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Economic order quantity model and Taguchi's cost of poor quality

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Abstract

In this paper we consider defective products and Taguchi's cost of poor quality in the economic order quantity (EOQ) model. We assume that the product quality performs a normal distribution function, and the Taguchi's poor quality cost has been involved. From our analysis, it has been found that the annual profit will be decreased if the poor quality of product and Taguchi's quality cost are involved in the model. It has also been found that economic order quantity in our model is larger than that in a traditional EOQ model.

Keywords: EOQ; Screening cost/time; Defective product; Taguchi's quality cost; Inventory

1. Introduction

Since Harris [1] proposed the famous EOQ model to the world, it has been broadly applied in many places. However, there are some drawbacks in the assumption of the original EOQ model and many researchers have tried to improve it with different viewpoints, and the absence of the inventory quality is one of these shortcomings. In a traditional EOQ model, there is no defect on the quality of inventory or production line. However, this assumption does not exit in the real world.

The relationship between quality and EOQ model has been diversely studied over the last decade and the work by Porteus was believed to be the starting point [2]. In Porteus' paper, the concept of quality control has been brought into a production system. Following his work, a stream of research has examined the relationship between the economics of inventory and quality of products. Rosenblatt and Lee [3] concluded that the presence of defective products motivates smaller lot sizes. In a subsequent paper, Lee and Rosenblatt [4] considered using process inspection during the production run so that the shift to out-of-control state can be detected and restored earlier. Tapiero [5] links optimal quality inspection policies and the resulting

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Nomenclature

c	purchasing price of unit product
d	screening cost per unit
$D(X)$	quality distribution function; (normal distribution function)
G	Taguchi loss parameter
h	holding cost
K	ordering cost
$L(X)$	loss of poor quality per unit products
LSL	lower specification limits
N	demand rate
p	defect rate
s	unit selling price of item within the specification limits
USL	upper specification limits
X	actual value of the quality characteristic
y	lot size per cycle
Z	screening rate
σ	population standard deviation of quality
μ_t	target quality characteristic

improvements in the manufacturing costs. Fine [6] uses a stochastic dynamic programming model to characterize optimal inspection policies. Fine and Porteus [7] refine the original work of Porteus to allow smaller investments over time with potential process improvement of random magnitude. Chand [8] brought the learning effect into the model. In a series of papers, Cheng [9,10] has involved the production process reliability into a classic economic order quantity model. Hong et al. [11] have established the relationship between process quality and investment. Salameh and Jaber [12] considered a special inventory situation where items, received or produced, are not of perfect quality.

In this paper, we consider the EOQ model and assume the quality of inventory performs a normal distribution function. When the quality of the inventory is out of the specification limits, defective products will be scraped. All the products within the specification limits will be kept, and be sold with a discount of Taguchi's cost of poor quality as its quality departs from the target value.

The Taguchi's poor quality cost has been proposed in a publication of Taguchi and Wu [13]. Taguchi defines quality as, 'The quality of a product is the (minimum) loss imparted by the product to the society from the time product is shipped' [14]. The classic case to introduce the Taguchi's poor quality cost is the case of Ford versus Mazda [15].

Ford has been planning to build a new transmission for its new model to sale in US. Ford builds transmission system itself and also asks Mazda to build transmission system with the same specifications. After launching the new products for a period, it has been noticed that the cars with Ford's transmission system generated far more warranty claims than products with Mazda's transmission system. After further study, it was observed that Ford's transmission system had high variability in their gearboxes while Mazda's gearboxes were close to target. Although Ford's products were within the specification limits and zero defects, they incurred a higher cost of poor quality.

In this paper, we make two significant contributions to the area. Firstly, the Taguchi's cost of poor quality has been brought into the traditional EOQ model. This extension makes it easier to evaluate the cost of quality distribution in a traditional EOQ model. Secondly, we extend the range of previous quality EOQ model studies. Previous studies only touch the poor quality cost of products outside the specification limits. In our model, the poor quality cost of products within the specification limits has been further examined.

In the next section, we will introduce our mathematical model and compare with the traditional EOQ model. After that, a numerical example has been used to verify our model. Finally, a few concluding are given.