Title

Example 46g — Endogenous treatment-effects model

Description   Remarks and examples   References   Also see

Description

To illustrate the treatment-effects model, we use the following data:

```
. use https://www.stata-press.com/data/r17/gsem_union3
(NLSY 1972)

. describe

Contains data from https://www.stata-press.com/data/r17/gsem_union3.dta
 Observations:         1,693                  NLSY 1972
    Variables:            24                  29 Mar 2020 11:30
                                              (_dta has notes)
-------------------------------------------------------------------------------
Variable      Storage   Display    Value
    name         type    format    label      Variable label
-------------------------------------------------------------------------------
idcode          int     %8.0g                 NLS ID
year            int     %8.0g                 Interview year
birth_yr        byte    %8.0g                 Birth year
age             byte    %8.0g                 Age in current year
race            byte    %8.0g      racelbl    Race
msp             byte    %8.0g                 1 if married, spouse present
nev_mar         byte    %8.0g                 1 if never married
grade           byte    %8.0g                 Current grade completed
collgrad        byte    %8.0g                 1 if college graduate
not_smsa        byte    %8.0g                 1 if not SMSA
c_city          byte    %8.0g                 1 if central city
south           byte    %8.0g                 1 if south
ind_code        byte    %8.0g                 Industry of employment
occ_code        byte    %8.0g                 Occupation
union           byte    %8.0g                 1 if union
wks_ue          byte    %8.0g                 Weeks unemployed last year
ttl_exp         float   %9.0g                 Total work experience
tenure          float   %9.0g                 Job tenure, in years
hours           byte    %8.0g                 Usual hours worked
wks_work        byte    %8.0g                 Weeks worked last year
ln_wage         float   %9.0g                 ln(wage/GNP deflator)
wage            double  %10.0g                Real wage
black           byte    %9.0g                 Race black
smsa            byte    %8.0g                 1 if SMSA
-------------------------------------------------------------------------------
Sorted by: idcode

. notes

_dta:
  1.  Data from National Longitudinal Survey of Young Women 14-27 years of age
      (NLSY) in 1968, Center for Human Resource Research, Ohio State
      University, first released in 1989.
  2.  These data from 1972 were subsetted for purposes of demonstration.
```

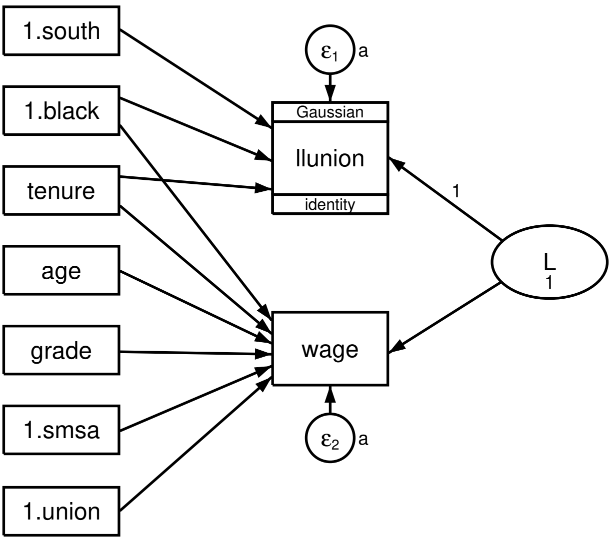
See *Structural models 8: Dependencies between response variables* and *Structural models 9: Unobserved inputs, outputs, or both* in [SEM] **Intro 5** for background.

Remarks and examples

Remarks are presented under the following headings:

Fitting the treatment-effects model

We wish to fit the following model:



We wish to estimate the "treatment effect" of being a union member. That is, we speculate that union membership has an effect on wages, and we want to measure that effect. The problem would be easy if we had data on the same workers from two different but nearly identical universes, one in which the workers were not union members and another in which they were.

The model above is similar to the Heckman selection model we fit in [SEM] **Example 45g**. The differences are that the continuous variable (`wage`) is observed in all cases and that we have a path from the treatment indicator (previously selection, now treatment) to the continuous variable. Just as with the Heckman selection model, we allow for correlation by introducing a latent variable with model identification constraints.

Before we can fit this model, we need to create new variables `llunion` and `ulunion`. `llunion` will equal 0 if `union` is 1 and missing otherwise. `ulunion` is the complement of `llunion`: it equals 0 if `union` is 0 and missing otherwise. `llunion` and `ulunion` will be used as the dependent variables in the treatment equation, providing the equivalent of a scaled probit regression.

```
. generate llunion = 0 if union == 1
(1,433 missing values generated)

. generate ulunion = 0 if union == 0
(709 missing values generated)
```

We can now fit this model with command syntax by typing

```
. gsem (wage <- age grade i.smsa i.black tenure 1.union L)
>      (llunion <- i.black tenure i.south L@1,
>       family(gaussian, udepvar(ulunion))),
>      var(L@1 e.wage@a e.llunion@a)
Fitting fixed-effects model:
Iteration 0:   log likelihood = -3376.1731
Iteration 1:   log likelihood = -3096.7893
Iteration 2:   log likelihood = -3061.7875
Iteration 3:   log likelihood = -3061.4973
Iteration 4:   log likelihood =  -3061.497
Iteration 5:   log likelihood =  -3061.497
Refining starting values:
Grid node 0:   log likelihood = -3064.9724
Fitting full model:
Iteration 0:   log likelihood = -3064.9427
Iteration 1:   log likelihood = -3060.3304
Iteration 2:   log likelihood = -3055.0099
Iteration 3:   log likelihood = -3096.6772
Iteration 4:   log likelihood = -3062.6735
Iteration 5:   log likelihood = -3054.2853
Iteration 6:   log likelihood =  -3051.673
Iteration 7:   log likelihood = -3051.5758
Iteration 8:   log likelihood =  -3051.575
Iteration 9:   log likelihood =  -3051.575
Generalized structural equation model                Number of obs     = 1,210
Response:        wage
Family:          Gaussian
Link:            Identity
                                                     Censoring of obs:
Lower response: llunion                                     Uncensored =     0
Upper response: ulunion                                  Left-censored =   957
Family:          Gaussian                               Right-censored =   253
Link:            Identity                               Interval-cens. =     0
Log likelihood = -3051.575
 ( 1)  [llunion]L = 1
 ( 2)  - [/]var(e.wage) + [/]var(e.llunion) = 0
 ( 3)  [/]var(L) = 1
```

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
wage						
age	.1487409	.0193291	7.70	0.000	.1108566	.1866252
grade	.4205658	.0293577	14.33	0.000	.3630258	.4781057
1.smsa	.9117044	.1249041	7.30	0.000	.6668969	1.156512
1.black	-.7882472	.1367077	-5.77	0.000	-1.056189	-.520305
tenure	.1524015	.0369595	4.12	0.000	.0799621	.2248408
1.union	2.945816	.2749549	10.71	0.000	2.406914	3.484718
L	-1.706795	.1288024	-13.25	0.000	-1.959243	-1.454347
_cons	-4.351572	.5283952	-8.24	0.000	-5.387207	-3.315936
llunion						
1.black	.6704049	.148057	4.53	0.000	.3802185	.9605913
tenure	.1282024	.0357986	3.58	0.000	.0580384	.1983664
1.south	-.8542673	.136439	-6.26	0.000	-1.121683	-.5868518
L	1	(constrained)				
_cons	-1.302676	.1407538	-9.25	0.000	-1.578548	-1.026804

```
     var(L)           1  (constrained)

 var(e.wage)   1.163821   .2433321                     .7725324    1.753298
var(e.llun~n)  1.163821   .2433321                     .7725324    1.753298
```

Notes:

1. The treatment effect is measured by the coefficient on the path *treatment_variable*-> *continuous_variable* or, in our case, `1.union->wage`. It is estimated to be 2.9458, which is practically large and statistically significant.

2. The interpretation formulas are the same as for the Heckman selection model in [SEM] **Example 45g**, namely,

$$\boldsymbol{\beta} = \boldsymbol{\beta}^*$$
$$\gamma = \gamma^* / \sqrt{\sigma^{2*} + 1}$$
$$\sigma^2 = \sigma^{2*} + \kappa^2$$
$$\rho = \kappa / \sqrt{(\sigma^{2*} + \kappa^2)(\sigma^{2*} + 1)}$$

   To remind you, $\boldsymbol{\beta}$ are the coefficients in the continuous-outcome equation, γ are the coefficients in the treatment equation, σ^2 is the variance of the error in the continuous-outcome equation, and ρ is the correlation between the errors in the treatment and continuous-outcome equations.

3. In the output above, σ^{2*} (`var(e.wage)`) is 1.1638 and κ (the path coefficient on `wage<-L`) is -1.7068. In [SEM] **Example 45g**, we calculated ρ by hand and then showed how to use the software to obtain the value and its standard error. This time, we will go right to the software.

   After obtaining symbolic names by typing `gsem, coeflegend`, we type the following to obtain ρ:

```
. nlcom (rho: _b[wage:L]/(sqrt(_b[/var(e.wage)] + 1)*sqrt(_b[/var(e.wage)] +
> _b[wage:L]^2)))
         rho: _b[wage:L]/(sqrt(_b[/var(e.wage)] + 1)*sqrt(_b[/var(e.wage)] + _
> b[wage:L]^2))
```

	Coefficient	Std. err.	z	P>|z|	[95% conf. interval]	
rho	-.574648	.060969	-9.43	0.000	-.6941451	-.4551509

4. We can obtain the untransformed treatment coefficients just as we did in [SEM] **Example 45g**.

5. Just as with the Heckman selection model, with `gsem`, the treatment-effects model can be applied to generalized outcomes and include multilevel effects. See Skrondal and Rabe-Hesketh (2004, chap. 14.5) for an example with a Poisson response function.

Fitting the model with the Builder

Use the diagram in *Fitting the treatment-effects model* above for reference.

1. Open the dataset.

   In the Command window, type

```
. use https://www.stata-press.com/data/r17/gsem_union3
. generate llunion = 0 if union == 1
. generate ulunion = 0 if union == 0
```

2. Open a new Builder diagram.

   Select menu item **Statistics > SEM (structural equation modeling) > Model building and estimation**.

3. Put the Builder in gsem mode by clicking on the button.

4. Create the independent variables.

   Select the Add observed variables set tool, , and then click in the diagram about one-fourth of the way in from the left and one-fourth of the way up from the bottom.

   In the resulting dialog box,

   a. select the *Select variables* radio button (it may already be selected);

   b. type `1.south`, `1.black`, `tenure`, `age`, `grade`, `1.smsa`, and `1.union` in the *Variables* control (typing `1.`*varname* rather than using the button to create `i.`*varname* prevents the rectangle corresponding to the base category for these binary variables from being created);

   c. select `Vertical` in the *Orientation* control; and

   d. click on **OK**.

   If you wish, move the set of variables by clicking on any variable and dragging it.

5. Create the generalized response for `llunion`.

   a. Select the Add generalized response variable tool, .

   b. Click about one-third of the way in from the right side of the diagram, to the right of the `1.black` rectangle.

   c. In the Contextual Toolbar, select `Gaussian, Identity` in the *Family/Link* control (it may already be selected).

   d. In the Contextual Toolbar, select `llunion` in the *Variable* control.

   e. In the Contextual Toolbar, click on the **Properties...** button.

   f. In the resulting *Variable properties* dialog box, click on the **Censoring...** button in the **Variable** tab.

   g. In the resulting *Censoring* dialog box, select the *Interval-measured, depvar is lower boundary* radio button. In the resulting *Interval-measured* box below, use the *Upper bound* control to select the variable `ulunion`.

   h. Click on **OK** in the *Censoring* dialog box, and then click on **OK** in the *Variable properties* dialog box. The Details pane will now show `llunion` as the lower bound and `ulunion` as the upper bound for our interval measure.

6. Create the endogenous `wage` variable.

   a. Select the Add observed variable tool, , and then click about one-third of the way in from the right side of the diagram, to the right of the `grade` rectangle.

   b. In the Contextual Toolbar, select `wage` with the *Variable* control.

7. Create paths from the independent variables to the dependent variables.

   a. Select the Add path tool, →.

   b. Click in the right side of the `1.south` rectangle (it will highlight when you hover over it), and drag a path to the left side of the `llunion` rectangle (it will highlight when you can release to connect the path).

c. Continuing with the → tool, create the following paths by clicking first in the right side of the rectangle for the independent variable and dragging it to the left side of the rectangle for the dependent variable:

```
1.black -> llunion
tenure -> llunion
1.black -> wage
tenure -> wage
age -> wage
grade -> wage
1.smsa -> wage
1.union -> wage
```

8. Clean up the direction of the error terms.

   We want the error for `llunion` to be above the rectangle and the error for `wage` to be below the rectangle, but it is likely they have been created in other directions.

   a. Choose the Select tool, ↖.
   b. Click in the `llunion` rectangle.
   c. Click on one of the **Error rotation** buttons, ↶ ↷, in the Contextual Toolbar until the error is above the rectangle.
   d. Click in the `wage` rectangle.
   e. Click on one of the **Error rotation** buttons, ↶ ↷, in the Contextual Toolbar until the error is below the rectangle.

9. Create the latent variable.

   a. Select the Add latent variable tool, ◯, and then click at the far right of the diagram and vertically centered between the `llunion` and `wage` variables.
   b. In the Contextual Toolbar, type `L` in the *Name* control and press *Enter*.

10. Draw paths from the latent variable to each endogenous variable.

    a. Select the Add path tool, →.
    b. Click in the upper-left quadrant of the `L` oval, and drag a path to the right side of the `llunion` rectangle.
    c. Continuing with the → tool, create another path by clicking first in the lower-left quadrant of the `L` oval and dragging a path to the right side of the `wage` rectangle.

11. Place constraints on the variances and on the path from `L` to `llunion`.

    a. Choose the Select tool, ↖.
    b. Click on the `L` oval. In the Contextual Toolbar, type `1` in the σ^2 box and press *Enter*.
    c. Click on the error oval attached to the `wage` rectangle. In the Contextual Toolbar, type `a` in the σ^2 box and press *Enter*.
    d. Click on the error oval attached to the `llunion` rectangle. In the Contextual Toolbar, type `a` in the σ^2 box and press *Enter*.
    e. Click on the path from `L` to `llunion`. In the Contextual Toolbar, type `1` in the β box and press *Enter*.

12. Clean up the location of the paths.

    If you do not like where a path has been connected to its variables, use the Select tool, , to click on the path, and then simply click on where it connects to a variable and drag the endpoint.

13. Estimate.

    Click on the **Estimate** button, , in the Standard Toolbar, and then click on **OK** in the resulting *GSEM estimation options* dialog box.

You can open a completed diagram in the Builder by typing

```
. webgetsem gsem_treat
```

References

Center for Human Resource Research. 1989. *National Longitudinal Survey of Labor Market Experience, Young Women 14–24 years of age in 1968*. Columbus, OH: Ohio State University Press.

Drukker, D. M. 2016. A generalized regression-adjustment estimator for average treatment effects from panel data. *Stata Journal* 16: 826–836.

Skrondal, A., and S. Rabe-Hesketh. 2004. *Generalized Latent Variable Modeling: Multilevel, Longitudinal, and Structural Equation Models*. Boca Raton, FL: Chapman & Hall/CRC.

Also see

[SEM] **Example 34g** — Combined models (generalized responses)

[SEM] **Example 45g** — Heckman selection model

[SEM] **Intro 5** — Tour of models

[SEM] **gsem** — Generalized structural equation model estimation command