Package 'splm'

October 13, 2010

Title Econometric Models for Spatial Panel Data

Version 0.2-01

Date 2010-09-22

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Description ML and GM estimation and diagnostic testing of econometric models for spatial panel data.

Depends R (>= 2.11.1), MASS, nlme, spdep, plm, Matrix, kinship, spam

License GPL-2

LazyLoad yes

R topics documented:

splm-package *Spatial panel models: estimation and testing*

Description

A comprehensive toolset for ML and GM estimation and diagnostic testing of econometric models for spatial panel data.

Details

Package:	splm
Type:	Package
Version:	0.2-1
Date:	2010-06-08
License:	GPL
LazyLoad:	yes

Author(s)

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References

Anselin, L. and Le Gallo, J. and Jayet, H. (2008) Spatial Panel Econometrics, *In* Matyas, L. and Sevestre, P. (eds), *The econometrics of Panel Data, Fundamentals and Recent Developments in Theory and Practice (3rd Edition)*, pages 624–660. Springer-Verlag, Berlin Heidelberg.

Baltagi, B.H., Song, S.H., Jung B. and Koh, W. (2007) Testing panel data regression models with spatial and serial error correlation. *Journal of Econometrics*, **140**, 5-51.

Baltagi, B.H., Song, S.H. and Koh, W. (2003) Testing panel data regression models with spatial error correlation. *Journal of Econometrics*, **117**, 123–150.

Elhorst, J.P. (2003) Specification and estimation of spatial panel data models, *International Regional Science Review*, **26**, pages 244–268.

Elhorst, J.P. (2009) Spatial panel data models, *In* Fischer, M.M. and Getis, A. (eds), *Handbook of Applied Spatial Analysis* Springer, Berlin.

Kapoor, M., Kelejian, H.H. and Prucha, I.R. (2007) Panel data model with spatially correlated error components, *Journal of Econometrics*, **140**, pages 97–130.

Kelejian, H.H. and Prucha, I.R. (1999) A Generalized Moments Estimator for the Autoregressive Parameter in a Spatial Model, *International Economic Review*, **40**, pages 509–533.

Kelejian, H.H. and Prucha, I.R. (1999) A Generalized Spatial Two Stage Least Square Procedure for Estimating a Spatial Autoregressive Model with Autoregressive Disturbances, *Journal of Real Estate Finance and Economics*, **17**, pages 99–121.

Kelejian, H.H. and Prucha, I.R. (2004) Estimation of Simultaneous systems of spatially interrelated cross sectional equations, *Journal of Econometrics*, **118**, pages 27–50.

Examples

```
data(Produc, package = "Ecdat")
data(usaww)
Produc <- Produc[Produc$year<1975, ]
fm <- log(gsp) ~ log(pcap) + log(pc) + log(emp) + unemp
GM<-spregm(log(gsp)~log(pcap)+log(pc)+log(emp)+unemp, data=Produc,w=usaww,method="fulweig
summary(GM)
respaterr <- spreml(fm, data = Produc, w = usaww, errors="semre")
summary(respaterr)
```

---

bsjktest *Baltagi, Song, Jung and Koh LM test for spatial panels*

Description

Baltagi, Song, Jung and Koh marginal or conditional LM test for spatial error correlation, serial error correlation or random effects in panel models

Usage

```
bsjktest(x,...)

## S3 method for class 'formula':
bsjktest(x, data, w, test=c(paste("C",1:3,sep="."),"J"), index=NULL, ...)
```

Arguments

x	an object of class `formula` or `splm`
data	an object of class `data.frame` or `pdata.frame`. An optional data frame containing the variables in the model. When the obect is a `data.frame`, the first two columns may contain the indexes. See `index`
index	if not NULL (default), a character vector to identify the indexes among the columns of the `data.frame`
w	An object of class `listw` or a `matrix`
test	One of `c(paste("C",1:3,sep="."),"J")` the test to be performed
...	additional arguments to be passed

Details

If `test="J"` the joint test for spatial or serial error correlation or random individual effects is returned; if `test` is one of `C.1`, `C.2` or `C.3` the conditional test for, respectively, spatial errror correlation; serial error correlation; random individual effects (with the other two effects possibly present) is returned.

Value

An object of class `htest`

Author(s)

Giovanni Millo

References

Baltagi, B.H., Song, S.H., Jung B. and Koh, W. (2007) Testing panel data regression models with spatial and serial error correlation. *Journal of Econometrics*, **140**, 5-51.

See Also

bsktest

Examples

```
data(Produc, package="Ecdat")
Produc <- Produc[Produc$year<1975, ]
data(usaww)
fm <- log(gsp)~log(pcap)+log(pc)+log(emp)+unemp
test1<-bsjktest(fm,data=Produc, w=usaww,
  test="C.1")
test1
```

---

bsktest *Baltagi, Song and Koh LM test for spatial panels*

Description

Baltagi, Song and Koh marginal or conditional LM test for spatial error correlation or random effects in panel models

Usage

```
bsktest(x,...)
## S3 method for class 'formula':
bsktest(x, data, w, test=c("SLM1","SLM2","LMJOINT","CLMlambda","CLMmu"), index=N
## S3 method for class 'lm':
bsktest(x, w, index=NULL, test=c("SLM1","SLM2","LMJOINT"), ...)
## S3 method for class 'splm':
bsktest(x, w, index=NULL, test=c("CLMlambda","CLMmu"), ...)
```

Arguments

x	an object of class formula or lm or splm
data	an object of class data.frame or pdata.frame. An optional data frame containing the variables in the model. When the obect is a data.frame, the first two columns may contain the indexes. See index
index	if not NULL (default), a character vector to identify the indexes among the columns of the data.frame
w	an object of class listw created for example by nb2listw
test	one of c("SLM1","SLM2","LMJOINT","CLMlambda","CLMmu"), the test to be performed
...	additional arguments to be passed

Value

an object of class `htest`

Author(s)

Gianfranco Piras

References

Baltagi, B.H., Song, S.H. and Koh, W. (2003) Testing panel data regression models with spatial error correlation. *Journal of Econometrics*, **117**, 123–150.

See Also

`bsjktest`

Examples

```
data(Produc, package="Ecdat")
Produc <- Produc[Produc$year<1975, ]
data(usaww)
fm <- log(gsp)~log(pcap)+log(pc)+log(emp)+unemp
test1<-bsktest(fm,data=Produc, w=mat2listw(usaww),
  test="SLM1")
class(test1)
test1
ml2 <- spfeml(fm, data = Produc, , mat2listw(usaww), model = "error", effects = "pooled")
class(ml2)
test5bis<-bsktest(ml2, w=mat2listw(usaww),index=Produc[,c(1,2)] ,test="CLMmu")
summary(test5bis)
```

`effects.splm` *method for extracting fixed effects*

Description

Methods used for extracting fixed effects from objects of class `splm` where `type` is one of "fixed effects lag" or "fixed effects error"

Usage

```
## S3 method for class 'splm':
effects(object,...)
```

Arguments

`object`	an object of class `'splm'`
`...`	additional arguments to be passed over

Details

If the argument `object` is not of class `splm` the function will terminate with an error.

If the argument `object` is of class `splm` but `type` is not one of "fixed effects lag" or "fixed effects error", the function will terminate with an error.

Value

An object of class `effects.splm`

`res`	a list whose elements are various type of fixed effects and the intercept (when present)

Author(s)

Gianfranco Piras `<gpiras@mac.com>`

References

Elhorst, J.P. (2003) Specification and estimation of spatial panel data models, *International Regional Science Review*, **26**, pages 244–268.

Elhorst, J.P. (2009) Spatial panel data models, *In* Fischer, M.M. and Getis, A. (eds), *Handbook of Applied Spatial Analysis* Springer, Berlin.

See Also

`spfeml` `print.effects.splm` `summary.effects.splm`

Examples

```
data(Produc, package = "Ecdat")
data(usaww)
Produc <- Produc[Produc$year<1975, ]
fm <- log(gsp) ~ log(pcap) + log(pc) + log(emp) + unemp
lag <- spfeml(fm, data = Produc, listw = mat2listw(usaww), effects = "sptpfe", method = "
summary(lag)
eff <- effects(lag)
print(eff)
err <- spfeml(fm, data = Produc, listw = mat2listw(usaww), model = "error", effects = "tp
summary(err)
eff <- effects(err)
print(eff)
```

`listw2dgCMatrix` *Interface between Matrix class objects and weights list*

Description

Interface between Matrix class objects and weights list

Usage

```
listw2dgCMatrix(listw, zero.policy = NULL)
```

Arguments

listw	a listw object created for example by nb2listw
zero.policy	See lagsarlm for details

Value

Matrix class object: a sparse Matrix

Author(s)

Gianfranco Piras <gpiras@mac.com>

Examples

```
library(spdep)
data(columbus)
listw<-nb2listw(col.gal.nb)
spW<-listw2dgCMatrix(listw)
```

---

print.effects.splm *method for printing fixed effects from objects of class effects.splm*

Description

Methods used for printing fixed effects from objects of class effects.splm generated using effects.splm

Usage

```
## S3 method for class 'effects.splm':
print(x,digits= max(3, getOption("digits") - 2), ...)
```

Arguments

x	an object of class effects.splm
digits	specifies the minimum number of significant digits to be printed in values. See print.default for details
...	additional arguments to be passed

Author(s)

Gianfranco Piras <gpiras@mac.com>

References

Elhorst, J.P. (2003) Specification and estimation of spatial panel data models, *International Regional Science Review*, **26**, pages 244–268.

Elhorst, J.P. (2009) Spatial panel data models, *In* Fischer, M.M. and Getis, A. (eds), *Handbook of Applied Spatial Analysis* Springer, Berlin.

See Also

spfeml print.effects.splm summary.effects.splm

Examples

```
data(Produc, package = "Ecdat")
data(usaww)
Produc <- Produc[Produc$year<1975, ]
fm <- log(gsp) ~ log(pcap) + log(pc) + log(emp) + unemp
lag <- spfeml(fm, data = Produc, listw = mat2listw(usaww), effects = "sptpfe", method = "
summary(lag)
eff <- effects(lag)
print(eff)
err <- spfeml(fm, data = Produc, listw = mat2listw(usaww), model = "error", effects = "tp
summary(err)
eff <- effects(err)
print(eff)
```

---

print.splm *print method for class splm*

Description

Method to print objects of class summary.splm and splm

Usage

```
## S3 method for class 'splm':
print(x, digits = max(3,getOption("digits") -3), ...)
```

Arguments

x	an object of class splm
digits	minimal number of significant digits, see print.default
...	additional arguments to be passed

Details

The summary function summary.splm returns an objects of class 'splm' organized in a coefficient matrix.

Also a matrix for the error components, or the spatial coefficients will be generated depending on the estimated model.

When the 'splm' is produced by the function 'spsegm', the summary will be generated looping over the number of equations in the system.

Author(s)

Giovanni Millo <Giovanni_Millo@Generali.com>, Gianfranco Piras<gpiras@mac.com>

See Also

spreml, spregm, spreml

Examples

```
data(Produc, package = "Ecdat")
data(usaww)
Produc <- Produc[Produc$year<1975, ]
GM<-spregm(log(gsp)~log(pcap)+log(pc)+log(emp)+unemp, data=Produc,w=usaww,method="fulweig
summary(GM)
```

`spfegm` *GM estimator for spatial panel data models*

Description

GM estimator for panel data models with spatially correlated errors components of the form:

$$y_N(t) = X_N(t)\beta + u_N(t)$$

$$u_N(t) = \rho W_N u_N(t) + \epsilon(t)$$

$$\epsilon_N = (e_T \otimes I_N)\mu_N + \nu_N$$

where μ_i are parameteres to be estimated, ρ, and the variance component σ^2_ν are estimated by GM, and the model coefficients by GLS.

Usage

```
spfegm(formula, data=list(), index=NULL, w, method = c("init","fulweigh"), effec
```

Arguments

`formula`	a description of the model to be fit. The details of model specification are given for `lm`
`data`	an object of class `data.frame` or `pdata.frame`. An optional data frame containing the variables in the model. When the obect is a `data.frame`, the first two columns may contain the indexes. See `index`
`index`	if not NULL (default), a character vector to identify the indexes among the columns of the `data.frame`
`w`	an object of class `listw` created for example by `nb2listw`. If a `matrix` is given as input the function will transform it using `mat2listw`
`method`	`"init"` (default) defines the set of GM estimator to be used. Alternative is `"fulweigh"` (See Details)
`effects`	one of `"pooled"` (no spatial effects, i.e. OLS on the pooled model), `"spfe"` (only spatial fixed effects), `"tpfe"` (only time period fixed effects), `"sptpfe"` (both time period and spatial fixed effects)
`lag`	if `TRUE` a spatial lag of the dependent variable is added to the regression equation
`endog`	default `NULL`. A string with the name of additional (other than the spatial lag) endogenous variables

instruments	default NULL. A string with the name of the instruments for the additional endogenous variables
verbose	default FALSE, If TRUE reports function values during optimization
control	a list of control parameters for the optimization

Details

When method=init, the initial estimator is calculated. This first set of GM estimators assign equal weigths to each of the moments conditions. When method=fulweigh, the second set of GM estimators is calculated. This set of estimators involve the expression for the variance covariance matrix of the sample moments calculated under the assumption of normally distributed innovations. The calculation of the trace terms in the expression of the variance covariance matrix of the sample moments uses codes from the Matrix package.

Value

An object of class "splm".

coefficients	GLS coefficients estimate of the model parameters
vcov	the variance covariance matrix of the estimated coefficients
residuals	the GLS residuals
fitted.values	difference between response variable and residuals
sigma2	GLS residuals variance
type	'random effect GM'
rho	a vector including the spatial parameter and the variance components (see Details)
model	the matrix of the data used
call	the call used to create the object

Author(s)

Gianfranco Piras <gpiras@mac.com>

References

Kapoor, M., Kelejian, H.H. and Prucha, I.R. (2007) Panel data model with spatially correlated error components, *Journal of Econometrics*, **140**, pages 97–130.

Kelejian, H.H. and Prucha, I.R. (1999) A Generalized Moments Estimator for the Autoregressive Parameter in a Spatial Model, *International Economic Review*, **40**, pages 509–533.

Kelejian, H.H. and Prucha, I.R. (1999) A Generalized Spatial Two Stage Least Square Procedure for Estimating a Spatial Autoregressive Model with Autoregressive Disturbances, *Journal of Real Estate Finance and Economics*, **17**, pages 99–121.

See Also

spreml, spsegm

Examples

```
data(Produc, package = "Ecdat")
data(usaww)
Produc <- Produc[Produc$year<1975, ]
GM<-spfegm(log(gsp)~log(pcap)+log(pc)+log(emp)+unemp-1, data=Produc,w=usaww,method="fulwe
summary(GM)
```

---

spfeml *Spatial Panel Fixed Effects Models Estimation*

Description

Maximum likelihood (ML) estimation of spatial panel fixed effects models

Usage

```
spfeml(formula, data=list(), index=NULL,listw, model=c("lag","error"),effects=c(
```

Arguments

formula	a description of the model to be fit
data	an object of class data.frame or pdata.frame. An optional data frame containing the variables in the model. When the obect is a data.frame, the first two columns may contain the indexes. See index
index	if not NULL (default), a character vector to identify the indexes among the columns of the data.frame
listw	an object of class listw created for example by nb2listw
model	one of c("lag","error")
effects	one of "pooled" (no spatial effects, i.e. OLS on the pooled model), "spfe" (only spatial fixed effects), "tpfe" (only time period fixed effects), "sptpfe" (both time period and spatial fixed effects)
method	"eigen" (default) - the Jacobian is computed as $\prod_{i=1}^{N}(1-\rho\omega_i)$ (with ω_i the eigenvalues of the spatial weigths matrix) using eigenw - (see lagsarlm for details)
na.action	see lagsarlm for details
quiet	default=TRUE; if FALSE, reports function values during optimization
zero.policy	see lagsarlm for details
interval	search interval for spatial parameters
tol.solve	tolerance for detecting linear dependence in the columns of matrices to be inverted (default= 1.0e-10)- (see lagsarlm for details)
control	a list of control parameters for the optimization - see lagsarlm for details
legacy	FALSE When TRUE and model is "lag" calculate goodness of fit measures

Details

The function deals with both fixed effects spatial lag and error models, of the form:

$$y = \rho(I_T \otimes W_N)y + (\iota_T \otimes \alpha) + X\beta + \epsilon$$

where ρ is called the spatial autoregressive coefficient, and:

$$y = (\iota_T \otimes \alpha) + X\beta + u$$

$$u = \lambda(\iota_T \otimes W_N)u + \epsilon$$

respectively, where λ is the spatial autocorrelation coefficient. Both ρ and λ are found by `optimize`, and the model parameters by a feasible GLS procedure.

The asymptotic standard error of ρ is only computed when `method=eigen`, because the full matrix operations involved would be costly for dimensions associated with the choice of `"spam"` or `"Matrix"`. The same applies to the coefficient covariance matrix.

The model variables are first transformed depending on the typology of fixed effects. As an example, if time period fixed effects are considered, the demeaned form is obtained by subtracting the average for each cross-sectional unit computed over the time dimension.

The transformed variables are then used in a concentrated likelihood approach to estimate the spatial parameters.

Once the spatial parameters are obtained, the model parameters are then estimated by a feasible GLS procedure.

Fixed effects can then be extracted using the function `effects`.

Value

An object of class `"splm"`.

`coefficients`	coefficients estimate of the model parameters
`vcov`	the asymptotic variance covariance matrix of the estimated coefficients (when calculated)
`type`	'fixed effects spatial lag (or error) model'
`spat.coeff`	the spatial coefficients ρ or λ
`residuals`	the GLS residuals
`fitted.values`	difference between response variable and residuals
`sigma2`	GLS residuals variance
`model`	the matrix of the data used
`call`	the call used to create the object
`logLik`	the value of the log likelihood function at the optimum
`method`	the method used to calculate the Jacobian
`effects`	the typology of effects included in the model
`res.eff`	a list whose elements are the fixed effects (see `effects`)

Author(s)

Gianfranco Piras <gpiras@mac.com>

References

Elhorst, J.P. (2003) Specification and estimation of spatial panel data models, *International Regional Science Review*, **26**, pages 244–268.

Elhorst, J.P. (2009) Spatial panel data models, *In* Fischer, M.M. and Getis, A. (eds), *Handbook of Applied Spatial Analysis* Springer, Berlin.

Anselin, L. and Le Gallo, J. and Jayet, H. (2008) Spatial Panel Econometrics, *In* Matyas, L. and Sevestre, P. (eds), *The econometrics of Panel Data, Fundamentals and Recent Developments in Theory and Practice (3rd Edition)*, pages 624–660. Springer-Verlag, Berlin Heidelberg.

See Also

spreml, spregm, effects

Examples

```
data(Produc, package = "Ecdat")
data(usaww)
Produc <- Produc[Produc$year<1975, ]
fm <- log(gsp) ~ log(pcap) + log(pc) + log(emp) + unemp
lag <- spfeml(fm, data = Produc, listw = mat2listw(usaww), effects = "sptpfe", method = "
summary(lag)
eff <- effects(lag)
err <- spfeml(fm, data = Produc, listw = mat2listw(usaww), model = "error", effects = "tp
summary(err)
eff <- effects(err)
print(eff)
write.effects.splm(eff)
```

---

spregm *GM estimator for spatial panel data models*

Description

GM estimator for panel data models with spatially correlated errors components of the form:

$$y_N(t) = X_N(t)\beta + u_N(t)$$

$$u_N(t) = \rho W_N u_N(t) + \epsilon(t)$$

$$\epsilon_N = (e_T \otimes I_N)\mu_N + \nu_N$$

where ρ, and the variance components σ^2_μ and σ^2_ν are estimated by GM, and the model coefficients by GLS.

Usage

```
spregm(formula, data=list(), index=NULL, w, method = c("init", "weigh", "fulweig
```

Arguments

formula	a description of the model to be fit. The details of model specification are given for lm
data	an object of class data.frame or pdata.frame. An optional data frame containing the variables in the model. When the obect is a data.frame, the first two columns may contain the indexes. See index
index	if not NULL (default), a character vector to identify the indexes among the columns of the data.frame
w	an object of class listw created for example by nb2listw. If a matrix is given as input the function will transform it using mat2listw
method	"init" (default) defines the set of GM estimator to be used. Alternatives are "weigh" and "fulweigh" (See Details)
lag	if TRUE a spatial lag of the dependent variable is added to the regression equation
endog	default NULL. A string with the name of additional (other than the spatial lag) endogenous variables
instruments	default NULL. A string with the name of the instruments for the additional endogenous variables
verbose	default FALSE, If TRUE reports function values during optimization
control	a list of control parameters for the optimization

Details

When method=init, the initial estimator is calculated. This first set of GM estimators is based only on a subset of the moments conditions and assigns equal weigths to each of them. When method=fulweigh, the second set of GM estimators is calculated. This estimator is based on the full set of moments conditions. It also involves the expression for the variance covariance matrix of the sample moments calculated under the assumption of normally distributed innovations. The calculation of the trace terms in the expression of the variance covariance matrix of the sample moments uses codes from the Matrix package. When method=weigh, the third set of GM estimator is used. This is motivated by computational issues. The procedure is analogous to the second one but uses a simplified expression for the variance covariance matrix of the sample moments

Note that σ_μ^2 is not reported. σ_1^2 is reported instead. However, a value for σ_μ^2 can easily be obtained from:

$$\sigma_1^2 = \sigma_\nu^2 + T\sigma_\mu^2$$

The function also produces an estimate for θ which is a function of the variance components.

Value

An object of class "splm".

coefficients	GLS coefficients estimate of the model parameters
vcov	the variance covariance matrix of the estimated coefficients
residuals	the GLS residuals
fitted.values	difference between response variable and residuals
sigma2	GLS residuals variance
type	'random effect GM'

rho	a vector including the spatial parameter and the variance components (see Details)
model	the matrix of the data used
call	the call used to create the object

Author(s)

Gianfranco Piras <gpiras@mac.com>

References

Kapoor, M., Kelejian, H.H. and Prucha, I.R. (2007) Panel data model with spatially correlated error components, *Journal of Econometrics*, **140**, pages 97–130.

Kelejian, H.H. and Prucha, I.R. (1999) A Generalized Moments Estimator for the Autoregressive Parameter in a Spatial Model, *International Economic Review*, **40**, pages 509–533.

Kelejian, H.H. and Prucha, I.R. (1999) A Generalized Spatial Two Stage Least Square Procedure for Estimating a Spatial Autoregressive Model with Autoregressive Disturbances, *Journal of Real Estate Finance and Economics*, **17**, pages 99–121.

See Also

spreml, spsegm

Examples

```
data(Produc, package = "Ecdat")
data(usaww)
Produc <- Produc[Produc$year<1975, ]
GM<-spregm(log(gsp)~log(pcap)+log(pc)+log(emp)+unemp, data=Produc,w=usaww,method="fulweig
summary(GM)
```

---

spreml *Spatial Panel Random Effects Model Estimation*

Description

Maximum likelihood (ML) estimation of spatial random effects panel of the form:

$$y_i t = X_i' t\beta + u_i t, i = 1, \ldots, N, t = 1, \ldots, T$$

with

$$u_t = \mu + \epsilon_t$$

and

$$\epsilon_t = \lambda W \epsilon_t + \nu_t$$

where

$$\nu_t = \rho \nu_t - 1 + e_t.$$

Depending on the restrictions on the vector of parameters one can differently combine error features giving rise to various nested specifications.

Usage

```
spreml(formula, data, index = NULL, w, lag=FALSE,
           errors = c("semsrre","semsr","srre","semre","re","sr","sem"),
           pvar = FALSE, hess=FALSE, quiet=TRUE,
           initval = c("zeros", "estimate"),
           x.tol=1.5e-18, rel.tol=1e-15,
           ...)
```

Arguments

formula	a symbolic description of the model to be estimated
data	an object of class data.frame or pdata.frame. An optional data frame containing the variables in the model. When the obect is a data.frame, the first two columns may contain the indexes. See index
index	if not NULL (default), a character vector to identify the indexes among the columns of the data.frame
w	an object of class listw or a matrix
lag	default=FALSE. If TRUE, a spatial lag of the dependent variable is added: Not yet implemented
errors	one of c("semsrre","semsr","srre","semre","re","sr","sem"). See details.
pvar	if TRUE the pvar function is called
hess	if TRUE use numerical Hessian instead of GLS for the standard errors of the estimates
quiet	if FALSE report function and parameters values during optimization
initval	one of c("zeros", "estimate"), the initial values for the parameters. If "zeros" a vector of zeros is used. if "estimate" the initial values are retreived from the estimation of the nested specifications. Alternatively, a numeric vector can be specified.
x.tol	Tolerance. See nlminb for details.
rel.tol	Relative tolerance. See nlminb for details.
...	additional argument to pass over to other functions

Details

The models are estimated by two-step Maximum Likelihood.

The covariance structures allowed are: "semsrre" random effects, spatial and serial correlation in the idiosyncratic error term; "semsr" spatial and serial correlation in the idiosyncratic error term; "srre" individual random effects and serial correlation; "semre" individual random effects and spatial correlation; "re" individual random effects; "sr" serial correlation; "sem" spatial correlation.

Value

An object of class "splm".

coefficients	coefficients estimate of the model parameters
arcoef	the coefficient for the spatial lag on y

`errcomp`	the estimates of the error variance components
`vcov`	the asymptotic variance covariance matrix of the estimated coefficients
`vcov.arcoef`	the asymptotic variance of the estimated spatial lag parameter
`vcov.errcomp`	the asymptotic variance covariance matrix of the estimated error covariance parameters
`type`	'random effects ML'
`residuals`	the model residuals
`fitted.values`	the fitted values, calculated as $\hat{y} = X\hat{\beta}$
`sigma2`	GLS residuals variance
`model`	the matrix of the data used
`call`	the call used to create the object
`logLik`	the value of the log likelihood function at the optimum
`errors`	the value of the `errors` argument

Author(s)

Giovanni Millo

References

Baltagi, B.H., Song, S.H., Jung B. and Koh, W. (2007) Testing panel data regression models with spatial and serial error correlation. *Journal of Econometrics*, **140**, 5-51.

See Also

`spregm`, `spfeml`

Examples

```
data(Produc, package = "Ecdat")
data(usaww)
Produc <- Produc[Produc$year<1974, ]
fm <- log(gsp) ~ log(pcap) + log(pc) + log(emp) + unemp
respaterr <- spreml(fm, data = Produc, w = usaww, errors="semre")
summary(respaterr)
```

`spsegm` *Spatial Simultaneous Equations*

Description

Feasible generalized three stages least square estimator (FGS3SLS) of symultaneous systems of spatially interrelated cross sectional equations of the form:

$$Y = YB + XC + \bar{Y}L + U$$

$$U = \bar{U}R + E$$

with $Y = (y_1, \ldots, y_m)$, $X = (x_1, \ldots, x_m)$, $U = (u_1, \ldots, u_m)$, $\bar{Y} = (\bar{y}_1, \ldots, \bar{y}_m)$ and $\bar{y}_j = Wy_j$ $j = 1, \ldots, m$, $E = (e_1, \ldots, e_m)$, $\bar{U} = (\bar{u}_1, \ldots, \bar{u}_m)$ and $\bar{u}_j = Wu_j$ $j = 1, \ldots, m$. B, C, L and $R = diag_{j=1}^{m}(\rho_j)$ are matrix of parameters

Usage

```
spsegm(formula,data=list(), panel=FALSE,index=NULL,
w, method='spatialsim', lags=NULL, errors=NULL, endogenous=NULL, zero.policy = F
```

Arguments

formula	a list of objects of class formula
data	an object of class data.frame or pdata.frame.An optional data frame containing the variables in the model. An optional data frame containing the variables in the model. When the obect is a data.frame, the first two columns may contain the indexes. See index
panel	logical. When TRUE, the data frame is a panel data set with cross-sectional and time observations
index	if not NULL (default), a character vector to identify the indexes among the columns of the data.frame
w	an object of class listw created for example by nb2listw or a matrix
method	spatialsim
lags	A logical list of length equal to the number of equations. If TRUE the spatial lag of the variable is included in the equation
errors	A logical vector. When TRUE a spatially autocorrelated error term is included in the corresponding equation
endogenous	A logical list of length equal to the number of equations. If TRUE the endogenous variable is included in the equation
zero.policy	See lagsarlm for details

Details

The function can be specified with any number of equations. The number of equations is determined through the formula object. The data can also be specified as a panel data frame. The logical argument PANEL should then be set to TRUE.

The logical list lags controls which spatial lags should be included in the equations. The logical list errors determines which equations should include an autoregressive term. The logical list endogenous determines which equations should include an autoregressive term.

Value

An object of class "splm".

coefficients	FG3SLS coefficients estimate of the model parameters (for all equations)
vcov	the variance covariance matrix of the estimated coefficients
type	'spsegm'
model	the matrix of the data used (responses in each equation are reported first, then the explanatory variables)
N	the number of cross-sectional observations
Eq	the number of equations in the system
k	the number of columns of the matrix of regressors (i.e. this corresponds to the number of explanatory variables in each equation only when spec="default")
call	the call used to create the object

terms	the terms object generated from formula and some optional arguments
Xnames	the names of the variables in the matrix of explanatory variables
Ynames	the names of the responses
spec	the argument spec

Author(s)

Gianfranco Piras<gpiras@mac.com>

References

Kelejian, H.H. and Prucha, I.R. (2004) Estimation of Simultaneous systems of spatially interrelated cross sectional equations, *Journal of Econometrics*, **118**, pages 27–50.

Kelejian, H.H. and Prucha, I.R. (1999) A Generalized Moments Estimator for the Autoregressive Parameter in a Spatial Model, *International Economic Review*, **40**, pages 509–533.

Kelejian, H.H. and Prucha, I.R. (1998) A Generalized Spatial Two Stage Least Square Procedure for Estimating a Spatial Autoregressive Model with Autoregressive Disturbances, *Journal of Real Estate Finance and Economics*, **17**, pages 99–121.

See Also

spregm

Examples

```
data(Produc, package = "Ecdat")
data(usaww)
Produc <- Produc[Produc$year<1973, ]
eq1 <- log(gsp) ~ log(pcap) + log(pc) + log(emp) + unemp
eq2 <- log(gsp) ~ log(pcap) + log(pc) + log(emp) + unemp
eq3 <- log(gsp) ~ log(pcap) + log(pc) + log(emp) + unemp
formula<-list(tp1 = eq1, tp2 = eq2, tp3=eq3)
w<-mat2listw(usaww)
se<-spsegm(formula, data=Produc, w=w, panel= TRUE,lags=list(c(TRUE,TRUE,TRUE),c(TRUE,TRUE
summary(se)
```

---

spseml *Spatial SUR - Lag and Error*

Description

Maximum likelihood estimation of symultaneous systems of spatial SUR model.

Usage

```
spseml(formula, data=list(),panel=TRUE,index=NULL,w,method="eigen",
quiet=NULL, model = c("lag","error"), zero.policy=NULL, interval=NULL, tol.solve
```

Arguments

formula	a list of objects of class formula
data	an object of class data.frame or pdata.frame. An optional data frame containing the variables in the model. When the obect is a data.frame, the first two columns may contain the indexes. See index
panel	logical. When TRUE, the data frame is a panel data set with cross-sectional and time observations
index	if not NULL (default), a character vector to identify the indexes among the columns of the data.frame
w	an object of class listw created for example by nb2listw or a matrix
method	spatialsim
quiet	default NULL
model	lag or error If lag, a spatial lag of the dependent variable is added in each equation. If error a spatially autocorrelated error term is assumed in each equation.
zero.policy	See lagsarlm for details
interval	search interval for spatial parameters
tol.solve	tolerance
trs	default NULL
control	A list of control parameters for the optimization
initval	the initial values of the spatial parameters

Details

The function can be specified with any number of equations. The number of equations is determined through the formula object. The data can also be specified as a panel data frame. The logical argument PANEL should then be set to TRUE.

Value

An object of class "splm".

coefficients	ML coefficients of the model parameters (for all equations)
vcov	the variance covariance matrix of the estimated coefficients
type	'spsegm'
model.data	the matrix of the data used (responses in each equation are reported first, then the explanatory variables)
model	lag or error
N	the number of cross-sectional observations
Eq	the number of equations in the system
K	the total number of explanatory variables in the system
call	the call used to create the object
terms	the terms object generated from formula and some optional arguments
Xnames	the names of the variables in the matrix of explanatory variables
Ynames	the names of the responses

spec	the number of explanatory variables in each equation
lags	a logical list
errors	a logical list
endogenous	a logical list
rho	the estimated spatial autocorrelation coefficients
method	"GM"

Author(s)

Gianfranco Piras<gpiras@mac.com>

References

Anselin, L. (1988) Spatial Econometrics: Methods and Models, *Kluwer Academic Publisher*.

See Also

spregm

Examples

```
data(Produc, package = "Ecdat")
data(usaww)
Produc <- Produc[Produc$year<1973, ]
eq1 <- log(gsp) ~ log(pcap) + log(pc) + log(emp) + unemp
eq2 <- log(gsp) ~ log(pcap) + log(pc) + log(emp) + unemp
eq3 <- log(gsp) ~ log(pcap) + log(pc) + log(emp) + unemp
formula<-list(tp1 = eq1, tp2 = eq2, tp3=eq3)
listw<-mat2listw(usaww)
sur.error<-spseml(formula, data = Produc, w = listw, model = "error", method = "eigen", q
summary(sur.error)
sur.lag<-spseml(formula, data = Produc, w = listw, model = "lag", method = "eigen", quiet
summary(sur.lag)
```

---

summary.splm *summary method for class splm*

Description

Method for summarizing the results of objects of class 'splm'

Usage

```
## S3 method for class 'splm':
summary(object,...)
```

Arguments

object	an object of class 'splm'
...	additional arguments to be passed

Details

The summary function `summary.splm` returns an objects of class 'splm' organized in a coefficient matrix.

Also a matrix for the error components, or the spatial coefficients will be generated depending on the estimated model.

When the `'splm'` is produced by the function 'spsegm', the summary will be generated looping over the number of equations in the system.

Value

An object of class `'summary.splm'`

Author(s)

Giovanni Millo <Giovanni_Millo@Generali.com>, Gianfranco Piras<gpiras@mac.com>

See Also

`spreml`, `spregm`, `spreml`, `effects`

Examples

```
data(Produc, package = "Ecdat")
data(usaww)
Produc <- Produc[Produc$year<1975, ]
GM<-spregm(log(gsp)~log(pcap)+log(pc)+log(emp)+unemp, data=Produc,w=usaww,method="fulweig
summary(GM)
```

---

usaww *Spatial weights matrix - US states*

Description

Spatial weights matrix of the US States based on a contiguity criteria.

Usage

```
usaww
```

Format

A matrix with elements different from zero if state i and j are neighbors

`write.effects.splm` *method for writing a table with fixed effects*

Description

Methods used for writing fixed effects to `filename`

Usage

```
## S3 method for class 'effects.splm':
write(x, file = "effects", ncolumns = if (is.character(x)) 1 else 5,
    append = FALSE, sep = ",")
```

Arguments

`x`	an object of class `'effects.splm'`
`file`	name of the file, default set to `"effects"`
`ncolumns`	the number of columns to write the data in
`append`	if `TRUE` the data are appended to the connection
`sep`	string to separate columns; default is = ","

Details

If the argument `object` is not of class `effects.splm` the function will terminate with an error message.

Author(s)

Gianfranco Piras `<gpiras@mac.com>`

References

Elhorst, J.P. (2003) Specification and estimation of spatial panel data models, *International Regional Science Review*, **26**, pages 244–268.

Elhorst, J.P. (2009) Spatial panel data models, *In* Fischer, M.M. and Getis, A. (eds), *Handbook of Applied Spatial Analysis* Springer, Berlin.

See Also

`spfeml`

Examples

```
data(Produc, package = "Ecdat")
data(usaww)
Produc <- Produc[Produc$year<1975, ]
fm <- log(gsp) ~ log(pcap) + log(pc) + log(emp) + unemp
lag <- spfeml(fm, data = Produc, listw = mat2listw(usaww), effects = "sptpfe", method = "
summary(lag)
eff <- effects(lag)
err <- spfeml(fm, data = Produc, listw = mat2listw(usaww), model = "error", effects = "tp
```

```
summary(err)
eff <- effects(err)
summary(eff)
write.effects.splm(eff)
```

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