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Editorial Board

Title

DETERMINATION OF LOT SIZE IN THE CONSTRUCTION OF SIX SIGMA BASED LINK SAMPLING PLANS

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Abstract:

The term 'Six Sigma' originated from the terminology associated with the statistical modeling of manufacturing processes. A six-sigma process is one in which 99.99999% of the products manufactured are statistically expected to be free of defects. Acceptance sampling is a statistical procedure for accepting or rejecting a lot or a batch items based on the number of non-conformities found in a sample. Various sampling plans have been designed and these procedures focus on the determination of lot size by assuming the lot size to be either too large or infinite. It is not very convincing to say that a lot is accepted or rejected on the basis of a fixed sample size irrespective of the lot size. Radhakrishnan and Vasanthamani (2009a, 2009b, 2011) determined the lot sizes for single sampling plans, double sampling plans, double sampling plans of the type DSP(0,1) for fixed AOQ. Further, Radhakrishnan and Vasanthamani (2010, 2009c) determined the lot size for single and double sampling plans DSP(0,1) based on six sigma quality levels also which are useful for the companies practicing six sigma initiatives in their organization.

In this paper an attempt is made to determine the size of the lot (N) of a Six sigma based link sampling plan with Poisson distribution as a base line distribution. A table is also constructed for the easy selection of the plan for various values of sample size (n_1, n_2), acceptance numbers (c_1=1, c_2=3) and Average Outgoing Quality (AOQ) with probability of acceptance $1–3.4 \times 10^{-6}$.

Key words and Phrases: Link Sampling Plan (LSP), size of the first sample and second sample (n_1, n_2), Acceptance numbers (c_1,c_2), Lot size (N), Lot quality (p), Average Outgoing Quality (AOQ).

Introduction:

Conditional sampling plans are special purpose plans. Sampling plans are classified as cumulative and non-cumulative type. In non-cumulative sampling plans results of current sample alone are used for arriving a decision whether to accept or reject a lot. In the cumulative type sampling plans, both current and past sample results are used for making a decision. Link Sampling Plan (LSP) is one among the conditional sampling plans, which is classified under cumulative type of sampling plan. The conditional sampling procedures have been developed to reduce the inspection cost of the decision process using sample results from neighboring and related lots. This is the main advantage of conditional sampling plans.

Harishchandra and Srivenkataramana (1982) have developed Link Sampling Plans. In this scheme whenever a second sample is required, the sample results from neighboring lots, (past and future) is used. The operating characteristic function of link sampling plan is identical with that of double sampling plan. Hence link sampling plan can be proposed as an alternative to double sampling situation. Moreover, if the lot requires a second sample for making a unique decision, in link sampling plan the average sample number is 'n' while in double sampling plan, the average sample number is more than 'n'. Radhakrishnan (2003) constructed Link sampling plan for a specified Maximum Allowable Average Outgoing Quality (MAAOQ) and other various entry parameters. Devaarul (2003) has made contributions to mixed sampling plans with Link sampling plan as attribute plan. Radhakrishnan and Sivakumaran (2010) constructed Six Sigma based Link Sampling Plans.

In a 2 class attribute Link Sampling Plan by attributes the lot acceptance procedure is characterized by the parameters N, n_1, n_2 c_1 and c_2 where N is the lot size, n_1, n_2 are the sample sizes and c_1 and c_2 are the acceptance numbers.

Conditions for Application:

- The production is steady so that results of past, present and future lots are broadly indicative of a continuing process.
- Lots are submitted sequentially in the order of their production.
- Inspection is attributes, with the quality defined as the proportion defective.
- Variation in lot quality exists.
- Human involvement is to be minimum in the process / system.

Glossary of symbols:

The symbols used in this paper are as follows:

N - Lot size

n_1 - First sample size

n_2 - Second sample size

c_1 - First acceptance number

c_2 - Second acceptance number

d_i - Number of defective items counted in the ith sample.

Operating procedure:

The operating procedure of a Link Sampling plan is as follows

Step 1 : From a lot 'i', select a random sample of size 'n_1=n and find the number of defectives 'd_i' in the sample

Step 2: If the number of defectives di $\leq c_1$, accept the lot.

Step 3 : If the number of defectives di > c_2, reject the lot.

Step 4 : If $c_1 < d_i \leq c_2$, combine the total number of defectives from the immediate preceding and succeeding lots, $D_i = d_{i-1} + d_i + d_{i+1}$.

Step 5: If $D_i \leq c_2$, accept the lot 'i' and reject the lot if $D_i > c_2$.

Operating Characteristic function:

Under Poisson model, the OC function of the two class attribute Link sampling plan as given by Dodge (1959) is

$$P_a(p) = \sum_{r=0}^{c_1} \frac{e^{-n_1p}(n_1p)^r}{r!} + \left[\sum_{k=c_1+1}^{c_2} \frac{e^{-n_1p}(n_1p)^k}{k!}\left\{\sum_{r=0}^{c_2-k} \frac{e^{-n_2p}(n_2p)^r}{r!}\right\}\right] \qquad (1)$$

Determination of the Lot Size:

By fixing the lot quality, sample sizes n_1 and n_2, the acceptance numbers c_1 & c_2 and AOQ with the probability of acceptance as 0.999997, the lot size are determined using the formula

$$AOQ = (p/N)[\,(N - n)\,P_{a1} + (\,N - n - 2n\,)\,P_{a2}] \qquad (2)$$

where $P_{a1} = \sum_{r=0}^{c_1} \frac{e^{-n_1p}(n_1p)^r}{r!}$, $P_{a2} = \sum_{k=c_1+1}^{c_2} \frac{e^{-n_1p}(n_1p)^k}{k!}\left\{\sum_{r=0}^{c_2-k} \frac{e^{-n_2p}(n_2p)^r}{r!}\right\}$

Provided by Duncan (1986) and the results are presented in the Table1(for various values of n_1, n_2 and $c_1=1$ and $c_2=3$) using excel package.

Example 1:

For a specified AOQ = 0.0518%, $n_1 = 75$, $n_2 = 150$, $c_1 = 1$, $c_2 = 3$ and Probability of acceptance 0.999997, the value of the lot size can be obtained from Table1 as N=19544. The selected Link Sampling Plan is N = 19544, $n_1 = 75$, $n_2 = 150$, $c_1 = 1$ and $c_2=3$ with the sigma level of (3.8, 3.6). The OC curve for the suggested plan is presented in figure 1.

Practical Application:

In a manufacturing company which practices six sigma initiatives, if the producer fixes the AOQ as 0.0518% (5180 non conformities out of 10, 00,000) , take a sample of 75 items from a lot of 19544 items manufactured in a particular day and count the number of non-conformities (d_i). If $d_i \leq 1$, accept that lot of items manufactured in that day and if $d_i > 3$, reject the lot of items manufactured in that day and inform the management for improving the quality of the lot. If $d_i = 2$ or 3, take a second sample of 150 items selecting 75 items from the immediate preceding lot and 75 items from the immediate succeeding lot, and count the number of non-conformities in each(d_{i-1}, d_{i+1}). Combine the total number of defectives from the immediate past and future lots, $D_i = d_{i-1} + d_i + d_{i+1}$. If $D_i \leq 3$ accept that lot of items manufactured in the same day, and if $D_i > 3$ reject the lot and inform the management for quality improvement.

Conclusion:

In this paper an attempt is made to determine the lot size of Six Sigma based link sampling Plans which has the probability of acceptance Pa(p) of the lot as $1\text{-}3.4 \times 10^{-6}$ using Poisson distribution as a base line distribution and suitable table is also provided for specified values of AOQ. This will help the floor engineers working in companies under developed and developing countries which are practicing six sigma initiatives in their organization, to suggest on the size of the lot to be submitted for inspection. This work can be extended for other sampling plans also.

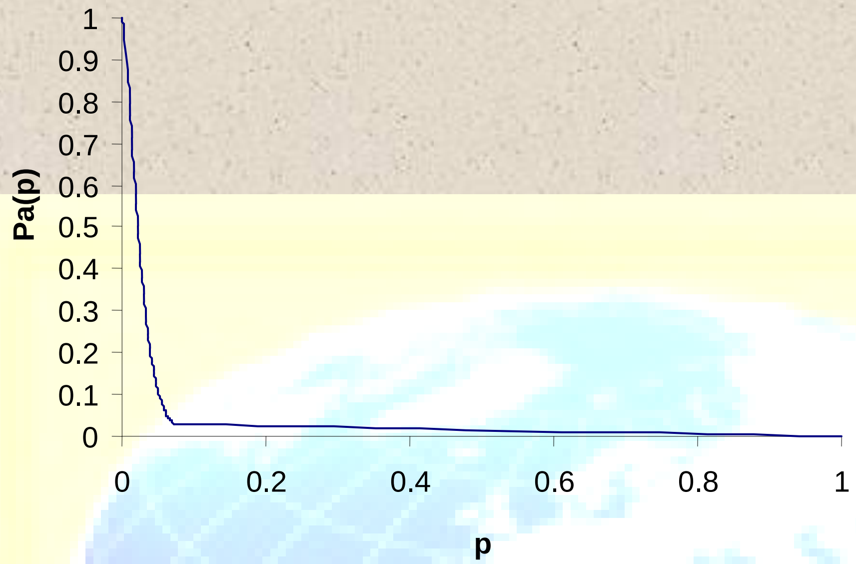

Figure 1: OC curve of six sigma based Link sampling plans

(for n_1=75, n_2=150, c_1=1, c_2=3)

Table 1: Lot Size N for Six sigma based Link Sampling plan(c_1=1,c_2=3)

AOQ%	n_1=200, n_2=400	n_1=150, n_2=300	n_1=100, n_2=200	n_1=75, n_2=150	n_1=50, n_2=100
0.0150	868				
0.0160	1116				
0.0170	1562				
0.0180	2604				
0.0190	7812				
0.0192	13022				
0.0215		868			
0.0220		976			
0.0250		3906			
0.0258		19536			

0.0370			1953		
0.0380			3906		
0.0385			7813		
0.0386			9767		
0.0387			13024		
0.0388			19540		
0.0389			39103		
0.0484				1085	
0.0504				2441	
0.0512				4883	
0.0514				6511	
0.0516				9768	
0.0518				19544	
0.0773					5582
0.0775					7815
0.0777					13029
0.0779					39149

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