Package ‘ssfa’

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Title Spatial Stochastic Frontier Analysis
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Description Spatial Stochastic Frontier Analysis (SSFA) is an original method for controlling the spatial heterogeneity in Stochastic Frontier Analysis (SFA) models by splitting the inefficiency term into three terms: the first one related to spatial peculiarities of the territory in which each single unit operates, the second one related to the specific production features and the third one representing the error term.
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The package implements the Spatial Stochastic Frontier model introduced by Fusco and Vidoli (2013). The method controls spatial heterogeneity in SFA models by splitting the inefficiency term into three parts: the first one related to spatial peculiarities of the territory in which each single unit operates, the second one related to the specific production features and the third one representing the error term.

Details

Package: ssfa
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Author(s)

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Maintainer: Elisa Fusco <fusco_elisa@libero.it>

References


description

eff.ssfa

SSFA efficiency

Description

This function returns the technical efficiency of each producer (without local spatial effects) calculated by the Battese and Coelli (1988) formulation modified by using an autoregressive specification in the inefficiency term $u$.

Usage

eff.ssfa(object, ...)

Arguments

object an object of class ssfa.

\[ \ldots \]

further arguments for methods.

Value

Technical efficiency of each producer (without local spatial effects).

References


See Also

u.ssfa

Examples

```r
library(ssfa)
data(SSFA_example_data)
data(Italian_W)
ssfa <- ssfa(log_y ~ log_x, data = SSFA_example_data, data_w=Italian_W, form = "production", par_rho=TRUE)
eff <- eff.ssfa(ssfa)
```

Description

This function returns the fitted values of the original data used to estimate the SSFA model.

Usage

```r
## S3 method for class 'ssfa'
fitted(object, ...)
```

Arguments

object an object of class ssfa.

\[ \ldots \]

further arguments for methods.
Examples

```r
library(ssfa)
data(SSFA_example_data)
data(Italian_W)
ssfa <- ssfa(log_y ~ log_x, data = SSFA_example_data, data_w=Italian_W, form = "production", par_rho=TRUE)
fitted.ssfa(ssfa)
```

---

**Italian_W**

*Italian provinces spatial weights matrix example*

---

**Description**

This is an example dataset that contains the 107 Italian provinces contiguity matrix (year 2008).

**Usage**

```r
data(Italian_W)
```

**Format**

A data frame with 107 x 107 row-standardized distances between observations (Italian provinces).

**References**

http://www.istat.it/it/archivio/104317#confini.

**Examples**

```r
data(Italian_W)
```

---

**l_hnv**

*SFA half-normal log likelihood function*

---

**Description**

This function is used to estimate the parameters of the classical SFA model where half-normal distribution of inefficiency term is assumed.

**Usage**

```r
L_hNV(p, y = y, X = X, sc = sc)
```
$L_{hNV\_rho}$

**Arguments**

- $p$: a vector with the parameters to be estimated.
- $y$: the dependent variable.
- $X$: the model matrix.
- $sc$: specifies the form of the frontier model ($-1 = \text{cost}, 1 = \text{production}$).

**Value**

Value of the SFA log likelihood function.

| $L_{hNV\_rho}$ | SSFA half-normal log likelihood function |

**Description**

This function is used to estimate the parameters of the SSFA model where half-normal distribution of inefficiency term is assumed.

**Usage**

$L_{hNV\_rho}(p, y = y, X = X, sc = sc, w = w, \text{sigm}au2\_sar = \text{sigm}au2\_sar)$

**Arguments**

- $p$: a vector with the parameters to be estimated.
- $y$: the dependent variable.
- $X$: the model matrix.
- $sc$: specifies the form of the frontier model ($-1 = \text{cost}, 1 = \text{production}$).
- $w$: the spatial weight matrix.
- $\text{sigm}au2\_sar$: is the variance of the spatial correlated part of the inefficiency term estimated into $ssfa\_fit$ function.

**Value**

Value of the SSFA log likelihood function.

**Note**

Please note that $\text{sigm}au2\_sar$ is not a free parameter because it is estimated into the $ssfa\_fit$ function.

**See Also**

$ssfa$
plot_fitted  SSFA plot

Description

This function allows to plot the data and the fitted values obtained by SSFA model.

Usage

plot_fitted(x, y, object, xlab, ylab, main, ...)

Arguments

x the x coordinates of points in the plot.
y the y coordinates of points in the plot.
object an object of class ssfa.
xlab a title for the x axis.
ylab a title for the y axis.
main an overall title for the plot.
... arguments to be passed to methods, such as graphical parameters (see par).

See Also

plot

Examples

library(ssfa)
data(SSFA_example_data)
data(Italian,W)

### SFA and SSFA comparison
sfa <- ssfa(log_y ~ log_x, data = SSFA_example_data, data_w=Italian,W,
            form = "production", par_rho=FALSE)
ssfa <- ssfa(log_y ~ log_x, data = SSFA_example_data, data_w=Italian,W,
            form = "production", par_rho=TRUE)

sfa_fitted <- fitted.ssfa(sfa)
plot_fitted(SSFA_example_data$log_x, SSFA_example_data$log_y, ssfa)
lines(sort(SSFA_example_data$log_x), sfa_fitted[order(SSFA_example_data$log_x)], col="red")
Description

This function allows to plot the residuals of the object against their spatially lagged values, augmented by reporting the summary of influence measures for the linear relationship between the data and the lag.

Usage

plot_moran(x, main, xlab, ylab, labels, listw, ...)

Arguments

x an object of class ssfa.
main an overall title for the plot.
xlab a label for the x axis.
labels a label for the y axis.
labels character labels for points with high influence measures, if set to FALSE, no labels are plotted for points with large influence.
listw a listw object from nb2listw (see nb2listw).
... arguments to be passed to methods, such as graphical parameters (see par).

References


See Also

moran.plot

Examples

library(ssfa)
data(SSFA_example_data)
data(Italian_W)

### SFA and SSFA comparison ###
sfa <- ssfa(log_y ~ log_x, data = SSFA_example_data, data.w=Italian_W, form = "production", par_rho=FALSE)
ssfa <- ssfa(log_y ~ log_x, data = SSFA_example_data, data.w=Italian_W,
residuals.ssfa  \textit{SSFA residuals}

\textbf{Description}

This function returns the residuals of the fitted SSFA model.

\textbf{Usage}

```r
## S3 method for class 'ssfa'
residuals(object, ...)
```

\textbf{Arguments}

- \texttt{object} an object of class \texttt{ssfa}.
- \texttt{...} further arguments for methods.

\textbf{Examples}

```r
library(ssfa)
data(SSFA_example_data)
data(Italian_W)
ssfa <- ssfa(log_y ~ log_x, data = SSFA_example_data,
             data_w=Italian_W, form = "production", par_rho=TRUE)
residuals.ssfa(ssfa)
```

\textbf{Description}

This function estimates the Spatial Stochastic Frontier model introduced by Fusco and Vidoli (2013) in the following form:

\[
\log(y_i) = \log(f(x_i; \beta_i)) + v_i - u_i \\
\]

\[
u_i = \rho \sum_i w_i, u_i + \tilde{u}_i
\]

where \(y_i\) are the outputs, \(x_i\) the inputs, \(v_i\) the stochastic noise, \(u_i\) the inefficiency term, \(\rho\) the spatial lag, \(w_i\) a standardized row of the spatial weights matrix and \(\tilde{u}_i\) the stochastic noise of the inefficiency term.
Usage

```r
ssfa(formula, data = NULL, data_w = NULL, intercept = TRUE, pars = NULL, par_rho = TRUE, form = "cost")
```

Arguments

- `formula`: an object of class `formula` (or one that can be coerced to that class): a symbolic description of the model to be fitted.
- `data`: an optional data frame containing the variables in the model.
- `data_w`: a data frame containing the spatial weight matrix.
- `intercept`: logical. If true the model includes intercept.
- `pars`: initial values for the parameters to be estimated.
- `par_rho`: logical. If true the function estimates the Spatial Stochastic Frontier (SSFA) otherwise the classical Stochastic Frontier (SFA).
- `form`: specifies the form of the frontier model as "cost" or "production".

Value

`ssfa` returns the following objects of class `ssfa`:

- `y`: the dependent variable.
- `x`: the covariates.
- `X`: the model matrix.
- `coef`: the estimated coefficients.
- `sc`: the form of the frontier model estimated (-1 = cost, 1 = production).
- `hess`: a symmetric matrix giving an estimate of the Hessian at the solution found.
- `logLik`: the value of the log likelihood function.
- `ols`: the linear model for the LR-test.
- `sigmav2`: the estimation of sigmav2: value of the stochastic error variance.
- `sigma2`: the estimation of sigma2: value of the total variance.
- `rho`: the estimation of the spatial lag parameter rho.
- `fun`: the distribution of the inefficiency term u.
- `list_w`: a listw object from `nb2listw` (See `nb2listw`).
**Note**

NOTE 1: In this version the distribution of the inefficiency term \( u \) is only "half-normal".

NOTE 2: The method used to maximize the log likelihood function is the Newton-Raphson. Please see the R function `maxNR` of the `maxlik` package for details (Henningsen and Toomet (2011)).

NOTE 3: Please note that the classical SFA inefficiency variance \( \sigma_u \), in the SSFA, is decomposed into \( \sigma_{u,dm} \) and \( \sigma_{u,sar} \), respectively the part of inefficiency variance due to DMU's specificities and to the spatial dependence, i.e. \( \sigma_u = \sigma_{u,dm} + \sigma_{u,sar} \) and consequently the total variance is given by \( \sigma^2 = \sigma_{u,dm} + \sigma_{u,sar} + \sigma_{v} \).

**Author(s)**

Fusco E. and Vidoli F.

**References**


**Examples**

```r
library(ssfa)
data(SSFA_example_data)
data(italian_W)
ssfa <- ssfa(log_y ~ log_x, data = SSFA_example_data, 
data_w = italian_W, form = "production", par_rho=TRUE)

### SSFA total variance decomposition
sigma2 = ssfa$sigma2_dmu + ssfa$sigma2_sar + ssfa$sigmav2
sigma2
ssfa$sigma2
```

---

**SSFA_example_data**  
**Example dataset**
**Description**

The dataset contains the simulated data used by Fusco and Vidoli (2013) to test the model. Data Generating Process (DGP) follows the construction criteria proposed by Banker and Natarajan (2008), also used by Johnson and Kuosmanen (2011), with the addition of a strong spatial correlation in the inefficiency term through a spatial lag parameter and a contiguity matrix (107 Italian provinces contiguity matrix, year 2008).

**Usage**

data(SSFA_example_data)

**Format**

A data frame with 107 observations (Italian provinces) and 2 variables:

- **DMU** the Decision Making Unit name.
- **log_x** the input vector (already in logarithmic form).
- **log_y** the output vector (already in logarithmic form).

**References**


**Examples**

data(SSFA_example_data)

---

**Description**

The function `print.ssf` is used to display the values of SFA and SSFA estimated coefficients. In particular:

- for SFA the function displays the Intercept, the regressors beta coefficients, the inefficiency variance sigma2, the stochastic error variance sigmav2 and the total variance sigma2;
- for SSFA the function displays, in addition, the decomposition of the inefficiency variance into sigma2_dmu and sigma2_sar, respectively the part of inefficiency variance due to DMU’s specificities and to the spatial dependence, and finally, the spatial lag parameter rho.

The function `summary.ssf` is used to display the summary results of SFA and SSFA. In particular:

- for SFA the summary shows the estimation of SFA coefficients (Intercept, beta coefficients, sigma2 and sigmav2) and others useful information as the total variance sigma2, the inefficiency variance.
parameter $\lambda$ ($\sigma_u/\sigma_v$), the Moran I statistic, the mean of efficiency, the LR-test and the AIC values;
- for SSFA the summary shows, in addition, the decomposition of the inefficiency variance into $\sigma_u2_{dmu}$ and $\sigma_u2_{sar}$ and the spatial lag parameter $\rho$.

Usage

```r
## S3 method for class 'ssfa'
print(x, ...)
## S3 method for class 'ssfa'
summary(object, ...)
```

Arguments

- `x` an object of class `ssfa`.
- `object` an object of class `ssfa`.
- `...` further arguments for methods.

Note

Please note that the classical SFA inefficiency variance $\sigma_u2$, in the SSFA, is decomposed into $\sigma_u2_{dmu}$ and $\sigma_u2_{sar}$, respectively the part of inefficiency variance due to DMU’s specificities and to the spatial dependence, i.e. $\sigma_u2 = \sigma_u2_{dmu} + \sigma_u2_{sar}$ and consequently the total variance is given by $\sigma_R = \sigma_u2_{dmu} + \sigma_u2_{sar} + \sigma_vR$.

References


Examples

```r
library(ssfa)
data(SSFA_example_data)
data(Italian_W)
ssfa <- ssfa(log_y ~ log_x, data = SSFA_example_data,
            data_w=Italian_W, form = "production", par_rho=TRUE)
print(ssfa)
summary(ssfa)
```
SSFA inefficiency

Description
This function returns the specific inefficiency of each producer (without local spatial effects) calculated by the Jondrow et al. (JLMS) (1982) formulation modified by using an autoregressive specification in the inefficiency term.

Usage
u.ssfa(object, ...)

Arguments
- object: an object of class ssfa.
- ...: further arguments for methods.

Value
Inefficiency of each producer (without local spatial effects).

References

See Also
eff.ssfa

Examples
library(ssfa)
data(SSFA_example_data)
data(Italian_W)
ssfa <- ssfa(log_y ~ log_x, data = SSFA_example_data, data_w=Italian_W, form = "production", par_rh0=TRUE)
ineff <- u.ssfa(ssfa)
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