Cox regression (counting process) — hazard ratios from late entries, changing covariates and repeated failures

Menu: Life Data ▸ Cox Regression (Counting Process)...

Part 1 — What the function does

What it calculates. Real maintenance records rarely start every unit at age 0 and watch it to its first failure: a pump joins a monitoring programme years after it was installed, a motor gets a new bearing type halfway through its life, a compressor fails, is repaired and fails again. Like Cox Regression (chapter 2.23), this analysis gives for each covariate a hazard ratio - how many times the risk of failure at any moment is multiplied per unit of the covariate - without assuming a life distribution. The difference is the worksheet: each row is an episode, an interval (start, stop] in which one unit was watched with fixed covariate values, ending in a failure or not. A unit counts as at risk at time t only inside its episodes, when start < t ≤ stop.

Your record	As episodes
A unit that entered observation late	One episode starting at the age of entry, not at 0
A covariate that changes at a known age	The life split at that age into two episodes, the first ending censored
A unit that fails, is repaired and runs again	One episode per run between failures

What ReliaEn prints	What it tells you
Partial log-likelihood with the null value and the global LR	How much the covariates add to a model without them
Hazard ratios: β, SE, HR with its interval, LR / p, verdict, and the PH check with four events or more	Each covariate's effect on the risk, and whether the data support it
A survival plot at the covariate mean and at a comparison point X*	How the average unit and a chosen unit compare

From which data. One row per episode: start, stop, a censor flag (0 = ended in a failure, 1 = still running), and one to three numeric covariate columns.

When an engineer uses it. When the records have late entries, covariates that change during a unit's life, or repeated failures per unit, and relative risks are wanted without a life distribution.

When not to use it.

Situation	Use instead
One life per unit, watched from age 0, with fixed covariates; or categorical covariates and residuals are needed	Life Data ▸ Cox Regression... (chapter 2.23)
The recurrence rate of a fleet over time, without covariates	Life Data ▸ Repairable Fleet... (chapter 3.3)
How much a repair restores a unit	Life Data ▸ Repairable Systems ▸ GRP / Kijima... (chapter 3.5)

Part 2 — The example's input data

Setting. A plant starts a monitoring programme for four valve actuators. Two are watched from age 0; one joins at age 1 and one at age 2. X1 is 1 for the actuators with the new seal kit. Three failed; the last actuator was still running at age 6. The reliability engineer wants to know whether the new kit changes the risk of failure.

Actuator	Start	Stop	Flag (1 = still running)	X1 (1 = new kit)
1	0	2	0	0
2	0	4	0	1
3	1	3	0	1
4	2	6	1	0

Input	Value
Ties method / Confidence %	Breslow ties / 95
X1* (comparison point)	1 - an actuator with the new kit
File in the worked-example zip	2-Cox-Counting-Process/Example-1.csv — columns Start, Stop, Flag, X1, 4 rows

	① K	② L	③ M	④ N	O
1	0	2	0	0	
2	0	4	0	1	
3	1	3	0	1	
4	2	6	1	0	
5					

The example data in the worksheet

- ① Column K: the start of each episode.
- ② Column L: the stop.
- ③ Column M: the censor flag.
- ④ Column N: the seal kit, X1.

Part 3 — How to use it, step by step

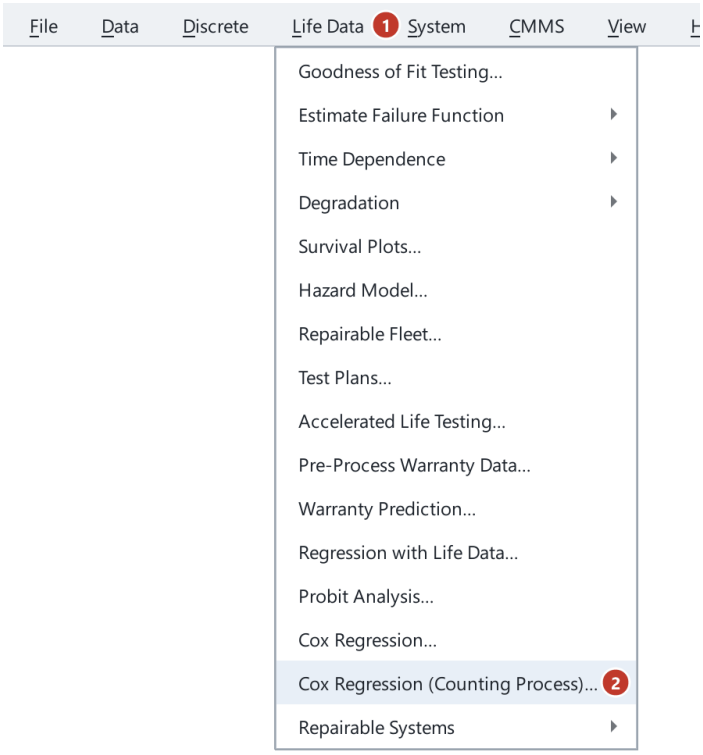
1. **Put the episodes in columns K to N.** Copy the 4 rows of Example-1.csv - its columns Start, Stop, Flag and X1 - into columns K, L, M and N of the worksheet, starting at row 1. Any free columns will do; the form names them in steps 3 to 6.

	① K	② L	③ M	④ N	O
1	0	2	0	0	
2	0	4	0	1	
3	1	3	0	1	
4	2	6	1	0	
5					

Step 1 — the episodes in columns K to N

- ① Column K: the start of each episode, 0, 0, 1 and 2.
- ② Column L: the stop, 2, 4, 3 and 6.
- ③ Column M: the censor flags; the 1 is the actuator still running at age 6.
- ④ Column N: the seal kit, 1 for the new kit.

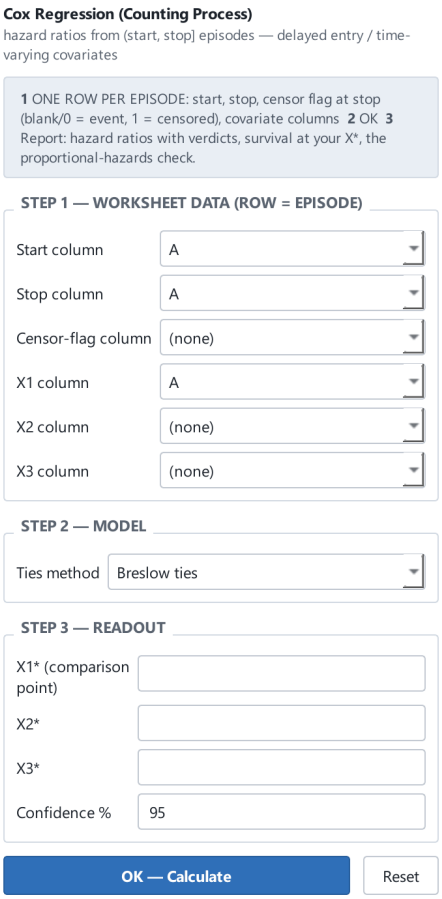
2. **Choose Life Data ▸ Cox Regression (Counting Process)...** in the menu bar. The form Cox Regression (Counting Process) opens in the left panel.



Step 2 — the menu path

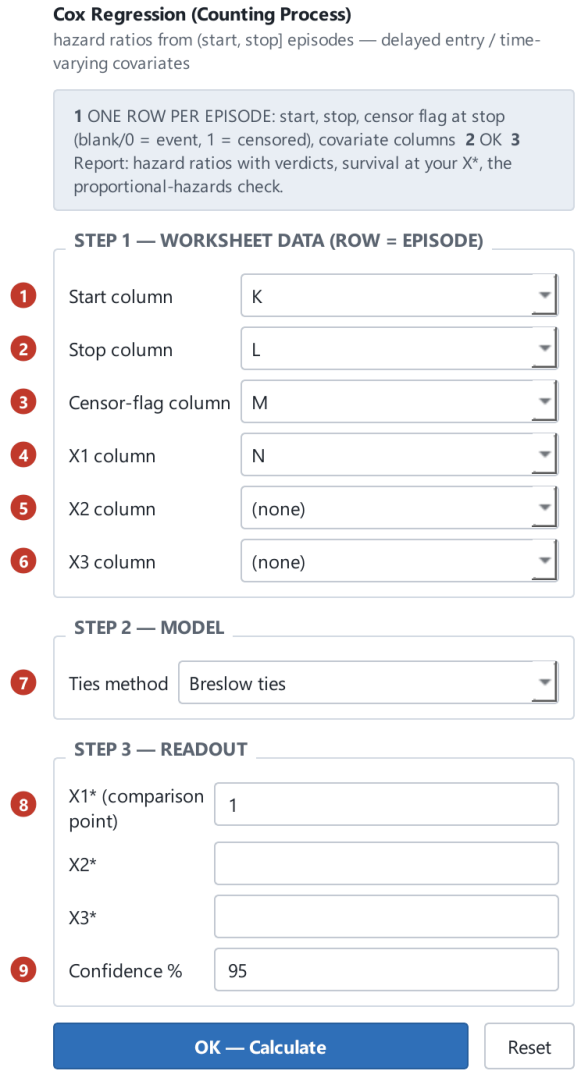
- ① Life Data: the menu.
- ② Cox Regression (Counting Process)...: the entry to click.

The form as it opens, before any box is set:



Step 2 — the form as it opens

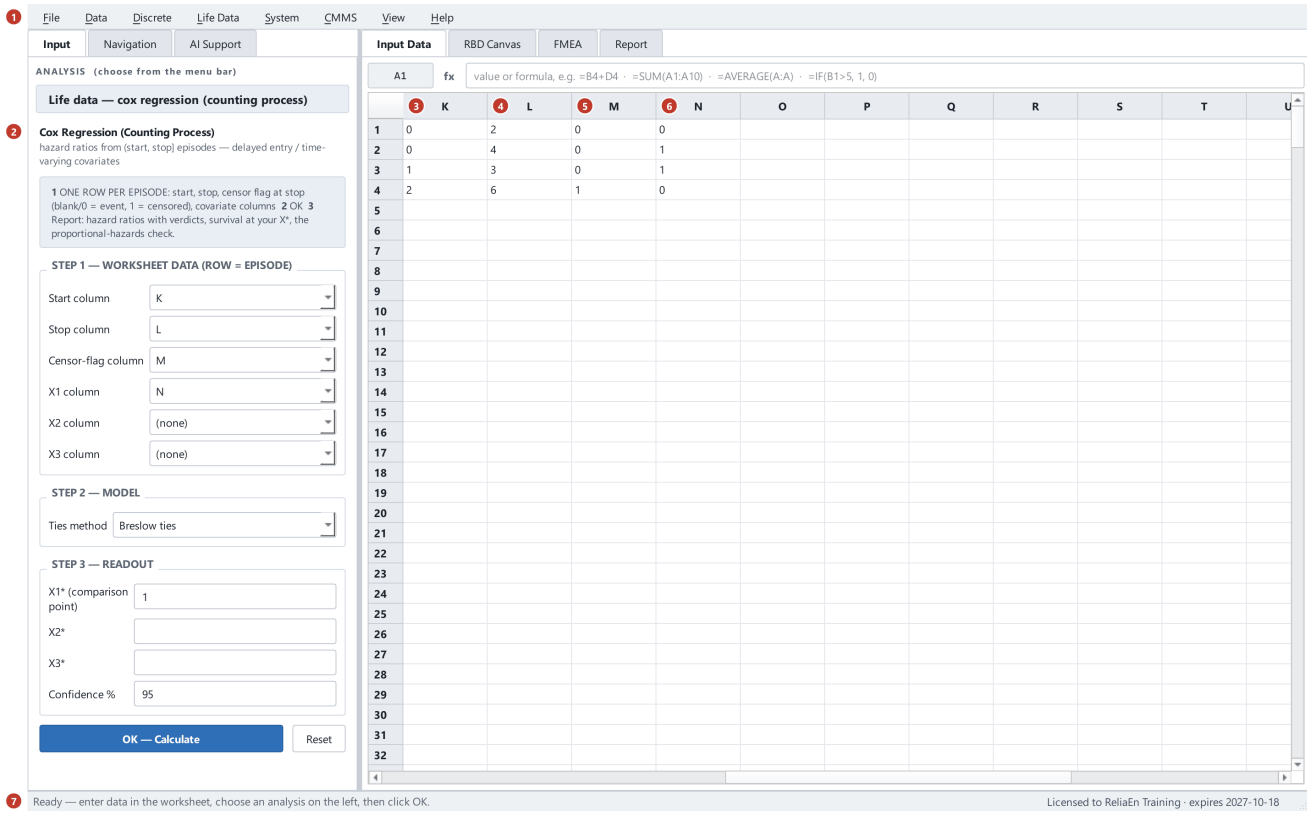
Steps 3 to 11 set or check the form's nine boxes, marked ① to ⑨ in the picture:



Steps 3 to 11 — the form set for this example

3. ① **In Start column, choose K.** The box opens on A.
4. ② **In Stop column, choose L.** The box opens on A.
5. ③ **In Censor-flag column, choose M.**
6. ④ **In X1 column, choose N.** The box opens on A.
7. ⑤ **Check that X2 column reads (none).** One covariate only.
8. ⑥ **Check that X3 column reads (none).**
9. ⑦ **Check that Ties method reads Breslow ties.**
10. ⑧ **In X1* (comparison point), type 1.** The survival plot's second curve is an actuator with the new kit.
11. ⑨ **Check that Confidence % reads 95.**

12. **Click OK — Calculate** at the foot of the form (② in the picture below). ReliaEn calculates and shows the report.



Step 12 — the window just before OK

- ① The menu bar: File, Data, Discrete, Life Data, System, CMMS, View, Help.
- ② The form, set as in steps 3 to 11; OK — Calculate at its foot.
- ③ Column K: the starts.
- ④ Column L: the stops.
- ⑤ Column M: the censor flags.
- ⑥ Column N: the seal kit.
- ⑦ The status bar: Ready — enter data in the worksheet, choose an analysis on the left, then click OK. and Licensed to ReliaEn Training · expires 2027-10-18.

Part 4 — The report, card by card

Life Data — Cox Regression (Counting Process)

2026-11-04 11:00:45

partial likelihood over counting risk sets {start < t ≤ stop} ; S(t|x) = S₀(t)^exp(βᵀ(x−x̄))

The report's head

- The title Life Data — Cox Regression (Counting Process), the date and time of the run, and the model in one line: partial likelihood over counting risk sets {start < t ≤ stop}; S(t|x) = $S_0(t)^{\exp(\beta^T(x-\bar{x}))}$.

INPUT DATA

1	Data	`this worksheet — 4 episodes: 3 events / 1 censored, 1 covariate(s)`
2	Ties method	`Breslow`
3	Model	`semi-parametric proportional hazards on (start, stop] episodes — no life distribution assumed`

Input data

- ① Data this worksheet — 4 episodes: 3 events / 1 censored, 1 covariate(s).
- ② Ties method Breslow.
- ③ Model semi-parametric proportional hazards on (start, stop] episodes — no life distribution assumed.

RESULTS

1	Partial log-likelihood	`-2.8700 (null -2.8904, global LR = 0.041)`

Results

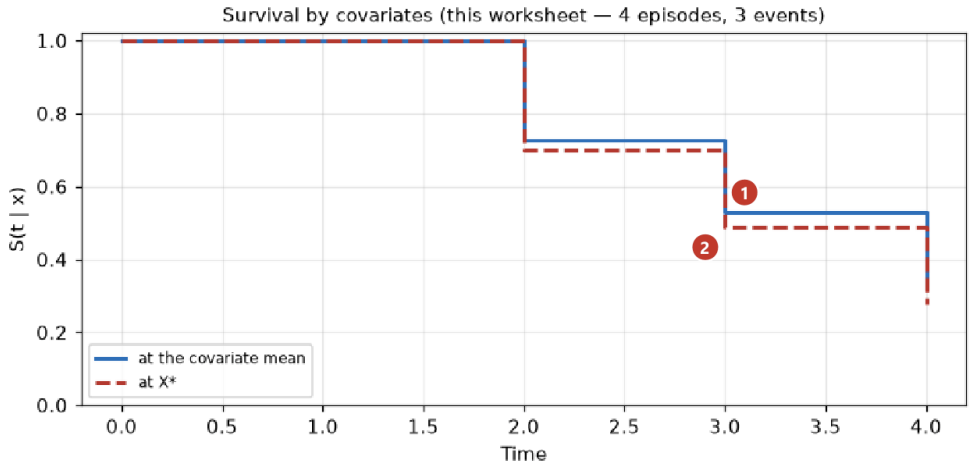
- ① Partial log-likelihood -2.8700 (null -2.8904, global LR = 0.041): the fit with the kit, the fit without it, and the test between them.

INTERPRETATION

1 Each hazard ratio multiplies the CURRENT risk per unit of its covariate — no claim about the life distribution's shape. A unit is at risk only INSIDE its episodes (start, stop]: delayed entries join the risk set late, split episodes carry time-varying covariates, repeated episodes per unit model recurrent events. Believe a ratio only if its verdict column and the proportional-hazards check both pass.

Interpretation

- ① ReliaEn's reading: Each hazard ratio multiplies the CURRENT risk per unit of its covariate — no claim about the life distribution's shape. A unit is at risk only INSIDE its episodes (start, stop]: delayed entries join the risk set late, split episodes carry time-varying covariates, repeated episodes per unit model recurrent events. Believe a ratio only if its verdict column and the proportional-hazards check both pass.



Interactive Plot

Survival by covariates (this worksheet — 4 episodes, 3 events)

- ① at the covariate mean: S(t | x) for the average actuator, stepping down at the failures at ages 2, 3 and 4.
- ② at X*: the same steps for an actuator with the new kit (X1 = 1), a little lower at each.

HAZARD RATIOS (THIS WORKSHEET — 4 EPISODES: 3 EVENTS / 1 CENSORED, 1 COVARIATE(S))

1 HR = e^β per covariate unit. The proportional-hazards check needs at least 4 events — not available here.

2 Term	3 β	4 SE	5 Hazard ratio [CI]	6 LR / p	7 Verdict
8 X1	0.2475	1.2403	1.2808 [0.1127, 14.5607]	0.041 / 0.8399	NOT significant

Hazard ratios (this worksheet — 4 episodes: 3 events / 1 censored, 1 covariate(s))

- ① HR = e^β per covariate unit. The proportional-hazards check needs at least 4 events — not available here.
- ② to ⑦ The columns Term, β, SE, Hazard ratio [CI], LR / p, Verdict.
- ⑧ The row for X1: β 0.2475, SE 1.2403, hazard ratio 1.2808 [0.1127, 14.5607], LR 0.041 / p 0.8399, NOT significant.

1 Licensed to ReliaEn Training · RL-2026-0017

The report's foot

- ① The licence line Licensed to ReliaEn Training · RL-2026-0017: the licence this report was made under.

Part 5 — How to interpret the results

Who is at risk when. The risk sets follow the episodes. At the first failure, age 2, three actuators are at risk - the one that joined at age 2 is not yet, because an episode does not count at its own start. At age 3 three are at risk again (the late joiner now among them), and at age 4 two.

Does the kit matter? The data cannot say. The new kit's hazard ratio is 1.2808 (β = 0.2475, SE 1.2403), but its 95 % interval runs from 0.1127 to 14.5607: from a ninth of the risk to fourteen times it. The partial log-likelihood moves only from −2.8904 without the kit to −2.8700 with it, LR = 0.041, p = 0.8399: NOT significant.

What to decide. Three failures cannot show whether the kit helps or harms; keep recording failures before changing the kit policy. With fewer than four events the report gives no proportional-hazards check, and says so.

Records written as episodes. Splitting one actuator's record into two episodes with the same X1 - say (0, 1] still running and (1, 4] ending in its failure - gives the same fit: the risk sets do not change. If a split changes the numbers, a covariate value differs between the pieces.