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New Two-Sided Complete Group Chain Sampling Plan for Pareto Distribution of the 2^{nd} Kind

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Abstract

This paper proposes plan that improve on existing group chain and modified group chain sampling plans. The plan is mixed in the sense that they combine elements from both preceding and succeeding lot information's. This combination gives a higher probability of lot acceptance and better operating characteristic curve. The design parameters such as the optimal group size and ideal operating characteristic values are established by satisfying the producer's and consumer's risks. The proposed plan will be mainly supportive in circumstances warranting small sample sizes.

Keywords: Two sided group chain sampling, operating characteristic curve, preceding and succeeding lots.

1. Introduction

When performing destructive life test using attribute data, where each sample unit is categorized as good or not good, the common practice is to use low acceptance numbers and a small sample to maintain the cost low. In acceptance sampling, single acceptance sampling plan is usually used with design parameters namely; lot or batch size N, sample size n and the acceptance number c. Epstein (1954) introduced a single acceptance sampling plan when the lifetime of a product follow exponential distribution. Many researchers established single acceptance sampling plans based on various truncated life test for different distributions: Baklizi (2003), Aslam et al. (2010a), Aslam et al. (2010b), Mughal et al. (2011), Mughal and Aslam (2011), Mughal (2011), Aslam et al. (2011), and Mughal and Ismail (2013). In single acceptance Sampling plan with c=0, the probability of acceptance of lot begins to drop very quickly, even for very small values of the lot fraction defective. Dodge (1955) suggested a different approach, known as chain sampling that might be a replacement for single acceptance sampling plan. In addition, Govindaraju and Lai (1998), Deva and Rebecca (2012), Mughal et al. (2015a), Mughal et al. (2015b) also proposed different chain sampling plans to over the difficulty of ordinary acceptance sampling plans. In established chain sampling plans, a single product is inspected but in real life situation, testers are used that can control more than one product at a time. This type of testing is called group acceptance sampling. The chain sampling plan developed by Mughal et al. (2015a) and Mughal et al. (2015b) considered only one sided chaining (preceding lots). In this research, new two-sided complete group chain acceptance sampling plan is introduced by regarding the collective information's of preceding, current as well as succeeding lots.

2. Symbols

g: Number of groups.
r: Number of testers.
n: Sample size.
d: Number of defective products.
i: Allowable acceptance number (preceding lot)
j: Allowable acceptance number (succeeding lot)
α : Producer's risk (Probability of rejecting a good lot).
β : Consumer's risk (Probability of accepting a bad lot).
λ: Shape parameter of Pareto distribution of the 2nd kind.
t_0: Test termination time.
μ_0: Specified average life of a product.
μ : True average life of a product.
P(p): Lot Acceptance Probability.
(μ / μ_0):Mean ratio

3. Inspection Procedure

I. Take a sample of size n products from lot, find the required number of g groups and distribute r products in each group.

II. Accept the lot if no defective d product d is observed. Reject the lot if d > 1, of d=1, go to next step III.

III. Also accept the lot if only one defective product either in preceding i, current and succeeding j sample is observed while the rest of the samples have no defectives products.

The cumulative distribution function (CDF) of a Pareto distribution of the 2nd kind, according to Pareto (1897) can be written as,

$$F(t;\sigma,\lambda)=1-\left(1+\frac{t}{\sigma}\right)^{-\lambda} \quad t>0,\sigma>0,\lambda>0 \qquad (3.1)$$

where σ and λ are scale and shape parameters respectively. The proposed plan is categorized by the three parameters $\mathrm{i, j}$ and g.We are interested to find the minimal group sizes when the specified value of consumer's risk does not greater than the probability of lot acceptance. The probability of lot acceptance of the proposed plan is provided in the following equation,

$$\mathrm{P_a(p) = P_0{}^i[P_0^{1-i} + 2P_0P_1^i + P_0^iP_1], i = j} \quad (3.2)$$

where $\mathrm{P_0}$ and $\mathrm{P_1}$ are the probability of observing none and one defective product respectively. Under the situation of Binomial model, the above equation (3.2) can be written in this form,

$$\mathrm{P_a(p) = (1-p)^{(r*g)} + 2(r*g*p)^i(1-p)^{(r*g)*(2i+1)-i} + (r*g*p)(1-p)^{(r*g)(2i+1)-1}} \quad (3.3)$$

Furthermore, p is the probability of defective product observing in pre-specified test termination time $\mathrm{t_0}$, then $\mathrm{t_0 = a\mu_0}$ and p can be evaluated to solving the following equation,

$$p = F(t;\sigma,\lambda) = 1 - \left[1 + \frac{a}{(\lambda-1)(\mu/\mu_0)}\right]^{-\lambda} \quad (3.4)$$

This above equation is used to develop the table1.Table1 demonstrated the minimal values of group size g for different values of Consumer's risk β, pre-fix test time a, testers r and allowable acceptance number (i, j). Once the optimal group sizes are obtained, one may be found lot acceptance probability when the perfect quality level of a product is required. For a predetermined value of r, i and j the operating characteristic values as a function of (μ/μ_0) are shown in Tables 2.

4. Comparison

Table3 offers a comparison of mean ratios of proposed plan with the established plan. It is interesting to note that the proposed plan increases the probability of lot acceptance and also reduce the sample size than the existing plans.

5. Conclusion

The new two-sided complete group chain sampling plan for Pareto distribution of the 2nd kind introduced in this paper and it is also an improvement of the established plans. The proposed plan used more information's from the prior as well as after lot quality record. The methodology of the OC function is evaluated and placed in table2. Comparatively studies are provided to prove that the proposed plan provides higher probability of lot acceptance over the established plans. It means that the proposed plan is likely to be more suitable for assessment involving life testing by attributes.

TABLE 1: Number of optimal groups required for the proposed plan for the Pareto distribution of the 2nd kind with λ =2

			a					
β	r	$i = j$	0.7	0.8	1.0	1.2	1.5	2.0
0.25	2	1	1	1	1	1	1	1
	3	2	1	1	1	1	1	1
	4	3	1	1	1	1	1	1
	5	4	1	1	1	1	1	1
0.10	2	1	1	1	1	1	1	1
	3	2	1	1	1	1	1	1
	4	3	1	1	1	1	1	1
	5	4	1	1	1	1	1	1
0.05	2	1	1	1	1	1	1	1
	3	2	1	1	1	1	1	1
	4	3	1	1	1	1	1	1
	5	4	1	1	1	1	1	1
0.01	2	1	1	1	1	1	1	1
	3	2	1	1	1	1	1	1
	4	3	1	1	1	1	1	1
	5	4	1	1	1	1	1	1

TABLE 2: Operating characteristics values having i = j=1, r=3, g=1 for Pareto distribution of the 2nd kind with λ = 2

β	a	2	4	6	8	10	12
0.25	0.7	0.1986	0.5679	0.8207	0.9677	1.0000	1.0000
0.05	0.8	0.1531	0.4836	0.7409	0.9044	1.0000	1.0000
0.05	1.0	0.0954	0.3533	0.5993	0.7802	0.9044	0.9885
0.10	1.2	0.0626	0.2624	0.4836	0.6669	0.8044	0.9044
	1.5	0.0356	0.1739	0.3533	0.5240	0.6669	0.7802
	2.0	0.0157	0.0954	0.2174	0.3533	0.4836	0.5993

TABLE 3: Comparisons of mean ratios when **a**=0.7, **r**=3, **g**=1, λ=2

β	a	(μ/μ_0)	Proposed Plan $i = j$=1	Mughal *et al.* (2015a) i=2	Mughal *et al.* (2015b) i=2
0.25	0.7	2	0.1986	0.1763	0.0267
0.05	0.8	4	0.5679	0.4426	0.1801
0.05	1.0	6	0.8207	0.6174	0.3405
0.10	1.2	8	0.9677	0.7256	0.4630
	1.5	10	1.0000	0.7950	0.5330
	2.0	12	1.0000	0.8415	0.6200

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