Package ‘systemfit’
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Description This package contains functions for fitting simultaneous
systems of linear and nonlinear equations using Ordinary Least
Squares (OLS), Weighted Least Squares (WLS), Seemingly
Unrelated Regressions (SUR), Two-Stage Least Squares (2SLS),
Weighted Two-Stage Least Squares (W2SLS), and Three-Stage Least
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R topics documented:

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bread.systemfit

Description

Extract the estimator for the bread of sandwiches (see bread).

Usage

```
## S3 method for class 'systemfit'
bread(obj, ...)
```

Arguments

- `obj` an object of class `systemfit`.
- `...` further arguments (currently ignored).

Value

Quadratic symmetric matrix, which is an estimator for the expectation of the negative derivative of the estimating function (see estfun.systemfit).
**Warnings**

The `sandwich` package must be loaded before this method can be used.

This method might not be suitable for specific formulas for 3SLS estimations in case of unbalanced systems or different instruments for different equations.

**Author(s)**

Arne Henningsen

**See Also**

`bread`, `systemfit`.

**Examples**

```r
data( "Kmenta" )
eqDemand <- consump ~ price + income
eqSupply <- consump ~ price + farmPrice + trend
system <- list( demand = eqDemand, supply = eqSupply )
inst <- ~ income + farmPrice + trend

## OLS estimation
fitols <- systemfit( system, "OLS", data = Kmenta )

## obtain the bread
library( "sandwich" )
bread( fitols )

## this is only true for OLS models
all.equal( bread( fitols ),
   solve( crossprod( model.matrix( fitols ) ) / 40 ) )

## 2SLS estimation
fit2sls <- systemfit( system, "2SLS", inst = inst, data = Kmenta )

## obtain the bread
bread( fit2sls )

## this is only true for 2SLS models
all.equal( bread( fit2sls ),
   solve( crossprod( model.matrix( fit2sls, which = "xHat" ) ) / 40 ) )

## iterated SUR estimation
fitsur <- systemfit( system, "SUR", data = Kmenta, maxit = 100 )

## obtain the bread
bread( fitsur )

## this should be true for SUR and WLS models
```
all.equal( bread( fitsur ),
  solve( t( model.matrix( fitsur ) ) %*%
         ( ( solve( fitsur$residCovEst ) %x% diag( nrow( Kmenta ) ) ) %*% model.matrix( fitsur ) ) / 40 ), check.attributes = FALSE )

## 3SLS estimation
fit3sls <- systemfit( system, "3SLS", inst = inst, data = Kmenta )

## obtain the bread
bread( fit3sls )

## this should be true for 3SLS and W2SLS models
all.equal( bread( fit3sls ),
  solve( t( model.matrix( fit3sls, which = "xHat" ) ) %*%
         ( ( solve( fit3sls$residCovEst ) %x% diag( nrow( Kmenta ) ) ) %*% model.matrix( fit3sls, which = "xHat" ) ) / 40 ), check.attributes = FALSE )

---

**coef.systemfit**  
*Coefficients of systemfit object*

**Description**

These functions extract the coefficients from an object returned by `systemfit`.

**Usage**

```r
## S3 method for class 'systemfit'
coef( object, modified.regMat = FALSE, ... )

## S3 method for class 'systemfit.equation'
coef( object, ... )

## S3 method for class 'summary.systemfit'
coef( object, modified.regMat = FALSE, ... )

## S3 method for class 'summary.systemfit.equation'
coef( object, ... )
```

**Arguments**

- **object**: an object of class `systemfit`, `systemfit.equation`, `summary.systemfit`, or `summary.systemfit.equation`.
- **modified.regMat**: logical. If TRUE, the coefficients of the modified regressor matrix (original regressor matrix post-multiplied by `restrict.regMat`) rather than the coefficients of the original regressor matrix are returned.
- **...**: other arguments.
Value

coef.systemfit returns a vector of all estimated coefficients.
coef.systemfit.equation returns a vector of the estimated coefficients of a single equation.
coef.summary.systemfit returns a matrix of all estimated coefficients, their standard errors, t-values, and p-values.
coef.summary.systemfit.equation returns a matrix of the estimated coefficients of a single equation, their standard errors, t-values, and p-values.

Author(s)

Arne Henningsen <arne.henningsen@googlemail.com>

See Also

systemfit.coef

Examples

data( "Kmenta" )
eqDemand <- consump ~ price + income
eqSupply <- consump ~ price + farmPrice + trend
system <- list( demand = eqDemand, supply = eqSupply )

## perform OLS on each of the equations in the system
fitols <- systemfit( system, data = Kmenta )

## all coefficients
coef( fitols )
coef( summary( fitols ) )

## coefficients of the first equation
coef( fitols$eq[[1]] )
coef( summary( fitols$eq[[1]] ) )

## coefficients of the second equation
coef( fitols$eq[[2]] )
coef( summary( fitols$eq[[2]] ) )

## estimation with restriction by modifying the regressor matrix
modReg <- matrix( 0, 7, 6 )
colnames( modReg ) <- c( "demIntercept", "demPrice", "demIncome", "supIntercept", "supPrice2", "supTrend" )
modReg[ 1, "demIntercept" ] <- 1
modReg[ 2, "demPrice" ] <- 1
modReg[ 3, "demIncome" ] <- 1
modReg[ 4, "supIntercept" ] <- 1
modReg[ 5, "supPrice2" ] <- 1
modReg[ 6, "supPrice2" ] <- 1
modReg[ 7, "supTrend" ] <- 1
fitols3 <- systemfit( system, data = Kmenta, restrict.regMat = modReg )
These functions calculate the confidence intervals of the coefficients from an object returned by `systemfit`.

### Usage

```r
## S3 method for class 'systemfit'
confint(object, parm = NULL, level = 0.95,
         usedFsys = NULL, ...)

## S3 method for class 'systemfit.equation'
confint(object, parm, level = 0.95,
         usedFsys = NULL, ...)
```

### Arguments

- `object`: an object of class `systemfit` or `systemfit.equation`.
- `parm`: not used yet.
- `level`: confidence level.
- `usedFsys`: logical. Use the degrees of freedom of the whole system (in place of the degrees of freedom of the single equation) to calculate the confidence intervals of the coefficients. If it is not specified (NULL), it is set to `TRUE` if restrictions on the coefficients are imposed and `FALSE` otherwise.
- `...`: other arguments.

### Value

An object of class `confint.systemfit`, which is a matrix with columns giving lower and upper confidence limits for each estimated coefficient. These will be labelled as `(1-level)/2` and `1 - (1-level)/2` in % (by default 2.5% and 97.5%).

### Author(s)

Arne Henningsen <arne.henningsen@googlemail.com>

### See Also

`systemfit`, `print.confint.systemfit`, `confint`
Examples

data("kmenta")
eqDemand <- consump ~ price + income
eqSupply <- consump ~ price + farmPrice + trend
system <- list(demand = eqDemand, supply = eqSupply)

## perform OLS on each of the equations in the system
fitols <- systemfit(system = system, data = Kmenta)

## confidence intervals of all coefficients
confint(fitols)

## confidence intervals of the coefficients of the first equation
confint(fitols$eq[[1]])

## confidence intervals of the coefficients of the second equation
confint(fitols$eq[[2]])

correlation.systemfit  Correlation between Predictions from Equation i and j

description

correlation returns a vector of the correlations between the predictions of two equations in a set of equations. The correlation between the predictions is defined as,

\[ r_{ijk} = \frac{x'_{ik}C_{ij}x_{jk}}{\sqrt{(x'_{ik}C_{ii}x_{ik})(x'_{jk}C_{jj}x_{jk})}} \]

where \( r_{ijk} \) is the correlation between the predicted values of equation i and j and \( C_{ij} \) is the cross-equation variance-covariance matrix between equations i and j.

Usage

correlation.systemfit(results, eqni, eqnj)

Arguments

results an object of type systemfit.
eqni index for equation i
eqnj index for equation j

Value

correlation returns a vector of the correlations between the predicted values in equation i and equation j.
createSystemfitModel

Create a Model for systemfit

Description

This function creates a model that can be estimated by systemfit. The data, disturbances, and — if not provided by the user — the coefficients as well as the disturbance covariance matrix are generated by random numbers.
**Usage**

```r
createSystemfitModel( nEq, nRegEq, nObs, coef = NULL, sigma = NULL )
```

**Arguments**

- `nEq`  
  the number of equations.
- `nRegEq`  
  the number of regressors in each equation (without the intercept).
- `nObs`  
  the number of observations.
- `coef`  
  an optional vector of coefficients.
- `sigma`  
  an optional covariance matrix of the disturbance terms.

**Value**

`createSystemfitModel` returns a list with following elements:

- `formula`  
  a list of the model equations (objects of class `formula`).
- `data`  
  a `data.frame` that contains the data.
- `coef`  
  a vector of (true) coefficients.
- `sigma`  
  the covariance matrix of the disturbance terms.

**Author(s)**

Arne Henningsen <arne.henningsen@googlemail.com>

**See Also**

- `systemfit`

**Examples**

```r
## create a model by random numbers
systemfitModel <- createSystemfitModel( 3, 4, 100 )

## estimate this model by "SUR"
fitsur <- systemfit( systemfitModel$formula, "SUR", data = systemfitModel$data )

## compare the "true" and the estimated coefficients
cbind( systemfitModel$coef, coef( fitsur ) )
```
estfun.systemfit  

Extract Gradients of the Objective Function at each Observation

Description

Extract the gradients of the objective function with respect to the coefficients evaluated at each observation ('Empirical Estimating Function', see estfun).

Usage

```r
## S3 method for class 'systemfit'
estfun( obj, residFit = TRUE, ... )
```

Arguments

- `obj`: an object of class `systemfit`.
- `residFit`: logical. If FALSE, the residuals are calculated based on observed regressors. If TRUE, the residuals are calculated based on fitted regressors. This argument is ignored if no instrumental variable are used.
- `...`: further arguments (currently ignored).

Value

Matrix of gradients of the objective function with respect to the coefficients evaluated at each observation.

Warnings

The `sandwich` package must be loaded before this method can be used.

In specific estimations with the 3SLS method, not all columns of the matrix returned by the `estfun` method sum up to zero, which indicates that an inappropriate estimating function is returned. This can be either with argument `residFit` set to TRUE or with this argument set to FALSE or even in both cases. This problem depends on the formula used for the 3SLS estimation and seems to be related to unbalanced systems and systems where different instruments are used in different equations.

Author(s)

Arne Henningsen

See Also

`estfun`, `systemfit`. 
Examples

data( "Kmenta" )
eqDemand <- consump ~ price + income
eqSupply <- consump ~ price + farmPrice + trend
system <- list( demand = eqDemand, supply = eqSupply )
inst <- ~ income + farmPrice + trend

## OLS estimation
fitols <- systemfit( system, "OLS", data = Kmenta )

## obtain the estimation function
library( "sandwich" )
estfun( fitols )

## this is only true for OLS models
all.equal( estfun( fitols ),
           unlist( residuals( fitols ) ) * model.matrix( fitols ) )

# each column should sum up to (approximately) zero
colSums( estfun( fitols ) )

## 2SLS estimation
fit2sls <- systemfit( system, "2SLS", inst = inst, data = Kmenta )

## obtain the estimation function
estfun( fit2sls )

## this is only true for 2SLS models
all.equal( estfun( fit2sls ),
           drop( rep( Kmenta$consump, 2 ) - model.matrix( fit2sls, which = "xHat" ) %*%
                coef( fit2sls ) ) * model.matrix( fit2sls, which = "xHat" ) )
all.equal( estfun( fit2sls, residFit = FALSE ),
           unlist( residuals( fit2sls ) ) * model.matrix( fit2sls, which = "xHat" ) )

# each column should sum up to (approximately) zero
colSums( estfun( fit2sls ) )
colSums( estfun( fit2sls, residFit = FALSE ) )

## iterated SUR estimation
fitsur <- systemfit( system, "SUR", data = Kmenta, maxit = 100 )

## obtain the estimation function
estfun( fitsur )

## this should be true for SUR and WLS models
all.equal( estfun( fitsur ),
           unlist( residuals( fitsur ) ) *
              ( solve( fitsur$residCovEst ) %*% diag( nrow( Kmenta ) ) ) %*%
              model.matrix( fitsur ) ), check.attributes = FALSE )
# each column should sum up to (approximately) zero
colSums( estfun( fitsur ) )

## 3SLS estimation
fit3sls <- systemfit( system, "3SLS", inst = inst, data = Kmenta )

## obtain the estimation function
estfun( fit3sls )
estfun( fit3sls, residFit = FALSE )

## this should be true for 3SLS and W2SLS models
all.equal( estfun( fit3sls ),
drop( rep( Kmenta$consump, 2 ) -
model.matrix( fit2sls, which = "xHat" ) ) %*% coef( fit3sls ) ) %*%
( ( solve( fit3sls$residCovEst ) ) %*% diag( nrow( Kmenta ) ) ) %*%
model.matrix( fit3sls, which = "xHat" ), check.attributes = FALSE )

all.equal( estfun( fit3sls, residFit = FALSE ),
unlist( residuals( fit3sls ) ) )

## each column should sum up to (approximately) zero
colSums( estfun( fit3s3ls ) )
colSums( estfun( fit3s3ls, residFit = FALSE ) )

---

### fitted.systemfit

**Fitted values**

#### Description

These functions extract the fitted values from an object returned by `systemfit`.

#### Usage

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

## S3 method for class 'systemfit.equation'
fitted( object, na.rm = FALSE, ... )
```

#### Arguments

- **object**: an object of class `systemfit` or `systemfit.equation`.
- **na.rm**: a logical value indicating whether NA values (corresponding to observations that were not included in the estimation) should be removed from the vector of fitted values before it is returned.
- **...**: other arguments.
Value

fitted.systemfit returns a data.frame of all fitted values, where each column contains the fitted values of one equation.

fitted.systemfit.equation returns a vector of the fitted values of a single equation.

Author(s)

Arne Henningsen <arne.henningsen@googlemail.com>

See Also

systemfit, fitted

Examples

data( "Kmenta" )
eqDemand <- consump ~ price + income
eqSupply <- consump ~ price + farmPrice + trend
system <- list( demand = eqDemand, supply = eqSupply )

## perform OLS on each of the equations in the system
fitols <- systemfit( system, data = Kmenta )

## all fitted values
fitted( fitols )

## fitted values of the first equation
fitted( fitols$eq[[1]] )

## fitted values of the second equation
fitted( fitols$eq[[2]] )

Description

This method extracts the model formulae from fitted objects returned by systemfit.

Usage

## S3 method for class 'systemfit'
formula( x, ... )

## S3 method for class 'systemfit.equation'
formula( x, ... )
Arguments

x an object of class systemfit.

... currently not used.

Value

formula.systemfit.equation returns the formula of a single equation of a systemfit object.

formula.systemfit.equation returns a list of formulae: one formula object for each equation of the systemfit object.

Author(s)

Arne Henningsen <arne.henningsen@googlemail.com>

See Also

systemfit, formula

Examples

data( "Kmenta" )
eqDemand <- consump ~ price + income
eqSupply <- consump ~ price + farmPrice + trend
system <- list( demand = eqDemand, supply = eqSupply )

## perform a SUR estimation
fitsur <- systemfit( system, "SUR", data = Kmenta )

## formula of the second equation
formula( fitsur$eq[[2]] )

## all formulae of the system
formula( fitsur )

GrunfeldGreene Grunfeld Data as published by Greene (2003)

Description

Panel data on 5 US firms for the years 1935-1954.

Usage

data("GrunfeldGreene")
Format

A data frame containing 20 annual observations on 3 variables for 5 firms.

- **invest**: gross investment.
- **value**: market value of the firm (at the end of the previous year).
- **capital**: capital stock of the firm (at the end of the previous year).
- **firm**: name of the firm ("General Motors", "Chrysler", "General Electric", "Westinghouse" or "US Steel").
- **year**: year.

Details

There exist several different versions of this data set, and this version is considered incorrect (see [http://www.stanford.edu/~clint/bench/grunfeld.htm](http://www.stanford.edu/~clint/bench/grunfeld.htm) for details). However, we provide this incorrect version to replicate the results published in Theil (1971) and Greene (2003). A correct version of this data set with 5 additional firms is available in the Ecdat package (data set Grunfeld).

Source


References


Examples

```r
## Repeating the OLS and SUR estimations in Greene (2003, pp. 351)
data( "GrunfeldGreene" )
library( plm )
GGPPanel <- plm.data( GrunfeldGreene, c( "firm", "year" ) )
formulaGrunfeld <- invest ~ value + capital
# OLS
greeneOls <- systemfit( formulaGrunfeld, "OLS",
data = GGPPanel )
summary( greeneOls )
sapply( greeneOls$eq, function(x){return(summary(x)$ssr/20)}) # sigma^2
# OLS Pooled
greeneOlsPooled <- systemfit( formulaGrunfeld, "OLS",
data = GGPPanel, pooled = TRUE )
summary( greeneOlsPooled )
sum( sapply( greeneOlsPooled$eq, function(x){return(summary(x)$ssr)}) )/97 # sigma^2
# SUR
```
hausman.systemfit

Description

hausman.systemfit returns the Hausman statistic for a specification test.

Usage

hausman.systemfit( results2sls, results3sls )

Arguments

results2sls result of a 2SLS (limited information) estimation returned by systemfit.
results3sls result of a 3SLS (full information) estimation returned by systemfit.

Details

The null hypotheses of the test is that all exogenous variables are uncorrelated with all disturbance terms. Under this hypothesis both the 2SLS and the 3SLS estimator are consistent but only the 3SLS estimator is (asymptotically) efficient. Under the alternative hypothesis the 2SLS estimator is consistent but the 3SLS estimator is inconsistent.

The Hausman test statistic is

\[ m = (b_2 - b_3)/(V_2 - V_3)(b_2 - b_3) \]
where $b_2$ and $V_2$ are the estimated coefficients and their variance covariance matrix of a 2SLS estimation and $b_3$ and $V_3$ are the estimated coefficients and their variance covariance matrix of a 3SLS estimation.

Value

`hausman.systemfit` returns a list of the class `htest` that contains the following elements:
- `q` vector of the differences between the estimated coefficients.
- `qVar` variance covariance matrix of `q` (difference between the variance covariance matrices of the estimated coefficients).
- `statistic` the Hausman test statistic.
- `parameter` degrees of freedom.
- `p.value` P-value of the test.
- `method` character string describing this test.
- `data.name` name of the data.frame used for estimation.

Author(s)

Jeff D. Hamann <jeff.hamann@forestinformatics.com>,
Arne Henningsen <arne.henningsen@googlemail.com>

References


See Also

`systemfit`

Examples

data( "Kmenta" )
eqDemand <- consump ~ price + income
eqSupply <- consump ~ price + farmPrice + trend
inst <- ~ income + farmPrice + trend
system <- list( demand = eqDemand, supply = eqSupply )

## perform the estimations
fit2sls <- systemfit( system, "2SLS", inst = inst, data = Kmenta )
fit3sls <- systemfit( system, "3SLS", inst = inst, data = Kmenta )

## perform the Hausman test
h <- hausman.systemfit( fit2sls, fit3sls )
print( h )
KleinI

Klein Model I

Description

Data for Klein’s (1950) Model I of the US economy.

Usage

data("KleinI")

Format

A data frame containing annual observations from 1920 to 1941

year Year.
consump Consumption.
corpProf Corporate profits.
corpProfLag Corporate profits of the previous year.
privWage Private wage bill.
invest Investment.
capitalLag Capital stock of the previous year.
gnp Gross national product.
gnpLag Gross national product of the previous year.
govWage Government wage bill.
govExp Government spending.
taxes Taxes.
wages Sum of private and government wage bill.
trend time trend measured as years from 1931.

Source

Greene (2003), Appendix F, Data Sets Used in Applications, Table F15.1.
http://pages.stern.nyu.edu/~wgreene/Text/econometricanalysis.htm

References

Examples

```r
# Repeating the estimations of Klein's (1950) Model I
# in Greene (2003, pp. 381 and 412)
data("KleinI")
eqConsump <- consump ~ corpProf + corpProfFlag + wages
eqInvest <- invest ~ corpProf + corpProfFlag + capital Lag
eqPrivWage <- privWage ~ gnp + gnpLag + trend
inst <- ~ govExp + taxes + govWage + trend + capital L ag + corpProf Flag + gnpLag
system <- list(Consumption = eqConsump, Investment = eqInvest,
PrivateWages = eqPrivWage)

# OLS
kleinOls <- systemfit(system, data = KleinI)
summary(kleinOls)

# 2SLS
klein2sls <- systemfit(system, "2SLS", inst = inst, data = KleinI, methodResidCov = "noDfCor")
summary(klein2sls)

# 3SLS
klein3sls <- systemfit(system, "3SLS", inst = inst, data = KleinI, methodResidCov = "noDfCor")
summary(klein3sls)

# 3SLS
kleinI3sls <- systemfit(system, "3SLS", inst = inst, data = KleinI, methodResidCov = "noDfCor", maxit = 500)
summary(kleinI3sls)
```

Description

These are partly contrived data from Kmenta (1986), constructed to illustrate estimation of a simultaneous-equation model.

Usage

```r
data("Kmenta")
```

Format

This data frame contains 20 annual observations of 5 variables:

- **consump**  food consumption per capita.
- **price**  ratio of food prices to general consumer prices.
- **income**  disposable income in constant dollars.
- **farmPrice**  ratio of preceding year’s prices received by farmers to general consumer prices.
- **trend**  time trend in years.
Details

The exogenous variables income, farmPrice, and trend are based on real data; the endogenous variables price and consump were generated by simulation.

Source

Kmenta (1986), Table 13-1, p. 687.

References


Examples

```r
## Replicating the estimations in Kmenta (1986), p. 712, Tab 13-2
data( "Kmenta" )
eqDemand <- consump ~ price + income
eqSupply <- consump ~ price + farmPrice + trend
inst <- ~ income + farmPrice + trend
system <- list( demand = eqDemand, supply = eqSupply )

## OLS estimation
fit0ls <- systemfit( system, data = Kmenta )
summary( fit0ls )

## 2SLS estimation
fit2sls <- systemfit( system, "2SLS", inst = inst, data = Kmenta )
summary( fit2sls )

## 3SLS estimation
fit3sls <- systemfit( system, "3SLS", inst = inst, data = Kmenta )
summary( fit3sls )

## I3LS estimation
fitI3ls <- systemfit( system, "3SLS", inst = inst, data = Kmenta,
maxit = 250 )
summary( fitI3ls )
```

linearHypothesis.systemfit

Test Linear Hypothesis

Description

Testing linear hypothesis on the coefficients of a system of equations by an F-test or Wald-test.
Usage

```r
## S3 method for class 'systemfit'
linearHypothesis( model, 
hypothesis.matrix, rhs = NULL, test = c("FT", "F", "Chisq"), 
vcov. = NULL, ... )
```

Arguments

- `model`: a fitted object of type `systemfit`.
- `hypothesis.matrix`: matrix (or vector) giving linear combinations of coefficients by rows, or a character vector giving the hypothesis in symbolic form (see documentation of `linearHypothesis` in package "car" for details).
- `rhs`: optional right-hand-side vector for hypothesis, with as many entries as rows in the hypothesis matrix; if omitted, it defaults to a vector of zeroes.
- `test`: character string, "FT", "F", or "Chisq", specifying whether to compute Theil’s finite-sample F test (with approximate F distribution), the finite-sample Wald test (with approximate F distribution), or the large-sample Wald test (with asymptotic Chi-squared distribution).
- `vcov.`: a function for estimating the covariance matrix of the regression coefficients or an estimated covariance matrix (function `vcov` is used by default).
- `...`: further arguments passed to `linearHypothesis.default` (package "car").

Details

Theil’s F statistic for systems of equations is

\[
F = \frac{(R\hat{b} - q)'(R(X'(\Sigma \otimes I)^{-1}X)^{-1}R')^{-1}(R\hat{b} - q)/j}{\hat{\epsilon}'(\Sigma \otimes I)^{-1}\hat{\epsilon}/(M \cdot T - K)}
\]

where \(j\) is the number of restrictions, \(M\) is the number of equations, \(T\) is the number of observations per equation, \(K\) is the total number of estimated coefficients, and \(\Sigma\) is the estimated residual covariance matrix. Under the null hypothesis, \(F\) has an approximate F distribution with \(j\) and \(M \cdot T - K\) degrees of freedom (Theil, 1971, p. 314).

The \(F\) statistic for a Wald test is

\[
F = \frac{(R\hat{b} - q)'(R\hat{\text{Cov}}[\hat{b}]R')^{-1}(R\hat{b} - q)}{j}
\]

Under the null hypothesis, \(F\) has an approximate F distribution with \(j\) and \(M \cdot T - K\) degrees of freedom (Greene, 2003, p. 346).

The \(\chi^2\) statistic for a Wald test is

\[
W = (R\hat{b} - q)'(R\hat{\text{Cov}}[\hat{b}]R')^{-1}(R\hat{b} - q)
\]

Asymptotically, \(W\) has a \(\chi^2\) distribution with \(j\) degrees of freedom under the null hypothesis (Greene, 2003, p. 347).
Value

An object of class anova, which contains the residual degrees of freedom in the model, the difference in degrees of freedom, the test statistic (either F or Wald/Chisq) and the corresponding p value. See documentation of `linearHypothesis` in package "car".

Author(s)

Arne Henningsen <arne.henningsen@googlemail.com>

References


See Also

`systemfit.linearHypothesis` (package "car"), `lrtest.systemfit`

Examples

data( "Kmenta" )
eqDemand <- consump ~ price + income
eqSupply <- consump ~ price + farmPrice + trend
system <- list( demand = eqDemand, supply = eqSupply )

## unconstrained SUR estimation
fitsur <- systemfit( system, method = "SUR", data=Kmenta )

# create hypothesis matrix to test whether beta_2 = \beta_6
R1 <- matrix( 0, nrow = 1, ncol = 7 )
R1[ 1, 2 ] <- 1
R1[ 1, 6 ] <- -1
# the same hypothesis in symbolic form
restrict1 <- "demand_price - supply_farmPrice = 0"

## perform Theil’s F test
linearHypothesis( fitsur, R1 ) # rejected
linearHypothesis( fitsur, restrict1 )

## perform Wald test with F statistic
linearHypothesis( fitsur, R1, test = "F" ) # rejected
linearHypothesis( fitsur, restrict1 )

## perform Wald-test with chi^2 statistic
linearHypothesis( fitsur, R1, test = "Chisq" ) # rejected
linearHypothesis( fitsur, restrict1, test = "Chisq" )

# create hypothesis matrix to test whether beta_2 = - \beta_6
R2 <- matrix( 0, nrow = 1, ncol = 7 )
R2[ 1, 2 ] <- 1
R2[ 1, 6 ] <- 1
logLik.systemfit

This method calculates the log-likelihood value of a fitted object returned by `systemfit`.

### Usage

```r
## S3 method for class 'systemfit'
logLik(object, ...)
```

### Arguments

- `object`: an object of class `systemfit`.
- `...`: currently not used.

### Value

A numeric scalar (the log-likelihood value) with 2 attributes: `nobs` (total number of observations in all equations) and `df` (number of free parameters, i.e. coefficients + elements of the residual covariance matrix).

### Author(s)

Arne Henningsen `<arne.henningsen@googlemail.com>`

### See Also

- `systemfit`, `logLik`
Examples

data("kmenta")
eqDemand <- consump ~ price + income
eqSupply <- consump ~ price + farmPrice + trend
system <- list( demand = eqDemand, supply = eqSupply )

## perform a SUR estimation
fitsur <- systemfit( system, "SUR", data = kmenta )

## residuals of all equations
logLik( fitsur )

---

**lrtest.systemfit**

*Likelihood Ratio test for Equation Systems*

**Description**

Testing linear hypothesis on the coefficients of a system of equations by a Likelihood Ratio test.

**Usage**

```r
## S3 method for class 'systemfit'
lrtest(object, ... )
```

**Arguments**

- `object` a fitted model object of class `systemfit`.
- `...` further fitted model objects of class `systemfit`.

**Details**

`lrtest.systemfit` consecutively compares the fitted model object `object` with the models passed in `...`.

The LR-statistic for systems of equations is

\[
LR = T \cdot \left( \log | \hat{\Sigma}_r | - \log | \hat{\Sigma}_u | \right)
\]

where \( T \) is the number of observations per equation, and \( \hat{\Sigma}_r \) and \( \hat{\Sigma}_u \) are the residual covariance matrices calculated by formula "0" (see `systemfit`) of the restricted and unrestricted estimation, respectively. Asymptotically, \( LR \) has a \( \chi^2 \) distribution with \( j \) degrees of freedom under the null hypothesis (Green, 2003, p. 349).

**Value**

An object of class `anova`, which contains the log-likelihood value, degrees of freedom, the difference in degrees of freedom, likelihood ratio Chi-squared statistic and corresponding p value. See documentation of `lrtest` in package "lmtest".
model.frame.systemfit

Author(s)
Arne Henningsen <arne.henningsen@googlemail.com>

References

See Also
systemfit, lrtest (package "lmtest"), linearHypothesis.systemfit

Examples

data( "Kmenta" )
eqDemand <- consump ~ price + income
eqSupply <- consump ~ price + farmPrice + trend
system <- list( demand = eqDemand, supply = eqSupply )

## unconstrained SUR estimation
fitsur <- systemfit( system, "SUR", data = Kmenta )

# create restriction matrix to impose $\beta_R = \beta_V$
R1 <- matrix( 0, nrow = 1, ncol = 7 )
R1[ 1, 2 ] <- 1
R1[ 1, 6 ] <- -1

## constrained SUR estimation
fitsur1 <- systemfit( system, "SUR", data = Kmenta, restrict.matrix = R1 )

## perform LR-test
lrTest1 <- lrtest( fitsur1, fitsur )
print( lrTest1 )  # rejected

# create restriction matrix to impose $\beta_R = - \beta_V$
R2 <- matrix( 0, nrow = 1, ncol = 7 )
R2[ 1, 2 ] <- 1
R2[ 1, 6 ] <- 1

## constrained SUR estimation
fitsur2 <- systemfit( system, "SUR", data = Kmenta, restrict.matrix = R2 )

## perform LR-test
lrTest2 <- lrtest( fitsur2, fitsur )
print( lrTest2 )  # accepted
Description

These functions return the data used by systemfit to estimate a system of equations.

Usage

## S3 method for class 'systemfit'
model.frame( formula, ... )

## S3 method for class 'systemfit.equation'
model.frame( formula, ... )

Arguments

formula an object of class systemfit or systemfit.equation.

... currently ignored.

Value

model.frame.systemfit returns a simple data frame (without a 'terms' attribute) that contains all variables used to estimate the entire system of equations.

model.frame.systemfit.equation returns a model frame (data frame with a 'terms' attribute) that contains all variables used to estimate the respective equation.

Author(s)

Arne Henningsen <arne.henningsen@googlemail.com>

See Also

systemfit, model.frame, and model.matrix.systemfit

Examples

data( "Kmenta" )
eqDemand <- consump ~ price + income
eqSupply <- consump ~ price + farmPrice + trend
system <- list( demand = eqDemand, supply = eqSupply )

## perform OLS of the system
fitols <- systemfit( system, data = Kmenta )

## data used to estimate the entire system
model.frame( fitols )

## data used to estimate the first equation
model.frame( fitols$eq[[ 1 ]] )
Construct Design Matrices for Systems of Equations

Description

These functions create design matrices from objects returned by \texttt{systemfit}.

Usage

\begin{verbatim}
## S3 method for class 'systemfit'
model.matrix( object, which = "x", ... )

## S3 method for class 'systemfit.equation'
model.matrix( object, which = "x", ... )
\end{verbatim}

Arguments

- \texttt{object}: an object of class \texttt{systemfit} or \texttt{systemfit.equation}.
- \texttt{which}: character string: "x" indicates the usual model matrix of the regressors, "xHat" indicates the model matrix of the fitted regressors, "z" indicates the matrix of instrumental variables.
- \texttt{...}: currently ignored.

Value

- \texttt{model.matrix.systemfit}: returns a design matrix to estimate the specified system of equations.
- \texttt{model.matrix.systemfit.equation}: returns a design matrix to estimate the specified formula of the respective equation.

Author(s)

Arne Henningsen \textless{}arne.henningsen@googlemail.com\textgreater{}

See Also

\texttt{systemfit, model.matrix}, and \texttt{model.frame.systemfit}

Examples

\begin{verbatim}
data( "Kmenta" )
eqDemand <- consump ~ price + income
eqSupply <- consump ~ price + farmPrice + trend
system <- list( demand = eqDemand, supply = eqSupply )

## perform OLS of the system
fitols <- systemfit( system, data = Kmenta )
\end{verbatim}
nlsystemfit

Description
Fits a set of structural nonlinear equations using Ordinary Least Squares (OLS), Seemingly Unrelated Regression (SUR), Two-Stage Least Squares (2SLS), Three-Stage Least Squares (3SLS).

Usage

nlsystemfit( method="OLS", eqns, startvals,
            eqnlabels=c(as.character(1:length(eqns))), inst=NULL,
            data=list(), solvtol=Machine$double.eps,
            maxiter=1000, ... )

Arguments

- **method**: the estimation method, one of "OLS", "SUR", "2SLS", "3SLS".
- **eqns**: a list of structural equations to be estimated.
- **startvals**: a list of starting values for the coefficients.
- **eqnlabels**: an optional list of character vectors of names for the equation labels.
- **inst**: one-sided model formula specifying instrumental variables or a list of one-sided model formulas if different instruments should be used for the different equations (only needed for 2SLS, 3SLS and GMM estimations).
- **data**: an optional data frame containing the variables in the model. By default the variables are taken from the environment from which nlsystemfit is called.
- **solvtol**: tolerance for detecting linear dependencies in the columns of X in the qr function calls.
- **maxiter**: the maximum number of iterations for the nlm function.
- ... arguments passed to nlm.

Details
The nlsystemfit function relies on nlm to perform the minimization of the objective functions and the qr set of functions.
A system of nonlinear equations can be written as:

\[ \epsilon_t = q(y_t, x_t, \theta) \]
\[ z_t = Z(x_t) \]

where \( \epsilon_t \) are the residuals from the \( y \) observations and the function evaluated at the coefficient estimates.

The objective functions for the methods are:

<table>
<thead>
<tr>
<th>Method</th>
<th>Instruments</th>
<th>Objective Function</th>
<th>Covariance of ( \theta )</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLS</td>
<td>no</td>
<td>( r'r )</td>
<td>( (X(diag(S)^{-1} \otimes I)X)^{-1} )</td>
</tr>
<tr>
<td>SUR</td>
<td>no</td>
<td>( r'(diag(S)^{-1}_{OLS} \otimes I)r )</td>
<td>( (X(diag(S)^{-1} \otimes I)X)^{-1} )</td>
</tr>
<tr>
<td>2SLS</td>
<td>yes</td>
<td>( r'(I \otimes W)r )</td>
<td>( (X(diag(S)^{-1} \otimes I)X)^{-1} )</td>
</tr>
<tr>
<td>3SLS</td>
<td>yes</td>
<td>( r'(S^{-1}_{2SLS} \otimes W)r )</td>
<td>( (X(diag(S)^{-1} \otimes W)X)^{-1} )</td>
</tr>
</tbody>
</table>

where, \( r \) is a column vector for the residuals for each equation, \( S \) is variance-covariance matrix between the equations \( \hat{\sigma}_{ij} = (\hat{e}_i \hat{e}_j) / \sqrt{(T - k_i) \ast (T - k_j)} \), \( X \) is matrix of the partial derivates with respect to the coefficients, \( W \) is a matrix of the instrument variables \( Z(Z'Z)^{-1}Z \), \( Z \) is a matrix of the instrument variables, and \( I \) is an nxn identity matrix.

The SUR and 3SLS methods requires two solutions. The first solution for the SUR is an OLS solution to obtain the variance-covariance matrix. The 3SLS uses the variance-covariance from a 2SLS solution, then fits all the equations simultaneously.

The user should be aware that the function is \textbf{VERY} sensitive to the starting values and the \texttt{nlm} function may not converge. The \texttt{nlm} function will be called with the \texttt{typsize} argument set the absolute values of the starting values for the OLS and 2SLS methods. For the SUR and 3SLS methods, the \texttt{typsize} argument is set to the absolute values of the resulting OLS and 2SLS coefficient estimates from the \texttt{nlm} result structure. In addition, the starting values for the SUR and 3SLS methods are obtained from the OLS and 2SLS coefficient estimates to shorten the number of iterations. The number of iterations reported in the summary are only those used in the last call to \texttt{nlm}, thus the number of iterations in the OLS portion of the SUR fit and the 2SLS portion of the 3SLS fit are not included.

\textbf{Value}

\texttt{nlsystemfit} returns a list of the class \texttt{nlsystemfit.system} and contains all results that belong to the whole system. This list contains one special object: "eq". It is a list and contains one object for each estimated equation. These objects are of the class \texttt{nlsystemfit.equation} and contain the results that belong only to the regarding equation.

The objects of the class \texttt{nlsystemfit.system} and \texttt{nlsystemfit.equation} have the following components (the elements of the latter are marked with an asterisk (*)):

- **eq** a list object that contains a list object for each equation.
- **method** estimation method.
- **resids** an \( n \times g \) matrix of the residuals.
- **g** number of equations.
- **n** total number of observations.
- **k** total number of coefficients.
- **b** vector of all estimated coefficients.
se  estimated standard errors of b.
t  t values for b.
p  p values for b.
bcov  estimated covariance matrix of b.
rcov  estimated residual covariance matrix.
drcov  determinant of rcov.
rcovest  residual covariance matrix used for estimation (only SUR and 3SLS).
rcor  estimated residual correlation matrix.
nlmest  results from the nlm function call
solveto1  tolerance level when inverting a matrix or calculating a determinant.

## elements of the class nlsystemfit.eq

eq  a list that contains the results that belong to the individual equations.
eqlabel*  the equation label of the ith equation (from the labels list).
formula*  model formula of the ith equation.
n*  number of observations of the ith equation.
k*  number of coefficients/regressors in the ith equation.
df*  degrees of freedom of the ith equation.
b*  estimated coefficients of the ith equation.
se*  estimated standard errors of b.
t*  t values for b.
p*  p values for b.
covb*  estimated covariance matrix of b.
predicted*  vector of predicted values of the ith equation.
residuals*  vector of residuals of the ith equation.
ssr*  sum of squared residuals of the ith equation.
mse*  estimated variance of the residuals (mean of squared errors) of the ith equation.
s2*  estimated variance of the residuals ($\hat{\sigma}^2$) of the ith equation.
rmse*  estimated standard error of the residuals (square root of mse) of the ith equation.
s*  estimated standard error of the residuals ($\hat{\sigma}$) of the ith equation.
r2*  R-squared (coefficient of determination).
adjr2*  adjusted R-squared value.

Author(s)

Jeff D. Hamann <jeff.hamann@forestinformatics.com>

References

See Also

systemfit, nlm, and qr

Examples

library(systemfit)
data(ppine)

hg.formula <- hg - exp( h0 + h1*log(tht) + h2*tht^2 + h3*elev + h4*cr)
dg.formula <- dg - exp( d0 + d1*log(dbh) + d2*hg + d3*cr + d4*ba )
labels <- list("height.growth", "diameter.growth")
inst <- ~ tht + dbh + elev + cr + ba
start.values <- c(h0=-0.5, h1=0.5, h2=-0.001, h3=0.0001, h4=0.08,
                 d0=-0.5, d1=0.009, d2=0.25, d3=0.005, d4=-0.02)
model <- list(hg.formula, dg.formula)

model.ols <- nlsystemfit("OLS", model, start.values, data=ppine, eqnlabels=labels)
print(model.ols)

model.sur <- nlsystemfit("SUR", model, start.values, data=ppine, eqnlabels=labels)
print(model.sur)

model.2sls <- nlsystemfit("2SLS", model, start.values, data=ppine, eqnlabels=labels, inst=inst)
print(model.2sls)

model.3sls <- nlsystemfit("3SLS", model, start.values, data=ppine, eqnlabels=labels, inst=inst)
print(model.3sls)

ppine

Tree Growth Data for Ponderosa Pine

Description

A subset of tree growth observations from a Ponderosa pine growth database.
The ppine data frame has 166 rows and 8 columns.

Usage

data(ppine)

Format

This data frame contains the following columns:

elev  Altitude of the plot, in feet above mean sea level.

smi  Summer moisture index is the ratio of growing season heating degree days to growing season precipitation.
**dbh** Diameter of the tree at breast height (4.5 feet).

**tht** Total stem height for the tree.

**cr** Crown ratio code. The scale is from 1 to 9 where a crown class of one represents a crown ratio between 0 and 15 percent. A crown ratio code of 2 represents a crown ratio value between 16 and 25%, ..., 8 = 76-85%, 9 >= 85%.

**ba** Plot basal area at the beginning of the growth period.

**dg** Five-year diameter increment.

**hg** Five-year height increment.

**Details**

The exogenous variables are `elev`, `smi`, `dbh`, `tht`, `cr`, and `ba`; the endogenous variables `dg` and `hg`. There are no lagged variables in the dataset and the observations are for a single remeasurement.

The data was provided by the USDA Forest Service Intermountain Research Station.

**Source**

William R. Wykoff <wykoff@fs.fed.us> Rocky Mountain Research Station, 1221 South Main Street, Moscow, ID 83843

**Examples**

```r
data(ppine)
```

### R Code

<table>
<thead>
<tr>
<th>predict.systemfit</th>
<th>Predictions from System Estimation</th>
</tr>
</thead>
</table>

**Description**

Returns the predicted values, their standard errors and the confidence limits of prediction.

**Usage**

```r
## S3 method for class 'systemfit'
predict(object, newdata = NULL,
        se.fit = FALSE, se.pred = FALSE,
        interval = "none", level=0.95,
        useDfSys = NULL, ...)
```

```r
## S3 method for class 'systemfit.equation'
predict(object, newdata = NULL,
        se.fit = FALSE, se.pred = FALSE,
        interval = "none", level=0.95,
        useDfSys = NULL, ...)
```
predict.systemfit

Arguments

object 
an object of class systemfit or systemfit.equation.
newdata 
An optional data frame in which to look for variables with which to predict. If it is NULL, the fitted values are returned.
se.fit 
return the standard error of the fitted values?
se.pred 
return the standard error of prediction?
interval 
Type of interval calculation ("none", "confidence" or "prediction")
level 
Tolerance/confidence level.
useDfSys 
logical. Use the degrees of freedom of the whole system (in place of the degrees of freedom of the single equation) to calculate the confidence or prediction intervals. If it not specified (NULL), it is set to TRUE if restrictions on the coefficients are imposed and FALSE otherwise.

... 
additional optional arguments.

Details

The variance of the fitted values (used to calculate the standard errors of the fitted values and the "confidence interval") is calculated by \( \text{Var}[E[y^0] - \hat{y}^0] = x^0 \text{Var}[\hat{b}] x^0' \)

The variances of the predicted values (used to calculate the standard errors of the predicted values and the "prediction intervals") is calculated by \( \text{Var}[y^0 - \hat{y}^0] = \hat{\sigma}^2 + x^0 \text{Var}[\hat{b}] x^0' \)

Value

predict.systemfit returns a dataframe that contains for each equation the predicted values ("<eqn-Lable>.pred") and if requested the standard errors of the fitted values ("<eqnLable>.se.fit"), the standard errors of the prediction ("<eqnLable>.se.pred"), and the lower ("<eqnLable>.lwr") and upper ("<eqnLable>.upr") limits of the confidence or prediction interval(s).

predict.systemfit.equation returns a dataframe that contains the predicted values ("fit") and if requested the standard errors of the fitted values ("se.fit"), the standard errors of the prediction ("se.pred"), and the lower ("lwr") and upper ("upr") limits of the confidence or prediction interval(s).

Author(s)

Arne Henningsen <arne.henningsen@googlemail.com>

References


See Also

systemfit.predict
print.confint.systemfit

Print confidence intervals of coefficients

Description

This function prints the confidence intervals of the coefficients of the estimated equation system.

Usage

## S3 method for class 'confint.systemfit'
print( x, digits=3, ... )

Arguments

x an object of type confint.systemfit.
digits number of digits to print.
... other arguments.

Author(s)

Arne Henningsen <arne.henningsen@googlemail.com>

See Also

systemfit, confint.systemfit and confint.systemfit.equation
Examples

data( "Kmenta" )
eqDemand <- consump ~ price + income
eqSupply <- consump ~ price + farmPrice + trend
system <- list( demand = eqDemand, supply = eqSupply )

## perform OLS on each of the equations in the system
fitols <- systemfit( system, data = Kmenta )

## calculate and print the confidence intervals
## of all coefficients
ci <- confint( fitols )
print( ci, digits=4 )

## calculate and print the confidence intervals
## of the coefficients of the second equation
ci2 <- confint( fitols$eq[[2]] )
print( ci2, digits=4 )

print.nlsystemfit  
Print output of nlsystemfit estimation

Description

These functions print a summary of the estimated equation system.

Usage

## S3 method for class 'nlsystemfit.system'
print( x, digits=6, ... )

## S3 method for class 'nlsystemfit.equation'
print( x, digits=6, ... )

Arguments

x  
an object of class nlsystemfit.system or nlsystemfit.equation.
digits  
number of digits to print.
...  
not used by user.

Author(s)

Jeff D. Hamann <jeff.hamann@forestinformatics.com>

See Also

nlsystemfit, summary.nlsystemfit.system
Examples

```r
library( systemfit )
data( ppine )

hg.formula <- hg ~ exp( h0 + h1*log(tht) + h2*tht*2 + h3*elev + h4*cr)
dg.formula <- dg ~ exp( d0 + d1*log(dbh) + d2*hg + d3*cr + d4*ba)
labels <- list( "height.growth", "diameter.growth" )
inst <- ~ tht + dbh + elev + cr + ba
start.values <- c(h0=-0.5, h1=0.5, h2=-0.001, h3=0.0001, h4=0.08,
                   d0=-0.5, d1=0.009, d2=0.25, d3=0.005, d4=-0.02)
model <- list( hg.formula, dg.formula )

model.ols <- nlsystemfit( "OLS", model, start.values, data=ppine, eqnlabels=labels )
print( model.ols )

model.3sls <- nlsystemfit( "3SLS", model, start.values, data=ppine,
                           eqnlabels=labels, inst=inst )
print( model.3sls )
```

print.systemfit

Print results of systemfit estimation

Description

These functions print a few results of the estimated equation system.

Usage

```r
## S3 method for class 'systemfit'
print( x, digits = max( 3, getOption("digits") - 1 ), ... )

## S3 method for class 'systemfit.equation'
print( x, digits = max( 3, getOption("digits") - 1 ), ... )
```

Arguments

- `x` an object of class systemfit or systemfit.equation.
- `digits` number of digits to print.
- `...` other arguments.

Author(s)

Jeff D. Hamann <jeff.hamann@forestinformatics.com>,
Arne Henningsen <arne.henningsen@googlemail.com>
residuals.systemfit

See Also

systemfit, summary.systemfit

Examples

data( "Kmenta" )
seqDemand <- consump ~ price + income
seqSupply <- consump ~ price + farmPrice + trend
system <- list( demand = eqDemand, supply = eqSupply )

## perform OLS on each of the equations in the system
fitols <- systemfit( system, data = Kmenta )

## results of the whole system
print( fitols )

## results of the first equation
print( fitols$eq[1] )

## results of the second equation
print( fitols$eq[2] )

residuals.systemfit      Residuals of systemfit object

Description

These functions extract the residuals from an object returned by systemfit.

Usage

## S3 method for class 'systemfit'
residuals( object, ... )

## S3 method for class 'systemfit.equation'
residuals( object, na.rm = FALSE, ... )

Arguments

object  an object of class systemfit or systemfit.equation.
na.rm   a logical value indicating whether NA values (corresponding to observations that
         were not included in the estimation) should be removed from the vector of resid-
         uals before it is returned.
...     other arguments.
Value
residuals.systemfit returns a data.frame of residuals, where each column contains the residuals of one equation.
residuals.systemfit.equation returns a vector of residuals.

Author(s)
Arne Henningsen <arne.henningsen@googlemail.com>

See Also
systemfit, residuals

Examples
data( "Kmenta" )
eqDemand <- consump ~ price + income
eqSupply <- consump ~ price + farmPrice + trend
system <- list( demand = eqDemand, supply = eqSupply )

## perform OLS on each of the equations in the system
fitols <- systemfit( system, data = Kmenta )

## residuals of all equations
residuals( fitols )

## residuals of the first equation
residuals( fitols$eq[[1]] )

## residuals of the second equation
residuals( fitols$eq[[2]] )

se.ratio.systemfit     Ratio of the Standard Errors

Description
se.ratio.systemfit returns a vector of the ratios of the standard errors of the predictions for two equations.

Usage
se.ratio.systemfit( resultsi, resultsj, eqni )

Arguments
resultsi an object of type systemfit.
resultsj an object of type systemfit.
eqni index for equation to obtain the ratio of standard errors.
Value

`se.ratio` returns a vector of the standard errors of the ratios for the predictions between the predicted values in equation i and equation j.

Author(s)

Jeff D. Hamann <jeff.hamann@forestinformatics.com>

References


See Also

`systemfit` and `correlation.systemfit`

Examples

data( "Kmenta" )
eqDemand <- consump ~ price + income
eqSupply <- consump ~ price + farmPrice + trend
inst <- ~ income + farmPrice + trend
system <- list( demand = eqDemand, supply = eqSupply )

## perform 2SLS on each of the equations in the system
fit2sls <- systemfit( system, "2SLS", inst = inst, data = Kmenta )
fit3sls <- systemfit( system, "3SLS", inst = inst, data = Kmenta )

## print the results from the fits
print( fit2sls )
print( fit3sls )
print( "covariance of residuals used for estimation (from 2sls)" )
print( fit3sls$residCovEst )
print( "covariance of residuals" )
print( fit3sls$residCov )

## examine the improvement of 3SLS over 2SLS by computing
## the ratio of the standard errors of the estimates
improve.ratio <- se.ratio.systemfit( fit2sls, fit3sls, 2 )
print( "summary values for the ratio in the std. err. for the predictions" )
print( summary( improve.ratio ) )

---

**summary.nl systemfit**  
**Summary of nl systemfit estimation**

**Description**

These functions print a summary of the estimated equation system.
Usage

## S3 method for class 'nlsystemfit.system'
summary( object, ... )

## S3 method for class 'nlsystemfit.equation'
summary( object, ... )

Arguments

object an object of class nlsystemfit.system or nlsystemfit.equation.
... not used by user.

Author(s)

Jeff D. Hamann <jeff.hamann@forestinformatics.com>

See Also

nlsystemfit, print.nlsystemfit.system

Examples

library( systemfit )
data( ppine )

hg.formula <- hg - exp( h0 + h1*log(tht) + h2*tht^2 + h3*elev + h4*cr)
dg.formula <- dg - exp( d0 + d1*log(dbh) + d2*hg + d3*cr + d4*ba )
labels <- list( "height.growth", "diameter.growth" )
inst <- ~ tht + dbh + elev + cr + ba
start.values <- c(h0=-0.5, h1=0.5, h2=-0.001, h3=0.0001, h4=0.08,
                   d0=-0.5, d1=0.009, d2=0.25, d3=0.005, d4=-0.02 )
model <- list( hg.formula, dg.formula )

model.ols <- nlsystemfit( "OLS", model, start.values, data=ppine, eqnlabels=labels )
print( model.ols )

model.sls <- nlsystemfit( "3SLS", model, start.values, data=ppine,
                         eqnlabels=labels, inst=inst )
print( model.sls )

summary.systemfit Summary of systemfit estimation

Description

These functions create and print summary results of the estimated equation system.
Usage

```r
## S3 method for class 'systemfit'
summary( object, useDfSys = NULL,
         residCov = TRUE, equations = TRUE, ... )

## S3 method for class 'systemfit.equation'
summary( object, useDfSys = NULL, ... )

## S3 method for class 'summary.systemfit'
print( x, 
       digits = max( 3, getOption("digits") - 1 ),
       residCov = x$printResidCov, equations = x$printEquations, ... )

## S3 method for class 'summary.systemfit.equation'
print( x, 
       digits = max( 3, getOption("digits") - 1 ), ... )
```

Arguments

- `object`: an object of class `systemfit` or `systemfit.equation`.
- `x`: an object of class `summary.systemfit` or `summary.systemfit.equation`.
- `useDfSys`: logical. Use the degrees of freedom of the whole system (in place of the degrees of freedom of the single equation) to calculate prob values for the t-test of individual coefficients. If not specified (NULL), it is set to TRUE if restrictions on the coefficients are imposed and FALSE otherwise.
- `digits`: number of digits to print.
- `residCov`: logical. If TRUE, the residual correlation matrix, the residual covariance matrix, and its determinant are printed.
- `equations`: logical. If TRUE, summary results of each equation are printed. If FALSE, just the coefficients are printed.
- `...`: not used by user.

Value

Applying `summary` on an object of class `systemfit` returns a list of class `summary.systemfit`. Applying `summary` on an object of class `systemfit.equation` returns a list of class `summary.systemfit.equation`. An object of class `summary.systemfit` contains all results that belong to the whole system. This list contains one special object: `eq`. This is a list and contains objects of class `summary.systemfit.equation`. These objects contain the results that belong to each of the estimated equations.

The objects of classes `summary.systemfit` and `summary.systemfit.equation` have the following components (elements that are marked with a * are available only in objects of class `summary.systemfit`; elements that are marked with a + are available only in objects of class `summary.systemfit.equation`):

- `method`: estimation method.
- `residuals`: residuals.
coefficients a matrix with columns for the estimated coefficients, their standard errors, t-statistic and corresponding (two-sided) p-values.
df degrees of freedom, a 2-vector, where the first element is the number of coefficients and the second element is the number of observations minus the number of coefficients.
coefCov estimated covariance matrix of the coefficients.
call* the matched call of systemfit.
ols.r.squared* OLS $R^2$ value of the entire system.
mcelroy.r.squared* McElroy’s $R^2$ value for the system.
iter* number of iteration steps (only if the estimation is iterated).
control* list of control parameters used for the estimation.
residCov* estimated residual covariance matrix.
residCovEst* residual covariance matrix used for estimation (only SUR and 3SLS).
residCor* correlation matrix of the residuals.
detResidCov* determinant of residCov.
eqnLabel+ equation label.
eqnNo+ equation number.
terms+ the 'terms' object used for the respective equation.
r.squared+ $R^2$ value of the respective equation.
adj.r.squared+ adjusted $R^2$ value of the respective equation.
sigma+ estimated standard error of the residuals of the respective equation.
ssr+ sum of squared residuals of the respective equation.
printResidCov* argument residCov.
printEquations* argument equations.

Author(s)

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Arne Henningsen <arne.henningsen@googlemail.com>

See Also

systemfit, print.systemfit

Examples

data( "Kmenta" )
eqDemand <- consump ~ price + income
eqSupply <- consump ~ price + farmPrice + trend
inst <- ~ income + farmPrice + trend
system <- list( demand = eqDemand, supply = eqSupply )
## systemfit

### Linear Equation System Estimation

**Description**

Fits a set of linear structural equations using Ordinary Least Squares (OLS), Weighted Least Squares (WLS), Seemingly Unrelated Regression (SUR), Two-Stage Least Squares (2SLS), Weighted Two-Stage Least Squares (W2SLS) or Three-Stage Least Squares (3SLS).

**Usage**

```r
systemfit( formula, method = "OLS", inst=NULL, data=list(), restrict.matrix = NULL, restrict.rhs = NULL, restrict.regMat = NULL, pooled = FALSE, control = systemfit.control( ... ), ... )
```

**Arguments**

- `formula`: an object of class formula (for single-equation models) or (typically) a list of objects of class formula (for multiple-equation models); if argument `data` is of class `plm.dim` (created with `plm.data`), this argument must be a single object of class `formula` that represents the formula to be estimated for all individuals.
- `method`: the estimation method, one of "OLS", "WLS", "SUR", "2SLS", "W2SLS", or "3SLS" (see details); iterated estimation methods can be specified by setting control parameter `maxiter` larger than 1 (e.g. 500).
- `inst`: one-sided model formula specifying instrumental variables or a list of one-sided model formulas if different instruments should be used for the different equations (only needed for 2SLS, W2SLS, and 3SLS estimations).
- `data`: an optional data frame containing the variables in the model. By default the variables are taken from the environment from which systemfit is called.
restrict.matrix

an optional j x k matrix to impose linear restrictions on the coefficients by 
restrict.matrix * b = restrict.rhs (j = number of restrictions, k = number
of all coefficients, b = vector of all coefficients) or a character vector giving
the restrictions in symbolic form (see documentation of linearHypothesis in
package "car" for details). The number and the names of the coefficients can
be obtained by estimating the system without restrictions and applying the coef
method to the returned object.

restrict.rhs

an optional vector with j elements to impose linear restrictions (see restrict.matrix);
default is a vector that contains j zeros.

restrict.regMat

an optional matrix to impose restrictions on the coefficients by post-multiplying
the regressor matrix with this matrix (see details).

control

list of control parameters. The default is constructed by the function systemfit.control.
See the documentation of systemfit.control for details.

pooled

logical, restrict coefficients to be equal in all equations (only for panel-like data).

... arguments passed to systemfit.control.

Details

The estimation of systems of equations with unequal numbers of observations has not been thor-
roughly tested yet. Currently, systemfit calculates the residual covariance matrix only from the
residuals/observations that are available in all equations.

If argument data is of class plm.data (created with plm.data and thus, contains panel data in long
format), argument formula must be a single equation that is applied to all individuals. In this case,
argument pooled specifies whether the coefficients are restricted to be equal for all individuals.

If argument restrict.regMat is specified, the regressor matrix X is post-multiplied by this matrix:
X^* = X · restrict.regMat. Then, this modified regressor matrix X^* is used for the estimation
of the coefficient vector b^*. This means that the coefficients of the original regressors (X), vec-
tor b, can be represented by b = restrict.regMat · b^*. If restrict.regMat is a non-singular
quadratic matrix, there are no restrictions on the coefficients imposed, but the coefficients b^*
are linear combinations of the original coefficients b. If restrict.regMat has less columns than rows,
linear restrictions are imposed on the coefficients b. However, imposing linear restrictions by the
restrict.regMat matrix is less flexible than by providing the matrix restrict.matrix and the
vector restrict.rhs. The advantage of imposing restrictions on the coefficients by the matrix
restrict.regMat is that the matrix, which has to be inverted during the estimation, gets smaller
by this procedure, while it gets larger if the restrictions are imposed by restrict.matrix and
restrict.rhs.

In the context of multi-equation models, the term “weighted” in “weighted least squares” (WLS)
and “weighted two-stage least squares” (W2SLS) means that the equations might have different
weights and not that the observations have different weights.

It is important to realize the limitations on estimating the residuals covariance matrix imposed
by the number of observations T in each equation. With g equations we estimate g * (g + 1)/2
elements using T * g observations total. Beck and Katz (1995,1993) discuss the issue and the
resulting overconfidence when the ratio of T/g is small (e.g. 3). Even for T/g = 5 the estimate
is unstable both numerically and statistically and the 95 approximately [0.5 * σ^2, 3 * σ^2], which is
inadequate precision if the covariance matrix will be used for simulation of asset return paths either for investment or risk management decisions. For a starter on models with large cross-sections see Reichlin (2002). [This paragraph has been provided by Stephen C. Bond – Thanks!]

Value

systemfit returns a list of the class systemfit and contains all results that belong to the whole system. This list contains one special object: "eq". It is a list and contains one object for each estimated equation. These objects are of the class systemfit.equation and contain the results that belong only to the regarding equation.

The objects of the class systemfit and systemfit.equation have the following components (the elements of the latter are marked with an asterisk (*)):

**call**
the matched call.

**method**
estimation method.

**rank**
total number of linear independent coefficients = number of coefficients minus number of linear restrictions.

**df.residual**
degrees of freedom of the whole system.

**iter**
number of iteration steps.

**coefficients**
vector of all estimated coefficients.

**coefCov**
estimated covariance matrix of coefficients.

**residCov**
estimated residual covariance matrix.

**residCovEst**
residual covariance matrix used for estimation (only WLS, W2SLS, SUR and 3SLS).

**restrict.matrix**
the restriction matrix.

**restrict.rhs**
the restriction vector.

**restrict.regMat**
matrix used to impose restrictions on the coefficients by post-multiplying the regressor matrix with this matrix.

**control**
list of control parameters used for the estimation.

**panelLike**
logical. Was this an analysis with panel-like data?

## elements of the class systemfit.eq

**eq**
a list that contains the results that belong to the individual equations.

**eqnLabel**
the label of this equation.

**eqnNo**
the number of this equation.

**terms**
the ’terms’ object used for the ith equation.

**inst**
instruments of the ith equation (only 2SLS, W2SLS, and 3SLS).

**termsInst**
the ’terms’ object of the instruments used for the ith equation (only 2SLS, W2SLS, and 3SLS).

**rank**
number of linear independent coefficients in the ith equation (differs from the number of coefficients only if there are restrictions that are not cross-equation).
nCoef.sys* total number of coefficients in all equations.
rank.sys* total number of linear independent coefficients in all equations.
df.residual* degrees of freedom of the ith equation.
df.residual.sys* degrees of freedom of the whole system.
coefficients* estimated coefficients of the ith equation.
covb* estimated covariance matrix of coefficients.
model* if requested (the default), the model frame of the ith equation.
modelInst* if requested (the default), the model frame of the instrumental variables of the ith equation (only 2SLS, W2SLS, and 3SLS).
x* if requested, the model matrix of the ith equation.
y* if requested, the response of the ith equation.
z* if requested, the matrix of instrumental variables of the ith equation (only 2SLS, W2SLS, and 3SLS).
fitted.values* vector of fitted values of the ith equation.
residuals* vector of residuals of the ith equation.

Author(s)
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References

See Also
lm and nlsystemfit
Examples

data( "Kmenta" )
eqDemand <- consump ~ price + income
eqSupply <- consump ~ price + farmPrice + trend
system <- list( demand = eqDemand, supply = eqSupply )

## OLS estimation
fitols <- systemfit( system, data = Kmenta )
print( fitols )

## OLS estimation with 2 restrictions
R restr <- matrix(0,2,7)
R restr[1,3] <- 1
R restr[1,7] <- -1
R restr[2,2] <- -1
R restr[2,5] <- 1
q restr <- c( 0, 0.5 )
fitols2 <- systemfit( system, data = Kmenta, restrict.matrix = R restr, restrict.rhs = q restr )
print( fitols2 )

## OLS estimation with the same 2 restrictions in symbolic form
restrict <- c( "demand_income - supply_trend = 0", "demand_price + supply_price = 0.5" )
fitols2b <- systemfit( system, data = Kmenta, restrict.matrix = restrict )
print( fitols2b )

# test whether both restricted estimators are identical
all.equal( coef( fitols2 ), coef( fitols2b ) )

## OLS with restrictions on the coefficients by modifying the regressor matrix
## with argument restrict.regMat
modReg <- matrix( 0, 7, 6 )
colnames( modReg ) <- c( "demIntercept", "demPrice", "demIncome", "supIntercept", "supPrice2", "supTrend" )
modReg[ 1, "demIntercept" ] <- 1
modReg[ 2, "demPrice" ] <- 1
modReg[ 3, "demIncome" ] <- 1
modReg[ 4, "supIntercept" ] <- 1
modReg[ 5, "supPrice2" ] <- 1
modReg[ 6, "supPrice2" ] <- 1
modReg[ 7, "supTrend" ] <- 1
fitols3 <- systemfit( system, data = Kmenta, restrict.regMat = modReg )
print( fitols3 )

## iterated SUR estimation
fitsur <- systemfit( system, "SUR", data = Kmenta, maxit = 100 )
print( fitsur )

## 2SLS estimation
inst <- ~ income + farmPrice + trend
systemfit.control  

Create list of control parameters for systemfit

Description

Create a list of control parameters for function systemfit. All control parameters that are not passed to this function are set to default values.

Usage

systemfit.control(
    maxiter = 1,
    tol = 1e-5,
    methodResidCov = "geomean",
)
centerResiduals = FALSE,
residCovRestricted = TRUE,
residCovWeighted = FALSE,
method3sls = "GLS",
singleEqSigma = NULL,
useMatrix = TRUE,
solvetol = .Machine$double.eps,
model = TRUE,
x = FALSE,
y = FALSE,
z = FALSE)

Arguments

maxiter maximum number of iterations for WLS, SUR, W2SLS and 3SLS estimations.
tol tolerance level indicating when to stop the iteration (only WLS, SUR, W2SLS and 3SLS estimations).
methodResidCov method for calculating the estimated residual covariance matrix, one of "noDfCor", "geomean", "max", or "Theil" (see details).
centerResiduals logical. Subtract the means from the residuals of each equation before calculating the estimated residual covariance matrix.
residCovRestricted logical. If 'FALSE' the residual covariance matrix for a WLS, SUR, W2SLS, or 3SLS estimation is obtained from an unrestricted first-step estimation.
residCovWeighted logical. If 'TRUE' the residual covariance matrix for a SUR or 3SLS estimation is obtained from a WLS or W2SLS estimation.
method3sls method for calculating the 3SLS estimator, one of "GLS", "IV", "GMM", "Schmidt", or "EViews" (see details).
singleEqSigma logical. use different σ²'s for each single equation to calculate the covariance matrix and the standard errors of the coefficients (only OLS and 2SLS)? If singleEqSigma is NULL, it is automatically determined: It is set to TRUE, if restrictions on the coefficients are imposed, and it is set to FALSE otherwise.
useMatrix logical. Use package matrix for matrix calculations?
solvetol tolerance level for detecting linear dependencies when inverting a matrix or calculating a determinant (see solve and det).
model, x, y, z logical. If 'TRUE' the corresponding components of the fit (the model frame, the model matrix, the response, and the matrix of instruments, respectively) are returned.

Details

If the estimation is iterated (WLS, SUR, W2SLS or 3SLS estimation with maxiter>1), the convergence criterion is

\[ \sqrt{\frac{\sum_{i}(b_{i,g} - b_{i,g-1})^2}{\sum_{i}b_{i,g-1}^2}} < tol \]
(\(b_{i,g}\) is the \(i\)th coefficient of the \(g\)th iteration step).

The method for calculating the estimated covariance matrix of the residuals (\(\hat{\Sigma}\)) can be one of the following (see Judge et al., 1985, p. 469):

- if \(\text{methodResidCov} = \text{\'noDfCor\'}\):
  \[
  \hat{\sigma}_{ij} = \frac{\hat{e}_i' \hat{e}_j}{T}
  \]

- if \(\text{methodResidCov} = \text{\'geomean\'}\):
  \[
  \hat{\sigma}_{ij} = \frac{\hat{e}_i' \hat{e}_j}{\sqrt{(T-k_i) \ast (T-k_j)}}
  \]

- if \(\text{methodResidCov} = \text{\'Theil\'}\):
  \[
  \hat{\sigma}_{ij} = \frac{\hat{e}_i' \hat{e}_j}{T-k_i-k_j + \text{tr}[X_i(X_i'X_i)^{-1}X_i'X_j(X_j'X_j)^{-1}X_j']}
  \]

- if \(\text{methodResidCov} = \text{\'max\'}\):
  \[
  \hat{\sigma}_{ij} = \frac{\hat{e}_i' \hat{e}_j}{T - \max(k_i,k_j)}
  \]

If \(i = j\), the formulas 'geomean', 'Theil', and 'max' are equal. All these three formulas yield unbiased estimators for the diagonal elements of the residual covariance matrix. If \(i \neq j\), only formula 'Theil' yields an unbiased estimator for the residual covariance matrix, but it is not necessarily positive semidefinite. Thus, it is doubtful whether formula 'Theil' is really superior to formula 'noDfCor' (Theil, 1971, p. 322).

The methods for calculating the 3SLS estimator lead to identical results if the same instruments are used in all equations. If different instruments are used in the different equations, only the GMM-3SLS estimator ("GMM") and the 3SLS estimator proposed by Schmidt (1990) ("Schmidt") are consistent, whereas "GMM" is efficient relative to "Schmidt" (see Schmidt, 1990).

If \(\text{residCovWeighted} \) is TRUE, systemfit does a OLS or 2SLS estimation in a first step. It uses the residuals from the first-step estimation to calculate the residual covariance matrix that is used in a second-step WLS or W2SLS estimation. Then, it uses the residuals from the second-step estimation to calculate the residual covariance matrix that is used in a final SUR or 3SLS estimation. This three-step method is the default method of command "TSCS" in the software LIMDEP that carries out "SUR" estimations in which all coefficient vectors are constrained to be equal (personal information from W.H. Greene, 2006/02/16). If no cross-equation restrictions are imposed, \(\text{residCovWeighted} \) has no effect on the estimation results.

**Value**

A list of the above components.

**Author(s)**

Arne Henningsen <arne.henningsen@googlemail.com>
terms.systemfit

References

See Also
systemfit

Examples
data( "Kmenta" )
eqDemand <- consump ~ price + income
eqSupply <- consump ~ price + farmPrice + trend
eqSystem <- list( demand = eqDemand, supply = eqSupply )

## SUR estimation: calculation of residual covariance
## matrix without correction for degrees of freedom
fisur <- systemfit( eqSystem, "SUR", data = Kmenta,
                   control = systemfit.control( methodResidCov = "noDfCor" ) )
print( fitsur )

---

terms.systemfit  Model Terms of systemfit Objects

Description
This method extracts the model terms from fitted objects returned by systemfit.

Usage

## S3 method for class 'systemfit'
terms( x, ... )

## S3 method for class 'systemfit.equation'
terms( x, ... )

Arguments

x  an object of class systemfit.
... currently not used.

Value

terms.systemfit.equation returns the model terms of a single equation of a systemfit object.
terms.systemfit.equation returns a list of model terms: one model term object for each equation of the systemfit object.
Author(s)
Arne Henningsen <arne.henningsen@googlemail.com>

See Also
systemfit, terms

Examples

data("Kmenta")
eqDemand <- consump ~ price + income
eqSupply <- consump ~ price + farmPrice + trend
system <- list( demand = eqDemand, supply = eqSupply )

## perform a SUR estimation
fitsur <- systemfit( system, "SUR", data = Kmenta )

## model terms of the second equation
terms( fitsur$eq[[ 2 ]] )

## all model terms of the system
terms( fitsur )

---

vcov.systemfit Variance covariance matrix of coefficients

Description
These functions extract the variance covariance matrix of the coefficients from an object returned by systemfit.

Usage

## S3 method for class 'systemfit'
vcov( object, modified.regMat = FALSE, ... )

## S3 method for class 'systemfit.equation'
vcov( object, ... )

Arguments

object an object of class systemfit or systemfit.equation.
modified.regMat logical. If TRUE, the covariance matrix of the coefficients of the modified regressor matrix (original regressor matrix post-multiplied by restrict.regMat) rather than the covariance matrix of the coefficients of the original regressor matrix is returned.

... other arguments.
vcov.systemfit

Value
vcov.systemfit returns the variance covariance matrix of all estimated coefficients.

Author(s)
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See Also
systemfit, vcov

Examples

data("Kmenta")
eqDemand <- consump ~ price + income
eqSupply <- consump ~ price + farmPrice + trend
system <- list(demand = eqDemand, supply = eqSupply)

## perform OLS on each of the equations in the system
fitols <- systemfit( system, data = Kmenta )

## variance covariance matrix of all coefficients
vcov( fitols )

## variance covariance matrix of the coefficients in the first equation
vcov( fitols$eq[1] )

## variance covariance matrix of the coefficients in the second equation
vcov( fitols$eq[2] )

## estimation with restriction by modifying the regressor matrix
modReg <- matrix( 0, 7, 6 )
colnames( modReg ) <- c( "demIntercept", "demPrice", "demIncome", "supIntercept", "supPrice2", "supTrend" )
modReg[1, "demIntercept"] <- 1
modReg[2, "demPrice"] <- 1
modReg[3, "demIncome"] <- 1
modReg[4, "supIntercept"] <- 1
modReg[5, "supPrice2"] <- 1
modReg[6, "supPrice2"] <- 1
modReg[7, "supTrend"] <- 1
fitsur <- systemfit( system, "SUR", data = Kmenta, restrict.regMat = modReg )
vcov( fitsur, modified.regMat = TRUE )
vcov( fitsur )
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