**stsplit — Split and join time-span records**

### Description

`stsplit` with the `at()` or `every(#)` option splits episodes into two or more episodes at the implied time points since being at risk or after a time point specified by `after()`. Each resulting record contains the follow-up on one subject through one time band. Expansion on multiple time scales may be obtained by repeatedly using `stsplit`. `newvar` specifies the name of the variable to be created containing the observation’s category. The new variable records the interval to which each new observation belongs and is bottom coded.

`stsplit, at(failures)` performs episode splitting at the failure times (per stratum).

`stjoin` performs the reverse operation, namely, joining episodes back together when such can be done without losing information.

### Quick start

Split episodes in `stset` data at analysis times 5, 10, and 15, and create new time category identifier `timecat`

```
  split timecat, at(5 10 15)
```

Split episodes at the value in `startvar`

```
  split timecat, at(0) after(time=startvar)
```

Split data at 30, 40, and 50 time units after the value in `startvar`

```
  split timecat, at(30 40 50) after(time=startvar)
```

Split data every 10 time units after `startvar`

```
  split timecat, every(10) after(time=startvar)
```

Split data at failure times

```
  split, at(failures)
```

As above, and create risk-set identifier variable `riskvar`

```
  split, at(failures) riskset(riskvar)
```

### Menu

**stsplit**

Statistics > Survival analysis > Setup and utilities > Split time-span records

**stjoin**

Statistics > Survival analysis > Setup and utilities > Join time-span records
Syntax

Split at designated times

\[ \text{stsplit newvar [if], \{at(numlist) | every(#)\} [stsplitDT_options]} \]

Split at failure times

\[ \text{stsplit [if], at(failures) [stsplitFT_options]} \]

Join episodes

\[ \text{stjoin [ , censored(numlist)]} \]

\[ \text{stsplitDT_options} \quad \text{Description} \]

<table>
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<tr>
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<td>*at(numlist)</td>
<td>split records at specified analysis times</td>
</tr>
<tr>
<td>*every(#)</td>
<td>split records when analysis time is a multiple of #</td>
</tr>
<tr>
<td>after(spec)</td>
<td>use time since spec for at() or every() rather than time since onset of risk; see Options</td>
</tr>
<tr>
<td>trim</td>
<td>exclude observations outside of range</td>
</tr>
<tr>
<td>nopreserve</td>
<td>do not save original data; programmer’s option</td>
</tr>
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*Either at(numlist) or every(#) is required with stsplit at designated times.

\[ \text{stsplitFT_options} \quad \text{Description} \]

<table>
<thead>
<tr>
<th>Main</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>*at(failures)</td>
<td>split at observed failure times</td>
</tr>
<tr>
<td>strata(varlist)</td>
<td>restrict splitting to failures within stratum defined by varlist</td>
</tr>
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</tr>
<tr>
<td>nopreserve</td>
<td>do not save original data; programmer’s option</td>
</tr>
</tbody>
</table>

*at(failures) is required with stsplit at failure times.

You must stset your dataset by using the id() option before using stsplit or stjoin; see [ST] stset. nopreserve does not appear in the dialog box.

Options for stsplit

\[ \text{at(numlist) or every(#)} \] is required in syntax one; \at(failures) is required for syntax two. These options specify the analysis times at which the records are to be split.

\at(5(5)20) splits records at \( t = 5, t = 10, t = 15, \) and \( t = 20. \)
If \( \text{at}([\ldots] \max) \) is specified, \( \max \) is replaced by a suitably large value. For instance, to split records every five analysis-time units from time zero to the largest follow-up time in our data, we could find out what the largest time value is by typing \text{summarize} \_t and then explicitly typing it into the \text{at}() option, or we could just specify \text{at}(0(5)\max).

\text{every}(#) is a shorthand for \text{at}(#(\#)\max); that is, episodes are split at each positive multiple of #.

\text{after}(\text{spec}) specifies the reference time for \text{at}() or \text{every}(). Syntax one can be thought of as corresponding to \text{after}(\text{time of onset of risk}), although you cannot really type this. You could type, however, \text{after}(\text{time=birthdate}) or \text{after}(\text{time=marrydate}) or \text{after}(\text{marrydate}).

\text{spec} has syntax
\[
\{\text{time}|\_t\} = \{\text{exp}|\min(\text{exp})|\asis(\text{exp})\}
\]

where
\text{time} specifies that the expression be evaluated in the same time units as \text{timevar} in \text{stset timevar}, .... This is the default.
\_t and \_\_t specify that the expression be evaluated in units of analysis time. \_t and \_\_t are synonyms; it makes no difference whether you specify one or the other.

\text{exp} specifies the reference time. For multiepisode data, \text{exp} should be constant within subject ID.

\text{min}(\text{exp}) specifies that for multiepisode data, the minimum of \text{exp} be taken within ID.

\text{asis}(\text{exp}) specifies that for multiepisode data, \text{exp} be allowed to vary within ID.

\text{trim} specifies that observations with values less than the minimum or greater than the maximum value listed in \text{at()} be excluded from subsequent analysis. Such observations are not dropped from the data; \text{trim} merely sets their value of variable \_st to 0 so that they will not be used, yet they can still be retrieved the next time the dataset is \text{stset}.

\text{strata(varlist)} specifies up to five strata variables. Observations with equal values of the variables are assumed to be in the same stratum. \text{strata()} restricts episode splitting to failures that occur within the stratum, and memory requirements are reduced when strata are specified.

\text{riskset(newvar)} specifies the name for a new variable recording the unique risk set in which an episode occurs, and missing otherwise.

The following option is available with \text{stsplit} but is not shown in the dialog box:

\text{nopreserve} is intended for use by programmers. It speeds the transformation by not saving the original data, which can be restored should things go wrong or if you press \text{Break}. Programmers often specify this option when they have already preserved the original data. \text{nopreserve} does not affect the transformation.

**Option for \text{stjoin}**

\text{censored(numlist)} specifies values of the failure variable, \text{failvar}, from \text{stset} \ldots, \text{failure} (\text{failvar=} \ldots) that indicate “no event” (censoring).

If you are using \text{stjoin} to rejoin records after \text{stsplit}, you do not need to specify \text{censored}(). Just do not forget to drop the variable created by \text{stsplit} before typing \text{stjoin}. See example 4 below.

Neither do you need to specify \text{censored}() if, when you \text{stset} your dataset, you specified \text{failure} (\text{failvar}) and not \text{failure} (\text{failvar=} \ldots). Then \text{stjoin} knows that \text{failvar} = 0 and \text{failvar} = . (missing) correspond to no event. Two records can be joined if they are contiguous
and record the same data and the first record has \( \text{failvar} = 0 \) or \( \text{failvar} = . \), meaning no event at that time.

You may need to specify `censored()`, and you probably do if, when you `stset` the dataset, you specified `failure(failvar=...)`. If `stjoin` is to join records, it needs to know what events do not count and can be discarded. If the only such event is \( \text{failvar} = . \), you do not need to specify `censored()`.

### Remarks and examples

Remarks are presented under the following headings:

- What \textit{stsplit} does and why
- Using \textit{stsplit} to split at designated times
- Time versus analysis time
- Splitting data on recorded ages
- Using \textit{stsplit} to split at failure times

### What \textit{stsplit} does and why

`stsplit` splits records into two or more records on the basis of analysis time or on a variable that depends on analysis time, such as age. `stsplit` takes data like

```
    id  _t0  _t  x1  x2  _d
    1   0   18  12  11  1
```

and produces

```
    id  _t0  _t  x1  x2  _d  tcat
    1   0   5   12  11  0   0
    1   5   10  12  11  0   5
    1  10  18  12  11  1   10
```

or

```
    id  _t0  _t  x1  x2  _d  agecat
    1   0   7   12  11  0   30
    1   7  17  12  11  0   40
    1  17  18  12  11  1   50
```

The above alternatives record the same underlying data: subject 1 had \( x1 = 12 \) and \( x2 = 11 \) during \( 0 < t \leq 18 \), and at \( t = 18 \), the subject failed.

The difference between the two alternatives is that the first breaks out the analysis times 0–5, 5–10, and 10–20 (although subject 1 failed before \( t = 20 \)). The second breaks out age 30–40, 40–50, and 50–60. You cannot tell from what is presented above, but at \( t = 0 \), subject 1 was 33 years old.

In our example, that the subject started with one record is not important. The original data on the subject might have been

```
    id  _t0  _t  x1  x2  _d
    1   0   14  12  11  0
    1   14  18  12  9   1
```

and then we would have obtained

```
    id  _t0  _t  x1  x2  _d  tcat
    1   0   5   12  11  0   0
    1   5   10  12  11  0   5
    1  10  14  12  11  0  10
    1  14  18  12   9  1  10
```
or

<table>
<thead>
<tr>
<th>id</th>
<th>_t0</th>
<th>_t</th>
<th>x1</th>
<th>x2</th>
<th>_d</th>
<th>agecat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>7</td>
<td>12</td>
<td>11</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>14</td>
<td>12</td>
<td>11</td>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>1</td>
<td>14</td>
<td>17</td>
<td>12</td>
<td>9</td>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>1</td>
<td>17</td>
<td>18</td>
<td>12</td>
<td>9</td>
<td>1</td>
<td>50</td>
</tr>
</tbody>
</table>

Also we could just as easily have produced records with analysis time or age recorded in single-year categories. That is, we could start with

<table>
<thead>
<tr>
<th>id</th>
<th>_t0</th>
<th>_t</th>
<th>x1</th>
<th>x2</th>
<th>_d</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>14</td>
<td>12</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>14</td>
<td>18</td>
<td>12</td>
<td>9</td>
<td>1</td>
</tr>
</tbody>
</table>

and produce

<table>
<thead>
<tr>
<th>id</th>
<th>_t0</th>
<th>_t</th>
<th>x1</th>
<th>x2</th>
<th>_d</th>
<th>tcat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>12</td>
<td>11</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td>12</td>
<td>11</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>12</td>
<td>11</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

or

<table>
<thead>
<tr>
<th>id</th>
<th>_t0</th>
<th>_t</th>
<th>x1</th>
<th>x2</th>
<th>_d</th>
<th>agecat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>12</td>
<td>11</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td>12</td>
<td>11</td>
<td>0</td>
<td>31</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>12</td>
<td>11</td>
<td>0</td>
<td>32</td>
</tr>
</tbody>
</table>

Moreover, we can even do this splitting on more than one variable. Let’s go back and start with

<table>
<thead>
<tr>
<th>id</th>
<th>_t0</th>
<th>_t</th>
<th>x1</th>
<th>x2</th>
<th>_d</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>18</td>
<td>12</td>
<td>11</td>
<td>1</td>
</tr>
</tbody>
</table>

Let’s split it into the analysis-time intervals 0–5, 5–10, and 10–20, and let’s split it into 10-year age intervals 30–40, 40–50, and 50–60. The result would be

<table>
<thead>
<tr>
<th>id</th>
<th>_t0</th>
<th>_t</th>
<th>x1</th>
<th>x2</th>
<th>_d</th>
<th>tcat</th>
<th>agecat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>5</td>
<td>12</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>7</td>
<td>12</td>
<td>11</td>
<td>0</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>10</td>
<td>12</td>
<td>11</td>
<td>0</td>
<td>5</td>
<td>40</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>17</td>
<td>12</td>
<td>11</td>
<td>0</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>1</td>
<td>17</td>
<td>18</td>
<td>12</td>
<td>11</td>
<td>1</td>
<td>10</td>
<td>50</td>
</tr>
</tbody>
</table>

Why would we want to do any of this?

We might want to split on a time-dependent variable, such as age, if we want to estimate a Cox proportional hazards model and include current age among the regressors (although we could instead use `stcox`’s `tvc()` option) or if we want to make tables by age groups (see [ST] `strate`).

**Using stsplit to split at designated times**

`stsplit`’s syntax to split at designated times is, ignoring other options,

```
stsplit newvar [if], at(numlist)
stsplit newvar [if], at(numlist) after(spec)
```
at() specifies the analysis times at which records are to be split. Typing at(5 10 15) splits records at the indicated analysis times and separates records into the four intervals 0–5, 5–10, 10–15, and 15+.

In the first syntax, the splitting is done on analysis time, \( t \). In the second syntax, the splitting is done on 5, 10, and 15 analysis-time units after the time given by \texttt{after(spec)}.

In either case, \texttt{stsplit} also creates \texttt{newvar} containing the interval to which each observation belongs. Here \texttt{newvar} would contain 0, 5, 10, and 15; it would contain 0 if the observation occurred in the interval 0–5, 5 if the observation occurred in the interval 5–10, and so on. To be precise,

<table>
<thead>
<tr>
<th>Category</th>
<th>Precise meaning</th>
<th>newvar value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–5</td>
<td>((-\infty, 5])</td>
<td>0</td>
</tr>
<tr>
<td>5–10</td>
<td>([5, 10])</td>
<td>5</td>
</tr>
<tr>
<td>10–15</td>
<td>([10, 15])</td>
<td>10</td>
</tr>
<tr>
<td>15+</td>
<td>((15, \infty])</td>
<td>15</td>
</tr>
</tbody>
</table>

If any of the \texttt{at()} numbers are negative (which would be allowed only by specifying the \texttt{after()} option and would be unusual), the first category is labeled one less than the minimum value specified by \texttt{at()}.

Consider the data

\[
\begin{array}{ccccccc}
\text{id} & \text{yr0} & \text{yr1} & \text{yrborn} & \text{x1} & \text{event} \\
1 & 1990 & 1995 & 1960 & 5 & 52 \\
2 & 1993 & 1997 & 1964 & 3 & 47 \\
\end{array}
\]

In these data, subjects became at risk in \texttt{yr0}. The failure event of interest is \texttt{event} = 47, so we \texttt{stset} our dataset by typing

\[
. \texttt{stset yr1, id(id) origin(time yr0) failure(event==47)}
\]

and that results in

\[
\begin{array}{cccccccc}
\text{id} & \_t0 & \_t & \text{yr0} & \text{yr1} & \text{yrborn} & \text{x1} & \text{event} & \_d \\
1 & 0 & 5 & 1990 & 1995 & 1960 & 5 & 52 & 0 \\
2 & 0 & 4 & 1993 & 1997 & 1964 & 3 & 47 & 1 \\
\end{array}
\]

In the jargon of \texttt{st}, variables \_t0 and \_t record the span of each record in analysis-time (\( t \)) units. Variables \texttt{yr0} and \texttt{yr1} also record the time span, but in time units. Variable \_d records 1 for failure and 0 otherwise.

Typing \texttt{stsplit cat, at(2 4 6 8)} would split the records on the basis of analysis time:

\[
. \texttt{stsplit cat, at(2 4 6 8)}
\]

\[
(3 \text{ observations (episodes) created})
\]

\[
. \texttt{order id \_t0 \_t yr0 yr1 yrborn x1 event \_d cat}
\]

\[
. \texttt{list id-cat}
\]

<table>
<thead>
<tr>
<th>id</th>
<th>_t0</th>
<th>_t</th>
<th>yr0</th>
<th>yr1</th>
<th>yrborn</th>
<th>x1</th>
<th>event</th>
<th>_d</th>
<th>cat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1990</td>
<td>1992</td>
<td>1960</td>
<td>5</td>
<td>.</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>1990</td>
<td>1994</td>
<td>1960</td>
<td>5</td>
<td>.</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>1990</td>
<td>1995</td>
<td>1960</td>
<td>5</td>
<td>52</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>1993</td>
<td>1995</td>
<td>1964</td>
<td>3</td>
<td>.</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>1993</td>
<td>1997</td>
<td>1964</td>
<td>3</td>
<td>47</td>
<td>1</td>
</tr>
</tbody>
</table>

The first record, which represented the analysis-time span \((0, 5]\), was split into three records: \((0, 2]\), \((2, 4]\), and \((4, 5]\). The \texttt{yrborn} and \texttt{x1} values from the single record were duplicated in \((0, 2]\), \((2, 4]\), and \((4, 5]\). The original \texttt{event} variable was changed to missing at \(t = 2\) and \(t = 4\) because we do not know the value of \texttt{event}; all we know is that \texttt{event} is 52 at \(t = 5\). The \texttt{_d} variable was correspondingly set to 0 for \(t = 2\) and \(t = 4\) because we do know, at least, that the subject did not fail.

\texttt{stsplit} also keeps your original time variables up to date in case you want to \texttt{streset} or \texttt{re-stset} your dataset. \texttt{yr1} was updated, too.

Now let’s go back to our original dataset after we \texttt{stset} it but before we split it.

\begin{verbatim}
 id  _t0  _t  yr0  yr1  yrborn  x1  event  _d
 1  0   5  1990 1995  1960   5  52    0
 2  0   4  1993 1997  1964   3  47    1
\end{verbatim}

and consider splitting on age. In 1990, subject 1 is age \(1990 - \texttt{yrborn} = 1990 - 1960 = 30\), and subject 2 is 29. If we type

\begin{verbatim}
 . stsplit acat, at(30 32 34) after(time=yrborn)
\end{verbatim}

we will split the data according to

\begin{verbatim}
   age <= 30  (called acat=0)  
  30 < age <= 32  (called acat=30)  
  32 < age <= 34  (called acat=32)  
      34 < age  (called acat=34)
\end{verbatim}

The result will be

\begin{verbatim}
 id  _t0  _t  yr0  yr1  yrborn  x1  event  _d  acat
 1  0   2  1990 1992  1960   5   .    0   30
 1  2   4  1990 1994  1960   5   .    0   32
 1  4   5  1990 1995  1960   5  52    0   34
 2  0   1  1993 1994  1964   3   .    0   0
 2  1   3  1993 1996  1964   3   .    0   30
 2  3   4  1993 1997  1964   3  47    1   32
\end{verbatim}

The original record on subject 1 corresponding to \((0, 5]\) was split into \((0, 2]\), \((2, 4]\), and \((4, 5]\) because those are the \(t\) values at which age becomes 32 and 34.

You can \texttt{stsplit} the data more than once. Now having these data, if we typed

\begin{verbatim}
 . stsplit cat, at(2 4 6 8)
\end{verbatim}

the result would be

\begin{verbatim}
 id  _t0  _t  yr0  yr1  yrborn  x1  event  _d  acat  cat
 1  0   2  1990 1992  1960   5   .    0   30   0
 1  2   4  1990 1994  1960   5   .    0   32   2
 1  4   5  1990 1995  1960   5  52    0   34   4
 2  0   1  1993 1994  1964   3   .    0   0    0
 2  1   2  1993 1995  1964   3   .    0   30   0
 2  2   3  1993 1996  1964   3   .    0   30   2
 2  3   4  1993 1997  1964   3  47    1   32   2
\end{verbatim}

Whether we typed

\begin{verbatim}
 . stsplit acat, at(30 32 34) after(time=yrborn)
 . stsplit cat, at(2 4 6 8)
\end{verbatim}
or

```
. stsplit cat, at(2 4 6 8)
. stsplit acat, at(30 32 34) after(time=yrborn)
```

would make no difference.

## Time versus analysis time

Be careful using the `after()` option if, when you `stset` your dataset, you specified `stset`s `scale()` option. We say be careful, but actually we mean be appreciative, because `stsplit` will do just what you would expect if you did not think too hard.

When you split a record on a time-dependent variable, `at()` is still specified in analysis-time units, meaning units of time/scale().

For instance, if your original data recorded time as Stata dates, that is, number of days since 1960,

```
14apr1993 27mar1995 12jul1959
```

and you previously `stset` your dataset by typing

```
. stset date1, id(id) origin(time date0) scale(365.25)
```

and you now wanted to split on the age implied by `birthdate`, you would specify the split points in years since birth:

```
. stsplit agecat, at(20(5)60) after(time=birth)
```

`at(20(5)60)` means to split the records at the ages, measured in years, of 20, 25, ..., 60.

When you `stset` your dataset, you basically told `st` how you recorded times (you recorded them as dates) and how to map such times (dates) into analysis time. That was implied by what you typed, and all of `st` remembers that. Typing

```
. stsplit agecat, at(20(5)60) after(time=birth)
```

tells `stsplit` to split the data on 20, 25, ..., 60 analysis-time units after `birthdate` for each subject.

## Splitting data on recorded ages

Recorded ages can sometimes be tricky. Consider the data

```
id yr0 yr1 age x1 event
1 1980 1996 30 5 52
```

When was `age = 30` recorded—1980 or 1996? Put aside that question because things are about to get worse. Say that you `stset` this dataset so that `yr0` is the `origin()`,

```
id _t0 _t yr0 yr1 age x1 event
1 0 16 1980 1996 30 5 52
```

...
and then split on analysis time by typing \texttt{sts\_split \_cat, at(5(5)20)}. The result would be

<table>
<thead>
<tr>
<th>id</th>
<th>_t0</th>
<th>_t</th>
<th>yr0</th>
<th>yr1</th>
<th>age</th>
<th>x1</th>
<th>event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>5</td>
<td>1980</td>
<td>1985</td>
<td>30</td>
<td>5</td>
<td>.</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>10</td>
<td>1980</td>
<td>1990</td>
<td>30</td>
<td>5</td>
<td>.</td>
</tr>
<tr>
<td>1</td>
<td>15</td>
<td>16</td>
<td>1980</td>
<td>1996</td>
<td>30</td>
<td>5</td>
<td>52</td>
</tr>
</tbody>
</table>

Regardless of the answer to the question on when age was measured, \texttt{age} is most certainly not 30 in the newly created records, although you might argue that age at baseline was 30 and that is what you wanted, anyway.

The only truly safe way to deal with ages is to convert them back to birthdates at the outset. Here we would, early on, type

\begin{verbatim}
. generate bdate = yr1 - age  (if age was measured at yr1)

or

. generate bdate = yr0 - age  (if age was measured at yr0)
\end{verbatim}

In fact, \texttt{stsplit} tries to protect you from making age errors. Suppose that you did not do as we just recommended. Say that age was measured at \texttt{yr1}, and you typed, knowing that \texttt{stsplit} wants a date,

\begin{verbatim}
. stsplit acat, at(20(5)50) after(time= yr1-age)
\end{verbatim}

on these already \texttt{stsplit} data. \texttt{stsplit} will issue the error message “\texttt{after()} should be constant within \texttt{id}”. To use the earliest date, you need to type

\begin{verbatim}
. stsplit acat, at(20(5)50) after(time= min(yr1-age))
\end{verbatim}

Nevertheless, be aware that when you \texttt{stsplit} data, if you have recorded ages in your data, and if the records were not already split to control for the range of those ages, then age values, just like all the other variables, are carried forward and no longer reflect the age of the newly created record.

\begin{verbatim}
Example 1: Splitting on age
\end{verbatim}

Consider the data from a heart disease and diet survey. The data arose from a study described more fully in Morris, Marr, and Clayton (1977) and analyzed in Clayton and Hills (1993). (Their results differ slightly from ours because the dataset has been updated.)
. use http://www.stata-press.com/data/r15/diet  
(Diet data with dates)

. describe  
Contains data from http://www.stata-press.com/data/r15/diet.dta
obs: 337  
vars: 11  
size: 8,088

variable name   type   format   label
id   int    %9.0g   Subject identity number
fail  byte   %8.0g   Outcome (CHD = 1 3 13)
job   byte   %8.0g   Occupation
month byte   %8.0g   month of survey
energy float  %9.0g   Total energy (1000kcals/day)
height float  %9.0g   Height (cm)
weight float  %9.0g   Weight (kg)
hienergy byte  %9.0g   Indicator for high energy
doe   int    %td    Date of entry
dox   int    %td    Date of exit
dob   int    %td    Date of birth

Sorted by: id

In this dataset, the outcome variable, fail, has been coded as 0, 1, 3, 5, 12, 13, 14, and 15. Codes 1, 3, and 13 indicated coronary heart disease (CHD), other nonzero values code other events such as cancer, and 0 is used to mean “no event” at the end of the study.

The variable hienergy is coded 1 if the total energy consumption is more than 2.75 Mcal and 0 otherwise.

We would like to expand the data, using age as the time scale with 10-year age bands. We do this by first stsetting the dataset, specifying the date of birth as the origin.

. stset dox, failure(fail) origin(time dob) enter(time doe) scale(365.25) id(id)
  id: id
  failure event: fail != 0 & fail < .
  obs. time interval: (dox[_n-1], dox]
  enter on or after: time doe
  exit on or before: failure
  t for analysis: (time-origin)/365.25
  origin: time dob

337  total observations
0  exclusions

337  observations remaining, representing
337  subjects
80  failures in single-failure-per-subject data
4,603.669  total analysis time at risk and under observation

at risk from t = 0
earliest observed entry t = 30.07529
last observed exit t = 69.99863

The origin is set to date of birth, making time-since-birth analysis time, and the scale is set to 365.25, so that time since birth is measured in years.
Let's list a few records and verify that the analysis-time variables \_t0 and \_t are indeed recorded as we expect:

```
. list id dob doe dox fail \_t0 \_t if id==1 | id==34
```

<table>
<thead>
<tr>
<th>id</th>
<th>dob</th>
<th>doe</th>
<th>dox</th>
<th>fail</th>
<th>_t0</th>
<th>_t</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>04jan1915</td>
<td>16aug1964</td>
<td>01dec1976</td>
<td>0</td>
<td>49.615332</td>
<td>61.908282</td>
</tr>
<tr>
<td>34</td>
<td>12jun1899</td>
<td>16apr1959</td>
<td>31dec1966</td>
<td>3</td>
<td>59.841205</td>
<td>67.550992</td>
</tr>
</tbody>
</table>

We see that patient 1 was 49.6 years old at time of entry into our study and left at age 61.9. Patient 34 entered the study at age 59.8 and exited the study with CHD at age 67.6.

Now we can split the data by age:

```
. stsplit ageband, at(40(10)70)
```

(stsplit added 418 observations (episodes) created)

The single record for the subject with id = 1 has expanded to three records. The first refers to the age band 40–49, coded 40, and the subject spends \_t − \_t0 = 0.384668 years in this band. The second refers to the age band 50–59, coded 50, and the subject spends 10 years in this band, and so on. The follow-up in each of the three bands is censored (\textit{fail} = .). The single record for the subject with id = 34 is expanded to two age bands; the follow-up for the first band was censored (\textit{fail} = .), and the follow-up for the second band ended in CHD (\textit{fail} = 3).

The values for variables that do not change with time, such as height, are simply repeated in the new records. This can lead to much larger datasets after expansion. Dropping unneeded variables before using \texttt{split} may be necessary.

---

**Example 2: Splitting on age and time in study**

To use \texttt{stsplit} to expand the records on two time scales simultaneously, such as age and time in study, we can first expand on the age scale as described in example 1, and then on the time-in-study scale with the command.
By splitting the data by using two time scales, we partitioned the data into time cells corresponding to a Lexis diagram as described, for example, in Clayton and Hills (1993). Also see Keiding (1998) for an overview of Lexis diagrams. Each new observation created by splitting the data records the time that the individual spent in a Lexis cell. We can obtain the time spent in the cell by calculating the difference \( t-t_0 \). For example, the subject with \( id=1 \) spent 0.384668 years \((50-49.615332)\) in the cell corresponding to age 40–49 and study time 0–5, and 4.615332 years \((54.615332-50)\) in the cell for age 50–59 and study time 0–5.

We can also do these expansions in reverse order, that is, split first on study time and then on age.

---

### Example 3: Explanatory variables that change with time

In the previous examples, time, in the form of age or time in study, is the explanatory variable to be studied or controlled for, but in some studies other explanatory variables also vary with time. The `stsplit` command can sometimes be used to expand the records so that in each new record such an explanatory variable is constant over time. For example, in the Stanford heart data (see [ST] `stset`), we would like to split the data and generate the explanatory variable `posttran`, which takes the value 0 before transplantation and 1 thereafter. The follow-up must therefore be divided into time before transplantation and time after.

We first generate for each observation an entry time and an exit time that preserve the correct follow-up time in such a way that the time of transplants is the same for all individuals. By summarizing `wait`, the time to transplant, we obtain its maximum value of 310. By selecting a value greater than this maximum, say, 320, we now generate two new variables:

```
. use http://www.stata-press.com/data/r15/stanford, clear
(Heart transplant data)
. generate enter = 320 - wait
. generate exit = 320 + stime
```

We have created a new artificial time scale where all transplants are coded as being performed at time 320. By defining `enter` and `exit` in this manner, we maintain the correct total follow-up time for each patient. We now `stset` and `stsplit` the data:
. stset exit, enter(time enter) failure(died) id(id)
    id: id
    failure event: died != 0 & died < .
obs. time interval: (exit[_n-1], exit]
enter on or after: time enter
exit on or before: failure

103 total observations
0 exclusions

103 observations remaining, representing
103 subjects
75 failures in single-failure-per-subject data
34,589.1 total analysis time at risk and under observation
    at risk from t = 0
    earliest observed entry t = 10
    last observed exit t = 2,119

. stsplit posttran, at(0,320)
(69 observations (episodes) created)
. replace posttran=0 if transplant==0
(34 real changes made)
. replace posttran=1 if posttran==320
(69 real changes made)

We replaced posttran in the last command so that it is now a 0/1 indicator variable. We can now generate our follow-up time, t1, as the difference between our analysis-time variables, list the data, and stset the dataset.

. generate t1 = _t - _t0
. list id enter exit _t0 _t posttran if id==16 | id==44

<table>
<thead>
<tr>
<th>id</th>
<th>enter</th>
<th>exit</th>
<th>_t0</th>
<th>_t</th>
<th>posttran</th>
</tr>
</thead>
<tbody>
<tr>
<td>41</td>
<td>44</td>
<td>320</td>
<td>360</td>
<td>360</td>
<td>0</td>
</tr>
<tr>
<td>110</td>
<td>16</td>
<td>292</td>
<td>320</td>
<td>292</td>
<td>0</td>
</tr>
<tr>
<td>111</td>
<td>16</td>
<td>292</td>
<td>628</td>
<td>320</td>
<td>1</td>
</tr>
</tbody>
</table>

. stset t1, failure(died) id(id)
    id: id
    failure event: died != 0 & died < .
obs. time interval: (t1[_n-1], t1]
exit on or before: failure

172 total observations
0 exclusions

172 observations remaining, representing
103 subjects
75 failures in single-failure-per-subject data
31,938.1 total analysis time at risk and under observation
    at risk from t = 0
    earliest observed entry t = 0
    last observed exit t = 1,799

.
Using \texttt{stsplit} to split at failure times

To split data at failure times, you would use \texttt{stsplit} with the following syntax, ignoring other options:

\begin{verbatim}
    stsplit [ \texttt{if} ], at(failures)
\end{verbatim}

This form of episode splitting is useful for Cox regression with time-varying covariates. Splitting at the failure times is useful because of a property of the maximum partial-likelihood estimator for a Cox regression model: the likelihood is evaluated only at the times at which failures occur in the data, and the computation depends only on the risk pools at those failure times. Changes in covariates between failure times do not affect estimates for a Cox regression model. Thus, to fit a model with time-varying covariates, all you have to do is define the values of these time-varying covariates at all failure times at which a subject was at risk (Collett 2015, chap. 8). After splitting at failure times, you define time-varying covariates by referring to the system variable \_\texttt{t} (analysis time) or the \texttt{timevar} variable used to \texttt{stset} the data.

After splitting at failure times, all \texttt{st} commands still work fine and produce the same results as before splitting. To fit parametric models with time-varying covariates, it does not suffice to specify covariates at failure times. Stata can fit “piecewise constant” models by manipulating data using \texttt{stsplit}, \{\texttt{at()} | \texttt{every()}\}.

\textbf{Example 4: Splitting on failure times to test the proportional-hazards assumption}

Collett (2015, 187–190) presents data on 26 ovarian cancer patients who underwent two different chemotherapy protocols after a surgical intervention. Here are a few of the observations:

\begin{verbatim}
. use http://www.stata-press.com/data/r15/ocancer, clear
. list patient time cens treat age rdisea in 1/6, separator(0)
\end{verbatim}

<table>
<thead>
<tr>
<th>patient</th>
<th>time</th>
<th>cens</th>
<th>treat</th>
<th>age</th>
<th>rdisea</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>66</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>38</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>72</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>53</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>43</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>0</td>
<td>2</td>
<td>59</td>
<td>2</td>
</tr>
</tbody>
</table>

The \texttt{treat} variable indicates the chemotherapy protocol administered, \texttt{age} records the age of the patient at the beginning of the treatment, and \texttt{rdisea} records each patient’s residual disease after surgery. After \texttt{stsetting} this dataset, we fit a Cox proportional-hazards regression model on \texttt{age} and \texttt{treat} to ascertain the effect of treatment, controlling for \texttt{age}.
. stset time, failure(cens) id(patient)
  id: patient
  failure event: cens != 0 & cens < .
  obs. time interval: (time[_n-1], time]
  exit on or before: failure

26 total observations
0 exclusions

26 observations remaining, representing
26 subjects
12 failures in single-failure-per-subject data
15,588 total analysis time at risk and under observation
  at risk from t = 0
  earliest observed entry t = 0
  last observed exit t = 1,227

. stcox age treat, nolog nohr
  failure _d: cens
  analysis time _t: time
  id: patient
Cox regression -- no ties
No. of subjects = 26 Number of obs = 26
No. of failures = 12
Time at risk = 15588
LR chi2(2) = 15.82
Log likelihood = -27.073767 Prob > chi2 = 0.0004

|     _t | Coef.  | Std. Err. |   z   | P>|z| | [95% Conf. Interval] |
|--------|--------|-----------|-------|------|----------------------|
|  age   | .1465698 | .0458537 | 3.20  | 0.001 | .0566982 .2364415   |
|  treat | -.7959324 | .6329411 | -1.26 | 0.209 | -2.036474 .4446094  |

One way to test the proportional-hazards assumption is to include in the model a term for the interaction between age and time at risk, which is a continuously varying covariate. This can be easily done by first splitting the data at the failure times and then generating the interaction term.

. stsplit, at(failures)
  (12 failure times)
  (218 observations (episodes) created)
. generate tage = age * _t
. stcox age treat tage, nolog nohr
  failure _d: cens
  analysis time _t: time
  id: patient
Cox regression -- no ties
No. of subjects = 26 Number of obs = 244
No. of failures = 12
Time at risk = 15588
LR chi2(3) = 16.36
Log likelihood = -26.806607 Prob > chi2 = 0.0010

|     _t | Coef.  | Std. Err. |   z   | P>|z| | [95% Conf. Interval] |
|--------|--------|-----------|-------|------|----------------------|
|  age   | .2156499 | .1126093 | 1.92  | 0.055 | -.0050602 .43636   |
|  treat | -.6635945 | .6695492 | -0.99 | 0.322 | -1.975887 .6486978  |
|  tage  | -.0002031 | .0002832 | -0.72 | 0.473 | -.0007582 .000352  |
Other time-varying interactions of age and time at risk could be generated. For instance,

```
. generate lntage = age * ln(_t)
. generate dage = age * (_t >= 500)
```

Although in most analyses in which we include interactions we also include main effects, if we include in a Cox regression a multiplicative interaction between analysis time (or any transformation) and some covariate, we should not include the analysis time as a covariate in `stcox`. The analysis time is constant within each risk set, and hence, its effect is not identified.

Technical note

If our interest really were just in performing this test of the proportional-hazards assumption, we would not have had to use `stsplit` at all. We could have just typed

```
. stcox age treat, tvc(age)
```

to have fit a model including $t\times age$, and if we wanted instead to include $\ln(t)\times age$ or $age_t \geq 500$, we could have typed

```
. stcox age treat, tvc(age) texp(ln(_t))
. stcox age treat, tvc(age) texp(_t >= 500)
```

Still, it is worth understanding how `stsplit` could be used to obtain the same results for instances when `stcox`’s `tvc()` and `texp()` options are not rich enough to handle the desired specification.

```
Technical note
```

Assume that we want to control for `rdisea` as a stratification variable. If the data are already split at all failure times, we can proceed with

```
. stcox age treat tage, strata(rdisea)
```

If the data are not yet split, and memory is scarce, then we could just split the data at the failure times within the respective stratum. That is, with the original data in memory, we could type

```
. stset time, failure(cens) id(patient)
. stsplit, at(failures) strata(rdisea)
. generate tage = age * _t
. stcox treat age tage, strata(rdisea)
```

This would save memory by reducing the size of the split dataset.

```
Technical note
```

Of course, the above model could also be obtained by typing

```
. stcox age treat, tvc(age) strata(rdisea)
```

without splitting the data.
Example 5: Cox regression versus conditional logistic regression

Cox regression with the “exact partial” method of handling ties is tightly related to conditional logistic regression. In fact, we can perform Cox regression via \texttt{clogit}, as illustrated in the following example using Stata’s cancer data. First, let’s fit the Cox model.

```stata
use http://www.stata-press.com/data/r15/cancer, clear
(Patient Survival in Drug Trial)
. generate id = _n
. stset studytim, failure(died) id(id)
    id: id
    failure event: died != 0 & died < .
    obs. time interval: (studytime[_n-1], studytime]
    exit on or before: failure
48 total observations
0 exclusions
48 observations remaining, representing
48 subjects
31 failures in single-failure-per-subject data
744 total analysis time at risk and under observation
at risk from t = 0
earliest observed entry t = 0
last observed exit t = 39
. stcox age drug, nolog nohr exactp
    failure _d: died
    analysis time _t: studytime
    id: id
Cox regression -- exact partial likelihood
No. of subjects = 48                  Number of obs =  48
No. of failures = 31                  Time at risk = 744
LR chi2(2) = 38.13                   Log likelihood = -73.10556
Prob > chi2 = 0.0000
                  _t         Coef.   Std. Err.     z  P>|z|      [95% Conf. Interval]
     age    .1169906    .0374955    3.12  0.002     .0435008   .1904805
    drug   -1.664873   .3437487   -4.84  0.000    -2.338608   -.9911376
```

We will now perform the same analysis by using \texttt{clogit}. To do this, we first split the data at failure times, specifying the \texttt{riskset()} option so that a risk set identifier is added to each observation. We then fit the conditional logistic regression, using \_d as the outcome variable and the risk set identifier as the grouping variable.
Example 6: Joining data that have been split with stsplit

Let’s return to the first example. We split the diet data into age bands, using the following commands:

```stata
use http://www.stata-press.com/data/r15/diet, clear
stset dox, failure(fail) origin(time dob) enter(time doe) scale(365.25) id(id)
stsplit ageband, at(40(10)70)
drop ageband
```

We can rejoin the data by typing stjoin:

```stata
stjoin
```

Nothing happened! stjoin will combine records that are contiguous and record the same data. Here, when we split the data, stsplit created the new variable ageband, and that variable takes on different values across the split observations. Remember to drop the variable that stsplit creates:

```stata
drop ageband
stjoin
```

Wilhelm Lexis (1837–1914) was born near Aachen in Germany. He studied law, mathematics, and science at the University of Bonn and developed interests in the social sciences during a period in Paris. Lexis held posts at universities in Strassburg (now Strasbourg, in France), Dorpat (now Tartu, in Estonia), Freiburg, Breslau (now Wroclaw, in Poland), and Göttingen. During this peripatetic career, he carried out original work in statistics on the analysis of dispersion, foreshadowing the later development of chi-squared and analysis of variance.
Acknowledgments

stsfilter and stjoin are extensions of lexis by David Clayton (retired) of the Cambridge Institute for Medical Research and Michael Hills (retired) of the London School of Hygiene and Tropical Medicine (Clayton and Hills 1995). The original stsplit and stjoin commands were written by Jeroen Weesie of the Department of Sociology at Utrecht University, The Netherlands (Weesie 1998a, 1998b), as was the revised stsplit command.

References


Also see

[ST] stset — Declare data to be survival-time data