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S Jayalakshmi
Assistant Professor, Department of Statistics, Bharathiar University, Coimbatore, Tamil Nadu, India

Neena Krishna PK
Ph.D., Research Scholar, Department of Statistics, Bharathiar University, Coimbatore, Tamil Nadu, India

Corresponding Author:
S Jayalakshmi
Assistant Professor, Department of Statistics, Bharathiar University, Coimbatore, Tamil Nadu, India

Selection of Bayesian skip lot sampling plan-3 with conditional repetitive group sampling plan using Trignometric Ratio Method

S Jayalakshmi and Neena Krishna PK

Abstract
Acceptance sampling plans on the basis of Bayesian methodology can be taken when the innovator has prior knowledge on the process fluctuation to take a opinion about the disposition of the lot. Bayesian sampling plan has a clear picture on the influences associated with the selection of appropriate prior distribution. This paper describes new method for Bayesian Skip Lot Sampling Plan-3 with Conditional Repetitive Group Sampling Plan using Trigonometric Ratio Methods. Tables and numerical examples are also provided.

Keywords: Bayesian skip lot sampling plan-3, conditional repetitive group sampling plan, Trignometric ratio method

1. Introduction
Acceptance Sampling is undoubtedly a opposing part, intiated as defensive accessory against the intimidation of depreciation in quality. Review of lot and ultimate product is fundamental to establish acceptable quality. Literally the concept of sampling inspection pays extra consideration to revamp the quality and lessen cost in terms of minimal sample size. Under this system manufactures are capable to take inventive production with the use of Bayesian Sampling Plan that is more powerful than current sampling plan, taking lesser surveillance cost and effectiveness over sample size. Bayesian Acceptance Sampling distribution access is combined with the usage of the prior process history for the choice of diffusion (Gamma-Poisson, Beta-Binomial) to explain the random variations involved in acceptance sampling. Bayesian Sampling Plans requires the customer to indicate exceptionally the distribution of the defectives from lot to lot.

The skip-lot Sampling methodology was advanced from the approach of continuous sampling plan, that is the quality authority of a product can be revised over the review of limited proportion of very large-conforming lots. The reference plan advanced for commerce purpose to overcome the inspected items of production towards producer risks and consumer risks, alpha and beta risks continued on lot-by-lot inspection. Dodge and Perry (1971) [2] establish the operation of Skip lot Sampling to the condition in one by one lot to be inspected is sampled confer to a few lot inspection plan is nominated as Skip lot Sampling Plan-2. Parker and Kessler (1981) [7] have altered the extant form of Skip lot Sampling Plan-2 under the principles in which at least one lot is consistently sampled from a construction of lot. Vijayaraghavan (1990) [11] described the Skip Lot Sampling Plan-3 which is also an extension of Skip Lot Sampling Plan -2 uses certain elementary methods of continuous sampling.

According to Hald (1981) [3] contributed an admirable relation and classical Bayesian theory and procedure for attributes of acceptance sampling. Calvin (1984) [1] has examined clearly and concisely the meaning of ‘how and when to perform Bayesian Acceptance Sampling’. Shankar and Mohapatra (1984) [9] advanced a modern sampling plan, it is an development of classical Repetitive Group Sampling Plan and nominated as Conditional Repetitive Group Sampling (CRGS) Plan. Kuralmani (1992) [5] made some improvement on Repetitive Group and certain relevant Conditional Sampling Plans. Latha (2002) [6] has explained the probability of acceptance for the Bayesian Single Sampling plan.

Pradeepa Veerakumari (2009) [8] has explained the evaluation of the performance measures for Bayesian conditional repetitive group sampling plan indexed through the quality levels. Suresh and Umamaheshwari (2014) [10] has evaluated the optimal design of Bayesian Skip-Lot Sampling Plan-2 with Conditional Repetitive Group Sampling Plan indexed through minimum angle method. In the present study, a new method for Bayesian Skip Lot -3 with Conditional Repetitive Group Sampling as reference plan indexed through trigonometric ratio method is constructed.

2. Conditions for the Application of Sampling Plan

1. The product consists, series of a successive lots produced by an necessarily continuing process.
2. Lots from the same authority which are generally expected under normal inspection.
3. For the given characteristics, normal acceptance method of each lot is consists of a applicable sample of the unit and make an analysis or test it. If the outcome of the test meet the specification limits then the lot is conforming otherwise nonconforming.

3. Operating Procedure

The operating Procedure of Skip Lot Sampling Plan-3 with Conditional Repetitive Group Sampling Plan as reference plan is as follows

1. Start with normal inspection using Conditional Repetitive Group Sampling Plan as reference plan.
2. When the consecutive i lots are accepted on normal inspection then switch to skipping inspection.
3. When one lot is rejected on skipping inspection then inspect the next k consecutive lots produced.
4. When one lot is rejected while inspecting k lots then switch to normal inspection.
5. When all the k consecutive lots are accepted, procced as in step 2.
6. Screen each rejected lot and correct or replace all the nonconforming units found.

The operating characteristic function of Bayesian Skip Lot Sampling Plan-3 with Conditional Repetitive Group Sampling Plan as reference plan

$$\bar{p} = \frac{fp + (1-f)\, p^{i}(2-p^{i})}{f + (1-f)\, p^{i}(2-p^{i})}$$

Where,

$$p = \frac{s^{s}}{(n\mu+s)^{s}} + \frac{(n\mu)s^{s+1}}{(2n\mu+in\mu+s)^{s+1}} + \frac{(n\mu)^{2} s^{s+1}(s+1)}{(3n\mu+2in\mu+s)^{s+2}} + \frac{n\mu^{3} s^{s+1}(s+1)(s+2)}{(4n\mu+3in\mu+s)^{s+3}}$$

4. For Specified AQL and LQL

Table 1 is developed for the choice of Bayesian Skip Lot-3 with Conditional Repetitive Group Sampling Plan as reference plan for Acceptable Quality Level (AQL) and Limiting Quality Level (LQL) are given. Table 2 added the operating ratio for the different combinations of α and β. (i.e. α =0.05 and β =0.50, α =0.05 and β =0.10, α =0.05 and β =0.05). The major steps are as follows:

1. Find the operating ratio $\frac{\mu_2}{\mu_1}$
2. Using the determined value of $\frac{\mu_2}{\mu_1}$, applied the value from table 2 which is equal or just greater than the observed operating ratio.
3. Also find the values of $n\mu_1$ *and* $n\mu_2$ from the table 1 and observed the sample size $n = \frac{n\mu_1}{\mu_1}$

Example 1 (α =0.05, β =0.50)

A leather manufacturing company makes leather bags at 2% defects in AQL and 9% defects in LQL. It is given μ_1 = 0.02 and μ_2 = 0.09 and observed the operating ratio $\frac{\mu_2}{\mu_1} = \frac{LQL}{AQL}$ = 4.5. Using table 2 one can take the value of R that is nearest to the operating ratio is R =4.5072. Thus one can easily calculate the corresponding values for f=1/4, s=2, i=2 and $n\mu_1$ =0.8751 from the table 1.Thus sample size can be find by using n= $\frac{n\mu_1}{\mu_1}$ = $\frac{0.8751}{0.02}$ = 43.755.The parameters of Bayesian Skip lot -3 with Conditional Repetitive Group Sampling Plan as reference plan is (44, 1/4, 2, 2).

5. Trignometric Ratio Method

This approach associates the comparisons of a few section of the OC curve against the comparable fraction of the ideal OC curve. The diameter of the line combining the acceptable quality level (AQL) and probability of acceptance of 50%, is to be create from desired OC curve of the sampling plan. The small value of ϴ mention that the curve reaches to ideal OC curve

$$\tan\theta = (\mu_2 - \mu_1)[p_a(\mu_1) - p_a(\mu_2)]$$

Two points on the OC curve for determined set of stipulation such as $(\mu_1, 1-\alpha)$ and (μ_2, β) and for the ideal condition of curve, to minimize the consumer's risk of desired sampling plan. Here, another approach of minimizing the angle between the lines joining the points (AQL, β), (AQL, 1-α) and is used under the study. By applying this method, one can attain a advanced plan.

The equation for $\tan\theta$ = *opposite side/adjacent side* = ntanθ = $(n\mu_2 - n\mu_1)/(1-\alpha-\beta)$

With the help of this expression, the angle θ is reduced for the given $n\mu_1$ and $n\mu_2$ values.

5.1 Selection Method of Bayesian Skip Lot Sampling Plan-3 with Conditional Repetitive Group Sampling through Trignometric Ratios

Table is constructed to choose plans for the given AQL (μ_1) and LQL (μ_2), α and β containing the minimum angle (ntan θ) between the lines found by the points (μ_1, β) (μ_2, 1-α) and (μ_1, 1-α), (μ_2, β). Tables 3.1 given different parameters minimum ntan θ versus the product of the sample size and the acceptable quality level ($n\mu_1$) and μ_2/μ_1 with obtained values of μ_1, μ_2 α and β. One can observe the proposed sampling plan from Table. The operating procedure of the minimum angle method is as follows:

1) Calculate the operating ratio μ_2/μ_1.

2) For the calculated value of μ_2/μ_1, adopt the corresponding value in the row headed by μ_2/μ_1 which is equal to or just greater than the computer ratio and obtain *f,s,i,* i_{crgs} *and* $n\mu_1$.

3) The sample size is obtained by $n = \dfrac{n\mu_1}{\mu_1}$.

4) Minimum angle can be found as $\theta = \tan^{-1}\{n\tan\theta / n\}$ }.

Illustration

For given μ_1=0.02 and μ_2= 0.15, one can obtain the Bayesian Skip Lot Sampling Plan-3 with Conditional Repetitive Group Sampling Plan as follows:

- $\dfrac{\mu_2}{\mu_1} = \dfrac{0.15}{0.02} = 7.5$, thus the nearest tabulated operating ratios is 7.55853.
- Find the parametric values corresponding to operating ratio is given i=3, s=3, i_{crgs} =3, f= 1/4, ntan θ =5.66726, $\alpha = 2\%$, $\beta = 3\%$ and $n\mu_1$=0.8209.
- n = $\dfrac{n\mu_1}{\mu_1}$ = 41.045 ≅ 41.
- $\theta = \tan^{-1}\{(n\tan\theta)/n\}$ = $\tan^{-1}(0.8209/41) = \tan^{-1}(0.13822) =$ 7.8695
- Thus the optimal plan is (41,1/4,3,3,3) with the minimum angle θ =7.8695.

Table 1: Certain Parametric values of Bayesian Skip Lot Sampling Plan-3 with Conditional Repetitive Group Sampling Plan as Reference Plan

f	s	i	i_{crgs}	0.99	0.95	0.90	0.75	0.50	0.10	0.05	0.01
1/2	2	2	1	0.2224	0.5012	0.7807	1.5095	2.7674	8.3658	12.0399	25.7973
	3	3	3	0.2238	0.4989	0.7485	1.3218	2.2039	6.0449	8.3642	15.6673
	4	4	5	0.2156	0.4966	0.7262	1.2200	1.9763	5.3329	7.1641	12.1911
	5	5	7	0.2170	0.4892	0.7061	1.1541	1.8592	4.9792	6.5617	10.6868
	6	6	9	0.2156	0.4846	0.6890	1.1074	1.7941	4.7469	6.1595	9.7778
1/3	2	2	1	0.2816	0.6851	1.0710	1.9838	3.4001	9.0768	12.6832	25.7388
	3	3	3	0.2817	0.6606	0.9699	1.5950	2.4805	6.1303	8.3689	15.5685
	4	4	5	0.2826	0.6373	0.9049	1.4110	2.1241	5.3337	7.1562	12.3380
	5	5	7	0.2796	0.6228	0.8571	1.2972	1.9476	4.9797	6.5802	10.7777
	6	6	9	0.2589	0.6050	0.8197	1.2195	1.8453	4.7388	6.1474	9.7059
1/4	2	2	1	0.3500	0.8751	1.3605	2.4063	3.9443	9.6993	13.1907	26.1086
	3	3	3	0.3403	0.8209	1.1686	1.8219	2.7021	6.2048	8.4552	15.4630
	4	4	5	0.3416	0.7702	1.0550	1.5630	2.2549	5.3354	7.1484	12.3805
	5	5	7	0.3446	0.7382	0.9782	1.4107	2.0226	4.9647	6.5296	10.8074
	6	6	9	0.3330	0.7040	0.9221	1.3101	1.8924	4.7382	6.1462	9.6842
1/5	2	2	1	0.3172	0.7700	1.1966	2.1669	3.6374	9.3279	12.8493	25.9495
	3	3	3	0.3051	0.7266	1.0566	1.6967	2.5773	6.1610	8.3728	15.5242
	4	4	5	0.3074	0.7005	0.9714	1.4782	2.1812	5.3342	7.1528	12.3981
	5	5	7	0.3114	0.6700	0.9115	1.3485	1.9789	4.9655	6.5316	10.8151
	6	6	9	0.2985	0.6490	0.8679	1.2592	1.8655	4.7386	6.1469	9.6968
2/3	2	2	1	0.2008	0.6154	0.6887	2.0976	2.5529	8.1350	11.9017	25.4799
	3	3	3	0.1996	0.4502	0.6755	1.2244	2.1097	6.0434	8.3477	15.8258
	4	4	5	0.1987	0.4466	0.6662	1.1519	1.9272	5.3328	6.5365	10.6214
	5	5	7	0.1991	0.4445	0.6522	1.1036	1.8335	4.9675	6.1486	9.7319
	6	6	9	0.1953	0.4422	0.6417	1.0674	1.7811	4.7394	4.7394	4.7394

Table 2: Operating Ratio Values against parameters for given α and β for Bayesian Skip Lot Sampling Plan-3 with Conditional Repetitive Group Sampling Plan as Reference Plan

f	s	i	i_{crgs}	$n\mu_1$ α=0.05	μ_2/μ_1 α=0.05 β=0.10	μ_2/μ_1 α=0.05 β=0.05	μ_2/μ_1 α=0.05 β=0.50	$n\mu_1$ α=0.01	μ_2/μ_1 α=0.01 β=0.10	μ_2/μ_1 α=0.01 β=0.05	μ_2/μ_1 α=0.01 β=0.50
1/2	2	2	1	0.5012	16.6915	24.0221	5.5215	0.2224	37.6162	54.1362	12.4433
	3	3	3	0.4989	12.1164	16.7652	4.4175	0.2238	27.0101	37.3732	9.84766
	4	4	5	0.4966	10.7388	14.4263	3.9796	0.2156	24.7355	33.2283	9.16651
	5	5	7	0.4892	10.1782	13.4131	3.8004	0.2170	22.9453	30.2384	8.56774
	6	6	9	0.4846	9.79550	12.7104	3.7022	0.2156	22.0176	28.5691	8.32142
1/3	2	2	1	0.6851	13.2488	18.5129	4.9629	0.2816	32.2327	45.0391	12.0742
	3	3	3	0.6606	9.27989	12.6686	3.7549	0.2817	21.7619	29.7088	8.80546
	4	4	5	0.6373	8.36921	11.2289	3.3329	0.2826	18.8738	25.3229	7.51627
	5	5	7	0.6228	7.99566	10.5655	3.1271	0.2796	17.8100	23.5347	6.96566
	6	6	9	0.6050	7.83272	10.1609	3.0500	0.2589	18.3037	23.7440	7.12746
1/4	2	2	1	0.8751	11.0836	15.0733	4.5072	0.3500	27.7123	37.6878	11.2694
	3	3	3	0.8209	7.55853	10.2999	3.2916	0.3403	18.2331	24.8467	7.94034
	4	4	5	0.7702	6.92729	9.28122	2.9276	0.3416	15.6182	20.9266	6.60099
	5	5	7	0.7382	6.72541	8.84529	2.7399	0.3446	14.407	18.948	5.86941
	6	6	9	0.7040	6.73039	8.73039	2.6880	0.3330	14.228	18.457	5.68288
1/5	2	2	1	0.7700	12.1141	16.6874	4.7238	0.3172	29.407	40.508	11.4672
	3	3	3	0.7266	8.47921	11.5232	3.5470	0.3051	20.193	27.442	8.44739
	4	4	5	0.7005	7.61484	10.2109	3.1137	0.3074	17.352	23.268	7.09564
	5	5	7	0.6700	7.41119	9.74865	2.9535	0.3114	15.945	20.974	6.35484
	6	6	9	0.6490	7.30138	9.47134	2.8744	0.2985	15.874	20.592	6.24958
2/3	2	2	1	0.6154	13.2190	19.3397	4.1483	0.2008	40.512	59.271	12.7136
	3	3	3	0.4502	13.4238	18.5422	4.6861	0.1996	30.277	41.822	10.5696
	4	4	5	0.4466	11.9408	14.6361	4.3152	0.1987	26.838	32.896	9.69904
	5	5	7	0.4445	11.1754	13.8326	4.1248	0.1991	24.949	30.881	9.20894
	6	6	9	0.4422	10.7177	10.7177	4.0278	0.1953	24.267	24.267	9.11981

Table 3: Minimum Angle of Bayesian Skip Lot Sampling Plan-3 with Conditional Repetitive Group Sampling Plan as Reference Plan using Trignometric Ratios

f	s	i	i_{crgs}	$n\mu_1$	$n\mu_2$	α	β	ntan θ	OR
1/2	2	2	1	0.5012	8.3658	0.01	0.02	8.107835	16.69154
	3	3	3	0.4989	6.0449	0.02	0.03	5.837895	12.11646
	4	4	5	0.4966	5.3329	0.05	0.1	5.689765	10.73882
	5	5	7	0.4892	4.9792	0.1	0.5	11.22500	10.17825
	6	6	9	0.4846	4.7469	0.5	0.01	8.698571	9.795501
1/3	2	2	1	0.6851	9.0768	0.01	0.02	8.651237	13.24887
	3	3	3	0.6606	6.1303	0.02	0.03	5.757579	9.279897
	4	4	5	0.6373	5.3337	0.05	0.1	5.525176	8.369214
	5	5	7	0.6228	4.9797	0.1	0.5	10.89225	7.995665
	6	6	9	0.6050	4.7388	0.5	0.01	8.436327	7.832727
1/4	2	2	1	0.8751	9.6993	0.01	0.02	9.097113	11.08365
	3	3	3	0.8209	6.2048	0.02	0.03	5.667263	7.558533
	4	4	5	0.7702	5.3354	0.05	0.1	5.370824	6.927292
	5	5	7	0.7382	4.9647	0.1	0.5	10.56625	6.725413
	6	6	9	0.7040	4.7382	0.5	0.01	8.233061	6.730398
1/5	2	2	1	0.7700	9.3279	0.01	0.02	8.822577	12.11416
	3	3	3	0.7266	6.1610	0.02	0.03	5.720421	8.479218
	4	4	5	0.7005	5.3342	0.05	0.1	5.451412	7.614847
	5	5	7	0.6700	4.9655	0.1	0.5	10.73875	7.411194
	6	6	9	0.6490	4.7386	0.5	0.01	8.346122	7.301387
2/3	2	2	1	0.6154	8.1350	0.01	0.02	7.752165	13.21904
	3	3	3	0.4502	6.0434	0.02	0.03	5.887579	13.42381
	4	4	5	0.4466	5.3328	0.05	0.1	5.748471	11.94089
	5	5	7	0.4445	4.9675	0.1	0.5	11.3075	11.17548
	6	6	9	0.4422	4.7394	0.5	0.01	8.769796	10.71777

6. Conclusion

Acceptance sampling plans are generally used in management to regulate even the produced component gratify the pre specified quality level or not. In this case, a company must have to take decision whether the lot is accepted or rejected in accordance with the random selection of lots. This present study focus on Bayesian Skip-Lot sampling plan-3 with Conditional Repetitive Group Sampling Plan as reference plan indexed through Trigonometric Ratio Method. The selection methods are based on the quality levels which is associated with operating characteristic (OC) functions. Adoption of Minimum Angle Criteria makes some part of OC curve can be easily examined with corresponding individual of the ideal OC curve which may protect both the producer and consumer which plays a powerful role. This is an enhanced technique which has further practicable situations not only used in the production sector but also applied in the employment sector, when compared to other plans. This technique makes benefit to the engineers and quality control practioners to choose on the lot size depending on the producer and consumer specifications.

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