Package 'bdynsys'

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Title Bayesian Dynamical System Model

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Imports plm, Formula, MASS, Hmisc, deSolve, pracma, caTools, matrixStats

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Description The package bdynsys for panel/longitudinal data combines methods to model changes in up to four indicators over times as a function of the indicators themselves and up to three predictors using ordinary differential equations (ODEs) with polynomial terms that allow to model complex and nonlinear effects. A Bayesian model selection approach is implemented. The package provides also visualisation tools to plot phase portraits of the dynamic system, showing the complex co-evolution of two indicators over time with the possibility to highlight trajectories for specified entities (e.g. countries, individuals). Furthermore the visualisation tools allow for making predictions of the trajectories of specified entities with respect to the indicators.

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NeedsCompilation no

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R topics documented:

`bayesfac` *Bayesian Model Selection with Bayesian Factor Computation (Internal Function)*

Description

`bayesfac` is the core code of the bayesian model selection in the bdynsys package. It is internally called in the main code `bdynsys`. It calls the functions `polyfitbayes`, `selectterms` and `findindexM`. It uses the Sum Square Errors from the previous model fitting step in `dysymod` to identify the best models for each number of modelparameters and computes then the Bayesian factor using a Monte Carlo Simulation for integration for these models, which may be then compared to find the overall best model. It prints the Bayesian factors for the best models for each number of modelparameters.It requires the package `caTools`.

Author(s)

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`bayfacfig` *Bayes Factors Plot*

Description

`bayfacfig` plot the Bayes Factors to visualy display the selected and the overall best model. It requires the packages `Hmisc` and `graphics`.

Usage

```
bayfacfig(indnr, modelnr, BF, markmod)
```

Arguments

indnr	an integer number indicating number of indicators, to be included in the modeling procedure
modelnr	number of models for which Bayes factors were obtained, and are to be compared now in the plot
BF	double numbers giving the Bayes factors for the models, to be compared, stored in a vector.
markmod	the number of the model (index of the Bayes factor in the vector), which is the overall best.

Author(s)

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Examples

```
## Bayes Factor plot for five models with two indicators to be compared in the
## bayesian fitting, with forth model being highlighted as the overall best model
bayfacfig(2, 5, c(-5.4534, -5.3955, -5.235, -4.99948, -5.321), 4)
```

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bdynsys *Bayesian Dynamic System Modeling*

Description

bdynsys is a package for panel/longitudinal data that combines methods to model changes in up to four indicators over time as a function of the indicators itself and up to four predictors using ordinary differential equations (ODEs) with polynomial terms that allow to model complex and nonlinear effects. A Bayesian model selection approach is implemented. The package provides also visualisation tools to plot phase portraits of the dynamic system, showing the complex co-evolution of two indicators over time with the possibility to highlight trajectories for specified entities (e.g. countries, individuals). bdynsys is also the name of the main function in the bdynsys package, that performs the bayesian dynamic systems modeling.

Usage

```
bdynsys(dataset, indnr, paramnr, x, y, z, v)
```

Arguments

dataset	a plm pdata.frame panel data frame.
indnr	an integer number indicating number of indicators, to be included in the modeling procedure
paramnr	an integer number indicating number of modelparameters, this is the maximum number of polynomial terms included.

x	a reference to variable from the paneldata to be included as indicator 1 in the modeling procedure.
y	a reference to variable from the paneldata to be included as indicator 2 in the modeling procedure.
z	a reference to variable from the paneldata to be included as indicator 3 in the modeling procedure.
v	a reference to variable from the paneldata to be included as indicator 4 in the modeling procedure.

Author(s)

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References

Ranganathan, S./Spaiser, V./Mann, R.P./Sumpter, D.J.T. (2014) *Bayesian Dynamical Systems Modelling in the Social Sciences*. PLoS ONE, 9(1):e86468.

Examples

```
## Bayesian Dynamic System Modeling with two variables and one modelparameter

bdynsys(datap, 2, 1, datap$logGDP, datap$EmanzV)
```

`bestfitmod` *Fitting of Dynamic System Models (Internal Function)*

Description

`bestfitmod` is a model fitting function internally called in the code `bdynsysdysymod`. It calls the functions `polyfitreg`. It creates the testing and training datasubsets for model fitting, passes them on to `polyfitreg` and receives back the Sum Square of Errors which are then stored in matrix for each indicator. It returns internally the Sum Square of Error matrices to `bdynsysdysymod`. It requires the package `caTools`.

Author(s)

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datap — *Test Panel Data Set: Cultural Values, GDP and Democracy from 1981-2012 in 74 countries*

Description

datap is a panel data frame, that was produced with plmpdata.frame. It is used as testdataset for the R package bdynsys. It contains 7 variables. The first is the panel_id variable with year and country specification. The six other variables are: EmanzV (emancipative values, based on WorldValueSurvey), SeculTradV (secular_vs_traditional values, based on WorldValueSurvey), SurvSelfV (survival_vs_selfexpression values, based on WorldValueSurvez), DemocrH (human-rights weighted democracy index, based on Freedom House data), GDP (GDP per capita, based on World Bank data) and logGDP (logged and rescaled (0-1) GDP per capita). The countries IDs in the data are as follows: 1: Albania, 2: Argentina, 3: Armenia, 4: Australia, 5: Austria, 6: Azerbaijan, 7: Bangladesh, 8: Belarus, 9: Belgium, 10: Bosnia and Herzigowina, 11: Brazil, 12: Bulgaria, 13: Canada, 14: Chile, 15: China, 16: Colombia, 17: Croatia, 18: Cyprus, 19: Czech Republik, 20: Denmark, 21: Egypt, 22: Estonia, 23: Finland, 24: France, 25: Georgia, 26: Germany, 27: Greece, 28: Hungary, 29: Iceland, 30: India, 31: Indonesia, 32: Iran, 33: Iraq, 34: Ireland, 35: Israel, 36: Italy, 37: Japan, 38: Jordan, 39: South Korea, 40: Latvia, 41: Lithunia, 42: Luxembourg, 43: Macedonia, 44: Malta, 45: Mexico, 46: Moldova, 47: Montenegro, 48: Morocco, 49: Netherlands, 50: New Zealand, 51: Nigeria, 52: Norway, 53: Pakistan, 54: Peru, 55: Philippines, 56: Poland, 57: Portugal, 58: Puerto Rico, 59: Romania, 60: Russian Federation, 61: Serbia, 62: Slovak Republic, 63: Slovenia, 64: South Africa, 65: Spain, 66: Sweden, 67: Switzerland, 68: Turkey, 69: Ukraine, 70: United Kingdom, 71: USA, 72: Uruguay, 73: Venezuela, 74: Vietnam

Format

panel data frame

References

Wezel, C. (2013) *Freedom Rising*. Cambridge: Cambridge University Press.

dysymod — *Modeling Dynamic Complex Systems with Ordinary Differential Equations (Internal Function)*

Description

dysymod is the core code of the dynamic system modeling in the bdynsys package. It is internally called in the main code bdynsys. It calls the functions polyfitreg and bestfitmod. It defines the polynomial terms, that are used to build the models and creates all possible model combinations and fits them. The best three models for each number of modelparameters are then selected. It prints the three selected models for each number of modelparameters and their Log Likelihood and R-squares. It requires the package caTools.

Author(s)

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`errorcorr` *Controlling Error Correlations in Models with Panel Data*

Description

`errorcorr` is an additional function in the bdynsys package. It calls functions `preprocess_data`. It computes the errors in the models (differential equations) and the covariances of the errors. It then uses the covarinaces to re-estimate the Betas of the models. The covarinace matrix is printed and the re-estimated Betas saved in a file. It requires the package `MASS`

Usage

```
errorcorr(dataset, indnr, x, y, f, xterms, yterms, nrterms, z, zterms, v, vterms)
```

Arguments

`dataset`	a `plm` `pdata.frame` panel data frame.
`indnr`	an integer number indicating number of indicators, to be included in the modeling procedure
`x`	a reference to variable from the paneldata to be included as indicator 1 in the modeling procedure.
`y`	a reference to variable from the paneldata to be included as indicator 2 in the modeling procedure.
`f`	a function that contains the models of the indicators.
`xterms`	a vector that contains the terms from the model dx/dt.
`yterms`	a vector that contains the terms from the model dy/dt.
`nrterms`	total number of in all equations, e.g. sum of terms in equation for dx/dt and terms in equation for dy/dt, if the number of variables is two.
`z`	a reference to variable from the paneldata to be included as indicator 3 in the modeling procedure.
`zterms`	a vector that contains the terms from the model dz/dt.
`v`	a reference to variable from the paneldata to be included as indicator 4 in the modeling procedure.
`vterms`	a vector that contains the terms from the model dv/dt.

Author(s)

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Examples

```
## Controlling Error Correlations with two indicators and with the following two models:
## dx/dt  = + 0.0012 /x^2 and dy/dt = + 0.0071 x^3

errorcorr(datap, 2, datap$logGDP, datap$EmanzV,
f <- function(Y=c()) rbind(0.0012/Y[1]^2, + 0.0071*Y[1]^3), c(11), c(14), 2)
```

---

findindexM *Finding Indexes of Polynomial Modelterms (Internal Function)*

Description

findindexM finds indexs of modelterms to be processed in selectterms if the user wishes to compare Bayes factors of models with two vs. model with three indicators or models with three vs. models with four indicators. The function is internally called in the code bdynsysbayesfacselectterms. It returns internally the indexes of modelterms to bdynsysbayesfacselectterms.

Author(s)

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---

phaseportdat *Phase Potrait with Data Trajectories for Specified Entities*

Description

phaseportdat creates a phase portrait (velocity plot, vectorfield) based on the two differential equations that were considered to be the overall best models for indicator 1 and indicator 2. The user may specify entities for which he/she wants to plot the data trajectories over the phase portrait. It calls the function preprocess_data. It requires the packages plm, pracma, deSolve and graphics.

Usage

```
phaseportdat(dataset, xv, yv, rangeX, rangeY, f, entidx1, entidx2, entidx3,
entidx4, entidx5, entidx6)
```

Arguments

dataset	a plm pdata.frame panel data frame.
xv	a reference to variable from the paneldata to be included as indicator 1 in the modeling procedure.
yv	a reference to variable from the paneldata to be included as indicator 2 in the modeling procedure.
rangeX	defines the range of the indicator 1.

rangeY	defines the range of the indicator 2.
f	a function that contains the models of the two indicators.
entidx1	index of an entity in the wide format data of a variable.
entidx2	index of an entity in the wide format data of a variable.
entidx3	index of an entity in the wide format data of a variable.
entidx4	index of an entity in the wide format data of a variable.
entidx5	index of an entity in the wide format data of a variable.
entidx6	index of an entity in the wide format data of a variable.

Author(s)

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Examples

```
## Phase Portrait with Data Trajectories with the following two models:
## dx/dt  = + 0.0012 /x^2 and dy/dt = + 0.0071 x^3

phaseportdat(datap, datap$logGDP, datap$EmanzV, seq(0, 1, by = 0.1), seq(0, 1, by = 0.1),
f <- function(t,Y=c()) rbind(0.0012/Y[1]^2, + 0.0071*Y[1]^3), 1, 2, 4, 5, 7, 9)
```

---

phaseportmod *Phase Potrait with Modeled Trajectories for Specified Entities*

Description

phaseportmod creates a phase portrait (velocity plot, vectorfield) based on the two differential equations that were considered to be the overall best models for indicator 1 and indicator 2. The user may specify entities for which he/she wants to obtain the predicted (modeled) trajectories over the phase portrait. The user may extend the period of time for the modeling to get future-predicted trjectories of the entities based on the models. It calls the function preprocess_data. It requires the packages plm, pracma, deSolve and graphics. The function produces graphs by some default settings. For specific requirements the user might want to modify the code according to his/her needs.

Usage

```
phaseportmod(dataset, yearnr, xv, yv, rangeX, rangeY, param, f, entidx1,
entidx2, entidx3, entidx4, entidx5, entidx6)
```

Arguments

dataset	a plm pdata.frame panel data frame.
yearnr	number of years for which the user wants to produce the phase portrait and obtain the modeled trajectories of the specified entities.
xv	a reference to variable from the paneldata to be included as indicator 1 in the modeling procedure.
yv	a reference to variable from the paneldata to be included as indicator 2 in the modeling procedure.
rangeX	defines the range of the indicator 1.
rangeY	defines the range of the indicator 2.
param	a vector with parameters from the two models in f.
f	a function that contains the models of the two indicators.
entidx1	index of an entity in the wide format data of a variable.
entidx2	index of an entity in the wide format data of a variable.
entidx3	index of an entity in the wide format data of a variable.
entidx4	index of an entity in the wide format data of a variable.
entidx5	index of an entity in the wide format data of a variable.
entidx6	index of an entity in the wide format data of a variable.

Author(s)

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Examples

```
## Phase Portrait with Model Trajectories over 30 years with the following two models:
## dx/dt  = 0.014 + 0.0064*x*y - 0.02*x and dy/dt = 0.106*x^3 - 0.062*y/x

phaseportmod(datap, 30, datap$logGDP, datap$DemocrH, seq(0, 1, by = 0.01), seq(0, 1, by = 0.01),
param <- c(0.014, -0.0064, -0.02, 0.106, -0.062), f <- function(t,Y=c())
rbind(0.014 + 0.0064*Y[1]*Y[2] - 0.02*Y[1], 0.106*Y[1]^3 - 0.062*(Y[2]/Y[1])), 1, 2, 4, 5, 7, 9)
```

---

plot_data *Plotting Data in Phase Plane with Data Trajectories for Specified Entities*

Description

plot_data plots data form indicator 1 and indicator 2 in phase plane. The user may specify entities for which he/she wants to plot the data trajectories over the plotted data. It calls the function preprocess_data. It requires the packages plm and graphics.

Usage

```
plot_data(dataset, xvar, yvar, rangeX, rangeY, entidx1, entidx2, entidx3,
entidx4, entidx5, entidx6)
```

Arguments

dataset	a plm pdata.frame panel data frame.
xvar	a reference to variable from the paneldata to be included as indicator 1 in the modeling procedure.
yvar	a reference to variable from the paneldata to be included as indicator 2 in the modeling procedure.
rangeX	defines the range of the indicator 1.
rangeY	defines the range of the indicator 2.
entidx1	index of an entity in the wide format data of a variable.
entidx2	index of an entity in the wide format data of a variable.
entidx3	index of an entity in the wide format data of a variable.
entidx4	index of an entity in the wide format data of a variable.
entidx5	index of an entity in the wide format data of a variable.
entidx6	index of an entity in the wide format data of a variable.

Author(s)

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Examples

```
## Plot Data in a Phase Plane with Data Trajectories for Specified Entities

plot_data(datap, datap$logGDP, datap$EmanzV, seq(0, 12, by = 0.5), seq(0, 1, by = 0.1),
1, 2, 3, 4, 5, 6)
```

---

polyfitbayes *Bayesian Model Fitting with Polynomial Terms als Predictors and Changes as Dependent Variable (Internal Function)*

Description

polyfitbayes is a modeling function internally called in the code bdynsysbayesfac. It computes the values for the independed variables, based on polynomial terms and a coefficient parameter space. The function then performs a Monte Carlo simulation to compute/integrate the log Bayes Factor. It returns internally the log Bayes factors for the best models and the modelindexes of those best models to bdynsysbayesfac.

Author(s)

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polyfitreg *Least Square Regression with Polynomial Terms als Predictors and Changes as Dependent Variable (Internal Function)*

Description

polyfitreg is a modeling function internally called in the code bdynsysdysymod as well as in bdynsysdysymodbestfitmod. It computes the values for the independed variables, based on polynomial terms and computes all possible regression models with all possible combinations of these independ variables (all possible combinations of polynimal terms) and the changes in the dependent variables which are to be predicted. The function estimates the Betas, computes the Sum Square of Error of all possible models as well as their Log Likelihood and R-squares. It returns internally the Sum Square of Error matrices to bdynsysdysymodbestfit and Betas to bdynsysdysymod.Log Likelihood and R-square are printed.

Author(s)

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preprocess_data *Data Processing for Bayesian Dynamic System Modeling (Internal Function)*

Description

preprocess_data is a core code in the bdynsys package to prepare the data for the bayesian dynamic system modeling. It is internally called in the main code bdynsys. It creates wide format matrixes for the indicators based on time and entity-id. It also reshapes the indicators into single columns ordered by time, computes the changes in the indicators at each timestep, reshapes them also into single colums ordered by time and stores them in variables. It furthermore removes missing values and scales the variables with their means. It returnes the processed variables to bdynsys and that way makes them availabe for usage in bdynsysdysymod and bdynsysbayesfac.It requires the package plm and matrixStats.

Author(s)

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selectterm *Deriving Best Models and their Polynomial Terms for Bayesian Model Fitting (Internal Function)*

Description

selectterms selects/indexes terms which are part of the models to be fitted in the Bayesian fitting procedure. The function is internally called in the code bdynsysbayesfac. The model selections is based on the Sum of Square Errors which were computed in the previous model fitting step in bdynsysdysymod. It returns internally the indexes of the best models polynomial terms to bdynsysbayesfac.

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Index