Journal of Current Science and Technology, May - August 2024 Vol. 14 No. 2, Article 23

ISSN 2630-0656 (Online)

Cite this article: Lawong, A., Kejornrak, A., Kriengkorakot, N., & Kriengkorakot, P. (2024). A BWM-TOPSIS linear programming model for evaluating the performance of health-promoting hospitals with McKinsey 7s framework in organizational management. *Journal of Current Science and Technology*, *14*(2), Article 23. https://doi.org/10.59796/jcst.V14N2.2024.23

Journal of Current Science and Technology

Journal homepage: https://jcst.rsu.ac.th

A BWM-TOPSIS Linear Programming Model for Evaluating the Performance of Health-Promoting Hospitals with McKinsey 7s Framework in Organizational Management

Amin Lawong[1], Arpakorn Kejornrak[2], Nuchsara Kriengkorakot[*1] and Preecha Kriengkorakot[1]

[1]Faculty of Engineering, Ubon Ratchathani University, Ubon Ratchathani, 34190, Thailand.
[2]Health Consumer Protection and Pharmacy Department, Maha Sarakham Provincial Health Office, Maha Sarakham, 44000, Thailand.

[*]Corresponding author; E-mail: nuchsara.k@ubu.ac.th

Received 29 September, 2023; Revised 4 November, 2023; Accepted 6 December, 2023
Published online 2 May, 2024

Abstract

This research addresses the critical aspect of evaluating operational performance in health promotion hospitals, which play a vital role in providing medical services to local communities. The research proposes an integrated method for performance assessment, utilizing the Best-Worst Method (BWM) and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) linear programming model. Taking the case of health promotion hospitals in Maha Sarakham province, Thailand, and considering the McKinsey 7s framework's seven criteria, BWM is employed to determine the criteria weights. Subsequently, the TOPSIS linear programming model selects the ideal health promotion hospital based on these weights. The BWM analysis reveals criteria weights in the following order: system, staff, skill, style, structure, strategy, and shared value. The TOPSIS linear programming model identifies SH12 as the top-performing health promotion hospital with a closeness coefficient value of 0.8821. Additionally, a Spearman's rank correlation test validates this proposed method against the original TOPSIS approach, yielding a correlation value of 1.0. These findings provide valuable guidance for organizations, particularly in shaping strategic policies and resource allocation within medical service units, medical equipment, and personnel management in organizational settings. This study offers that the proposed method is simpler and will aid in the ongoing analysis of strengths and weaknesses in the improvement of organizations and development, helping organizations adapt to changes.

Keywords: *Health promoting hospital; Best-Worst Method; BWM; TOPSIS linear programming model; McKinsey 7s framework*

1. Introduction

Assessment of operational performance is a systematic process used by organizations to evaluate how effectively and efficiently they are achieving their operational objectives and goals (Janati et al., 2021). This assessment involves measuring and analyzing various aspects of an organization's day-to-day operations to identify strengths, weaknesses, areas for improvement, and opportunities for optimization. The primary aim is to ensure that an organization's operations are aligned with its strategic objectives and that resources are used effectively to deliver value to customers and stakeholders (Chin et al., 2003; Somwethee et al., 2023). Key components of the assessment of operational performance typically include: (1) Key Performance Indicators (KPIs): Organizations define specific KPIs that align with their operational goals. These KPIs can vary widely depending on the nature of the organization but often include metrics related to productivity, efficiency, quality, customer satisfaction, cost control, and more. (2) Data Collection and Analysis: Gathering relevant data and information is crucial for assessing operational performance. This may involve collecting data on production processes, customer feedback, financial metrics, and other relevant operational data. Data is then analyzed to identify trends, patterns, and areas of concern. (3) Benchmarking: Organizations often compare their operational performance to industry benchmarks or best practices. Benchmarking helps identify areas where an organization may be falling behind or excelling compared to competitors or industry standards. (4) Process Mapping and Improvement: Examining operational processes is a fundamental part of the assessment. Organizations use techniques like process mapping to visualize how work is done. This can reveal bottlenecks, redundancies, and areas where processes can be streamlined or improved. (5) Quality Control: Assessing the quality of products or services is essential. Quality control measures, such as Six Sigma or Total Quality Management (TQM), are employed to maintain and enhance quality standards. (6) Resource Utilization: Evaluating how resources (including personnel, materials, and equipment) are allocated and used is critical. The goal is to ensure that resources are used efficiently and that there is no unnecessary waste. (7) Customer Feedback: Gathering feedback from customers is essential to understanding how well an organization is meeting customer expectations. Customer satisfaction surveys and feedback mechanisms help in this regard. (8) Employee Engagement: Engaged and motivated employees are often more productive and contribute positively to operational performance. Assessing employee morale and engagement is, therefore, crucial. (9) Financial Analysis: Financial metrics like profitability, cost control, and revenue growth are integral to assessing the overall health of an organization's operations. (10) Risk Management: Identifying and mitigating operational risks is also part of the assessment. This includes assessing vulnerabilities and implementing strategies to manage and reduce risks.

Health-promotion hospitals are government agencies that provide services and medical advice to people in the area and nearby areas as an important aspect of medical services. Therefore, each health promotion hospital needs to be managed within the organization to meet the needs of the people and according to the policy direction of the Ministry. In Thailand, there are a total of 9,871 health-promotion hospitals with roles and responsibilities (Pokpermdee, & Mekbunditkul, 2020). It is the first line of the primary care unit that is responsible for the health of people. People at the sub-district level and nearby areas. Therefore, medical services are important for patient care. Each health-promoting hospital must have its own organizational management. Under the management policy of the Ministry of Public Health. In this research study, a case study on a health-promoting hospital (seventeen alternatives) in the Muang district, Maha Sarakham province, which has important issues in terms of organizational management, Management tools are therefore important tools for analyzing the management of an organization. And finding guidelines is an important factor in managing an organization. From the literature survey and data survey, it was found that the health-promoting hospitals in this case study still lack the suitable tools to analyze factors or criteria affecting organizational development.

The McKinsey 7S Framework, crafted by McKinsey & Company, a prominent consultancy, during the 1980s, serves as a management model. Its purpose lies in scrutinizing and evaluating the internal facets of an organization that possess the capacity to influence its triumph and efficiency. The framework derives its name, 7S, from its incorporation of seven interconnected elements, all coincidentally commencing with the letter "S." These seven elements can be delineated as follows (Demir, & Kocaoglu, 2019; Odeh, 2021; Chmielewska et al., 2022): (1) Strategy: This element pertains to the organizational roadmap for accomplishing its goals and objectives. It encompasses the company's comprehensive business strategy, its approach to markets, competition, and strategies for growth. (2) Structure: The concept of structure revolves around how the organization is structured. This encompasses its hierarchy, reporting lines, and the manner in which various functions or departments are partitioned and coordinated. (3) Systems: Systems refer to the array of processes, procedures, and routines governing how work is conducted within the organization. This encompasses both formal and informal systems in place. (4) Skills: Skills denote the proficiencies and competencies of the organization's workforce. It encompasses the knowledge, expertise, and capabilities possessed by employees. (5) Staff: Staff pertains to the individuals comprising the organization, encompassing their numbers, qualifications, and roles. Additionally, it considers aspects like recruitment, training, and development. (6) Shared

Values: Shared values encompass the fundamental beliefs, principles, and corporate culture inherent within the organization. These values define the organization's identity and serve as guiding principles for its actions and decisions. (7) Style: Style delves into the leadership style and management approach prevailing within the organization. It encompasses the behavior and attributes of top management and their interactions with employees. The robustness and alignment of these seven elements play a pivotal role in determining an organization's success. When these elements are harmonized and mutually reinforced, the organization is deemed to be in a state of "fit," which significantly enhances its potential for effectiveness and triumph. Conversely, any inconsistencies or misalignments among these elements can pose challenges and impede the organization's ability to attain its objectives. The McKinsey 7S Framework is widely employed as a diagnostic tool to assess the current state of an organization, pinpoint areas necessitating attention or enhancement, and formulate strategies to achieve alignment and heighten organizational performance. It is a versatile model adaptable to various types of organizations and scenarios (Gokdeniz et al., 2017; Jollyta et al., 2021; Şalvarli, & Kayiskan, 2018). In summary, the McKinsey 7S framework offers several distinct advantages that contribute to its effectiveness as a management tool. One of its primary strengths lies in its holistic approach to organizational analysis. By encapsulating seven interconnected elements: strategy, structure, systems, skills, style, staff, and shared values, the framework provides a comprehensive view of an organization. This holistic perspective enables leaders to assess various facets of the organization simultaneously, encompassing both tangible and intangible aspects such as strategy, culture, and personnel. Additionally, the framework emphasizes the interdependence and alignment of these elements, ensuring that they work cohesively towards common goals. This aspect facilitates a clear understanding of how different components interact and influence each other, fostering better decision-making, effective planning, and seamless implementation of strategic initiatives. Ultimately, the framework's ability to integrate multiple dimensions of an organization's functioning enhances its utility in diagnosing issues, strategizing, managing change, and promoting alignment, thereby contributing significantly to organizational effectiveness and success. This is the main reason why the McKinsey 7S Framework model, an effective tool for analyzing and evaluating the performance of this organization, is being utilized.

The Best-Worst Method (BWM), developed by Jafar Rezaei (Rezaei, 2015), is a multi-criteria decision-making (MCDM) technique used for ranking and prioritizing a set of alternatives based on a defined set of criteria. It is an extension and refinement of the Analytic Hierarchy Process (AHP) (Saaty, 1987), and Analytic Network Process (ANP) methodologies (Kheybari et al., 2020). The BWM method was introduced to address some of the limitations and complexities associated with AHP and ANP. BWM's structured approach, ease of use, and versatility make it a promising method for a wide range of applications. Here is how the Best-Worst Method works: (1) Identify Criteria: First, we need to determine the criteria or attributes that are relevant to the decision-making process. These criteria should be specific to the problem being tried trying to solve. (2) Select Alternatives: Identify a set of alternatives or options that you want to evaluate or prioritize. These are the choices you're considering. (3) Pairwise Comparison: For each criterion, we will perform a pairwise comparison of the alternatives. You determine which alternative is the "best" with respect to that criterion and which is the "worst." This comparison is done for each criterion individually. (3) Scoring: Assign numerical scores to the alternatives based on the pairwise comparisons. The "best" alternative for each criterion receives the highest total score from experts, while the "worst" alternative for each criterion receives the lowest total score from experts. (4) Weighting Criteria: The optimal weights of each criterion are calculated using a linear programming model. The alternative with the highest total score is considered the best criteria, while the one with the lowest total score is the worst criteria. The Best-Worst Method is particularly useful when you have multiple criteria to consider, and it helps decision-makers prioritize options objectively. It can be applied in various contexts. For example, Kheybari et al. (2023) introduced BWM to design a bioethanol sustainable supply chain. Özer et al. (2020) used BWM to select the best location of piezoelectric tiles. Ahmad et al. (2023) proposed multichoice BWM for group decision-making. Radwan et al. (2021) applied a hybrid group (BWM and Evaluation based on Distance from Average (EDAS)) to site selection. Raj et al. (2018) used fuzzy BWM to evaluate the sustainability performance of an aircraft manufacturing firm. Similarity: Salimi, & Rezaei (2018) used BWM to identify the weights (importance) of evaluating a firm's R&D. Finally, Yadollahi et al. (2018) used BWM to evaluate and determine the factors affecting the service experience in bank. Lawong (2023) proposed method for addressing the optimal location selection for emergency medical service bases using a hybrid approach (BWM and linear programming model). It considered various factors and resulted in the choice of seven suitable locations. Additionally, it provides a structured approach to decision-making and can help in clarifying preferences and trade-offs among alternatives (Pamučar et al., 2020; Sadjadi, & Karimi, 2018). Although the BWM method has been applied in various fields, no researchers have yet used the BWM method with the McKinsey 7s framework to evaluate the performance of health-promoting hospitals.

The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), First proposed by Hwang, & Yoon (1981), is a multi-criteria decision-making (MCDM) method used for ranking a set of alternatives based on their similarity to an ideal solution. It helps decision-makers choose the best alternative when faced with multiple criteria or attributes (Deng et al., 2000; Yoon, & Hwang, 1995). Here's how TOPSIS works (Vommi, 2017): (1) Identification of Criteria: Define the criteria or attributes that are relevant to the decision problem. These could be factors like cost, quality, efficiency, or any other considerations depending on the specific context. (2) Normalization: Normalize the values of each criterion for all alternatives. This step ensures that the different criteria, which might have different units or scales, can be compared on a common scale. Common normalization methods include min-max normalization or z-score normalization. (3) Weight Assignment: Assign weights to each criterion to reflect their relative importance or priority. These weights are typically determined through discussions with experts or stakeholders and can be expressed as percentages or numerical values. (4) Ideal and Negative-Ideal Solutions: Calculate the ideal (best) and negative-ideal (worst) solutions for each criterion. The ideal solution represents the best value for each criterion, while the negative-ideal solution represents the worst value. These solutions are determined based on whether each criterion is to be maximized or minimized. (5) Similarity Measurement: Compute the similarity (closeness) of each alternative to the ideal and negative-ideal solutions using a distance or similarity metric. The most commonly used similarity measure is the Euclidean distance, but other measures like the Minkowski distance or cosine similarity can also be used. (6) TOPSIS Score: Calculate the TOPSIS score for each alternative by considering both the similarity to the ideal solution and the dissimilarity from the negative-ideal solution. This is typically done by subtracting the dissimilarity from the similarity. (7) Ranking: Rank the alternatives based on their TOPSIS scores in descending order. The alternative with the highest TOPSIS score is considered the most preferred or optimal solution. TOPSIS is a useful method for solving decision-making problems where there are multiple criteria to consider, and it provides a systematic way to evaluate and rank alternatives based on these criteria. It has a wide range of applications across various domains where decision-makers need to evaluate and rank alternatives based on multiple criteria. Here are some common applications of TOPSIS: (1) decisions selection provider cold chain logistics (Wiangkam et al., 2022), location section (Ponhan, & Sureeyatanapas, 2020; Radwan et al., 2021), technology selection (Halicka, 2020), product selection (Akgül et al., 2021; Bertolini et al., 2020; Sharifi et al., 2022; Liao et al., 2015), material selection (Chede et al., 2021; Das et al., 2019; Bachchhav et al., 2023; Jha et al., 2022), international expansion selection (Christian et al., 2016), selection underground mining (Mijalkovski et al., 2022), selection supplier (Abdel-Basset et al., 2019; Sureeyatanapas et al., 2018; Gupta, & Vijayvargy, 2021; Yildiz, 2019), selection farmwork (Krawczyńska-Piechna, 2015), multi-response optimization (Sriburum et al., 2023), and other related research studies (Motia, & Reddy, 2020; Le Roux et al., 2023). Recently, To-on et al. (2023) proposed the TOPSIS linear programming model with response surface methodology for solving multi-response optimization problems, which is a case study of lightweight concrete. The proposed TOPSIS linear programming model is a modified version of the original TOPSIS method. This method is attractive and powerful because it has fewer calculation steps than the original TOPSIS version. It can be solved by using various optimization software programs. In addition, it can be used to solve large-scale MADM problems. To overcome the weaknesses of each method as shown in the above literature, a group of researchers (Wang et al., 2022; Bafail, & Abdulaal, 2020; Putra et al., 2020; Nilashi et al., 2022; Cho, & Chae, 2022) have proposed the combination of the BWM and the TOPSIS method for solving MCDM problems. The combination of BWM and TOPSIS leverages the strengths of both methods to provide a structured, comprehensive, and reliable approach to solving complex MCDM problems, facilitating informed and well-supported decision-making processes.

In this paper, the combination of the BWM and the TOPSIS linear programming model is a reliable and practical tool for evaluating the performance of the health-promoting hospitals based on the McKinsey 7s framework: a case of 17 health-promoting hospitals in Maha Sarakham province, Thailand. This is one way to improve and develop government agencies to be more efficient in their operations.

This paper is organized as follows: section 1 introduces research studies and a review of literature techniques for solving MADM problems for evaluating the performance of health-promoting hospitals in organization management is based on the McKinsey 7s framework. section 2 is the objective of this research. section 3 describes the proposed method. Finally, section 4 presents results and discussion. Conclusions appear in section 5.

2. Objectives

The objective of this research is to introduce the BWM-TOPSIS linear programming model as a means of assessing the efficiency of health promotion hospitals, with a focus on those within Maha Sarakham province. This approach aligns with the McKinsey 7s framework and aims to enhance the operational efficiency of government agencies.

3. Methodology

The methodology for evaluating the performance of health-promoting hospitals based on the McKinsey 7s framework in organization management involves a systematic and structured approach. This section outlines the steps and procedures followed in this research. Based on a case study of the health-promoting hospitals with seventeen hospitals in Maha Sarakham province. The BWM-TOPSIS linear programming model will be presented for evaluating the performance of health promotion hospitals in organizational management. This process involves four main steps, as illustrated in Figure 1.

3.1 Define criteria based on the McKinsey 7s framework assessment of the performance of health-promoting hospitals

The McKinsey 7s framework is a valuable management instrument providing a comprehensive method for evaluating and improving an organization's overall efficiency. It encompasses seven interconnected components that collectively influence an organization's achievements. Seven criteria from the McKinsey 7s framework have been established in the field of organizational management (Office of Primary Health System Support Ministry of Public Health, 2023). In this paper, we conducted individual interviews with five experts, all from the District Health Promotion Hospitals in Maha Sarakham province. Each of these experts has more than 10 years of professional experience in the field and possesses significant expertise in the respective area. Details of the results obtained from the experts are shown in Table 1.

3.2 Calculate the criteria weights using the BWM method based on expert opinions

The BWM is a comprehensive multi-criteria decision-making approach used to calculate the criteria weights based on expert opinions. It achieves this by comparing items in pairs and identifying the most favorable and unfavorable choices (Salimi, & Rezaei, 2018). The BWM provides a thorough representation of participants' preferences, allowing decision-makers to gain insights into the trade-offs between various factors and make well-informed and balanced decisions. The process involves the following steps: (1) Identifying the set of decision criteria based on the McKinsey 7S framework, encompassing Strategy, Structure, Systems, Skills, Staff, Style, and Shared Values. These criteria were determined through a questionnaire administered to five experts from the District Health Promotion Hospitals in Maha Sarakham Province. (2) Determining the best and worst criteria, a task carried out by experts. (3) Establishing pairwise comparisons of the best criterion against all other criteria, using a scale from 1 to 9, as determined by experts. (4) Establishing pairwise comparisons of the worst criterion against all other criteria, using a scale from 1 to 9, as determined by experts. (5) Calculating the optimal weights based on the collected data. The BWM model are shown in Equations (1) to (5).

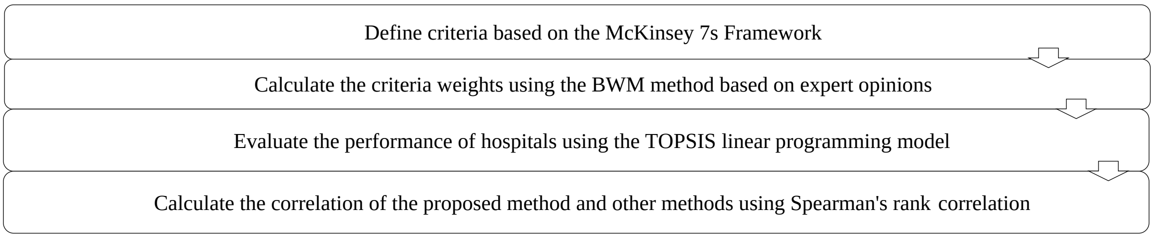

Figure 1 The proposed framework for this research

Table 1 Criteria of the McKinsey 7s Framework.

McKinsey 7s framework	Criteria	Definition	Criteria types
Strategy	C1	Number of outpatients receiving services in the fiscal year	Cost
Structure	C2	Number of medical equipment	Benefit
System	C3	Number of services in the service unit	Benefit
Style	C4	Number of regular civil servants	Benefit
Staff	C5	Number of personal	Benefit
Skill	C6	Number of academic positions	Benefit
Shared Valued	C7	Number of people responsible	Benefit

Table 2 Table of consistency index (CI)

Criteria a_{BW}	3	4	5	6	7	8	9
3	0.2087	0.2087	0.2087	0.2087	**0.2087**	0.2087	0.2087
4	0.1581	0.2352	0.2738	0.2928	0.3102	0.3154	0.3273
5	0.2111	0.2848	0.3019	0.3309	0.3479	0.3611	0.3741
6	0.2164	0.2922	0.3565	0.3924	0.4061	0.4168	0.4225
7	0.2090	0.3313	0.3734	0.3931	0.4035	0.4108	0.4298
8	0.2267	0.3409	0.4029	0.423	0.4379	0.4543	0.4599
9	0.2122	0.3653	0.4055	0.4225	0.4445	0.4587	0.4747

Objective function:

$$\text{Min}\, z = \xi^{L} \tag{1}$$

Constraints:

$$\left| w_B - a_{Bj} w_j \right| \le \xi^{L}, \text{ for all j} \tag{2}$$

$$\left| w_j - a_{jW} w_w \right| \le \xi^{L}, \text{ for all j} \tag{3}$$

$$\sum_j w_j = 1 \tag{4}$$

$$w_j \ge 0 \text{ , for all j} \tag{5}$$

These give the consistency index values, and Eq. (6) gives the formula for the consistency ratio as shown in Table 2.

$$\text{Consistency ratio} = \frac{\xi^{L*}}{\text{Consistency index}} \tag{6}$$

In this model, the primary objective of the linear BWM model's objective function is to minimize the measure of consistency in comparisons. Equation (2) guarantees that the absolute disparity between the weight values of the best criterion and each criterion 'j' does not exceed this measure of consistency. Equation (3) assures that the absolute difference between the weight values of the worst criterion and each criterion 'j' is also within the bounds of this consistency measure. Equation (4) ensures that the sum of the determined criteria weights equals one. Equation (5) enforces that the criterion weight remains greater than or equal to zero. Finally, in Equation (6), the consistency ratio can be computed by dividing the consistency measure by the consistency index.

3.3 Evaluate the performance of health-promoting hospitals using the TOPSIS linear programming model

The TOPSIS linear programming model is introduced as a tool for selecting and ranking the performance of health-promoting hospitals, as outlined by To-on et al. (2023), it has several advantages: (1) It involves a single-step calculation process, reducing errors from traditional methods; (2) It allows compatibility with various optimization software; (3) It can handle large input data problems, processing them quickly and minimizing other potential errors.

Stage 1: Prepare dataset of decision matrix for the ranking.

$$X = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_I \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_J \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1J} \\ x_{21} & x_{22} & \cdots & x_{2J} \\ \cdots & \cdots & \cdots & \cdots \\ x_{I1} & x_{I2} & \cdots & x_{IJ} \end{bmatrix} \end{array} \begin{array}{l} , A_i \, (i = 1, 2, ..., I) \\ , C_j \, (j = 1, 2, ..., J) \\ , x_{ij} \, (i = 1, 2, ..., I; J = 1, 2, ..., J) \end{array} \tag{7}$$

where A_i is the candidate alternative.

C_j is the criteria relating to alternative performance.

x_{ij} is the performance rating of candidate alternative (dataset of each candidate alternative i with respect to criterion j).

$$y = \begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1J} \\ y_{21} & y_{22} & \cdots & y_{2J} \\ \cdots & \cdots & \cdots & \cdots \\ y_{I1} & y_{I2} & \cdots & y_{IJ} \end{bmatrix}, y_{ij} \, (i = 1, 2, ..., I; J = 1, 2, ..., J) \tag{8}$$

$$y_{ij} = x_{ij} \Big/ \sqrt{\sum_{i=1}^{I} x_{ij}^2} \text{ , for beneficial criteria} \tag{9}$$

$$y_{ij} = 1 - x_{ij} \Big/ \sqrt{\sum_{i=1}^{I} x_{ij}^2} \text{ , for cost criteria} \tag{10}$$

where y_{ij} is the normalized rating by vector normalization.

Stage 2: Calculate the relative closeness coefficient to the ideal solutions (overall preference score).

$$\mathrm{CC}_i = \max \frac{\lambda_i^- \left(\sum_{j=1}^{J} \sqrt{w_j^2 \left((y_{ij})^2 - (y_j^-)^2 \right)} \right)}{\lambda_i^- \left(\sum_{j=1}^{J} \sqrt{w_j^2 \left((y_{ij})^2 - (y_j^-)^2 \right)} \right) + \lambda_i^+ \left(\sum_{j=1}^{J} \sqrt{w_j^2 \left((y_j^+)^2 - (y_{ij})^2 \right)} \right)}, \tag{11}$$

$\lambda_i^- = \lambda_i^+, \lambda_i^-, \lambda_i^+ \geq 0, \; i = 1, 2, ..., I, w_j \geq 0, \; j = 1, 2, ..., J.$

Where λ_i^- is variables are the optimal weights of the summation of the distances from the negative ideal solution to alternative i

λ_i^+ is variables are the optimal weights of the summation of the distances from the positive ideal solution to alternative i

w_j is the weight criteria by BWM method**.**

y_j^- is the negative ideal values of each criterion j, $y_j^- = \min\{y_{ij}\}, \forall j, \quad j = 1, 2, ..., J.$

y_j^+ is the positive ideal values of each criterion j, $y_j^+ = \min\{y_{ij}\}, \forall j, \quad j = 1, 2, ..., J.$

CC_i is the relative closeness coefficient value of each alternative i

The TOPSIS linear programming model (To-on et al., 2023) can be defined in Equation (12).

$$
\begin{aligned}
&\mathrm{CC}_i = \max \lambda_i^- \left(\sum_{j=1}^{J} \sqrt{w_j^2 \left((y_{ij})^2 - (y_j^-)^2 \right)} \right), \\
&\lambda_i^- \left(\sum_{j=1}^{J} \sqrt{w_j^2 \left((y_{ij})^2 - (y_j^-)^2 \right)} \right) + \lambda_i^+ \left(\sum_{j=1}^{J} \sqrt{w_j^2 \left((y_j^+)^2 - (y_{ij})^2 \right)} \right) = 1, \ \forall i = 1, 2, ..., I, \\
&\lambda_i^- \left(\sum_{j=1}^{J} \sqrt{w_j^2 \left((y_{ij})^2 - (y_j^-)^2 \right)} \right) \le \lambda_i^- \left(\sum_{j=1}^{J} \sqrt{w_j^2 \left((y_{ij})^2 - (y_j^-)^2 \right)} \right) + \\
&\lambda_i^+ \left(\sum_{j=1}^{J} \sqrt{w_j^2 \left((y_j^+)^2 - (y_{ij})^2 \right)} \right), \ \forall i = 1, 2, ..., I, \ \lambda_i^- = \lambda_i^+{}_i, \ \lambda_i^-, \lambda_i^+ \ge 0, \ i = 1, 2, ..., I, \ j = 1, 2, ..., J.
\end{aligned} \tag{12}
$$

The higher the CC_i value, the more favorable the ranking of the alternative.

3.4 Calculate the correlation of the proposed method and other methods using Spearman's rank correlation test

Subsequently, in step 3.3, the outcomes derived from the BWM-TOPSIS linear programming model will be subjected to validation through Spearman's rank correlation test in conjunction with the TOPSIS method. This validation step is essential to affirm the method's consistency and reliability. Sensitivity analysis was carried out by varying input weight criteria across four scenarios: scenario 1 (50% cost weight and 50% benefit weight), scenario 2 (30% cost weight and 70% benefit weight), scenario 3 (70% cost weight and 30% benefit weight), and scenario 4 (10% cost weight and 90% benefit weight), in accordance with the approach presented by Dehghan-Manshadi et al. (2007). This approach serves as a decision-making option when management seeks to determine the weighting of costs and benefits, emphasizing performance in alignment with the evaluation criteria.

4. Results and discussion

4.1 Results of the criteria based on the McKinsey 7s framework assessment of the performance of health-promoting hospitals

In the initial phase, we conducted a comprehensive review of literature pertaining to the McKinsey 7s framework. This examination revealed the framework's effectiveness as a tool for enhancing the efficiency of government agencies. Consequently, we opted to leverage these tools for the enhancement of healthcare-promoting hospitals' organizational management. Subsequently, a panel of five experts collaboratively identified seven criteria that align with the McKinsey 7s framework. These criteria encompass: Strategy (C1): Number of outpatients receiving services in the fiscal year, Structure (C2): Number of medical equipment, Systems (C3): Number of services in the service unit, Style (C4): Number of regular civil servants, Staff (C5): Number of personal, Skills (C6): Number of academic positions, and Shared Values (C7): Number of people responsible.

4.2 Results of the criteria weights using the BWM

In this phase, application of the BWM method to determine the criteria weights of the health-promoting hospitals. The calculation steps are:

(1) Identifying the set of decision criteria based on the McKinsey 7S framework in section 4.1

(2) Determining the best and worst criteria, a task carried out by experts. After that, experts or decision-makers assign a score indicating which one is the best and which one is the worst for each comparison. The relevant information systems (C3): Number of services in the service unit is chosen as the best criterion, and the worst criterion is chosen as the shared values (C7): Number of people responsible, as shown in Table 3.

Table 3 The rating scale for selecting the best criterion and the worst criterion by five experts

Experts selected the best criteria, worst criteria	McKinsey 7S framework						
	Strategy (C1)	**Structure (C2)**	**System (C3)**	**Style (C4)**	**Staff (C5)**	**Skill (C6)**	**Shared Valued (C7)**
Expert 1	8,9	9,8	9,5	8,2	8,4	8,3	7,1
Expert 2	4,2	3,1	5,3	9,7	7,5	8,6	6,4
Expert 3	9,7	8,6	7,5	4,3	6,4	5,2	3,1
Expert 4	8,3	6,1	9,3	7,2	6,1	7,2	6,1
Expert 5	9,3	9,3	9,3	8,2	8,2	8,2	7,2
Total score	38,24	35,19	39,19	36,16	35,16	36,15	29,9

Note. Rating scale 1-9 (few important, very important),

Table 4 Pairwise comparison matrix based on the opinion of five experts

Best Criteria System (C3), Worst Criteria Shared Valued (C7) to Others	Strategy (C1)	Structure (C2)	System (C3)	Style (C4)	Staff (C5)	Skill (C6)	Shared Valued (C7)
Expert 1	8,3	6,6	1,7	4,5	2,6	3,4	7,1
Expert 2	7,5	5,5	1,6	6,6	3,5	6,6	6,1
Expert 3	7,4	4,4	1,8	5,7	4,7	5,5	5,1
Expert 4	6,6	7,3	1,6	4,4	3,3	4,7	8,1
Expert 5	7,4	5,6	1,7	3,5	4,5	3,5	7,1
Geometric mean (Best Criteria)	7.0	5.3	1.0	4.3	3.1	4.0	6.5
Geometric mean (Worst Criteria)	4.3	4.6	6.8	5.3	5.0	5.3	1.0

Note. Rating scale 1-9 (few important, very important),

As indicated in Table 3, five experts provided ratings on a scale of 1 to 9, signifying the importance of each criterion through a questionnaire. The process involved identifying both the most significant criteria, calculated as the sum of the highest criteria (for instance, C1 = 8 + 4 + 9 + 8 + 9 = 38), and the least significant criteria, calculated as the sum of the lowest criteria (for instance, C1 = 9 + 2 + 7 + 3 + 3 = 24). Subsequently, these best and worst criteria were subjected to a comparative analysis employing the BWM method. As a result, the best criterion and the worst criterion were C3 (total score = 39) and C7 (total score = 9) respectively.

(3) Establishing pairwise comparisons of the best criterion against all other criteria, using a scale from 1 to 9, as determined by experts. And (4) Establishing pairwise comparisons of the worst criterion against all other criteria, using a scale from 1 to 9, as determined by experts. After obtaining the best criterion and the worst criterion, the pairwise comparison was used to compare each criterion or alternative with all others in pairs. The pairwise comparison method based on the opinions of group experts is shown in Table 4.

The value of C1 for the best criterion was determined by calculating the geometric mean of each evaluation score in the pairwise comparison, as shown in Table 4. This is due to the fact that expert opinions vary considerably (Saaty, 1995). The definition of the geometric mean is given in Equation (13).

$$\text{G.M.} = \sqrt[n]{x_1.x_2.x_3...x_n} \qquad (13)$$

where x_i is comparison scores obtained from each expert, $i = 1, 2, 3, ..., n.$

For example, the value of C1 for the best criterion was obtained as 7, $\sqrt[5]{8 \times 7 \times 7 \times 6 \times 7}$ = 7.0 Based on the same calculation of value of C1 for the best criterion, the value of C1 for the worst criterion was obtained as 4.3, $\sqrt[5]{3 \times 5 \times 4 \times 6 \times 4} = 4.3$. Details of all values of the pairwise comparison were shown in Table 5.

(5) Calculating the optimal weights based on the collected data as follows Eqs. (1)–(6) were solved using the MS Excel solver. The optimal weights of each criterion are shown in Table 6.

As depicted in Table 6, Criterion C3, denoting the number of services within the service unit, carries the highest weight. It is succeeded by C5, C6, C4, C2, C1, and C7 in descending order of importance. This prioritization underscores the significance of C3 in delivering medical services to the public, as it is interconnected with all other criteria in organizational management, encompassing medical service units, medical equipment, and personnel. The consistency ratio was assessed in accordance with Equation (6). The objective function value and consistency ratio were both found to be less than 1, in line with the findings of Liang et al. (2020), with a consistency index (CI) of 0.4035 (a_{aw} and seven criteria), as illustrated in Table 2.

4.3 The results of the BWM-TOPSIS linear programming model

The optimal weights derived through the BWM method in section 4.2 are utilized in the TOPSIS linear programming model to obtain the CC_i scores for ranking of alternatives (Hospitals). Equation (12) was solved using LINGO software. The obtained CC_i scores were shown in Table 7.

Table 5 Results data from pairwise comparison by Geometric mean

Criteria	C1	C2	C3	C4	C5	C6	C7
Best (C3)	7.0	5.3	1.0	4.3	3.1	4.0	6.5
Worst(C7)	4.3	4.6	6.8	5.3	5.0	5.3	1.0

Table 6 Criteria weights obtained from BWM

Criteria	C1	C2	C3	C4	C5	C6	C7
Weights	0.0715	0.0944	0.3886	0.1164	0.1614	0.1251	0.0426
Parameters	**Objective function**	**Values** 0.1117					
	Consistency ratio	**Values** 0.2768					

Table 7 The obtained CC_i scores obtained from the proposed method

Alternative	Criteria						
	C1	C2	C3	C4	C5	C6	C7	CC_i
SH1	16,338	20	16	4	8	3	4,599	0.7621
SH2	13,227	21	16	3	9	1	6,408	0.5501
SH3	27,405	13	14	4	9	2	3,505	0.5176
SH4	21,359	14	14	4	9	3	5,179	0.6218
SH5	26,806	22	15	4	8	1	4,767	0.5096
SH6	15,630	16	8	4	7	3	3,514	0.2573
SH7	15,200	12	14	3	3	0	6,354	0.1859
SH8	13,778	10	14	5	8	1	6,237	0.3712
SH9	18,385	5	14	5	5	4	3,399	0.5864
SH0	15,096	17	17	5	9	3	6,736	0.8337
SH11	13,250	14	13	4	5	0	2,659	0.1672
SH12	12,957	11	22	4	5	3	2,094	0.8821
SH13	27,078	11	16	4	9	0	3,453	0.4411
SH14	13,448	17	20	2	6	1	2,907	0.6775
SH15	16,750	13	14	5	9	2	3,975	0.5147
SH16	10,031	12	15	5	9	2	3,643	0.5642
SH17	12,603	12	14	3	6	0	3,113	0.2120

As indicated in Table 7, the outcomes demonstrate that, according to the BWM-TOPSIS linear programming model, the higher performance is denoted by the higher value of CC_i score. Based on the decision-making scores, the top five alternatives, listed in descending order, are SH12, SH10, SH1, SH14, and SH4. The ranking of alternatives using the BWM-TOPSIS linear programming model is compared to the original TOPSIS method, resulting in the same sequence. Consequently, the proposed BWM-TOPSIS linear programming model aligns with the outcomes of both methods, with SH12 being the selected health-promoting hospital with the best performance. Verify the proposed model, as shown in Table 8.

4.4 The results of Spearman's rank correlation

Table 8 shows that Spearman's rank correlation was used to obtain the correlation for the proposed method and the original TOPSIS method. The correlation value was obtained as 1.0. This indicates a very high level of consistency with the original TOPSIS method, both methods yield the same results in the ranking. Hence, the proposed method is simpler and practical, can be effectively applied, and is reliable to address various MCDM problems.

4.5 The results of Sensitivity analysis

The findings in Table 9 reveal that altering the weight assigned to each criterion, achieved by adjusting the percentage distribution between cost and benefit for each criterion type through the TOPSIS method, leads to distinct rankings in each scenario. This flexibility empowers administrators to employ guidelines for determining criterion weights based on the McKinsey 7s framework when making decisions regarding the enhancement or advancement of health-promoting hospitals.

Table 8 The Score of each model for selection alternative and ranking

Alternative	CC_i	BWM-original TOPSIS	CC_i	BWM-TOPSIS linear programing
		Ranking		Ranking
SH1	0.6482	3	0.7621	3
SH2	0.5366	8	0.5501	8
SH3	0.4893	10	0.5176	10
SH4	0.5559	5	0.6218	5
SH5	0.4875	11	0.5096	11
SH6	0.3762	14	0.2573	14
SH7	0.3326	16	0.1859	16
SH8	0.4456	13	0.3712	13
SH9	0.5442	7	0.5864	7
SH10	0.7029	2	0.8337	2
SH11	0.3248	17	0.1672	17
SH12	0.7494	1	0.8821	1
SH13	0.4549	12	0.4411	12
SH14	0.6023	4	0.6775	4
SH15	0.5118	9	0.5147	9
SH16	0.5519	6	0.5642	6
SH17	0.3572	15	0.2120	15

Table 9 Sensitivity analysis of each case and ranking alternative

Alternative	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
	CC_i	Ranking	CC_i	Ranking	CC_i	Ranking	CC_i	Ranking
SH1	0.6514	9	0.6793	2	0.6401	11	0.7089	2
SH2	0.7306	3	0.6289	5	0.7929	3	0.5493	8
SH3	0.2011	16	0.3438	16	0.0996	16	0.4884	11
SH4	0.4180	14	0.5298	11	0.3647	14	0.6486	3
SH5	0.2231	15	0.3672	15	0.1157	15	0.4972	10
SH6	0.6512	10	0.6079	6	0.6716	10	0.5702	5
SH7	0.5989	11	0.4688	14	0.6749	9	0.3532	14
SH8	0.6940	5	0.5800	7	0.7603	7	0.4823	12
SH9	0.5341	13	0.5554	9	0.5227	13	0.5710	4
SH10	0.7212	4	0.7456	1	0.7112	8	0.7714	1
SH11	0.6553	8	0.4864	13	0.7651	6	0.3106	16
SH12	0.7450	2	0.6425	4	0.8079	2	0.5609	6
SH13	0.1622	17	0.2644	17	0.0820	17	0.3410	15
SH14	0.6885	6	0.5520	10	0.7711	5	0.4261	13
SH15	0.5981	12	0.5710	8	0.6099	12	0.5456	9
SH16	0.8100	1	0.6769	3	0.9062	1	0.5502	7
SH17	0.6722	7	0.4944	12	0.7918	4	0.2976	17

5. Conclusions

In conclusion, this research article has introduced a comprehensive decision-making framework for organizational management, employing the Best-Worst Method (BWM) to select criteria based on the McKinsey 7s framework within the context of health-promoting hospitals. The study further utilizes the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) linear programming model to identify the best-performing health-promotion hospital among seventeen candidates in the Mueang Maha Sarakham District, Maha Sarakham Province. The assessment of health-promoting hospitals' performance, guided by the McKinsey 7s framework encompassing seven criteria (strategy, structure, system, style, staff, skill, and shared value), is a pivotal aspect of this study. Expert evaluations, followed by BWM calculations, have assigned weights to these criteria. These weights derived from the BWM method have facilitated weight normalization and subsequent ranking of alternative health-promoting hospitals through the TOPSIS linear programming model. Consequently, this research serves a dual purpose: the identification of crucial criteria in organizational management and the recognition of the top-performing health-promoting hospitals. Notably, SH12, SH10, and SH1 emerged as the leading performers, with closeness coefficients of 0.8821, 0.8337, and 0.7621, respectively. Additionally, the study conducted sensitivity analysis of criteria weights in group decision-making, where cost and benefit percentages were considered. The findings underscore the effectiveness of the BWM-TOPSIS linear programming model in evaluating health-promoting hospital performance. Importantly, this research offers insights into an organization's strengths and weaknesses, enhancing the provision of quality medical services to the local populace. Furthermore, it provides a foundation for organizations to formulate strategic policies and allocate resources efficiently, with a specific focus on three critical areas: medical service units, medical equipment, and personnel management. This approach aligns with the Ministry of Public Health's policy on best health care hospitals. Moreover, it’s a tool for aid ongoing analysis strength and weakness in improvement of organizations and development, helping organizations adapt to changes.

Although the proposed method was applied for a case study in Maha Sarakham province, the tools presented can be applied to other areas or different case studies because these tools are generally accepted standard methods for organizational evaluation. Undoubtedly, applying the methods presented in this case study to other cases remains essential for increased reliability. Future research endeavors will delve into decision-making within the context of employing fuzzy and combined decision-making methods for evaluating organizational performance across diverse contexts. further advancing our understanding of effective management strategies.

6. Acknowledgements

The authors extend their appreciation to the Department of Industrial Engineering at the Faculty of Engineering, Ubon Ratchathani University, Kalasin University, and the Maha Sarakham Provincial Public Health Office for their indispensable assistance and support throughout the course of this research.

7. References

Abdel-Basset, M., Saleh, M., Gamal, A., & Smarandache, F. (2019). An approach of TOPSIS technique for developing supplier selection with group decision making under type-2 neutrosophic number. *Applied Soft Computing*, *77,* 438-452. https://doi.org/10.1016/j.asoc.2019.01.035

Ahmad, Q. S., Khan, M. F., & Ahmad, N. (2023). A Group Decision-Making Approach in MCDM: An Application of the Multichoice Best–Worst Method. *Applied Sciences*, *13*(12), 1-17. https://doi.org/10.3390/app13126882

Akgül, E., Bahtiyari, M. İ., Kizilkaya Aydoğan, E., & Benli, H. (2021). Use of Topsis Method for Designing Different Textile Products in Coloration via Natural Source “Madder.” *Journal of Natural Fibers*, *19*(14), 8993–9008. https://doi.org/10.1080/15440478.2021.1982106

Bachchhav, B., Bharne, S., Choudhari, A., & Pattanshetti, S. (2023). Selection of spot welding electrode material by AHP, TOPSIS, and SAW. *Materials Today: Proceedings*. https://doi.org/10.1016/j.matpr.2023.02.253

Bafail, O. A., & Abdulaal, R. M. S. (2022, January 12 - 14). *A Combined BWM-TOPSIS Approach Versus AHP-TOPSIS Approach: An Application to Solid Waste Management* [Conference presentation]. IEIM 2022, 2022 The 3rd International Conference on Industrial Engineering and Industrial Management. ACM. https://doi.org/10.1145/3524338.3524343

Bertolini, M., Esposito, G., & Romagnoli, G. (2020). A TOPSIS-based approach for the best match between manufacturing technologies and product specifications. *Expert Systems with Applications*, *159*, 1-32. https://doi.org/10.1016/j.eswa.2020.113610

Chede, S. J., Adavadkar, B. R., Patil, A. S., Chhatriwala, H. K., & Keswani, M. P. (2021). Material selection for design of powered hand truck using TOPSIS. *International Journal of Industrial and Systems Engineering*, *39*(2), 236- 249. https://doi.org/10.1504/ijise.2021.118257

Chin, K.-S., Pun, K.-F., & Lau, H. (2003). Development of a knowledge-based self-assessment system for measuring organisational performance. *Expert Systems with Applications*, *24*(4),443–455. https://doi.org/10.1016/s0957-4174(02)00192-6

Chmielewska, M., Stokwiszewski, J., Markowska, J., & Hermanowski, T. (2022). Evaluating Organizational Performance of Public Hospitals using the McKinsey 7-S Framework. *BMC Health Services Research*, *22*(1), 1-12. https://doi.org/10.1186/s12913-021-07402-3

Cho, J., & Chae, M. (2022). Systematic Approach of TOPSIS Decision-Making for Construction Method Based on Risk Reduction Feedback of Extended QFD-FMEA. In Z. Wu (Ed.), *Mathematical Problems in Engineering*, 2022,1-23. https://doi.org/10.1155/2022/1458599

Christian, A. V., Zhang, Y., & Salifou, C. K. (2016). Country Selection for International Expansion: TOPSIS Method Analysis. *Modern Economy*, *7*(4), 470-476. https://doi.org/10.4236/me.2016.74052

Das, S. S., Chakraborti, P., Bhowmik, C., & Singh, R. (2019). Decision-Making for Selection of Most Suitable Materials for Biomedical Applications. *Lecture Notes in Mechanical Engineering*, 901–917. https://doi.org/10.1007/978-981-13-6577-5_87

Dehghan-Manshadi, B., Mahmudi, H., Abedian, A., & Mahmudi, R. (2007). A novel method for materials selection in mechanical design: Combination of non-linear normalization and a modified digital logic method. *Materials & Design*, *28*(1), 8–15. https://doi.org/10.1016/j.matdes.2005.06.023

Demir, E., & Kocaoglu, B. (2019). The use of McKinsey s 7S framework as a strategic planning and economic assestment tool in the process of digital transformation. *Pressacademia*, *9*(9), 114-119. https://doi.org/10.17261/pressacademia.2019.1078

Deng, H., Yeh, C.-H., & Willis, R. J. (2000). Inter-company comparison using modified TOPSIS with objective weights. *Computers & Operations Research*, *27*(10), 963–973. https://doi.org/10.1016/s0305-0548(99)00069-6

Gokdeniz, I., Kartal, C., & Komurcu, K. (2017). Strategic Assessment based on 7S McKinsey Model for a Business by Using Analytic Network Process (ANP). *International Journal of Academic Research in Business and Social Sciences*, *7*(6), 342-353. https://doi.org/10.6007/ijarbss/v7-i6/2967

Gupta, S., & Vijayvargy, L. (2021). Selection of Green Supplier in Automotive Industry: An Expert Choice Methodology. *IOP Conference Series: Earth and Environmental Science*, *795*(1), 1-10. https://doi.org/10.1088/1755-1315/795/1/012036

Halicka, K. (2020). Technology Selection Using the TOPSIS Method. *Foresight and STI Governance*, *14*(1), 85-96. https://doi.org/10.17323/2500-2597.2020.1.85.96

Hwang, C. L. & Yoon, K. (1981). Multiple Attribute Decision Making. *Lecture Notes in Economics and Mathematical Systems*. Springer Berlin Heidelberg.

Janati, A., Gholizadeh, M., Hajizadeh, A., & Bahreini, R. (2021). Factors Affecting Organization Performance Assessment: A Comprehensive Review. *Health Technology Assessment in Action*, *4*(2). https://doi.org/10.18502/htaa.v4i2.6229

Jha, M. K., Gupta, S., Chaudhary, V., & Gupta, P. (2022). Material selection for biomedical application in additive manufacturing using TOPSIS approach. *Materials Today: Proceedings*, *62*,1452-1457. https://doi.org/10.1016/j.matpr.2022.01.423

Jollyta, D., Oktarina, D., Astri, R., Kadim, L. A. N., & Dasriani, N. G. A. (2021). Cluster Analysis Based on McKinsey 7s Framework in Improving University Services. *Journal of Artificial Intelligence and Engineering Applications (JAIEA)*, *1*(1), 1-8. https://doi.org/10.59934/jaiea.v1i1.45

Kheybari, S., Davoodi Monfared, M., Salamirad, A., & Rezaei, J. (2023). Bioethanol sustainable supply chain design: A multi-attribute bi-objective structure. *Computers & Industrial Engineering*, *180*, 27-34. https://doi.org/10.1016/j.cie.2023.109258

Kheybari, S., Rezaie, F. M., & Farazmand, H. (2020). Analytic network process: An overview of applications. *Applied Mathematics and Computation*, *367*, Article 124782. https://doi.org/10.1016/j.amc.2019.124780

Krawczyńska-Piechna, A. (2015). Application of TOPSIS Method in Formwork Selection Problem. *Applied Mechanics and Materials*, *797*, 101-107. Trans Tech Publications, Ltd. https://doi.org/10.4028/www.scientific.net/amm.797.101

Lawong, A. (2023). A Hybrid BWM-MCLP Method for Selecting Emergency Medical Service Locations: A Case Study in Maha Sarakham Province, Thailand. *Engineering Access*, *9*,102–108. https://doi.org/10.14456/MIJET.2023.13

Le Roux, D., Olivès, R., & Neveu, P. (2023). Combining entropy weight and TOPSIS method for selection of tank geometry and filler material of a packed-bed thermal energy storage system. *Journal of Cleaner Production*, *414*, Article 137588. https://doi.org/10.1016/j.jclepro.2023.137588

Liang, F., Brunelli, M., & Rezaei, J. (2020). Consistency issues in the best worst method: Measurements and thresholds. *Omega*, *96*, Article 102175. https://doi.org/10.1016/j.omega.2019.102175

Liao, C.-N., Lin, C.-H., & Fu, Y.-K. (2015). Integrative Model for The Selection of a New Product Launch Strategy, Based On ANP, TOPSIS And MCGP: A Case Study. *Technological and Economic Development of Economy*, *22*(5), 715-737.

https://doi.org/10.3846/20294913.2015.1074951

Mijalkovski, S., Efe, O. F., Despodov, Z., Mirakovski, D., & Mijalkovska, D. (2022). Underground Mining Method Selection with the Application of TOPSIS Method. *GeoScience Engineering*, *68*(2), 125–133. https://doi.org/10.35180/gse-2022-0075

Motia, S., & Reddy, S. R. N. (2020). Application of TOPSIS method in selection of design attributes of decision support system for fertilizer recommendation. *Journal of Information and Optimization Sciences, 41*(7), 1689–1704. https://doi.org/10.1080/02522667.2020.1799513

Nilashi, M., Mardani, A., Liao, H., Ahmadi, H., Manaf, A. A., & Almukadi, W. (2019). A Hybrid Method with TOPSIS and Machine Learning Techniques for Sustainable Development of Green Hotels Considering Online Reviews. *Sustainability*, *11*(21), Article 6013. https://doi.org/10.3390/su11216013

Odeh, G. (2021). Implementing Mckinsey 7S Model of Organizational Diagnosis and Planned Change, Best Western Italy Case Analysis. *Journal of International Business and Management*, *11*(4), 01-08. https://doi.org/10.37227/jibm-2021-09-1438

Office of Primary Health System Support Ministry of Public Health. (2023). *Health Resource Information System Primary care unit*. Retrieved October 10, 2023, from http://gishealth.moph.go.th/pcu/admin/report.php

Özer, A. S., Hasani, H., Genç, E. B., Kutlu, N., Temur, G. T., & Sivri, Ç. (2020). Using Best Worst Method for Location Selection of Piezoelectric Tiles. *Lecture Notes in Mechanical Engineering*, 27-34. https://doi.org/10.1007/978-3-030-62784-3_3

Pamučar, D., Ecer, F., Cirovic, G., & Arlasheedi, M. A. (2020). Application of Improved Best Worst Method (BWM) in Real-World Problems. *Mathematics*, *8*(8), Article 1342. https://doi.org/10.3390/math8081342

Pokpermdee, P., & Mekbunditkul, T. (2020). Level Categorization of Sub-district Health Promoting Hospitals in Thailand, *Journal of Health Science*, *29*(2), 323–331.

Ponhan, K., & Sureeyatanapas, P. (2022). A comparison between subjective and objective weighting approaches for multi-criteria decision making: A case of industrial location selection. *Engineering and Applied Science Research*, *49*(6), 763–771.

Putra, A. P. E., Sardi, I. L., & Adityaji, R. (2022, November 22-23). *Implementation of Hybrid BWM-TOPSIS Method in the Selection of Tour Guide (Case Study: Guidemu)* [Conference presentation]. 2022 1st International Conference on Software Engineering and Information Technology (ICoSEIT). IEEE. https://doi.org/10.1109/icoseit55604.2022.10030070

Radwan, N. M., Elstohy, R., & Hanna, W. K. (2021). A Proposed Method for Multi-Criteria Group Decision Making: An Application to Site Selection. *Applied Artificial Intelligence*, *35*(7), 505–519. Informa UK Limited. https://doi.org/10.1080/08839514.2021.1901031

Raj, A., & Srivastava, S. K. (2018). Sustainability performance assessment of an aircraft manufacturing firm. *Benchmarking: International Journal*, *25*(5), 1500-1527. https://doi.org/10.1108/bij-01-2017-0001

Rezaei, J. (2015). Best-worst multi-criteria decision-making method. *Omega*, *53*, 49–57. https://doi.org/10.1016/j.omega.2014.11.009

Saaty, R. W. (1987). The analytic hierarchy process what it is and how it is used. *Mathematical Modelling*, *9*(3-5), 161-176. https://doi.org/10.1016/0270-0255(87)90473-8

Saaty, T. L. (1995). *The Analytic Hierarchy Process for Decision in a Complex World.* RWS Publication, Pittsburgh. PA: USA.

Sadjadi, S., & Karimi, M. (2018). Best-worst multi-criteria decision-making method: A robust approach. *Decision Science Letters, 7*(4), 323-340. https://doi.org/10.5267/j.dsl.2018.3.003

Salimi, N., & Rezaei, J. (2018). Evaluating firms' R&D performance using best worst method. *Evaluation and Program Planning*, *66*,147–155. https://doi.org/10.1016/j.evalprogplan.2017.10.002

Salvarli, M. S., & Kayiskan, D. (2018). An analysis of McKinsey 7-S model and its application on organizational efficiency. *International Journal of Scientific and Technological Research*, *4*(7), 103-111.

Sharifi, F., Vahdatzad, M. A., Barghi, B., & Azadeh-Fard, N. (2022). Identifying and ranking risks using combined FMEA-TOPSIS method for new product development in the dairy industry and offering mitigation strategies: case study of Ramak Company. *International Journal of System Assurance Engineering and Management*, *13*(5), 2790–2807. https://doi.org/10.1007/s13198-022-01672-8

Somwethee, P., Aujirapongpan, S., & Ru-Zhue, J. (2023). The influence of entrepreneurial capability and innovation capability on sustainable organization performance: Evidence of community enterprise in Thailand. *Journal of Open Innovation: Technology, Market, and Complexity*, *9*(2), Article 100082. https://doi.org/10.1016/j.joitmc.2023.100082

Sriburum, A., Wichapa, N., & Khanthirat, W. (2023). A Novel TOPSIS Linear Programming Model Based on the Taguchi Method for Solving the Multi-Response Optimization Problems: A Case Study of a Fish Scale Scraping Machine. *Engineered Science*, *23*, Article 882. https://doi.org/10.30919/es882

Sureeyatanapas, P., Sriwattananusart, K., Niyamosoth, T., Sessomboon, W., & Arunyanart, S. (2018). Supplier selection towards uncertain and unavailable information: An extension of TOPSIS method. *Operations Research Perspectives*, *5*, 69-79. https://doi.org/10.1016/j.orp.2018.01.005

To-on, P., Wichapa, N., & Khanthirat, W. (2023). A novel TOPSIS linear programming model based on response surface methodology for determining optimal mixture proportions of lightweight concrete blocks containing sugarcane bagasse ash. *Heliyon*, *9*(7), e17755. https://doi.org/10.1016/j.heliyon.2023.e17755

Vommi, V. (2017). TOPSIS with statistical distances: A new approach to MADM. *Decision science letters*, *6*(1), 49-66. https://doi.org/10.5267/j.dsl.2016.8.001

Wang, Y., Liu, P., & Yao, Y. (2022). BMW-TOPSIS: A generalized TOPSIS model based on three-way decision. *Information Sciences*, *607*, 799–818. Elsevier BV. https://doi.org/10.1016/j.ins.2022.06.018

Wiangkam, N., Jamrus, T., & Sureeyatanapas, P. (2022). The decision-making for selecting cold chain logistics providers in the food industry. *Engineering and Applied Science Research*, *49*(6), 811–818.

Yadollahi, S., Kazemi, A., & Ranjbarian, B. (2018). Identifying and prioritizing the factors of service experience in banks: A Best-Worst method. *Decision Science Letters*, *7*(4), 455-464. https://doi.org/10.5267/j.dsl.2018.1.002

Yildiz, A. (2019). Green supplier selection using topsis method: A case study from the automotive supply industry. *Journal of Engineering Research and Applied Science*, *8*(2), 1146-1152.

Yoon, K., & Hwang, C.-L. (1995). *Multiple Attribute Decision Making: An Introduction*. 104, SAGE Publications, Inc. https://doi.org/10.4135/9781412985161