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Fuzzy economic order quantity model with imperfect items, shortages and inspection errors

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Abstract

This paper studies a fuzzy EOQ engineering problem with imperfect quality and shortages. An inspector may make two types of errors while screening the received lot and an imperfect screening process (Raouf et al., 1983) is adopted. The fraction of defectives in the ordered lot is assumed to be a fuzzy number. A fuzzy EOQ model is formulated to describe this inventory engineering problem and optimal solutions are obtained. The effect of fuzziness of fraction of defectives on optimal solutions is illustrated by a numerical example.

Keywords: EOQ; Fuzzy set; Imperfect quality; Shortages; Misclassification errors

1. Introduction

In the traditional economic order quantity models, the basic assumption is that 100% of ordered items are perfect. However, the lot sizes ordered may contain some defective products due to deficient maintenance, weak production control and so on. Then the screening process is adopted to identify the imperfect items. Also, there may be some inspection errors in the imperfect screening process. Recently, many researchers investigate the inventory problems with defective products.

Rosenblatt and Lee (1986) developed an EPQ model with imperfect quality, where the elapsed time from in-control state to out-control state is assumed to be a random variable. Lee and Rosenblatt (1987) investigated an EOQ model with fixed defective rate and inspection and obtained an inspection policy and the optimal order size. Salameh and Jaber (2000) proposed an EPQ model with random defective rate and perfect screening process. A joint lot sizing and inspection strategy is derived. Hayek and Salameh (2001) studied the economic production quantity problem with defective items and rework time. The percentage of defectives is a random variable with a uniform distribution. Chiu (2003) generalized the Hayek and Salameh (2001)'s model by assuming only a part of the imperfect items are reworked to become perfect.

The underlying assumption in the above models is that the screening process is perfect and error-free. In real situation, the human error is unavoidable while screening. Raouf et al. (1983) presented one of the first inspection policies for the human error in inspection process. Duffuaa and Khan (2002) extended Raouf et al. (1983)'s model by incorporating a number of misclassifications. Duffuaa and Khan (2005)

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studied the optimal inspection policy under different kinds of misclassifications. Khan, Jaber and Bonney (2011) generalized the Salameh andJaber(2000)'s model by considering the imperfect screening process and adopting the approach in Raouf et al. (1983) to depict the misclassifications.

Recently, it is more reasonable to describe some parameters as fuzzy variables for the unreliability and scarcity of historical data. Chang (2004) studied an EOQ model with fuzzy defective rate and fuzzy demand. Li and Zhang (2008) dealt with the order inventory problem with shortages and imperfect items. The annual demand and cost parameters are assumed to be trapezoidal fuzzy numbers. Vijayan and Kumaran (2009) examined the EOT model with fuzzy arrival rate and fuzzy cost components.

This paper modified the Khan, Jaber and Bonney (2011)'s model by considering shortages and fuzzy fraction of defectives.

2. Notations

D number of units demanded per year; y order quantity; w maximum backorder level allowed; c unit variable cost; k fixed ordering cost; s unit selling price of a nondefective item; v unit selling price of a defective item; x screening rate; d unit screening cost; h unit holding cost; T cycle length; m_1 proportion of nondefective items are classified to be defective; m_2 proportion of defective items are classified to be nondefective; $\tilde{p}$ percentage of defective items in y, which is a triangular fuzzy number $\tilde{p} = (p - \Delta_1, p, p + \Delta_2)$; t_1 time to build up a backorder level of w units; t_2 time to eliminate the backorder level of w units; t_3 time to screen y units ordered per cycle; T cycle length; B_1 number of items that are classified as defective in one cycle; B_2 number of defective items that are returned from the market in one cycle; C_a cost of accepting a defective item; C_r cost of rejecting a nondefective item.

3. Mathematical model

Consider a lot size of y being replenished instantaneously at the beginning of each cycle. It is assumed that each lot contains a fuzzy proportion $\tilde{p}$ of defective items. Each lot received is screened by an inspector with a screening rate x and fixed misclassification rate, which means that a proportion m_1 of nondefective items are classified to be defective and a proportion m_2 of defective items are classified to be nondefective. The items that are returned from the market are sold at a discounted price at the end of each cycle. The behavior of the inventory level is illustrated in Fig.1.

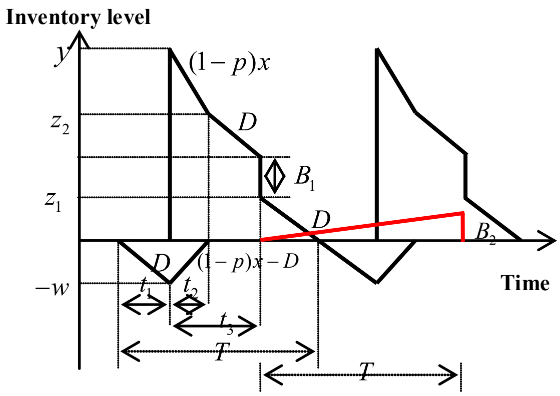

Fig.1. Behaviour of the inventory level over time.