The Estimation of Time-to-failure of DVD with 25℃

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【 The Estimation of Time-to-failure of DVD with 25℃ temperature level using bootstrap regression analysis】

【step 1】Randomly select the 4 set of data from the block of 4 temperature(85℃、80,75℃,65℃) and the same 80%RH,let Y be the logarithmic values. Find the regression line Y of the inverse number of absolute temperatures A=273.15+85 80 75 65.

Time-to-failure of DVD-R A from the data of Table 1-1、for example,the second value from 85℃,the first value from 80℃,the forth value from 75℃,and the 8-th value from65℃.

t=:198 258 627 2850

logarithmic values of t are

]Y=:log t [log=:^.

5.28827 5.55296 6.44095 7.95507

Then the regression line Y of A=:1,.%273.15+85 80 75 65 is

]b=:Y %. A

_41.9489 16853.8

【Step 2】Predict the Time-to-failure of DVD-R with temperature 25℃using the the regression line seeked by Step1.

Using the regression coefficients b, predicted logarithmic value of the Time-to-failure of DVD-R with 25℃ is

]s=:+/(1,%273.15+25)*b

14.579

Then T=the exponential value of s is

]T=:exp s [exp=:^

2.14574e6

Fuethermore,Year-to-failure is

]Y=:T % 8766(=24×365.25)

244.78

【Step 3：bootstrap metod】Repeat N times of Step 1 and Step2, the N-touple of times-to-failure of DVD-R with temperature 25℃ and find out the 5%-point, median and mean value.

Let the N=1000-touple of times-to-failure of DVD-R with temperature 25℃ be

$Y=Y_1, Y_2, \cdots\cdots\cdots, Y_N\}$

and be the descending order of Y

$\{Y^*_1, Y^*_2, \cdots\cdots\cdots, Y^*_N\}$

then Y^*_{50}、Y^*_{500} are 5%-point and median,and mean value is given by

$$M = \{Y_1^* + Y^*_2 + \cdots\cdots\cdots + Y^*_N\}/N = \{Y_1 + Y_2 + \cdots\cdots\cdots + Y_N\}/N$$

【Step 4】Repeat K-times Step3, K set of 5%-point, median and mean value of times-to-failure of DVD-R with temperature 25℃.

Let K set of (5%-point, median and mean value)' s be

$\{Y1^*_{50}, Y2^*_{50}, \cdots\cdots\cdots, YK^*_{50}\}$

$\{Y1^*_{500}, Y2^*_{500}, \cdots\cdots\cdots, YK^*_{500}\}$

$\{M1, M2, \cdots\cdots\cdots, MK\}$

and we can find the mean values and their standard errors as follows：

$$\overline{Y}_{50} = \left\{Y1^*_{50} + Y2^*_{50} + \cdots\cdots\cdots + YK^*_{50}\right\}/K \; ; \; S_{50} = \sqrt{\sum_{j=1}^{K}\left(Yj^*_{50} - \overline{Y}_{50}\right)^2 / K(K-1)}$$

$$\overline{Y}_{500} = \left\{Y1^*_{500} + Y2^*_{500} + \cdots\cdots\cdots + YK^*_{500}\right\}/K \; ; \; S_{500} = \sqrt{\sum_{j=1}^{K}\left(Yj^*_{500} - \overline{Y}_{500}\right)^2 / K(K-1)}$$

$$\vec{M} = \left\{M1 + M2 + \cdots\cdots\cdots + MK\right\}/K \; ; \; S_M = \sqrt{\sum_{j=1}^{K}\left(Mj - \vec{M}\right)^2 / K(K-1)}$$

Table 1-1 (DVD-R A-Brand)

R	Brand	A									
	Disc	1	2	3	4	5	6	7	8	9	10
65℃80%		2349	2370	2437	2690	2690	2692	2760	2850	2910	2940
75℃80%		452	477	561	627	657	1197	—	—	—	—
80℃80%		258	275	291	324	327	345	—	—	—	—
85℃80%		184	198	211	211	213	221	—	—	—	—

Table 1-2 (DVD-R B-Brand)

R	Brand	B									
	Disc	1	2	3	4	5	6	7	8	9	10
65℃80%		—	—	—	—	—	—	10264	9298	9465	9407
75℃80%		6970	7110	7240	3731	3725	3728	—	—	—	—
80℃80%		4428	—	—	3195	3148	3147	—	—	—	—
85℃80%		2338	—	—	2177	2170	2060	—	—	—	—

Table 1-3 (DVD-R C-Brand)

R	Brand	C									
	Disc	1	2	3	4	5	6	7	8	9	10
65℃80%		3850	3920	3978	4010	4220	4270	4324	4962	5227	5677
75℃80%		1745	1820	2320	3135	3616	4215	—	—	—	—
80℃80%		1591	1680	1805	1812	2094	2132	—	—	—	—
85℃80%		858	920	930	950	1074	1082	—	—	—	—

Table 1-4 (DVD-R D-Brand)

RAM	Brand	D									
	Disc	1	2	3	4	5	6	7	8	9	10
65℃80%		2710	2730	2740	2750	2750	3260	3452	3644	3784	3949
75℃80%		1670	1740	1747	1762	1840	2110	—	—	—	—
80℃80%		858	879	906	1020	1085	1210	—	—	—	—
85℃80%		391	413	435	630	650	650	—	—	—	—

Brand of DVD-R	time-to-failure(Year)	standard error
DVD-R A	154(Median)	0.244
DVD-R B	37(Median)	0.030
DVD-R C	17(Median)	0.031
DVD-R D	29(Median)	0.059

Table 2-1 (DVD-RW A-Brand)

RW	Brand	A									
	Disc	1	2	3	4	5	6	7	8	9	10
65℃80%		8304	13015	8065	7532	8009	—	—	—	—	—
75℃80%		1092	690	683	601	754	—	—	—	—	—
80℃80%		424	307	3744	306	376	—	—	—	—	—
85℃80%		98	92	123	102	103	—	—	—	—	—

Table 2-2 (DVD-RW B-Brand)

RW	Brand	B									
	Disc	1	2	3	4	5	6	7	8	9	10
65℃80%		9971	10004	9194	10832	9279	—	—	—	—	—
75℃80%		4435	4444	4438	4428	4419	—	—	—	—	—
—80℃80%		4408	4306	3927	4365	4431	—	—	—	—	—
85℃80%		1623	1599	1606	1662	2200	—	—	—	—	—

Table 2-3 (DVD-RW C-Brand)

RW	Brand	C									
	Disc	1	2	3	4	5	6	7	8	9	10
65℃80%		2607	2074	2509	4387	2016	—	—	—	—	—
75℃80%		1059	1062	1069	1061	1056	—	—	—	—	—
80℃80%		541	540	529	539	536	—	—	—	—	—
85℃80%		300	308	394	395	394	—	—	—	—	—

Brand of DVD-RW	time-to-failure(Year)	standard error
DVD-RW A	27925(Median)	30.34
DVD-RW B	54(Median)	0.200
DVD-RW C	28(Median)	0.044

Table 3-1 (DVD-RAM A-Brand)

RAM	Brand	A									
	Disc	1	2	3	4	5	6	7	8	9	10
65℃80%		10249	13543	8864	10819	8529	7568	9165	9114	10079	9630
75℃80%		4859	4252	3460	2126	1649	2019	—	—	—	—
80℃80%		1946	2618	1700	1705	1643	1744	—	—	—	—
85℃80%		586	587	539	389	532	505	—	—	—	—

Table 3-2 (DVD-RAM B-Brand)

RAM	Brand	B									
	Disc	1	2	3	4	5	6	7	8	9	10
65℃80%		6329	8758	6782	6547	7565	7047	7893	8030	4085	7406
75℃80%		3778	2745	3380	2307	1942	1799	—	—	—	—
80℃80%		1472	1388	1310	1015	1203	1239	—	—	—	—
85℃80%		590	599	529	389	532	505	—	—	—	—

Table 3-3 (DVD-RAM C-Brand)

RAM	Brand	C									
	Disc	1	2	3	4	5	6	7	8	9	10
65℃80%		8493	9243	7213	9292	8047	12223	5900	8365	8397	7401
75℃80%		3253	2587	4246	3369	5130	4860	—	—	—	—
80℃80%		1692	1179	4636	2006	1238	1611	—	—	—	—
85℃80%		925	600	1249	563	525	625	—	—	—	—

Table 3-4 (DVD-RAM D-Brand)

RAM	Brand	D									
	Disc	1	2	3	4	5	6	7	8	9	10
65℃80%		2469	1151	579	2504	3886	5496	2478	8277	560	6490
75℃80%		284	464	563	231	199	280	—	—	—	—
80℃80%		570	431	1101	467	1424	1127	—	—	—	—
85℃80%		178	146	209	124	104	121	—	—	—	—

Table 3-5 (DVD-RAM E-Brand)

RAM	Brand	E									
	Disc	1	2	3	4	5	6	7	8	9	10
65℃80%		6010	10337	10647	8209	14450	2726	2795	2160	560	6496
75℃80%		6076	3383	5593	2120	1216	1808	—	—	—	—
80℃80%		1613	1061	587	1301	746	2209	—	—	—	—
85℃80%		288	244	976	876	1036	959	—	—	—	—

Brand of DVD-RAM	time-to-failure(Year)	standard error
DVD-RAM A	611(Median)	2.452
DVD-RAM B	428(Median)	1.019
DVD-RAM C	377(Median)	1.254
DVD-RAM D	120(Median)	1.073
DVD-RAM E	130(Median)	1.334

【Program for calculate the 5%-point,median and mean value with 25℃】

```
    bootp1000=:3 :0

s=.1,.%273.15+85 80 75 65+#r=."
s0=.1,%273.15+25 [ n=.1000
while. n>#r
   do. r=.r,^+/s0*(^.>(([:?#){])L:0 y.)%.s
end.
(49 499{r),(+/%#)r=./:~r
)
```

```
    rept_d=:4 :0

r=.,."
while. x.>#r do.r=.r,bootp1000 y. end.
r=.m,:%:(+/*:r-"1 m=.(+/r)%n)%n*<:n=.#r
r;8.3":r%8766
)
```

```
RA65=:2000+349 370 382 437 690 692 780 850 910 940

RA75=:452 477 561 627 657 1197
RA80=:258 275 291 324 327 345
RA85=:184 198 211 211 213 221
RA=:RA85;RA80;RA75;RA65
RB65=:9000+1264 298 465 293 407
RB75=:6970 7110 7240 3731 3725 3728
RB80=:4428 3195 3148 3147
RB85=:2338 2177 2170 2060
RB=:RB85;RB80;RB75;RB65
RC65=:4000+_150 _80 _22 10 220 270 324 962 1227 1677
RC75=:1745 1820 2320 3135 3616 4215
RC80=:1591 1680 1805 1812 2094 2132
RC85=:858 920 930 950 1074 1082
RC=:RC85;RC80;RC75;RC65
RD65=:2000+710 730 740 750 750
RD65=:RD65,3000+260 452 644 784 949
RD75=:1670 1740 1747 1762 1840 2110
RD80=:858 879 906 1020 1085 1210
RD85=:391 413 435 630 650 650
RD=:RD85;RD80;RD75;RD65
```

```
RWA65=:8304 13015 8065 7532 8009

RWA75=:1092 690 683 601 754
RWA80=:424 307 374 306 376
RWA85=:98 92 123 102 103
RWA=:RWA85;RWA80;RWA75;RWA65
RWB65=:9971 10004 9194 10832 9279
RWB75=:4435 4444 4438 4428 4419
RWB80=:4408 4306 3927 4365 4431
RWB85=:1623 1599 1606 1662 2200
RWB=:RWB85;RWB80;RWB75;RWB65
RWC65=:2607 2074 2509 4387 2016
RWC75=:1059 1062 1069 1061 1056
RWC80=:541 540 529 539 536
RWC85=:300 308 394 595 394
RWC=:RWC85;RWC80;RWC75;RWC65
```

RAMA65=:10249 13543 8864 10819 8529 7568 9165 9114 10079 9630

RAMA75=:4859 4252 3460 2126 1649 2019

RAMA80=:1946 2616 1700 1705 1643 1744

RAMA85=:586 587 539 952 864 425

RAMA=:RAMA85;RAMA80;RAMA75;RAMA65

RAMB65=:6329 8758 6782 6547 7565 7047 7893 8030 4085 7406

RAMB75=:3776 2746 3380 2307 1942 1799

RAMB80=:1472 1388 1310 1015 1203 1239

RAMB85=:590 599 529 389 532 505

RAMB=:RAMB85;RAMB80;RAMB75;RAMB65

RAMC65=:8493 9243 7213 7292 8047 12223 5900 8365 9397 7401

RAMC75=:3253 2587 4246 3369 5130 4860

RAMC80=:1692 1179 4636 2006 1238 1611

RAMC85=:825 600 1249 563 526 625

RAMC=:RAMC85;RAMC80;RAMC75;RAMC65

RAMD65=:2469 1151 579 2504 3886 6496 2478 8277 560 8496

RAMD75=:284 464 563 231 199 280

RAMD80=:570 431 1101 467 1424 1127

RAMD85=:178 146 209 124 104 121

RAMD=:RAMD85;RAMD80;RAMD75;RAMD65

RAME65=:6010 10337 10647 8209 14450 2726 2795 2150 3865 3224

RAME75=:6078 3383 5593 2120 1216 1808

RAME80=:1613 1061 587 1301 746 2209

RAME85=:288 244 876 876 1036 959

RAME=:RAME85;RAME80;RAME75;RAME65

bootp1000 RA

739855 1.38818e6 1.44756e6

10 rept_d RA

745990 1.34765e6 1.43634e6 4590.64 6959.63 3809.67	85.100 153.736 163.853 0.524 0.794 0.435

【Left hand of box gives the 5％-point,median and mean value with 25℃ and right handgives translated year.】

100 rept_d RA

749015 1.3557e6 1.42978e6 1250.27 2151.04 1741.01	85.446 154.654 163.105 0.143 0.245 0.199

100 rept_d RA

746296 1.34965e6 1.4266e6 1205.02 2142.41 1892.85	85.135 153.965 162.742 0.137 0.244 0.216

100 rept_d RA

745382 1.35398e6 1.42649e6 1294.47 2375.52 1790.93	85.031 154.458 162.729 0.148 0.271 0.204

100 rept_d RB

213879 325151 339658 414.683 260.984 310.926	24.399 37.092 38.747 0.047 0.030 0.035

100 rept_d RC

77296.6 144933 180108 157.03 268.419 276.472	8.818 16.533 20.546 0.018 0.031 0.032

100 rept_d RD

89526.1 252438 316878 99.5281 517.629 732.15	10.213 28.797 36.149 0.011 0.059 0.084

100 rept_d RWA

1.37172e8 2.44794e8 4.13109e8	15648.227 27925.387 47126.237

324221 265978 1.35461e6	36.986 30.342 154.530

100 rept_d RWB

225945 470325 486022 340.087 1752.84 481.996	25.775 53.653 55.444 0.039 0.200 0.055

100 rept_d RWC

55757.7 248049 563783 105.286 382.373 2440.66	6.361 28.297 64.315 0.012 0.044 0.278

100 rept_d RAMA

1.43377e6 5.36017e6 7.1959e6 5390.39 21493.2 21561.3	163.560 611.473 820.887 0.615 2.452 2.460

100 rept_d RAMB

555028 3.75195e6 4.24927e6 3594.51 8929.5 9028.73	63.316 428.012 484.745 0.410 1.019 1.030

100 rept_d RAMC

587459 3.30482e6 4.59363e6 3720.96 10990.8 15197.4	67.016 377.004 524.029 0.424 1.254 1.734

100 rept_d RAMD

3692.07 1.04986e6 1.40041e7 31.2246 9410.05 86858.2	0.421 119.765 1597.550 0.004 1.073 9.909

100 rept_d RAME

26077.4 1.14295e6 1.49051e7 198.96 11696.9 152117	2.975 130.384 1700.328 0.023 1.334 17.353

Bootstrap method advocated by B.Efron(1979) can give the effective solution for

the problem which is hard to approach by some analytic methods.

The main point of this method is that “the process of analytic methods” is replaced by “the many time repetition of calculations using computer”. By this powerful method, various complicated problems are able to solve under very loose conditions.

B.Efron(1979):Bootstrap methods:Another look at the jackknife.**Ann.Statist.**7,1-26.
A.C.Davison,D.V.Hinkley and G.A.Young(2003).Recent developments bootstrap methodology. **Statistical Science**,18-2,141-157.