of all the variables present in the model
mat	vector of maturities (in years) used in the estimation
Economies	string-vector containing the names of the economies of the system. If the ModelType selected is "JPS", "JPS jointP", "GVAR sepQ", then only one economy can be selected. For the other models, more than one economy must be selected.
DataFrequency	character-based-vector. Avaialable options are: "Daily All Days", "Daily Business Days", "Weekly", "Monthly", "Quarterly", "Annually"

JLLinputs	list of necessary inputs for the estimation of JLL-based models (see "JLL" function)
GVARinputs	list of necessary inputs for the estimation of GVAR-based models (see "GVAR" function)

Details

To ensure that the risk factors matrix is correctly built for the model "JPS", the global factors should be allocated on the first G rows of this matrix.

Value

List of necessary inputs for constructing the model's log-likelihood function

Examples

```
# Example 1:
data(CM_Factors)
data(CM_Yields)

ModelType <- "JPS"
Economies <- "Mexico"
Factors <- RiskFactors
N <- 3
GlobalVar <- c("GBC", "CPI_OECD") # Global Variables
DomVar <- c("Eco_Act", "Inflation") # Domestic Variables
FactorLabels <- LabFac(N, DomVar,GlobalVar, Economies, ModelType)

mat <- c(0.25, 0.5, 1, 3, 5, 10)
DataFrequency <- "Monthly"

i <- length(Economies)
ATSMInputs <- InputsForMLEdensity(ModelType, Yields, Factors, FactorLabels, mat,
                                  Economies, DataFrequency)
# Example 2:
data(CM_Factors)
data(CM_Yields)
data(CM_Factors_GVAR)

ModelType <- "GVAR jointQ"
Economies <- c("China", "Brazil", "Mexico", "Uruguay")
mat <- c(0.25, 0.5, 1, 3, 5, 10)
DataFrequency <- "Monthly"
Factors  <- RiskFactors
N <- 3
GlobalVar <- c("GBC", "CPI_OECD") # Global Variables
DomVar <- c("Eco_Act", "Inflation") # Domestic Variables
FactorLabels <- LabFac(N, DomVar,GlobalVar, Economies, ModelType)

GVARinputs <- list()
GVARinputs$Economies <- Economies
```

```
GVARinputs$GVARFactors <- FactorsGVAR
GVARinputs$VARXtype <- "unconstrained"
GVARinputs$Wgvar <- matrix( c(0, 0.83, 0.86, 0.38,
               0.65, 0, 0.13, 0.55,
               0.32, 0.12, 0, 0.07,
               0.03, 0.05, 0.01, 0), nrow = 4, ncol = 4)
ATSMInputs <- InputsForMLEdensity(ModelType, Yields, Factors, FactorLabels, mat, Economies,
                                  DataFrequency, JLLinputs= NULL , GVARinputs)

# Example 3:
if (requireNamespace('neldermead', quietly = TRUE)) {

data(CM_Factors)
data(CM_Yields)
ModelType <- "JLL jointSigma"
GlobalVar <- c("GBC", "CPI_OECD") # Global Variables
DomVar <- c("Eco_Act", "Inflation") # Domestic Variables
N <- 3
Economies <- c( "China", "Brazil", "Mexico", "Uruguay")
FactorLabels <- LabFac(N, DomVar, GlobalVar, Economies, ModelType)

Factors <- RiskFactors
mat <- c(0.25, 0.5, 1, 3, 5, 10)
DataFrequency <- "Monthly"
JLLinputs <- list()
JLLinputs$Economies <- Economies
JLLinputs$DomUnit <- "China"
JLLinputs$WishSigmas <- 1
JLLinputs$SigmaNonOrtho <- NULL
JLLinputs$JLLModelType <- ModelType

ATSMInputs <- InputsForMLEdensity(ModelType, Yields, Factors, FactorLabels, mat, Economies,
                                  DataFrequency, JLLinputs)
} else {
 message("skipping functionality due to missing Suggested dependency")
}
```

`InputsForMLEdensity_BS` *Generates several inputs that are necessary to build the likelihood function - Bootstrap version*

Description

Generates several inputs that are necessary to build the likelihood function - Bootstrap version

Usage

```
InputsForMLEdensity_BS(
  ModelType,
  Y_artificial,
  Z_artificial,
  FactorLabels,
  mat,
  Economies,
  DataFrequency,
  JLLinputs = NULL,
  GVARinputs = NULL
)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
Y_artificial	time series of yields (CJ x T or JxT)
Z_artificial	time series of the risk factors (F x T)
FactorLabels	string-list based which contains the labels of all the variables present in the model
mat	vector of maturities (in years) used in the estimation
Economies	string-vector containing the names of the economies of the system. If the ModelType selected is "JPS", "JPS jointP", "GVAR sepQ", then only one economy can be selected. For the other models, more than one economy must be selected.
DataFrequency	character-based-vector. Avaialable options are: "Daily All Days", "Daily Business Days", "Weekly", "Monthly", "Quarterly", "Annually"
JLLinputs	list of necessary inputs for the estimation of JLL-based models (see "JLL" function)
GVARinputs	list of necessary inputs for the estimation of GVAR-based models (see "GVAR" function)

InputsForOutputs *Collect the inputs that are used to construct the numerical and the graphical outputs*

Description

Collect the inputs that are used to construct the numerical and the graphical outputs

Usage

```
InputsForOutputs(
  ModelType,
  Horiz,
  ListOutputWished,
  OutputLabel,
  WishStationarityQ,
  WishGraphYields = 0,
  WishGraphRiskFactors = 0,
  WishOrthoJLLgraphs = 0,
  WishBootstrap = 0,
  ListBoot = NULL,
  WishForecast = 0,
  ListForecast = NULL
)
```

Arguments

`ModelType`	String-vector containing the label of the model to be estimated
`Horiz`	Single numerical vector conataining the desired horizon of analysis for the outputs
`ListOutputWished`	List of desired graphical outputs. Available options are: "Fit","IRF", "FEVD", "GIRF", "GFEVD".
`OutputLabel`	Name of the output label to be stored
`WishStationarityQ`	User must set 1 is she whises to impose the largest eigenvalue under the Q to be strictly smaller than 1, otherwise set 0.
`WishGraphYields`	Binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise. Default is set as "0".
`WishGraphRiskFactors`	Binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise. Default is set as "0".
`WishOrthoJLLgraphs`	Binary variable: set 1, if the user wishes orthogonalized JLL-based graphs to be generated; or set 0, otherwise. Default is set as "0"
`WishBootstrap`	Binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise. Default is set as "0".
`ListBoot`	List containing the four following elements: 1. "methodBS": Desired bootstrap method among (a) 'bs' (standard residual bootstrap), (b) 'wild' (wild bootstrap), (c) 'block' (block bootstrap); 2. "BlockLength": if block bootstrap is chosen, then the user has to specify the lenght of the block (single numerical vector); 3. "ndraws": number of draws;

4. "pctg": level of confidence (single numerical vector expressed in basis points)

`WishForecast` Binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise. Default is set as "0".

`ListForecast` list containing the three following elements:

1. "ForHoriz": forecast horizon;
2. "t0Sample": index of the first variable of the information set;
3. "t0Forecast": index of the first forecast cut-off date.

Value

List of necessary inputs to generate the graphs of the outputs of the desired model

Examples

```
ModelType <- "JPS"
Horiz <- 100
DesiredOutputGraphs <- c("Fit", "GIRF", "GFEVD")
OutputLabel <- "Test"
WishStationarityQ <- 1
WishGraphRiskFac <- 0
WishGraphYields <- 1


InputsList <- InputsForOutputs(ModelType, Horiz, DesiredOutputGraphs, OutputLabel,
                               WishStationarityQ, WishGraphYields, WishGraphRiskFac)
```

`IRFandGIRFbs_jointQ` *Creates the confidence bounds and the graphs of IRFs and GIRFs after bootstrap ("joint Q" models)*

Description

Creates the confidence bounds and the graphs of IRFs and GIRFs after bootstrap ("joint Q" models)

Usage

```
IRFandGIRFbs_jointQ(
  ModelType,
  ModelBootstrap,
  NumOutPE,
  InputsForOutputs,
  Economies,
  PathsGraphs
)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelBootstrap	list containing the complete set of model parameters after bootstrap estimation procedure
NumOutPE	list of model parameter point estimates
InputsForOutputs	list conataining the desired inputs for the construction of the outputs of interest
Economies	string-vector containing the names of the economies which are part of the economic system
PathsGraphs	path of the folder in which the graphs will be saved

---

IRFandGIRFbs_jointQ_Ortho

Creates the confidence bounds and the graphs of IRFs and GIRFs after bootstrap (JLL-based models)

Description

Creates the confidence bounds and the graphs of IRFs and GIRFs after bootstrap (JLL-based models)

Usage

```
IRFandGIRFbs_jointQ_Ortho(
  ModelType,
  ModelBootstrap,
  NumOutPE,
  InputsForOutputs,
  Economies,
  PathsGraphs
)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelBootstrap	list containing the complete set of model parameters after bootstrap estimation procedure
NumOutPE	list of model parameter point estimates
InputsForOutputs	list conataining the desired inputs for the construction of the outputs of interest
Economies	string-vector containing the names of the economies which are part of the economic system
PathsGraphs	path of the folder in which the graphs will be saved

IRFandGIRFbs_sepQ — *Creates the confidence bounds and the graphs of IRFs and GIRFs after bootstrap ("sep Q" models)*

Description

Creates the confidence bounds and the graphs of IRFs and GIRFs after bootstrap ("sep Q" models)

Usage

```
IRFandGIRFbs_sepQ(
  ModelType,
  ModelBootstrap,
  NumOutPE,
  InputsForOutputs,
  Economies,
  PathsGraphs
)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelBootstrap	list containing the complete set of model parameters after bootstrap estimation procedure
NumOutPE	list of model parameter point estimates
InputsForOutputs	list conataining the desired inputs for the construction of the outputs of interest
Economies	string-vector containing the names of the economies which are part of the economic system
PathsGraphs	path of the folder in which the graphs will be saved

IRFgraphsJLLOrtho — *IRFs graphs for orthogonalized risk factors of JLL-based models*

Description

IRFs graphs for orthogonalized risk factors of JLL-based models

Usage

```
IRFgraphsJLLOrtho(
  ModelType,
  NumOut,
  WishPdynamicsgraphs,
  WishYieldsgraphs,
  IRFhoriz,
  PathsGraphs
)
```

Arguments

ModelType	a string-vector containing the label of the model to be estimated
NumOut	list of computed outputs containing the model fit, IRFs, FEVDs, GIRFs, and GFEVDs
WishPdynamicsgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
WishYieldsgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
IRFhoriz	single numerical vector conataining the desired horizon of analysis for the IRFs
PathsGraphs	Path of the folder in which the graphs will be saved

---

IRFgraphsJoint *IRFs graphs for ("joint Q" models)*

Description

IRFs graphs for ("joint Q" models)

Usage

```
IRFgraphsJoint(
  ModelType,
  NumOut,
  WishPdynamicsgraphs,
  WishYieldsgraphs,
  IRFhoriz,
  PathsGraphs
)
```

Arguments

ModelType	a string-vector containing the label of the model to be estimated
NumOut	list of computed outputs containing the model fit, IRFs, FEVDs, GIRFs, and GFEVDs
WishPdynamicsgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
WishYieldsgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
IRFhoriz	single numerical vector conataining the desired horizon of analysis for the IRFs
PathsGraphs	Path of the folder in which the graphs will be saved

---

IRFgraphsSep *IRFs graphs for ("sep Q" models)*

Description

IRFs graphs for ("sep Q" models)

Usage

```
IRFgraphsSep(
  ModelType,
  NumOut,
  WishPdynamicsgraphs,
  WishYieldsgraphs,
  IRFhoriz,
  PathsGraphs,
  Economies
)
```

Arguments

ModelType	a string-vector containing the label of the model to be estimated
NumOut	list of computed outputs containing the model fit, IRFs, FEVDs, GIRFs, and GFEVDs
WishPdynamicsgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
WishYieldsgraphs	binary variable: set 1, if the user wishes graphs to be generated; or set 0, otherwise
IRFhoriz	single numerical vector conataining the desired horizon of analysis for the IRFs
PathsGraphs	Path of the folder in which the graphs will be saved
Economies	a string-vector containing the names of the economies which are part of the economic system

IRFjoint *IRFs for "joint Q" models*

Description

IRFs for "joint Q" models

Usage

```
IRFjoint(ModelType, ModelPara, IRFhoriz, FactorLabels, Economies)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelPara	list of model parameter estimates (see the "Optimization" function)
IRFhoriz	single numerical vector conataining the desired horizon of analysis for the IRFs
FactorLabels	string-list based which contains all the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

Details

Structural shocks are identified via Cholesky decomposition

IRFjointOrthoJLL *Orthogonalized IRFs for JLL models*

Description

Orthogonalized IRFs for JLL models

Usage

```
IRFjointOrthoJLL(ModelType, ModelPara, IRFhoriz, FactorLabels, Economies)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelPara	list of model parameter estimates (see the "Optimization" function)
IRFhoriz	single numerical vector conataining the desired horizon of analysis for the IRFs
FactorLabels	string-list based which contains all the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

Details

Structural shocks are identified via Cholesky decomposition

IRFjointOrthoJLL_BS *IRFs after bootstrap for JLL-based models*

Description

IRFs after bootstrap for JLL-based models

Usage

```
IRFjointOrthoJLL_BS(
  ModelType,
  ModelParaBoot,
  IRFhoriz,
  FactorLabels,
  Economies
)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelParaBoot	list of model parameter estimates (see the "Optimization" function) after a bootstrap draw
IRFhoriz	single numerical vector conataining the desired horizon of analysis for the IRFs
FactorLabels	string-list based which contains all the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

---

IRFjoint_BS *IRFs after bootstrap for "joint Q" models*

Description

IRFs after bootstrap for "joint Q" models

Usage

```
IRFjoint_BS(ModelType, ModelParaBoot, IRFhoriz, FactorLabels, Economies)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelParaBoot	list of model parameter estimates (see the "Optimization" function) after a bootstrap draw
IRFhoriz	single numerical vector conataining the desired horizon of analysis for the IRFs
FactorLabels	a string-list based which contains all the labels of all the variables present in the model
Economies	a string-vector containing the names of the economies which are part of the economic system

---

IRFsep *IRFs for "sep Q" models*

Description

IRFs for "sep Q" models

Usage

```
IRFsep(ModelType, ModelPara, IRFhoriz, FactorLabels, Economies)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelPara	list of model parameter estimates (See the "Optimization" function)
IRFhoriz	single numerical vector conataining the desired horizon of analysis for the IRFs
FactorLabels	string-list based which contains the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

Details

Structural shocks are identified via Cholesky decomposition

IRFsep_BS *IRFs after bootstrap for "sep Q" models*

Description

IRFs after bootstrap for "sep Q" models

Usage

```
IRFsep_BS(ModelType, ModelParaBoot, IRFhoriz, FactorLabels, Economies)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelParaBoot	list of model parameter estimates (see the "Optimization" function) after a bootstrap draw
IRFhoriz	single numerical vector conataining the desired horizon of analysis for the IRFs
FactorLabels	string-list based which contains all the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

JLL *Set of inputs present at JLL's P-dynamics*

Description

Set of inputs present at JLL's P-dynamics

Usage

```
JLL(NonOrthoFactors, N, JLLinputs)
```

Arguments

NonOrthoFactors	Risk factors before the orthogonalization (FxT)
N	Number of country-specific spanned factors
JLLinputs	List of necessary inputs to estimate JLL outputs: 1. Economies: set of economies that are part of the economic system (string-vector) 2. "DomUnit": name of the economy which is assigned as the dominant unit. If no dominant unit is assigned, then this variable is defined as "None"

3. WishSigmas: equal to "1" if one wishes the variance-covariance matrices and the Cholesky factorizations (can take long if they need to be estimated). Set "0", otherwise.
4. SigmaNonOrtho: NULL or some K x K matrix from the non-orthogonalized dynamics
5. JLLModelType: available options are "JLL original", "JLL jointSigma" or "JLL NoDomUnit"

Details

For the models 'JLL original' or "JLL jointSigma" the name of one dominant economy must assigned.
For the model 'JLL NoDomUnit', the name of one dominant economy must be set as "None".

Value

List of model parameters from both the orthogonalized and non-orthogonalized versions of the JLL's based models

References

Jotiskhatira, Le and Lundblad (2015). "Why do interest rates in different currencies co-move?" (Journal of Financial Economics)

Examples

```
if (requireNamespace('neldermead', quietly = TRUE)) {

data(CM_Factors)
ZZ <- RiskFactors
N <- 3

JLLinputs <- list()
JLLinputs$Economies <- c( "China", "Brazil", "Mexico", "Uruguay")
JLLinputs$DomUnit <- "China"
JLLinputs$WishSigmas <- 1
JLLinputs$SigmaNonOrtho <- NULL
JLLinputs$JLLModelType <- "JLL original"
JLL(ZZ, N, JLLinputs)

#'} else {
 message("skipping functionality due to missing Suggested dependency")
}
```

K1XQStationary *Impose stationarity under the Q-measure*

Description

Impose stationarity under the Q-measure

Usage

```
K1XQStationary(StationaryEigenvalues)
```

Arguments

StationaryEigenvalues	Binary variable: set "1" if the user whises the largest eigenvalue to be strictly smaller than 1. Set "0", otherwise

Value

list

Examples

```
stat <- 1 # Takes values 1 and 0
K1XQStationary(stat)
```

killa *Eliminates the @*

Description

Eliminates the @

Usage

```
killa(s)
```

Arguments

s	text vector containing the feature of the variable

References

This function is a modified version of the "killa" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling).

LabelsSpanned *Generate the labels of the spanned factors*

Description

Generate the labels of the spanned factors

Usage

```
LabelsSpanned(N)
```

Arguments

N	number of spanned factors

LabelsStar *Generate the labels of the star variables*

Description

Generate the labels of the star variables

Usage

```
LabelsStar(FactorLabels)
```

Arguments

FactorLabels	Factor labels

LabFac *Generates the labels factors*

Description

Generates the labels factors

Usage

```
LabFac(N, DomVar, GlobalVar, Economies, ModelType)
```

Arguments

N	number of spanned factors per country (scalar)
DomVar	character-vector containing the names of the domestic variables
GlobalVar	character-vector containing the names of the global variables
Economies	string-vector containing the names of the economies which are part of the economic system
ModelType	string-vector containing the label of the model to be estimated

Value

List containing the country-specific risk factor labels

Examples

```
N <- 2
DomVar <- c("inflation", "Economic growth")
GlobalVar <- "Commodity Prices"
Economies <- c("U.S.", "Canada", "Germany", "Japan")
ModelType <- "JPS"

VarLabels <- LabFac(N, DomVar, GlobalVar, Economies, ModelType)
```

Maturities *Create a vector of numerical maturities in years*

Description

Create a vector of numerical maturities in years

Usage

```
Maturities(DataYields, Economies, UnitYields)
```

Arguments

DataYields	matrix containing all yields of the system (JxT,if the model is single-country-based or CJxT if the model is multy-country-based)
Economies	vector containing names of all the economies of the system
UnitYields	(i) "Month": if maturity of yields are expressed in months or (ii) "Year": if maturity of yields are expressed in years

Value

Vector containing all observed maturities expressed in years

Examples

```
data('CM_Yields')
Economies <- c("China", "Brazil", "Mexico", "Uruguay")
Maturities(Yields, Economies, "Month")
```

`MLEdensity_jointQ` *Compute the maximum likelihood function ("joint Q" models)*

Description

Compute the maximum likelihood function ("joint Q" models)

Usage

```
MLEdensity_jointQ(
  K1XQ,
  r0,
  SSZ,
  K0Z,
  K1Z,
  se,
  Gy.0,
  mat,
  Y,
  Z,
  P,
  Wpca,
  We,
  WpcaFull,
  dt,
  Economies,
  FactorLabels,
  ModelType,
  GVARinputs,
  JLLinputs,
  nargout
)
```

Arguments

`K1XQ`	risk-neutral feedback matrix (NxN)
`r0`	long-run interest rate (scalar)
`SSZ`	variance-covariance matrix (KxK)
`K0Z`	intercept from the P-dynamics (Kx1)
`K1Z`	feedback matrix from the P-dynamics (KxK)

se	Variance of the portfolio of yields observed with error (scalar)
Gy.0	matrix of contemporaneous terms from the P-dynamics (KxK)
mat	vector of maturities (in years) of yields used in estimation (J x 1)
Y	matrix of yields used in estimation (J x T)
Z	complete set of spanned and unspanned factors (KxT)
P	complete set of spanned factors (NxT)
Wpca	matrix of weights of the portfolios observed without errors (NxJ)
We	matrix of weights of the portfolios observed with errors ((J-N)xJ)
WpcaFull	composite matrix of weights the portfolios observed with and without errors
dt	time interval unit of the model (scalar). For instance, if data is (i) monthly, dt <- 12; (ii) quarterly, dt <- 4; (iii) yearly, dt <- 1.
Economies	set of economies that are part of the economic system (vector of text)
FactorLabels	string-list based which contains the labels of all the variables present in the model
ModelType	feasible options are (i) "VAR jointQ", (ii) "GVAR jointQ" or (iii) "JLL jointSigma"
GVARinputs	if the model chosen is the "GVAR sepQ", the "GVARinputs" should be specified (see "GVAR" function)
JLLinputs	if the model chosen is the "JLL jointSigma". "JLLinputs" should contain (i) DomUnit, (ii) WishSigmas, (iii) SigmaNonOrtho, (iv) JLLModelType (See JLL function)
nargout	if nargout== 1: provides only the values of the likelihood; if nargout== 2: complete ATSM outputs

References

This function is an extended version of the "A0N_MLEdensity_WOE" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at: https://cepr.org/40029

`MLEdensity_jointQ_sepSigma`

Compute the maximum likelihood function ("joint Q" models for separate Sigma estimation)

Description

Compute the maximum likelihood function ("joint Q" models for separate Sigma estimation)

Usage

```
MLEdensity_jointQ_sepSigma(
  K1XQ,
  r0,
  SSZ,
  K0Z,
  K1Z,
  se,
  Gy.0,
  mat,
  Y,
  Z,
  P,
  Wpca,
  We,
  WpcaFull,
  dt,
  Economies,
  FactorLabels,
  ModelType,
  JLLinputs,
  nargout
)
```

Arguments

K1XQ	risk-neutral feedback matrix (NxN)
r0	long-run interest rate (scalar)
SSZ	variance-covariance matrix (KxK)
K0Z	intercept from the P-dynamics (Kx1)
K1Z	feedback matrix from the P-dynamics (KxK)
se	Variance of the portfolio of yields observed with error (scalar)
Gy.0	matrix of contemporaneous terms from the P-dynamics (KxK)
mat	vector of maturities (in years) of yields used in estimation (J x 1)
Y	matrix of yields used in estimation (J x T)
Z	complete set of spanned and unspanned factors (KxT)
P	complete set of spanned factors (NxT)
Wpca	matrix of weights of the portfolios observed without errors (NxJ)
We	matrix of weights of the portfolios observed with errors ((J-N)xJ)
WpcaFull	composite matrix of weights the portfolios observed with and without errors
dt	time interval unit of the model (scalar). For instance, if data is (i) monthly, dt <- 12; (ii) quarterly, dt <- 4; (iii) yearly, dt <- 1.
Economies	Set of economies that are part of the economic system (vector of text)

FactorLabels	string-list based which contains the labels of all the variables present in the model
ModelType	feasible options are (i) "JLL original" or (ii) "JLL NoDomUnit"
JLLinputs	if the model chosen is the "JLL jointSigma", "JLLinputs" should be specified (see "JLL" function)
nargout	if nargout== 1: provides only the values of the likelihood; if nargout== 2: complete ATSM outputs

References

This function is an extended version of the "A0N_MLEdensity_WOE" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at: https://cepr.org/40029

MLEdensity_sepQ *Compute the maximum likelihood function ("sep Q" models)*

Description

Compute the maximum likelihood function ("sep Q" models)

Usage

```
MLEdensity_sepQ(
  K1XQ,
  r0,
  SSZ,
  K0Z,
  K1Z,
  se,
  Gy.0,
  mat,
  Y,
  Z,
  P,
  Wpca,
  We,
  WpcaFull,
  dt,
  Economy,
  FactorLabels,
  ModelType,
  GVARinputs = NULL,
  nargout
)
```

Arguments

K1XQ	risk-neutral feedback matrix (NxN)
r0	long-run interest rate (scalar)
SSZ	variance-covariance matrix (KxK)
K0Z	intercept from the P-dynamics (Kx1)
K1Z	feedback matrix from the P-dynamics (KxK)
se	Variance of the portfolio of yields observed with error (scalar)
Gy.0	matrix of contemporaneous terms from the P-dynamics (KxK)
mat	vector of maturities (in years) of yields used in estimation (J x 1)
Y	matrix of yields used in estimation (J x T)
Z	complete set of spanned and unspanned factors (KxT)
P	complete set of spanned factors (NxT)
Wpca	matrix of weights of the portfolios observed without errors (NxJ)
We	matrix of weights of the portfolios observed with errors ((J-N)xJ)
WpcaFull	composite matrix of weights the portfolios observed with and without errors
dt	time interval unit of the model (scalar). For instance, if data is (i) monthly, dt <- 12; (ii) quarterly, dt <- 4; (iii) yearly, dt <- 1.
Economy	name of the economy under study
FactorLabels	string-list based which contains the labels of all the variables present in the model
ModelType	Feasible options are: (i) "JPS", (ii) "JPS jointP" or (iii) "GVAR sepQ"
GVARinputs	if the model chosen is the "GVAR sepQ", the "GVARinputs" should be specified (see "GVAR" function)
nargout	if nargout== 1: provides only the values of the likelihood; if nargout== 2: complete ATSM outputs

References

This function is modified version of the "A0N_MLEdensity_WOE" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at: https://cepr.org/40029

ModelPara *Replications of the JPS (2014) outputs by the MultiATSM package*

Description

Unspanned macro risk model outputs by the MultiATSM package

Usage

```
data("JPSrep")
```

Format

list of inputs and outputs

inputs general model inputs

ests model parameters estimates (JPS form)

llk log-likelihood of the observations

rot model parameters estimates (rotation form)

MultiATSM *ATSM Package*

Description

Estimation of several classes of affine term structure of interest rates models.

Author(s)

Rubens Moura <rubens.gtmoura@gmail.com>

NumOutputs *Construct the model numerical outputs (model fit, IRFs, GIRFs, FEVDs, and GFEVDs)*

Description

Construct the model numerical outputs (model fit, IRFs, GIRFs, FEVDs, and GFEVDs)

Usage

```
NumOutputs(ModelType, ModelPara, InputsForOutputs, FactorLabels, Economies)
```

Arguments

ModelType	a string-vector containing the label of the model to be estimated
ModelPara	List of model parameter estimates (See the "Optimization" function)
InputsForOutputs	list conataining the desired horizon of analysis for the model fit, IRFs, GIRFs, FEVDs, and GFEVDs
FactorLabels	a string-list based which contains all the labels of all the variables present in the model
Economies	a string-vector containing the names of the economies which are part of the economic system

Value

List of the model numerical outputs, namely

1. Model fit of bond yields
2. IRFs
3. FEVDs
4. GIRFs
5. GFEVDs

Examples

```
# See examples in the vignette file of this package (Section 4).
```

NumOutputs_Bootstrap *Numerical outputs (IRFs, GIRFs, FEVD, and GFEVD) for bootstrap*

Description

Numerical outputs (IRFs, GIRFs, FEVD, and GFEVD) for bootstrap

Usage

```
NumOutputs_Bootstrap(
  ModelType,
  ModelParaBoot,
  InputsForOutputs,
  FactorLabels,
  Economies
)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelParaBoot	list of model parameter estimates (see the "Optimization" function) after a bootstrap draw
InputsForOutputs	list conataining the desired inputs for the construction of the model fit, IRFs, GIRFs, FEVDs, and GFEVDs
FactorLabels	string-list based which contains all the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

Optimization *Peform the minimization of mean(f)*

Description

Peform the minimization of mean(f)

Usage

```
Optimization(
  f,
  tol,
  varargin,
  FactorLabels,
```

```
  Economies,
  ModelType,
  JLLinputs = NULL,
  GVARinputs = NULL
)
```

Arguments

f	vector-valued objective function (function)
tol	convergence tolerance (scalar). For ML estimation, a reasonable value is tol <- 1e-4
varargin	list containg starting values and constraints: for each input argument K (of f), we need four inputs that look like: 1. a starting value: K0 2. a variable label ('K0') followed by a ':' followed by a type of constraint. The constraint can be: • 'bounded': bounded matrix; • 'Jordan' or 'Jordan MultiCountry': a matrix of Jordan type; • 'psd': psd matrix; • 'stationary': largest eigenvalue of the risk-neutral feedback matrix is strictly smaller than 1; • 'diag' or 'BlockDiag': a diagonal or block diagonal matrix. • 'JLLstructure': to impose the zero-restrictions on the variance-voriance matrix along the lines of the JLL models 3. a lower bound lb (lb <- NULL -> no lower bound) 4. an upper bound ub (ub <- NULL -> no upper bound) 5. Specification of the optimization settings: • 'iter off': hide the printouts of the numerical optimization routines; • 'fminunc only': only uses fminunc for the optimization; • "fminsearch only': only uses fminsearch for the optimization.
FactorLabels	string-list based which contains the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system
ModelType	string-vector containing the label of the model to be estimated
JLLinputs	inputs used in the estimation of the JLL-based models; Default is set to NULL
GVARinputs	inputs used in the estimation of the GVAR-based models; Default is set to NULL

Details

If a variable name starts with a '@', it means that that parameter will be analytically concentrated out in the specification of f. In this case, no starting value is needed for this particular parameter (an empty matrix can be provided as a starting value).

Value

(i) out: list of second output produced by f (the first output of f must be the objective value to be minimized).
(ii) x: list containing parameter estimates

References

This function is based on the "LS__opt" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at: https://cepr.org/40029

Examples

```
#' # See examples in the vignette file of this package (Section 4).
```

Optimization_Boot *Peform the minimization of mean(f) (adapted for the bootstrap setting)*

Description

Peform the minimization of mean(f) (adapted for the bootstrap setting)

Usage

```
Optimization_Boot(
  f,
  tol,
  varargin,
  FactorLabels,
  Economies,
  ModelType,
  JLLinputs = NULL,
  GVARinputs = NULL
)
```

Arguments

f	vector-valued objective function (function)
tol	convergence tolerance (scalar). For ML estimation, a reasonable value is tol <- 1e-4
varargin	list containg starting values and constraints: for each input argument K (of f), we need four inputs that look like: 1. a starting value: K0

2. a variable label ('K0') followed by a ':' followed by a type of constraint. The constraint can be:
   - 'bounded': bounded matrix;
   - 'Jordan' or 'Jordan MultiCountry': a matrix of Jordan type;
   - 'psd': psd matrix;
   - 'stationary': largest eigenvalue of the risk-neutral feedback matrix is strictly smaller than 1;
   - 'diag' or 'BlockDiag': a diagonal or block diagonal matrix.
   - 'JLLstructure': to impose the zero-restrictions on the variance-voriance matrix along the lines of the JLL models
3. a lower bound lb (lb <- NULL -> no lower bound)
4. an upper bound ub (ub <- NULL -> no upper bound)
5. Specification of the optimization settings:
   - 'iter off': hide the printouts of the numerical optimization routines;
   - 'fminunc only': only uses fminunc for the optimization;
   - "fminsearch only': only uses fminsearch for the optimization.

`FactorLabels` string-list based which contains the labels of all the variables present in the model

`Economies` string-vector containing the names of the economies which are part of the economic system

`ModelType` string-vector containing the label of the model to be estimated

`JLLinputs` inputs used in the estimation of the JLL-based models; Default is set to NULL

`GVARinputs` inputs used in the estimation of the GVAR-based models; Default is set to NULL

Details

If a variable name starts with a '@', it means that that parameter will be analytically concentrated out in the specification of f. In this case, no starting value is needed for this particular parameter.An empty matrix can be provided as a starting value

Value

(i) out: list of second output produced by f (the first output of f must be the objective value to be minimized)
(ii) x: list containing parameter estimates

References

This function is based on the "LS__opt" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at: https://cepr.org/40029

`OutputConstructionJoint` *Numerical outputs (variance explained, model fit, IRFs, GIRFs, FEVDs, and GFEVDs) for "joint Q" models*

Description

Numerical outputs (variance explained, model fit, IRFs, GIRFs, FEVDs, and GFEVDs) for "joint Q" models

Usage

```
OutputConstructionJoint(
  ModelType,
  ModelPara,
  InputsForOutputs,
  FactorLabels,
  Economies
)
```

Arguments

`ModelType`	string-vector containing the label of the model to be estimated
`ModelPara`	list of model parameter estimates (see the "Optimization" function)
`InputsForOutputs`	list conataining the desired horizon of analysis for the model fit, IRFs, GIRFs, FEVDs, and GFEVDs
`FactorLabels`	string-list based which contains all the labels of all the variables present in the model
`Economies`	string-vector containing the names of the economies which are part of the economic system

`OutputConstructionJoint_BS` *Gathers all the model numerical ouputs after bootstrap for "joint Q" models*

Description

Gathers all the model numerical ouputs after bootstrap for "joint Q" models

Usage

```
OutputConstructionJoint_BS(
  ModelType,
  ModelParaBoot,
  InputsForOutputs,
  FactorLabels,
  Economies
)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelParaBoot	list of model parameter estimates (see the "Optimization" function) after a bootstrap draw
InputsForOutputs	list conataining the desired inputs for the cunstruction of IRFs, GIRFs, FEVDs, and GFEVDs
FactorLabels	string-list based which contains all the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

---

OutputConstructionSep *Numerical outputs (variance explained, model fit, IRFs, GIRFs, FEVDs, and GFEVDs) for "sep Q" models*

Description

Numerical outputs (variance explained, model fit, IRFs, GIRFs, FEVDs, and GFEVDs) for "sep Q" models

Usage

```
OutputConstructionSep(
  ModelType,
  ModelPara,
  InputsForOutputs,
  FactorLabels,
  Economies
)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelPara	list of model parameter estimates (See the "Optimization" function)
InputsForOutputs	list conataining the desired horizon of analysis for the model fit, IRFs, GIRFs, FEVDs, and GFEVDs
FactorLabels	string-list based which contains all the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

---

OutputConstructionSep_BS

Gathers all the model numerical ouputs after bootstrap for "sep Q" models

---

Description

Gathers all the model numerical ouputs after bootstrap for "sep Q" models

Usage

```
OutputConstructionSep_BS(
  ModelType,
  ModelParaBoot,
  InputsForOutputs,
  FactorLabels,
  Economies
)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelParaBoot	list of model parameter estimates (see the "Optimization" function) after a bootstrap draw
InputsForOutputs	list conataining the desired inputs for the cunstruction of the model fit, IRFs, GIRFs, FEVDs, and GFEVDs
FactorLabels	string-list based which contains all the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

ParaLabels *Create the variable labels used in the estimation*

Description

Create the variable labels used in the estimation

Usage

```
ParaLabels(ModelType, WishStationarityQ)
```

Arguments

ModelType	a string-vector containing the label of the model to be estimated
WishStationarityQ	User must set "1" is she whises to impose the largest eigenvalue under the Q to be strictly smaller than 1. Otherwise set "0"

Value

list containing the features of the parameters that will be used in the estimation

Examples

```
ModelType <- "GVAR jointQ"
WishStationarityQ <- 1
ParaLabels(ModelType, WishStationarityQ)
```

pca_weights_one_country *Weigth matrix from principal components (matrix of eigenvectors)*

Description

Weigth matrix from principal components (matrix of eigenvectors)

Usage

```
pca_weights_one_country(Y, Economy)
```

Arguments

Y	matrix dimension (J x T), where J - the number of maturities and T - time series length
Economy	string-vector containg the name of one economy

Value

matrix (J x J)

Examples

```
data("CM_Yields")
pca_weights_one_country(Yields, Economy= "Brazil")
```

PdynamicsSet_BS *Compute some key parameters from the P-dynamics (Bootstrap set)*

Description

Compute some key parameters from the P-dynamics (Bootstrap set)

Usage

```
PdynamicsSet_BS(
  ModelType,
  AllFactorsUnderP,
  FactorLabels,
  Economies,
  JLLinputs = NULL,
  GVARinputs = NULL
)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
AllFactorsUnderP	complete set of factors that may be used in the estimation of P (KxT)
FactorLabels	string-list based which contains the labels of all the variables present in the model (see "LabFac" function)
Economies	string-vector containing the names of the economies which are part of the economic system
JLLinputs	List containing the necessary inputs for the estimation of the JLL-based models (see "JLL" function). Default is set to NULL.
GVARinputs	List containing the necessary inputs for the estimation of the GVAR-based models (see "GVAR" function). Default is set to NULL.

pos2x *Transform a positive number y to back to x by:*

Description

Transform a positive number y to back to x by:

Usage

```
pos2x(y)
```

Arguments

y	scalar

References

This function is based on the "pos2x" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at: https://cepr.org/40029

Reg_K1Q *Estimate the risk-neutral feedbak matrix K1Q using linear regressions*

Description

Estimate the risk-neutral feedbak matrix K1Q using linear regressions

Usage

```
Reg_K1Q(Y, mat, Z, dt, type)
```

Arguments

Y	matrix of yields used in estimation (J x T)
mat	vector of maturities (in years) of yields used in estimation (J x 1)
Z	pricing factors (can be yields-based or non-yields/macro variables) (N x T)
dt	time unit of the model (scalar). For instance, if data is (i) monthly, dt <- 12; (ii) quarterly, dt <- 4; (iii) yearly, dt <- 1.
type	'Jordan' -> K1Q will be of the Jordan type

Value

Risk neutral feedback matrix K1Q.

References

This function is based on the "Reg_K1Q" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at: https://cepr.org/40029

Examples

```
data(CM_Yields)

Y_China <- Yields[1:6,]
Z_China <- Spanned_Factors(Y_China, Economies ="China", N=3)
mat <-c(0.25 , 0.5 , 1, 3, 5, 10)
dt <- 1/12
type <- 'Jordan'
Reg_K1Q(Y_China, mat, Z_China, dt, type)
```

Reg__OLSconstrained *Restricted OLS regression*

Description

Restricted OLS regression

Usage

```
Reg__OLSconstrained(Y, X, Bcon, G)
```

Arguments

Y	left hand side variables (M x T)
X	regressors (i.e. N-1 variables + the intercept) (N x T)
Bcon	constraints matrix (M x N). If Bcon(i,j) = nan –> B(i,j) is a free parameter
G	weighting matrix (psd) - (M x M). Default is set to be identity

Details

Estimate of B is obtained by minimizing the objective:
sum_t (Y_t-B X_t)' G^-1 (Y_t-B*X_t)
subject to the constraint that B = Bcon for all non-nan entries of Bcon

Value

matrix of coefficient (M x N)

References

This function is based on the "Reg__OLSconstrained" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at:
https://cepr.org/40029

`RemoveNA` *Exclude series that contain NAs*

Description

Exclude series that contain NAs

Usage

```
RemoveNA(YieldsData, MacroData, Economies)
```

Arguments

`YieldsData`	List of country-specific bond yields
`MacroData`	List of country-specific and global economic variables
`Economies`	string-vector containing the names of the economies which are part of the economic system

Value

return the time series data that were not initially composed by NAs.

`RiskFactors` *Data: Risk Factors - Candelon and Moura (2021)*

Description

Risk factors data used in Candelon and Moura (2021)

Usage

```
data("CM_Factors")
```

Format

matrix containing the risk factors of the models

References

Candelon, B. and Moura, R. "A Multi-Country Model of the Term Structures of Interest Rates with a GVAR".

RiskFactorsGraphs *Spanned and unspanned factors plot*

Description

Spanned and unspanned factors plot

Usage

```
RiskFactorsGraphs(ModelType, ModelOutputs, Economies, FactorLabels)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelOutputs	list of model parameter estimates (see the "Optimization" function)
Economies	string-vector containing the names of the economies which are part of the economic system
FactorLabels	string-list based which contains the labels of all the variables present in the model

RiskFactorsPrep *Builds the complete set of time series of the risk factors (spanned and unspanned)*

Description

Builds the complete set of time series of the risk factors (spanned and unspanned)

Usage

```
RiskFactorsPrep(
  FactorSet,
  Economies,
  FactorLabels,
  Initial_Date,
  Final_Date,
  DataFrequency
)
```

Arguments

FactorSet	Factor set list (see e.g. "CM_Factors_GVAR" data file)
Economies	string-vector containing the names of the economies which are part of the economic system
FactorLabels	string-list based which contains the labels of all the variables present in the model
Initial_Date	Sample starting date (yyyy-mm-dd)
Final_Date	Sample last date (yyyy-mm-dd)
DataFrequency	character-based vector: "Daily All Days", "Daily Business Days", "Weekly", "Monthly", "Quarterly", "Annually"

Value

Risk factors used in the estimation of the desired ATSM

RMSEjoint *Compute the root mean square error ("joint Q" models)*

Description

Compute the root mean square error ("joint Q" models)

Usage

```
RMSEjoint(ForecastOutputs)
```

Arguments

ForecastOutputs	List of country-specific forecasts (see "ForecastYieldsjointQ" function)

RMSEsep *Compute the root mean square error ("sep Q" models)*

Description

Compute the root mean square error ("sep Q" models)

Usage

```
RMSEsep(ForecastOutputs)
```

Arguments

ForecastOutputs	List of country-specific forecasts (see "ForecastYieldsSepQ" function)

SpannedFactorsjointQ *Gather all spanned factors ("joint Q" models)*

Description

Gather all spanned factors ("joint Q" models)

Usage

```
SpannedFactorsjointQ(ModelType, ModelPara, Economies, t0Sample, tlastObserved)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelPara	set of model parameters
Economies	string-vector containing the names of the economies which are part of the economic system
t0Sample	index for the initial sample date
tlastObserved	index for the last observation of the information set

SpannedFactorsSepQ *Gather all spanned factors ("sep Q" models)*

Description

Gather all spanned factors ("sep Q" models)

Usage

```
SpannedFactorsSepQ(ModelType, ModelPara, Economies, t0Sample, tlastObserved)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelPara	set of model parameters
Economies	string-vector containing the names of the economies which are part of the economic system
t0Sample	index for the initial sample date
tlastObserved	index for the last observation of the information set

Spanned_Factors *Compute the country-specific spanned factors*

Description

Compute the country-specific spanned factors

Usage

```
Spanned_Factors(Yields, Economies, N)
```

Arguments

Yields	matrix (J x T), where J - the number of maturities and T - time series length
Economies	C-dimensional string-vector containing the names of the economies which are part of the economic system
N	scalar: desired number of spanned factors (maximum number allowed is N= J)

Value

Matrix containing the N spanned for all the countries of the system (CJ xT)

Examples

```
data(CM_Yields)
Economies <- c("China", "Brazil", "Mexico", "Uruguay")
N <- 3
Spanned_Factors(Yields, Economies, N)
```

sqrtm_robust *Compute the square root of a matrix*

Description

Compute the square root of a matrix

Usage

```
sqrtm_robust(m)
```

Arguments

m	squared matrix (KxK)

Value

squred matrix x (KxK) such that x

References

#' This function is a modified version of the "sqrtm_robust" function by Le and Singleton (2018). "A Small Package of Matlab Routines for the Estimation of Some Term Structure Models." (Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at: https://cepr.org/40029

`StarFactors` *Generates the star variables necessary for the GVAR estimation*

Description

Generates the star variables necessary for the GVAR estimation

Usage

```
StarFactors(RiskFactors, Economies, W)
```

Arguments

`RiskFactors`	time series of the risk factors (F x T)
`Economies`	string-vector containing the names of the economies which are part of the economic system
`W`	GVAR transition matrix (C x C)

Value

List containg the star factors of each country of the economic system

Examples

```
data(CM_Factors)
Economies <- c("China", "Brazil", "Mexico", "Uruguay")
Wgvar <- matrix( c(0, 0.83, 0.86, 0.38, 0.65, 0, 0.13, 0.55,
         0.32, 0.12, 0, 0.07, 0.03, 0.05, 0.01, 0), nrow = 4, ncol = 4)
rownames(Wgvar) <- Economies
colnames(Wgvar) <- Economies
StarFactors(RiskFactors, Economies, Wgvar)
```

TradeFlows *Data: Trade Flows - Candelon and Moura (2021)*

Description

Trade Flows data used in Candelon and Moura (2021)

Usage

```
data("CM_Trade")
```

Format

list containing the bilateral trade flows

References

Candelon, B. and Moura, R. "A Multi-Country Model of the Term Structures of Interest Rates with a GVAR".

Transition_Matrix *Compute the transition matrix required in the estimation of the GVAR model*

Description

Compute the transition matrix required in the estimation of the GVAR model

Usage

```
Transition_Matrix(
  t_First,
  t_Last,
  Economies,
  type,
  DataPath = NULL,
  Data = NULL
)
```

Arguments

t_First	Sample starting date (year)
t_Last	Sample last date (year)
Economies	Vector containing the names of all the economies of the system.
type	Three possibilities: • "Full Sample": if one wishes ALL weight matrices of each year from which data is available (it may extrapolate the sample period); • "Sample Mean": if one wishes a SINGLE weight matrix containing the average of weights over of the entire sample period; • Some year in particular (e.g. "1998", "2005" ...).
DataPath	path of the Excel file containing the data (if any). The default is linked to the Excel file available in the package.
Data	Data for computing the transition matrix. Default is set to NULL.

Details

NOTE: if there is missing data for any country of the system for that particularly year, then the transition matrix will include only NAs.

Value

matrix or list of matrices

Examples

```
data(CM_Trade)

t_First <- "2006"
t_Last <-  "2019"
Economies <- c("China", "Brazil", "Mexico", "Uruguay")
type <- "Sample Mean"
Transition_Matrix(t_First, t_Last, Economies, type, DataPath = NULL, Data = TradeFlows)
```

---

true2aux *Map constrained parameters b to unconstrained auxiliary parameters a.*

Description

Map constrained parameters b to unconstrained auxiliary parameters a.

Usage

```
true2aux(b, ctype, lb, ub, Economies, FactorLabels, JLLinputs = NULL)
```

Arguments

b	Constrained parameter
ctype	character-based vector that describes the contraints. Constraints are: • 'Jordan'; • 'Jordan; stationary' • 'Jordan MultiCountry' • 'Jordan MultiCountry; stationary' • 'stationary' • 'psd' • 'BlockDiag' • 'bounded' • 'diag' • 'JLLstructure'
lb	lower bounds of b (for the bounded case). Accomodates a scalar or a matrix.
ub	upper bounds of b (for the bounded case). Accomodates a scalar or a matrix.
Economies	string-vector containing the names of the economies which are part of the economic system
FactorLabels	string-list based which contains the labels of all the variables present in the model
JLLinputs	list of necessary inputs for the estimation of JLL-based models (see "JLL" function)

Value

unconstrained auxiliary matrix.

References

This function is a modified and extended version of the "true2aux" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at: https://cepr.org/40029

---

update_para *converts the vectorized auxiliary parameter vector x to the parameters that go directly into the likelihood function.*

Description

converts the vectorized auxiliary parameter vector x to the parameters that go directly into the likelihood function.

Usage

```
update_para(
  x,
  sizex,
  ii,
  con,
  FactorLabels,
  Economies,
  JLLinputs = NULL,
  GVARinputs = NULL,
  varargin
)
```

Arguments

x	vector containing all the vectorized auxiliary parameters
sizex	matrix (6x2) containing the size information of all parameters
ii	if empty: converts all the parameters; otherwise converts some specific parameters
con	if con = 'concentration', then set the value of the parameter whose name contains @ to empty
FactorLabels	string-list based which contains the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system
JLLinputs	Set of necessary inputs used in the estimation of the JLL-based models
GVARinputs	Set of necessary inputs used in the estimation of the GVAR-based models
varargin	variable inputs used in the optimization (see "Optimization" function)

Value

same form as varargin, except now the parameters are updated with the values provided by the auxiliary x. Importantly, by construction, all the constraints on the underlying parameters are satisfied.

References

This function is a modified version of the "update_para" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at:
https://cepr.org/40029

VAR *Estimates a VAR(1)*

Description

Estimates a VAR(1)

Usage

```
VAR(RiskFactors, VARtype, Bcon = NULL)
```

Arguments

RiskFactors	matrix containing all the risk factors (K x T)
VARtype	string-vector which accommodates two possibilities: 'unconstrained' or 'constrained'
Bcon	constraints matrix (K+1 x N) - should contain an intercept. IfBcon(i,j) = nan –> B(i,j) is a free parameter. Default is set to NULL.

Value

intercept, feedback matrix and the variance-covariance matrix of a VAR(1)

Examples

```
data("CM_Factors")
#Example 1
VAR(RiskFactors, VARtype= 'unconstrained')
#Example 2
K <- nrow(RiskFactors)
Bcon <-matrix(0, nrow = K, ncol = K+1)
Bcon[,1:3] <- NaN
VAR(RiskFactors, VARtype= 'constrained', Bcon)
```

VarianceExplainedJoint

Percentage explained by the spanned factors of the variations in the set of observed yields for "joint Q" models

Description

Percentage explained by the spanned factors of the variations in the set of observed yields for "joint Q" models

Usage

```
VarianceExplainedJoint(ModelType, ModelPara, FactorLabels, Economies)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelPara	list of model parameter estimates (see the "Optimization" function)
FactorLabels	string-list based which contains all the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

---

VarianceExplainedSep *Percentage explained by the spanned factors of the variations in the set of observed yields for "sep Q" models*

Description

Percentage explained by the spanned factors of the variations in the set of observed yields for "sep Q" models

Usage

```
VarianceExplainedSep(ModelType, ModelPara, FactorLabels, Economies)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelPara	List of model parameter estimates (see the "Optimization" function)
FactorLabels	string-list based which contains all the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

---

x2bound *Transform x to a number bounded btw lb and ub by:*

Description

Transform x to a number bounded btw lb and ub by:

Usage

```
x2bound(x, lb, ub, nargout)
```

Arguments

x	number to be transformed (scalar)
lb	lower bound (scalar)
ub	upper bound (scalar)
nargout	"1" or "2" (scalar)

References

This function is based on the "x2bound" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling). Available at: https://cepr.org/40029

---

x2pos *Transform x to a positive number by: y = log(e^x + 1)*

Description

Transform x to a positive number by: y = log(e^x + 1)

Usage

```
x2pos(x, nargout)
```

Arguments

x	scalar or vector
nargout	1 or 2

References

This function is based on the "x2pos" function by Le and Singleton (2018).
"A Small Package of Matlab Routines for the Estimation of Some Term Structure Models."
(Euro Area Business Cycle Network Training School - Term Structure Modelling) Available at: https://cepr.org/40029

Yields — *Data: Yields - Candelon and Moura (2021)*

Description

Yields data used in Candelon and Moura (2021)

Usage

```
data("CM_Yields")
```

Format

matrix containing the Yields of the models

References

Candelon, B. and Moura, R. "A Multi-Country Model of the Term Structures of Interest Rates with a GVAR".

YieldsFitJoint — *Computes two measures of model fit for bond yields*

Description

Computes two measures of model fit for bond yields

Usage

```
YieldsFitJoint(ModelType, ModelPara, FactorLabels, Economies)
```

Arguments

ModelType	string-vector containing the label of the model to be estimated
ModelPara	list of model parameter estimates (see the "Optimization" function)
FactorLabels	string-list based which contains all the labels of all the variables present in the model
Economies	string-vector containing the names of the economies which are part of the economic system

Details

"Model-implied yields" is the measure of fit based exclusively on the risk-neutral parameters, whereas the "Model-Fit" takes into account both the risk-neutral and the physical parameters.

References

See, for instance, Jotiskhatira, Le and Lundblad (2015). "Why do interest rates in different currencies co-move?" (Journal of Financial Economics)

`YieldsFitsep` *Computes two measures of model fit for bond yields*

Description

Computes two measures of model fit for bond yields

Usage

```
YieldsFitsep(ModelType, ModelPara, FactorLabels, Economies)
```

Arguments

`ModelType`	a string-vector containing the label of the model to be estimated
`ModelPara`	List of model parameter estimates (See the "Optimization" function)
`FactorLabels`	a string-list based which contains the labels of all the variables present in the model
`Economies`	a string-vector containing the names of the economies which are part of the economic system

Details

"Model-implied yields" is the measure of fit based exclusively on the risk-neutral parameters, whereas the "Model-Fit" takes into account both the risk-neutral and the physical paameters.

References

See, for instance, Jotiskhatira, Le and Lundblad (2015). "Why do interest rates in different currencies co-move?" (Journal of Financial Economics)

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