Example 47g — Exponential survival model

Description

In this example, we demonstrate how to fit parametric survival models with `gsem`. Specifically, in this example, we fit an exponential model, but much of the discussion applies to Weibull, gamma, loglogistic, and lognormal models as well.

```
. use https://www.stata-press.com/data/r18/gsem_kva
(Generator experiment)

. describe

Contains data from https://www.stata-press.com/data/r18/gsem_kva.dta
 Observations:            12                  Generator experiment
    Variables:             3                  23 Jan 2023 21:41
                                              (_dta has notes)
```

Variable name	Storage type	Display format	Value label	Variable label
failtime	int	%9.0g		Time until failure (hrs.)
load	byte	%9.0g		Overload (kVA)
bearings	byte	%9.0g		Has new bearings

```
Sorted by:

. notes

_dta:
  1. Artificial experimental data on two types of bearings in emergency
     generators.
  2. The purpose is to compare the ability to withstand overloads of new-style
     bearings to old-style bearings.
  3. All generators are run until failure.
  4. Experiments were performed under overloads of 20, 25, 30, 35, and 40 kVA.
```

See *Structural models 7: Survival models* in [SEM] **Intro 5** for background.

Remarks and examples

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Remarks are presented under the following headings:

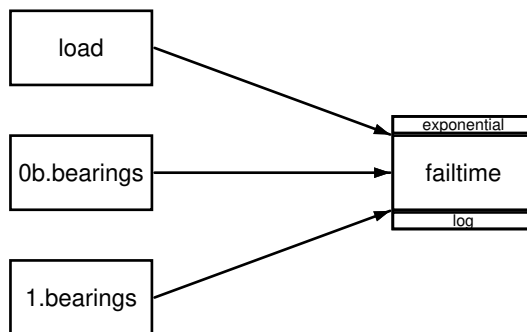> *Fitting the exponential model*
> *Obtaining hazard ratios*
> *Fitting the model with the Builder*

Fitting the exponential model

We wish to fit the following model:

That is, we wish to fit an exponential model in which the failure time of bearings (failtime) depends on the amount of overload (load) and whether the bearings are the new style (bearings = 1) or the old style (bearings = 0).

To fit this model, we use the gsem command with the exponential option.

```
. gsem (failtime <- load i.bearings), exponential

Iteration 0:  Log likelihood =  -84108.99
Iteration 1:  Log likelihood = -67.363768
Iteration 2:  Log likelihood = -66.855013
Iteration 3:  Log likelihood = -62.300033
Iteration 4:  Log likelihood = -62.227842
Iteration 5:  Log likelihood = -62.227568
Iteration 6:  Log likelihood = -62.227568

Generalized structural equation model          Number of obs    =      12
Response: failtime                              No. of failures =      12
Family:    Exponential                          Time at risk     = 896.00
Form:      Proportional hazards
Link:      Log
Log likelihood = -62.227568
```

	Coefficient	Std. err.	z	P>|z|	[95% conf. interval]	
failtime						
load	.0611166	.0354318	1.72	0.085	−.0083284	.1305616
1.bearings	−.2194825	.5773503	−0.38	0.704	−1.351068	.9121033
_cons	−5.756595	1.056403	−5.45	0.000	−7.827106	−3.686084

Notes:

1. By default, exponential models are fit in the proportional-hazards metric. The exponential option can be replaced with family(exponential, aft) if you want to fit the model in the accelerated failure-time metric.

2. gsem reports coefficients. These coefficients match those reported by the equivalent streg command,

   ```
   . stset failtime
   . streg load bearings, distribution(exponential) nohr
   ```

3. Without the nohr option, streg reports hazard ratios, which are the exponentiated coefficients.

Obtaining hazard ratios

The `estat eform` command reports exponentiated coefficients for models fit with `gsem`, so we can obtain hazard ratios as follows.

```
. estat eform
```

	exp(b)	Std. err.	z	P>|z|	[95% conf. interval]	
failtime						
load	1.063023	.0376648	1.72	0.085	.9917062	1.139468
1.bearings	.8029342	.4635743	−0.38	0.704	.2589635	2.489553
_cons	.0031619	.0033402	−5.45	0.000	.0003988	.02507

The hazard ratio of 0.80 for `bearings = 1` indicates that the predicted hazard of failure for the new style of bearing is 80% of the hazard for a bearing of the old type, provided that they have the same loading.

Fitting the model with the Builder

Use the diagram in *Fitting the exponential model* above for reference.

1. Open the dataset.

    In the Command window, type

    ```
    . use https://www.stata-press.com/data/r18/gsem_kva
    ```

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 ^G_{SEM} button.

4. Create the exponential regression component for `failtime`.

    Select the Add regression component tool, ▷•, and then click in the diagram about one-third of the way in from the left and halfway down.

    In the resulting dialog box,

    a. select `failtime` in the *Dependent variable* control;

    b. check *Make response generalized*;

    c. select `Exponential, Log` in the *Family/Link* control;

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

    e. use the *Independent variables* control to select the variable `load`;

    f. include the levels of the factor variable `bearings` by clicking on the `...` button next to the *Independent variables* control. In the resulting dialog box, select the *Factor variable* radio button, select `Main effect` in the *Specification* control, and select `bearings` in the *Variables* control for *Variable 1*. Click on **Add to varlist**, and then click on **OK**;

    g. select `Left` in the *Independent variables' direction* control;

    h. click on **OK**.

    If you wish, move the component by clicking on any variable and dragging it.

5. Clean up.

   The box for `failtime` is created closer to the independent variables than it is in the example diagram. Use the Select tool, ![arrow], and click on the box for `failtime`. Drag it to the right to allow more space for results along the paths.

6. Estimate.

   Click on the **Estimate** button, ![icon], 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_exp
```

Also see

[SEM] **Example 48g** — Loglogistic survival model with censored and truncated data

[SEM] **Example 49g** — Multiple-group Weibull survival model

[SEM] **Intro 5** — Tour of models

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

[SEM] **estat eform** — Display exponentiated coefficients