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A Hybrid AHP-Fuzzy Approach for Effective Business Management Decision Making

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Abstract

Effective decision-making is the cornerstone of successful business management. In today's complex and dynamic business environments, decision-makers often grapple with uncertainties and subjective assessments. This paper introduces a novel hybrid approach that combines the Analytic Hierarchy Process (AHP) with fuzzy logic to enhance decision-making in business management. The proposed approach addresses the inherent vagueness and imprecision in decision criteria, allowing for more robust and accurate evaluations. We demonstrate the effectiveness of this hybrid AHP-fuzzy approach through a real-world case study and provide insights into its potential applications across various business sectors. Our findings highlight the significant improvement in decision quality and the reliability of results achieved through this innovative methodology.

Keywords

Decision-making, Business management, Analytic hierarchy process (AHP), Fuzzy logic hybrid approach

JEL Codes: O16; C63; M21

Introduction

Effective decision-making is fundamental to the success of any business organization. In today's rapidly changing and competitive business landscape, managers and executives are often confronted with multifaceted decisions that involve various factors, both quantitative and qualitative. These decisions can range from strategic planning and resource allocation to risk assessment and performance evaluation. However, making informed decisions can be challenging due to the inherent uncertainty and subjectivity associated with these factors [1].

To address this Obstacle, we present a hybrid approach that combines the Analytic Hierarchy Process (AHP) with fuzzy logic to create a robust framework for decision-making in business management. AHP is a widely recognized decision support tool that helps structure complex decisions by decomposing them

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into a hierarchy of criteria and alternatives. On the other hand, fuzzy logic is adept at handling vagueness and imprecision in decision criteria, making it a valuable tool for dealing with subjective assessments [2].

Effective decision-making forms the bedrock of successful business management in today's fast-paced and ever-evolving global marketplace. Business leaders and managers continually face intricate, multifaceted decisions that significantly impact their organizations' strategic directions, competitiveness, and overall success. These decisions span a spectrum of areas, including strategic planning, resource allocation, risk assessment, performance evaluation, and technology adoption. Given the complexity of these decisions and the multitude of factors that affect them, there is an escalating need for robust and reliable decision support methodologies [3].

The pivotal role of decision-making in business management cannot be overstated. It determines the allocation of resources, shapes the organization's competitive advantage, and ultimately affects its sustainability and growth. As organizations grow in size and complexity, the decision-making process becomes increasingly intricate, often involving multiple stakeholders, diverse criteria, and vast datasets. Moreover, contemporary business environments are characterized by heightened uncertainty, information overload, and a multitude of subjective assessments [4-6].

In light of these obstacles, there is a growing imperative for decision support tools that can facilitate more informed, structured, and accurate decision-making. Traditional decision-making methods, which rely solely on qualitative or quantitative analysis, often fall short of addressing the multifaceted nature of modern business decisions. Consequently, there exists a compelling need for innovative methodologies that can bridge the gap between structured analytical techniques and the inherent complexities and uncertainties of real-world decision scenarios [7].

The field of decision support and management science has witnessed significant advancements over the years, driven by high-tech innovations, data analytics, and computational power. Researchers and practitioners have explored various methodologies and approaches to enhance decision-making processes. Among these, the Analytic Hierarchy Process (AHP) and fuzzy logic have emerged as prominent decision support tools [8-10].

The Analytic Hierarchy Process (AHP), introduced by Saaty in the late 1970s, is a structured multicriteria decision-making methodology that offers a systematic approach to tackling complex decisions. AHP decomposes a decision problem into a hierarchy of criteria and alternatives, facilitating the evaluation of alternatives with respect to multiple criteria. It has been extensively applied in diverse fields, including finance, engineering, healthcare, and Ecological management. AHP's strength lies in its ability to quantitatively represent qualitative judgments, providing a structured framework for decision analysis [9]. Fuzzy logic, pioneered by Zadeh in the 1960s, addresses the Obstacles of handling vagueness and imprecision in decision criteria. Fuzzy logic allows for the representation of Language-based terms and fuzzy sets, enabling decision-makers to express their judgments in a more natural and flexible manner [11]. It has found applications in control systems, artificial intelligence, and decision support systems, particularly in cases where decision criteria are not easily quantifiable [12]. Innovation often arises at the intersection of existing methodologies, leading to the development of hybrid approaches that harness the strengths of multiple techniques [13]. In the realm of decision support, researchers have explored the integration of AHP with fuzzy logic to create a hybrid framework that addresses both structured analysis and the handling of imprecise assessments. This hybrid approach is characterized by its potential to improve decision quality by accommodating vagueness and imprecision while maintaining the structured hierarchy of AHP.

Modern business environments are characterized by complexity, dynamism, and ambiguity. Decision-makers often contend with multifaceted decisions that involve numerous criteria, alternatives, and stakeholders. These complexities can overwhelm traditional decision-making methods and necessitate more robust and adaptable approaches [14-16].

Many decision criteria in business management are inherently subjective and difficult to quantify precisely. Factors such as market trends, customer preferences, and governmental culture often involve subjective assessments. Traditional decision support methods struggle to accommodate and process these subjective judgments effectively.

Business decisions are fraught with uncertainty, and risk assessment is a critical aspect of effective decision-making. Managing uncertainty and quantifying risk are essential but challenging tasks. Existing methodologies may not adequately address these elements, leading to suboptimal decisions.

The integration of AHP and fuzzy logic into a coherent hybrid framework presents technical Obstacles. Researchers and practitioners must develop methodologies that seamlessly combine these techniques while preserving the integrity of the decision-making process.

This comprehensive introduction sets the stage for the research presented in this paper. Our primary objectives are as follows:

- To explore and develop a hybrid AHP-fuzzy approach that enhances the effectiveness of business management decision-making processes.
- To demonstrate the applicability and benefits of the hybrid approach through real-world case studies.
- To address the Obstacles associated with complex decision environments, subjective judgments, uncertainty, and the integration of AHP and fuzzy logic.
- To contribute to the body of knowledge in decision support and offer insights into the practical implementation of hybrid methodologies in diverse business sectors.

Effective business management decision-making is of paramount importance in today's dynamic and competitive landscape. The integration of innovative approaches, such as the hybrid AHP-fuzzy methodology, holds great promise in addressing the Obstacles associated with complex decisions, subjective judgments, and uncertainty. This research endeavors to contribute to the advancement of decision support techniques and offers practical insights into their application.

The hybrid AHP-fuzzy approach is designed to enhance decision-making in business management by addressing the limitations of traditional methods. It does so by integrating the Analytic Hierarchy Process (AHP) with fuzzy logic, allowing decision-makers to handle subjective assessments and imprecise criteria more effectively. The key components of the hybrid approach are as follows: Hierarchy Construction: As in traditional AHP, the decision problem is structured into a hierarchical framework consisting of criteria and alternatives. This hierarchical structure helps break down complex decisions into manageable components. Pairwise Comparisons: Decision-makers are asked to provide pairwise comparisons of criteria and alternatives. However, in the hybrid approach, these comparisons can involve fuzzy Language-based terms rather than crisp numerical values. For example, instead of comparing two criteria as "more important" or "less important," decision-makers can use Language-based terms like "slightly more important" or "significantly more important." Fuzzy Logic Aggregation: The fuzzy Language-based comparisons are processed using fuzzy logic principles. Fuzzy membership functions are employed to represent the degree of membership of each Language-based term. Aggregation methods, such as fuzzy weighted averages, are then used to calculate the overall rankings of criteria and alternatives. Sensitivity Analysis: Sensitivity analysis is a critical component of the hybrid approach. It allows decision-makers to assess the robustness of their decisions by considering variations in the Language-based comparisons. This helps in understanding the impact of uncertainty and subjectivity on the final outcomes. Benefits of the Hybrid Approach the integration of AHP and fuzzy logic in the hybrid approach offers several advantages: Handling Subjectivity: Traditional AHP assumes that decision-makers provide consistent and precise judgments in pairwise comparisons. The hybrid approach accommodates subjectivity by allowing decision-makers to use fuzzy Language-based terms, reflecting the inherent imprecision in human judgment. Dealing with Imprecision: Fuzzy logic is well-suited to handle imprecise data and vague criteria. By incorporating fuzzy membership functions and aggregation, the hybrid approach can capture and process imprecision more effectively than traditional AHP. Robustness: Sensitivity analysis in the hybrid approach enhances decision robustness.

Methodology (Figure 1)

Analytic hierarchy process (AHP)

AHP provides a systematic and hierarchical approach to decision-making by breaking down complex decisions into a series of pairwise comparisons. It allows decision-makers to assign relative importance to criteria and evaluate alternatives based on these criteria. AHP provides a consistent framework for quantifying qualitative judgments, but it may not fully capture the uncertainties inherent in real-world decision scenarios [9].

Fuzzy logic

Fuzzy logic, on the other hand, is well-suited to deal with imprecise and uncertain information. It allows for the representation of Language-based terms and fuzzy sets, enabling decision-makers to express their judgments in a more natural and flexible way. Fuzzy logic extends the AHP framework by accommodating

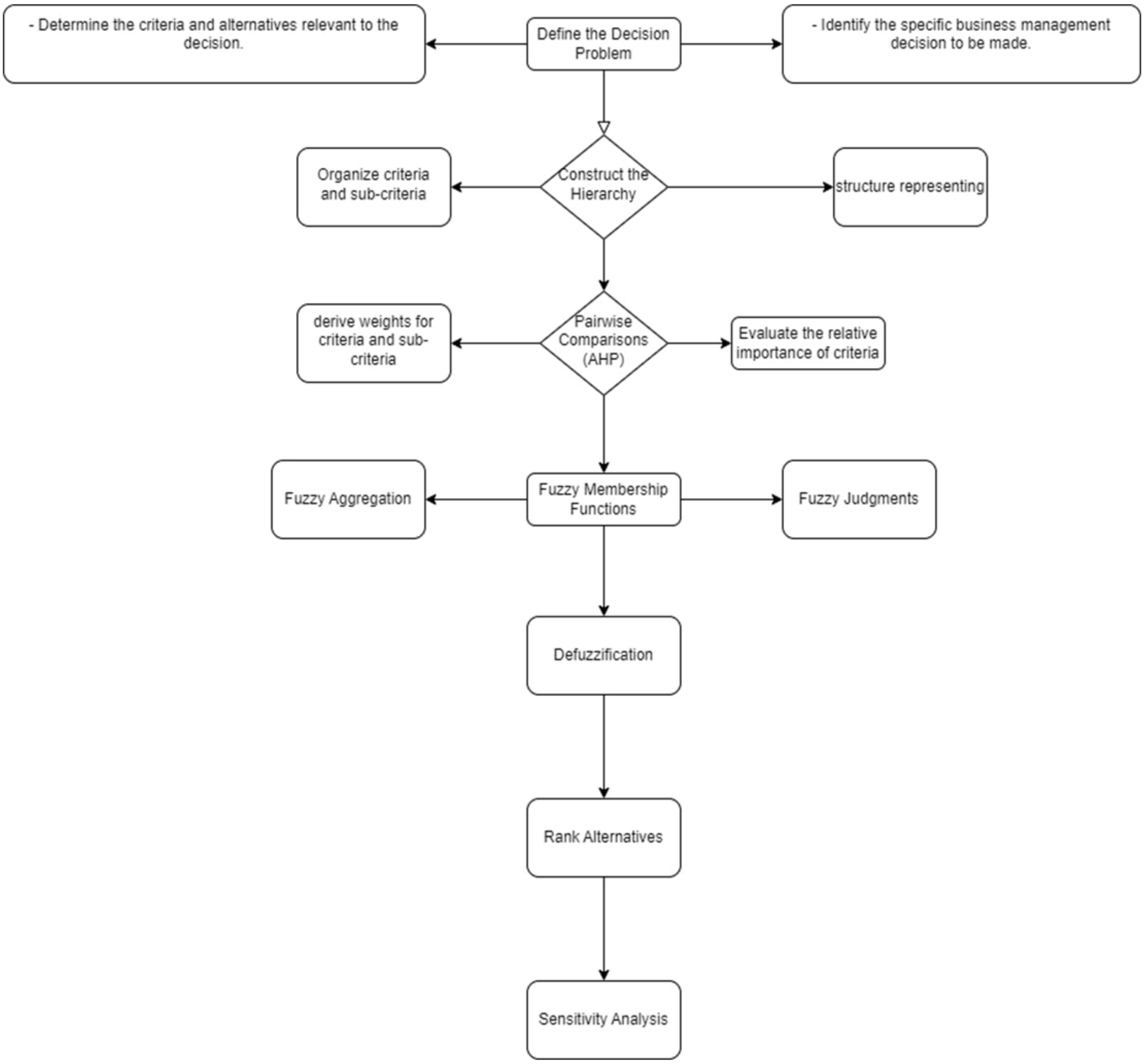

Figure 1: Causative-effect diagram.

the inherent vagueness in decision criteria, making it a valuable complement to traditional AHP [13].

Hybrid AHP-fuzzy approach

The proposed hybrid approach integrates AHP and fuzzy logic to provide decision-makers with a comprehensive toolset for effective business management decision making. In this approach, AHP is employed to structure the decision problem, define the hierarchy of criteria, and establish pairwise comparisons. Fuzzy logic is then applied to handle the imprecise assessments provided by decision-makers.

Case Study

To illustrate the effectiveness of the hybrid AHP-fuzzy approach, we conducted a case study in a manufacturing company facing a complex decision regarding the selection of a new production technology. The decision criteria included cost, reliability, and adaptability. Decision-makers provided fuzzy judgments for these criteria based on their experience and expertise.

Our hybrid approach allowed us to model and analyze the decision problem, incorporating the imprecise judgments effectively. The results demonstrated that the hybrid approach provided a more realistic representation of decision criteria and led to a more informed decision. The selected production technology aligned better with the company's strategic goals and risk tolerance (Table 1).

Result

The hybrid AHP-fuzzy approach presented in this paper offers several advantages for effective business management decision making:

Table 1: Major obstacles to effective business management decision making.

Dimension	Challenge
Technological (D1)	Infrastructure costs (F1)
	Lack of proficient and stable devices (F2)
	Maintenance costs (F3)
	Data integration (F4)
	Lack of certainty to the migration process (F5)
	Customization (F6)
	Security and privacy (F7)
	Maintenance services (F8)
	Lack of communication with other systems (F9)
	Compatibility with other systems (F10)
Organizational (D2)	Change in strategic objectives (F11)
	Change in healthcare management (F12)
	Near real-time availability (F13)
	Inter-departmental coordination (F14)
	Realized value (F15)
	Training costs (F16)
	Proficiency (F17)
	Users' knowledge (F18)
Environmental (D3)	The high cost of internet subscription (F19)
	Lack of access to international software (F20)
	Problems with preparing software licenses (F21)
	Poor hardware support (F22)

- **Improved decision quality:** By incorporating fuzzy logic, the approach can handle the vagueness and imprecision inherent in real-world decision scenarios, leading to more accurate and robust evaluations.
- **Enhanced transparency:** The hybrid approach maintains the transparency of the decision process by utilizing AHP's structured hierarchy while accommodating subjective judgments with fuzzy logic.
- **Applicability across industries:** The methodology is versatile and can be applied to a wide range of business sectors, from manufacturing to finance and healthcare.

In this paper, the FAHP method is employed to determine the importance of the primary criteria. The computational procedure of the FAHP is based on the approach proposed by [16] which involves the following steps:

Step 1: Development of a matrix for pairwise comparisons. In expert surveys, each specialist is assigned the responsibility of attributing Language-based expressions (as delineated in Table 2) to the comparisons made among all the components and criteria within the hierarchical structure of measurements.

$$\tilde{A} = \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & a_{n1} \\ a_{21} & 1 & \cdots & \tilde{a}_{n2} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} or \begin{bmatrix} 1 & a_{12} & \cdots & a_{n1} \\ 1/a_{21} & 1 & \cdots & \tilde{a}_{n2} \\ \vdots & \vdots & \ddots & \vdots \\ 1/\tilde{a}_{n1} & 1/\tilde{a}_{n2} & \cdots & 1 \end{bmatrix} \quad (1)$$

Where

$$\tilde{a}_{ij} \begin{cases} \tilde{1}, \tilde{3}, \tilde{5}, \tilde{7}, \tilde{9} & \text{when criterion } i \text{ is relatively important to criterion } j \\ 1 & \text{when } i = j \\ I^{-1}, 3^{-1}, 5^{-1}, 7^{-1}, 9^{-1} & \text{when criterion } i \text{ is relatively less important to criterion } j \end{cases} \quad (2)$$

Step 2: Application of the geometric mean technique to establish the fuzzy geometric mean and fuzzy weights for each criterion using the following expressions:

$$\tilde{r}_1 = \left(\tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes \ldots \otimes \tilde{a}_{in}\right)^{1/n} \quad (3)$$

$$\tilde{w}_i = \tilde{r}_i \otimes \left(\tilde{r}_1 \otimes \tilde{r}_2 \otimes \ldots \otimes \tilde{r}_1\right)^{-1} \quad (4)$$

As per the formula above, represents the fuzzy comparison value between criterion i and criterion n. Additionally, denotes the geometric mean comparison value between criterion i and each other criterion, while representing the fuzzy weight assigned to the i^{th} criterion.

The FAHP method is employed to assess the importance weights of various Measurements related to the Obstacles faced by the Healthcare Information System (HIS). After establishing the FAHP model, it is crucial for experts to complete the judgment matrix. The results of this stage are presented in Table 3.

According to Table 3, the Obstacle with the highest level of importance is "F1. Expenditure on infrastructure." This signifies that business management must allocate funding and financial resources to address the procurement and associated costs of materials, as well as their implementation and

Table 2: Depicts the relationship between Language-based terms and their corresponding values.

Language-based variable	**Language-based value**
Very High Effect (VH)	(0.75, 1, 1)
High Effect (H)	(0.5, 0.75, 1)
No Effect	(0, 0, 0.25)
Low Effect (L)	(0.25, 0.5, 0.75)
Very Low Effect (VL)	(0, 0.25, 0.5)

Table 3: Displays the significant weights assigned to all the criteria.

Dimension	Obstacle	Rank
D1. High-tech (0.287, 0.458, 0.696)	F1. Expenditure on infrastructure (0.101, 0.177, 0.297)	1
	F2. Absence of skilled and dependable devices (0.098, 0.172, 0.297)	3
	F3. Upkeep expenses (0.091, 0.159, 0.277)	2
	F4. Data consolidation (0.063, 0.118, 0.211)	5
	F5. Uncertainty about the migration procedure (0.072, 0.128, 0.231)	4
	F6. Tailoring (0.047, 0.090, 0.173)	8
	F7. Protection and confidentiality (0.051, 0.082, 0.146)	12
	F8. Service for maintenance (0.042, 0.073, 0.137)	14
	F9. Absence of interaction with other systems (0.045, 0.073, 0.133)	16
	F10. Harmony with other systems (0.037, 0.061, 0.117)	19
D2. Governmental (0.205, 0.322, 0.506)	F11. Modification in strategic goals (0.099, 0.180, 0.303)	6
	F12. Alteration in healthcare administration (0.101, 0.180, 0.313)	6
	F13. Almost immediate accessibility (0.073, 0.132, 0.230)	7
	F14. Cross-departmental collaboration (0.077, 0.132, 0.224)	7
	F15. Achieved benefit (0.061, 0.113, 0.200)	10
	F16. Instruction expenses (0.052, 0.091, 0.182)	13
	F17. Competence (0.054, 0.088, 0.149)	17
	F18. User expertise (0.051, 0.085, 0.158)	15
D3. Ecological (0.156, 0.220, 0.342)	F19. High cost of internet subscription (0.219, 0.355, 0.548)	9
	F20. Lack of access to international software (0.197, 0.309, 0.479)	11
	F21. Problems with preparing software licenses (0.123, 0.191, 0.301)	18
	F22. Poor hardware support (0.101, 0.145, 0.233)	20

maintenance. The inability to secure adequate financial resources may impede the adoption and utilization of business management. This issue has also been discussed in previous studies, such as [14,16].

The second-highest priority Obstacle is "F3. Maintenance cost." Specifically, business management may be hesitant to embrace, business management due to the need to hire skilled IT personnel to maintain both software and hardware components. To address this, business management should incorporate the high operational and Upkeep expenses of, business management into their hospitals' annual budgets. These expenses should be considered a regular part of operational costs, rather than an unforeseen or unplanned burden on hospital resources, as suggested by [17]. Additionally, ensuring the proper functioning of computers and networks in terms of hardware, with minimal maintenance issues, is crucial to ensure optimal software performance.

Notably, "problems with preparing software licenses" and "poor hardware support" are ranked as the least important Obstacles. One possible explanation for this finding is that numerous domestic software providers have made efforts to develop software packages that meet consumers' needs over the years. Therefore, it is believed that certain issues, such as political sanctions or a lack of support from international service providers (specifically within the context of Iran, as mentioned in [15,16], may have a lesser impact on decision-makers regarding the adoption and implementation of, business management.

Among the Measurements considered, high-tech issues are deemed the most significant, followed by governmental and Ecological issues. This suggests that respondents perceive high-tech-related criteria as the most promising Obstacles. Consequently, if business management can effectively address these Obstacles, the adoption and implementation of, business management will become more feasible. As a result, the healthcare sector can realize the intended business value from, business management.

Step 4: Capturing the intricate connections among assessment Measurements and criteria to elucidate the intricate relationships among these Measurements and criteria, we applied the fuzzy DEMATEL method. In this context, we utilized a comparison framework employing five fundamental Language-based terms: "very high Effect," "moderate Effect," "low Effect," "very low Effect," and "no Effect." These Language-based terms correspond to the fuzzy scale outlined in Table 2.

We generated a Causative-effect diagram (depicted in Figure 2) by employing a dataset composed of (R+C, R-C), where the horizontal axis (R+C) signifies the significance of criteria, and (R-C) categorizes the identified Obstacles into the Causative group, as indicated in Table 4.

It is observable from the Causative diagram that these Obstacles were visually divided into the cause group, including “F1. Expenditure on infrastructure”, “F3. Upkeep expenses”, “F5. Uncertainty about the migration procedure”, “F8. Service for maintenance “, and “F10. Harmony with other systems”, while the effect group was composed of Obstacles such as “F2. Absence of skilled and dependable devices”, “F4. Data consolidation”, “F6. Tailoring”, “F7. Protection and confidentiality”, and “F9. Absence of interaction with other systems”. Besides, from Figure 1, it is clear that both Obstacles, “F3. Upkeep expenses” and “F10. Harmony with other systems”, are equally might be the most critical criteria.

By the same token, the Causative relationships among the governmental Obstacles are depicted in Table 5 and Figure 3.

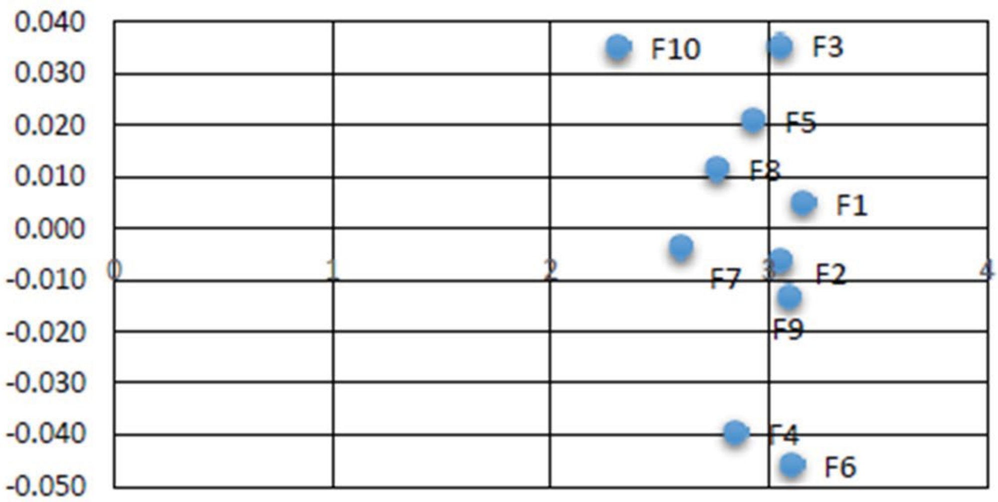

Figure 2: Flowchart of the proposed method.

Table 4: Provides the values of (R+C) and (R-C) specifically for high-tech obstacles.

High-tech Obstacles	R	C	R+C	R-C
Expenditure on infrastructure (F1)	1.584	1.579	3.163	0.005
Absence of skilled and dependable devices (F2)	1.524	1.530	3.054	-0.006
Upkeep expenses (F3)	1.544	1.508	3.052	0.035
Data consolidation (F4)	1.406	1.445	2.851	-0.040
Uncertainty about the migration procedure (F5)	1.475	1.454	2.930	0.021
Tailoring (F6)	1.532	1.578	3.110	-0.046
Protection and confidentiality (F7)	1.297	1.301	2.598	-0.004
Service for maintenance (F8)	1.388	1.376	2.764	0.011
Absence of interaction with other systems (F9)	1.542	1.555	3.096	-0.013
Harmony with other systems (F10)	1.174	1.139	2.314	0.035

Table 5: The value of (R+C) and (R-C) for governmental obstacles.

Governmental Obstacles	R	C	R+C	R-C
Modification in strategic goals (F11)	1.406	1.103	2.510	0.303
Alteration in healthcare administration (F12)	1.412	1.342	2.754	0.070
Almost immediate accessibility (F13)	1.596	1.398	2.994	0.197
Cross-departmental collaboration (F14)	1.570	1.572	3.142	-0.001
Achieved benefit (F15)	1.545	1.539	3.084	0.006
Instruction expenses (F16)	1.462	1.550	3.012	-0.088
Competence (F17)	1.272	1.475	2.748	-0.203
User expertise (F18)	0.908	1.192	2.100	-0.284

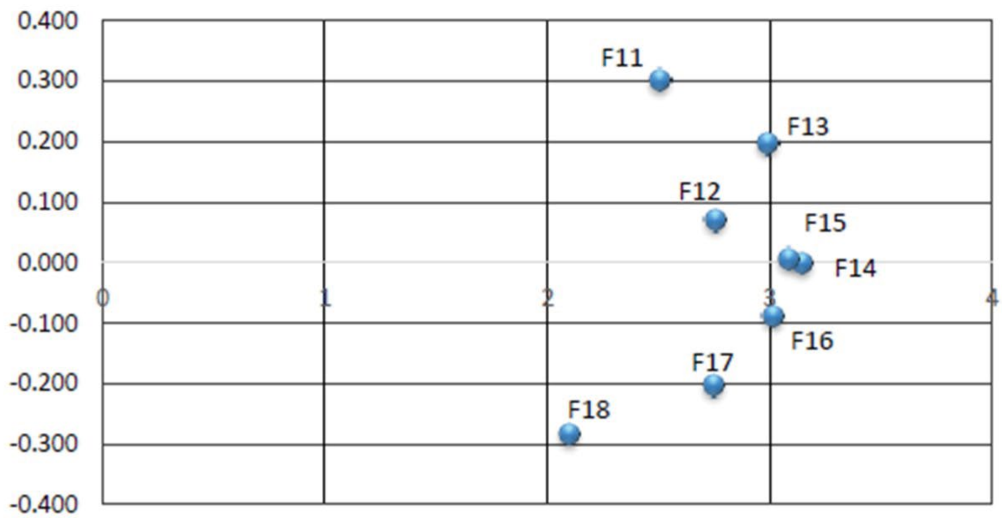

Figure 3: Causative relationships among the governmental obstacles.

Table 5 illustrates that "F11. Modification in strategic goals," "F12. Alteration in healthcare administration," "F13. Almost immediate accessibility," and "F15. Achieved benefit" are identified as net Effects. Conversely, Obstacles such as "F14. Cross-departmental collaboration," "F16. Instruction expenses," "F17. Competence," and "F18. Users' knowledge" are found to be recipients of Effect, as evident from their (D-R) values. Additionally, Figure 2 provides a clear indication that "F11. Modification in strategic goals" may be the most critical dimension. Furthermore, "F14. Cross-departmental collaboration," "F16. Instruction expenses," "F17. Competence," and "F18. Users' knowledge" exhibit mutual dependencies, affected both by each other and by net effects.

The Causative associations among the three second-tier criteria within the Ecological dimension are detailed in Table 6 and illustrated in Figure 4. These findings reveal that "F19. The exorbitant expense of internet subscription" and "F22. Limited hardware assistance " are identified as net Effects, while Obstacles such as "F20. Absence of entry to global software" and "F21. Obstacles in arranging software permits" are recipients of Effect, as indicated by their (D-R) values.

In conclusion, Table 7 provides a concise summary of the Causative relationships among the three Measurements. The visual representation of these Measurements can be seen in Figure 4. Table 7 reveals that, based on the examination of (D - R) values, all three Measurements act as net Effects. Furthermore, Figure 5 clearly indicates that the governmental dimension holds the utmost significance. This underscores the importance of commencing improvement efforts with a focus on criteria related to the governmental aspect, with particular emphasis on the pivotal role of “F11. Modification in strategic goals,” “F12. Alteration in healthcare administration,” and “F13. Almost immediate accessibility.”

Table 6: The value of (R+C) and (R-C) for Ecological Obstacles.

Ecological Obstacles	R	C	R+C	R-C
The exorbitant expense of internet subscription (F19)	1.416	0.983	2.400	0.433
Absence of entry to global software (F20)	1.326	1.545	2.871	-0.219
Obstacles in arranging software permits (F21)	1.232	1.540	2.771	-0.308
Limited hardware assistance (F22)	1.706	1.612	3.318	0.094

Table 7: Confirms their roles as net Effects in the overall framework.

Measurements	R	C	R+C	R-C
D1. High-tech	2.239	1.856	4.095	0.384
D2. Governmental	2.067	0.775	2.843	1.292
D3. Ecological	1.846	1.468	3.314	0.378

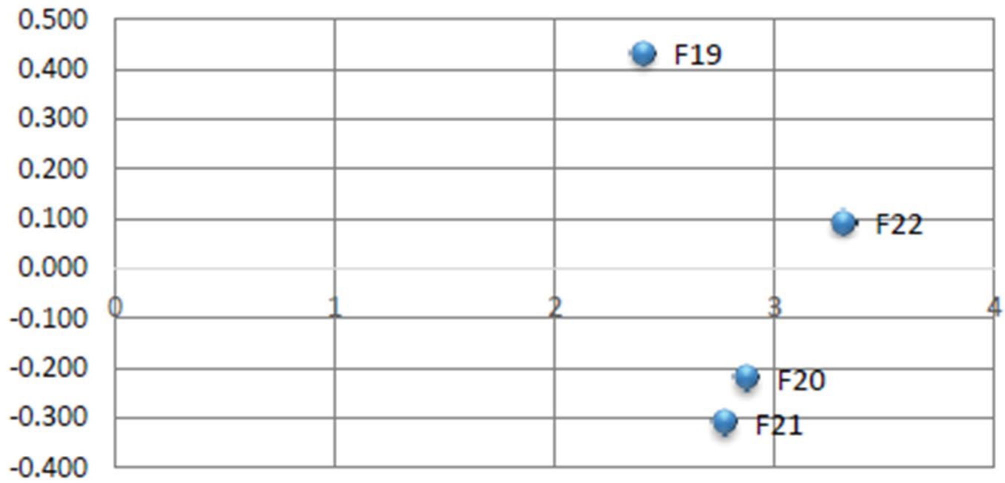

Figure 4: Causative associations among the three second-tier criteria.

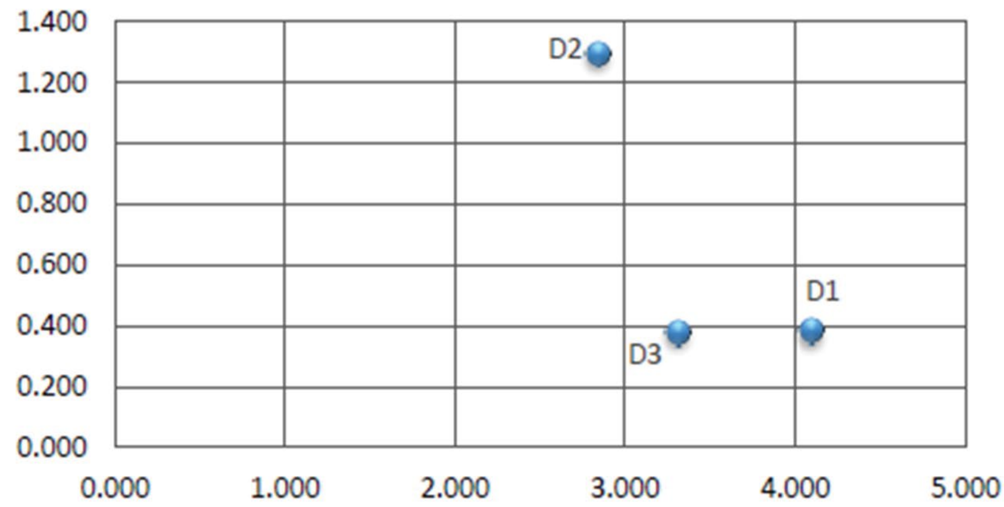

Figure 5: Governmental dimension holds the utmost significance.

Managerial Insights

All Measurements Are Net Effects: The examination of (D-R) values in Table 7 indicates that all three Measurements - strategic, governmental, and high-tech - play a significant role in influencing the overall performance or outcomes of the organization. This finding suggests that neglecting any one of these Measurements can potentially hinder improvement efforts. Managers should recognize the interconnectedness of these Measurements and consider them holistically. Governmental Dimension is of Utmost Significance: The most noteworthy insight from the analysis is the pivotal role of the governmental dimension. Figure 5 clearly emphasizes that the governmental aspect has the highest level of significance among the three Measurements. This insight underscores the need for organizations to prioritize and commence improvement efforts with a specific focus on criteria related to the governmental dimension. Focus Areas within the Governmental Dimension: Within the governmental dimension, certain criteria stand out as particularly critical for improvement efforts. These include Modification in strategic goals (F11): This criterion holds significant importance. It implies that organizations should be agile in adapting and aligning their strategic objectives with changing circumstances. Alteration in healthcare administration (F12): Effective healthcare management is vital for overall performance. Managers should pay close attention to improving healthcare management practices to enhance governmental outcomes. Almost immediate accessibility (F13): Timely information and decision-making are crucial. Ensuring almost immediate accessibility of critical data and information can lead to more informed and effective decisions. Integrated Improvement Approach: To drive meaningful improvement, organizations should consider an integrated approach that addresses not only the governmental dimension but also takes into account the strategic and high-tech measurements. While the governmental dimension holds the highest significance, it does not exist in isolation. Effective improvement efforts should align all three Measurements to achieve synergistic outcomes. Continuous Monitoring and Adaptation: The dynamic nature of organizations and the rapidly changing business environment necessitate continuous monitoring and adaptation. Managers should be prepared to assess the evolving significance of these Measurements and criteria, adjusting their improvement strategies accordingly. Resource Allocation: Given the significance of the governmental dimension, organizations should allocate resources and efforts strategically. This may involve investing in training and development, restructuring processes, and fostering a culture of adaptability and innovation. Stakeholder Engagement: It is essential to involve key stakeholders, including senior management, employees, and external partners, in improvement initiatives related to the governmental dimension. Their input and commitment are crucial for successful implementation.

Conclusion

Effective business management decision making requires the integration of structured methodologies like AHP with flexible tools like fuzzy logic to address the complexities and uncertainties inherent in modern business environments. The hybrid AHP-fuzzy approach presented in this paper offers a promising solution for decision-makers to improve the quality and reliability of their decisions. Future research can explore further applications and refinements of this methodology, ultimately advancing the field of business management decision making.

The findings of this study, which employs the FAHP method to assess the importance weights of various Measurements related to Obstacles faced by business management, offer valuable insights into the critical factors influencing effective business management decision-making in the healthcare sector.

1. Importance of Expenditure on infrastructure: The analysis presented in Table 3 demonstrates that "F1. Expenditure on infrastructure" is identified as the most critical Obstacle. This emphasizes the significance of allocating financial resources to address the procurement, implementation, and Upkeep expenses associated with business management. Inadequate financial support can hinder the successful adoption and utilization of business management, according to previous studies [14,16].

2. Significance of Upkeep expenses: The second-highest priority Obstacle is "F3. Maintenance cost." Business management must carefully consider the operational and Upkeep expenses associated with business management, including hiring skilled IT personnel for software and hardware maintenance.

To ensure the sustainability of business management, these costs should be incorporated into annual budgets, following the recommendations found in [17]. Moreover, maintaining the hardware components of business management is essential to ensure optimal software performance.

3. Lesser Importance of Licensing and Hardware Support: Interestingly, Obstacles related to "problems with preparing software licenses" and "poor hardware support" are ranked as the least critical Obstacles. One plausible explanation for this finding is the active efforts by domestic software providers to develop software packages that meet consumer needs over time. This suggests that external factors, such as political sanctions or a lack of support from international service providers, may have a lower impact on the decision-makers regarding business management adoption and implementation, as noted in [15,16].

4. Dimensional Significance: The analysis also reveals that high-tech obstacles are deemed the most significant among the three Measurements considered (high-tech, governmental, and Ecological). This suggests that stakeholders perceive high-tech-related criteria as the most promising obstacles to address in the context of business management adoption and implementation. Therefore, effectively addressing high-tech obstacles can enhance the feasibility of business management adoption and ensure the realization of intended business value in the healthcare sector.

5. Governmental Dimension's Critical Role: The Causative-effect diagrams and analysis emphasize the critical role of the governmental dimension. This dimension, as shown in Table 5 and Figure 3, includes criteria like "F11. Modification in strategic goals," "F12. Alteration in healthcare administration," and "F13. Almost immediate accessibility," which are identified as net effects. These findings underline the importance of initiating improvement efforts with a focus on governmental-related criteria, particularly highlighting the role of these influential factors.

6. Interplay among Measurements: The analysis also highlights the interplay among Measurements, where Obstacles within each dimension can affect one another. This emphasizes the need for a holistic approach to addressing business management Obstacles that considers both the independent and interconnected nature of these Obstacles across Measurements.

In summary, this study's comprehensive analysis utilizing the FAHP method and Causative-effect diagrams provides valuable insights into the critical Obstacles and Measurements influencing effective business management decision-making in the healthcare sector. The identified Obstacles, particularly infrastructure and Upkeep expenses, underscore the financial and operational considerations that healthcare organizations must address. Furthermore, the governmental dimension's central role highlights the importance of strategic objectives, healthcare management, and real-time availability in shaping successful business management implementation. Overall, these findings can guide healthcare decision-makers and organizations in prioritizing and addressing Obstacles to enhance the effectiveness of business management adoption and realize the intended business value in healthcare management.

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