Reidentifying the Compromise Model in the Analytical Decision Process: Application of the SITW and S-TFN Approaches

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Abstract

The paper presents a novel approach to re-identifying the compromise model in analytical decision-making processes, using SITW and S-TFN techniques and the TOPSIS method. Focusing on the importance of criteria weights and benchmarks, the study compares the proposed methods with traditional approaches such as CRITIC-TOPSIS. The results show the higher efficiency of SITW and S-TFN in correlation with the compromise ranking. The proposed techniques open up new possibilities in re-identifying decision-making models, emphasizing the importance of precise determination of weights and reference points.

Keywords: Re-identifying, Multi-Criteria Decision Analysis, E-commerce, Criteria weights, Compromise ranking.

1. Introduction

Companies' decisions are critical in today's business world, especially e-commerce. Due to technological advances and the globalization of markets, competition between companies is becoming more intense [7]. In addition, customer expectations of speed, personalization, and satisfaction with the shopping experience are increasing. In e-commerce, the need to consider multiple, sometimes conflicting, factors when making decisions is apparent. Companies must consider various aspects, such as operating costs, customer preferences, the effectiveness of marketing efforts, the quality of services provided, and sustainable business practices [8]. In such a complex environment, Multi-Criteria Decision Analysis (MCDA) methods have become invaluable in effectively dealing with this challenge.

MCDA methods are extensively used in e-commerce for various problems, including risk assessment and sustainable Last-Mile Delivery (LMD). For LMD efficiency and sustainability, methods such as F-WASPAS and F-AHP were utilized in a Vietnam case study [9]. Additionally, MCDA supports product and service recommendations. The BHARAT model, for instance, helps recommend favorable e-commerce sites to users, enhancing personalized shopping experiences [6]. Thus, MCDA methods aid in risk analysis, delivery efficiency, and personalized recommendations in e-commerce.

Due to the availability of multiple methods in Multi-Criteria Decision Analysis, choosing the proper method to solve a particular problem can be challenging. To deal with this difficulty, many research papers suggest using compromise approaches combining results from different methods to create a consistent ranking. An example of such an approach is the work by Bączkiewicz et al. [1], which focuses on the problems of both e-commerce and aggregating rankings from different MCDA methods. This study used the Borda method to combine rankings from MCDA methods such as TOPSIS-COMET, COCOSO, EDAS, MAIRCA, and MABAC. This method resulted in a stable and consistent final ranking that was effective for the recommendation problem.

The Rank position method is a widely used MCDA technique that aggregates rankings from different methods, creating a unified order of decision options based on attractiveness [2]. However, its main limitation is its focus on ranking aggregation without a continuous model for evaluating new options. This static nature is less effective in dynamic environments like e-commerce, where new products and strategies frequently emerge. Additionally, the method lacks information on criteria weights and identifying the ideal point in the decision space, both critical for accurately ordering decision options. Criteria weights help determine the relative importance of different options, while the ideal point signifies the most desirable choice. Incorporating these elements can significantly enhance the effectiveness and relevance of e-commerce recommendations, making them more tailored to individual user preferences.

This paper will focus on the possibility of re-identification of the criteria weights and reference points as core values in triangular fuzzy numbers, which are used for the normalization process. The re-identification of these parameters is crucial for creating a continuous compromise model that can be re-identified in a way that maximally reflects the compromise ranking used with the help of the Borda method. It will use re-identification techniques to identify weights and reference points more accurately to achieve this goal. Stochastic Identification of Weights (SITW) [4] and Stochastic IdenTification of Triangular Fuzzy Numbers (S-TFN) [3] techniques will be used in this work. These advanced re-identification techniques will allow more precise and flexible determination of weights and reference points in triangular fuzzy numbers. As a result, the resulting compromise model will be able to better adapt to changing conditions and dynamically introduce new decision options in e-commerce.

The section is divided as follows: The Section 2 focuses on the study presented on the re-identification of a continuous model based on compromise ranking. The Section 3 provides conclusions and directions for future research.

2. Study case

This paper will discuss an approach for re-indetifying a continuous model based on compromise ranking. To illustrate the concept, it will use the problem presented by Bączkiewicz et al. in their paper [1] on phone recommendations. In the case they analyzed, 12 criteria and 1,039 alternatives were considered and evaluated using methods such as TOPSIS-COMET, COCOSO, EDAS, MAIRCA, and MABAC. Based on these evaluations, a compromise ranking was generated using an approach based on Copeland's method. In this re-identification approach, the Rank position method will be used as a compromise tool to obtain a new compromise ranking.

This study examines the model for re-identification using the SITW and S-TFN approaches, employing the TOPSIS method. In the hybrid S-TFN and TOPSIS method, fuzzy normalization replaces standard normalization. Stochastic optimization finds the kernels of triangular fuzzy numbers for normalizing the decision matrix, optimizing for maximum correlation with the compromise ranking. The SITW approach in TOPSIS identifies the weights to re-identify the compromise model, using the Differential Evolution (DE) method. DE parameters are 1000 epochs, a population of 50, μ_f and μ_{cr} set to 0.5, and mutation and crossover probabilities of 0.1. The preliminaries for the methods used can be found in the `pymcdm` [5] library.

The research results showed that the parameter optimization process proceeded as expected, as confirmed by the analysis of the fitness function. For the SITW method, the maximum correlation value r_w was 0.9731, while for the S-TFN method, the value reached 0.9735. These results confirm the effectiveness of the methods used, both in terms of the use of weights and the reference point in the form of TFNs values, in the context of re-identifying the compromise model based on the TOPSIS method. The correlation values suggest a high degree of agreement between the re-identified and the original ranking, demonstrating the effectiveness of both the SITW and S-TFN methods in the reidentification process.

The re-identification process using the S-TFN-TOPSIS approach resulted in the following core values for TFNs: $C_1^{core} = 98.0000, C_2^{core} = 0.9969, C_3^{core} = 2017$, $C_4^{core} = 12, C_5^{core} = 330.8991, C_6^{core} = 107624.4910, C_7^{core} = 14209.0178, C_8^{core} = 24$, $C_9^{core} = 4033, C_{10}^{core} = 4, C_{11}^{core} = 3, C_{12}^{core} = 60$. The bounds for these TFNs were defined as the minimum and maximum values derived from the decision matrix. As can be seen, many of the core values obtained are consistent with the bounds, which is also reflected in the types of criteria after applying min-max normalization. However, some non-linearities in the results are observed, especially in the case of criterion five, where the core value does not coincide with the boundary values and is closer to the middle of the interval.

Similarly, nonlinear criteria can be identified for criteria two and seven, which is evident in the TFN values. Despite the consistent reflection of the boundary values in the core results, some non-linearities and deviations may indicate specific relationships between criteria or the influence of other factors on the reidentification process. Such non-linearities may result from complex relationships between criteria or errors in input data.

In the SITW re-identification process, the following weights were obtained: 0.0000, 0.0000, 0.1154, 0.0000, 0.1508, 0.1089, 0.0000, 0.1638, 0.1890, 0.1313, 0.1408, 0.0000. Some weights are zero, indicating that certain criteria did not affect the final compromise ranking. The most impactful criteria are C_3, C_5, C_6, C_8, C_9, C_{10}, and C_{11}, crucial in the decision-making process. These weights differ significantly from those obtained using the CRITIC method, highlighting the impact of input data, methodology, and criteria interpretation. This underscores the importance of selecting the appropriate re-identification method, as it significantly influences the final compromise ranking in multi-criteria analysis. Detailed comparisons are available in Figure 1.

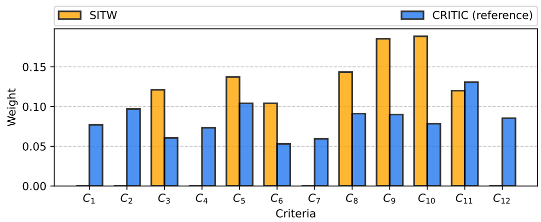
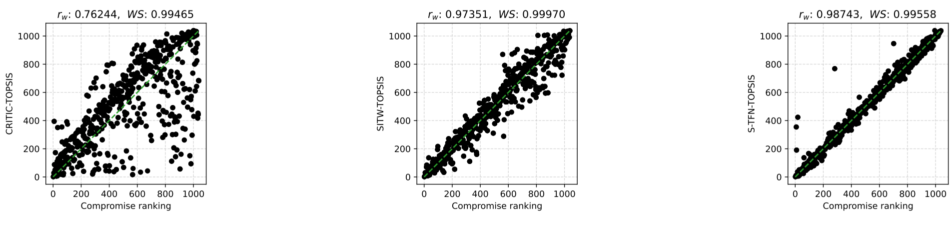


Fig. 1. Comparison of weights obtained from the SITW-TOPSIS and reference (CRITIC) approaches.



(a) CRITIC-TOPSIS approach. **(b)** SITW-TOPSIS approach **(c)** S-TFN-TOPSIS approach

Fig. 2. Comparison of rankings from selected approaches to compromise ranking.

A crucial aspect of the analysis is evaluating the rankings. Figure 2 compares three different rankings with the compromise ranking. Specifically, Figure 2a shows the CRITIC-TOPSIS ranking, another Figure 2b compares the SITW-TOPSIS ranking, and Figure 2c illustrates the S-TFN-TOPSIS ranking against the compromise ranking. The CRITIC-TOPSIS method has the lowest fit, with a correlation value r_w of 0.7624, despite a high initial fit (WS of 0.9947). In contrast, the SITW-TOPSIS and S-TFN-TOPSIS methods show higher correlations of 0.9735 and 0.9874, respectively. These methods also demonstrate better fit at the top of the rankings, with WS values of 0.9970 for SITW-TOPSIS and 0.9956 for S-TFN-TOPSIS. This analysis concludes that SITW-TOPSIS and S-TFN-TOPSIS methods better reflect discrete rankings in a continuous model compared to the CRITIC-TOPSIS approach.

3. Conclusions

The analysis showed that re-identifying a continuous model to achieve a near-compromise ranking is possible with SITW-TOPSIS and S-TFN-TOPSIS methods. These methods effectively reflected the discrete ranking in the continuous model and provided valuable information like reference points for normalization and criterion weights. Compared to the CRITIC-TOPSIS approach, the re-identification-based approaches proved more effective. The coefficients r_w and WS confirmed this, with significantly higher values for SITW-TOPSIS and S-TFN-TOPSIS, demonstrating their ability to reflect the actual trade-off ranking better and improve decision-making efficiency.

Future research should expand the range of fuzzy numbers used in the re-identification process, as other fuzzy numbers may offer new perspectives and better results. Additionally, developing continuous model re-identification approaches based on uncertain data is crucial, as real-world settings often involve uncertainty and missing data, affecting accuracy and reliability.

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