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Expected value of generalized trapezoidal bipolar fuzzy number to solve a multi-item marketing planning inventory model with allowable shortages

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ABSTRACT

Decision makers often grapple with the complexity of multi-faceted real-life problems, where uncertainty arises from both positive and negative states of mind. This duality reflects the decision maker's optimistic and pessimistic perspectives during the decision-making process. To address this, our paper introduces innovative concepts and frameworks for generalized bipolar trapezoidal fuzzy numbers. We propose novel arithmetic operations on these fuzzy numbers, computing the negative α-cut and positive β-cut methods. Furthermore, we uniquely compute the convex combination of expected values from both the positive and negative membership parts. These theoretical advancements are applied to a practical case study: a multi-item marketing planning inventory model with allowable shortages. Our proposed method's efficacy is highlighted through detailed numerical illustrations, sensitivity analyses and comparative studies complemented by compelling graphical presentations

1. Introduction

In imprecise environments, managing inventory becomes a complex task due to the inherent uncertainties in demand, supply, and other operational factors. Traditional inventory models often assume precise data, which is rarely available in real-world scenarios. To address this, fuzzy set theory and its extensions, such as bipolar fuzzy sets, have been introduced. These mathematical tools allow for more flexible and realistic modelling of uncertainty by accommodating both positive and negative aspects of information. The concept of the fuzzy set was introduced by L. Zadeh in 1978 [1]. In real-life situations, human decision-making involves both positive and negative aspects. Zhang [2] expanded on this by introducing the bipolar fuzzy set, a generalization of the fuzzy set, which operates within the interval $[-1, 1]$. Dubois et al. [3,4] described the positive component of a bipolar fuzzy number as corresponding to observation and experimentation, while the negative component relates to impossibility. Zhang [5] further developed a series of bipolar models. The concept of bipolar h-ideals using positive t-cuts and negative s-cuts of bipolar fuzzy numbers was first introduced by Zhou [6] and further developed by Li [7]. Subsequently, Akram [8] expanded on this foundation by applying the idea to bipolar fuzzy graphs. Talebi and Rashmanlou [9] contributed to this field by exploring various properties of these bipolar fuzzy graphs. In addition, Akram et al. [10] integrated bipolar fuzzy numbers into multi-criteria decision-making problems, showcasing their utility in complex decision contexts. The ranking of trapezoidal bipolar fuzzy information systems based on total ordering was then advanced by Akram and Arshad [11]. Further, Ghanbari et al. [12] utilized the duality principle in bipolar fuzzy linear programming problems, highlighting the versatility and practical applications of bipolar fuzzy numbers in optimization scenarios.

In most of the inventory models (both EOQ and EPQ), demand plays a key role. The stock dependent demand in an inventory model first commenced by Gupta and Vrat [13]. Later Wu et al. [14], Rani et al. [15] and Garg [16] developed some multi-objective Inventory models with stock-dependent demand for both deteriorating and non-deteriorating items. There are huge developed Inventory models based on a single item. However, several manufacturing companies produce more than one item in each production cycle. Abu-El-Ata and Kotb [17] developed a multi-item inventory model under varying holding costs with some limitations. Zhou et al. [18] developed a EPQ models for items with imperfect quality and one-time-only discount. Mandal and Maiti [19] developed a multi-item fuzzy EOQ model using genetic algorithm. An inventory model with back orders with fuzzy parameter and decision variables was commenced by Kazemi et al. [20]. Later Mahata and Goswami [21] exercised an fuzzy inventory items with imperfect quality and shortage back ordering under crisp and fuzzy decision variables. Mahata and Mahata [22] analysed a fuzzy EOQ model for deteriorating item under trade credit financing. A fuzzy

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