Retraction

Retraction: Triangular fuzzy numbers model with cost parameters (J. Phys.: Conf. Ser. 1916 012124)

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This article (and all articles in the proceedings volume relating to the same conference) has been retracted by IOP Publishing following an extensive investigation in line with the COPE guidelines. This investigation has uncovered evidence of systematic manipulation of the publication process and considerable citation manipulation.

IOP Publishing respectfully requests that readers consider all work within this volume potentially unreliable, as the volume has not been through a credible peer review process.

IOP Publishing regrets that our usual quality checks did not identify these issues before publication, and have since put additional measures in place to try to prevent these issues from reoccurring. IOP Publishing wishes to credit anonymous whistleblowers and the Problematic Paper Screener [1] for bringing some of the above issues to our attention, prompting us to investigate further.

[1] Cabanac G, Labbé C and Magazinov A 2021 arXiv:2107.06751v1

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Triangular fuzzy numbers model with cost parameters

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Abstract. The scope of our research work is to analyze a purchasing model in which the uncontrolled variables are fuzzified. The fuzzy cost parameters are defuzzified and an optimal solution of the ordering quantity, maximum inventory and annual cost are estimated. Numerical example and sensitivity analysis has been done to explain the mathematical model.

Key words: Triangular fuzzy numbers-GMI method-Signed distance method.

1. Introduction

Different types of impreciseness are inherent in day to day life decision making problems that are classically modeled by probabilistic approach. In such cases arises a question that how to define inventory optimization and interpret their optimal solution. In this situation, it is more convenient to approach these models using fuzzy concepts than probability concepts.

Zadeh used fuzzy numbers to approach the new products and seasonal items for an improved solution. Since then the uncertainties are shown in several articles by Chang, Yao & Lee and Yao & Chang. A systematic progress in development of inventory models from crisp parameters to fuzzy parameters has been arrived [1-4]. Park & Vujosevic improved the inventory models by handling fuzzy numbers. An EOQ model with uncertain warehouse space and order quantity was determined by Mandal&Maiti whereas Chang considered a model with fuzzy backorders.

Yao & Chang defuzzified a fuzzy purchasing model using signed distance method. Later Kazemiteral improved the model using GMI method for defuzzification. Syed & Aziz developed an EOQ model without shortage with ordering cost and holding cost as imprecise variables and optimized the annual total cost [5-9].

In this paper a purchasing model is presented with various costs and the demand as imprecise variables. The triangular fuzzy numbers are used to represent fuzzy quantities. GMI and SD method are applied for defuzzification. The model is solved using extended Lagrange method to obtain the optimal value of the ordering quantity, inventory level and hence the total cost. The optimal values are obtained for both crisp and decision making model and the results are compared. Sensitivity analysis is done and a numerical solution is obtained [10-14].

2. Preliminaries
A fuzzy set \( X \) on the given universal set is a set of ordered pair \( \tilde{A} = \{ y, \mu_A(y) : y \in Y \} \).

\( \mu_A : Y \rightarrow [0,1] \) is the membership function.

**Definition 2.1**

Let \( \tilde{B} = (u,v,w) \). Then the defuzzification of \( \tilde{B} \) by GMI method is

\[ \theta(\tilde{B}) = \frac{1}{6}[u + 4v + w] \]

**Definition 2.2**

Let \( \tilde{B} = (u,v,w) \). Then the SD method of defuzzification of \( \tilde{B} \) is

\[ d(\tilde{B}) = \frac{1}{4}[u + 2v + w] \]

3. **Assumptions and Notations**

- Production is instantaneous;
- The inventory systems involve only one item;
- \( \tilde{S} \) - Fuzzy order cost
- \( \tilde{d} \) - Fuzzy demand rate
- \( \tilde{c} \) - Fuzzy holding cost
- \( \tilde{p} \) - Fuzzy penalty cost
- \( \tilde{l} \) - Fuzzy Lot size
- \( \tilde{M} \) - Fuzzy inventory level
- \( \tilde{TC} \) - Fuzzy total cost

4. **The Karush-Kuhn-Tucker Approach**

An optimal solution of an NLPP has been obtained by Kuhn & Tucker followed by Karush with the derivation of necessary optimality conditions involving inequality constraints. In this research, KKT conditions are used to solve the proposed inventory model.

5. **Mathematical Model**

The formula for economic order quantity (EOQ) in scientific inventory management is given by equation 1:

\[ TC = \frac{Sd}{l} + \frac{M^2c}{2l} + \frac{(l-M)^2p}{2l} \]

5.1 **Crisp Model:**
The analytical solutions are

\[ I' = \sqrt[1]{\frac{2 \pi d (c + p)}{c p}} \]  

\[ M' = \sqrt[1]{\frac{2 \pi d (c + p)}{c (c + p)}} \]  

5.2 Fuzzy model

\[ S = (S - \delta_1, S, S + \delta_2), S > \delta_1 \]

\[ \tilde{d} = (d - \delta_1, d, d + \delta_2), d > \delta_1 \]

\[ \tilde{c} = (c - \delta_3, c, c + \delta_4), c > \delta_3 \]

\[ \tilde{p} = (p - \delta_5, p, p + \delta_6), p > \delta_5 \]

\[ M = (M - \delta_7, M, M + \delta_8), M > \delta_7 \]

\[ \tilde{l} = (l - \delta_9, l, l + \delta_{10}), l > \delta_9 \]

are the triangularised input variables. The annual price of the prescribed model for acycle is

\[ \tilde{TC} = \frac{\tilde{Sd}}{\tilde{l}} + \frac{\tilde{M}^2 (c + p)}{2\tilde{l}} + \frac{\tilde{lp}}{2} - \tilde{MP} \]

Defuzzification of \( \tilde{TC} \) is as follows.

5.2.1 Graded-Mean Integration method

The annual cost is determined by
By the extended Lagrange method, an optimal value of ordering quantity and maximum inventory is obtained.

\[ I^* = \sqrt{\frac{2(S + \delta_2)(d + \delta_1) + 8Sd + 2(S - \delta_1)(d - \delta_1)}{p - \delta_1 + 4p + p + \delta_6}} \star \sqrt{\frac{(c - \delta_5 + p - \delta_6 + 4(c + p) + c + \delta_6 + p + \delta_6)}{c - \delta_5 + 4c + c + \delta_6}} \]

\[ M^* = \sqrt{\frac{2(S + \delta_2)(d + \delta_1) + 8Sd + 2S(-\delta_1)(d - \delta_1)}{(c - \delta_5 + p - \delta_6 + 4(c + p) + c + \delta_6) + p + \delta_6}(c - \delta_5 + 4c + c + \delta_6))} \]

5.2.2 Signed Distance Method

The annual optimum cost in this method is given by

\[ d(\bar{TC}) = \frac{1}{4} \left( \frac{(S - \delta_1)(d - \delta_1)}{l + \delta_1} + \frac{(c - \delta_5 + p - \delta_6)(M - \delta_12)}{2(l + \delta_12)} + \frac{(l - \delta_1)(p - \delta_2)}{2} - (M + \delta_10)(p + \delta_8) \right) \]

\[ + 2 \left[ \frac{S d}{l} + \frac{(c + p) M^2}{2l} + \frac{l p - M p}{2} \right] \]

\[ + 1 \left[ \frac{(S + \delta_2)(d + \delta_1)}{d - \delta_11} + \frac{(c + \delta_6 + p + \delta_6)(M + \delta_10)}{2(l - \delta_11)} + \frac{(l + \delta_11)(p + \delta_8)}{2} - (M - \delta_1)(p - \delta_1) \right] \]

An optimal solution of the \( I^* \) and \( M^* \) is obtained using Karush-Kuhn Tucker method given by

\[ I^* = \sqrt{\frac{2(S + \delta_2)(d + \delta_1) + 4Sd + 2(S - \delta_1)(d - \delta_1)}{p - \delta_1 + 2p + p + \delta_8}} \star \sqrt{\frac{(c - \delta_5 + p - \delta_6 + 2(c + p) + c + \delta_6 + p + \delta_6)}{c - \delta_5 + 2c + c + \delta_6}} \]

\[ M^* = \sqrt{\frac{2(S + \delta_2)(d + \delta_1) + 4Sd + (S - \delta_1)(d - \delta_1)(p - \delta_1 + 2p + p + \delta_8)}{(c - \delta_5 + p - \delta_6 + 2(c + p) + c + \delta_6 + p + \delta_6)(c - \delta_5 + 2c + c + \delta_6))} \]

6. Numerical Examples

The triangular fuzzy numbers for \( S,d,c \) and \( p \) are as follows in table 1-4.

Table 1. Input Parameters as triangular fuzzy numbers
Table 2. Crisp Values of S,D,H&m

| S  | d   | c     | p     |
|----|-----|-------|-------|
| (15,150,165) | (6000,60000,78000) | (.05,.25,.34) | (.5,5,6.5) |
| (30,150,195) | (12000,60000,84000) | (.06,.25,.36) | (1,5,7.5) |
| (45,150,180) | (30000,60000,72000) | (.11,.25,.38) | (1.5,5,7.5) |
| (60,150,225) | (36000,60000,90000) | (.09,.25,.39) | (2.6,5,6.5) |
| (75,150,210) | (42000,60000,93000) | (.10,.25,.36) | (2.4,5,8.5) |

Table 3. Optimal solution of decision variables by GMI Method

| Lotsize | Maximum Inventory | Total Cost (crisp) | Total cost (Fuzzy) | Membership value |
|---------|-------------------|-------------------|-------------------|-----------------|
| 8601    | 8185              | 1752.76           | 1896.22           | 0.5029          |
| 8830    | 8412              | 1875.88           | 1990.94           | 0.9248          |
| 8426    | 8014              | 1930.26           | 2790.23           | 0.0650          |
| 9107    | 8666              | 2068.38           | 2137.80           | 0.2312          |
| 8836    | 8406              | 2136.20           | 2213.60           | 0.9090          |

Table 4. Optimal solution of decision variables by Signed Distance Method

| f*     | M*     | TC(Crisp) | TC* (Fuzzy) | Membership value |
|--------|--------|-----------|-------------|-----------------|
| 8556   | 8130   | 1600.08   | 1809.63     | 0.9371          |
| 8902   | 8483   | 1762.55   | 1951.11     | 0.5526          |
| 8286   | 7876   | 1860.12   | 1949.44     | 0.7634          |
| 9311   | 8856   | 2046.32   | 2165.02     | 0.0985          |
| 8900   | 8163   | 2187.98   | 2285.17     | 0.5545          |

7. Sensitivity Analysis

From the numerical example, the following optimal values are obtained.
By Graded men integration method, the maximum membership function corresponds to
f* = 8830, M* = 8412, TC*=1990.94
By Signed distance method, the maximum membership function corresponds to
f* = 8556, M* = 8130, TC*=1809.63

8. Conclusion

The research, we have considered a purchasing model involving cost parameters and demand rate as input variables and the lot size and maximum inventory level as decision variables. To compare the
real life situation, the major cost parameters are taken as uncertain and used triangular fuzzy numbers to define them. The solution is optimized by utilizing the extended Lagrange method along with GMI and Signed distance method for defuzzification.

The sensitivity analysis gives a better optimal solution under fuzzy situation than crisp model. It can also be concluded that the SD method is more efficient over the GMI method in optimization.

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