

Description

`cnsreg` fits constrained linear regression models.

Quick start

Linear regression with coefficients for x_1 and x_2 constrained to equality

```
constraint 1 x1 = x2  
cnsreg y x1 x2 x3, constraints(1)
```

Add constraint $x_2 = x_3$ to impose $x_1 = x_2 = x_3$

```
constraint 2 x2 = x3  
cnsreg y x1 x2 x3, constraints(1 2)
```

Constrain the coefficient for x_4 to be -1

```
constraint 3 x4 = -1  
cnsreg y x1 x2 x3 x4, constraints(1-3)
```

Menu

Statistics > Linear models and related > Constrained linear regression

Syntax

```
cnsreg depvar indepvars [if] [in] [weight] , constraints(constraints) [options]
```

<i>options</i>	Description
Model	
* <u>constraints</u> (<i>constraints</i>)	apply specified linear constraints
<u>noconstant</u>	suppress constant term
SE/Robust	
<u>vce</u> (<i>vcetype</i>)	<i>vcetype</i> may be <u>ols</u> , <u>robust</u> , <u>cluster</u> <i>clustvar</i> , <u>bootstrap</u> , or <u>jackknife</u>
Reporting	
<u>level</u> (#)	set confidence level; default is <u>level</u> (95)
<u>nocnsreport</u>	do not display constraints
<u>display_options</u>	control columns and column formats, row spacing, line width, display of omitted variables and base and empty cells, and factor-variable labeling
<u>mse1</u>	force MSE to be 1
<u>collinear</u>	keep collinear variables
<u>coeflegend</u>	display legend instead of statistics

* constraints(*constraints*) is required.

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

depvar and *indepvars* may contain time-series operators; see [U] 11.4.4 Time-series varlists.

bayesboot, bootstrap, by, collect, fp, jackknife, mi estimate, rolling, statsby, and svy are allowed; see [U] 11.1.10 Prefix commands.

vce(bootstrap) and vce(jackknife) are not allowed with the mi estimate prefix; see [MI] mi estimate.

With the fp prefix (see [R] fp), constraints cannot be specified for the variable containing fractional polynomial terms.

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

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

vce(), mse1, and weights are not allowed with the svy prefix; see [SVY] svy.

aweights, fweights, iweights, and pweights are allowed; see [U] 11.1.6 weight.

mse1, collinear, and coeflegend do not appear in the dialog.

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

Options

Model
<u>constraints</u> (<i>constraints</i>), <u>noconstant</u> ; see [R] Estimation options.
SE/Robust
<u>vce</u> (<i>vcetype</i>) specifies the type of standard error reported, which includes types that are derived from asymptotic theory (<u>ols</u>), that are robust to some kinds of misspecification (<u>robust</u>), that allow for intragroup correlation (<u>cluster</u> <i>clustvar</i>), and that use bootstrap or jackknife methods (<u>bootstrap</u> , <u>jackknife</u>); see [R] <u>vce_option</u> .
<u>vce</u> (<u>ols</u>), the default, uses the standard variance estimator for ordinary least-squares regression.

Reporting

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

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

The following options are available with *cnsreg* but are not shown in the dialog box:

mse1 is used only in programs and ado-files that use *cnsreg* to fit models other than constrained linear regression. *mse1* sets the mean squared error to 1, thus forcing the variance–covariance matrix of the estimators to be $(\mathbf{X}'\mathbf{D}\mathbf{X})^{-1}$ (see [Methods and formulas](#) in [R] [regress](#)) and affecting calculated standard errors. Degrees of freedom for *t* statistics are calculated as *n* rather than $n - p + c$, where *p* is the total number of parameters (prior to restrictions and including the constant) and *c* is the number of constraints.

mse1 is not allowed with the *svy* prefix.

collinear, *coeflegend*; see [R] [Estimation options](#).

Remarks and examples

For a discussion of constrained linear regression, see [Greene \(2018, 126–127\)](#); [Hill, Griffiths, and Lim \(2018, 271–273\)](#); or [Davidson and MacKinnon \(1993, 17\)](#).

► Example 1: One constraint

In principle, we can obtain constrained linear regression estimates by modifying the list of independent variables. For instance, if we wanted to fit the model

$$\text{mpg} = \beta_0 + \beta_1 \text{price} + \beta_2 \text{weight} + u$$

and constrain $\beta_1 = \beta_2$, we could write

$$\text{mpg} = \beta_0 + \beta_1(\text{price} + \text{weight}) + u$$

and run a regression of *mpg* on *price + weight*. The estimated coefficient on the sum would be the constrained estimate of β_1 and β_2 . Using *cnsreg*, however, is easier:

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

```
. constraint 1 price = weight
. cnsreg mpg price weight, constraint(1)
```

Constrained linear regression

```
Number of obs =    74
F(1, 72)       =   37.59
Prob > F       =   0.0000
Root MSE      =   4.7220
```

```
( 1) price - weight = 0
```

	mpg	Coefficient	Std. err.	t	P> t	[95% conf. interval]	
	price	-.0009875	.0001611	-6.13	0.000	-.0013086	-.0006664
	weight	-.0009875	.0001611	-6.13	0.000	-.0013086	-.0006664
	_cons	30.36718	1.577958	19.24	0.000	27.22158	33.51278

We define constraints by using the `constraint` command; see [R] [constraint](#). We fit the model with `cnsreg` and specify the constraint number or numbers in the `constraints()` option.

Just to show that the results above are correct, here is the result of applying the constraint by hand:

```
. generate x = price + weight
. regress mpg x
```

Source	SS	df	MS	Number of obs	=	74
Model	838.065767	1	838.065767	F(1, 72)	=	37.59
Residual	1605.39369	72	22.2971346	Prob > F	=	0.0000
				R-squared	=	0.3430
				Adj R-squared	=	0.3339
Total	2443.45946	73	33.4720474	Root MSE	=	4.722

mpg	Coefficient	Std. err.	t	P> t	[95% conf. interval]	
x	-.0009875	.0001611	-6.13	0.000	-.0013086	-.0006664
_cons	30.36718	1.577958	19.24	0.000	27.22158	33.51278

◀

► Example 2: Multiple constraints

Models can be fit subject to multiple simultaneous constraints. We simply define the constraints and then include the constraint numbers in the `constraints()` option. For instance, say that we wish to fit the model

$$\text{mpg} = \beta_0 + \beta_1 \text{price} + \beta_2 \text{weight} + \beta_3 \text{displ} + \beta_4 \text{gear_ratio} + \beta_5 \text{foreign} + \beta_6 \text{length} + u$$

subject to the constraints

$$\begin{aligned}\beta_1 &= \beta_2 = \beta_3 = \beta_6 \\ \beta_4 &= -\beta_5 = \beta_0/20\end{aligned}$$

(This model, like the one in example 1, is admittedly senseless.) We fit the model by typing

```
. constraint 1 price=weight
. constraint 2 displ=weight
. constraint 3 length=weight
. constraint 5 gear_ratio = -foreign
. constraint 6 gear_ratio = _cons/20
```

```
. cnsreg mpg price weight displ gear_ratio foreign length, c(1-3,5-6)
Constrained linear regression
```

Number of obs =	74
F(2, 72)	= 785.20
Prob > F	= 0.0000
Root MSE	= 4.6823

```

( 1) price - weight = 0
( 2) - weight + displacement = 0
( 3) - weight + length = 0
( 4) gear_ratio + foreign = 0
( 5) gear_ratio - .05*_cons = 0

```

mpg	Coefficient	Std. err.	t	P> t	[95% conf. interval]	
price	-.000923	.0001534	-6.02	0.000	-.0012288	-.0006172
weight	-.000923	.0001534	-6.02	0.000	-.0012288	-.0006172
displacement	-.000923	.0001534	-6.02	0.000	-.0012288	-.0006172
gear_ratio	1.326114	.0687589	19.29	0.000	1.189046	1.463183
foreign	-1.326114	.0687589	-19.29	0.000	-1.463183	-1.189046
length	-.000923	.0001534	-6.02	0.000	-.0012288	-.0006172
_cons	26.52229	1.375178	19.29	0.000	23.78092	29.26365

There are many ways we could have specified the `constraints()` option (which we abbreviated `c()` above). We typed `c(1-3,5-6)`, meaning that we want constraints 1 through 3 and 5 and 6; those numbers correspond to the constraints we defined. The only reason we did not use the number 4 was to emphasize that constraints do not have to be consecutively numbered. We typed `c(1-3,5-6)`, but we could have typed `c(1,2,3,5,6)` or `c(1-3,5,6)` or `c(1-2,3,5,6)` or even `c(1-6)`, which would have worked as long as constraint 4 was not defined. If we had previously defined a constraint 4, then `c(1-6)` would have included it.

◀

Stored results

`cnsreg` stores the following in `e()`:

Scalars

<code>e(N)</code>	number of observations
<code>e(df_m)</code>	model degrees of freedom
<code>e(df_r)</code>	residual degrees of freedom
<code>e(F)</code>	<i>F</i> statistic
<code>e(p)</code>	<i>p</i> -value for model test
<code>e(rmse)</code>	root mean squared error
<code>e(ll)</code>	log likelihood
<code>e(N_clust)</code>	number of clusters
<code>e(rank)</code>	rank of <code>e(V)</code>

Macros

<code>e(cmd)</code>	<code>cnsreg</code>
<code>e(cmdline)</code>	command as typed
<code>e(depvar)</code>	name of dependent variable
<code>e(wtype)</code>	weight type
<code>e(wexp)</code>	weight expression
<code>e(title)</code>	title in estimation output
<code>e(clustvar)</code>	name of cluster variable
<code>e(vce)</code>	<i>vce</i> type specified in <code>vce()</code>
<code>e(vcetype)</code>	title used to label Std. err.
<code>e(properties)</code>	<code>b</code> <code>V</code>

<code>e(predict)</code>	program used to implement predict
<code>e(marginsok)</code>	predictions allowed by margins
<code>e(asbalanced)</code>	factor variables fvset as asbalanced
<code>e(asobserved)</code>	factor variables fvset as asobserved
Matrices	
<code>e(b)</code>	coefficient vector
<code>e(Cns)</code>	constraints matrix
<code>e(V)</code>	variance–covariance matrix of the estimators
<code>e(V_modelbased)</code>	model-based variance
Functions	
<code>e(sample)</code>	marks estimation sample

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

Matrices	
<code>r(table)</code>	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 n be the number of observations, p be the total number of parameters (prior to restrictions and including the constant), and c be the number of constraints. The coefficients are calculated as $\mathbf{b}' = \mathbf{T}\{(\mathbf{T}'\mathbf{X}'\mathbf{W}\mathbf{X}\mathbf{T})^{-1}(\mathbf{T}'\mathbf{X}'\mathbf{W}\mathbf{y} - \mathbf{T}'\mathbf{X}'\mathbf{W}\mathbf{X}\mathbf{a}')\} + \mathbf{a}'$, where \mathbf{T} and \mathbf{a} are as defined in [P] [makecns](#). $\mathbf{W} = \mathbf{I}$ if no weights are specified. If weights are specified, let $\mathbf{v}: 1 \times n$ be the specified weights. If `fweight` frequency weights are specified, $\mathbf{W} = \text{diag}(\mathbf{v})$. 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 mean squared error is $s^2 = (\mathbf{y}'\mathbf{W}\mathbf{y} - 2\mathbf{b}'\mathbf{X}'\mathbf{W}\mathbf{y} + \mathbf{b}'\mathbf{X}'\mathbf{W}\mathbf{X}\mathbf{b})/(n - p + c)$. The variance–covariance matrix is $s^2\mathbf{T}(\mathbf{T}'\mathbf{X}'\mathbf{W}\mathbf{X}\mathbf{T})^{-1}\mathbf{T}'$.

This command supports the Huber/White/sandwich estimator of the variance and its clustered version using `vce(robust)` and `vce(cluster clustvar)`, respectively. See [P] [_robust](#), particularly [Introduction](#) and [Methods and formulas](#).

`cnsreg` also supports estimation with survey data. For details on VCEs with survey data, see [SVY] [Variance estimation](#).

References

- Christodoulou, D. 2020. [Stata tip 137: Interpreting constraints on slopes of rank-deficient design matrices](#). *Stata Journal* 20: 493–498.
- Davidson, R., and J. G. MacKinnon. 1993. *Estimation and Inference in Econometrics*. New York: Oxford University Press.
- Greene, W. H. 2018. *Econometric Analysis*. 8th ed. New York: Pearson.
- Hill, R. C., W. E. Griffiths, and G. C. Lim. 2018. *Principles of Econometrics*. 5th ed. Hoboken, NJ: Wiley.

Also see

- [R] [cnsreg postestimation](#) — Postestimation tools for cnsreg
- [R] [regress](#) — Linear regression
- [MI] [Estimation](#) — Estimation commands for use with mi estimate
- [SVY] [svy estimation](#) — Estimation commands for survey data
- [U] [20 Estimation and postestimation commands](#)

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