

# Package ‘feisr’

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**Title** Estimating Fixed Effects Individual Slope Models

**Version** 1.0.1

**URL** <https://github.com/ruettenauer/feisr>

**BugReports** <https://github.com/ruettenauer/feisr/issues>

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**Description** Provides a function ('feis') to estimate fixed effects individual slope (FEIS) models. The FEIS model constitutes a more general version of the often-used fixed effects (FE) panel model, as implemented in the package 'plm' by Croissant and Millo (2008) <doi:10.18637/jss.v027.i02>. In FEIS models, data are not only person 'demeaned' like in conventional FE models, but 'detrended' by the predicted individual slope of each person or group. Estimation is performed by applying least squares ('lm') to the transformed data. For more details on FEIS models see Bruederl and Ludwig (2015, ISBN:1446252442); Frees (2001) <doi:10.2307/3316008>; Polachek and Kim (1994) <doi:10.1016/0304-4076(94)90075-2>; Wooldridge (2010, ISBN:0262294354). To test consistency of conventional FE and random effects estimators against heterogeneous slopes, the package also provides an artificial regression test ('feistest') and a bootstrapped version ('bsfeistest') of the Hausman test.

**Depends** R (>= 3.4.0)

**License** GPL (>= 2)

**Encoding** UTF-8

**LazyData** true

**RdMacros** Rdpack

**Imports** aod, Formula, plm, Rdpack, stats

**Suggests** texreg, testthat

**RoxygenNote** 6.1.1

## R topics documented:

bsfeistest	2
feis	4

feistest . . . . .	6
mwp . . . . .	7
slopes . . . . .	8
summary.feis . . . . .	9
<b>Index</b>	<b>11</b>

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bsfeistest	<i>Bootstrapped Regression Test</i>
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**Description**

Estimates a bootstrapped Hausmann test for fixed effects individual slope models.

**Usage**

```
bsfeistest(model = NA, type = c("all", "bs1", "bs2", "bs3"),
  rep = 500, seed = NULL, prog = TRUE, ...)
```

**Arguments**

model	an object of class "feis".
type	one of "all" (the Default), "bs1" for test of FEIS against FE only, "bs2" for test of FE against RE only, and "bs3" for test of FEIS against RE only (see also Details).
rep	the number of repetitions to be used in bootstrapping (default is 500).
seed	the seed used for random sampling in bootstrapping. Needs to be a valid integer. If not specified, the current seed is used.
prog	... logical. If TRUE (the Default) shows the progress in the output window.
...	further arguments.

**Details**

The function computes a bootstrapped version of the Hausman test (Hausman 1978). Pairs cluster bootstrapping (Cameron et al. 2008) is used to obtain the empirical variance-covariance matrix of the estimators, either for FEIS and conventional FE, convention FE and RE, or FEIS and RE.

type="bs1" estimates a bootstrapped Hausmann test comparing fixed effects individual slope models and conventional fixed effects models. In this case, bsfeistest tests for inconsistency of the convetional FE model due to heterogeneous slopes. type="bs2" estimates a bootstrapped version of the well-known Hausmann test comparing conventional fixed effects models against random effects models. type="bs3" estimates a bootstrapped Hausman directly comparing FEIS against RE, thereby testing for inconsistency of the RE model due to either heterogeneous slopes or time-constant omitted heterogeneity. Bootstrapping is perfomed by resampling with replacement while keeping the number of groups identical to the number of groups in the original dataset. [wald.test](#) is used to perform a Wald chi-squared test on the differences between coefficients.

**Value**

An object of class "feistest", containing the following elements:

wald_feis	an object of class "wald.test" (see <a href="#">wald.test</a> ) testing the fixed effects individual slopes model against the conventional fixed effects model (type="bs1").
wald_fe	an object of class "wald.test" (see <a href="#">wald.test</a> ) testing the fixed effects model against the random effects model (type="bs2").
wald_re	an object of class "wald.test" (see <a href="#">wald.test</a> ) testing the fixed effects individual slopes model against the random effects model (type="bs3").
vcov1	the empirical (bootstrapped) variance-covariance matrix of the coefficients obtained from FEIS and FE (type="bs1").
vcov2	the empirical (bootstrapped) variance-covariance matrix of the coefficients obtained from FE and RE (type="bs2").
vcov3	the empirical (bootstrapped) variance-covariance matrix of the coefficients obtained from FEIS and RE (type="bs3").
bscoef.feis	a matrix containing the estimated FEIS coefficients of each bootstrap run.
bscoef.fe	a matrix containing the estimated FE coefficients of each bootstrap run.
bscoef.re	a matrix containing the estimated RE coefficients of each bootstrap run.
call	the matched call.
formula	an object of class "Formula" describing the model.
type	the type of performed test(s).
sample	a list containing the IDs sampled in each run.
seed	the seed used for bootstrapping.

**References**

- Cameron AC, Gelbach JB, Miller DL (2008). "Bootstrap-Based Improvements for Inference with Clustered Errors." *Review of Economics and Statistics*, **90**(3), 414–427. ISSN 0034-6535, doi: [10.1162/rest.90.3.414](#).
- Hausman JA (1978). "Specification Tests in Econometrics." *Econometrica*, **46**(6), 1251–1271. ISSN 00129682.

**See Also**

[feis](#), [feistest](#), [plm](#), [wald.test](#), [phtest](#)

**Examples**

```
data("mwp", package = "feisr")
feis.mod <- feis(lnw ~ marry + enrol | year,
                data = mwp, id = "id", robust = TRUE)
bsht <- bsfeistest(feis.mod, type = "bs1", rep = 5, seed = 1234, prog = FALSE)
summary(bsht)
```

feis

*Fixed Effects Individual Slope Estimator***Description**

Estimates fixed effects individual slope estimators by applying linear `lm` models to "detrended" data.

**Usage**

```
feis(formula, data, id, robust = FALSE, intercept = FALSE,
      dropgroups = FALSE, ...)
```

**Arguments**

<code>formula</code>	a symbolic description for the model to be fitted (see Details).
<code>data</code>	a <code>data.frame</code> containing the specified variables.
<code>id</code>	the name of a unique group / person identifier (as string).
<code>robust</code>	logical. If TRUE estimates cluster robust standard errors (default is FALSE).
<code>intercept</code>	logical. If TRUE estimates the model with an intercept (default is FALSE).
<code>dropgroups</code>	logical. If TRUE groups without any within variance on a slope variable are dropped, if FALSE those variables are omitted for the respective groups only (default is FALSE).
<code>...</code>	further arguments.

**Details**

`feis` is a special function to estimate linear fixed effects models with individual-specific slopes. In contrast to conventional fixed effects models, data are not person "demeaned", but "detrended" by the predicted individual slope of each person (Bruederl and Ludwig 2015; Wooldridge 2010).

Estimation requires at least  $q+1$  observations per unit, where  $q$  is the number of slope parameters (including a constant). `feis` automatically selects only those groups from the current data set which have at least  $q+1$  observations. The function returns a warning if units with  $<q+1$  observations are dropped.

The function requires a two-part formula, in which the second part indicates the slope parameter(s). If, for example, the model is  $y \sim x_1 + x_2$ , with the slope variables  $x_3$  and  $x_4$ , the model can be estimated with:

- `formula = y ~ x1 + x2 | x3 + x4`

If the second part is not specified (and individual "slopes" are estimated only by an intercept), the model reduces to a conventional fixed effects (within) model. In this case please use the well-established `plm` (`model="within"`) function instead of `feis`.

If specified, `feis` estimates panel-robust standard errors. Panel-robust standard errors are robust to arbitrary forms of serial correlation within groups formed by `id` as well as heteroscedasticity across groups (see Wooldridge 2010, pp. 379-381).

**Value**

An object of class "feis", containing the following elements:

<code>coefficients</code>	the vector of coefficients.
<code>vcov</code>	the variance-covariance matrix of the coefficients.
<code>residuals</code>	the vector of residuals (computed from the "detrended" data).
<code>df.residual</code>	degrees of freedom of the residuals.
<code>formula</code>	an object of class "Formula" describing the model.
<code>model</code>	the original model frame as a <code>data.frame</code> containing the original variables used for estimation.
<code>modelhat</code>	a constructed model frame as a <code>data.frame</code> containing the predicted values from the first stage regression using the slope variable(s) as predictor(s).
<code>modeltrans</code>	a constructed model frame as a <code>data.frame</code> containing the "detrended" variables used for the final model estimation and the untransformed slope variables.
<code>response</code>	the vector of the "detrended" response variable.
<code>fitted.values</code>	the vector of fitted values (computed from the "detrended" data).
<code>id</code>	a vector containing the unique person identifier.
<code>call</code>	the matched call.
<code>assign</code>	assign attributes of the formula.
<code>na.omit</code>	(where relevant) a vector of the omitted observations. The only handling method of NAs is "omit".
<code>contrasts</code>	(only where relevant) the contrasts used.
<code>arg</code>	a list containing the used methods. Only "feis" and "individual" effects available.
<code>slopevars</code>	a character vector containing the names of the slope variables.
<code>r2</code>	R squared of the "detrended" model.
<code>adj.r2</code>	adjusted R squared of the "detrended" model.
<code>vcov_arg</code>	a character containing the method used to compute the variance-covariance matrix.

**References**

Bruederl J, Ludwig V (2015). "Fixed-Effects Panel Regression." In Best H, Wolf C (eds.), *The Sage Handbook of Regression Analysis and Causal Inference*, 327–357. Sage, Los Angeles. ISBN 1446252442.

Wooldridge JM (2010). *Econometric Analysis of Cross Section and Panel Data*. MIT Press, Cambridge, Mass. ISBN 0262294354.

**See Also**

[plm](#), [feistest](#)

**Examples**

```
data("mwp", package = "feisr")
feis.mod <- feis(lnw ~ marry + enrol + as.factor(yeargr) | exp + I(exp^2),
                data = mwp, id = "id", robust = TRUE)
summary(feis.mod)
```

feistest

*Artificial Regression Test***Description**

Estimates a regression-based Hausmann test for fixed effects individual slope models.

**Usage**

```
feistest(model = NA, robust = FALSE, type = c("all", "art1", "art2",
      "art3"), ...)
```

**Arguments**

model	an object of class "feis".
robust	logical. If TRUE uses cluster robust standard errors (Default is FALSE).
type	one of "all" (the Default), "art1" for test of FEIS against FE only, "art2" for test of FE against RE only, and "art3" for test of FEIS against RE only (see also Details).
...	further arguments.

**Details**

The Hausmann test can be computed by estimating a correlated random effects model (see Wooldridge 2010, pp. 328-334). This is achieved by estimating a Mundlak (Mundlak 1978) specification using random effects models with [plm](#). Subsequently, `feistest` tests whether the time-constant variables / slope variables are correlated with the unobserved heterogeneity by using a Wald chi-squared test with [wald.test](#).

`type="art1"` estimates an extended regression-based Hausmann test comparing fixed effects individual slope models and conventional fixed effects models. For `art1` the Mundlak-specification (Mundlak 1978) includes the person-specific averages, but additionally the person-specific slope estimates used for "detrending" in [feis](#). This allows to test whether we can omit the estimated values based on the slopes and reduce the model to a conventional FE model. The Wald test of `type="art1"` is applied to the slope variables only. `type="art2"` estimates the conventional regression-based Hausmann test (as described in Wooldridge 2010, pp. 328-334) comparing conventional fixed effects models against random effects models. `type="art3"` estimates a regression-based Hausmann test comparing FEIS directly against RE, thereby testing for inconsistency of the RE model due to either heterogeneous slopes or time-constant omitted heterogeneity. For `art3` the Mundlak-specification includes only the person-specific slopes, and no averages. This allows to test whether we can omit the estimated values based on the slopes and reduce the model to a conventional RE model.

If specified (`robust=TRUE`), `feistest` uses panel-robust standard errors.

**Value**

An object of class "feistest", containing the following elements:

wald_feis	an object of class "wald.test" (see <a href="#">wald.test</a> ) testing the fixed effects individual slopes model against the conventional fixed effects model ( <code>type="art1"</code> ).
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wald_fe	an object of class "wald.test" (see <a href="#">wald.test</a> ) testing the fixed effects model against the random effects model (type="art2").
wald_re	an object of class "wald.test" (see <a href="#">wald.test</a> ) testing the fixed effects individual slopes model against the random effects model (type="art3").
vcov1	the variance-covariance matrix of CREIS (type="art1").
vcov2	the variance-covariance matrix of CRE (type="art2").
vcov3	the variance-covariance matrix of CREIS without the means (type="art3").
CREIS	an object of class "plm" (see <a href="#">plm</a> ) estimating a Correlated Random Effect Individual Slope model (type="art1").
CRE	an object of class "plm" (see <a href="#">plm</a> ) estimating a Correlated Random Effect model (type="art2").
CREIS2	an object of class "plm" (see <a href="#">plm</a> ) estimating a Correlated Random Effect Individual Slope model without including the covariates' means (type="art3").
call	the matched call.
robust	logical. If TRUE cluster robust standard errors were used (Default is FALSE).
formula	an object of class "Formula" describing the model.
type	the type of performed test(s).

## References

- Mundlak Y (1978). "On the Pooling of Time Series and Cross Section Data." *Econometrica*, **46**(1), 69. ISSN 00129682.
- Wooldridge JM (2010). *Econometric Analysis of Cross Section and Panel Data*. MIT Press, Cambridge, Mass. ISBN 0262294354.

## See Also

[feis](#), [bsfeistest](#), [plm](#), [wald.test](#), [phtest](#)

## Examples

```
data("mwp", package = "feisr")
feis.mod <- feis(lnw ~ marry + enrol | year,
               data = mwp, id = "id", robust = TRUE)
ht <- feistest(feis.mod, robust = TRUE, type = "all")
summary(ht)
```

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mwp

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*Panel data including wages and family status*


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## Description

A random sample from the National Longitudinal Survey of Youth (NLSY79 2012). It contains information on wages, family status, and work experience for a random sample of men. For a description of the original dataset and variable construction see Ludwig and Brüderl (2018).

## Usage

```
mwp
```

**Format**

A data frame with 3100 observations and 17 variables:

- id** unique person identifier
- year** survey year
- lnw** natural log of hourly wage rate
- exp** work experience in current job, in years
- expq** work experience in current job squared
- marry** family status (=0 if not married, =1 if married)
- evermarry** indicator if ever married (=0 if never married, =1 if married at some point)
- enrol** current enrolment in education (=0 not enrolled, =1 enrolled)
- yeduc** years of formal education
- age** respondents current age
- cohort** respondents birth cohort
- yeargr** grouped year (1=1979-1980, 2=1981-1985, 3=1986-1990, 4=1991-1995, 5=1996-2000)
- yeargr1** dummy indicating grouped year=1
- yeargr2** dummy indicating grouped year=2
- yeargr3** dummy indicating grouped year=3
- yeargr4** dummy indicating grouped year=4
- yeargr5** dummy indicating grouped year=5

**Source**

Ludwig and Brüderl (2018)

**References**

Ludwig V, Brüderl J (2018). “Is There a Male Marital Wage Premium? New Evidence from the United States.” *American Sociological Review*, **83**(4), 744–770. ISSN 0003-1224, doi: [10.1177/0003122418784909](https://doi.org/10.1177/0003122418784909).

NLSY79 (2012). *National Longitudinal Survey of Youth 1979 Cohort, 1979-2012*. Bureau of Labor Statistics, U.S. Department of Labor.

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slopes	<i>Extract individual slopes</i>
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**Description**

Extracts the individual slopes (alpha\_i) from a feis object created by feis.

**Usage**

slopes(model = NA, ...)



**Arguments**

model	an object of class "feis".
...	further arguments.

**Details**

The function extracts a matrix containing the individual slope parameters ( $\alpha_i$ ), which equals the coefficient(s) of regressing the dependent variable on the slope parameter(s).

If slope variables are perfectly collinear within a cluster, one variable is dropped and the function returns  $\emptyset$  for the respective slope and cluster.

**Value**

An  $N \times J$  matrix containing the individual slopes for each cluster unit  $N$  and slope variable  $J$ . Rownames indicate the cluster id.

**Examples**

```
data("Produc", package = "plm")
feis.mod <- feis("log(gsp) ~ log(pcap) + log(pc) + log(emp) + unemp | year",
               data = Produc, id = "state", robust = TRUE)
slps <- slopes(feis.mod)
```

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summary.feis	<i>Summary for feis objects</i>
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**Description**

The summary method for feis objects generates some additional information about estimated feis models.

**Usage**

```
## S3 method for class 'feis'
summary(object, vcov = NULL, ...)
```

**Arguments**

object	an object of class "plm".
vcov	a variance-covariance matrix furnished by the user or a function to calculate one.
...	further arguments.

**Value**

An object of class "summary.feis", containing the elements of the feis object (see [feis](#)). The following objects are modified:

coefficients	a matrix with the estimated coefficients, standard errors, t-values, and p-values, if argument vcov is NULL the standard errors are calculated by the vcov in the input object.
r.squared	a vector containing R squared and adjusted R squared.

**Examples**

```
data("mwp", package = "feisr")
feis.mod <- feis(lnw ~ marry | exp,
                 data = mwp, id = "id")
summary(feis.mod)
```

# Index

## \*Topic **datasets**

mwp, [7](#)

bsfeistest, [2](#), [7](#)

feis, [3](#), [4](#), [6–9](#)

feistest, [3](#), [5](#), [6](#)

mwp, [7](#)

phptest, [3](#), [7](#)

plm, [3–7](#)

slopes, [8](#)

summary.feis, [9](#)

wald.test, [2](#), [3](#), [6](#), [7](#)