

# Package ‘systemfit’

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**Title** Estimating Systems of Simultaneous Equations

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**Suggests** plm (>= 1.0-1), MASS, sem

**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 Squares (3SLS).

**License** GPL (>= 2)

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---

coef.systemfit      *Coefficients of systemfit object*

---

## Description

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

## Usage

```
## 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 )
coef( fitols3, modified.regMat = TRUE )
coef( fitols3 )

```

---

confint.systemfit *Confidence intervals of coefficients*

---

## Description

These functions calculate the confidence intervals of the coefficients from an object returned by `systemfit`.

## Usage

```

## 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

<code>object</code>	an object of class <code>systemfit</code> or <code>systemfit.equation</code> .
<code>parm</code>	not used yet.
<code>level</code>	confidence level.
<code>useDfSys</code>	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 not specified (NULL), it is set to TRUE if restrictions on the coefficients are imposed and FALSE otherwise.
<code>...</code>	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, 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.

**Author(s)**

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

**References**

Greene, W. H. (1993) *Econometric Analysis, Second Edition*, Macmillan.  
 Hasenauer, H; Monserud, R and T. Gregoire. (1998) Using Simultaneous Regression Techniques with Individual-Tree Growth Models. *Forest Science*. 44(1):87-95  
 Kmenta, J. (1997) *Elements of Econometrics, Second Edition*, University of Michigan Publishing

**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 2SLS on each of the equations in the system
fit2sls <- systemfit( system, "2SLS", inst = inst, data = Kmenta )
print( fit2sls )
print( fit2sls$rcov )

## perform the 3SLS
fit3sls <- systemfit( system, "3SLS", inst = inst, data = Kmenta )
print( fit3sls )
print( "covariance of residuals used for estimation (from 2sls)" )
print( fit3sls$rcovest )
print( "covariance of residuals" )
print( fit3sls$rcov )

## examine the correlation between the predicted values
## of supply and demand by plotting the correlation over
## the value of q
r12 <- correlation.systemfit( fit3sls, 1, 2 )
```

```
plot( Kmenta$consump, r12, main="correlation between predictions from supply and demand" )
```

---

```
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

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

## Arguments

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

## Value

`createSystemfitModel` returns a list with following elements:

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

## Author(s)

Arne Henningsen (arne.henningsen@googlemail.com)

## See Also

[systemfit](#)

## Examples

```
## 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 ) )
```

---

fitted.systemfit    *Fitted values*

---

## Description

These functions extract the fitted values from an object returned by [systemfit](#).

## Usage

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

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

## Arguments

object	an object of class <code>systemfit</code> or <code>systemfit.equation</code> .
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]] )
```

---

formula.systemfit *Model Formulae of systemfit Objects*

---

## 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> 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

Greene (2003), Appendix F, Data Sets Used in Applications, Table F13.1. <http://pages.stern.nyu.edu/~wgreene/Text/econometricanalysis.htm> (a subset of this data set is available in Theil (1971), p. 296).

## References

- Greene, W.H. (2003). *Econometric Analysis*, 5th edition. Prentice Hall, Upper Saddle River (NJ).
- Grunfeld, Y. (1958). *The Determinants of Corporate Investment*, Unpublished Ph.D. Dissertation, University of Chicago.
- Theil, Henri (1971). *Principles of Econometrics*, John Wiley & Sons, New York.

## Examples

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

## Repeating the OLS and SUR estimations in Theil (1971, pp. 295, 300)
GrunfeldTheil <- subset( GrunfeldGreene,
  firm %in% c( "General Electric", "Westinghouse" ) )
GTPanel <- plm.data( GrunfeldTheil, c( "firm", "year" ) )
formulaGrunfeld <- invest ~ value + capital
# OLS
theilOls <- systemfit( formulaGrunfeld, "OLS",
  data = GTPanel )
summary( theilOls )
# SUR
theilSur <- systemfit( formulaGrunfeld, "SUR",
  data = GTPanel, methodResidCov = "noDfCor" )
```

```
summary( theilSur )
```

---

```
hausman.systemfit Hausman Test
```

---

### 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 following elements:

<code>q</code>	vector of the differences between the estimated coefficients.
<code>qVar</code>	variance covariance matrix of <code>q</code> (difference between the variance covariance matrices of the estimated coefficients).
<code>statistic</code>	the Hausman test statistic.
<code>parameter</code>	degrees of freedom.
<code>p.value</code>	P-value of the test.
<code>method</code>	character string describing this test.
<code>data.name</code>	name of the data.frame used for estimation.

**Author(s)**

Jeff D. Hamann (jeff.hamann@forestinformatics.com),  
Arne Henningsen (arne.henningsen@googlemail.com)

**References**

Greene, W. H. (1993) *Econometric Analysis, Fifth Edition*, Macmillan.  
Hausman, J. A. (1978) Specification Tests in Econometrics. *Econometrica*. 46:1251-1271.  
Kmenta, J. (1997) *Elements of Econometrics, Second Edition*, University of Michigan Publishing

**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
fit2spls <- systemfit( system, "2SLS", inst = inst, data = Kmenta )
fit3spls <- systemfit( system, "3SLS", inst = inst, data = Kmenta )

## perform the Hausman test
h <- hausman.systemfit( fit2spls, fit3spls )
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

Greene, W.H. (2003). *Econometric Analysis*, 5th edition. Prentice Hall, Upper Saddle River (NJ).

Klein, L. (1950). *Economic Fluctuations in the United States, 1921–1941*. John Wiley, New York.

### Examples

```
## Repeating the estimations of Klein's (1950) Model I
## in Greene (2003, pp. 381 and 412)
data( "KleinI" )
eqConsump <- consump ~ corpProf + corpProfLag + wages
eqInvest <- invest ~ corpProf + corpProfLag + capitalLag
eqPrivWage <- privWage ~ gnp + gnpLag + trend
inst <- ~ govExp + taxes + govWage + trend + capitalLag + corpProfLag + gnpLag
system <- list( Consumption = eqConsump, Investment = eqInvest,
  PrivateWages = eqPrivWage )
# OLS
kleinOls <- systemfit( system, data = KleinI )
summary( kleinOls )
# 2SLS
klein2spls <- systemfit( system, "2SLS", inst = inst, data = KleinI,
  methodResidCov = "noDfCor" )
summary( klein2spls )
# 3SLS
klein3spls <- systemfit( system, "3SLS", inst = inst, data = KleinI,
  methodResidCov = "noDfCor" )
summary( klein3spls )
# I3SLS
kleinI3spls <- systemfit( system, "3SLS", inst = inst, data = KleinI,
  methodResidCov = "noDfCor", maxit = 500 )
summary( kleinI3spls )
```

**Description**

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

**Usage**

```
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**

Kmenta, J. (1986). *Elements of Econometrics*, Second Edition, Macmillan, New York.

**Examples**

```
## 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
fitOls <- systemfit(system, data = Kmenta)
summary(fitOls)
```

```
## 2SLS estimation
fit2spls <- systemfit( system, "2SLS", inst = inst, data = Kmenta )
summary( fit2spls )

## 3SLS estimation
fit3spls <- systemfit( system, "3SLS", inst = inst, data = Kmenta )
summary( fit3spls )

## I3LS estimation
fitI3spls <- systemfit( system, "3SLS", inst = inst, data = Kmenta,
  maxit = 250 )
summary( fitI3spls )
```

---

```
linear.hypothesis.systemfit
      Test Linear Hypothesis
```

---

## Description

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

## Usage

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

## Arguments

<code>model</code>	a fitted object of type <code>systemfit</code> .
<code>hypothesis.matrix</code>	matrix (or vector) giving linear combinations of coefficients by rows, or a character vector giving the hypothesis in symbolic form (see documentation of <a href="#">linear.hypothesis</a> in package "car" for details).
<code>rhs</code>	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.
<code>test</code>	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).
<code>vcov.</code>	a function for estimating the covariance matrix of the regression coefficients or an estimated covariance matrix (function <code>vcov</code> is used by default).
<code>...</code>	further arguments passed to <a href="#">linear.hypothesis.default</a> (package "car").

**Details**

Theil's  $F$  statistic for systems of equations is

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

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

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

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

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

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 `linear.hypothesis` in package "car".

**Author(s)**

Arne Henningsen (arne.henningsen@googlemail.com)

**References**

Greene, W. H. (2003) *Econometric Analysis, Fifth Edition*, Prentice Hall.

Theil, Henri (1971) *Principles of Econometrics*, John Wiley & Sons, New York.

**See Also**

`systemfit`, `linear.hypothesis` (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
linear.hypothesis( fitsur, R1 ) # rejected
linear.hypothesis( fitsur, restrict1 )

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

## perform Wald-test with chi^2 statistic
linear.hypothesis( fitsur, R1, test = "Chisq" ) # rejected
linear.hypothesis( 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
# the same hypothesis in symbolic form
restrict2 <- "demand_price + supply_farmPrice = 0"

## perform Theil's F test
linear.hypothesis( fitsur, R2 ) # accepted
linear.hypothesis( fitsur, restrict2 )

## perform Wald test with F statistic
linear.hypothesis( fitsur, R2, test = "F" ) # accepted
linear.hypothesis( fitsur, restrict2 )

## perform Wald-test with chi^2 statistic
linear.hypothesis( fitsur, R2, test = "Chisq" ) # accepted
linear.hypothesis( fitsur, restrict2, test = "Chisq" )

```

---

logLik.systemfit    *Log-Likelihood value of systemfit object*

---

## Description

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

**Usage**

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

**Arguments**

object	an object of class <code>systemfit</code> .
...	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**

```
## 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

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

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".

**Author(s)**

Arne Henningsen (arne.henningsen@googlemail.com)

**References**

Greene, W. H. (2003) *Econometric Analysis, Fifth Edition*, Prentice Hall.

**See Also**

`systemfit`, `lrtest` (package "lmtest"), `linear.hypothesis.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 \eqn{\beta_2 = \beta_6}
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  $\beta_2 = -\beta_6$ 
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

```

---

```
model.frame.systemfit
```

*Extracting the Data of a systemfit Object*

---

## 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 ]] )
```

---

```
model.matrix.systemfit
```

*Construct Design Matrices for Systems of Equations*

---

**Description**

These functions create design matrices from objects returned by [systemfit](#).

**Usage**

```
## S3 method for class 'systemfit':
model.matrix( object, ... )

## S3 method for class 'systemfit.equation':
model.matrix( object, ... )
```

**Arguments**

object	an object of class <code>systemfit</code> or <code>systemfit.equation</code> .
...	currently ignored.

**Value**

`model.matrix.systemfit` returns a design matrix to estimate the specified system of equations.

`model.matrix.systemfit.equation` returns a design matrix to estimate the specified formula of the respective equation.

**Author(s)**

Arne Henningsen (arne.henningsen@googlemail.com)

**See Also**

[systemfit](#), [model.matrix](#), and [model.frame.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 )

## design matrix of the entire system
model.matrix( fitols )

## design matrix of the first equation
model.matrix( fitols$eq[[ 1 ] ] )
```

---

nlssystemfit

*Nonlinear Equation System Estimation*

---

**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**

```
nlssystemfit( 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 nlssystemfit 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 nlssystemfit 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:

$$\begin{aligned}\epsilon_t &= q(y_t, x_t, \theta) \\ z_t &= Z(x_t)\end{aligned}$$

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:

Method	Instruments	Objective Function	Covariance of $\theta$
OLS	no	$r'r$	$(X(diag(S)^{-1} \otimes I)X)^{-1}$
SUR	no	$r'(diag(S)_{OLS}^{-1} \otimes I)r$	$(X(S^{-1} \otimes I)X)^{-1}$
2SLS	yes	$r'(I \otimes W)r$	$(X(diag(S)^{-1} \otimes I)X)^{-1}$
3SLS	yes	$r'(S_{2SLS}^{-1} \otimes W)r$	$(X(diag(S)^{-1} \otimes W)X)^{-1}$

where, r is a column vector for the residuals for each equation, S is variance-covariance matrix between the equations ( $\hat{\sigma}_{ij} = (\hat{e}_i' \hat{e}_j) / \sqrt{(T - k_i) * (T - k_j)}$ ), X is matrix of the partial derivatives 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 **VERY** sensitive to the starting values and the nlm function may not converge. The nlm function will be called with the typsize argument set the

absolute values of the starting values for the OLS and 2SLS methods. For the SUR and 3SLS methods, the `typsize` argument is set to the absolute values of the resulting OLS and 2SLS coefficient estimates from the `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 `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.

## Value

`nlssystemfit` returns a list of the class `nlssystemfit.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 `nlssystemfit.equation` and contain the results that belong only to the regarding equation.

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

<code>eq</code>	a list object that contains a list object for each equation.
<code>method</code>	estimation method.
<code>resids</code>	an $n \times g$ matrix of the residuals.
<code>g</code>	number of equations.
<code>n</code>	total number of observations.
<code>k</code>	total number of coefficients.
<code>b</code>	vector of all estimated coefficients.
<code>se</code>	estimated standard errors of <code>b</code> .
<code>t</code>	t values for <code>b</code> .
<code>p</code>	p values for <code>b</code> .
<code>bcov</code>	estimated covariance matrix of <code>b</code> .
<code>rcov</code>	estimated residual covariance matrix.
<code>drcov</code>	determinant of <code>rcov</code> .
<code>rcovest</code>	residual covariance matrix used for estimation (only SUR and 3SLS).
<code>rcor</code>	estimated residual correlation matrix.
<code>nlmest</code>	results from the <code>nlm</code> function call
<code>solvetol</code>	tolerance level when inverting a matrix or calculating a determinant.
<code>eq</code>	a list that contains the results that belong to the individual equations.
<code>eqnlabel*</code>	the equation label of the <i>i</i> th equation (from the labels list).
<code>formula*</code>	model formula of the <i>i</i> th equation.
<code>n*</code>	number of observations of the <i>i</i> th equation.
<code>k*</code>	number of coefficients/regressors in the <i>i</i> th equation.
<code>df*</code>	degrees of freedom of the <i>i</i> th equation.
<code>b*</code>	estimated coefficients of the <i>i</i> th 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

- Gallant, R. H. (1987) *Nonlinear Equation Estimation*, John Wiley and Sons, 610 pp.  
 SAS Institute (1999) *SAS/ETS User's Guide, Version 8*, Cary NC: SAS Institute 1546 pp.

### 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 <- nlssystemfit( "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 ([wwykoff@fs.fed.us](mailto:wwykoff@fs.fed.us)) *Rocky Mountain Research Station, 1221 South Main Street, Moscow, ID 83843*

**Examples**

```
data(ppine)
```

---

```
predict.systemfit Predictions from System Estimation
```

---

**Description**

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

**Usage**

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

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

**Arguments**

object	an object of class <code>systemfit</code> or <code>systemfit.equation</code> .
newdata	An optional data frame in which to look for variables with which to predict. If it is <code>NULL</code> , 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 ( <code>NULL</code> ), it is set to <code>TRUE</code> if restrictions on the coefficients are imposed and <code>FALSE</code> 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  $Var[E[y^0] - \hat{y}^0] = x^0 Var[b] x^{0'}$

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

**Value**

`predict.systemfit` returns a dataframe that contains for each equation the predicted values ("`<eqnLable>.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**

Greene, W. H. (2003) *Econometric Analysis, Fifth Edition*, Macmillan.

Gujarati, D. N. (1995) *Basic Econometrics, Third Edition*, McGraw-Hill.

Kmenta, J. (1997) *Elements of Econometrics, Second Edition*, University of Michigan Publishing.

**See Also**

[systemfit](#), [predict](#)

**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 )

## predicted values and limits
predict( fitols )

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

## predicted values of the second equation
predict( fitols$eq[[2]] )
```

---

```
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 <code>confint.systemfit</code> .
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 <code>nlsystemfit.system</code> or <code>nlsystemfit.equation</code> .
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

```
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

```
## 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 <code>systemfit</code> or <code>systemfit.equation</code> .
digits	number of digits to print.
...	other arguments.

## Author(s)

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

## See Also

[systemfit](#), [summary.systemfit](#)

## 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 )

## 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

<code>object</code>	an object of class <code>systemfit</code> or <code>systemfit.equation</code> .
<code>na.rm</code>	a logical value indicating whether NA values (corresponding to observations that were not included in the estimation) should be removed from the vector of residuals before it is returned.
<code>...</code>	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

Hasenauer, H; Monserud, R and T. Gregoire. (1998) Using Simultaneous Regression Techniques with Individual-Tree Growth Models. *Forest Science*. 44(1):87-95

**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
fit2spls <- systemfit( system, "2SLS", inst = inst, data = Kmenta )
fit3spls <- systemfit( system, "3SLS", inst = inst, data = Kmenta )

## print the results from the fits
print( fit2spls )
print( fit3spls )
print( "covariance of residuals used for estimation (from 2spls)" )
print( fit3spls$residCovEst )
print( "covariance of residuals" )
print( fit3spls$residCov )

## examine the improvement of 3SLS over 2SLS by computing
## the ratio of the standard errors of the estimates
improve.ratio <- se.ratio.systemfit( fit2spls, fit3spls, 2 )
print( "summary values for the ratio in the std. err. for the predictions" )
print( summary( improve.ratio ) )

```

---

```
summary.nlsystemfit
```

*Summary of nlsystemfit 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 <code>nlsystemfit.system</code> or <code>nlsystemfit.equation</code> .
...	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.3spls <- nlsystemfit( "3SLS", model, start.values, data=ppine,
                          eqnlabels=labels, inst=inst )
print( model.3spls )
```

---

summary.systemfit *Summary of systemfit estimation*

---

**Description**

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

**Usage**

```
## 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 <code>systemfit</code> or <code>systemfit.equation</code> .
x	an object of class <code>summary.systemfit</code> or <code>summary.systemfit.equation</code> .
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 it 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 <code>systemfit</code> .
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)**

Jeff D. Hamann (jeff.hamann@forestinformatics.com),  
 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 )

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

## results of the system
summary( fitols )

## short results of the system
summary( fitols, residCov = FALSE, equations = FALSE )

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

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

```

**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**

```
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 <code>formula</code> (for single-equation models) or (typically) a list of objects of class <code>formula</code> (for multiple-equation models); if argument <code>data</code> is of class <code>plm.dim</code> (created with <code>plm.data</code> ), this argument must be a single object of class <code>formula</code> 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 <code>maxiter</code> 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 <code>systemfit</code> is called.  |
| restrict.matrix | an optional $j \times k$ matrix to impose linear restrictions on the coefficients by <code>restrict.matrix * b = restrict.rhs</code> ( $j$ = 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 <a href="#">linear.hypothesis</a> 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 <code>coef</code> method to the returned object. |
| restrict.rhs    | an optional vector with $j$ elements to impose linear restrictions (see <code>restrict.matrix</code> ); 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).  |

<code>control</code>	list of control parameters. The default is constructed by the function <code>systemfit.control</code> . See the documentation of <code>systemfit.control</code> for details.
<code>pooled</code>	logical, restrict coefficients to be equal in all equations (only for panel-like data).
<code>...</code>	arguments passed to <code>systemfit.control</code> .

## Details

The estimation of systems of equations with unequal numbers of observations has not been thoroughly 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.dim` (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:  $X^* = X \cdot \text{restrict.regMat}$ . 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 ( $X$ ), vector  $b$ , can be represented by  $b = \text{restrict.regMat} \cdot b^*$ . 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  $[0.5 * \sigma^2, 3 * \sigma^2]$ , 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 (\*)):

<code>call</code>	the matched call.
<code>method</code>	estimation method.
<code>rank</code>	total number of linear independent coefficients = number of coefficients minus number of linear restrictions.
<code>df.residual</code>	degrees of freedom of the whole system.
<code>iter</code>	number of iteration steps.
<code>coefficients</code>	vector of all estimated coefficients.
<code>coefCov</code>	estimated covariance matrix of <code>coefficients</code> .
<code>residCov</code>	estimated residual covariance matrix.
<code>residCovEst</code>	residual covariance matrix used for estimation (only WLS, W2SLS, SUR and 3SLS).
<code>restrict.matrix</code>	the restriction matrix.
<code>restrict.rhs</code>	the restriction vector.
<code>restrict.regMat</code>	matrix used to impose restrictions on the coefficients by post-multiplying the regressor matrix with this matrix.
<code>control</code>	list of control parameters used for the estimation.
<code>panelLike</code>	logical. Was this an analysis with panel-like data?
<code>eq</code>	a list that contains the results that belong to the individual equations.
<code>eqnLabel*</code>	the label of this equation.
<code>eqnNo*</code>	the number of this equation.
<code>terms*</code>	the 'terms' object used for the <i>ith</i> equation.
<code>inst*</code>	instruments of the <i>ith</i> equation (only 2SLS, W2SLS, and 3SLS).
<code>rank*</code>	number of linear independent coefficients in the <i>ith</i> equation (differs from the number of coefficients only if there are restrictions that are not cross-equation).
<code>nCoef.sys*</code>	total number of coefficients in all equations.
<code>rank.sys*</code>	total number of linear independent coefficients in all equations.
<code>df.residual*</code>	degrees of freedom of the <i>ith</i> equation.
<code>df.residual.sys*</code>	degrees of freedom of the whole system.
<code>coefficients*</code>	estimated coefficients of the <i>ith</i> equation.
<code>covb*</code>	estimated covariance matrix of <code>coefficients</code> .
<code>model*</code>	if requested (the default), the model frame of the <i>ith</i> equation.
<code>x*</code>	if requested, the model matrix of the <i>ith</i> equation.
<code>y*</code>	if requested, the response of the <i>ith</i> equation.
<code>z*</code>	if requested, the matrix of instrumental variables of the <i>ith</i> equation (only 2SLS, W2SLS, and 3SLS).
<code>fitted.values*</code>	vector of fitted values of the <i>ith</i> equation.
<code>residuals*</code>	vector of residuals of the <i>ith</i> equation.

**Author(s)**

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 Jeff D. Hamann (jeff.hamann@forestinformatics.com)

**References**

- Beck, N.; J.N. Katz (1995) What to do (and not to do) with Time-Series Cross-Section Data, *The American Political Science Review*, 89, pp. 634-647.
- Beck, N.; J.N. Katz; M.R. Alvarez; G. Garrett; P. Lange (1993) Government Partisanship, Labor Organization, and Macroeconomic Performance: a Corrigendum, *American Political Science Review*, 87, pp. 945-48.
- Greene, W. H. (2003) *Econometric Analysis, Fifth Edition*, Prentice Hall.
- Judge, George G.; W. E. Griffiths; R. Carter Hill; Helmut Luetkepohl and Tsoung-Chao Lee (1985) *The Theory and Practice of Econometrics, Second Edition*, Wiley.
- Kmenta, J. (1997) *Elements of Econometrics, Second Edition*, University of Michigan Publishing.
- Reichlin, L. (2002) *Factor models in large cross-sections of time series*, Working Paper, ECARES and CEPR.
- Schmidt, P. (1990) *Three-Stage Least Squares with different Instruments for different equations*, *Journal of Econometrics* 43, p. 389-394.
- Theil, H. (1971) *Principles of Econometrics*, Wiley, New York.

**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
Rrestr <- matrix(0,2,7)
Rrestr[1,3] <- 1
Rrestr[1,7] <- -1
Rrestr[2,2] <- -1
Rrestr[2,5] <- 1
qrestr <- c( 0, 0.5 )
fitols2 <- systemfit( system, data = Kmenta,
                    restrict.matrix = Rrestr, restrict.rhs = qrestr )
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
fit2sls <- systemfit( system, "2SLS", inst = inst, data = Kmenta )
print( fit2sls )

## 2SLS estimation with different instruments in each equation
inst1 <- ~ income + farmPrice
inst2 <- ~ income + farmPrice + trend
instlist <- list( inst1, inst2 )
fit2sls2 <- systemfit( system, "2SLS", inst = instlist, data = Kmenta )
print( fit2sls2 )

## 3SLS estimation with GMM-3SLS formula
inst <- ~ income + farmPrice + trend
fit3sls <- systemfit( system, "3SLS", inst = inst, data = Kmenta,
                    method3sls = "GMM" )
print( fit3sls )

## Examples how to use systemfit() with panel-like data
## Repeating the SUR estimations in Greene (2003, p. 351)
data( "GrunfeldGreene" )
library( plm )
GGPanel <- plm.data( GrunfeldGreene, c( "firm", "year" ) )
formulaGrunfeld <- invest ~ value + capital
# SUR
greeneSur <- systemfit( formulaGrunfeld, "SUR",

```

```

    data = GGPanel, methodResidCov = "noDfCor" )
summary( greeneSur )
# SUR Pooled
greeneSurPooled <- systemfit( formulaGrunfeld, "SUR",
    data = GGPanel, pooled = TRUE, methodResidCov = "noDfCor",
    residCovWeighted = TRUE )
summary( greeneSurPooled )

## Further examples are in the documentation to the data sets
## 'KleinI' and 'GrunfeldGreene'.

```

---

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

<code>maxiter</code>	maximum number of iterations for WLS, SUR, W2SLS and 3SLS estimations.
<code>tol</code>	tolerance level indicating when to stop the iteration (only WLS, SUR, W2SLS and 3SLS estimations).
<code>methodResidCov</code>	method for calculating the estimated residual covariance matrix, one of "noDfCor", "geomean", "max", or "Theil" (see details).
<code>centerResiduals</code>	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.
method3spls	method for calculating the 3SLS estimator, one of "GLS", "IV", "GMM", "Schmidt", or "EViews" (see details).
singleEqSigma	logical. use different $\sigma^2$ s for each single equation to calculate the covariance matrix and the standard errors of the coefficients (only OLS and 2SLS)? If <code>singleEqSigma</code> 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 <code>Matrix</code> for matrix calculations?
solveto1	tolerance level for detecting linear dependencies when inverting a matrix or calculating a determinant (see <code>solve</code> and <code>det</code> ).
model, x, y, z	logical. If 'TRUE' the corresponding components of the fit (the model frame, the model matrix, the matrix of instruments, the response) are returned.

## Details

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

$$\sqrt{\frac{\sum_i (b_{i,g} - b_{i,g-1})^2}{\sum_i b_{i,g-1}^2}} < \text{tol}$$

( $b_{i,g}$  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 `methodResidCov='noDfCor'`:

$$\hat{\sigma}_{ij} = \frac{\hat{e}'_i \hat{e}_j}{T}$$

if `methodResidCov='geomean'`:

$$\hat{\sigma}_{ij} = \frac{\hat{e}'_i \hat{e}_j}{\sqrt{(T - k_i) * (T - k_j)}}$$

if `methodResidCov='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 `methodResidCov='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 `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, `residCovWeighted` has no effect on the estimation results.

### Value

A list of the above components.

### Author(s)

Arne Henningsen (arne.henningsen@googlemail.com)

### References

Judge, George G.; W. E. Griffiths; R. Carter Hill; Helmut Luetkepohl and Tsoung-Chao Lee (1985) *The Theory and Practice of Econometrics, Second Edition*, Wiley.

Schmidt, P. (1990) *Three-Stage Least Squares with different Instruments for different equations*, Journal of Econometrics 43, p. 389-394.

Theil, H. (1971) *Principles of Econometrics*, Wiley, New York.

### 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
fitsur <- 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.

## Value

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

## Author(s)

Arne Henningsen (arne.henningsen@googlemail.com)

## 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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