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RELIABILITY TEST PLANS BASED ON LOG-LOGISTIC DISTRIBUTION

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ABSTRACT

The well known Log-Logistic Distribution as suggested by Balakrishnan et al.(1987) is considered with a known shape parameter(β = 3). In reliability studies the item that are put to test, to collect the life of the items in order to decide upon accepting or rejecting a submitted lot, are called reliability test plans. For a given producer's risk, sample size, termination number and waiting time to terminate the test plan are computed. The preferability of the test plan over similar plans existing in the literature are established.

KEYWORDS

Log-Logistic distribution (β = 3), Reliability test plan, Producers risk, Acceptance sample number.

1. INTRODUCTION

A life test is an experiment that is conducted to determine whether or not a product needs the specified requirements for average life. Generally in such a test fixed number of products taken as a sample out of a submitted lot of those products. To decide upon acceptance or otherwise of the lot on the basis of the observed life times of sampled test procedure requires a specification of sample size, a terminating rule to arrive at a decision, the criterion that defines, the preferability or otherwise of the lot and above all the risks associated with the decisions. Since exponential distribution the CFR model the central distribution in reliability studies, Epstein (1954) developed reliability test plans for exponential distribution. Truncated live of this type are developed by Sobel & Tischendrof (1959) for exponential distribution. Gupta & Groll (1961) constructed similar sampling plans based gamma life test sample data. Goode & Kao (1961) constructed sampling plans based on Weibull distribution. Kantam & Rosaiah (1998) suggested acceptance sampling plans based on life tests when the failure density model of the products is half-logistic distribution. The reliability test plans based on gamma variate was suggested by Kantam & SriRam (2010). Kantam *et al.* (2012) constructed similar reliability test plans for exponentiated exponential distribution.

In this paper we present a different approach to the construction of sampling plans for Log logistic distribution with shape parameter (β = 3) following Braverman (1981, Ch II). By considering the Log logistic distribution (β = 3) as the failure density governing the life times of the product in the submitted lot and made an attempt to construct the necessary test plan that can be used to decide upon accepting or otherwise of the submitted lot of product. Rosaiah *et al.* (2008) suggested similar plans for Inverse Rayleigh distribution, the operating characteristic of such plan are also presented. The necessary theory of the present plans is given in Section 2, the operating characteristics are given in Section 3, and comparative study is presented in Section 4.

2 RELIABILITY TEST PLANS

Let a lot of products of indefinitely large size be submitted for sampling inspection and decision to reject or accept. Let us assume that the probability density function of life of a product is a Log Logistic distribution (β = 3) with scale parameter σ, whose probability density function f(x, σ), cumulative distribution function F(x, σ) are given in equations

$$f(x) = \frac{3}{\sigma}\frac{\left(\frac{x}{\sigma}\right)^2}{\left(1+\left(\frac{x}{\sigma}\right)^3\right)^2};\ x > 0, \sigma > 0 \qquad (2.1)$$

$$F(x) = \frac{\left(\frac{x}{\sigma}\right)^3}{\left(1+\left(\frac{x}{\sigma}\right)^3\right)};\ x > 0,\ \sigma > 0 \qquad (2.2)$$

Let 'α' be the probability of rejecting the submitted lot that is truly good in some sense- known as producer's risk. Naturally 'α' should be as small as possible. We can think of the decision making in two different ways.

(i) Let σ_o be a specified value of σ representing the mean life of the product and 't_o' be pre-assigned time at which the life testing experiment of sample products is designed to be terminated. Hence 't_o' may be called "Terminating time". Gupta & Groll (1961) suggested the minimum sample size required is 'n' and an acceptance number c, such that if c or less failures occur out of 'n', before the time 't_o', the lot would be accepted with a probability (1- α). This approach is basically counting number of failures out of n, with in the terminating time 't_o' and hence the life testing experiment would be stopped as soon as the time 't_o'

is reached or (c+1)st failure is realized whichever is earlier. A typical table of Srinivasa Rao (2001) is reproduced here in order to illustrate by an example and presented in Table 2.1

Suppose an experimenter wishes (Gupta & Groll 1961, p.g. 952) to know that the true mean life $1.5\sigma_0$ is atleast 5000 hours with probability 0.95 and the experiment designed to stop at 1000 hours after starting. For an acceptance number c = 2 from the above table the minimum sample size required is the entry corresponding to c = 2, $t_o/\sigma_o = 0.5995$ and this is 34. Hence it is suggested that if 34 products are put to test at time "0" with an aim of stopping the test at the 1000th hour, we accept the lot with probability of 0.95, if the number of failures before the 1000th hour is less than or equal to 2. The lot shall be rejected of the number of failures with in 1000th hour is 3 or more.

(ii) Alternatively one can think of another reliability test plan. Let 'n' stand for the number of sampled items to be inspected and 'r' be natural number such that if 'r' failures are realized before the termination time 't_o' the lot would be rejected, that is the experiment is stopped as soon as r^{th} failure is reached or termination time 't_o' is reached whichever is earlier and in this sense 'r' is called termination number. The sample size naturally depends on cost considerations and expected waiting time to reach a decision. Large sample sizes may decrease expected waiting time but increase cost of experimentation. As a balance between these two aspects, let us consider the sample size as a multiple of termination number.

We know that the probability of 'r' failures out of 'n' tested items is given by

$\binom{n}{r} p^r q^{n-r}$ where p= F(x, σ) the cumulative distribution function of the log-logistic distribution, hence acceptance probability of lot is

$$P_a = \sum_{i=0}^{r-1} \binom{n}{r} p^r q^{n-r} \qquad (2.3)$$

For specified producer's risk say α, termination number r, sample size 'n' as a multiple of 'r' we can write the above equation as

$$\sum_{i=0}^{r-1} \binom{kr}{r} p^r q^{kr-r} = 1-\alpha \qquad (2.4)$$

Using the cumulative probability of binomial distribution the above equation can be solved for p. Equating F(x,σ) to p we can get the value of x/ σ corresponding to p, that is x/σ is the solution of

$$F(x;\sigma) = \frac{\left(\frac{x}{\sigma}\right)^3}{\left(1+\left(\frac{x}{\sigma}\right)^3\right)} = p \qquad (2.5)$$

As an example suppose we have to construct a life test sampling plan with an acceptance probability of 0.95 for lots with an acceptable mean life of 1000 hours and termination number 5, sample size 10. From Table 2.2 the entry against r = 5 under the column 2r is 0.241702, since the acceptable mean life is given to be 660 hours. For a log-logistic distribution this implies $\sigma_0 = 660$. If the termination time is given by 't_0' the table value says that $t/1.5\sigma_0 = 0.241702$, ie., $t_0 = 660\times0.241702 = 158.5232 = 159$.

This test plan will be implemented as follows: Select 10 items from the submitted lot and put them to test if the 5th failure is realized before 159th hour of the test reject the lot, otherwise accept the lot in either case terminating the experiment as soon as the 5th failure is reached or 159th hour of the test time is reached whichever is earlier. In the case of acceptance the assurance is that the average life of the submitted products is at least 660 hours.

As a comparison of our test plan with that of Srinivasa Rao (2001) for α =0.25, 0.10, 0.05, 0.01. Using the common entries for n, r (=c+1) in both approaches. The termination times for average life are given in Table 2.3.

We have tabulated from the above Equations 2.2, 2.3 the values of x/σ for α =0.25, 0.10, 0.05, 0.01; r=1(1)10, k=2(1)10, in Table 2.2 for log-logistic distribution and these tables can be another reliability test plans. These tables show that for the same α, sample size acceptance number, termination time of second approach is much earlier than in the first approach. Resulting in a considerable saving in the waiting time to come to a decision for any specified value of 'σ'.

3 OPERATING CHARACTERISTIC CURVE

If the true but unknown life of the product deviates from the specified life of the product, it should result in a considerable change in the probability of acceptance of the lot based on the sampling plan. Hence the probability of acceptance can be regarded as a function of the deviation of specified average from the true average. This function is called operating characteristic function of the sampling plan, hence the operating characteristic lies between 0 and 1. Specifically if F (T/σ) is the cumulative distribution function of the life time random variable of the product, σ_0 corresponds to specified life, we can write

$$F\left(\frac{T}{\sigma}\right) = \left(\frac{T}{\sigma}, \frac{\sigma_0}{\sigma}\right) \qquad \text{....(3.1)}$$

where σ corresponds to true but unknown average life. The ratio σ_0/σ in the R.H.S of above equation can be taken as a measure of changes between true and specified lives. For instance $\sigma_0/\sigma < 1$ implies true mean life is more than the declared life leading to more acceptance probability or less failure risk. Similarly σ_0/σ more than 1 implies less acceptance probability or more failure risk. Hence giving a set of hypothetical values say $\sigma_0/\sigma = 0.1(0.1)0.9$ we can have the corresponding acceptance probabilities of acceptance given by Equation (2.3) for a sampling plan forms the O.C. curve of the plan. Here we have selected some plans and O.C. values of these plans are given in Tables 3.1 to 3.8 and the graph between σ_0/σ, the probability of acceptance given by Equation 3.1 for a sampling plan forms the O.C. curve of the plans and were given by the Figures 1 to 8.

4 COMPARATIVE STUDY

The upper entry in each occupied cell of Table (4.1) corresponds to the proportion of termination time of the test plan in the present paper. The lower entry corresponds to the similar quantity of the sampling plan of Srinivasa Rao (2001). These entries reveal that the terminating time of this test plan is uniformly smaller than the corresponding time of the plan in Srinivasa Rao (2001). Therefore, the present test plans would result in saving the experimental time in order to decide to accept or reject a submitted lot on the basis of the sample times taken from the lot.

TABLE 4.1: LLD COMMON ENTRIES OF SCALED TERMINATION TIME (t/σ_0)

	n r c	2r	3r	4r	5r	6r	8r
(1- α)=0.25	1 0	261 1200	94 899				36 599
	2 1	267 1200	171 899				
	3 2	337 1200	210 899				
0.1	1 0	52 1500	35 1200		21 899		
	2 1	150 1500		71 899			
0.05	1 0	25 2249	17 1200			8 899	
	2 1	101 1500	64 1200		37 899		
0.01	1 0	5 2249		27 1500	20 1200		
	2 1	43 2249	27 1500	20 1200			

The first entry in above table corresponds to test plan by our approach and the second one relates to that of Srinivasa Rao (2001).

CONCLUSION

In this paper an acceptance decision rule is developed based on the life test when the life distribution of test items follows log-logistic distribution, its shape parameter (β = 3), for the use of plans by the practitioners.

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TABLES

TABLE 2.1: LOG LOGISTIC DISTRIBUTION RELIABILITY TEST PLANS GIVES CONSUMERS RISK

P*	c	t/σ_0 0.5995	0.8994	1.2	1.5	2.2494	2.9991	3.7495	4.4991
0.75	0	8	3	2	1	1	1	1	1
	1	15	6	4	3	2	2	2	2
	2	22	9	6	4	3	3	3	3
	3	38	11	7	6	5	4	4	4
	4	35	14	9	7	6	5	5	5
	5	41	17	11	9	7	6	6	6
	6	47	19	13	10	8	7	7	7
	7	54	22	14	11	9	9	8	8
	8	60	25	16	13	10	10	9	9
	9	66	27	18	14	11	11	10	10
	10	72	30	19	15	13	12	11	11
	11	79	32	21	17	14	13	12	12
	12	85	35	23	18	15	14	13	13
	13	91	37	24	20	16	15	14	14
	14	97	40	26	21	17	16	15	15
	15	103	42	28	22	18	17	17	16
0.90	0	12	5	3	2	1	1	1	1
	1	21	8	5	4	3	2	2	2
	2	29	11	7	5	4	4	3	3
	3	36	14	9	7	5	5	4	4
	4	44	17	11	8	6	6	5	5
	5	51	20	13	10	8	7	7	6
	6	58	23	14	11	9	8	8	7
	7	64	26	16	13	10	9	9	8
	8	71	29	18	14	11	10	10	9
	9	78	31	20	16	12	11	11	11
	10	84	34	22	17	13	12	12	12
	11	91	37	23	18	14	13	13	13
	12	98	40	25	20	16	14	14	14
	13	104	42	27	21	17	15	15	15
	14	111	45	29	23	18	17	16	16
	15	117	48	30	24	19	18	17	17
0.95	0	16	6	3	3	2	1	1	1
	1	25	10	6	4	3	3	2	2
	2	34	13	8	6	4	4	4	3
	3	42	16	10	8	6	5	5	4
	4	49	19	12	9	7	6	6	6
	5	57	22	14	11	8	7	7	7
	6	64	25	16	12	9	8	8	8
	7	71	28	18	14	10	9	9	9
	8	79	31	19	15	12	10	10	10
	9	86	34	21	17	13	12	11	11
	10	93	37	23	18	14	13	12	12
	11	99	40	25	19	15	14	13	13
	12	106	43	27	21	16	15	14	14
	13	113	45	29	22	17	16	15	15
	14	120	48	30	24	19	17	16	16
	15	127	51	32	25	20	18	17	17
0.99	0	24	9	5	4	2	2	2	2
	1	35	13	8	6	4	3	3	3
	2	45	17	10	7	5	4	4	4
	3	54	20	12	9	6	6	5	5
	4	62	24	14	11	8	7	6	6
	5	70	27	16	12	9	8	7	7
	6	78	30	18	14	10	9	8	8
	7	86	34	20	15	11	10	10	9
	8	94	37	22	17	13	11	11	10
	9	101	40	24	19	14	12	12	11
	10	109	43	26	20	15	14	13	12
	11	116	46	28	22	16	15	14	13
	12	124	49	30	23	17	16	15	14
	13	131	52	32	25	19	17	16	16
	14	138	55	34	26	20	18	17	17
	15	145	57	36	28	21	19	18	18

TABLE 2.2: LOG-LOGISTIC DISTRIBUTION RELIABILITY TEST PLAN GIVEN PRODUCER'S RISK

(1- α)	r\n	2r	3r	4r	5r	6r	7r	8r	9r	10r
0.75	1	0.260613	0.094470	0.071313	0.057019	0.04781	0.040841	0.035877	0.031965	0.028768
	2	0.267056	0.171122	0.126048	0.100004	0.082655	0.070387	0.061592	0.044635	0.049072
	3	0.333710	0.210630	0.153795	0.121295	0.100472	0.085635	0.074460	0.065982	0.059106
	4	0.375902	0.234647	0.171121	0.134758	0.111110	0.094470	0.082235	0.072877	0.065259
	5	0.404641	0.251320	0.182848	0.143804	0.118184	0.100942	0.087799	0.077682	0.069767
	6	0.426695	0.263690	0.191613	0.150224	0.123922	0.052300	0.091769	0.080979	0.072877
	7	0.443546	0.273013	0.197829	0.155600	0.128194	0.109126	0.094924	0.083925	0.075259
	8	0.455909	0.280803	0.203457	0.159857	0.120295	0.111601	0.097215	0.086065	0.077275
	9	0.467276	0.286964	0.207742	0.162940	0.134203	0.114108	0.099069	0.087799	0.078910
	10	0.476279	0.292318	0.211356	0.166058	0.136428	0.116136	0.100942	0.089111	0.080148
0.90	1	0.052305	0.035076	0.026430	0.021046	0.017572	0.015857	0.013147	0.011776	0.010628
	2	0.150224	0.095237	0.070538	0.055650	0.045949	0.039182	0.034283	0.030467	0.027352
	3	0.216481	0.135870	0.099069	0.078090	0.064501	0.054972	0.047810	0.042346	0.037786
	4	0.262853	0.163561	0.118699	0.093114	0.076870	0.065239	0.057019	0.050352	0.045034
	5	0.296831	0.183514	0.133099	0.104269	0.086065	0.073271	0.063401	0.056332	0.050352
	6	0.323000	0.198527	0.143804	0.113018	0.093114	0.078910	0.068620	0.060876	0.054630
	7	0.343664	0.211356	0.152599	0.119734	0.098603	0.083950	0.072877	0.064501	0.057710
	8	0.361079	0.221684	0.159857	0.125514	0.103312	0.087799	0.076060	0.067483	0.060519
	9	0.375902	0.230018	0.166058	0.130361	0.107168	0.090877	0.079321	0.070152	0.062674
	10	0.387864	0.236984	0.171760	0.134203	0.110607	0.094017	0.081396	0.072093	0.064501
0.95	1	0.025749	0.017207	0.012835	0.010351	0.008650	0.007345	0.000646	0.005763	0.005194
	2	0.101414	0.064503	0.047185	0.037235	0.030962	0.026431	0.002291	0.020443	0.018315
	3	0.162321	0.101414	0.073667	0.058057	0.047810	0.040892	0.035610	0.031461	0.028292
	4	0.207742	0.128730	0.093115	0.073271	0.060520	0.051232	0.044731	0.039464	0.035342
	5	0.241702	0.149045	0.108144	0.084778	0.069767	0.059457	0.051651	0.045643	0.040891
	6	0.269598	0.165432	0.119734	0.094017	0.077275	0.065610	0.057019	0.050353	0.045338
	7	0.292318	0.178887	0.129275	0.090070	0.083501	0.070925	0.061592	0.054299	0.048756
	8	0.310658	0.190248	0.136968	0.107656	0.088673	0.075259	0.065239	0.057710	0.051651
	9	0.326866	0.199282	0.144381	0.113101	0.092665	0.078910	0.068620	0.060520	0.054299
	10	0.340656	0.207742	0.150224	0.117670	0.096755	0.081815	0.071313	0.063037	0.056332
0.99	1	0.005103	0.003350	0.002542	0.002036	0.017039	0.001435	0.001276	0.001204	0.001006
	2	0.042641	0.027120	0.019851	0.157880	0.012990	0.011051	0.009677	0.008527	0.007690
	3	0.087364	0.069147	0.039747	0.031212	0.025749	0.021863	0.019075	0.016846	0.015103
	4	0.138038	0.078090	0.056675	0.044429	0.036417	0.030962	0.027120	0.026022	0.021453
	5	0.159244	0.097676	0.070538	0.055310	0.045643	0.038620	0.033501	0.029732	0.026660
	6	0.186190	0.114108	0.080230	0.064501	0.052965	0.045034	0.039181	0.034546	0.030962
	7	0.201983	0.128194	0.092216	0.072485	0.058396	0.050352	0.043829	0.038620	0.034811
	8	0.229252	0.139804	0.100942	0.078910	0.063606	0.054064	0.047810	0.042346	0.037786
	9	0.246481	0.150224	0.108144	0.084778	0.069767	0.059106	0.051324	0.045338	0.040604
	10	0.262018	0.159245	0.115119	0.089992	0.072037	0.062674	0.054299	0.048124	0.043233

TABLE 3.1: LOG-LOGISTIC DISTRIBUTION O.C. VALUES OF SELECTED RELIABILITY TEST PLANS FOR A GIVEN CONSUMER'S RISK

	n=2,r=1	n=3,r=1	n=8,r=1	n=4,r=2	n=6,r=2	n=6;r=3	n=9;r=3
	t/σ_0=1.2	t/σ_0=0.8994	t/σ_0=0.5995	t/σ_0=1.2	t/σ_0=0.8994	t/σ_0=1.2	t/σ_0=0.8994
	P_a	P_a	P_a	P_a	P_a	P_a	P_a
σ_0/σ	1-α=0.75	1-α=0.75	1-α=0.75	1-α=0.75	1-α=0.75	1-α=0.75	1-α=0.75
0.1	0.996553	0.997821	0.998278	0.999982	0.999992	1.000000	1.000000
0.2	0.972915	0.982740	0.986317	0.998905	0.999505	0.999951	0.999984
0.3	0.912835	0.943311	0.954656	0.988775	0.994713	0.998400	0.999449
0.4	0.810757	0.872377	0.896227	0.948108	0.973659	0.984333	0.993958
0.5	0.676290	0.770183	0.808471	0.852534	0.916856	0.926653	0.966817
0.6	0.530276	0.645404	0.694953	0.701011	0.809307	0.794636	0.888088
0.7	0.394212	0.512557	0.565301	0.523835	0.656072	0.601939	0.738963
0.8	0.281513	0.386777	0.432940	0.359710	0.483947	0.402688	0.540869
0.9	0.195837	0.278999	0.311258	0.231602	0.325551	0.243057	0.345314
1	0.134373	0.193961	0.209929	0.142859	0.201845	0.136252	0.194123
1.1	0.091829	0.131125	0.133037	0.086011	0.117093	0.072904	0.098012
1.2	0.062940	0.086955	0.079500	0.051277	0.064596	0.038063	0.045507
1.3	0.043468	0.057000	0.045031	0.030552	0.034409	0.019709	0.019883
1.4	0.030334	0.037172	0.024330	0.018372	0.017932	0.010235	0.008343
1.5	0.021424	0.024237	0.012627	0.011166	0.009242	0.005371	0.003419
1.6	0.015325	0.015862	0.006340	0.006884	0.004750	0.002861	0.001387
1.7	0.011104	0.010447	0.003101	0.004311	0.002450	0.001551	0.000562
1.8	0.008149	0.006938	0.001487	0.002743	0.001274	0.000858	0.000230
1.9	0.006054	0.004652	0.000704	0.001774	0.000670	0.000484	0.000000

TABLE 3.2 LOG-LOGISTIC DISTRIBUTION O.C. VALUES OF SELECTED RELIABILITY TEST PLANS FOR A GIVEN PRODUCER'S RISK

	n=2,r=1	n=3,r=1	n=8,r=1	n=4,r=2	n=6,r=2	n=6;r=3	n=9;r=3
	t/σ_0=0.260613	t/σ_0=0.09947	t/σ_0=0.035877	t/σ_0=0.267056	t/σ_0=0.171122	t/σ_0=0.333710	t/σ_0=0.210630
	P_a	P_a	P_a	P_a	P_a	P_a	P_a
σ_0/σ	1-α=0.75	1-α=0.75	1-α=0.75	1-α=0.75	1-α=0.75	1-α=0.75	1-α=0.75
0.1	0.999965	0.999997	1.000000	1.000000	1.000000	1.000000	1.000000
0.2	0.999717	0.999980	0.999997	1.000000	1.000000	1.000000	1.000000
0.3	0.999045	0.999932	0.999990	0.999998	1.000000	1.000000	1.000000
0.4	0.997738	0.999838	0.999976	0.999991	0.999998	1.000000	1.000000
0.5	0.995589	0.999684	0.999954	0.999966	0.999994	0.999998	1.000000
0.6	0.992397	0.999454	0.999992	0.999900	0.999998	0.999990	0.999999
0.7	0.987967	0.999133	0.999873	0.999749	0.999996	0.999961	0.999997
0.8	0.982118	0.998706	0.999811	0.999448	0.999902	0.999875	0.999991
0.9	0.974684	0.998158	0.999731	0.998895	0.999803	0.999654	0.999975
1	0.965517	0.997475	0.999631	0.997560	0.999632	0.999152	0.999936
1.1	0.954495	0.996641	0.999508	0.996452	0.999353	0.998120	0.999853
1.2	0.941523	0.995642	0.999362	0.994164	0.998920	0.996174	0.999686
1.3	0.926536	0.994464	0.999189	0.990832	0.998272	0.992773	0.999376
1.4	0.909504	0.993092	0.998987	0.986161	0.997359	0.987213	0.998828
1.5	0.890434	0.991512	0.998754	0.979835	0.996032	0.978658	0.997910
1.6	0.869369	0.989711	0.998488	0.971527	0.994251	0.966198	0.996440
1.7	0.846390	0.987676	0.998187	0.960921	0.991880	0.948942	0.994182
1.8	0.821614	0.985393	0.997848	0.947727	0.988794	0.926130	0.990838
1.9	0.795193	0.982850	0.998747	0.931704	0.984852	0.897245	0.986058

TABLE 3.3 LOG-LOGISTIC DISTRIBUTION O.C. VALUES OF SELECTED RELIABILITY TEST PLANS FOR A GIVEN CONSUMER 'S RISK

	n=2,r=1	n=3,r=1	n=5,r=1	n=4,r=2	n=8,r=2
	t/σ_0=1.5	t/σ_0=1.2	t/σ_0=0.8994	t/σ_0=1.5	t/σ_0=0.8994
	P_a	P_a	P_a	P_a	P_a
σ_0/σ	1-α=0.90	1-α=0.90	1-α=0.90	1-α=0.90	1-α=0.90
0.1	0.993284	0.994834	0.996370	0.999932	0.999985
0.2	0.948111	0.959649	0.971400	0.995997	0.999084
0.3	0.839945	0.872144	0.907315	0.962666	0.999038
0.4	0.67629	0.730023	0.796478	0.852534	0.953654
0.5	0.494626	0.556159	0.647128	0.657511	0.861019
0.6	0.334511	0.386147	0.482007	0.438190	0.702189
0.7	0.214807	0.247511	0.328274	0.259802	0.504168
0.8	0.134373	0.149365	0.205322	0.142859	0.316068
0.9	0.083513	0.086664	0.119126	0.075613	0.174257
1	0.052245	0.049257	0.064991	0.039578	0.085976
1.1	0.033153	0.027827	0.033844	0.020848	0.038817
1.2	0.021424	0.01579	0.017067	0.011166	0.016410
1.3	0.014122	0.009063	0.008442	0.006115	0.006635
1.4	0.009498	0.005283	0.004140	0.003432	0.002612
1.5	0.006513	0.003136	0.002030	0.001975	0.001016
1.6	0.004551	0.001897	0.001001	0.001166	0.000395
1.7	0.003235	0.00117	0.000499	0.000705	0.000154
1.8	0.002338	0.000736	0.000252	0.000436	0.000000

TABLE 3.4 LOG-LOGISTIC DISTRIBUTION O.C. VALUES OF SELECTED RELIABILITY TEST PLANS FOR A GIVEN PRODUCER'S RISK

	n=2,r=1	n=3,r=1	n=5,r=1	n=4,r=2	n=8,r=2
	t/σ_0=0.052305	t/σ_0=0.035076	t/σ_0=0.021046	t/σ_0=0.150224	t/σ_0=0.070538
	P_a	P_a	P_a	P_a	P_a
σ_0/σ	1-α=0.90	1-α=0.90	1-α=0.90	1-α=0.90	1-α=0.90
0.1	1.000000	1.000000	1.000000	1.000000	1.000000
0.2	0.999998	0.999999	1.000000	1.000000	1.000000
0.3	0.999992	0.999997	0.999999	1.000000	1.000000
0.4	0.999982	0.999992	0.999997	1.000000	1.000000
0.5	0.999964	0.999984	0.999994	0.999999	1.000000
0.6	0.999938	0.999972	0.999990	0.999997	1.000000
0.7	0.999902	0.999956	0.999984	0.999992	1.000000
0.8	0.999853	0.999934	0.999976	0.999982	0.999999
0.9	0.999791	0.999906	0.999966	0.999964	0.999998
1	0.999714	0.999871	0.999953	0.999932	0.999997
1.1	0.999619	0.999828	0.999938	0.999880	0.999994
1.2	0.999506	0.999776	0.999919	0.999798	0.999990
1.3	0.999372	0.999716	0.999898	0.999675	0.999983
1.4	0.999215	0.999645	0.999872	0.999497	0.999974
1.5	0.999035	0.999563	0.999843	0.999244	0.999961
1.6	0.998829	0.999470	0.999809	0.998895	0.999943
1.7	0.998595	0.999364	0.999771	0.998425	0.999918
1.8	0.998333	0.999245	0.999728	0.997803	0.999884
1.9	0.998040	0.999113	0.999680	0.996995	0.999840

TABLE 3.5 LOG-LOGISTIC DISTRIBUTION O.C. VALUES OF SELECTED RELIABILITY TEST PLANS FOR A GIVEN CONSUMER 'S RISK

	n=2,r=1	n=3,r=1	n=6,r=1	n=4,r=2	n=6,r=2	n=10,r=2
	t/σ_0=2.2496	t/σ_0=1.2	t/σ_0=0.8994	t/σ_0=1.5	t/σ_0=1.2	t/σ_0=0.8994
	P_a	P_a	P_a	P_a	P_a	P_a
σ_0/σ	1-α=0.95	1-α=0.95	1-α=0.95	1-α=0.95	1-α=0.95	1-α=0.95
0.1	0.977613	0.994833	0.995645	0.999782	0.999994	0.999976
0.2	0.840020	0.959648	0.965778	0.988531	0.996288	0.998539
0.3	0.585051	0.872143	0.889834	0.903477	0.964186	0.984930
0.4	0.334661	0.730022	0.761042	0.677225	0.851290	0.929760
0.5	0.170321	0.556139	0.593182	0.388282	0.639060	0.799619
0.6	0.083556	0.386147	0.416547	0.175065	0.392276	0.597436
0.7	0.041566	0.247511	0.262714	0.067431	0.198105	0.376686
0.8	0.021444	0.149360	0.149596	0.024212	0.085164	0.199193
0.9	0.011564	0.086664	0.077840	0.008633	0.032610	0.089457
1	0.006519	0.049250	0.037620	0.003171	0.011650	0.034954
1.1	0.003832	0.027827	0.017194	0.001219	0.004010	0.012237
1.2	0.002339	0.015790	0.007561	0.000493	0.001371	0.003953
1.3	0.001479	0.009060	0.003490	0.000210	0.000400	0.001210
1.4	0.000962	0.005280	0.001381	0.000000	0.000160	0.000359
1.5	0.000643	0.003135	0.000587	0.000000	0.000000	0.000105
1.6	0.000440	0.001897	0.000251	0.000000	0.000000	0.000000
1.7	0.000308	0.001170	0.000109	0.000000	0.000000	0.000000
1.8	0.000220	0.000736	0.000000	0.000000	0.000000	0.000000
1.9	0.000160	0.000471	0.000000	0.000000	0.000000	0.000000

TABLE 3.6 LOG-LOGISTIC DISTRIBUTION O.C. VALUES OF SELECTED RELIABILITY TEST PLANS FOR A GIVEN PRODUCER'S RISK

	n=2,r=1	n=3,r=1	n=6,r=1	n=4,r=2	n=6,r=2	n=10,r=2
	t/σ_0=0.002749	t/σ_0=0.0170207	t/σ_0=0.008650	t/σ_0=0.10140	t/σ_0=0.064503	t/σ_0=0.037235
	P_a	P_a	P_a	P_a	P_a	P_a
σ_0/σ	1-α=0.95	1-α=0.95	1-α=0.95	1-α=0.95	1-α=0.95	1-α=0.95
0.1	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
0.2	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
0.3	0.999999	1.000000	1.000000	1.000000	1.000000	1.000000
0.4	0.999998	0.999999	1.000000	1.000000	1.000000	1.000000
0.5	0.999996	0.999998	1.000000	1.000000	1.000000	1.000000
0.6	0.999993	0.999997	0.999999	1.000000	1.000000	1.000000
0.7	0.999990	0.999995	0.999999	0.999999	1.000000	1.000000
0.8	0.999984	0.999992	0.999998	0.999998	1.000000	1.000000
0.9	0.999978	0.999989	0.999997	0.999997	0.999999	1.000000
1	0.999970	0.999985	0.999996	0.999993	0.999999	1.000000
1.1	0.999960	0.999980	0.999995	0.999988	0.999998	1.000000
1.2	0.999948	0.999974	0.999993	0.999981	0.999997	1.000000
1.3	0.999933	0.999966	0.999991	0.999969	0.999995	0.999999
1.4	0.999917	0.999958	0.999989	0.999951	0.999992	0.999999
1.5	0.999898	0.999948	0.999987	0.999927	0.999988	0.999999
1.6	0.999876	0.999937	0.999984	0.999892	0.999982	0.999998
1.7	0.999851	0.999925	0.999981	0.999845	0.999974	0.999997
1.8	0.999823	0.999911	0.999977	0.999782	0.999964	0.999996
1.9	0.999792	0.999895	0.999973	0.999700	0.999950	0.999994

TABLE 3.7 LOG-LOGISTIC DISTRIBUTION O.C. VALUES OF SELECTED RELIABILITY TEST PLANS FOR A GIVEN CONSUMER'S RISK

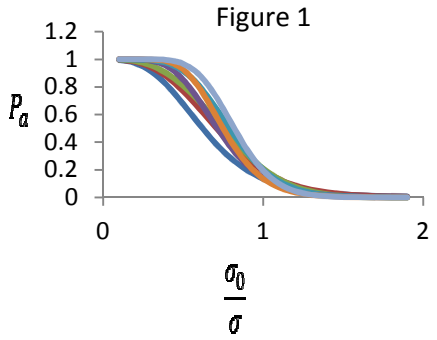
	n=2,r=1	n=4,r=1	n=5,r=1	n=4,r=2	n=6,r=2	n=8,r=2
	t/σ_0=2.24964	t/σ_0=1.5	t/σ_0=1.2	t/σ_0=2.2494	t/σ_0=1.5	t/σ_0=1.2
	P_a	P_a	P_a	P_a	P_a	P_a
σ_0/σ	1-α=0.99	1-α=0.99	1-α=0.99	1-α=0.99	1-α=0.99	1-α=0.99
0.1	0.977620	0.986613	0.991405	0.999252	0.999832	0.999917
0.2	0.840057	0.898914	0.933647	0.962717	0.990338	0.995071
0.3	0.585125	0.705508	0.796123	0.763216	0.916586	0.953492
0.4	0.334736	0.457368	0.591871	0.438520	0.710183	0.814356
0.5	0.170374	0.244655	0.376125	0.194216	0.427327	0.570658
0.6	0.083608	0.111897	0.204765	0.075730	0.201154	0.315169
0.7	0.041584	0.046142	0.097572	0.028732	0.078755	0.138661
0.8	0.021453	0.018056	0.042048	0.011188	0.027581	0.050733
0.9	0.011569	0.006974	0.016972	0.004576	0.009181	0.016294
1	0.006523	0.002730	0.006619	0.001980	0.003030	0.004833
1.1	0.003835	0.001099	0.002555	0.000906	0.001019	0.001379
1.2	0.002341	0.000459	0.000994	0.000437	0.000354	0.000391
1.3	0.001479	0.000199	0.000394	0.000221	0.000128	0.000112
1.4	0.000963	0.000000	0.000160	0.000117	0.000000	0.000000
1.5	0.000644	0.000000	0.000000	0.000000	0.000000	0.000000
1.6	0.000441	0.000000	0.000000	0.000000	0.000000	0.000000
1.7	0.000309	0.000000	0.000000	0.000000	0.000000	0.000000
1.8	0.000220	0.000000	0.000000	0.000000	0.000000	0.000000
1.9	0.000160	0.000000	0.000000	0.000000	0.000000	0.000000

TABLE 3.8 LOG-LOGISTIC DISTRIBUTION O.C. VALUES OF SELECTED RELIABILITY TEST PLANS FOR A GIVEN PRODUCER'S RISK

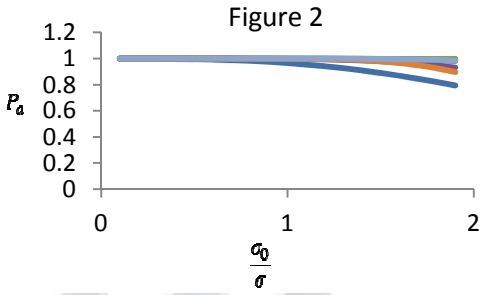
	n=2,r=1	n=4,r=1	n=5,r=1	n=4,r=2	n=6,r=2	n=8,r=2
	t/σ_0=0.005103	t/σ_0=0.002542	t/σ_0=0.002036	t/σ_0=0.042641	t/σ_0=0.027120	t/σ_0=0.019851
	P_a	P_a	P_a	P_a	P_a	P_a
σ_0/σ	1-α=0.99	1-α=0.99	1-α=0.99	1-α=0.99	1-α=0.99	1-α=0.99
0.1	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
0.2	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
0.3	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
0.4	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
0.5	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
0.6	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
0.7	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
0.8	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
0.9	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
1	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
1.1	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
1.2	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
1.3	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
1.4	0.999999	1.000000	1.000000	1.000000	1.000000	1.000000
1.5	0.999999	1.000000	1.000000	1.000000	1.000000	1.000000
1.6	0.999999	1.000000	1.000000	0.999999	1.000000	1.000000
1.7	0.999999	1.000000	1.000000	0.999999	1.000000	1.000000
1.8	0.999998	1.000000	1.000000	0.999999	1.000000	1.000000
1.9	0.999998	1.000000	1.000000	0.999998	1.000000	1.000000

FIGURES

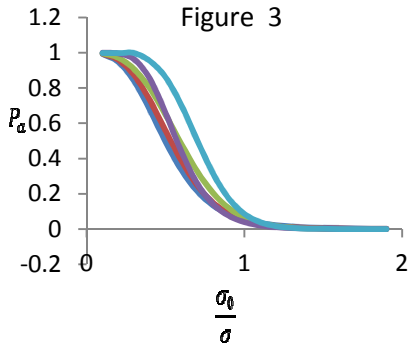
LOG-LOGISTIC DISTRIBUTION O.C. CURVESOF TABLE 3.1 (1-α=0.75) FOR A GIVEN CONSUMER'S RISK



LOG-LOGISTIC DISTRIBUTION O.C. CURVESOF TABLE 3.2 (1-α=0.75)) FOR A GIVEN PRODUCER'S RISK

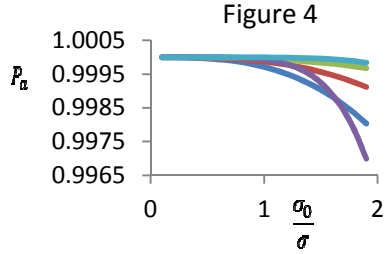


LOG-LOGISTIC DISTRIBUTION O.C. CURVESOF TABLE 3.3 (1-α=0.90) FOR A GIVEN CONSUMER'S RISK

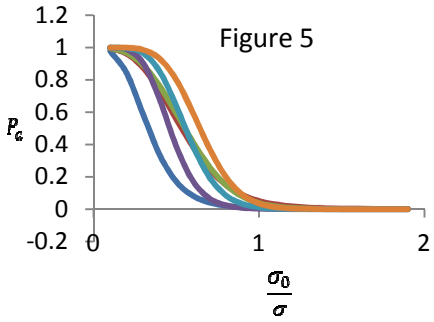


LOG-LOGISTIC DISTRIBUTION O.C. CURVESOF TABLE 3.4 (1-α=0.90) FOR A GIVEN PRODUCER'S RISK

Figure 4

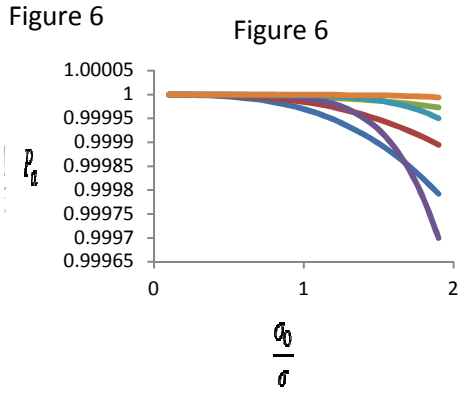


LOG-LOGISTIC DISTRIBUTION O.C. CURVESOF TABLE 3.5 (1-α=0.95) FOR A GIVEN CONSUMER'S RISK



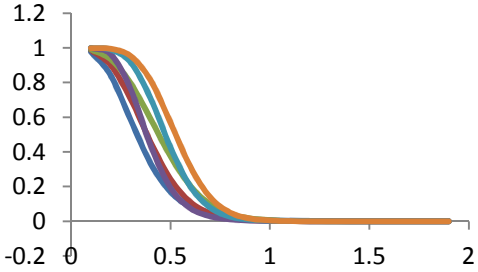
LOG-LOGISTIC DISTRIBUTION O.C. CURVESOF TABLE 3.6 (1-α=0.95) FOR A GIVEN PRODUCER'S RISK

Figure 6

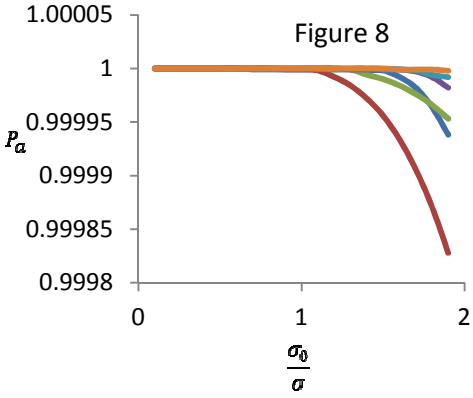


LOG-LOGISTIC DISTRIBUTION O.C. CURVESOF TABLE 3.7 (1-α=0.99) FOR A GIVEN CONSUMER'S RISK

FIGURE 7



LOG-LOGISTIC DISTRIBUTION O.C. CURVESOF TABLE 3.8 (1-α=0.99) FOR A GIVEN PRODUCER'S RISK



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