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Double Acceptance Sampling Plan for Odd Generalized Exponential Log-logistic Distribution Based on Truncated Life Test

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Abstract: According to the results of industrial research, product failure time is correlated with fatigue weakness, which is typically produced by repeated stress variations. A double acceptance sampling strategy was presented for shortened life tests where the lifespan of test products follows an odd generalized exponential log-logistic distribution (OGELLD), according to the findings of this study. The minimum sample sizes for the first and second samples are calculated using a producer's risk of 0.05 to ensure that the actual median life is greater than the specified life at the chosen consumer confidence level. Based on various ratios of genuine median life to stipulated life, we analyzed operational features; we observed that reduced producer risk at the defined level was associated with the lowest median ratios to the specified level. Finally, an illustration is offered to help in the grasp of the suggested framework.

***Keywords*:** single acceptance sampling, producer's risk, double acceptance sampling, consumer's confidence

1. Introduction

In the current global business market, quality is a significant factor to gain industry appraisal. The product lifetime plays an important role in attracting consumers to higher quality products. Therefore, the companies are trying to maintain quality at all stages of the manufacturing process by using several statistical tools and techniques during the inspection. It minimizes products with defects being accepted. It ultimately increases consumer confidence with the durability of the product. Considering the cost and time associated with testing the products, inspecting all the products is not practicable in all scenarios. The acceptance sampling method is the most commonly utilized method for lot sentencing in such instances [1]. The acceptance sampling scheme aids in inspecting raw materials, in-process products, and completed products. It helps numerous sentencing judgments and companies improve the quality of their products. Acceptance sampling programs provide both suppliers and buyers with the necessary levels of security, as well as high acceptance probabilities for good lots and low acceptance probabilities for bad lots. A Type-I error, whose possibility is also described as the producer's risk, happens when a consumer rejects a good (genuine) product that meets the specified life requirements. A Type-II error, whose risk is also known as the consumer's risk, happens when a consumer purchases a defective (genuine) product that does not meet the requisite life conditions. The dangers linked with these two types of errors (rejecting genuine goods/accepting a non-genuine product) may significantly impact the decision to reject

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or accept. Expanding the sample size is one way of lowering both the consumer's and the producer's risk, although it may result in the producer making a loss. As a result, to avoid these risks, we need to implement a practical acceptance sampling approach. Furthermore, to bring down experiment time, reduced life tests are usually employed.

Several studies have been conducted in the past to develop single-sample techniques based on reduced life tests in various statistical distributions [2]. Because there are more than the allowable number of failures during the specified experiment length, the experiment and lot are terminated and rejected in a single sampling plan using a shorter life test, as described above. Alternatively, if there are fewer failures after the trial, we will accept the entire batch of results.

Because of the ease with which the technique can be implemented, much attention has been paid to researching the acceptance of single sampling plans for the testing and inspection of items in a variety of sample circumstances over the last few decades. Many authors have created single sampling strategies for a wide range of distributions. Gupta and Gupta [3], Gupta [4], Kantam et al. [5], Tsai and Wu [6], Balakrishnan et al. [7], and Rao et al. [8] have all emerged recently.

In the field of quality control, see Duncan [9] where the normal distribution is frequently used as a statistical distribution, a double-sampling strategy has been reported to reduce producer risk or sample size. It has long been recognized that double-sampling plans can minimize sample size while also reducing producer risk in the field of quality control, where normal distribution is frequently utilized. Consider the case of Duncan [9], to make judgments concerning double sampling, it is necessary to consider the information gained through the preceding process decisions. Aslam [10] presented double acceptance sampling for the Rayleigh distribution based on shortened life tests, which he found to be effective. Aslam et al. [11, 12] proposed double acceptance sampling plans for the Weibull model and generic life distributions based on truncated life tests for the Weibull model and generic life distributions. Aslam and Jun [13] looked into the feasibility of a double acceptance sampling strategy for a generalized log-logistic distribution with known shape parameters. Rao [14, 15] proposed double acceptance sampling strategies based on truncated life tests for the Marshall-Olkin extended exponential and Marshall-Olkin extended Lomax distributions. Based on the results of their brief life tests, Aslam et al. [2] developed double acceptance sampling plans for Burr type - XII distribution percentiles. Truncated life tests in a generalized exponential distribution were used by Ramaswamy and Anburajan [16] to produce double acceptance sampling, which they published in 2012. Gui [17] developed a twofold acceptance sampling scheme based on the Maxwell distribution to reduce the time required for time-reduced life testing. Malathi and Muthulakshmi [18] developed a zero-one double acceptance sampling strategy for shortened life testing based on the Marshall-Olkin extended exponential distribution. Mahdy and Ahmed [19] discovered new distribution in designing of double acceptance sampling plan with the application. Musa et al. [20] developed double acceptance sampling plans for percentiles based on the inverse Rayleigh distribution. Hamurkaroğlu et al. [21] developed single and double-sampling plans based on the time-truncated life tests for the compound Weibull-exponential distribution. Tripathi et al. [22] developed a double and group acceptance sampling plan for truncated life tests based on inverse log-logistic distribution. Saha et al. [23] developed single and double acceptance sampling plans for truncated life tests based on transmuted Rayleigh distribution. A double acceptance sampling plan for exponentiated Fréchet distribution with known shape parameters was developed by Sridhar et al. [24]. Saranya et al. [25] developed a design of double-sampling inspection plans for life tests under time censoring based on Pareto type IV distribution.

The purpose of this research is to develop double acceptance sampling strategies for shorter life testing, which is based on the idea that a product's lifespan follows an odd generalized exponential log-logistic distribution (OGELLD). This distribution is critical when conducting a survival study. The most widely used failure criteria are zero and one, with lots being accepted if the first sample of the lot shows no failures and lots being rejected if there are two or more failures. A lot is the whole amount of a given material. The quantity of an item ordered for delivery on a given date or made in a single production run is referred to as the lot size. When one sample fails, a second sample is picked and examined for the same period as the failed sample. The consumer confidence level established for the first sample is used to compute the minimum sample sizes for the first and second samples. The operational factors influencing the genuine median life/specified life ratio need to be looked at. To lower the producer's risk, minimum ratio values are also specified. Section 2 discusses OGELLD, and Section 3 describes the architecture of the proposed double-sampling plan. Section 4 investigates the operational characteristics of the proposed double-sampling plan. Section 5 includes case studies that demonstrate the recommended sampling strategy. The sixth section concludes with a synopsis of the key points.

2. OGELLD

OGELLD was popularized and extensively studied by Rosaiah et al. [26]. For example, the OGELLD's probability density function (PDF) and cumulative distribution function (CDF) may be found here,

Rosaiah et al. [26] popularized OGELLD and conducted in-depth research on it. PDF and CDF for the OGELLD, for instance, can be found here:

$$f(t;\sigma,\lambda,\theta,\gamma)=\frac{\gamma\theta}{\lambda\sigma}(t/\sigma)^{\theta-1}\left[1-e^{\frac{-1}{\lambda}(t/\sigma)^{\theta}}\right]^{\gamma-1}e^{-\frac{1}{\lambda}(t/\sigma)^{\theta}},\ t>0,\sigma,\lambda,\theta,\gamma>0 \tag{1}$$

$$\text{and } F(t;\sigma,\lambda,\theta,\gamma)=\left[1-e^{\frac{-1}{\lambda}(t/\sigma)^{\theta}}\right]^{\gamma},t>0,\ \sigma,\lambda,\theta,\gamma>0 \tag{2}$$

where λ is the scale parameter and θ, γ are the shape parameters. When designing single sampling plans, if we take $\gamma = 1$, it is named odd exponential log-logistic distribution (OELLD). The shape parameters are considered to be known a priori in this investigation. When failure data is available, they can be approximated.

Let us consider $F(t_q)=q$, the 100q-th percentile of the OGELLD of equation (2) can be obtained as:

$$t_q=\sigma\eta_q,\quad \text{where}\quad \eta_q=\left[-\lambda\ln(1-q^{1/\gamma})\right]^{1/\theta} \tag{3}$$

In general, the mean cannot be calculated in closed form, according to equation (3), let t_q^0 be the specified value for t_q.

Let us consider $q = 0.5$, the median (50th percentile) of the OGELLD given as:

$$m=\sigma\left[-\lambda\ln\left(1-(0.5)^{1/\gamma}\right)\right]^{1/\theta} \tag{4}$$

The median is proportional to the scale parameters when the two shape parameters are fixed. As a result, irrespective of θ for the OELLD median ($\gamma = 1$). Thus equation (2) can be expressed as:

$$p=\left[1-e^{\left(\frac{-1}{\lambda}\right)\left(\frac{a\eta_q}{m/m_0}\right)^{\theta}}\right]^{\gamma} \tag{5}$$

where m_0 is the specified value of m, $\eta_q=\left[-\lambda\ln(1-q^{1/\gamma})\right]^{1/\theta}$ and m/m_0 is the median ratio of the product.

3. The design of the proposed sampling plan

In this part, the OGELLD purposed double acceptance sampling plan is explained. Let's say a life test is being conducted and will be finished sequentially. The lot will be authorized and referred to as a good one if the median lifetime of a product, as shown by m, can be used to describe its quality and the lifetime data supports the following null hypothesis. $H_0:t_q\geq t_q^0$ for median ($m \geq m_0$) verses alternative hypothesis $H_1:t_q<t_q^0$ for the median ($m < m_0$).

In this hypothesis test, the consumer's risk β is employed as the significance level, and the consumer's confidence level is 1-β. The creation of a twofold acceptance sampling plan and its operational guidelines are as follows:

i) Take a first sample of size n_1 from a lot, and count the number of non-conforming objects, d_1.

ii) If $d_1 \leq c_1$, accept the lot; otherwise, reject the lot if $d_1 \geq c_2$.

iii) If $c_1 < d_1 < c_2$, then take a second sample of size n_2 and observe the number of non-conforming items, d_2.

iv) If $d_1 + d_2 \leq c_2$, accept the lot; otherwise, reject the lot.

The operating procedure of double acceptance sampling plan (DASP) for truncated life test [13] is proposed as follows:

Step 1: The lot is accepted; if drawn a random sample of size n_1 from the lot and put on the test, then see c_1 or less failure is observed before a predetermined experiment time t_0 otherwise the life test is truncated to reject the lot before or at t_0. Suppose $(c_2 + 1)$ failures are accumulated before or at t_0, where $(c_1 < c_2)$.

Step 2: If the number of failures by t_0 is between $(c_1 + 1)$ and c_2 then draw a second sample of size n_2 for life testing till a prescribed termination time t_0. If at most c_2 failures are observed from the two samples, then the lot is accepted. Otherwise, the lot is rejected.

The operating method for a DASP for a life test is presented below in the form of a flow chart.

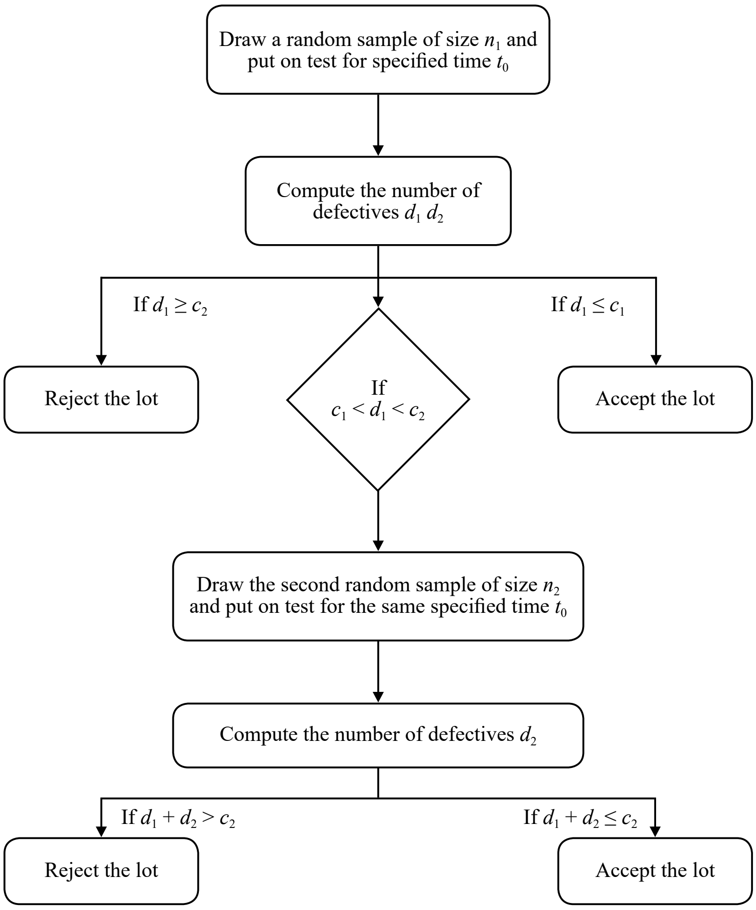

Figure 1. Flow chart for the proposed DASP

The termination period should typically be fixed as a multiple of the stated life, m_0 in which case $t_0 = am_0$ for a specified multiplier a. The proposed sampling plan could be employed based on five parameters namely (n_1, n_2, c_1, c_2, a), where $(c_1 < c_2)$.

The binomial distribution is deemed large enough to be useful in estimating the lot acceptance probability. See, for instance, Stephens [27] for additional justification. The likelihood of the lot being accepted is calculated for the suggested twofold acceptance sampling plan by

$$L(p) = P_a = \sum_{i=0}^{c_1} \binom{n_1}{i} p^i (1-p)^{n_1 - i} + \sum_{x=c_1+1}^{c_2} \binom{n_1}{x} p^x (1-p)^{n_1 - x} \left[\sum_{i=0}^{c_2 - x} \binom{n_2}{i} p^i (1-p)^{n_2 - i} \right]. \tag{6}$$

Here, P is the chance of an item failing earlier than t_0, which is specified in equation (5).

Since consumers prefer an acceptance sampling plan with lower acceptance numbers than the present double-sampling plan, we have specifically discussed and are concerned about the projected double-sampling plan, also known as zero and one failure schemes. When a lot is approved with several test-failed products, the consumers may be unaware of what is happening, but it is easy to assess the quality of each item. In the zero and one failure schemes, the lot acceptance probability of equation (6) falls to zero and one.

$$P_a = (1-p)^{n_1}\left[1+n_1 p(1-p)^{n_2-1}\right] \tag{7}$$

Therefore, the minimum sample sizes n_1 and n_2 ensuring $m \geq m_0$ at confidence level 1-β can be obtained as the solution to the following inequality:

$$(1-p_0)^{n_1}\left[1+n_1 p_0(1-p_0)^{n_2-1}\right] \leq \beta \tag{8}$$

where p_0 is the probability in equation (5) evaluated at $m = m_0$, as

$$p_0 = \left[1-\exp\left\{-\frac{1}{\lambda}\left(\eta_q a\right)^{\theta}\right\}\right]^{\gamma} \tag{9}$$

Given that there may be infinitely many sample sizes that meet equation (8), we want to locate them by minimizing the average sample number (ASN).

$$\text{ASN} = n_1 P_1 + (n_1+n_2)(1-P_1) \tag{10}$$

where p_1 the likelihood that an application will be accepted or rejected is based on the first sample provided by

$$P_1 = 1-\sum_{i=c_1+1}^{c_2}\binom{n_1}{i}(p)^i(1-p)^{n_1-1} \tag{11}$$

For $c_1 = 0$ and $c_2 = 1$, we have

$$\text{ASN} = n_1 + n_1 n_2 p(1-p)^{n_1-1} \tag{12}$$

To obtain the fewest sample sizes for the zero and one failure schemes in our suggested approach, the following optimization problem must be resolved:

minimize $\text{ASN} = n_1 + n_1 n_2 p(1-p)^{n_1-1}$ (13a)

subject to the constraints,

$$P_a = (1-p_0)^{n_1}\left[1+n_1 p_0(1-p_0)^{n_2-1}\right] \leq \beta \tag{13b}$$

$$1 \leq n_2 \leq n_1 \tag{13c}$$

n_1, n_2 are integers. (13d)

The equations from (13a) through (13d) may be able to generate more than one feasible plan parameter combination. As a result, we must select the plan parameters that will result in the lowest possible ASN. For a single sampling strategy, the sample size may be calculated.

$$\left(1-p_0\right)^n \le \beta \tag{14}$$

For instance, Table 1 displays the minimal sample sizes for the first and second samples under the OGELLD for a range of 1-β (0.75, 0.90, 0.95, 0.99), a (0.3, 0.5, 0.7, 0.9, 1.1, 1.5, 1.9), four combinations of (λ = 1.5, θ = 1.5, 2.0 and γ = 1.0, 1.5, 2.0) are measured. Since the experiment time is relatively brief, it can be shown that sample sizes grow quickly as (θ or γ) increases. When the experiment runs for a longer period, they essentially stay the same regardless of (θ or γ). The first and second sample sizes for the OGELLD with 1-β = 0.90, λ = 1.5 and various as a function of a are shown in Figures 2 and 3.

Table 1. Minimum sample sizes under OGELLD

		a							
(λ, θ, γ)	1-β	0.3	0.5	0.7	0.9	1.1	1.5	1.7	1.9
(1.5, 2.0, 2.0)	0.75	158,129 (197.20)	25,18 (30.14)	8,6 (9.57)	4,3 (4.63)	2,2 (2.39)	1,1 (1.11)	1,1 (1.05)	1,1 (1.02)
	0.90	235,188 (271.40)	36,28 (41.19)	11,11 (13.00)	6,3 (6.34)	3,3 (3.35)	2,1 (2.03)	2,1 (2.01)	1,1 (1.02)
	0.95	288,256 (321.90)	44,38 (48.82)	14,13 (15.51)	7,4 (7.32)	4,3 (4.19)	2,1 (2.03)	2,1 (2.01)	1,1 (1.02)
	0.99	423,409 (441.00)	65,53 (67.17)	21,15 (21.53)	10,5 (10.13)	6,3 (6.05)	3,1 (3.00)	3,1 (3.00)	2,1 (2.00)
(1.5, 1.5, 2.0)	0.75	51,43 (63.96)	13,12 (16.46)	6,5 (7.26)	4,2 (4.38)	3,1 (3.13)	2,1 (2.06)	1,1 (1.11)	1,1 (1.07)
	0.90	76,62 (87.91)	19,19 (22.62)	9,6 (9.91)	5,4 (5.54)	4,2 (4.15)	2,2 (2.13)	2,1 (2.03)	2,1 (2.01)
	0.95	94,80 (104.32)	24,22 (26.73)	11,8 (11.81)	6,5 (6.47)	4,3 (4.23)	3,1 (3.02)	2,1 (2.03)	2,1 (2.01)
	0.99	137,136 (142.94)	36,26 (36.99)	16,10 (16.32)	9,6 (9.16)	6,3 (6.06)	3,3 (3.06)	3,1 (3.01)	2,2 (2.02)
(1.5, 1.5, 1.5)	0.75	29,24 (36.09)	10,9 (12.50)	5,5 (6.29)	4,2 (4.36)	3,1 (3.14)	2,1 (2.08)	2,1 (2.04)	1,1 (1.10)
	0.90	43,35 (49.59)	15,12 (17.07)	8,5 (8.73)	5,3 (5.38)	4,2 (4.16)	2,2 (2.16)	2,1 (2.04)	2,1 (2.02)
	0.95	53,45 (58.71)	18,17 (20.08)	10,6 (10.55)	6,4 (6.35)	4,4 (4.33)	3,1 (3.03)	2,2 (2.09)	2,1 (2.02)
	0.99	78,64 (80.65)	27,20 (27.75)	14,9 (14.29)	9,5 (9.12)	6,4 (6.09)	4,2 (4.02)	3,2 (3.02)	3,1 (3.00)
(1.5, 1.5, 1.0)	0.75	15,14 (19.10)	7,7 (8.92)	5,3 (5.66)	3,3 (3.68)	3,1 (3.15)	2,1 (2.11)	2,1 (2.07)	2,1 (2.04)
	0.90	23,18 (26.25)	11,8 (12.29)	7,4 (7.54)	5,3 (5.35)	4,2 (4.18)	3,1 (3.05)	2,2 (2.15)	2,1 (2.04)
	0.95	28,25 (31.11)	13,12 (14.40)	8,7 (8.73)	6,4 (6.31)	4,4 (4.36)	3,2 (3.09)	3,1 (3.02)	2,2 (2.09)
	0.99	41,38 (42.57)	19,19 (19.75)	12,8 (12.25)	8,7 (8.22)	6,5 (6.14)	4,3 (4.05)	4,1 (4.01)	3,2 (3.02)

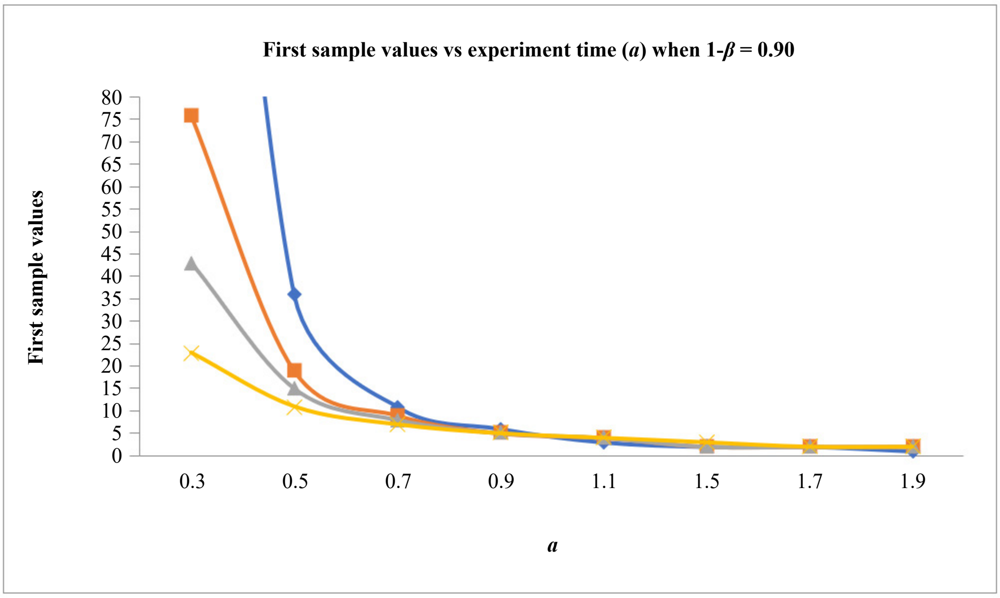

Figure 2. The first sample size against experiment time for OGELLD

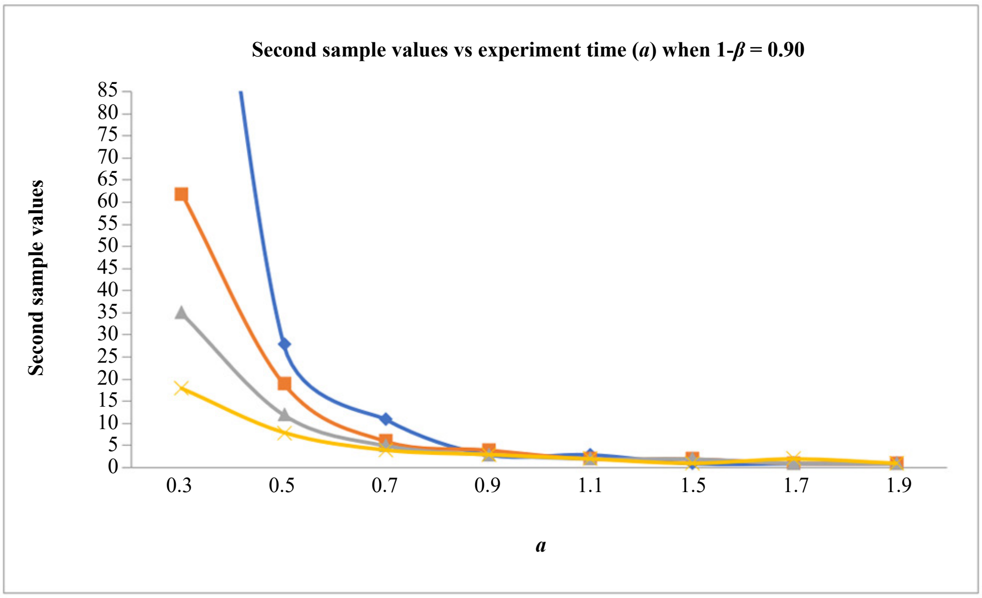

Figure 3. The second sample size against experiment time for OGELLD

4. Operating characteristics (OC)

If the genuine median is higher than the given life, the acceptance probability will increase. As a result, we must understand the plan's operational features regarding the ratio between the genuine median life and the stipulated life, that is t_q/t_q^0 , i.e. m/m_0. A strategy will undoubtedly be more appealing if its OC increases more rapidly to one. The OC values for the OGELLD with of are shown in Tables 2 to 5 with 1-β (0.75, 0.90, 0.95, 0.99), a (0.3, 0.5, 0.7, 0.9, 1.1, 1.5, 1.9), four combinations of (λ = 1.5, θ = 1.5, 2.0 and γ = 1.0, 1.5, 2.0).

Table 2. OC values for OGELLD with $\lambda = 1.5$, $\theta = \gamma = 2.0$

				t_q/t_q^0					
1-β	n_1	n_2	a	2	4	6	8	10	12
0.75	158	129	1.3	0.9984	0.9991	0.9990	1.0000	1.0000	1.0000
	25	18	0.5	0.9922	0.9901	0.9991	1.0000	1.0000	1.0000
	8	6	0.7	0.9996	0.9998	0.9999	1.0000	1.0000	1.0000
	4	3	0.9	0.9977	0.9992	0.9999	1.0000	1.0000	1.0000
	2	2	1.1	0.9907	0.9939	0.9999	1.0000	1.0000	1.0000
	1	1	1.5	0.9381	0.9994	0.9999	1.0000	1.0000	1.0000
	1	1	1.7	0.8803	0.9984	0.9999	1.0000	1.0000	1.0000
	1	1	1.9	0.7987	0.9966	0.9998	1.0000	1.0000	1.0000
0.90	235	188	0.3	0.9979	0.9991	0.9990	1.0000	1.0000	1.0000
	36	28	0.5	0.9989	0.9997	1.0000	1.0000	1.0000	1.0000
	11	11	0.7	0.9989	0.9999	1.0000	1.0000	1.0000	1.0000
	6	3	0.9	0.9932	0.9999	0.9999	1.0000	1.0000	1.0000
	3	3	1.1	0.9740	0.9998	0.9999	1.0000	1.0000	1.0000
	2	1	1.5	0.8451	0.9981	0.9999	1.0000	1.0000	1.0000
	2	1	1.7	0.7237	0.9954	0.9998	1.0000	1.0000	1.0000
	1	1	1.9	0.5767	0.9901	0.9995	0.9999	1.0000	1.0000
0.95	288	256	0.3	0.9946	0.9992	0.9999	1.0000	1.0000	1.0000
	44	38	0.5	0.9919	0.9999	0.9999	1.0000	1.0000	1.0000
	14	13	0.7	0.9899	0.9989	0.9997	1.0000	1.0000	1.0000
	7	4	0.9	0.9932	0.9992	0.9999	0.9999	1.0000	1.0000
	4	3	1.1	0.9740	0.9998	0.9999	1.0000	1.0000	1.0000
	2	1	1.5	0.8451	0.9981	0.9999	1.0000	1.0000	1.0000
	2	1	1.7	0.7237	0.9954	0.9998	1.0000	1.0000	1.0000
	1	1	1.9	0.5767	0.9901	0.9995	0.9999	1.0000	1.0000
0.99	423	409	0.3	0.9990	0.9993	0.9999	1.0000	1.0000	1.0000
	65	53	0.5	0.9991	0.9995	0.9999	1.0000	1.0000	1.0000
	21	15	0.7	0.9989	0.9996	0.9999	1.0000	1.0000	1.0000
	10	5	0.9	0.9932	0.9991	0.9999	1.0000	1.0000	1.0000
	6	3	1.1	0.9740	0.9998	0.9999	1.0000	1.0000	1.0000
	3	1	1.5	0.8451	0.9981	0.9999	1.0000	1.0000	1.0000
	2	1	1.7	0.7237	0.9954	0.9998	1.0000	1.0000	1.0000
	2	1	1.9	0.5767	0.9901	0.9995	0.9999	1.0000	1.0000

Table 3. OC values for OGELLD with $\lambda = \theta = 1.5$, $\gamma = 2.0$

				t_q/t_q^0					
1-β	n_1	n_2	a	2	4	6	8	10	12
0.75	51	43	0.3	0.9867	0.9989	0.9997	0.9999	1.0000	1.0000
	13	15	0.5	0.9976	0.9991	0.9997	0.9999	1.0000	1.0000
	6	5	0.7	0.9975	0.9989	0.9996	1.0000	1.0000	1.0000
	4	2	0.9	0.9908	0.9992	0.9999	1.0000	1.0000	1.0000
	3	1	1.1	0.9759	0.9993	0.9999	1.0000	1.0000	1.0000
	2	1	1.5	0.9088	0.9964	0.9996	0.9999	1.0000	1.0000
	1	1	1.7	0.8541	0.9931	0.9992	0.9998	1.0000	1.0000
	1	1	1.9	0.7872	0.9880	0.9985	0.9997	0.9999	1.0000
0.90	76	62	0.3	0.9920	0.9995	0.9999	1.0000	1.0000	1.0000
	19	19	0.5	0.9988	0.9993	0.9999	1.0000	1.0000	1.0000
	9	6	0.7	0.9926	0.9998	0.9999	1.0000	1.0000	1.0000
	5	4	0.9	0.9742	0.9993	0.9999	1.0000	1.0000	1.0000
	4	2	1.1	0.9352	0.9980	0.9998	1.0000	1.0000	1.0000
	2	2	1.5	0.7814	0.9895	0.9998	0.9998	0.9999	1.0000
	2	1	1.7	0.6738	0.9804	0.9976	0.9995	0.9999	1.0000
	2	1	1.9	0.5579	0.9666	0.9956	0.9991	0.9997	0.9999
0.95	94	80	0.3	0.9940	0.9995	1.0000	1.0000	1.0000	1.0000
	24	22	0.5	0.9988	1.0000	1.0000	1.0000	1.0000	1.0000
	11	8	0.7	0.9926	0.9998	1.0000	1.0000	1.0000	1.0000
	6	5	0.9	0.9742	0.9993	0.9999	1.0000	1.0000	1.0000
	4	3	1.1	0.9352	0.9980	0.9998	1.0000	1.0000	1.0000
	3	1	1.5	0.7814	0.9895	0.9998	0.9998	0.9999	1.0000
	2	1	1.7	0.6738	0.9804	0.9976	0.9995	0.9999	1.0000
	2	1	1.9	0.5579	0.9666	0.9956	0.9991	0.9997	0.9999
0.99	137	136	0.3	0.9949	0.9993	1.0000	1.0000	1.0000	1.0000
	36	26	0.5	0.9976	0.9996	0.9999	1.0000	1.0000	1.0000
	16	10	0.7	0.9858	0.9997	0.9999	1.0000	1.0000	1.0000
	9	6	0.9	0.9516	0.9987	0.9999	1.0000	1.0000	1.0000
	6	3	1.1	0.8836	0.9960	0.9996	0.9999	1.0000	1.0000
	3	3	1.5	0.6481	0.9798	0.9976	0.9995	0.9999	1.0000
	3	1	1.7	0.5067	0.9630	0.9953	0.9990	0.9997	0.9999
	2	2	1.9	0.3726	0.9381	0.9915	0.9982	0.9995	0.9998

Table 4. OC values for OGELLD with $\lambda = \theta = \gamma = 1.5$

				t_q/t_q^0					
1-β	n_1	n_2	a	2	4	6	8	10	12
0.75	29	24	0.3	0.9920	0.9992	0.9999	1.0000	1.0000	1.0000
	10	9	0.5	0.9953	0.9998	0.9999	1.0000	1.0000	1.0000
	5	5	0.7	0.9817	0.9990	0.9998	0.9999	1.0000	1.0000
	4	2	0.9	0.9523	0.9970	0.9995	0.9999	0.9999	1.0000
	3	1	1.1	0.9031	0.9931	0.9987	0.9996	0.9999	0.9999
	2	1	1.5	0.7477	0.9761	0.9953	0.9986	0.9995	0.9998
	2	1	1.7	0.6507	0.9614	0.9922	0.9976	0.9991	0.9996
	1	1	1.9	0.5498	0.9420	0.9877	0.9962	0.9985	0.9993
0.90	43	35	0.3	0.9995	0.9999	0.9990	0.9999	1.0000	1.0000
	15	12	0.5	0.9953	0.9998	0.9999	1.0000	1.0000	1.0000
	8	5	0.7	0.9817	0.9990	0.9998	1.0000	1.0000	1.0000
	5	3	0.9	0.9523	0.9970	0.9995	0.9999	0.9999	1.0000
	4	2	1.1	0.9031	0.9931	0.9987	0.9996	0.9999	0.9999
	2	2	1.5	0.7477	0.9761	0.9953	0.9986	0.9995	0.9998
	2	1	1.7	0.6507	0.9614	0.9922	0.9976	0.9991	0.9996
	2	1	1.9	0.5498	0.9420	0.9877	0.9962	0.9985	0.9993
0.95	53	45	0.3	0.9991	0.9999	0.9999	0.9999	1.0000	1.0000
	18	17	0.5	0.9924	0.9996	0.9999	0.9999	1.0000	1.0000
	10	6	0.7	0.9708	0.9983	0.9997	0.9999	1.0000	1.0000
	6	4	0.9	0.9261	0.9951	0.9991	0.9998	0.9999	1.0000
	4	4	1.1	0.8548	0.9888	0.9979	0.9994	0.9998	0.9999
	3	1	1.5	0.6505	0.9620	0.9924	0.9977	0.9991	0.9996
	2	2	1.7	0.5359	0.9397	0.9873	0.9961	0.9985	0.9993
	2	1	1.9	0.4259	0.9107	0.9802	0.9939	0.9976	0.9989
0.99	78	64	0.3	0.9974	0.9989	0.9999	1.0000	1.0000	1.0000
	27	20	0.5	0.9867	0.9993	0.9999	1.0000	1.0000	1.0000
	14	9	0.7	0.9503	0.9970	0.9995	0.9999	0.9999	1.0000
	9	5	0.9	0.8787	0.9914	0.9984	0.9996	0.9998	0.9999
	6	4	1.1	0.7721	0.9805	0.9963	0.9989	0.9996	0.9998
	4	2	1.5	0.5039	0.9360	0.9867	0.9960	0.9984	0.9993
	3	2	1.7	0.3748	0.9002	0.9780	0.9932	0.9973	0.9988
	3	1	1.9	0.2649	0.8551	0.9660	0.9892	0.9957	0.9980

Table 5. OC values for OGELLD with $\lambda = \theta = 1.5$, $\gamma = 1.0$

				t_q/t_q^0					
1-β	n_1	n_2	a	2	4	6	8	10	12
0.75	15	14	0.3	0.9954	0.9994	0.9998	0.9999	1.0000	1.0000
	7	7	0.5	0.9805	0.9973	0.9992	0.9997	0.9998	0.9999
	5	3	0.7	0.9512	0.9929	0.9978	0.9991	0.9995	0.9997
	3	3	0.9	0.9065	0.9855	0.9954	0.9980	0.9990	0.9994
	3	1	1.1	0.8479	0.9746	0.9919	0.9965	0.9982	0.9989
	2	1	1.5	0.7010	0.9414	0.9805	0.9913	0.9954	0.9973
	2	1	1.7	0.6203	0.9191	0.9724	0.9876	0.9935	0.9961
	2	1	1.9	0.5395	0.8931	0.9626	0.9831	0.9910	0.9947
0.90	23	18	0.3	0.9926	0.9990	0.9997	0.9999	0.9999	1.0000
	11	8	0.5	0.9689	0.9956	0.9987	0.9994	0.9997	0.9998
	7	4	0.7	0.9243	0.9885	0.9964	0.9985	0.9992	0.9995
	5	3	0.9	0.8596	0.9767	0.9926	0.9968	0.9983	0.9990
	4	2	1.1	0.7790	0.9598	0.9869	0.9942	0.9970	0.9982
	3	1	1.5	0.5942	0.9099	0.9689	0.9860	0.9926	0.9956
	2	2	1.7	0.5017	0.8775	0.9564	0.9801	0.9894	0.9937
	2	1	1.9	0.4152	0.8407	0.9415	0.9730	0.9855	0.9913
0.95	28	25	0.3	0.9911	0.9988	0.9996	0.9998	0.9999	1.0000
	13	12	0.5	0.9631	0.9948	0.9984	0.9993	0.9996	0.9998
	8	7	0.7	0.9109	0.9863	0.9957	0.9981	0.9990	0.9994
	6	4	0.9	0.8362	0.9723	0.9911	0.9961	0.9980	0.9988
	4	4	1.1	0.7446	0.9523	0.9843	0.9931	0.9964	0.9979
	3	2	1.5	0.5408	0.8942	0.9631	0.9833	0.9911	0.9948
	3	1	1.7	0.4425	0.8567	0.9484	0.9764	0.9873	0.9925
	2	2	1.9	0.3530	0.8146	0.9310	0.9679	0.9827	0.9897
0.99	41	38	0.3	0.9856	0.9981	0.9994	0.9998	0.9999	0.9999
	19	19	0.5	0.9419	0.9914	0.9974	0.9989	0.9994	0.9997
	12	8	0.7	0.8644	0.9779	0.9930	0.9969	0.9984	0.9991
	8	7	0.9	0.7600	0.9560	0.9856	0.9937	0.9967	0.9981
	6	5	1.1	0.6407	0.9255	0.9748	0.9888	0.9941	0.9965
	4	3	1.5	0.4046	0.8404	0.9419	0.9732	0.9856	0.9914
	4	1	1.7	0.3047	0.7881	0.9196	0.9623	0.9796	0.9878
	3	2	1.9	0.2222	0.7311	0.8937	0.9492	0.9722	0.9833

The OC values are depicted in Figure 4 as a function of the m/m_0. when $1 - \beta = 0.90$ and $a = 0.7$ for the OGELLD with different shape parameters (θ =1.5, 2.0 and γ =1.0, 1.5, 2.0). When the shape parameter is set to a greater value, the OC rises more quickly to one. It is due in part to the larger sample numbers necessary for higher shape parameters.

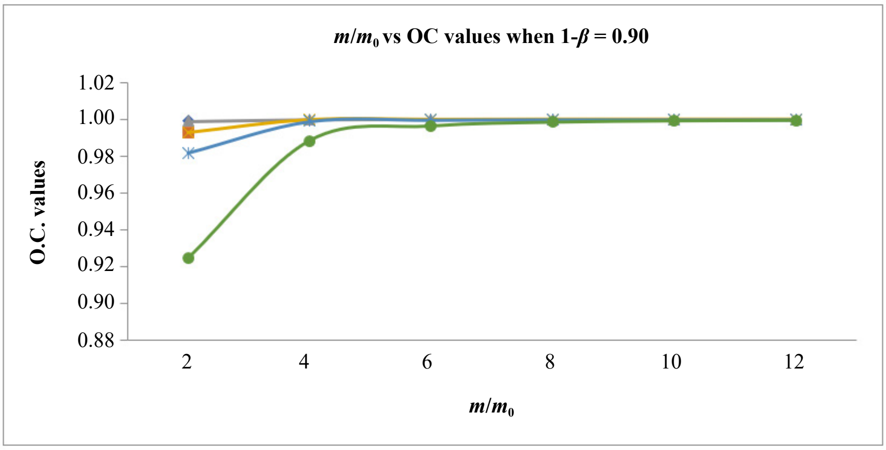

Figure 4. OC values against median ratio for OGELLD 1-β = 0.90

Imagine the producer wants to know what the lowest possible product quality will keep their risk at a specific level. So, by solving for the minimum median ratio m/m_0 . at the producer's risk of α,

$$P_a \geq 1-\alpha \tag{15}$$

where P_a is supplied by equation (6) or (7) for the zero and one failure schemes, respectively, and p is given by equation (7) for the zero-failure scheme (5). The identical sample sizes that were previously obtained in Table 1 will be utilized again. To illustrate, in Table 6, the minimal median ratio for OGELLD is shown under the stipulated levels of consumer trust and test periods.

Table 6. Minimum median ratios to the specified life at producer's risk for OGELLD

		a							
(λ, θ, γ)	1-β	0.3	0.5	0.7	0.9	1.1	1.5	1.7	1.9
(1.5, 2.0, 2.0)	0.75	1.7062	1.7489	1.8044	1.9066	1.9391	2.0812	2.3563	2.6364
	0.90	1.8829	1.9350	2.0210	2.0717	2.1968	2.4582	2.7816	2.6364
	0.95	1.9988	2.0576	2.1400	2.1863	2.3261	2.4582	2.7816	2.6364
	0.99	2.2183	2.2624	2.3381	2.3935	2.5336	2.7233	2.7816	3.1153
(1.5, 1.5, 2.0)	0.75	2.0764	2.1603	2.2512	2.3321	2.4319	2.8969	2.6288	2.9343
	0.90	2.3685	2.4988	2.5549	2.6911	2.8514	3.1918	3.2841	3.6684
	0.95	2.5621	2.6831	2.7732	2.8969	2.9922	3.3201	3.2841	3.6684
	0.99	2.9630	3.0120	3.1260	3.2841	3.3445	3.7750	3.7594	4.0437
(1.5, 1.5, 1.5)	0.75	2.5840	2.6752	2.7397	2.8514	2.8514	3.2960	3.7439	3.1807
	0.90	3.0836	3.1696	3.2031	3.2723	3.4855	3.7286	3.7439	4.1736
	0.95	3.4072	3.5398	3.5398	3.6245	3.8715	3.8880	4.2123	4.1736
	0.99	4.0437	4.1169	4.1736	4.2918	4.4385	4.7642	4.8662	4.9456
(1.5, 1.5, 1.0)	0.75	4.0080	4.0437	4.0258	4.0437	3.9386	4.2517	4.8146	5.3850
	0.90	5.1414	5.1414	5.0556	5.1706	5.2301	5.3850	5.7241	5.3850
	0.95	6.0277	6.0680	6.0277	6.0277	6.0680	6.1501	6.1087	6.4103
	0.99	7.8493	7.9872	7.5245	7.7821	7.7160	7.7160	7.2254	7.7821

5. Use of tables

Example 1: Assume that the lifetime of an item is determined by an OGELLD with the form parameter. The median lifetime of the product, with a confidence level of 0.75, must be more than or equal to 1,400 hours for the maker to know this. The experiment is terminated at 980 hours using the zero and one failure approaches of the double-sampling strategy. The minimal sample sizes needed are listed in Table 1, along with the experiment termination multiplier. It is appropriate to understand this sampling strategy as follows. A 980-hour test is performed on eight items first; if there are no failures, the lot is accepted. If the experiment fails more than once, it is terminated entirely. A second sample of size 6 will be chosen and put through 980 hours of testing once just one failure has been attained. If the second sample does not contain any failures (or if both samples contain one failure), the lot will be accepted; otherwise, it will be refused.

To reduce risk, the manufacturer can be concerned about the likelihood of acceptance as quality rises. Think about a scenario where a manufacturer is required to know the quality level at which a risk of less than 0.05 will materialize. This data is shown in Table 6. The minimal ratio for both is 1.8044. Thus, the actual median duration for the product should be at least 2,526.16 hours.

Example 2: A range of bulbs, such as tube lights and energy-saving bulbs (ESBs), are available on the market to decrease the amount of electricity used. An ESB, which is the newest type of light bulb, is less expensive, uses less electricity, and lasts longer than regular bulbs. Assume that the producer is interested in the sample sizes for the truncated life test when the zero and one failure approaches of the double-sampling plan are applied. The main goal is to ensure that there is a 90% chance that the median lifespan will exceed 6,000 hours. The ESBs are believed to be followed by an OGELLD. The sample sizes needed when the experiment's time frame is restricted to 4,200 hours are shown in Table 1. In terms of the median ratio to the required lifetime, Table 3 displays the OC values for the three quality levels. Given that this design's ASN is 9.91, a comparison to a single sampling plan with a sample size of roughly 10 and an acceptable number of 0 would be useful. The OC values based on the median ratio are shown in Table 3. We claim that the proposed plan generates more desired OC values than the single sample plan since its OC values rise more quickly as the quality level rises. The suggested technique requires fewer sample numbers in terms of ASN than the single sampling plan to reach the same OC values at higher quality levels.

6. Conclusion

To decide whether to accept or reject the offered batch, it was advised to employ a double-sampling technique based on a shorter life test. The objects were made to have a lifespan that matched an OGELLD, which is essential in system reliability studies, due to the diversity in failure rate. There was a special discussion and creation of tables for the double-sampling scheme's zero and one failure methods. The number of samples needed drops significantly as the experiment's duration increases, even though sample sizes for the intermediate length of the experiment are less sensitive to the shape parameter or the confidence level. Through the use of an example, it was demonstrated that the double-sampling plan is superior to the single-sample plan in terms of operational features. The developed sampling plans are valuable in the electronic and chemical industries. The cost of sample size selection is involved in these businesses. In the future, the proposed plan could be extended to repetitive sampling and double sample plans under neutrosophic statistics.

Conflict of interest

There is no conflict of interest for this study.

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