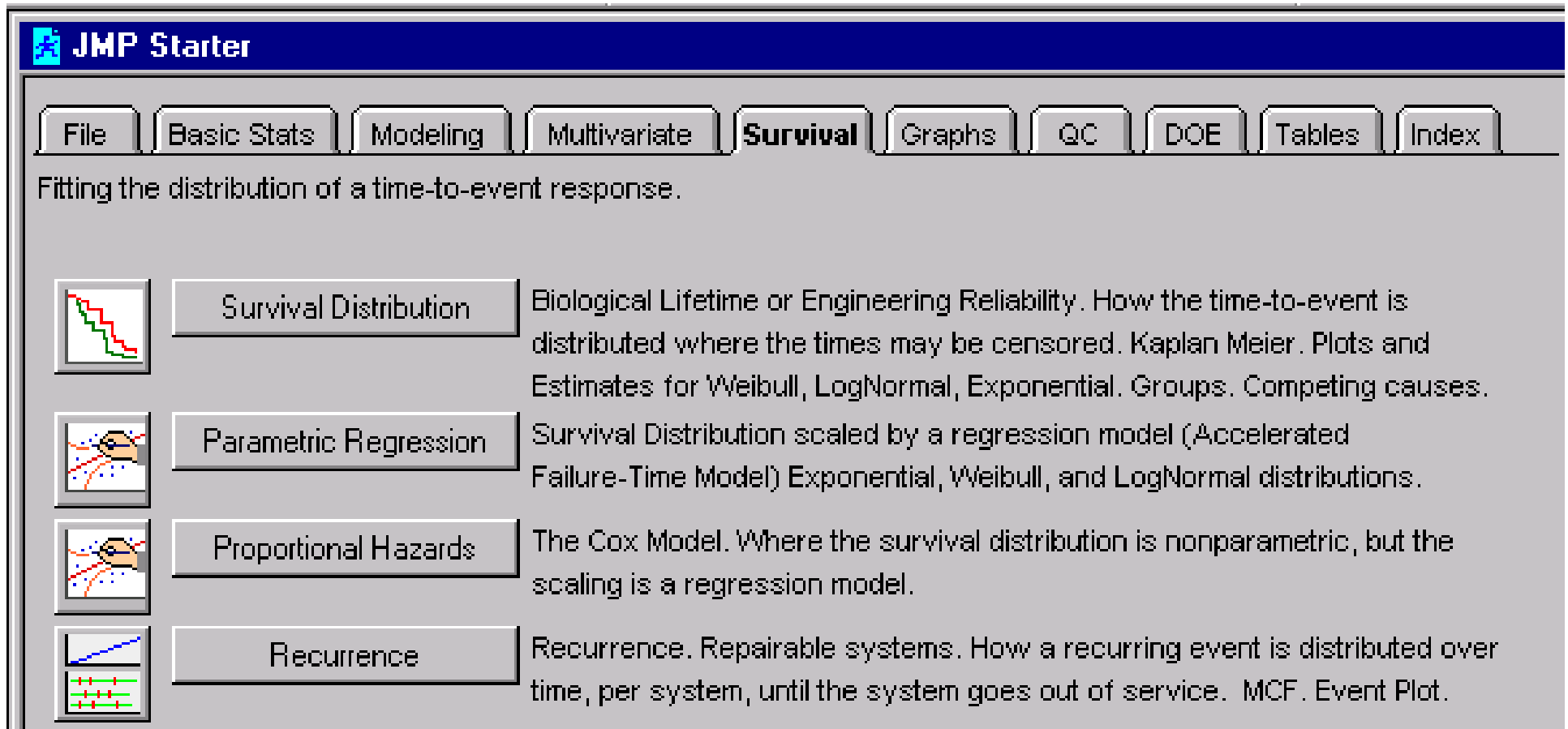


**A Case Study in Competing Risk
Reliability Analysis Using JMP Software**
Bradley Jones
SAS Institute, Inc.

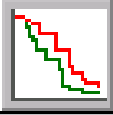
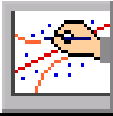
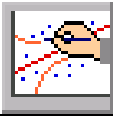
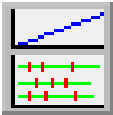
Outline

- Overview of Reliability (Survival) Analysis in JMP 4.0
- A JMP Script - Competing Causes GUI
- Analysis of some pseudo-data
- Analysis of Process data

Overview of Reliability Analysis in JMP 4.0



The screenshot shows the JMP Starter window with a blue title bar containing the JMP logo and the text "JMP Starter". Below the title bar is a menu bar with buttons for "File", "Basic Stats", "Modeling", "Multivariate", "Survival", "Graphs", "QC", "DOE", "Tables", and "Index". The "Survival" button is highlighted. Below the menu bar, the text "Fitting the distribution of a time-to-event response." is displayed. The main area contains four rows of options, each with a small icon, a button label, and a descriptive text:

Icon	Option Label	Description
	Survival Distribution	Biological Lifetime or Engineering Reliability. How the time-to-event is distributed where the times may be censored. Kaplan Meier. Plots and Estimates for Weibull, LogNormal, Exponential. Groups. Competing causes.
	Parametric Regression	Survival Distribution scaled by a regression model (Accelerated Failure-Time Model) Exponential, Weibull, and LogNormal distributions.
	Proportional Hazards	The Cox Model. Where the survival distribution is nonparametric, but the scaling is a regression model.
	Recurrence	Recurrence. Repairable systems. How a recurring event is distributed over time, per system, until the system goes out of service. MCF. Event Plot.

JMP Starter Window

Univariate Survival Launch Dialog

Survival / Reliability

The distribution of the time until an event

Select Columns

- Weibull 1
- Weibull 2
- Observed Time
- Censor 1
- No Censoring

Cast Selected Columns into Roles

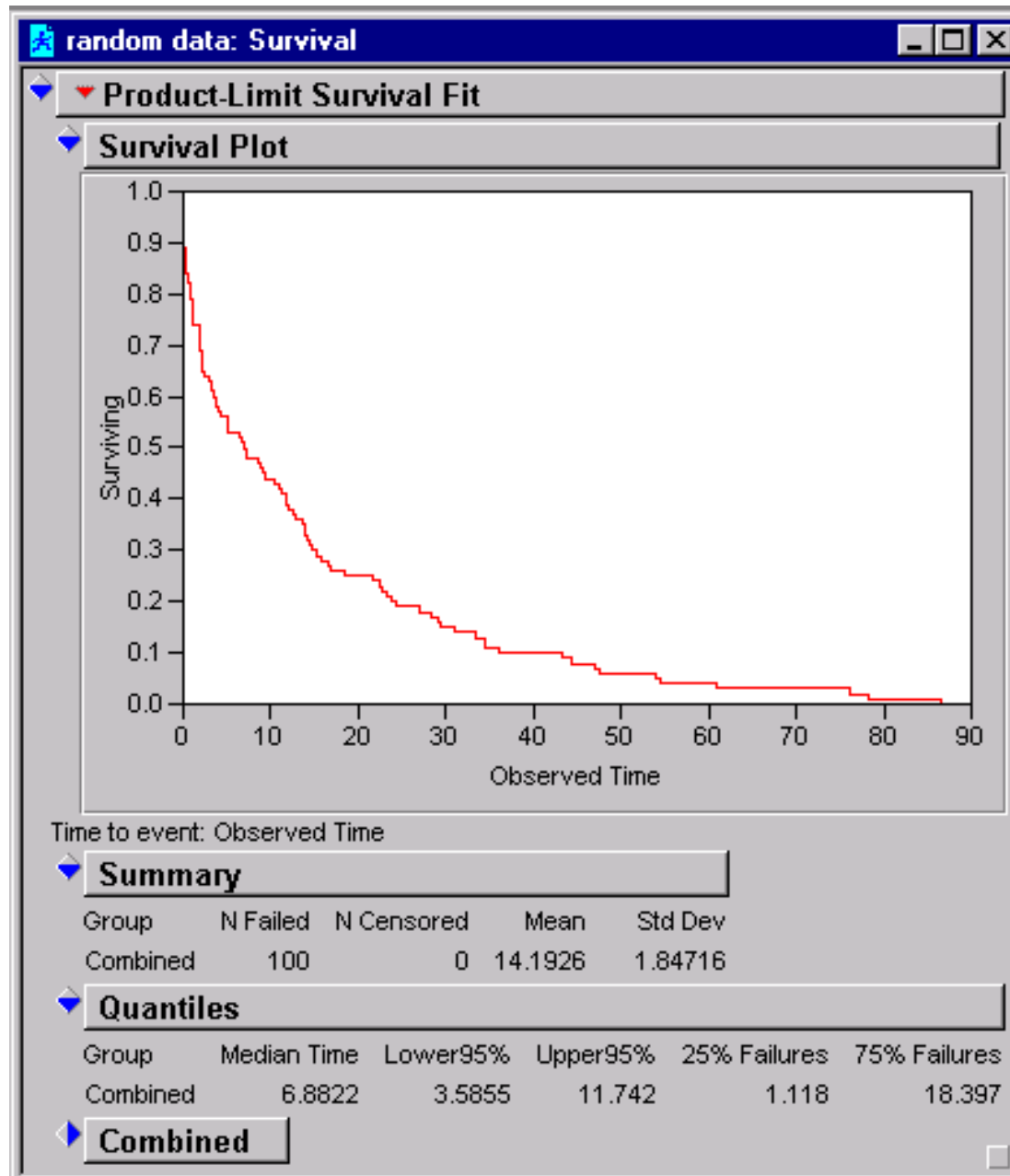
Y, Time to Event	<input checked="" type="checkbox"/> Observed Time
Grouping	<i>optional</i>
Censor	<i>optional numeric</i>
Freq	<i>optional numeric</i>
By	<i>optional</i>

Censor=0 indicates censored time

Action

- OK
- Cancel
- Remove
- Recall
- Help

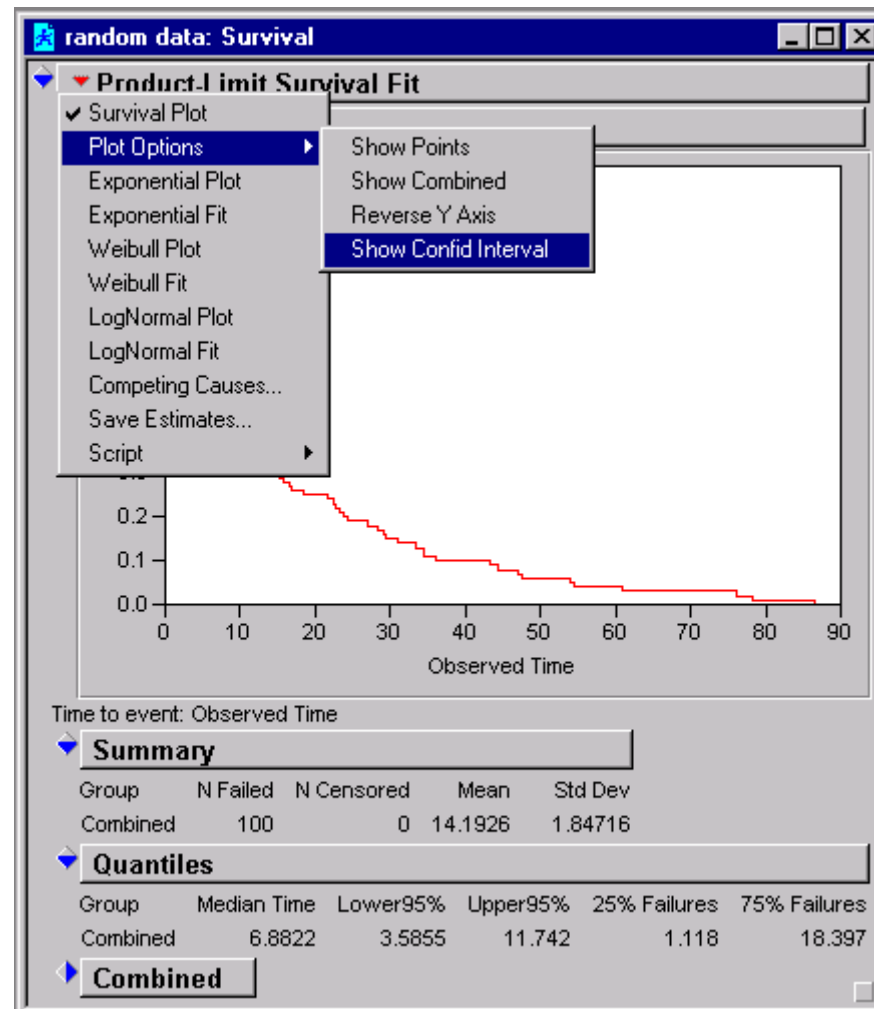
Default Analysis



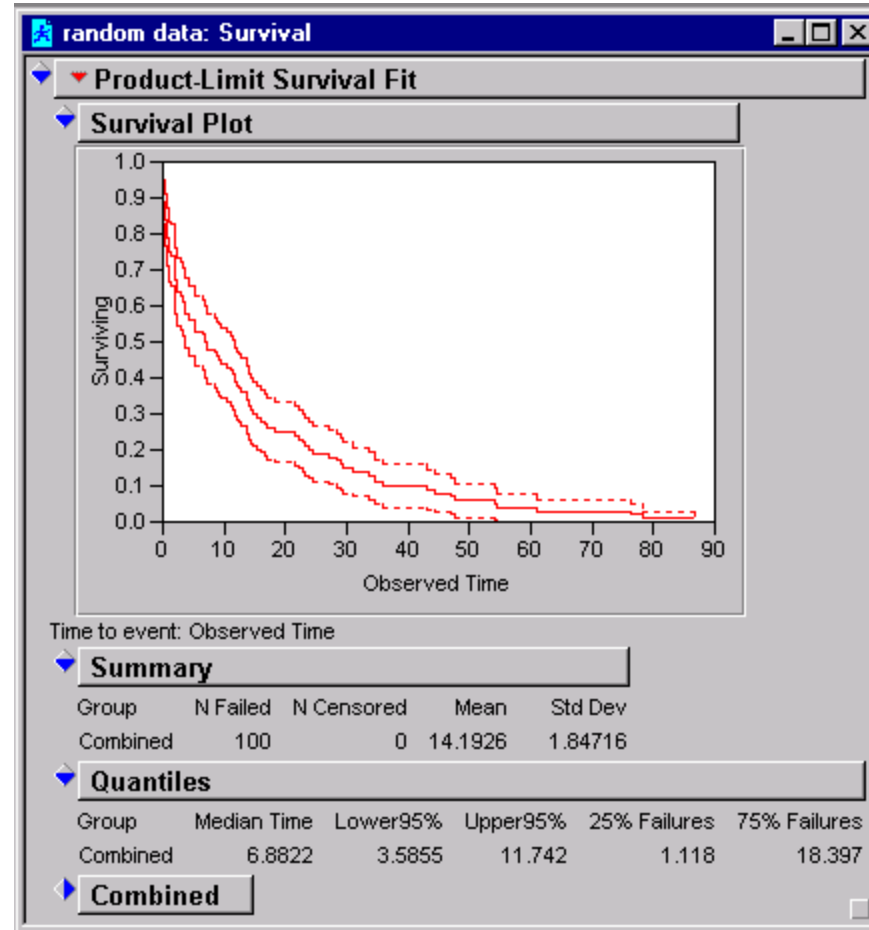
Default Analysis cont.

Combined						
Observed Time	Survival	Failure	SurvStdErr	N Failed	N Censored	At Risk
0.0000	1.0000	0.0000	0.0000	0	0	100
0.0000	0.9900	0.0100	0.0099	1	0	100
0.0005	0.9800	0.0200	0.0140	1	0	99
0.0013	0.9700	0.0300	0.0171	1	0	98
0.0014	0.9600	0.0400	0.0196	1	0	97
0.0279	0.9500	0.0500	0.0218	1	0	96
0.0329	0.9400	0.0600	0.0237	1	0	95
0.0355	0.9300	0.0700	0.0255	1	0	94
0.0419	0.9200	0.0800	0.0271	1	0	93
0.0424	0.9100	0.0900	0.0286	1	0	92
0.0475	0.9000	0.1000	0.0300	1	0	91
0.0718	0.8900	0.1100	0.0313	1	0	90
0.2082	0.8800	0.1200	0.0325	1	0	89
0.2210	0.8700	0.1300	0.0336	1	0	88
0.2453	0.8600	0.1400	0.0347	1	0	87
0.2891	0.8500	0.1500	0.0357	1	0	86
0.3240	0.8400	0.1600	0.0367	1	0	85
0.6482	0.8300	0.1700	0.0376	1	0	84
0.6529	0.8200	0.1800	0.0384	1	0	83
0.6870	0.8100	0.1900	0.0392	1	0	82
0.7316	0.8000	0.2000	0.0400	1	0	81
0.7633	0.7900	0.2100	0.0407	1	0	80
1.0445	0.7800	0.2200	0.0414	1	0	79

Options Menu Choice...



...and Results



Scripting Options Choice...

The screenshot shows the Minitab 'random data: Survival' window. The main menu is expanded to 'Product Limit Survival Fit', and the 'Script' option is selected, opening a sub-menu. The sub-menu options are: Redo Analysis, Save Script to Datable, Save Script to Report, Save Script to Script Window (highlighted), Save Script for All Objects, and Data Table Window. Below the menu, a small plot shows a survival curve with a y-axis from 0.0 to 0.1 and an x-axis from 0 to 20. The plot is titled 'Time to event: Observed Time'. Below the plot are two summary tables.

Summary

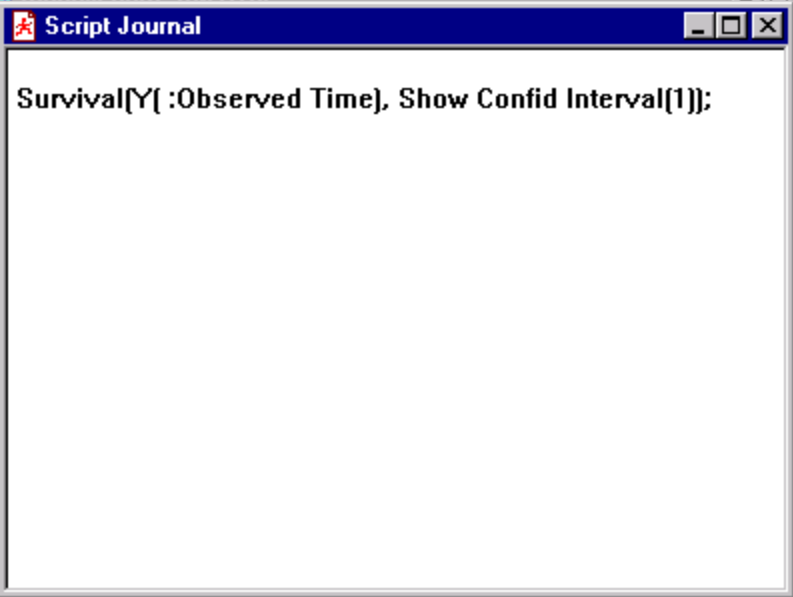
Group	N Failed	N Censored	Mean	Std Dev
Combined	100	0	14.1926	1.84716

Quantiles

Group	Median Time	Lower95%	Upper95%	25% Failures	75% Failures
Combined	6.8822	3.5855	11.742	1.118	18.397

Combined

...and Results

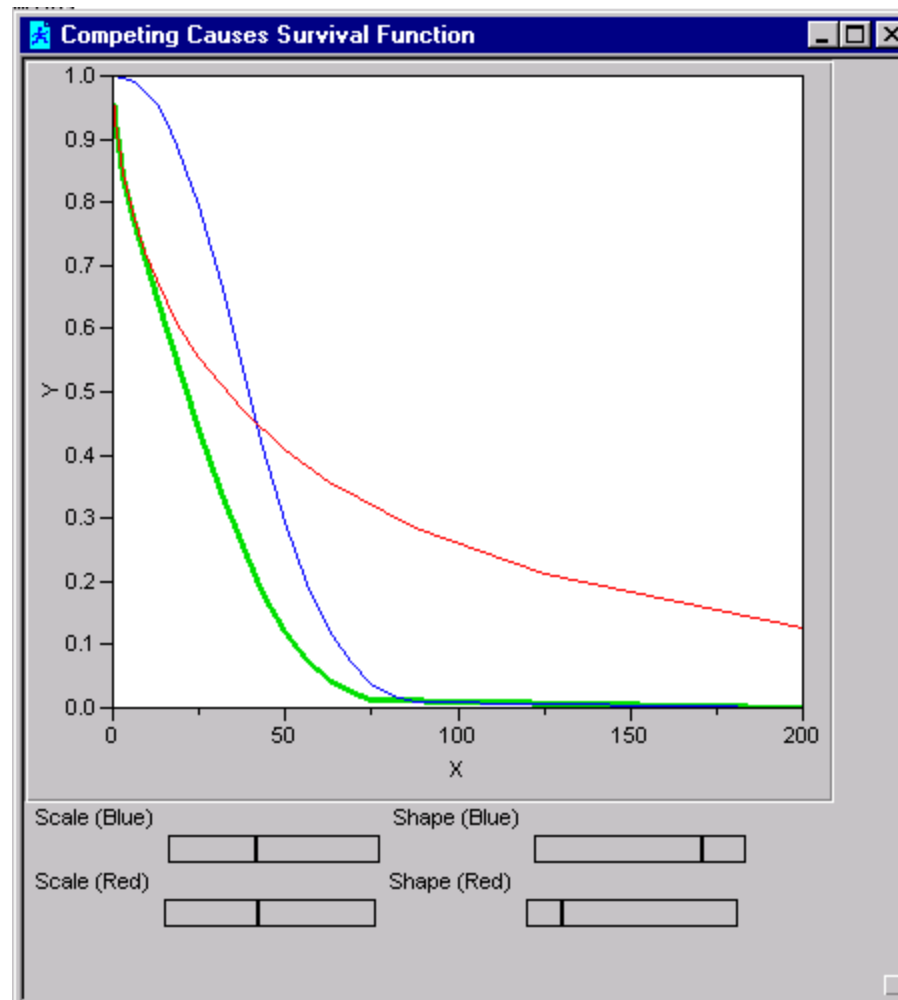


```
Survival[Y( :Observed Time), Show Confid Interval(1)];
```

The image shows a screenshot of a software window titled "Script Journal". The window has a blue title bar with standard window controls (minimize, maximize, close). The main content area is white and contains a single line of text: "Survival[Y(:Observed Time), Show Confid Interval(1)];".

Submitting the script above reproduces the analysis.

A JMP Script - Competing Causes GUI



Script

```
// Competing Causes Interactive Survival Plot
x=1; y=1;
shape1 = 2.4;          scale1 = log10(46);
shape2 = 0.6;          scale2 = log10(60);

survival = expr((1-Weibull Distribution(x, shape1, 10^scale1, 0))*(1-Weibull Distribution(x, shape2, 10^scale2, 0)));

gBox = Graph Box(FrameSize(500,300),Double Buffer,
  XScale(0,200),yScale(0,1),
  pen color("green");pen size(3);
  YFunction(survival,x),
  pen color("blue");pen size(1);
  YFunction(1-Weibull Distribution(x, shape1, 10^scale1, 0),x),
  pen color("red");pen size(1);
  YFunction(1-Weibull Distribution(x, shape2, 10^scale2, 0),x));

plot = gBox[FrameBox(1)];
NewWindow("Competing Causes Survival Function",
  v list box (gBox,
    h list box (textbox(" Scale (Blue) "),
      slider box (0,4, scale1,plot<<reshow()),
      textbox(" Shape (Blue) "),
      slider box (0.1,3, shape1,plot<<reshow()))),
    h list box (textbox(" Scale (Red) "),
      slider box (0,4, scale2,plot<<reshow()),
      textbox(" Shape (Red) "),
      slider box (0.1,3, shape2,plot<<reshow()))
  )
);
```

Analysis of some pseudo-data

random data			Weibull 1	Weibull 2	Observed Time	Censor 1	No Censoring
shape1	2.2						
scale1	60	1	22.3155051	74.4623742	22.3155051	0	0
shape2	0.5	2	74.7972305	6.68356133	6.68356133	1	0
scale2	20	3	46.7373946	12.4615701	12.4615701	1	0
Survival Analysis		4	106.637942	1.93713951	1.93713951	1	0
Competing Causes		5	65.4554171	0.03548392	0.03548392	1	0
Survival with Censoring		6	35.7751211	11.9222539	11.9222539	1	0
		7	34.4962115	49.1092064	34.4962115	0	0
		8	47.5089675	139.357424	47.5089675	0	0
Columns (5/0)		9	54.3235326	14.0128334	14.0128334	1	0
<input checked="" type="checkbox"/> Weibull 1 +		10	58.2916965	13.9316213	13.9316213	1	0
<input checked="" type="checkbox"/> Weibull 2 +		11	47.1946481	1.11802666	1.11802666	1	0
<input checked="" type="checkbox"/> Observed Time +		12	59.1734895	15.8112388	15.8112388	1	0
<input checked="" type="checkbox"/> Censor 1 +		13	54.0477133	109.05329	54.0477133	0	0
<input checked="" type="checkbox"/> No Censoring +		14	35.9812974	53.969673	35.9812974	0	0
		15	33.4184061	35.6681479	33.4184061	0	0
		16	86.6135264	155.049008	86.6135264	0	0
		17	30.8565057	65.3996424	30.8565057	0	0
Rows		18	20.3678807	0.73163429	0.73163429	1	0
All Rows	100	19	47.0602404	218.163575	47.0602404	0	0
Selected	0	20	10.2799769	4.07989686	4.07989686	1	0
Excluded	0						
Hidden	0						
Labelled	0						

Column Formulae

Weibull 2

Table Columns: Weibull 1, Weibull 2, Observed Time, Censor 1, No Censoring

Functions (grouped): Row, Numeric, Transcendental, Trigonometric, Character, Comparison, Conditional, Probability, Statistical

OK, Cancel, Apply, Clear, Help

$scale2 * \left(-\text{Log} \left(1 - \text{Random Uniform}() \right) \right)^{\frac{1}{shape2}}$

Observed Time

Table Columns: Weibull 1, Weibull 2, Observed Time, Censor 1, No Censoring

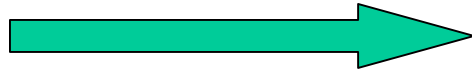
Functions (grouped): Row, Numeric, Transcendental, Trigonometric, Character, Comparison, Conditional, Probability, Statistical

OK, Cancel, Apply, Clear, Help

$\text{Min}(\text{Weibull 1}, \text{Weibull 2})$

random data

- random data
- shape1 2.2
- scale1 60
- shape2 0.5
- scale2 20
- Survival Analysis
- Competing Causes
- Survival with Censoring



random data: Survival

Product-Limit Survival Fit

Survival Plot

Time to event: Observed Time

Weibull Plot

Summary

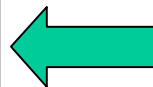
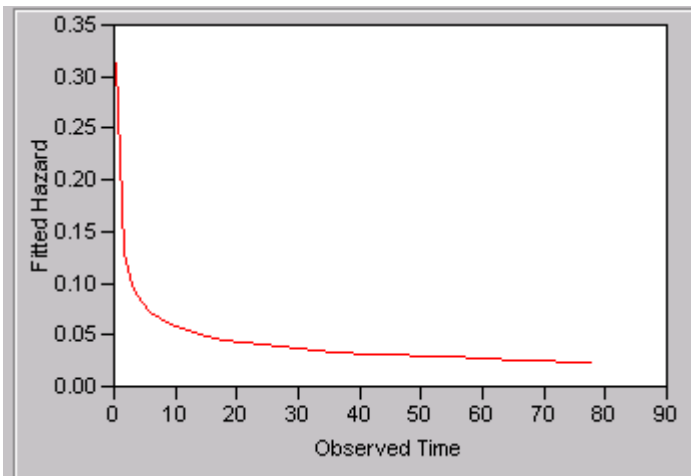
Quantiles

Combined

Competing Causes

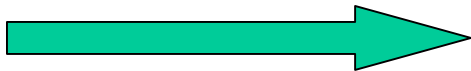
Weibull Parameter Estimates

No Censoring	Alpha	Beta	N Failed	N Censored	logLikelihood
0	9.849671791	0.5761583490	100	0	-219.12917



random data

- random data
- shape1 2.2
- scale1 60
- shape2 0.5
- scale2 20
- Survival Analysis
 - Competing Causes
 - Survival with Censoring



random data: Survival

Product-Limit Survival Fit

Survival Plot

Time to event: Observed Time

Weibull Plot

Summary

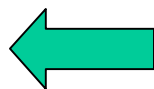
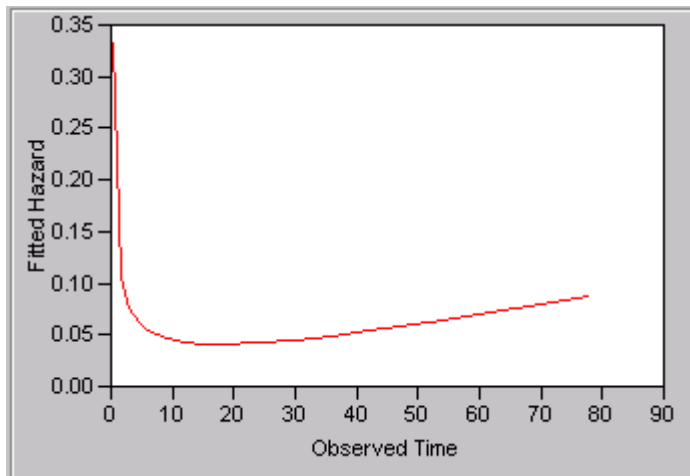
Quantiles

Combined

Competing Causes

Weibull Parameter Estimates

Censor 1	Alpha	Beta	N Failed	N Censored	logLikelihood
0	49.43716520	2.17633191	22	78	-26.376237
1	14.74048389	0.45548560	78	22	-215.92035



Analysis of Process data

failure mode		30 Col	Up Time	Failure Mode	Censor
Survival Analysis					209
Survival for FM 209					
Competing Causes					
Columns (4/0)					
<input checked="" type="checkbox"/>	Up Time				
<input checked="" type="checkbox"/>	Failure Mode				
<input checked="" type="checkbox"/>	Censor 209 +				
<input checked="" type="checkbox"/>	Zero 🚗 +				
Rows					
All Rows	2264				
Selected	1				
Excluded	0				
Hidden	0				
Labelled	0				
		1	134.18167	808	1
		2	2.1366667	808	1
		3	0	808	1
		4	31.951665	711	1
		5	33.471668	104	1
		6	0	104	1
		7	0.0517	104	1
		8	0	104	1
		9	0.07	104	1
		10	0.0733	104	1
		11	0.0583	104	1
		12	0.0783	104	1
		13	0	104	1
		14	0	104	1
		15	0.0733	806	1
		16	0.182	104	1

Top Failure Modes

cause model		Failure Mode	Alpha	Beta	N Failed
	1	305	2095.58539	0.41802564	184
	2	804	1672.63641	0.58103421	159
	3	209	840.662431	0.61528138	150
	4	605	257.659589	1.05085605	107
	5	406	6050.50221	0.69328967	93
	6	304	777.941571	0.81241961	68
	7	302	3385390.49	0.3135513	67
	8	412	536139.398	0.31297188	64
	9	706	695.017697	0.89973746	61
	10	210	14264.7619	0.48370601	57
	11	808	6479.30876	0.55011778	54
	12	408	16575014.6	0.28865867	48

cause model

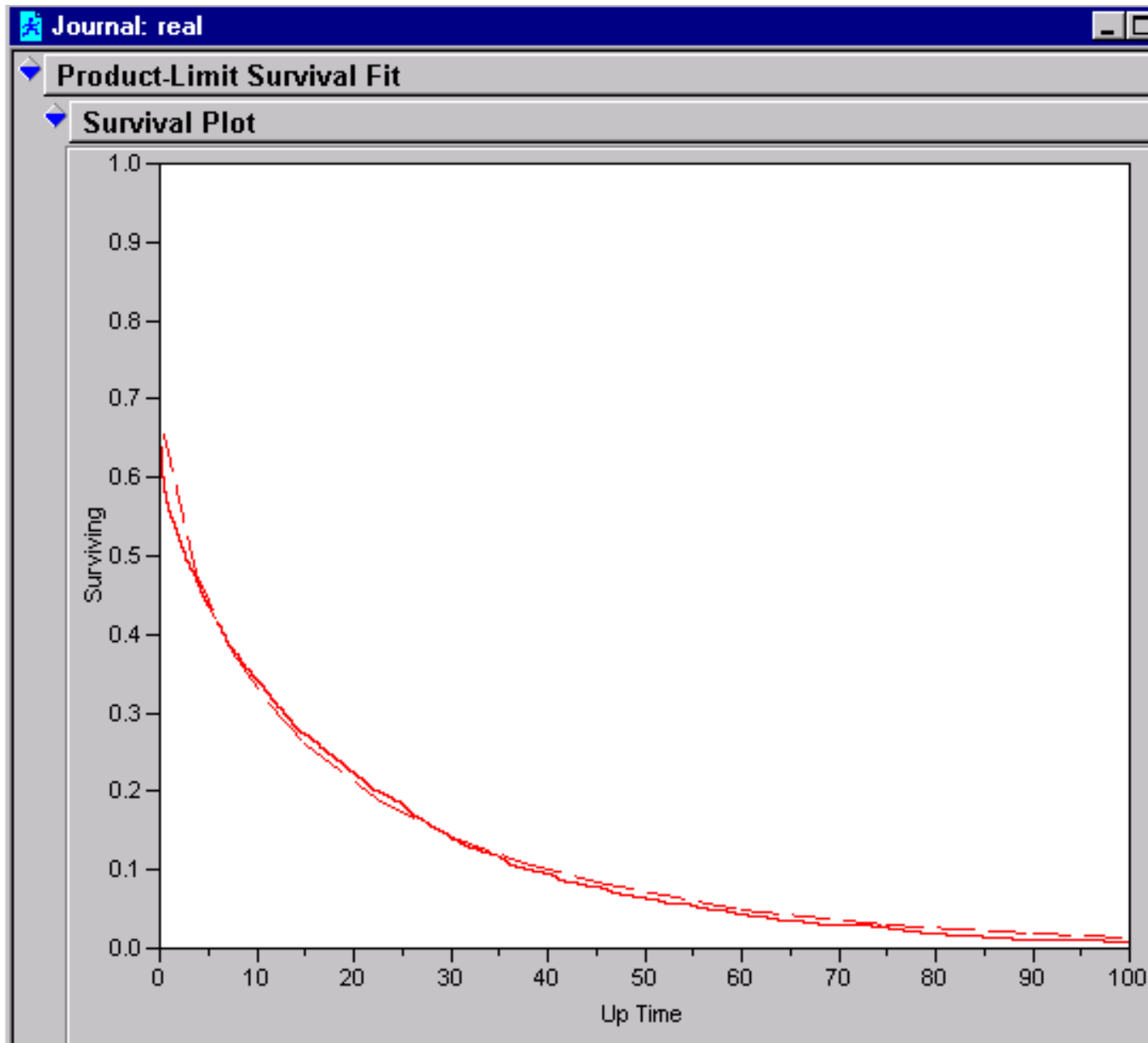
Columns (4/0)

- Failure Mode
- Alpha
- Beta
- N Failed

Rows

All Rows	77
Selected	0
Excluded	0
Hidden	0
Labelled	0

Competing Causes Fitted Survival



Omitting Causes

