Description

In this example, we demonstrate how to fit parametric survival models with \texttt{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.

\begin{verbatim}
. use https://www.stata-press.com/data/r17/gsem_kva
(Generator experiment)
. describe
Contains data from https://www.stata-press.com/data/r17/gsem_kva.dta
   Observations: 12   Generator experiment
   Variables: 3   23 Jan 2021 21:41
(_dta has notes)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Storage type</th>
<th>Display format</th>
<th>Value label</th>
</tr>
</thead>
<tbody>
<tr>
<td>failtime</td>
<td>int</td>
<td>%9.0g</td>
<td>Time until failure (hrs.)</td>
</tr>
<tr>
<td>load</td>
<td>byte</td>
<td>%9.0g</td>
<td>Overload (kVA)</td>
</tr>
<tr>
<td>bearings</td>
<td>byte</td>
<td>%9.0g</td>
<td>Has new bearings</td>
</tr>
</tbody>
</table>

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 \textit{Structural models 7: Survival models} in \textbf{[SEM] Intro 5} for background.

Remarks and examples

Remarks are presented under the following headings:

\begin{itemize}
\item \textit{Fitting the exponential model}
\item \textit{Obtaining hazard ratios}
\item \textit{Fitting the model with the Builder}
\end{itemize}
Fitting the exponential model

We wish to fit the following model:

\[
\text{failtime} = \alpha + \beta \cdot \text{load} + \gamma \cdot \text{bearings} 
\]

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 \texttt{gsem} command with the \texttt{exponential} option.

\[
\text{. gsem (failtime <- load i.bearings), exponential}
\]

\[
\begin{array}{l}
\text{Iteration 0: log likelihood = -84108.99} \\
\text{Iteration 1: log likelihood = -67.363768} \\
\text{Iteration 2: log likelihood = -66.855013} \\
\text{Iteration 3: log likelihood = -62.300033} \\
\text{Iteration 4: log likelihood = -62.227842} \\
\text{Iteration 5: log likelihood = -62.227568} \\
\text{Iteration 6: log likelihood = -62.227568} \\
\end{array}
\]

Generalized structural equation model

<table>
<thead>
<tr>
<th>Response: failtime</th>
<th>Number of obs = 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family: Exponential</td>
<td>Time at risk = 896.00</td>
</tr>
<tr>
<td>Form: Proportional hazards</td>
<td></td>
</tr>
<tr>
<td>Link: Log</td>
<td></td>
</tr>
</tbody>
</table>

Log likelihood = -62.227568

| Coefficient | Std. err. | z | P>|z| | [95% conf. interval] |
|-------------|-----------|---|-----|---------------------|
| failtime    |           |   |     |                     |
| load        | 0.0611166 | 0.0354318 | 1.72 | 0.085 | -0.0083284 | 0.1305616 |
| 1.bearings  | -0.2194825 | 0.5773503 | -0.38 | 0.704 | -1.351068 | 0.9121033 |
| _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 \texttt{exponential} option can be replaced with \texttt{family(exponential, aft)} if you want to fit the model in the accelerated failure-time metric.

2. \texttt{gsem} reports coefficients. These coefficients match those reported by the equivalent \texttt{streg} command,

\[
\text{. stset failtime} \\
\text{. streg load bearings, distribution(exponential) nohr}
\]

3. Without the \texttt{nohr} option, \texttt{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 0.2507   |
```

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/r17/gsem_kva
   ```

2. Open a new Builder diagram.

3. Put the Builder in `gsem` mode by clicking on the $\subset$ button.

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

   Select the Add regression component tool, $\subset$, 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 $\subset$ 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.
Example 47g — Exponential survival model

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, ⬇️, and click on the box for failtime. Drag it to the right to allow more space for results along the paths.

   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
   
   . wgetsem 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