

Description

`eivreg` fits errors-in-variables regression models when one or more of the independent variables are measured with error. To use `eivreg`, you must have an estimate of each independent variable's reliability or assume it is measured without error.

Quick start

Regression of `y` on `x1`, `x2`, and `x3` adjusted for `x1` measured with 90% reliability

```
eivreg y x1 x2 x3, reliab(x1 .9)
```

Same as above, but also specify 80% reliability for `x2`

```
eivreg y x1 x2 x3, reliab(x1 .9 x2 .8)
```

Menu

Statistics > Linear models and related > Errors-in-variables regression

Syntax

```
eivreg depvar [indepvars] [if] [in] [weight] [ , options ]
```

options

Description

Model

```
reliab(indepvar # [indepvar # [...] ])
```

specify measurement reliability for each *indepvar* measured with error

Reporting

```
level(#)
```

set confidence level; default is level(95)

```
display_options
```

control columns and column formats, row spacing, line width, display of omitted variables and base and empty cells, and factor-variable labeling

```
coeflegend
```

display legend instead of statistics

indepvars may contain factor variables; see [U] 11.4.3 **Factor variables**.

bootstrap, by, collect, jackknife, rolling, and statsby are allowed; see [U] 11.1.10 **Prefix commands**.

Weights are not allowed with the bootstrap prefix; see [R] **bootstrap**.

aweights are not allowed with the jackknife prefix; see [R] **jackknife**.

aweights and fweights are allowed; see [U] 11.1.6 **weight**.

coeflegend does not appear in the dialog box.

See [U] 20 **Estimation and postestimation commands** for more capabilities of estimation commands.

Options

Model

reliab(*indepvar* # [*indepvar* # [...]])

 specifies the measurement reliability for each independent variable measured with error. Reliabilities are specified as pairs consisting of an independent variable name (a name that appears in *indepvars*) and the corresponding reliability r , $0 < r \leq 1$. Independent variables for which no reliability is specified are assumed to have reliability 1. If the option is not specified, all variables are assumed to have reliability 1, and the result is thus the same as that produced by regress (the ordinary least-squares results).

Reporting

level(#); see [R] **Estimation options**.

display_options: nocl, nopvalues, noomitted, vsquish, noemptycells, baselevels, allbaselevels, novllabel, fvwrap(#), fvwrapon(*style*), cformat(%*fmt*), pformat(%*fmt*), sformat(%*fmt*), and nolstretch; see [R] **Estimation options**.

The following option is available with eivreg but is not shown in the dialog box:

coeflegend; see [R] **Estimation options**.

Remarks and examples

For an introduction to errors-in-variables regression, see [Draper and Smith \(1998, 89–91\)](#) or [Kmenta \(1997, 352–357\)](#). [Treiman \(2009, 258–261\)](#) compares the results of errors-in-variables regression with conventional regression. Also see [Lockwood and McCaffrey \(2020\)](#) for how to use `sem` (see [\[SEM\]](#) `sem`) to fit errors-in-variables regression.

Errors-in-variables regression models are useful when one or more of the independent variables are measured with additive noise. Standard regression (as performed by `regress`) would underestimate the effect of the variable, and the other coefficients in the model can be biased to the extent that they are correlated with the poorly measured variable. You can adjust for the biases if you know the reliability:

$$r = 1 - \frac{\text{noise variance}}{\text{total variance}}$$

That is, given the model $\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \mathbf{u}$, for some variable \mathbf{x}_i in \mathbf{X} , the \mathbf{x}_i is observed with error, $\mathbf{x}_i = \mathbf{x}_i^* + \mathbf{e}$, and the noise variance is the variance of \mathbf{e} . The total variance is the variance of \mathbf{x}_i .

► Example 1

Say that in our automobile data, the weight of cars was measured with error, and the reliability of our measured weight is 0.85. The result of this would be to underestimate the effect of `weight` in a regression of, say, `price` on `weight` and `foreign`, and it would also bias the estimate of the coefficient on `foreign` (because being of foreign manufacture is correlated with the weight of cars). We would ignore all of this if we fit the model with `regress`:

```
. use https://www.stata-press.com/data/r19/auto
(1978 automobile data)
. regress price weight foreign
```

Source	SS	df	MS	Number of obs = 74		
				F(2, 71) = 35.35		
Model	316859273	2	158429637	Prob > F = 0.0000		
Residual	318206123	71	4481776.38	R-squared = 0.4989		
				Adj R-squared = 0.4848		
Total	635065396	73	8699525.97	Root MSE = 2117		

price	Coefficient	Std. err.	t	P> t	[95% conf. interval]	
weight	3.320737	.3958784	8.39	0.000	2.531378	4.110096
foreign	3637.001	668.583	5.44	0.000	2303.885	4970.118
_cons	-4942.844	1345.591	-3.67	0.000	-7625.876	-2259.812

With `eivreg`, we can account for our measurement error:

```
. eivreg price weight foreign, reliab(weight .85)
```

Errors-in-variables regression

Variable	Assumed reliability					
weight	0.8500		Number of obs	=		74
*	1.0000		F(2, 71)	=		18.46
			Prob > F	=		0.0000
			R-squared	=		0.6483
			Root MSE	=		1773.54

price	Coefficient	Std. err.	t	P> t	[95% conf. interval]	
weight	4.31985	.7134251	6.06	0.000	2.89732	5.742379
foreign	4637.32	849.0221	5.46	0.000	2944.418	6330.222
_cons	-8257.017	2390.337	-3.45	0.001	-13023.21	-3490.821

The effect of weight is increased—as we knew it would be—and here the effect of foreign manufacture is also increased. A priori, we knew only that the estimate of foreign might be biased; we did not know the direction.

◀

□ Technical note

Swept under the rug in our example is how we would determine the reliability, r . We can easily see that a variable is measured with error, but we may not know the reliability because the ingredients for calculating r depend on the unobserved noise.

For our example, we made up a value for r , and in fact we do not believe that weight is measured with error at all, so the reported `eivreg` results have no validity. The regress results were the statistically correct results here.

But let’s say that we do suspect that weight is measured with error and that we do not know r . We could then experiment with various values of r to describe the sensitivity of our estimates to possible error levels. We may not know r , but r does have a simple interpretation, and we could probably produce a sensible range for r by thinking about how the data were collected.

If the reliability, r , is less than the R^2 from a regression of the poorly measured variable on all the other variables, including the dependent variable, the information might as well not have been collected; no adjustment to the final results is possible. For our automobile data, running a regression of weight on foreign and price would result in an R^2 of 0.6743. Thus, the reliability must be at least 0.6743 here. If we specify a reliability that is too small, `eivreg` will inform us and refuse to fit the model:

```
. eivreg price weight foreign, reliab(weight .6742)
reliability r() too small
r(399);
```

Returning to our problem of how to estimate r , too small or not, if the measurements are summaries of scaled items, the reliability may be estimated using the `alpha` command; see [MV] [alpha](#). If the score is computed from factor analysis and the data are scored using `predict`’s default options (see [MV] [factor postestimation](#)), the square of the standard deviation of the score is an estimate of the reliability.

□

► Example 2

Consider a model with more than one variable measured with error. For instance, say that our model is that price is a function of weight, foreign, and mpg and that both weight and mpg are measured with error.

```
. eivreg price weight foreign mpg, reliab(weight .85 mpg .95)
```

Errors-in-variables regression

Variable	Assumed reliability		
weight	0.8500	Number of obs	= 74
mpg	0.9500	F(3, 70)	= 9.58
*	1.0000	Prob > F	= 0.0000
		R-squared	= 0.8522
		Root MSE	= 1158.04

price	Coefficient	Std. err.	t	P> t	[95% conf. interval]	
weight	9.69903	3.768985	2.57	0.012	2.182027	17.21603
foreign	6918.624	2259.531	3.06	0.003	2412.132	11425.12
mpg	627.6764	431.0284	1.46	0.150	-231.9826	1487.335
_cons	-38545.27	20960.72	-1.84	0.070	-80350.11	3259.564



Stored results

eivreg stores the following in e():

Scalars

- e(N) number of observations
- e(df_m) model degrees of freedom
- e(df_r) residual degrees of freedom
- e(r2) R^2
- e(F) F statistic
- e(rmse) root mean squared error
- e(rank) rank of e(V)

Macros

- e(cmd) eivreg
- e(cmdline) command as typed
- e(depvar) name of dependent variable
- e(rellist) *indepvars* and associated reliabilities
- e(wtype) weight type
- e(wexp) weight expression
- e(properties) b V
- e(predict) program used to implement predict
- e(marginsok) predictions allowed by margins
- e(asbalanced) factor variables fvset as asbalanced
- e(asobserved) factor variables fvset as asobserved

Matrices

- e(b) coefficient vector
- e(V) variance-covariance matrix of the estimators

Functions

- e(sample) marks estimation sample

In addition to the above, the following is stored in `r()`:

Matrices

`r(table)`

matrix containing the coefficients with their standard errors, test statistics, p -values, and confidence intervals

Note that results stored in `r()` are updated when the command is replayed and will be replaced when any `r-class` command is run after the estimation command.

Methods and formulas

Let the model to be fit be

$$\begin{aligned} \mathbf{y} &= \mathbf{X}^* \boldsymbol{\beta} + \boldsymbol{\epsilon} \\ \mathbf{X} &= \mathbf{X}^* + \mathbf{U} \end{aligned}$$

where \mathbf{X}^* are the true values and \mathbf{X} are the observed values. $\boldsymbol{\epsilon}$ and \mathbf{U} are assumed to be independent and have zero means and finite fourth moments. $\text{Var}(\mathbf{U})$ is assumed to be diagonal.

Let \mathbf{W} be the user-specified weights. If no weights are specified, $\mathbf{W} = \mathbf{I}$. If weights are specified, let \mathbf{v} be the specified weights. If `fweight` frequency weights are specified, then $\mathbf{W} = \text{diag}(\mathbf{v})$. If `aweight` analytic weights are specified, then $\mathbf{W} = \text{diag}\{\mathbf{v}/(\mathbf{1}'\mathbf{v})(\mathbf{1}'\mathbf{1})\}$, meaning that the weights are normalized to sum to the number of observations.

The estimates \mathbf{b} of $\boldsymbol{\beta}$ are obtained as $\mathbf{A}^{-1}\mathbf{X}'\mathbf{W}\mathbf{y}$, where $\mathbf{A} = \mathbf{X}'\mathbf{W}\mathbf{X} - \mathbf{S}$. \mathbf{S} is a diagonal matrix with elements $(1 - r_j)s_j^2$. Here r_j is the user-specified reliability coefficient for the j th explanatory variable (or 1 if not specified), and s_j^2 is the (appropriately weighted) sample variance of the variable.

The root mean squared error is $(\mathbf{y}'\mathbf{W}\mathbf{y} - \mathbf{b}\mathbf{A}\mathbf{b}')/(n - p)$, where n is the number of observations and p is the number of estimated parameters. The variance–covariance matrix of the estimators is obtained based on the formulas provided in [Stefanski and Boos \(2002\)](#), [Buonaccorsi \(2010\)](#), and [Fuller \(1987\)](#). For each $i = 1, 2, \dots, n$, let residual $e_i = y_i - \mathbf{x}_i\mathbf{b}$, where \mathbf{x}_i is the i th row of \mathbf{X} . Consider matrix \mathbf{H} , where the i th row of \mathbf{H} , \mathbf{h}_i , is

$$\mathbf{h}_i' = \begin{pmatrix} e_i x_{i1} + (x_{i1} - \bar{x}_1)^2(1 - r_1)b_1 \\ e_i x_{i2} + (x_{i2} - \bar{x}_2)^2(1 - r_2)b_2 \\ \vdots \\ e_i x_{ip} + (x_{ip} - \bar{x}_p)^2(1 - r_p)b_p \end{pmatrix}$$

where \bar{x}_j is the weighted mean of the j th variable.

If analytic weights, `aweights`, are specified, the variance–covariance matrix is $\mathbf{A}^{-1} \mathbf{H}'\mathbf{W}\mathbf{H}\mathbf{A}^{-1}$; otherwise, it is $\mathbf{A}^{-1}\mathbf{H}'\mathbf{W}\mathbf{H}\mathbf{A}^{-1}$.

References

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Also see

[R] **eivreg postestimation** — Postestimation tools for eivreg

[R] **regress** — Linear regression

[SEM] **Example 24** — Reliability

[U] **20 Estimation and postestimation commands**

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