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Integrated inventory and inspection policies for stochastic demand

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Abstract

In this paper, we develop integrated inventory inspection models with and without replacement of nonconforming items. Inspection policies include no inspection, sampling inspection, and 100% inspection. We consider a buyer who places an order from a supplier when his inventory level drops to a certain point, due to demand which is stochastic in nature. When a lot is received, the buyer uses some type of inspection policy. The fraction nonconforming is assumed to be a random variable following a beta distribution. The order quantity, reorder point and the inspection policy are decision variables. In the inspection policy involving determining sampling plan parameters, constraints on the buyer and manufacturer risks is set in order to obtain a fair plan for both parties. A solution procedure for determining the operating policies for inventory and inspection consisting of order quantity, sample size, and acceptance number is proposed. Numerical examples are presented to conduct a sensitivity analysis for important model parameters and to illustrate important issues about the developed models.

Keywords: Stochastic demand; Stochastic inventory model; Inspection; Sampling inspection

1. Introduction

In the typical inventory control model, the buyer of a commodity places an order for a predetermined quantity from a manufacturer, when his inventory drops to a predetermined reorder level. The order quantity and reorder point are determined such that the total cost of holding ordering and shortage is minimized. There is a basic assumption that all the items received are of good quality and can satisfy demand. But in many practical situations, there will be a fraction of sub-standard items in the lot. These sub-standard products are not fit for use and can cause shortage and other inconveniences. When the order is received, the buyer may assess the product quality before stocking it for immediate and later usage. The buyer may perform 100% inspection or use sampling inspection to make his assessment. Although quality should be inspected into the product at the manufacturing level through appropriate quality control tools, there are many practical situations where

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acceptance sampling procedures can be attractive. For example, Duncan (1986) suggested that acceptance sampling is a viable tool when "lot quality wanders about in an unpredictable manner".

The order quantity, reorder point and inspection policy decisions are interrelated. The sampling plan depends on the lot size. Also, nonconforming items discovered during inspection may affect inventory decisions depending on whether they are replaced or discarded. The integration of both decisions in a joint model will permit the simultaneous determination of the parameters of the inventory and inspection policies. Economic savings may result from such integration.

There is a vast literature dealing with the effect of nonconforming items on ordering and lot sizing decisions (see for example Ben-Daya and Rahim (2001)) while much less attention has been devoted to the joint determination of inventory and inspection policies. Peters et al. (1988) proposed a cost model that combines a stochastic continuous review inventory system with a Bayesian quality control system for a lot-by-lot acceptance sampling plan. It is assumed that rejected lots will increase lead time. Numerical examples illustrate the economic advantage of the combined model. An extension of this model for two products was developed by Cheung and Leung (2000). Hanna and Jobe (1996) also included quality costs into the lot-sizing decision assuming random fraction nonconforming. Unfortunately, the model has some flaws in the way the randomness of the fraction nonconforming is included in the model. In their model the sampling plan is specified and the question is to find lot size under random fraction nonconforming. Ben-Daya et al. (2006) proposed joint inventory and inspection policy for deterministic demand. Two models were developed for replacement and nonreplacement cases. It was shown from numerical examples that the inspection plan obtained by considering risk constraints is fair to both parties at a reasonable increase in cost.

In this paper, we propose an integrated inventory inspection model which has the following features:

- The order quantity, reorder point and the inspection policy are decision variable.
- The model involving acceptance sampling determines the order quantity, reorder point and the parameters of the sampling plan under constraints on the buyer and manufacturer risks.
- Models are developed for the case when nonconforming items are replaced and also for the case where nonconforming items are discarded without replacement.
- Inspection policies include no inspection, sampling inspection, and 100% inspection. The policy adopted is the one leading to least overall cost.

A solution procedure for determining the operating policies for inventory and inspection consisting of order quantity, reorder point, sample size, and acceptance number is proposed. Numerical examples are presented to illustrate important issues about the developed models.

The remainder of this paper is organized as follows. Problem definition, notation and assumptions are presented in Section 2. Some preliminaries results needed for deriving the proposed models are developed in Section 3. Joint inventory inspection model with and without replacement are developed in Sections 5 and 4, respectively. Section 6 contains models analysis and presents a solution procedure for determining optimal solutions. In Section 7, some numerical results are used to illustrate important issues related to the proposed models. Finally, Section 6 contains a summary of the paper and some concluding remarks.

2. Problem definition, notation and assumptions

Consider a buyer who places orders of size 'Q' from a supplier when the commodity's stock level drops down to 'r' as a result of a stochastic demand. Due to uncertainty in demand during lead time (time between order placed and received) there are chances of stockouts if demand is underestimated and high holding costs if demand is overestimated. If shortages occur, they are backordered i.e. customers are not lost but their demand is satisfied with some extra penalty 'π'. When a lot is received, the buyer may use some type of inspection policy to decide if the lot should be accepted and placed in inventory, or rejected with corrective action. When a lot-by-lot acceptance plan is adopted, a sample of size 'n' units is taken from the lot and inspected. If this sample contains defectives less than or equal to the critical number 'c', the whole lot is accepted or else the lot is subjected to 100% screening. Nonconforming items may be either replaced or simply discarded. Manufacturer and buyer decide to have some protection for both parties by agreeing on some levels of producer's