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Supplier Evaluation at Small-Medium Enterprise Using Simple Additive Weighting

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Abstract

This study focuses on the importance of information systems in today's intensely competitive business landscape. Companies of all sizes rely on information systems to stay afloat, streamline operations, and make informed decisions based on accurate data. To remain competitive, a medium-sized company specializing in vending motorcycle accessories and spare parts faced various challenges, including determining the best supplier for each item. To address this issue, a decision support system was developed using the Simple Additive Weighting technique. This method calculates the weighted sum of performance evaluations for each option based on all qualities. The system underwent user acceptance testing and achieved a flawless success rate of 100%. Overall, this study highlights the crucial role of decision support systems in enabling businesses to make strategic decisions based on accurate and reliable data.

Keywords: Decision Support System, Simple Additive Weighting, Small Medium Enterprise.

1. INTRODUCTION

Information technology is rapidly developing and revolutionizing the industrial paradigm by combining computer and telecommunications technology. These changes are reducing the time and distance gap between consumer demand and their needs, ultimately impacting the behavior of the business environment [1]. Consequently, these changes influence management decision-making processes, leading to the formation of quickly adaptable organizational structures through the integration of information technology [2].

Information technology involves a set of computers for managing data, a network system that connects computers as required, and communication technology that facilitates data distribution and global accessibility [3]. This development has encouraged many companies to adopt the latest information technology to enhance their business operations. Previous research shows that 38% of organizations found technological advancements to have a significant positive

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impact on their business decisions in the years ahead. Nevertheless, there are also negative impacts such as increased competition, economic value, and political interference [4]. The information system plays a vital role in planning activities and empowering resources within a company. With the assistance of these systems, businesses can effectively process existing data and information [5].

Information systems have been implemented not only in large companies but also in small companies. The use of information systems has become crucial for companies of all sizes to remain competitive and not fall behind their rivals. The implementation of information systems can affect all users within a company, from low-level employees to top management, who use the operating system on a daily basis [6]. These systems are used by small and large businesses alike to maintain their competitiveness in the ever-evolving technological landscape. Micro, Small, and Medium Enterprises (SMEs) play a significant role in the Indonesian economy, with the number of SMEs reaching 65.47 million units in 2019, an increase of 1.98% compared to the previous year's 64.19 million units [7]. This number accounts for 99.99% of the total businesses in Indonesia, with only 0.01% being large-scale businesses. The majority of these businesses are micro businesses, with 64.6 million units or 98.67% of the total SMEs throughout Indonesia. The Minister of Cooperatives and SMEs, Teten Masduki, aims to collect 14.5 million data on cooperatives and SMEs in 2022 and 65 million data on cooperatives and SMEs in 2024 [8].

A medium-sized enterprise, operating as a sales agent for various categories of motorcycle parts and accessories, provides an excellent illustration of MSMEs. Like many other MSMEs, the enterprise faces common issues due to the lack of implementation of information systems. These issues include human errors, input errors, and human fraud that can lead to inaccurate data and data redundancy. As the enterprise continues to grow, it becomes crucial to have an information system capable of accurately recording all information [9]. Additionally, the enterprise aims to make well-informed decisions on supplier selection by identifying the best supplier category for each type of goods. Hence, a supplier analysis decision support system has been developed, utilizing the SAW (Simple Additive Weighting) approach. The SAW algorithm facilitates the calculation of a weighted average of performance ratings for each option across all criteria [10]. By using this approach, the system can execute supplier analysis accurately and efficiently.

2. RESEARCH METHODS

2.1 Research Object

The focus of this research is Aneka Motor, an SME operating as a medium-sized company in the motorcycle parts and accessories agency segment. The owner,

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Yosef Wijaya, established the shop in 1999 as a humble store selling various motorbike accessories from select companies. Over time, the store expanded to offer new brands and a more comprehensive range of accessories. Initially, the store focused on motorcycle servicing and maintenance, with no wholesale options and few products, generating a monthly revenue of 30-50 million. However, in 2003, Aneka Motor started to transform into a wholesale store offering accessories and spare components, leading to a surge in monthly sales of $300-$500 million. Between 2005 and 2018, the company experienced significant growth with a turnover of 1-3 billion. However, in 2019, there was a sharp decline of approximately 50% in turnover. Since early 2021, there has been a spike in turnover, increasing by around 30%.

2.2 Research Flow

For the design of the future system, this study will utilize the Rapid Application Development (RAD) methodology. This approach was chosen because of its simplicity and ability to produce quick results without incurring high costs, making it a perfect fit for the research subject's small scale. RAD is an effective incremental development technique that prioritizes rapid and efficient development cycles [11]. Therefore, it is an ideal methodology for businesses seeking to develop systems or applications within a short time frame while maintaining high levels of quality and functionality. By utilizing the power of RAD, this study aims to deliver an exceptional system that will exceed user expectations.

As shown in Figure 1, the RAD methodology comprises several distinct phases, including Requirement Planning, User Design, Construction, and Cutover. The Requirement Planning phase involves close consultation with stakeholders to identify the software application's user requirements. The User Design phase focuses on creating a cycle of prototypes, tests, and refinement using Unified Modeling Language (UML) and the Simple Additive Weighting (SAW) method. This stage is critical to ensure that the system design aligns with user needs and preferences. The Construction phase involves the development of the HTML user interface using the PHP programming language, while the MySQL database is run using XAMPP. This phase is vital for constructing the functional elements of the system and ensuring their integration. Finally, the Cutover phase aims to verify that the program works consistently and complies with the stakeholders' objectives and specifications. The Black Box Testing method will be used to conduct testing, resulting in User Acceptance Testing (UAT) that will validate the system's functionality and usability.

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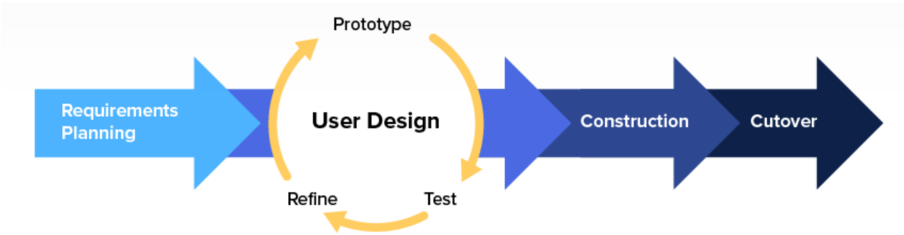

Figure 1. RAD Phases [12]

The following methods are applied for Requirement Planning:

1. Interviews: One of the data collection techniques utilized is interviews or question and answer sessions. The Owner of Aneka Motor SME was interviewed to gather information and data on common problems related to stock and sales. The results of the interviews will be used to conduct a needs analysis of the system to be developed. The interview questions were based on several journals related to the goods stock system and are attached in the appendix.
2. Observation: The observation method was employed to collect data by directly observing the activities of the stock goods and sales carried out by Aneka Motor, the subject of this research. This was done to better understand the business processes that occur and make adjustments to the system accordingly.
3. Literature Review: A literature study was conducted for one month by collecting data and information from journal references, books, and other literature studies related to the problems identified in this research. This was done to gain a comprehensive understanding of the issues and to inform the development of an effective solution.

The Simple Additive Weighting (SAW) method, also known as the weighted sum method, is often used to solve selection problems in multi-process decision-making systems [13]. The basic concept of SAW is to calculate the weighted sum of the performance ratings for each alternative on all attributes. Additionally, the SAW method requires normalizing the decision matrix (X) on a scale that can compare with all existing alternative ratings.

SAW is chosen for this research for several reasons. First, it offers decision-makers a simple and user-friendly approach to evaluating and prioritizing complex alternatives [15]. The method is known for its simplicity and effectiveness, allowing decision-makers to compare different options quickly and easily based on predetermined criteria, leading to a more informed decision-making process. Second, SAW is a highly flexible decision-making method that can be easily adapted to diverse scenarios. It allows for the inclusion of both subjective and objective criteria and can be tailored to reflect the preferences and specific

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requirements of stakeholders and decision-makers [16]. To achieve normalization of the decision matrix, the formula represented in Equation 1 is utilized.

$$r_{ij} = \begin{cases} \frac{x_{ij}}{Max_{ij}} & \text{if } j \text{ is a benefit criterion} \\ \frac{Min_{ij}}{x_{ij}} & \text{if } j \text{ is a cost criterion} \end{cases} \quad (1)$$

Where?
r_{ij}=Normalized performance rating value
x_{ij}=Attribute values owned by each criterion
Max_{ij}=The largest value of each criterion
Min_{ij}=The smallest value of each criterion

The steps used in completing the simple additive weighting method are:

1) Determine i number of alternatives $A=\{a_1, a_2, a_3, \ldots a_i\}$.
2) Determine j number of criteria $C=\{c_1, c_2, c_3, \ldots c_j\}$.
3) For each criterion, decide whether it is Benefit or Cost.
4) Determine the preference weight $W=\{w_1, w_2, w_3, \ldots w_j\}$ for each criterion.
5) Decide matrix X formed by assigning a score for each alternative on each criterion.

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1j} \\ \vdots & & \ddots & \vdots \\ x_{i1} & x_{i2} & \cdots & x_{ij} \end{bmatrix} \quad (2)$$

6) Normalize the decision matrix by using formula 1. The results are placed into a normalization matrix N.

$$N = \begin{bmatrix} n_{11} & n_{12} & \cdots & n_{1j} \\ \vdots & & \ddots & \vdots \\ n_{i1} & n_{i2} & \cdots & n_{ij} \end{bmatrix} \quad (3)$$

7) Ranking results $R = \{r_1, r_2, r_3, \ldots r_i\}$ is obtained by calculation using formula 4. The larger r_i value indicates that alternative a_i is a better alternative.

$$r_i = \sum_{j=1}^{n} w_j n_{ij} \quad (4)$$

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3. RESULT AND DISCUSSION

3.1 Requirement Planning

To start, an interview was conducted with the Owner to gain a better understanding of the business process employed at the shop. Based on the results of this interview, a system will be created to meet the shop's needs. However, the shop has not evaluated its suppliers, resulting in issues related to product quality and delivery that can ultimately decrease customer satisfaction. Table 1 displays the outcome of the requirement planning phase. As the shop lacks well-defined criteria and sub-criteria to assess supplier performance, it has not been able to conduct a thorough evaluation of its suppliers or make informed decisions. Furthermore, the shop has not assigned any weight to these criteria, exacerbating the issue. To address this, a web-based supplier evaluation application will be developed. This application will feature Supplier Input, a list of criteria and sub-criteria, weight assignment for each criterion, supplier assessments, and decision result viewing functionalities.

Table 1. Requirement Planning

Current Issues	Proposed Solution
Lack of Supplier data	Supplier Input
Criteria have not been determined	Make a list of criteria
Sub-Criteria has not been determined	Make a list of sub-criteria
Weight for each Criteria has not been determined	Determine the weight of each criterion
The supplier has never been evaluated	Assess each Supplier
Choosing the best supplier has never been done	View the decision result

3.2 User Design

Figure 2 illustrates a Use Case Diagram that presents the Supplier Evaluation application currently under development. The system comprises an actor, which is the admin in this case. The admin has the responsibility of inputting a list of suppliers and defining the criteria and sub-criteria that will be employed to evaluate the suppliers. After setting up the criteria and sub-criteria, the admin assigns weights to each one based on their respective significance. With this information, the admin can assess the suppliers they wish to compare, and the system will generate the results of the matrix normalization using SAW. The SAW system provides a comprehensive approach to supplier assessment, enabling admins to evaluate and compare multiple suppliers based on various criteria.

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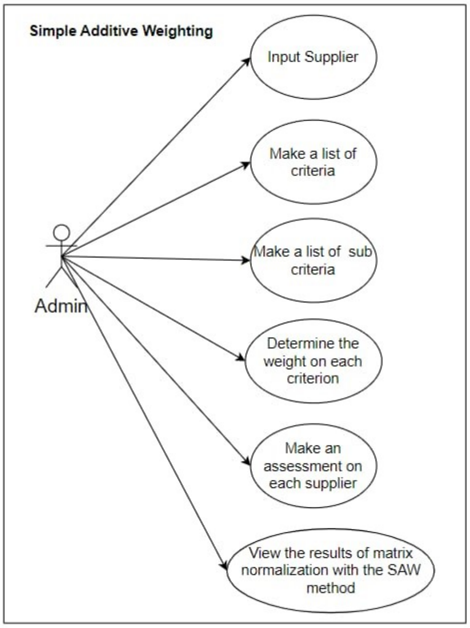

Figure 2. Use Case Diagram of Aneka Motor's System

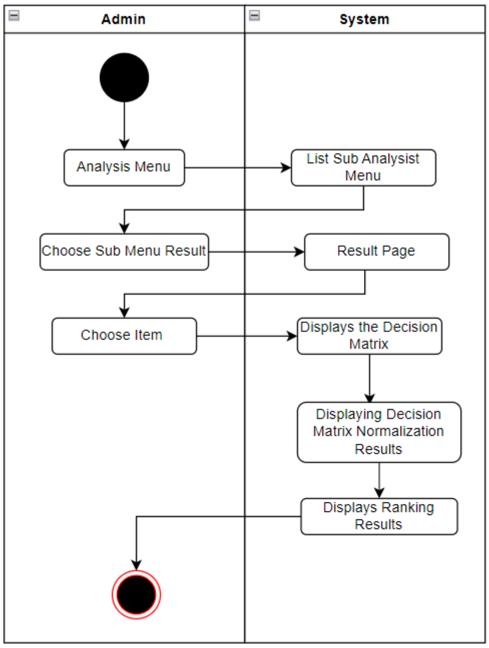

Figure 3. Activity Diagram of Aneka Motor's System

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Figure 3 illustrates an Activity Diagram that outlines the process of supplier evaluation using the SAW system. The diagram shows that the system will display a list of sub-analysis menus from the analysis menu, allowing the admin to choose a specific sub-menu leading to the Results Page. On the Results Page, the admin can select items to compare, prompting the system to generate a decision matrix. The matrix is then normalized, and each criterion is assigned weight, resulting in a ranking of suppliers based on their overall performance. In Figure 4, Class Diagrams are interconnected to illustrate the relationship between each class in the system. The six entities include admin, slogin, supplier, weight, scriteria, and evaluation. The association relationships that exist between the entities signify the actions within the system.

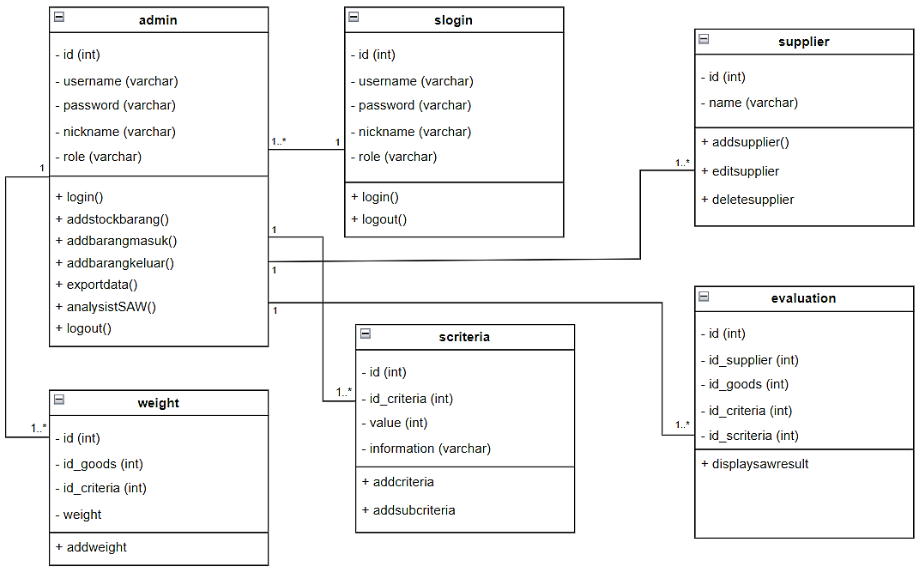

Figure 4. Class Diagram of Aneka Motor's System

3.3 Construction

The Construction phase is a crucial stage in which the HTML user interface is developed using the PHP programming language, and the MySQL database is operated using XAMPP. This stage aims to create the functional components of the system and ensure their seamless integration, providing a robust foundation for subsequent testing and deployment phases.

The following discussion compares the results of the manual SAW calculation with the supplier evaluation outcomes generated by the system. The SAW calculation process is employed to analyze suppliers. The first step involves determining the weight of each criterion, with Aneka Motor's SAW including transportation speed,

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discount rate, service, warranty, product authenticity, and payment term criteria. These criteria are fixed and cannot be replaced.

In Table 2, the weight rating for each criterion is given. The criteria labeled as C1, C2, C5, and C6 have been given a weight of 0.2, while the remaining criteria weight of 0.1. At this stage, the criteria given for the assessment are:

1) C1 = Transportation Speed, namely the speed in sending goods from suppliers to stores.
2) C2 = Discount Rate, namely the size of the discount rate given by the supplier of goods.
3) C3 = Services, namely services provided by suppliers of goods in collecting data on goods orders, making warranty claims, and making payments.
4) C4 = Warranty, namely the period of warranty for each item by the supplier.
5) C5 = Authenticity of Goods, namely whether the product provided by the supplier is original or not.
6) C6 = Payment Tempo, namely the period for making payments on each order by the supplier.

Table 2. Criteria in Aneka Motor's System

Criteria Code	Criteria Name	Criteria Attributes	Criteria Weight
C1	Transport Speed	Cost	0.2
C2	Discount Rate	Benefit	0.2
C3	Service	Benefit	0.1
C4	Warranty	Benefit	0.1
C5	Authenticity of Goods	Benefit	0.2
C6	Payment Term	Benefit	0.2

Table 3. Decision Matrix

Options	Criteria					
	C1	**C2**	**C3**	**C4**	**C5**	**C6**
Andi	0.200	0.050	0.075	0.075	0.200	0.025
Budi	0.100	0.050	0.075	0.050	0.200	0.025
Alto	0.050	0.050	0.100	0.050	0.200	0.050

Table 3 presents the decision matrix, where the Owner has provided scores for the options and criteria. Upon analyzing the results, it was found that Supplier Andi obtained the highest score for the C1 and C4 criteria. In contrast, Supplier Budi did not score the highest in any of the criteria and had the same score for C2 and C5. Finally, Supplier Alto outperformed the other options by obtaining the highest score in the C3 and C6 criteria.

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Following this, the normalization process was carried out using Formula 1, and the results are presented in Table 4. In the SAW calculation for the benefit criteria, the value is divided by the highest score for each criterion. For the cost criteria, the lowest value is divided by the value for each criterion. This was applied to C1 with cost criteria and C2 to C6 with benefit criteria.

Table 4. Normalization Matrix

Options	Criteria					
	C1	**C2**	**C3**	**C4**	**C5**	**C6**
Andi	0.250	1.000	0.750	1.000	1.000	0.500
Budi	0.500	1.000	0.750	0,667	1.000	0.500
Alto	1.000	1.000	1.000	0,667	1.000	1.000

The subsequent step involves the computation of ranking results, as illustrated in Table 5. Based on the provided criteria, Supplier Alto obtained the highest score of 0.9667, making it the clear winner and outperforming the other options. Supplier Budi attained the second position in the ranking, while Supplier Andi came in third, closely behind Supplier Budi.

Table 5. Ranking Results

Options	Criteria						Results
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	
Andi	0.0500	0.2000	0.0750	0.1000	0.2000	0.1000	0.7250
Budi	0.1000	0.2000	0.0750	0.0667	0.2000	0.1000	0.7417
Alto	0.2000	0.2000	0.1000	0.0667	0.2000	0.2000	0.9667

The result of the matrix normalization calculations utilizing the Simple Additive Weighting (SAW) technique within the system is presented in Figure 5. The ranking process is performed to determine the most suitable supplier for Michelin motorcycle tires. The results obtained from the manual calculation of the SAW method align perfectly with those generated by the system, providing assurance that the system is functioning correctly and delivering accurate outputs. The Supplier Alto obtains the highest score of 0.9667, indicating that it is the best alternative supplier for Rays 201 Motor Tires 120/70. As a result, the system provides a 100% accurate result.

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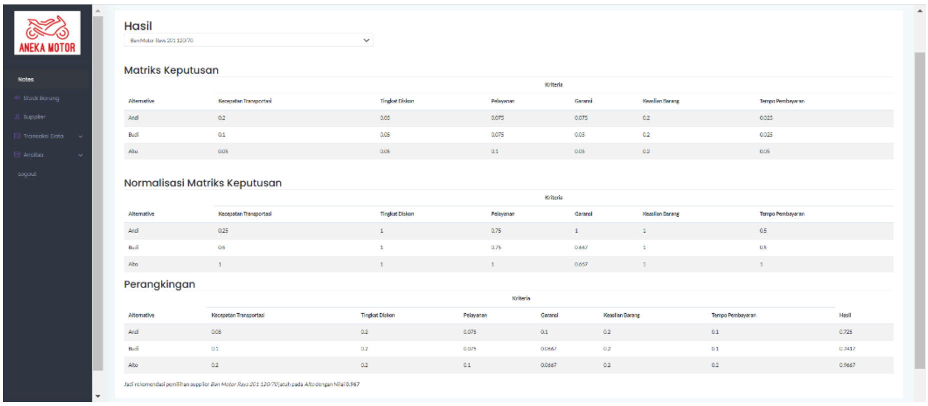

Figure 5. Results obtained through SAW matrix normalization calculation.

3.4 Cutover

The Cutover phase is the final step in ensuring the program's consistency and adherence to the stakeholders' objectives and specifications. It involves rigorous testing using the Black Box Testing method, which produces UAT results. Once the system is developed, the next step is to conduct testing to identify any errors in the system. The purpose of UAT is to ensure that the system meets the users' requirements. Mikael Wijaya, an admin of Aneka Motor, carried out the UAT.

Table 6 presents the UAT results of the system's various features. The table shows that the system's features were extensively tested, and all tests resulted in a "Pass" status, indicating that the expected results were met. All of its features are functioning as intended, resulting in accurate and consistent results. Therefore, it can be concluded that the system meets the users' requirements.

Table 6. User Acceptance Test

Features	Step Test	Result Expected	Status
Input Suppliers	Add Supplier	Supplier Data is correctly added.	Pass
	Edit Supplier	Supplier Data is correctly changed.	Pass
	Delete Supplier	Supplier's flag is changed correctly to disabled	Pass
Make a list of Criteria	Add criteria	Criteria are successfully added	Pass
	Edit criteria	Criteria are successfully changed	Pass
	Delete criteria	Criteria are successfully removed	Pass
Make a list of Sub Criteria	Add sub-criteria	Sub Criteria are successfully added	Pass
	Edit sub-criteria	Sub Criteria are successfully changed	Pass

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	Delete sub-criteria	Sub Criteria are successfully removed	Pass
Determine the weight of each criterion	Add the weight	Successfully add a new weight for each criterion	Pass
	Edit the weight	Successfully change the weight for each criterion	Pass
	Delete the weight	Successfully remove weight for each criterion	Pass
View the results of matrix normalization with the SAW method	View the results	matrix normalization with the SAW method is successfully shown	Pass

4. CONCLUSION

Upon conducting the supplier ranking process utilizing the SAW matrix normalization calculation method, it has been unequivocally established that Supplier Alto represents the most optimal alternative for Michelin motorcycle tires, specifically the Rays 201 Motor Tires 120/70. The consistency between the manual calculation and system-generated results further indicates a high degree of accuracy in the process, affirming the SAW matrix normalization method as an exceedingly effective tool for supplier ranking in this context. Furthermore, in the conclusive phase of testing the decision support system, constructed using UAT, all features exhibited a 100% success rate. Consequently, the research findings have led the researchers to propose multiple recommendations that can serve as a reference or guide for building an efficient decision support system that can compare a range of methods.

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