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Mini Review



# Which Objective Weight Method Is Better: PCA or Entropy?

**Robert M.X. Wu[1,2*] & Yongwen Wang [3]**

[1]*School of Engineering and Technology, Central Queensland University, Australia*

[2] *Shanxi Normal University, China*

[3] *Shanxi Fenxi Mining Industry (Group)*

***Corresponding author:** Robert M.X. Wu, School of Engineering and Technology, Central Queensland University, Australia

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## Abstract

Multi-criteria decision-making (MCDM) methods have significantly been used for evaluating and ranking critical factors with conflicting characteristics in different fields and disciplines. Up-to-date literature indicated no study reported which method was most suitable for assessing hazard, risk, and emergency assessment. Practicians were still seeking a single responsive approach to keep the computing system's lower load. The recent study indicated the PCA as the predominant, and the Entropy method as the second most widely adopted method. However, there was no answer for a better approach between the PCA and Entropy method. The practical implication suggested that comparative analysis should always be conducted to each case and determine the appropriate weighting method in the relevant circumstances or business system applications.

**Keywords:** PCA, Entropy, Multi-criteria decision-making, weighting methods

## Introduction

Multi-criteria decision-making (MCDM) methods have significantly been used for evaluating and ranking critical factors with conflicting characteristics in different fields and disciplines [1- 4]. Literature divided MCDM methods into subjective methods, objective methods, and subjective and objective mixed methods. They depended on whether weight is calculated indirectly from the given methods, directly from the domain experts [4], or the decision-makers. Until 2019, 56 single and mixed MCDM methods were reported [1]. Each MCDM procedure has been developed with different advantages and disadvantages, however, though the scholars usually select an approach based on the nature and intricacy of the problem [5]. Up-to-date literature indicated no study reported which method was most suitable for evaluating hazard, risk, and emergency assessment. Relatively limited attention was paid to the appropriate selection for such decision problems [1]. Practicians were still seeking a single responsive approach to keep the computing system's lower load [6].

## A Mini-Review on Weighting Methods

Subjective weighting methods depended on the assessments of decision-makers. The design and determination of weights could be interpreted in terms of value judgments, that methods based on the subjective opinions of individual experts were preferred [7]. They had at least two limitations: improper human judgments raising the level of vagueness [8] and a large number of comparisons making the application of the model more complex [9]. Objective methods determined the weight-based known evaluation information by solving a mathematical model, which was particularly useful in situations where the decision-makers did not exist, or the options of the decision-maker were inconsistent [4]. Several objective methods have mainly been used, including Criteria significance

Through Intercriteria Correlation (CRITIC), Entropy, FANMA, The Principal Component Analysis (PCA), and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). Subjective and objective-mixed methods were adopted in various studies to combine the advantages of different methods to make up for the deficiency of subjective methods and reduce the potential bias of a single method [7]. However, complex computing processes to the real-time system could significantly increase the computational burden for system implementation [10].

## Which is a Better Objective Method

Different objective methods might lead to completely different values in the estimates of the weights of the criteria [7]. They might lead to inconsistent results and other results to solve the same case [1,4,7]. No single method could be better for weighting the criteria [6]. A recent study indicated the PCA as the predominant, and the Entropy method as the second most widely adopted method [6].

The PCA method was a dimension reduction technique to transform a high-dimensional dataset into a low-dimensional one while preserving the information content [11, 12]. The main idea of the PCA was to analyze the characteristic properties of a covariance matrix to obtain the principal components of data (eigenvectors) and their weights (eigenvalues) by retaining the lower-order principal components (corresponding to the maximum eigenvalue) [13]. It distilled multiple, potentially correlated variables into new, independent constructs/factors; typically, the number of constructs is much smaller than the number of variables in the original datasets [11]. The PCA could be handy for identifying the most critical variables or the main contributing factors to the phenomenon based on the common factors under investigation: it might then conclude the linear relationship between variables by extracting the most relevant information in the datasets [11,14]. The PCA method could also effectively reduce computational complexity and rapidly select solutions to emergency decision-making in a large dataset group [15]. Notably, the PCA method was sensitive to outliers in the datasets [16]. This method might be well-applied for developing predicting and forecasting systems. It could be a promising alternative for other weighting schemes [17]. However, the PCA method was not developed for identifying a subset of variables among many variables [11].

The Entropy method might establish the objective weights for the attributes/responses: defining the importance of every response but not including any thoughtfulness of the preference of the decision-makers [18]. It was considered suitable for all the decision-making processes that required weight determination [19]. The Entropy might deliver a quantitative measure of information content that could compare and analyze the effect of using different statistical models, algorithms, and corresponding tuning parameters [20]: the lower the Entropy of the criterion, the more valuable information the criterion contains [7]. The Entropy method might measure variables' uncertainty and evaluate how the controlling factors influenced the outcome [21]. This method was highly influential in modeling and mapping different natural hazards [13]. Other studies also believed that the Entropy method allowed a quantitative appraisal of effectiveness and advantage/cost responses [18]. The Entropy method provided higher accuracy than the PCA method: the higher the number of dimensions in the datasets, the more accurate the entropy measure. The main disadvantage of the entropy method for assessing weight was the high sensitivity or hypersensitivity of significance to the entropy values of various criteria [7]. But the Entropy values demonstrated higher sensitivity for evaluating the weight to the higher dimensional datasets than the lower dimensions.

## Conclusion

There was no answer for a better approach between the PCA and Entropy method. The PCA method could be handy and rapidly select solutions for identifying the critical variables or factors and effectively used in large datasets in hazard, risk, and emergency decision-making. The PCA method was sensitive to outliers in the datasets and might be well-applied for developing predicting and forecasting systems. But it was not suitable for evaluating a subset of variables. The Entropy method might be adopted for all the cases requiring the MCDM. It could deliver, compare, and analyze different quantitative measures of information content and might measure variables' uncertainty. Generally, the Entropy method provided higher accuracy than the PCA method. But the Entropy method demonstrated more heightened sensitivity to the higher dimensional datasets.

Although both the PCA and Entropy methods ignored decision-maker opinions and avoided personal bias, they determined the weights of criteria based on the information in the decision-making matrix using specific mathematical models [9]. The rationality of all objective methods for evaluating the consequences for MCDM tasks was questionable: specific algorithms for accurate methods to assess the importance of criteria still require further study [7]. The practical implication suggested that comparative analysis should always be conducted to each case and determine the appropriate weighting method in the relevant circumstances or business system applications.

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## Conflicts of Interest

The authors declare no conflict of interest.

## References

1. Watrobski J, Jankowski J, Ziemba P, Karczmarczyk A, Ziolo M (2019) Generalised framework for multi-criteria method selection. Omega 86: 107-124.
2. Jellali A, Hachicha W, Aljuaid AM (2021) Sustainable configuration of the tunisian olive oil supply chain using a fuzzy TOPSIS-based approach. Sustainability 13: 1-19.
3. Petridis K, Drogalas G, Zografidou E (2021) Internal auditor selection using a TOPSIS/non-linear programming model. Annals of operations research 296: 513-539.

4. Peng XD, Garg (2021) H Intuitionistic fuzzy soft decision-making method based on CoCoSo and CRITIC for CCN cache placement strategy selection. The Artificial intelligence review, pp. 1-38.
5. Mishra AR, Rani P, Pandey K (2021) Fermatean fuzzy CRITIC-EDAS approach for the selection of sustainable third-party reverse logistics providers using improved generalized score function. Journal of ambient intelligence and humanized computing, pp. 1-17.
6. Wu RMX, Zhang ZW, Yan WJ, Fan JF, Gou JW, et al. (2022) A Comparative Analysis of The PCA and Entropy Weight Methods to Establish the Indexing Measurement. PLoS ONE 17: 1-26.
7. Mukhametzyanov I (2021) Specific character of objective methods for determining weights of criteria in MCDM problems: Entropy, CRITIC and SD. Applications in Management and Engineering 4: 76-105.
8. Ecer F, Pamucar D, mardani A, Alrasheedi M (2021) Assessment of renewable energy resources using new interval rough number extension of the level based weight assessment and combinative distance-based assessment. Renewable energy 170: 1156-1177.
9. Žižović M, Pamučar D (2019) New model for determining criteria weights: level-based weight assessment (LBWA) model. Applications in Management and Engineering 2: 126-137.
10. Dragicevic T, Novak M (2019) Weighting factor design in model predictive control of power electronic converters: An artificial neural network approach. IEEE Transactions on Industrial Electronics 66: 8870-8880.
11. Conlon KC, Mallen E, Gronlund CJ, Berrocal VJ, Larsen L, et al. (2020) Mapping human vulnerability to extreme heat: a critical assessment of heat vulnerability indices created using principal components analysis. Environmental health perspectives 128: 1-14.
12. Abdel-Fattah MK, Mohamed ES, Wagdi EM, Shahin SA, Aldosari AA, et al. (2021) Quantitative evaluation of soil quality using principal component analysis: the case study of El-Fayoum depression Egypt. Sustainability 13: 1-19.
13. Hong JH, Su ZLT, Lu EHC (2020) Spatial perspectives toward the recommendation of remote sensing images using the INDEX indicator, based on principal component analysis. Remote sensing 12: 1-33.
14. Medina Pena NJ, Abebe YA, Sanchez A, Vojinovic Z (2020) assessing socioeconomic vulnerability after a hurricane: A combined use of an index-based approach and principal components analysis. Sustainability 12: 1-31.
15. Xian SD, Wan WH, Yang ZJ (2020) Interval-valued pythagorean fuzzy Linguistic TODIM based on PCA and its application for emergency decision. International Journal of Intelligent Systems 35: 2049-2086.
16. Neumayer S, Nimmer M, Setzer S, Steidl G (2019) On the Robust PCA and Weiszfeld's Algorithm. Applied Mathematics & Optimization 82: 1017-1048.
17. Maciejowska K, Uniejewski B, Serafin T (2020) PCA forecast averaging - predicting day-ahead and in traday electricity prices. Energies 13: 1-19.
18. Kumar R, Bilga PS, Singh S (2017) Multi objective optimization using different methods of assigning weights to energy consumption responses, surface roughness and material removal rate during rough turning operation. Journal of Cleaner Production 164: 45-57.
19. Teixeira SJ, Ferreira JJ, Wanke P, Moreira Antunes JJ (2021) Evaluation model of competitive and innovative tourism practices based on information entropy and alternative criteria weight. Tourism Economics: The Business and Finance of Tourism and Recreation 27: 23-44.
20. Hansen TM (2021) Entropy and information content of geostatistical models. Mathematical Geosc.
21. Ziarh GF, Asaduzzaman M, Dewan A, Nashwan MS, Shahid S (2021) Integration of catastrophe and entropy theories for flood risk mapping in peninsular Malaysia. Journal of flood risk management 14: 1-13.