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Designing Optimal Repetitive Sampling Plan Using Truncated Poisson distribution

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Abstract- Acceptance sampling plan for attributes develop to control the quality, where both the consumers and the producers get benefit for better quality of the product. Repetitive group sampling plan is one of the most adoptable and cost effective sampling plan to get the product accepted with high quality level desired for production process. In this scenario overall risk to make wrong decision is reduced by considering the concept of truncation. Tables and a procedure for the acceptance and limiting level are developed to minimize the producers and consumers risks using the Truncated Poisson distribution. Optimality criteria are compared using Operating Characteristics curve with the already existing work.

***Keywords*:** Attribute plan, OC curve, Producer's Risk, consumer risk, Repetitive Group Sampling (RGS), Truncated Poisson Distribution.

I. INTRODUCTION

Acceptance sampling plan is commonly used quality control techniques by the industries to make the decision of the materials produced. This decision depends over the acceptance number.

Consumers need producers of their desired goods and services to produce, while producers need the consumers in utilize maximum consumption of their goods and services. This relationship can exist in any market environment. Consumers always seek to maximize their satisfaction which is their overall goal of consuming any goods and services while producers always seek to maximize their profit (revenue) which is their overall goal of the transaction.

Both the consumers and producers are interested in low risk for accepting and rejecting of material produced. Sample size and the probability of lot acceptance are the two important points to make the decision regarding the minimization of risk. This is analyzed by operating characteristic curve, which visualize the sampling plan under study. (p_1, $1 - \alpha$) and (p_2, β) are two points of the operating characteristic curve of acceptance sampling plans of non-Bayesian risk- based design, where p_1 is Acceptance Quality Level, p_2 is Limiting Quality Level, α is Producer's risk, and β is Consumer's risk. The fixed risk of sampling plan for discreteness of the parameter is changed to Pa (p_1) $\geq$ 1- α and Pa (p_2) $\leq \beta$.

Acceptance number and sample size are the two parameters determined with minimal sample size to meet two points of requirements.

II. REVIEW OF THE LITERATURE

Sherman has constructed tables at the Indifference Quality Level (p_0) for the conformation of an RGS plan by using the slope of the OC curve[1]. Hamaker has designed the sampling plan by considering (p_1, h_1), (p_2, h_2) and (p^*, h^*) and made the elaborate studies about the slope [2]. G.B.Wetherill and W.K. Chiu reviewed the recent development in economic aspects with some major belief of schemes adopted by acceptance sampling plans [3]. C.R.Rao reviewed some contributions related to weighted distribution and he explained the arrival of the distribution through some related examples [4]. Dodge has composed normal and tightened plans, as (n; c_2, c_1) [(n, c_2) and (n, c_1) are normal and tightened single sampling plans respectively with c_2>c_1] [5]. Soundararajan inspected the sampling plan for attributes of fixed sample size [6].

In Wortham, A.W and Mogg.J developed Dependent stage sampling plan supplement for already used two stage sampling plans, here the probability of lot acceptance is dependent on the submitted prior lot probability of acceptance. The common properties and concepts of the dependent stage acceptance sampling is compared with chain sampling plans[7].

Schilling , Duncan , Montgomery etc., Published the tables to different sample size and acceptance number for known operating ratio p_2/p_1. In practice the fractional parts p_1 and p_2 that are not usually observed[8,9,10] . Because tables are formed for the fixed parameter (n, Ac) of the plans which are integers. Soundararajan and Ramasamy found the values for the selection of RGS plan indicates through (AQL, AOQL); (p_0, h_0) and (p^*, h^*)[11,12]. The study was extended by Govindaraj who found the OC function for the RGS plan [13].K.Subramani has constructed a table for the quick switching system to reduce the sum of risk [14].

Following to this K.Subramani and V.Haridoss used the Weighted Poisson distribution to reduce the amount of risk to single sampling attributes plan for known AQL and LQL [15]. Cameron A.C, Johansson. P developed the new class parametric regression model for under and over dispersed count data [16].

G.P.Patil and C.R.Rao. examined several discrete models using the examples including sample survey with probability and several important distributions with their size based forms are recorded and concluded that the weight functions in the weighted distribution need not be bounded by unit[17]. Followed by this Patil.G.P, Rao.C.R and Ratnaparki.M.V explained the theory and practical structures of discrete weighted distribution of unified prior work of different models with some new results [18].

Joan Del Castillo and Pérez-Casany made an attempt on over dispersion (aggregation) and under dispersion (repulsion) situation to fit the discrete data [19]. R.Radhakrishnan and L.Mohana Priya developed the CRGS plan with Weighted Poisson distribution as an elementary distribution and it is collated with the CRGS plan with Poisson distribution as an elementary distribution [20]. J.R.Singh, A.Sanvalia has developed SSP for variables with known coefficient of variation to the index value of AQL and LQL [21]. Subramani.K and Haridoss.V had given the selection of minimum sample size for Repetitive Sampling Plan using Weighted Poisson Distribution.

Sherman established the new attribute sampling plan for with simple operation procedure and design. The operation producer for repetitive sampling plan and sequential sampling plan are similar. The most appropriate sample size as well as the required protection to the consumers and producers can be derived using this sampling scheme. By giving an intermediate sample size it is more effective than single and sequential plan [18].

III. OPERATING PROCEDURE OF REPETITIVE GROUP SAMPLING PLANS

The modus operandi for repetitive group sampling is as follows:

1. The observed number of Non-conformities (d) is observed in the submitted lots for selected sample size n.
2. If the Non-conformity (d) is atmost to acceptance number c_1 acquire the lot, if it exceeds than c_2, reject the lot.
3. If $c_1 < d \le c_2$, utilize the information of the next proceeding lot and checkup with previous two conditions already followed.

IV. TRUNCATED POISSON DISTRIBUTION

When $k > 0$, the truncation stipulates and the truncated distribution will become the Truncated Poisson distribution. From the standard Poisson distribution the PMF of the Truncated distribution can be derived as follows $g(k;\lambda) = P(X = k|k > 0) = \frac{f(k;\lambda)}{1-f(0;\lambda)} = \frac{\lambda^k e^{-\lambda}}{k!(1-e^{-\lambda})} = \frac{\lambda^k}{(e^{\lambda}-1)k!}$

The Zero Truncated Poisson distribution is also known as Positive Poisson Distribution or Conditional Poisson distribution, since it is a discrete distribution which supports the group of positive integers. If the value of the random variable is positive then the Truncated Poisson distribution will be the joint Probability distribution of the discrete random variable with the condition of the Poisson distribution.

a. Selection of Minimum Risk Repetitive Group Sampling Plan:

The least sum of risks of RGS plan is selected for given AQL (p_1) and LQL (p_2) from the Table I. In this table, for fixed operating ratio p_2/p_1, the maximum producer's risk is assumed as 10% and 11% as the consumer's risk. The body of the table gives the acceptance number Ac_1 and Ac_2 and the associated producer's risk(α) and consumer's risk(β) against the product of sample size (n) and AQL (p_1) (i.e., np_1). RGS attributes plan for the given value of p_2, p_1, α & β found out in the table I as follows.

1. Find the ratio p_2/p_1
2. For the evaluated ratio values, enter Table I with row topic p_2/p_1. The calculated value of operating ratio is atmost to the computed ratio.
3. For the identified row of step 2, with the tabulated risk of producers and consumers are just atmost to the desired risks such that the parameters Ac_1 and Ac_2 are determined

4. For the fixed acceptance number of previous step, the sample size is found as n= np_1/p_1, np_1 values are given as the column heading.

For Example:

The RGS plans involving minimum risk for fixed p_1=0.01, α= 0.05, p_2=0.04 and β= 0.05.

i) Operating ratio is 4

ii) Tabulated operating ratio

iii) The parameter Ac_1= 18 and Ac_2=1 shown in the body of the table, which obtains α =0 and β =0.016 against the desired α = 0.05 and β = 0.05.

iv) The sample number is found as n = np_1/p_1= 1.5/0.01 = 150

b. Comparative study with K.Subramani's Procedure Of Selecting Repetitive Group Sampling Attributes Plan

For the value of α and β K.Subramani (1991) has given the table to select an RGS plan for given p_1 and p_2. In our work we constructed the table, which does not assume any fixed value of α and β, it gives RGS plan for rounded values of the operating ratio. The parameter in the table I have the minimum sum of risk which directly assumes p_2/p_1 values corresponding to producer's and consumer's risk.

Let us consider K.Subramani's (1991) table, if p_1 = 0.01 and p_2 = 0.06 is fixed with α = 0.05 and β = 0.10, then the operating ratio will be 5 with np_1 = 0.6, where Ac_1 = 0, Ac_2 = 3 and n = 60 for desired α = 0.05 and β = 0.10 against the actual value α = 0.01 and β = 0.05.

Under the same conditions, from Table I of an RGS plan , Ac_1 = 18 , Ac_2 = 11 and n = 60 for which α = 0 and β = 0 giving α + β = 0 against the desired α + β = 0.06 which is lesser than K.Subramani's (1991) sum of risks.

c. Selection of the plan for fixed sample size

For the practical or administrative purpose the table 1 is used to select a RGS plan with fixed sample size. For example, if n is fixed as 200, AQL (p_1) as 0.01 and LQL (p_2) as 0.04, one gets np_1= (200) (0.01) = 2.0 and p_2/p_1 = 0.04/0.01 = 4. For n = 200, we found the minimum sum of risk from the Table I as Ac_1 = 18, Ac_2 = 9 (α = 0.02, β = 0.2) to the corresponding value of np_1 and p_2/p_1.

d. Procedure for Table construction:

Sherman (1965) has shown that the OC function of an RGS is

$$P_a(p) = \frac{P(d \le Ac_1;n)}{1-P(d \le Ac_2;n)+P(d \le Ac_1;n)} \quad ---(1)$$

$$P(d \le Ac_1;n) = \sum_{d=1}^{Ac_1} \frac{(np)^d}{(e^{np}-1)(d)!} \; ; \quad d = 1,2,3 \ldots, \quad \text{and}$$

$$P(d \le Ac_2;n) = \sum_{d=1}^{Ac_2} \frac{(np)^d}{(e^{np}-1)(d)!} \; ; \quad d = 1,2,3 \ldots,$$

By fixing np_1, the value of np_2 is found as (np_1) (p_2/p_1). For minimum $1 - P_a(p_1) + P_a(p_1)$, the parameter Ac_1 and Ac_2, are found out using computer program from Ac_1 = 1(1)30, Ac_2 = Ac_1+1(1) Ac_1+15. The producer's and consumer's risk are obtained for minimum sum of risks for corresponding Ac_1 and Ac_2 values.

V. CONCLUSION

The basic purpose of this paper is to reduce consumer and producer risk. Here we developed the table for RGS plan with the operational ratio using truncated Poisson distribution. The Analysis carried out for fixed value of np_1 and p_2/p_1. It is observed that for the value of α = 0.05 and β = 0.10 of p_1= 0.01 and p_2 = 0.06, the risk is minimized compared to the repetitive group sampling plan using Poisson distribution. Based on this process we have arrived the decision for the various combination of the values and conclude that the sum of risk is minimized using the Truncated Poisson distribution than the Poisson distribution. Thus it is useful for the vendors to supply their product with minimum inspections to gain the maximum profit and also it helps the buyers to get quality product for reasonable cost.

OC Curve:

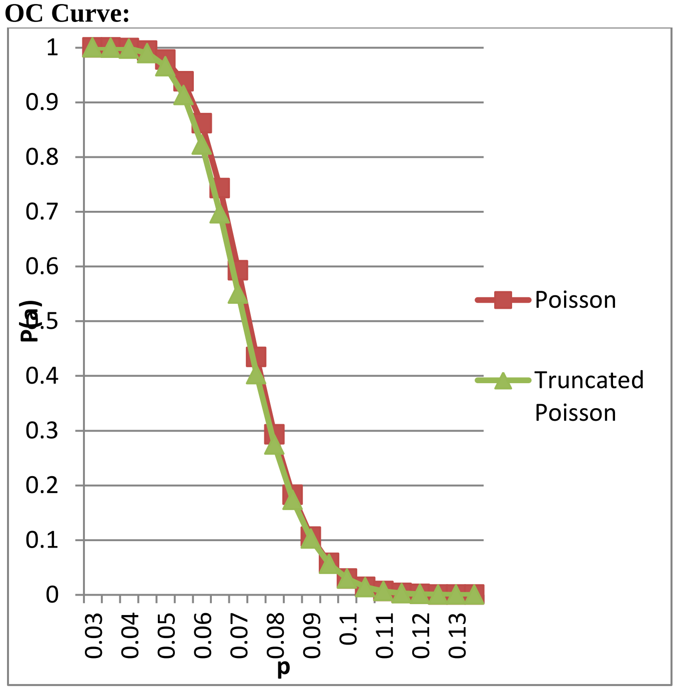

Figure 1: Operating Characteristic curve of RGS

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AUTHORS PROFILE

Dr. K. Subramani pursued M.Sc, M.Phil & Ph.D from Bharathiar University in 1985, 1987 & 1993. He is currently working as a Assistant Professor in the Department of Statistics , Government Arts college , Coimbatore - 18 from 2007. He is a life member of IAPQR since 1997. He served as a Reviewer in the International Journal of Quality and Reliability Management. He has published more than 25 research papers in reputed international journals including Communication in Statistics (USA), Journal of Applied Statistics (UK) & IJQRM (UK). His main research work focuses on Statistical Quality Control (Acceptance Sampling Plans). He has 24 years of teaching experience and 28 years of research experience.

Mrs. S.Ambika pursued M.Sc, M.Phil & MBA from Bharathiar University in 2005, 2010, &2012. She is currently pursuing Part-Time Ph.D in the Department of Statistics, Government Arts College, Coimbatore-18. She has 10 years of teaching experience and is currently working as Assistant Professor in the Department of Mathematics and Statistics, Sri Krishna Arts and Science College, Coimbatore- 08. She has published more than 8 papers in National and International journals and is available online.

Dr. Haridoss Venugopal is an Assistant Professor in the Department of Statistics, Madras Christian College. He has published 13 research papers in reputed international journals and presented 6 papers in national and international conferences.

TABLE 1: Parameters of Repetitive Group Sampling Plan for Given p_2/p_1 and np_1

np_1 p_2/p_1	0.05	0.075	0.10	0.15	0.20	0.25	0.30	0.4	0.5	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	7.0	8.0	9.0
50.0	1, 1 2, 22	1,2 0.1,1 1	1,3 0.2, 4	1,4 0.01, 0.4	1,5 0,0.4	1,8 0,0	1,8 0,0	1,10 0,0	1,11 0,0	1,14 0,0	1,1 5 0,0	3, 19 0, 0	14, 27 0,0	31, 44 0,0							
45.0		1,2 0.09, 15	1,3 0.3, 6	1,4 0.01, 0.9	1,5 0,0.1	1,6 0,0. 01	1,7 0,0	1,9 0,0	1,11 0,0	1,14 0,0	1,1 5 0,0	3, 19 0, 0	9,2 4 0,0	31, 39 0,0							
40.0		1,2 4,16	1,3 0.2, 9	1,4 0.01, 2	1,5 0,0.3	1,5 0,0. 04	1,7 0,0	1,8 0,0	1,10 0,0	1,13 0,0	1,1 5 0,0	3, 18 0, 0	5,2 1 0,0	14, 27 0,0							
35.0		1,2 4,21	1,3 0.2, 13	1,3 0.4,3	1,4 0.03, 0.7	1,5 0,0. 1	1,6 0,0. 03	1,8 0,0	1,9 0,0	1,13 0,0	1,1 5 0,0	2, 17 0, 0	3,1 9 0,0	7,2 1 0,0							
30.0		1,2 4,27	1,1 5,1 6	1,3 0.4,6	1,4 0.03, 2	1,5 0,0. 5	1,5 0,0. 1	1,7 0,0	1,9 0,0	1,12 0,0	1,1 4 0,0	2, 17 0, 0	3,1 9 0,0	5,2 1 0,0	9, 24 0, 0						
25.0			1,1 5,2 2	1,3 04,11	1,3 0.7,4	1,4 0.0 6,1	1,5 0,0. 5	1,6 0,0.0 5	1,8 0,0	1,11 0,0	1,1 3 0,0	1, 15 0, 0	3,1 9 0,0	5,2 1 0,0	5, 21 0, 0	14, 27 0,0					
20.0					1,3 0.7,9	1,4 0.0 6,4	1,4 0.1, 2	1,5 0.02, 0.9	1,7 0,0.0 5	1,9 0,0	1,1 2 0,0	1, 15 0, 0	2,1 7 0,0	3,1 9 0,0	4, 17 0, 0	9,2 4 0,0	14, 27 0,0				
17.0						1,3 1,7	1,4 0.1, 4	1,5 0.02, 0.9	1,7 0,0.2	1,9 0,0	1,1 1 0,0	1, 15 0, 0	2,1 7 0,0	3,1 9 0,0	5, 21 0, 0	8,2 3 0,0	11, 26 0,0	16, 31 0,0			
15.0							1,4 2,6	1,4 0.3,2	1,5 0.06, 0.5	1,8 0,0.0 2	1,1 0 0,0	1, 14 0, 0	2,1 6 0,0	3,1 8 0,0	3, 19 0, 0	7,2 2 0,0	10, 25 0,0	12, 27 0,0			
12.0								1,4 0.3,5	1,5 0.06, 2	1,7 0,0.1	1,9 0,0	1, 13 0, 0	1,1 5 0,0	2,1 7 0,0	3, 19 0, 0	5,2 1 0,0	8,2 3 0,0	11, 26, 0,0	14, 28 0,0		
11.0								1,4 0.3,8	1,4 0.6,2	1,6 0.04, 0.3	1,8 0,0. 02	1, 12 0, 0	1,1 5 0,0	2,1 7 0,0	3, 19 0, 0	5,2 1 0,0	8,2 3 0,0	11, 26, 0,0	14, 28 0,0	15, 30 0,0	18, 33 0,0
10.0								1,3 3,9	1,4 0.6,4	1,6 0.04, 0.5	1,8 0,0. 06	1, 12 0, 0	1,1 5 0,0	2,1 6 0,0	3, 18 0, 0	5,2 1 0,0	7,2 2 0,0	10, 25 0,0	12, 27 0,0	15, 30 0,0	17, 32 0,0

Key
Ac_1, Ac_2
α
%, β %

np_1 p_2/p_1	0.5	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0
9.5	18, 7 0,0	18,7 0,0	1,8 0,0.1	1,11 0,0	1,1 4 0,0	1,1 5 0,0	3,1 7 0,0	5,1 9 0,0	7,2 1 0,0	10,2 4 0,0	12,2 6 0,0	14,2 8 0,0	16,3 0 0,0	19,3 3 0,0	24,3 8 0,0					
9.0		18,7 0,0.0 3	1,7 0.02,0. 1	1,11 0,0	1,1 4 0,0	1,1 5 0,0	2,1 6 0,0	5,1 9 0,0	7,2 1 0,0	9,23 0,0	12,2 6 0,0	14,2 8 0,0	16,3 0 0,0	18,3 2 0,0	22,3 6 0,0					
8.5			18,7 0.01,0. 2	1,11 0,0	1,1 3 0,0	1,1 5 0,0	2,1 6 0,0	4,1 8 0,0	7,2 1 0,0	9,23 0,0	11,2 5 0,0	14,2 8 0,0	16,3 0 0,0	18,3 2 0,0						

8.0	1,10 0,0.0 1	1,1 3 0,0	1,1 5 0,0	2,1 6 0,0	4,1 8 0,0	6,2 0 0,0	9,23 0,0	11,2 5 0,0	13,2 7 0,0	15,2 9 0,0	18,3 2 0,0						
7.5		1,1 3 0,0	1,1 5 0,0	2,1 6 0,0	4,1 8 0,0	6,2 0 0,0	8,22 0,0	11,2 5 0,0	13,2 7 0,0	15,2 9 0,0	17,3 1 0,0						
7.0		1,1 2 0,0	1,1 4 0,0	2,1 5 0,0	4,1 8 0,0	6,2 0 0,0	8,22 0,0	10,2 4 0,0	12,2 6 0,0	14,2 8 0,0	16,3 0 0,0						
6.5			1,1 4 0,0	1,1 5 0,0	3,1 7 0,0	5,1 9 0,0	7,21 0,0	10,2 4 0,0	12,2 6 0,0	14,2 8 0,0	16,3 0 0,0	19,3 3 0,0					
6.0			1,1 4 0,0	1,1 5 0,0	3,1 7 0,0	5,1 9 0,0	7,21 0,0	9,23 0,0	11,2 5 0,0	13,2 7 0,0	15,2 9 0,0	18,3 2 0,0	22,3 6 0,0				
5.5					3,1 7 0,0	5,1 9 0,0	6,20 0,0	8,22 0,0	10,2 4 0,0	12,2 6 0,0	14,2 8 0,0	16,2 9 0,0	21,3 5 0,0	26,3 6 0,0			
5.0					2,1 6 0,0	4,1 8 0,0	6,20 0,0	8,22 0,0	10,2 4 0,0	11,2 5 0,0	13,2 7 0,0	18,3 2 0,0	20,3 4 0,0	24,3 8 0,0			
4.5					2,1 6 0,0	4,1 8 0,0	5,19 0,0	7,21 0,0	9,23 0,0	10,2 4 0,0	13,2 7 0,0	16,3 0 0,0	19,3 3 0,0	23,3 7 0,0	27,4 2 0,0	27,4 3 0,0	27,4 3 0,0
4.						3,1 7 0,0	5,19 0,0	7,21 0,0	8,22 0,0	10,2 4 0,0	12,2 6 0,0	15,2 9 0,0	18,3 2 0,0	21,3 5 0,0	28,4 1 0,0	28,4 1 0,0	28,4 1 0,0

