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Determination of Economic Order Quantity in a fuzzy EOQ Model using of GMIR Deffuzification

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A B S T R A C T

Inappropriate inventory control policies and its incorrect implementation can cause improper operation and uncompetitive advantage of organization logistic operation in the market. Therefore, analysis inventory control policies are important to be understood, including carrying cost, ordering cost, warehouse renting cost, and buying cost. In this research, Economic Order Quantity (EOQ) problem in fuzzy condition is reviewed in two different situations. The first model concerned to costs (carrying cost, ordering cost, warehouse renting cost and buying cost), which is considered as triangular fuzzy numbers. The second model was in addition to inventory the cost system, in which annual demand is also reviewed as fuzzy numbers. In each model, graded mean integration representation (GMIR) deffuzification was used for parameters deffuzification. Then, the final objective from this analysis was to obtain economic quantity formula through derivation.

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1. INTRODUCTION

Inappropriate inventory control policies and its incorrect implementation can cause improper operation and uncompetitive advantage of organization logistic operation in the market. Therefore, analysis inventory control policies are important to be understood, including carrying cost, ordering cost, warehouse renting cost, and buying cost. (Asiedu & Gu, 1998)

Several researches have been conducted. Some of them considered product faulty rate as fuzzy model (Chang, 2004). Yao and Lee solved an Economic Order Quantity (EOQ) model with fuzzy delayed order quantity (Yao & Lee, 1996). Then, Yao and Chiang solved an EOQ model by considering delay time and fuzzy order quantity (Yao & Chiang, 2003). Other EOQ model have been reported by several researchers (Liberatore, 1979; Roy & Maiti, 1997; Chen & Hsieh, 1999; Salameh & Jaber, 2000; Vijayan & Kumaran, 2008; Zhao & Tang, 2009; Björk, 2009; Ding, 2013; Riza *et al.*, 2016).

Based on the previous study (Mojaveri *et al.*, 2016), the purpose of this study was to determine economic order quantity (EOQ) in a fuzzy model using graded mean integration representation (GMIR) deffuzification. We used two different situations. The first model parameters concerned to costs (carrying cost, ordering cost, warehouse renting cost and buying cost), which is considered as triangular fuzzy numbers. The second model was in addition to inventory system costs, in which annual demand is also reviewed as fuzzy numbers. Since it is impossible to mention all the implemented researches in here, this study deal only with these implemented works briefly.

2. METHOD

In this research, EOQ problem in fuzzy condition is reviewed in two different situations. The first model parameters concerned to costs of the model (carrying cost, ordering cost, warehouse renting cost and buying cost), which is considered as triangular fuzzy numbers. The second model was in addition to inventory system costs, in which annual demand is also reviewed as fuzzy numbers.

3. RESULTS AND DISCUSSION

3.1. GMIR Diffuzification Method

The GMIR diffuzification method was firstly presented by Chen and Hsieh (1999). This method used for defuzzification of α–αth ranking average integral quantity of a LR fuzzy number. If _A ̃=(a_1,a_2,a_3) is a triangular fuzzy number, its GMIR equals to

$$\vartheta(\tilde{A}) = \frac{\int_0^1 \frac{\alpha\left(m^{-1}(\alpha)+n^{-1}(\alpha)\right)}{2} d\alpha}{\int_0^1 \alpha \, d\alpha}$$

$$= \int_0^1 \alpha\left(m^{-1}(\alpha)+n^{-1}(\alpha)\right) d\alpha$$

$$= \frac{1}{6}(a_1 + 4a_2 + a_3) \qquad (1)$$

3.2. Economic Order Quantity Model In The Classic Sense

The classic EOQ model, which is considered in this paper, include ordering, carrying, buying, and warehause renting costs. (Min & Peng, 2007). The correlation can be written in the following formula

$$k(Q) = \left(\frac{D}{Q}\right)C_O + \left(\frac{Q}{2}\right)C_h + W.Q + C.D \qquad (2)$$

where *C*, *W*, *Ch*, *Co*, *Q*, and *D* parameters, respectively, are the annual demand rates,

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the order quantity in each time, the ordering cost in each time, and the carrying cost of each unit of product.

Therefore, the optimal economic order quantity is equal to

$$\frac{\partial k(Q)}{\partial Q} = o \rightarrow Q^* = \sqrt{\frac{DC_O}{W+(C_h/2)}} \quad (3)$$

3.3. Economic Order Quantity Model In The Fuzziness Mode Of Cost

In this condition, we assumed that crisp quantities for costs of inventory system do not exist. Based on this assumption, we consider this cost can act as triangular fuzzy numbers. Or, the correlation can be written as $\tilde{C}_h = (C_h - \Delta_3, C_h, C_h + \Delta_4)$, $\tilde{C}_O = (C_o - \Delta_1, C_o, C_o + \Delta_2)$, $W = (W - \Delta_5, W, W + \Delta_6)$, $C = (C - \Delta_7, C, C + \Delta_8)$.

Therefore in the fuzzy mode, the total cost of the entire system is written as

$$\tilde{k}(Q) = \left(\frac{D}{Q}\right)\tilde{C}_O + \left(\frac{Q}{2}\right)\tilde{C}_h + W.Q + \tilde{C}.D \quad (4)$$

GMIR is used for deffuzification of this function. This reason provides defuzzification of mentioned-function by using of this method to be formulated as

$$k^*(Q) = \frac{1}{6}\left[\left(\frac{D}{Q}\right)(C_o - \Delta_1) + \left(\frac{Q}{2}\right)(C_h - \Delta_3) + (W - \Delta_5)Q + (C - \Delta_7)D\right] + \frac{2}{3}\left[\left(\frac{D}{Q}\right)C_o + \left(\frac{Q}{2}\right)C_h + W.Q + C.D\right] + \frac{1}{6}\left[\left(\frac{D}{Q}\right)(C_o + \Delta_2) + \left(\frac{Q}{2}\right)(C_h + \Delta_4) + (W + \Delta_6)Q + (C + \Delta_8)D\right] \quad (5)$$

Since (∂^2 K^* (Q_i))/(∂ 〖Q_i〗 ^2)>0, as a result k^* (Q) is convex, therefore its least quantity occur in Q^* , so by setting first derivative equal to zero toward Q, the optimal quantity of Q^* is obtained as

k^* = √((D(Co – Δ₁)+4D+D(Co +Δ₂))/(1/2 [(Cₕ – Δ₃)+ 〖4C〗 h+(Ch + Δ₄)]+[(W – Δ₅)+4W+(W + Δ₆)])) (6)

3.4. EOQ Model With Fuzzy Annual Demand And Fuzzy Costs

In this section, the quantity of annual demand is calculated in the fuzzy form. According to this condition, the fuzzy total cost function is obtained as

K̃(Q)=(D̃/Q) C̃_O+(Q/2) C̃ₕ + W̃.Q + C̃.D̃

(7)

where triangular fuzzy numbers are defined as D̃ = (D – δ1 ,D ,D+δ₂) C̃ₕ = (Cₕ – δ₅ ,Cₕ ,Cₕ + δ₆), C̃O = (Co – δ₃ ,Co ,Co + δ₄)، W̃ = (W – δ₇, W , W + δ₈)، C̃ = (C – δ₉, C ,C + δ₁₀).

For defuzzification of this function similar to previous section, the GMIR method has been used, so defuzzification of mentioned-function by using this method would be obtained as

Q^* = √(((D – δ₁)(Co – δ₃)+4DCo+(D+δ₂)(Co + δ₄))/(1/2 [(Cₕ – δ₅)+ 〖4C〗 _h+(Cₕ + δ₆)]+[(W – δ₇)+4W+(W + δ₈)])) (8)

4. CONCLUSION AND FUTURE RESEARCH

This present proposes a novel solution procedure for an EOQ inventory model under fuzzy sense. In the real world, the inventory model main parameters cannot determine under crisp sense. One of the best tools that can main inventory model parameters determined with fuzzy sets theory. We represented holding, ordering, purchasing, rent costs and demand rate fuzzify usingtrapezoidal fuzzy numbers. For first, the GMIR method applied in fuzzy EOQ model, and economic order quantity calculated. The EOQ model extended under uncertainty, stochastic and fuzzy stochastic sense and optimal order quantity compare with EOQ output model under fuzzy sense.

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6. AUTHORS' NOTE

The author(s) declare(s) that there is no conflict of interest regarding the publication of this article. Authors confirmed that the data and the paper are free of plagiarism.

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