



Using the Fuzzy Best Worst Method for Evaluating Strategic Planning Models

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Abstract: During the last few decades, various strategic planning models have been suggested in the literature. It is difficult for a company to decide which of these models is most useful to adopt, as each of them shows different strengths and weaknesses. We consider this problem a multicriteria decision problem and investigate the evaluation of six strategic planning models in the context of smaller and medium-sized manufacturing companies in Iran. We consider a methodology that supports the analysis of the input from several decision-makers based on multiple criteria and assume vagueness in the input data elicited from them. For the purpose considered, the fuzzy best worst method (FBWM) appears appropriate. Based on a literature review, six evaluation criteria for strategic management models are considered: formality, clarity, measurability, objectivity, coverage, and consistency. These criteria are evaluated based on the input provided by thirteen managers using linguistic variables. FBWM is used to provide criteria weights that are used to determine fuzzy scores for the six considered strategic planning models. Finally, a defuzzification of the scores indicates the model by Wright is best suited for the application purpose. A consistency analysis included in FBWM shows that the input provided by the managers is sufficiently consistent.

Keywords: strategic planning models; multicriteria decision making; fuzzy best worst method; fuzzy sets; small and medium-sized manufacturing companies

1. Introduction

Although several strategic planning models have been developed for varied objectives or situations, it is not evident whether using a specific model for a situation is preferable. Because there is a dearth of direction in this area, many businesses struggle with strategic planning concerns and may suffer serious economic consequences as a result. Despite some studies being done on the evaluation of strategic planning models, none of them prioritized the models or suggested a particular model that Iranian small and medium manufacturing enterprises should use. A research gap might be filled by looking into the use of multi-criteria decision-making techniques to prioritize strategic planning models. As a result, the focus of the current study is on determining the priority of strategic planning models in small and medium manufacturing enterprises in Iran.

The lack of empirical research on strategic planning and the evaluation of strategic planning models in Iran is one of the main justifications for conduction this study.

Our study aims to prioritize strategic planning models using the fuzzy best-worst method that provides SMEs with a practical strategic planning model for the actual application. The focus of the current study is Iran's manufacturing industry. Due to the considerable contribution that the manufacturing sector has made to the Iranian economy, particularly in recent years, manufacturing SMEs were selected.



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2. Study Background

2.1. Small and Medium-Sized Enterprises

In many countries, small and medium-sized enterprises (SMEs) provide a very significant contribution to the economy. This also holds for Iran where they play a key role in reducing the unemployment rate and raising the gross domestic product [1,2] and contribute to opportunities for employment, skill development, and entrepreneurial spirit. It has also been pointed out that supporting SMEs in Iran contributes to innovation, technology, and development activities and significantly strengthens supplier networks.

Iranian SMEs are considered particularly important for the manufacturing industry and related value chains, and are, thus, conducive to the country's economic growth prospects. Suresh and Mohideen [3], pointed out that SMEs play a key role in the improvement of business activities in various countries. According to Chen [4], Osinde [5], and Dusko [6], the industrialization, growth of incomes, empowerment, and entrepreneurship is based on SMEs' achievements. However, various external constraints, such as an insufficient access to financial means, inferior infrastructure, erratic policies, and international sanctions, Iranian SMEs operate under extremely unstable and challenging conditions. Various studies have been conducted in developed economies, where SMEs do not encounter some of these restrictions [7–9].

The selection and implementation of specific strategic planning models and related activities may significantly improve the situation for SMEs, not only in a chaotic environment but in general in a challenging competitive environment. Therefore, evaluating and prioritizing strategic planning models is an important issue that is insufficiently studied for SMEs.

Two studies investigated the evaluation of strategic planning models in Iran: The study by Khatami and Mehzadzade [10] presents a comparative analysis for the evaluation of strategic planning models. The second one classifies strategic planning models by focusing on the type of organization. However, the current study attempts to evaluate and prioritize strategic planning models from a different perspective by using FBWM as a novel decision-making technique.

2.2. Multiple Criteria Decision-Making Models

2.2.1. Decision-Making

In decision-making optimal alternatives are to be selected from a set of alternatives [11,12]. In general, decision-making is considered one of the main tasks of managers and a key activity in management, e.g., for specifying organizational policies, formulating goals, selecting, and evaluating major activities. The achievement of the organization's goals depends, to a large degree, on the quality of managerial decision-making.

The decision-making process is based the following steps:

- Specification of a problem
- Determination of criteria or objectives
- Determination of alternatives
- Evaluation and selection of an alternative
- Implementation of the selected alternative

2.2.2. Multicriteria Decision-Making (MCDM)

Usually, decision-making models involve several criteria or objectives, which is then denoted as multicriteria decision making (MCDM). The respective model can be divided into two general categories (see [13,14] for an overview):

- Multiobjective decision-making (MODM)
- Multiattribute decision-making (MADM)

In MODM, mathematically formulated optimization problems are considered, which usually involve a set of alternatives characterized by constraints. In MADM, a finite and an explicitly given set of alternatives are analyzed and prioritized, considering several criteria. Very often, practical decision problems can be formulated as MADM problems.

2.2.3. Fuzzy Best Worst Method (FBWM)

FBWM is an MCDM (MADM) technique that was developed by Guo and Zhao [15]. This method is an extended version of the best-worst method in a fuzzy environment. Decision-makers first determine the best (most desirable, most important) and the worst (least desirable, least important) criteria. The two criteria (best and worst) are then compared in a structured way against each other and against other criteria. The weights of the criteria and alternatives are then determined by formulating and solving a max-min optimization problem. Linguistic terms, which are easily understandable by the decision makers, are then used as for expressing triangular fuzzy numbers, which describe the reference comparisons for the best and the worst criteria. The fuzzy scores of the alternatives are then calculated by multiplying the criteria values and the fuzzy weights concerning the considered criteria. By applying the graded mean integration representation (GMIR) method, crisp ranking scores of alternatives are finally derived. It is possible to assess the validity of fuzzy preference comparisons by using a consistency ratio [15].

2.3. Strategic Planning Models

Six strategic planning models out of hundreds of models that are mostly well known and approved by managers in Iranian SMEs are briefly discussed in the following and subsequently evaluated in our study.

2.3.1. The Bryson Model

Bryson [16] stated that organizations can adapt to a new environment more successfully using strategic planning in the sense of making substantial decisions that define the character and orientation of an organization's activities in its legal and institutional environment.

A brief description of the planning steps in the Bryson model is as follows:

- 1. Initial setup: First of all, the purpose, the preferred process steps, the format and timing of reports, the role, responsibilities, and composition of the strategic planning steering committee, and the strategic planning team are specified.
- 2. Formal and informal mandates for the organization are identified and clarified.
- 3. Specification of mission and values: Based on a stakeholder analysis, an organization should create a mission statement.
- 4. Evaluation of the external environment: The opportunities and threats that an organization is facing are to be determined. This should include further investigations of stakeholder groups, such as customers, clients, or users of the organizations, as well as actual or potential competitors or partners, together with political, economic, social, and technological developments.
- 5. Evaluation of the internal environment: The strengths and weaknesses of the organization are to be determined. This should include assessments of organizational resources (input), current strategy (process), and performance (outputs).
- 6. Strategic issues are to be identified as essential policy questions with impact on mandates, mission and values, products, service levels, the mix of stakeholders, cost, financing, management, or organizational structure. Three fundamental methods for identifying strategic issues are suggested, the direct approach, the goal approach, and the scenario approach.
- 7. Strategy development: The issues identified in the previous step are addressed by developing strategies. This includes the identification of realistic alternatives for resolving strategic issues, a specification of obstacles to their realization, and the creation of suggestions to implement the alternatives or remove the obstacles. Then, the team must decide which steps are to be taken during the next one or two years to realize the suggestions. Finally, a thorough work schedule needs to be set up during the following six to twelve months.

8. A future description of the organization should be provided, showing the full potential of the process (the organization's "vision of success") [16].

2.3.2. The Wright Model

Wright suggested a hierarchical model of an organization that offers a tolerant perspective on strategic planning [10,17] based on the business environment and environmental factors. Additionally, based on an industry analysis, the strengths and weaknesses, threats, and opportunities are to be identified. The objectives and mission of a company are specified based on internal resources and external opportunities. Based on specified goals, three levels of a strategy are defined: management, activity, and function. At the management level, macrostrategies are formulated. At the activity level, the strategy is to be transformed into operations across the organization. At the function level, the tasks, and responsibilities of employees are established as specific plans.

2.3.3. The Wheelen and Hunger Model

Wheelen and Hungar [18] specified the fundamental components of strategic planning, including environmental analysis, strategy formulation, strategy implementation, evaluation, and control. The steps can be described as follows:

- 1. Environmental analysis: Strategic factors, i.e., internal and external components relevant for the analysis of the organizations' strategic decisions, are to be pointed out. The external environment includes elements (opportunities and threats) outside of the company and usually beyond the immediate control of the management. The internal environment (strengths and weaknesses) considers aspects within the company that can be controlled by the management.
- 2. Strategy formulation: Criteria for achieving competitive advantages are required for the strategy formulation. In addition, the mission of the company, related weaknesses, realistic goals, and policy standards are to be specified. The mission identifies an organization's contribution to society, such as offered services and products. Goals should be specified as concrete actions, whereas policies are a comprehensive set of rules that support the organization's goals and plans.
- 3. Strategy implementation: Strategies are to be realized by specifying programs (such as lists of actions), budgets, and procedures.
- 4. Evaluation and control: The actual performance should be monitored and compared to the planned performance as a part of the evaluation and control process.
- Feedback/Learning process: Frequently, it is necessary to go back and amend or correct decisions made earlier in the process.

2.3.4. The Hill and Jones Model

Hill and Jones [19] suggested a strategic planning model with two main phases: strategy formulation and strategy implementation. In the first phase, the company mission and key goals are to be formulated based on the company's current business model. In addition, an external analysis, an internal analysis, and strategic choices are to be provided. In the second phase, the organizational structure, culture, and control systems are specified as the bases for the strategy implementation. The model comprises the following steps:

- 1. Mission statement: The organization's mission statement should provide the framework for formulating strategies. It should include four elements: a statement of the purpose (mission), a statement of a desired future state (vision), a statement of the core principles (values), and a statement of a significant goal.
- 2. External analysis: The external analysis identifies strategic opportunities and threats that may impact the organization's mission. Three interrelated environments should be investigated: the industry environment, the national environment, and the socioe-conomic environment.
- 3. Internal analysis: This analysis focuses on the company's resources, abilities, and competencies and aims to identify the company's strengths and weaknesses.

- SWOT analysis: A SWOT analysis considers strengths, weaknesses, opportunities, and threats together with the aim of specifying tactics for taking advantage of opportunities, parrying threats, utilizing and enhancing strengths, and eliminating weaknesses.
- 5. Strategies: Strategies are to be determined to establish or maintain competitive advantages based on different alternative potential tactics that should address four main categories: functional level, business level, global level, and corporate level strategies. The strategy implementation requires the specification of actions at these levels to carry out a strategic plan. This also presupposes a suitable organizational structure, culture, and control systems.
- 6. Governance and ethics: A governance system must be established to ensure that everyone in the company conforms to legal and ethical rules, as well as to the company's objectives.
- 7. Organizational structure, culture, and control: The organizational structure determines the specific value-creation tasks to be performed by employees, as well as how these tasks contribute to productivity, quality, innovation, or customer satisfaction, i.e., the creation of competitive advantages. The organizational culture includes values, norms, beliefs, and attitudes that determine how employees interact with each other and with external stakeholders. A control system provides information on the performance of the organization and may provide incentives for employees.

2.3.5. The Bowman and Asch Model

Bowman and Asch [20] suggested a strategic planning model based on subjective and objective aspects. In the strategic planning process, the present situation is analyzed first. The strategic changes then result from interrelated objective and subjective aspects leading to a new strategic setup. The strategic planning process in the model includes the following steps:

- 1. Present situation: Analysis of the firm's current status and strategic setup.
- Strategic change: Modifications to the current strategy are to be specified. Changes may be local or organization-wide; they may result from a complex planning process or emerge as hasty decisions made under pressure.
- 3. The "new strategic setup" loop: Strategic change is considered an ongoing process.
- 4. Objective conditions: These include the current and future environment of a company, such as the competitive situation, the economic and technological settings, the political and social context, and the company's use of resources.
- 5. Subjective conditions: The social, psychological, and political elements of an organization are referred to as subjective conditions. These elements have developed as a result of previous management decisions, the external environment, leadership style, and the organizational structure of a company.

2.3.6. The David Model

David's [21] strategic planning model addresses the following three questions: Where is the firm now? Where does it want to go? How is the firm going to get there?

The strategic planning process begins with the identification of the organization's current vision, mission, objectives, and strategies and also considers business ethics, social responsibility, and environmental sustainability issues. The strategic planning steps are as follows.

- Mission and vision statements: The mission statement answers the question "what is our business?" whereas the vision statement addresses the question "what do we wish to become?"
- 2. External audit: A list of opportunities and threats is provided based on an external audit. Usually, five major categories of external forces can be identified: (1) economic force, (2) social, cultural, demographic, and environmental forces, (3) political, governmental, and legal forces, (4) technical force, and (5) competitive force.

- 3. Internal audit: An internal analysis is used to identify the functional strengths and weaknesses of the company based on data from management, marketing, finance and accounting, production and operations, and research and development.
- 4. Establishment of long-term objectives: Objectives should be qualitative, measurable, practical, intelligible, difficult, hierarchical, attainable, and consistent across the company.
- 5. Strategy analysis and selection: Various courses of action should be identified to achieve the company's mission and objectives.
- 6. Strategy implementation: Specific actions are to be implemented that require motivation, strong leadership, and collaboration within an organization.
- 7. Strategy evaluation: The organization's performance as a result of strategy implementation should be measured. This includes the following three activities: examining the fundamental principles of the strategy, comparing expected and actual results, and taking countermeasures where required.
- 8. Business ethics, social responsibilities, and environmental sustainability: These factors should be considered throughout the whole strategic planning process. Business ethics are guidelines that direct behavior and decision-making within enterprises. Social responsibility refers to the safeguarding or improvement of welfare in society. Sustainability refers to the protection of the natural environment.
- 9. Global considerations: Strategic decisions are usually influenced by global factors. Thus, strategic planning [21] requires the understanding of rivals, markets, prices, suppliers, distributors, governments, creditors, shareholders, and customers.

3. Evaluation of Strategic Planning Models

3.1. Quality Criteria for Strategic Planning Models

Assessing strategic planning models based on qualitative criteria by applying a multicriteria decision-making method, i.e., the FBWM, is the main part of our study since managers and owners of SMEs seek the most appropriate model for their organizations.

The effectiveness of the strategic planning process is considered a main factor of resulting strategic plans. A poorly designed planning process will usually not result in a high-quality strategic plan [22].

According to Mellalieu [23], strategic planning should address strategic issues in a well-founded way and include the communication with employees who need to be informed about the planning process. The following factors should be considered during an auditing to evaluate the quality of strategic planning:

- Strategic planning should adequately address all strategic questions, and objectives to seize crucial opportunities and defeat crucial threats.
- Strategic planning should determine and prioritize key tasks.
- Strategic planning should take care for risks and uncertainty.
- Strategic planning should include monitoring and control during strategy implementation. Rumelt [24] proposed the following criteria for evaluating strategic planning:
- Consistency: Strategic planning should take care for consistency among objectives and policies.
- Consonance: The strategic planning process should allow for flexibility and adequacy in response to the company environment, problems and challenges.
- Advantage: Strategic planning should focus on competitive advantages.
- Feasibility: The planning process should consider of organizational resources and related constraints.

According to Cox [25], a strategic planning should be based on the following features:

- Priority: It should be possible to modify strategic plans in response to changing requirements or available resources.
- Measurability: Strategic planning should have measurable goals.

- Flexibility and responsiveness: The strategic plan should consider risks and uncertainties, new opportunities, or adjustments in resource availability.
- Simplicity: The planning process should be short and simple.

After reviewing the literature, the criteria that should be considered for assessing strategic planning models in our study are as follows:

Formality: Strategic planning includes all key elements (vision, mission, values, strategic issues, strategic objectives, and performance measurement) [22,26]).

Clarity: According to the Office of Management and Budget (OMB), clarity is based on the requirement that data and metadata are presented in a clear and comprehensible manner [27]. Therefore, we interpret clarity as the criterion that strategic objectives and strategies are clearly defined in a strategic planning model.

Measurability: Mellalieu [23] assumes measurability to be a key factor in strategic planning as it fundamental to any control system with respect to the appropriate implementation of the strategy. According to Cox [25], strategic planning is appropriate if objectives are measurable, achievable, and time sensitive. Therefore, we interpret measurability as the ability of a strategic planning model to measure, monitor, and evaluate strategic objectives.

Objectivity: According to the Quality Assurance Framework, objectivity is interpreted as the extent to which strategic planning meets the real needs of clients. Objectivity is also referred to as reliability and serviceability by the World Bank and the UNESCO Institute. Hiraga et al. [28] considered objectivity is the ability of a strategic plan to clearly point out the outcomes of the strategic objectives. In the context of our study, objectivity is considered the criterion that reflects the reliability and serviceability of a strategic planning model.

Coverage: Coverage considers to what extent the strategic planning addresses critical issues, opportunities, and threats as identified in the analysis phase. Rumelt [24] divided the coverage into the dimensions feasibility and consonance. While feasibility is the ability of a strategic plan to utilize organizational resources to solve strategic issues, consonance is interpreted as adaptability of the strategic plan to the change in the company environment. Mellalieu [23] suggested that the objectives and goals in strategic planning should take sufficient advantage of available opportunities to overcome threats. In our study, coverage refers to the comprehensive inclusion of key elements such as the company environment, strategic issues, strategies, and action plans into the strategic planning model.

Consistency: Consistency is related to the flexibility of strategic planning and its adaptability to environmental changes [29]. Consistency in strategic planning may help organizations overcome competitors' reactions [30] and other threats resulting from an uncertain environment [31,32]. In addition, flexibility in strategic planning will help an organization, take advantage of being a first mover before its competitors [33], and support improvements in capability and profitability [34,35]. Thus, we interpret consistency as the criterion that represents the adaptability of a strategic planning model concerning environmental changes.

3.2. Method of Analysis

To analyze the collected data, the fuzzy best-worst method is applied and the Lingo 18.0 software is used to solve the problem. The best worst method is a multi-criteria decisionmaking technique which successfully integrated with the fuzzy set theory. The resulting FBWM technique is based on the decision-maker's judgments using fuzzy linguistic terms. The six criteria above (also cf. Table 1) were defined to assess strategic planning models. Six strategic planning models (Bryson, Wright, Wheelen and Hunger, Hill and Jones, Bowman and Asch, and David) were selected as alternatives. Then, based on the decision maker's judgments, the most appropriate strategic planning model was recommended for the Iranian manufacturing SMEs.

Several studies [36–43] have recently applied FBWM for assessment of alternatives.

Criteria	Formality	Clarity	Measurability	Objectivity	Coverage	Consistency
Description	The vision, mission, values, strategic issues, and strategic objectives, and strategies, performance measures are included in the strategic planning model.	Strategic objectives and strategies in the model could be clearly stated.	Strategic objectives could be measured, monitored, and evaluated.	It shows reliability and serviceability of strategic planning.	The subjects such as operating environment, strategic issues, and a set of strategies and action plans are covered by strategic planning model.	In response to the environmental change, the strategic planning model seems consistent.

Table 1. Description of criteria.

3.3. Using the Fuzzy Best Worst Method in the Assessment of the Strategic Planning Models

We applied a new MCDM technique "FBWM" to analyze the problem and find the prioritization of strategic planning models in Iranian manufacturing SMEs. In MCDM techniques, the assessment criteria should be specified first. Next, weights of criteria should be determined. Then, each alternative should be assessed based on each criterion. Finally, the final priority of alternatives will be provided by multiplying the weights of criteria and alternatives.

The data required for the analysis was collected in interviews with thirteen managers from SMEs. Table 2 provides further information about the managers who participated in the interviews.

Table 2. Information	regarding the decision-makers involved.	

	Gender	Position	Experience (Years)	Сотрапу Туре
1	male	production planning manager	9	manufacturing
2	male	production manager	10	manufacturing
3	male	sales manager	8	manufacturing
4	male	factory supervisor	9	manufacturing
5	male	human resource manager	15	manufacturing
6	male	CEO	29	manufacturing
7	male	financial manager	20	manufacturing
8	male	internal manager	10	manufacturing
9	male	financial manager	7	manufacturing
10	male	budget planning manager	8	manufacturing
11	male	human resource manager	16	manufacturing
12	male	counselor	30	manufacturing
13	male	staff manager	9	manufacturing

Based on the fuzzy best-worst method, at first, the best (C_B) and the worst (C_W) criteria were determined by managers. Next, the best criterion to the others and others to the worst were compared by managers based on a 5-point Likert scale of linguistic terms such as Equally Important (EI), Weakly Important (WI), Fairly Important (FI), Very Important (VI), and Absolutely Important (AI). Then, the managers' verbal assessment should be converted into a fuzzy rating (using triangular fuzzy numbers is a frequently used approach). Table 3 represents the transformation of linguistic terms.

Table 3. Linguistic terms.

Linguistic Terms	Membership Function
EI: Equally Important	(1, 1, 1)
WI: Weakly Important	(2/3, 1, 3/2)
FI: Fairly Important	(3/2, 2, 5/2)
VI: Very Important	(5/2, 3,7/2)
AI: Absolutely Important	(7/2, 4,9/2)

We decided not to use questionnaires for the respective elicitation of information due to the extent of strategic planning models and criteria descriptions and the fact that the managers are usually busy. Instead, we interviewed the managers to collect the required data. The respective calculation procedure is described as follows:

Step 1. Comparison of best criterion to the others and others to the worst

To determine the best and worst criteria, a sheet with the descriptions of the criteria was submitted to the managers and asked them to read the descriptions and reply which of the criteria is the "best" criterion and which one is the "worst" in evaluating strategic planning models. Then, the managers were requested to evaluate the importance of the best criterion for others and the worst for others using the linguistic terms.

Tables 4 and 5 represent the judgment comparison of the best criterion to the others and the others to the worst of the managers.

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13
CB Criteria	C2	C3	C1	C1	C1	C6	C5	C1	C3	C1	C3	C3	C6
C1	VI	FI	EI	EI	EI	FI	EI	EI	FI	EI	VI	EI	VI
C2	EI	VI	FI	AI	FI	FI	WI	VI	FI	FI	VI	FI	VI
C3	EI	EI	FI	FI	FI	AI	FI	FI	EI	FI	EI	EI	FI
C4	FI	VI	FI	FI	VI	EI	VI	FI	FI	FI	AI	FI	AI
C5	VI	FI	VI	VI	VI	FI	EI	AI	VI	VI	VI	AI	VI
C6	VI	AI	EI	FI	AI	EI	VI	FI	FI	FI	FI	EI	EI

Table 4. Comparison of best criterion to the others.

Table 5. Comparison of the other criteria to the worst.

	Criteria	C1	C2	C3	C4	C5	C6
M1	C5	FI	AI	AI	FI	EI	FI
M2	C6	VI	FI	AI	FI	FI	EI
M3	C4	VI	EI	EI	EI	WI	FI
M4	C2	AI	EI	VI	VI	FI	VI
M5	C6	AI	FI	FI	FI	FI	EI
<i>M6</i>	C3	VI	VI	EI	FI	FI	AI
M7	C6	FI	FI	EI	EI	VI	EI
M8	C5	AI	VI	FI	FI	EI	VI
M9	C4	FI	FI	VI	EI	WI	FI
M10	C5	VI	FI	FI	FI	EI	FI
M11	C4	FI	FI	AI	EI	FI	VI
M12	C6	VI	FI	EI	EI	VI	EI
M13	C4	FI	FI	FI	EI	FI	AI

The linguistic terms in Tables 4 and 5 should be transformed into fuzzy values using Table 3.

Step 2. Calculating the consistency ratio of pairwise comparisons

The consistency ratio for fuzzy best-worst group decision-making could be calculated as described in [44]. The method applies input-based consistency measurements. It is a simple method that provides immediate feedback. The formula for the input-based consistency ratio is as follows:

$$CR^{I} = \max_{j} CR^{I}_{j} \tag{1}$$

where

$$CR_{j}^{I} = \begin{cases} \left| \frac{R\left(\tilde{a}_{Bj} * \tilde{a}_{jW} - \tilde{a}_{BW}\right)}{R\left(\tilde{a}_{BW} * \tilde{a}_{BW} - \tilde{a}_{BW}\right)} \right| & \tilde{a}_{BW} \neq (1, 1, 1) \\ 0 & \tilde{a}_{BW} = (1, 1, 1) \end{cases}$$
(2)

- CR¹: global input-based consistency ratio for all criteria
- CR_i¹: level of local consistency related to the criterion j
- \tilde{a}_{B_i} : the fuzzy value of the best criterion compared to criterion j
- \tilde{a}_{iW} : the fuzzy value of criterion j compared to the worst criterion

The basic operational rules of triangular fuzzy numbers are presented (see Equations (A1)–(A6) in Appendix A).

Applying graded mean integration representation (GMIR), the triangular fuzzy numbers can be transformed into crisp values (Equation (3)) [45].

If
$$\widetilde{a}_j = l_j + m_j + u_j \rightarrow R(\widetilde{a}_j) = \frac{l_j + 4 * m_j + u_j}{6}$$
 (3)

 \widetilde{a}_{i} : real fuzzy number

- l_i : lower bound
- *m*_i: median
- u_i : upper bound

The consistency assessment of outcomes is given in Table 6 of the consistency ratio threshold according to [46].

Table 6. Input-based consistency measurement threshold for various combinations according to [44].

Scales	2	4	-	(-	0	0	
Criteria	3	4	5	0	7	8	9	
3	0.1667	0.1121	0.1354	0.133	0.1294	0.1309	0.1359	
4	0.1667	0.1529	0.1994	0.199	0.2457	0.2521	0.2681	
5	0.1667	0.1898	0.2306	0.2643	0.2819	0.2958	0.3062	
6	0.1667	0.2206	0.2546	0.3044	0.3029	0.3154	0.3337	
7	0.1667	0.2527	0.2716	0.3144	0.3144	0.3408	0.3517	
8	0.1667	0.2577	0.2844	0.3221	0.3251	0.362	0.362	
9	0.1667	0.2683	0.296	0.3262	0.3403	0.3657	0.3662	

Let the scales of the row dimension in Table 6 indicate the estimated size $R(\tilde{a}_{BW})$. Since $R(\tilde{a}_{BW})$ may not be an integer and the row dimension data in the database is wholly integer, it can approximate the integer value to produce $R(\tilde{a}_{BW})$.

Using Equations (1) and (2), the consistency ratio of the pairwise comparison for Manager 1 is calculated.

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$$\begin{split} \hat{a}_{BW} &= \hat{a}_{25} = \left(\frac{7}{2}, 4, \frac{9}{2}\right) \\ CR_{1}^{I} &= \left\{ \left| \frac{R(\tilde{a}_{21} * \tilde{a}_{15} - \tilde{a}_{25})}{R(\tilde{a}_{25} * \tilde{a}_{25} - \tilde{a}_{25})} \right| = \left| \frac{(\frac{5}{2}, 3, \frac{7}{2}) * (\frac{3}{2}, 2, \frac{5}{2}) - (\frac{7}{2}, 4, \frac{9}{2})}{(\frac{7}{2}, 4, \frac{9}{2}) - (\frac{7}{2}, 4, \frac{9}{2})} \right| = 0.172 \\ CR_{2}^{I} &= \left\{ \left| \frac{R(\tilde{a}_{22} * \tilde{a}_{25} - \tilde{a}_{25})}{R(\tilde{a}_{25} * \tilde{a}_{25} - \tilde{a}_{25})} \right| = \left| \frac{(1,1,1) * (\frac{7}{2}, 4, \frac{9}{2}) - (\frac{7}{2}, 4, \frac{9}{2})}{(\frac{7}{2}, 4, \frac{9}{2}) - (\frac{7}{2}, 4, \frac{9}{2})} \right| = 0 \\ CR_{3}^{I} &= \left\{ \left| \frac{R(\tilde{a}_{23} * \tilde{a}_{35} - \tilde{a}_{25})}{R(\tilde{a}_{25} * \tilde{a}_{25} - \tilde{a}_{25})} \right| = \left| \frac{(1,1,1) * (\frac{7}{2}, 4, \frac{9}{2}) - (\frac{7}{2}, 4, \frac{9}{2})}{(\frac{7}{2}, 4, \frac{9}{2}) - (\frac{7}{2}, 4, \frac{9}{2})} \right| = 0 \\ CR_{4}^{I} &= \left\{ \left| \frac{R(\tilde{a}_{24} * \tilde{a}_{45} - \tilde{a}_{25})}{R(\tilde{a}_{25} * \tilde{a}_{25} - \tilde{a}_{25})} \right| = \left| \frac{(\frac{3}{2}, 2, \frac{5}{2}) * (\frac{3}{2}, 2, \frac{5}{2}) - (\frac{7}{2}, 4, \frac{9}{2})}{(\frac{7}{2}, 4, \frac{9}{2}) - (\frac{7}{2}, 4, \frac{9}{2})} \right| = 0.0069 \\ CR_{5}^{I} &= \left\{ \left| \frac{R(\tilde{a}_{25} * \tilde{a}_{25} - \tilde{a}_{25})}{R(\tilde{a}_{25} * \tilde{a}_{25} - \tilde{a}_{25})} \right| = \left| \frac{(\frac{7}{2}, 4, \frac{9}{2}) * (1,1,1) - (\frac{7}{2}, 4, \frac{9}{2})}{(\frac{7}{2}, 4, \frac{9}{2}) - (\frac{7}{2}, 4, \frac{9}{2})} \right| = 0 \\ CR_{6}^{I} &= \left\{ \left| \frac{R(\tilde{a}_{26} * \tilde{a}_{65} - \tilde{a}_{25})}{R(\tilde{a}_{25} * \tilde{a}_{25} - \tilde{a}_{25})} \right| = \left| \frac{(\frac{5}{2}, 3, \frac{7}{2}) * (\frac{3}{2}, 2, \frac{5}{2}) - (\frac{7}{2}, 4, \frac{9}{2})}{(\frac{7}{2}, 4, \frac{9}{2}) - (\frac{7}{2}, 4, \frac{9}{2})} \right| = 0.172 \\ \end{array}\right\}$$

It is found that there is sufficient consistency in the judgments of Manager 1, comparing the provided results with the values in Table 6.

Table 7 lists the findings of the global input-based consistency ratio for all criteria as well as the degree of local consistency for all managers.

Manager	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13
CRI	0.172	0.172	0.164	0.172	0.172	0.172	0.164	0.172	0.089	0.089	0.172	0	0.172
$\mathbf{CR}_{1}^{\mathbf{I}}$	0.172	0.172	0	0	0	0.172	0.164	0	0.089	0	0.172	0	0.172
CR_2^I	0	0.172	0.164	0	0.041	0.172	0.048	0.172	0.089	0.089	0.172	0	0.172
CR_3^I	0	0	0.164	0.172	0.041	0	0.164	0.172	0	0.089	0	0	0.041
CR_4^I	0.0069	0.172	0	0.172	0.172	0.165	0	0.0069	0	0.089	0	0	0
CR_5^I	0	0.041	0.02	0.172	0.172	0.0069	0	0	0.025	0	0.172	0	0.172
CR_6^I	0.172	0	0.164	0.172	0	0	0	0.172	0.089	0.089	0.172	0	0

Table 7. Global input-based consistency ratio and the local consistency level of each manager.

There is sufficient consistency in all the managers' judgments by comparing the obtained values in Table 7 with the values in Table 6.

Step 3. Criteria weights' calculation

The following linear programming model is proposed to find criteria weights [36]:

$$\begin{split} & \operatorname{Min} \sum_{i} \widetilde{\xi}_{i} \\ s.t. \begin{cases} \left| \begin{array}{c} \frac{\widetilde{W}_{B}^{i}}{\widetilde{W}_{B}^{i}} - \widetilde{a}_{Bj}^{i} \right| \leq \widetilde{\xi}_{i} \\ \left| \begin{array}{c} \frac{\widetilde{W}_{I}^{i}}{\widetilde{W}_{W}^{i}} - \widetilde{a}_{JW}^{i} \right| \leq \widetilde{\xi}_{i} \\ \sum R(\widetilde{W}_{j}^{i}) = 1 \\ \widetilde{W}_{j}^{i} \geq 0 \\ \mu_{j} = \frac{\sum R(\widetilde{W}_{j}^{i})}{d}, \quad \forall j \\ R\left(\widetilde{W}_{j}^{i}\right) = \frac{l_{j}^{i} + 4 \ast m_{j}^{i} + u_{j}^{i}}{6} \end{split} \end{split}$$

where $\widetilde{W}_{B}^{i} = (l_{B}^{i}, m_{B}^{i}, u_{B}^{i}), \widetilde{W}_{W}^{i} = (l_{W}^{i}, m_{W}^{i}, u_{W}^{i}), \widetilde{W}_{j}^{i} = (l_{j}^{i}, m_{j}^{i}, u_{j}^{i}), \widetilde{a}_{Bj}^{i} = (l_{Bj}^{i}, m_{Bj}^{i}, u_{Bj}^{i}), \widetilde{a}_{W}^{i} = (l_{Bj}^{i}, m_{Bj}^{i}), \widetilde{a}_{W}^{i} = (l_{Bj}^{i}, m_{Bj}^{i}, u_{Bj}^{i}), \widetilde{a}_{W}^{i} = (l_{Bj}^{i}, m_{Bj}^{i}, u_{Bj}^{i}), \widetilde{a}_{W}^{i} = (l_{Bj}^{i}, m_{Bj}^{i}), \widetilde{a}_{W}^{i}), \widetilde{a}_{W}^{i} = (l_{Bj$

 $i \in D = \{1, 2, \dots, 13\}$: indices of the decision-makers (managers)

 $j \in C = \{1, 2, \dots, 6\}$: indices of the criteria

 $l \in A = \{1, 2, \dots, 6\}$: indices of the alternatives

B: index of the best criterion

W: index of the worst criterion

 $W_{\rm B}^{\rm 1}$: the fuzzy weight of the best criterion for the i-th decision-maker

 $W_{\rm W}^{\rm i}$: the fuzzy weight of the worst criterion for the i-th decision-maker

 $\tilde{\xi}_i$: the fuzzy dependent variable of consistency ratio for the i-th decision-maker

 W_i^i : the fuzzy weight of criterion j for the i-th decision-maker

 μ_{i} : aggregated weight of criterion j

 \tilde{a}_{Bi}^{i} : the fuzzy value of the best criterion compared to the j-th criterion for the i-th decision-maker

 \tilde{a}_{jW}^{i} : the fuzzy value of the j-th criterion compared to the worst criterion for the i-th decision-maker.

Suppose $\tilde{\xi}_i = (k_i^*, k_i^*, k_i^*)$, the model can be transformed as follows:

$$S.t. \begin{cases} \operatorname{Min} \sum_{i} k_{i}^{*} \\ \left| \frac{(l_{B}^{i}, m_{B}^{i}, u_{B}^{i})}{(l_{j}^{i}, m_{j}^{i}, u_{J}^{i})} - l_{Bj}^{i}, m_{Bj}^{i}, u_{Bj}^{i} \right| \leq k_{i}^{*} \\ \left| \frac{(l_{i}^{i}, m_{i}^{i}, u_{J}^{i})}{(l_{W}^{i}, m_{W}^{i}, u_{M}^{i})} - l_{JW}^{i}, m_{JW}^{i}, u_{JW}^{i} \right| \leq k_{i}^{*} \\ \frac{\int_{j=1}^{6} R\left(\widetilde{W}_{j}\right) = 1}{l_{j}^{i} \leq m_{j}^{i} \leq u_{J}^{i}} \\ l_{j}^{i} \geq 0 \\ k_{i}^{*} \geq 0 \\ j = 1, 2, 3, 4, 5, 6 \\ i = 1, 2, \dots, 13 \\ \mu_{j} = \frac{\sum R(\widetilde{W}_{j})}{d}, \forall j \end{cases}$$

The final weights of the criteria were calculated by applying Lingo 18.0 software. The results are shown in Table 8 and Figure 1.

Table 8. Aggregated weights of criteria.

μ_1	μ_2	μ3	μ_4	μ_5	μ_6
0.202	0.201	0.186	0.114	0.135	0.165



Figure 1. Criteria weights.

Analysis of the criteria shows that C_1 received the highest weight (0.202), while C_4 received the lowest weight (0.114). In other words, from the perspective of the managers who were questioned, formality is the most significant criterion and objectivity is the least important criterion. The following relationship is found for the final criteria weights: $\mu_1 \succ \mu_2 \succ \mu_3 \succ \mu_6 \succ \mu_5 \succ \mu_4$.

Step 4. Determining fuzzy values for strategic planning models

Equations (4)–(6) can be used to determine the final fuzzy values of the strategic planning models. According to Amiri et al. [36] and Kheybari et al. [47], the normalized

value of alternative $l(\tilde{x_1})$ for criterion j assigned by the i-th decision-maker for positive and negative criteria should be determined using Equations (5) and (6).

$$\widetilde{V}_{l}^{i} = \sum_{j=1}^{n} \mu_{j} \widetilde{p}_{lj}^{i}, \text{ for all } i$$
(4)

$$\widetilde{p}_{lj}^{i} = \frac{\widetilde{x}_{lj}^{i}}{\sum_{j} \widetilde{x}_{lj}^{i}}, \text{ for positive criteria}$$
(5)

$$\widetilde{p}_{lj}^{i} = \frac{\frac{1}{\widetilde{x}_{lj}^{i}}}{\sum_{j} \frac{1}{\widetilde{x}_{lj}^{i}}}, \text{ for negative criteria}$$
(6)

$$\widetilde{x}^{i}_{lj} = (a^{i}_{lj}, \ b^{i}_{lj}, \ c^{i}_{lj})$$

where

 μ_i : aggregated weight of criterion j.

 \widetilde{p}_{lj}^{i} : the normalized value of the alternative l for criterion j assigned by i-th decision-maker.

 \hat{x}_{li}^{i} : the value of alternative l for criterion j for the i-th decision-maker.

Table 9 indicate the managers' point of view regarding the assessment of each strategic planning model based on the predetermined criteria. The detailed assessment of the Bryson model is represented in Table 9. Similar analyses (not shown here in details) were conducted for the Wright model, the Wheelen model, the model by Hill and Jones, the model by Bowman and Asch, and David's model.

Table 9. The Bryson model evaluation based on the criteria.

Manager Criteria	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13
C1	М	VH	Н	Η	Η	М	VH	М	VH	Η	Н	Н	Η
C2	Н	VH	М	Η	VH	Η	Η	Η	Η	М	Н	М	L
C3	М	М	М	L	М	L	Η	М	М	Η	VH	М	М
C4	М	М	Н	М	Η	L	М	L	М	Η	Н	Н	М
C5	Н	Η	М	Η	М	М	Η	М	М	М	Н	Н	Η
C6	L	L	L	М	VH	Η	Η	М	Η	Η	Н	М	М

Following a standard approach, the linguistic terms are then converted to fuzzy triangular numbers by applying Table 10. As a result, the fuzzy values of each strategic planning model based on each criterion are determined.

Table 10. Linguistic variables [43].

Linguistic Terms	Triangular Fuzzy Numbers				
VL: Very Low	(0, 0.1, 0.3)				
L: Low	(0.1, 0.3, 0.5)				
M: Medium	(0.3, 0.5, 0.7)				
H: High	(0.5, 0.7, 0.9)				
VH: Very High	(0.7, 0.9, 1)				

The normalization of alternative values in relation to each criterion comes next. Equation (5) is used for normalization because all criteria are positive. Using Equation (4), the final rank of the strategic planning models would be determined after normalizing the values.

Step 5. Prioritizing strategic planning models

By integrating all the fuzzy values, the final fuzzy rank of strategic planning models are calculated. In line with [41,44], the geometric mean is applied in our study to incorporate the fuzzy values of the strategic planning models.

The geometric average is defined as the product of the n-th root of the products of values, where n is the number of values. A set of values $\{v_1, v_2, ..., v_n\}$ is described by its geometric average, GA, calculated as follows:

$$GA(v_1, v_2, ..., v_n) = \left(\prod_{i=1}^n v_i\right)^{1/n} = \sqrt[n]{v_1.v_2....v_n}$$
(7)

Applying the geometric mean, the final fuzzy value of alternatives is shown in the Figure 2.



Figure 2. Final fuzzy values of alternatives.

Figure 2 allows for identifying the ranges of evaluation for the six considered strategic planning models. It can be interpreted as follows: Considering the upper values of models, the strategic planning models are prioritized as follows, Wright \succ Bryson \succ Bowman and Asch \succ Wheelen \succ Hill and Jones \succ David. Using modal values, the priority of the models is Bryson \approx David \succ Hill and Jones \succ Wright \approx Bowman and Asch \succ Wheelen, while applying lower value provides a different prioritization, David \succ Hill and Jones \succ Bryson \succ Bryson \succ Wheelen \approx Bowman and Asch \succ Wheelen \approx Bowman and Asch \succ Wright.

Step 6. Defuzzification of fuzzy vales

The defuzzification of fuzzy results is necessary to reach a crisp value of alternatives. The final value of alternatives is calculated by using Equation (7) (see Table 11).

Table 11. Final values of alternatives.

	Bryson	Wright	Wheelen	Hill and Jones	Bowman and Asch	David
Value	0.183	0.19	0.178	0.18	0.182	0.18

Considering the values in Table 11, the final rank of strategic planning models is as follows:

Wright \succ Bryson \succ Bowman and Asch \succ David \approx Hill and Jones \succ Wheelen.

4. Discussion and Conclusions

This research was intended to question an appropriate strategic planning model for Iranian manufacturing SMEs using the fuzzy best-worst method. Although many authors and developers of strategic planning models have stated that various models can be used depending on the situation, their application is unclear, and there is no guidance in this field. As a result, many organizations that use this method of planning are faced with strategic problems and have suffered significant losses. As a result, some SMEs in Iran are looking for proper strategic planning to implement in their businesses. This issue encouraged us to do the current research in order to find and propose a suitable strategic planning model for small and medium-sized enterprises. To the best of our knowledge, no research has been carried out to assess different strategic planning models for Iranian manufacturing SMEs by applying multi-criteria decision-making techniques. There are only two studies in Iran that deal with evaluating strategic planning models. A comparative study and evaluation of strategic planning models were performed by Khatami and Mehzadzade [10], and another study categorized strategic planning models by focusing on the type of organization. While the first study presented a comparative qualitative evaluation of strategic planning models and proposed a general model for enterprises, the other study only introduced some of the strategic planning models based on the type of enterprise. None of the previous studies evaluated strategic planning models by applying a multicriteria decision-making technique in Iranian SMEs.

Prioritizing strategic planning models using the fuzzy best-worst method, Wright's strategic planning model based on the judgments of 13 managers in Iranian manufacturing SMEs got the highest score among all the models, which shows that managers in SMEs tend to apply a practical and easy-to-understand model.

The models by Bryson, Bowman and Asch, David, Hill and Jones, and Wheelen were assessed with subsequent priorities. Wright's strategic planning model is not too complex in comparison to the other models in the current research. This model is easy to understand for both managers and employees in SMEs. It can be inferred that managers in Iranian manufacturing SMEs tend to go for a model that is not only practical but also easy to use. Our study also represented that in the assessment of the strategic planning models, the formality criterion was the most important criterion from the SME managers' point of view.

One of the limitations of our study is that the results of the different models are not very different, so somewhat changed data in the information assessed by decision-makers could lead to a different choice. It is therefore recommended to conduct a new evaluation based on individual preferences when a company wants to carefully select a model for their purposes. Another limitation of our study is the focus on SMEs in Iran. Therefore, it is also recommended to perform further studies in other geographic regions to evaluate strategic planning models or to conduct a respective case study for larger companies.

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Appendix A. Basic Operational Rules of Triangular Fuzzy Numbers

Suppose two triangular fuzzy numbers $\tilde{a}_1 = (l_1, m_1, u_1)$, $\tilde{a}_2 = (l_2, m_2, u_2)$ and λ as a positive real number, the basic operational rules of triangular fuzzy number are as follows: [32,39,44,48–50].

$$\widetilde{a}_1 \oplus \widetilde{a}_2 = (l_1 + l_2, m_1 + m_2, u_1 + u_2)$$
 (A1)

$$\widetilde{a}_1 \ominus \widetilde{a}_2 = (l_1 - l_2, m_1 - m_2, u_1 - u_2)$$
 (A2)

$$\widetilde{a}_1 \otimes \widetilde{a}_2 = (l_1 * l_2, m_1 * m_2, u_1 * u_2)$$
 (A3)

$$\lambda \otimes \widetilde{a}_1 = \lambda \widetilde{a}_1 = (\lambda * l_1, \lambda * m_1, \lambda * u_1)$$
(A4)

$$-\tilde{a}_1 = (-l_1, -m_1, -u_1) \tag{A5}$$

$$\widetilde{a}_{1}^{-1} = \frac{1}{\widetilde{a}_{1}} = \left(\frac{1}{u_{1}}, \frac{1}{m_{1}}, \frac{1}{l_{1}}\right)$$
(A6)

 \oplus is the symbol of aggregation or addition;

 \ominus is the symbol of subtraction;

 \otimes is the symbol of multiplication.

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