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Comparison of the SAW (Simple Additive Weighting), AHP (Analytic Hierarchy Process) and Wieghted Product (WP) Methods in Catering Vendor Selection

Unggul Utan Sufandi, Mayang Anglingsari Putri, Mochamad Bagoes Satria Junianto, Minrohayati

Abstract— **This study aims to develop a Decision Support System (DSS) for selecting the most suitable catering vendor for the UT Business Center by employing three decision-making methods: Simple Additive Weighting (SAW), Analytic Hierarchy Process (AHP), and Weighted Product (WP), alongside expert evaluation. Selecting an appropriate catering vendor is crucial to supporting university operations and events; therefore, the decision-making process must be based on objective and efficient criteria. Given the differences in the working principles of these three methods, it is essential to conduct a comparative analysis between AHP, SAW, and WP to determine the most suitable approach for catering vendor selection at the UT Business Center. The results of the study indicate varying levels of accuracy depending on the weighting scenario: Scenario 1 (Uniform Criterion Weights): Accuracy levels were AHP (83.33%), SAW (100%), and WP (100%). Scenario 2 (Expert-Determined Criterion Weights): Accuracy levels were AHP (58.83%), SAW (66.67%), and WP (66.67%).**

Index Terms — AHP;SAW;WP; DSS;

I. Introduction

The Business and Investment Management Center of Universitas Terbuka (Pusat Bisnis UT), commonly known as the UT Business Center, plays a crucial role in supporting various academic and non-academic activities held within the university environment. The UT Business Center serves as a strategic venue for hosting events, seminars, conferences, and other activities that require various supporting facilities, including catering services. In this regard, providing high-quality food and beverages tailored to the needs of each event is a key factor influencing the smooth execution and success of an event. Therefore, selecting the right and high-quality catering vendor is essential to ensure that events run smoothly and satisfy all parties involved.

However, in practice, the selection of catering vendors is often done manually, which can lead to uncertainty and difficulties in choosing the vendor that best suits the available needs and budget. Decisions based on personal experience or preference may compromise service quality and even impact the reputation of hosted events. Given this situation, the UT Business Center requires a specialized method for vendor selection by utilizing a Decision Support System (DSS) to assist management in the decision-making process.

A model-based system consists of a series of steps (procedures) in data processing and system considerations to assist managers in making decisions [1][2]. A Decision Support System is a computer-based information system that generates various decision alternatives to help management address both structured and unstructured problems using data and models [3].

With advancements in technology and decision analysis methodologies, various methods are now available to help solve vendor selection problems more systematically and objectively. The Fuzzy Multiple Attribute Decision Making (FMADM) method is used to address cases involving multiple important attributes. FMADM includes methods such as Simple Additive Weighting (SAW), Weighted Product (WP), ELECTRE, TOPSIS, and Analytic Hierarchy Process (AHP) [3][4].

The Analytic Hierarchy Process (AHP) allows decision-making based on pairwise comparisons between various criteria and alternatives. In AHP, decision-makers can assign weights to each criterion deemed important, such as food quality, price, service, customer satisfaction, and the vendor’s experience in handling similar events. This method makes the decision-making process more transparent, objective, and measurable [5].

Previous studies have demonstrated the effectiveness of DSS applications in various selection processes. In PT. Sasmita Abadi Gloves, the implementation of a DSS using AHP and SAW successfully reduced the selection process from 7-10 days to just 3-5 days. This system also enabled a more objective selection of the

Unggul Utan Sufandi is a Head of Universitas Terbuka Business Center and a lecturer at the Department of Information System, Faculty of Science and Technology, Terbuka University, Indonesia. (email : unggul@ecampus.ut.ac.id)

Mayang Anglingsari Putri author is a lecturer at the Department of Information System, Faculty of Science and Technology, Terbuka University, Indonesia. (email : mayang.anglingsari@ecampus.ut.ac.id)

Mochamad Bagoes Satria Junianto author is a lecturer at the Department of Information System, Faculty of Science and Technology, Terbuka University, Indonesia. (email : mochamad.bagoes@ecampus.ut.ac.id)

Minrohayati author is a lecturer at the Department Faculty of Economic and Business, Terbuka University, Indonesia (email : minrohayati@ecampus.ut.ac.id)

best candidates and doubled the efficiency of the selection process [6]. In Kampung Inggris Pare, the AHP method was applied to assist in selecting the best language learning centers based on predetermined criteria such as teaching quality, facilities, price, and location, helping students make better decisions [7]. Another study combined AHP and VIKOR to select outstanding teachers at SMAN 2 Purbalingga based on four criteria: pedagogy, personality, social skills, and professionalism. AHP was used to determine the weight of each criterion, while VIKOR ranked the teacher alternatives. Testing using a black box approach showed 100% accuracy, proving that the system effectively facilitated the selection of outstanding teachers [8]. Other research applied AHP and SAW normalization to support idea promotion in Mobile IMS [9]. Research conducted by [10] implemented the Analytical Hierarchy Process (AHP) and Simple Additive Weighting (SAW) methods in Member Financing (Case Study: Sharia Savings and Loan Cooperative Tunas Artha Mandiri (KSPPS TAM) in Nganjuk Regency).

The WP method is a popular multi-criteria decision analysis technique and, like all FMADM methods, is widely used for decision-making. WP was chosen for its ability to provide optimal solutions in ranking systems. This method is based on relatively simple computational complexity, allowing for quick calculations, and has been extensively referenced in ranking systems and DSS applications [3].

AHP excels in addressing problems that involve multiple criteria and alternatives that must be considered simultaneously. Its application in alternative selection is expected to yield better decisions by assigning appropriate weights to relevant criteria [11]. Additionally, AHP reduces reliance on subjective decisions that may not always reflect the interests of the organization or event as a whole [12]. However, despite its many advantages, testing the system built for AHP implementation remains necessary to ensure that the results obtained meet user expectations and needs.

Given the differences in how these three methods operate, it is essential to conduct a comparative analysis of AHP, SAW, and WP to determine the most suitable method for catering vendor selection at the UT Business Center. This research aims to identify a more effective solution that can help the Business Center select the best vendors with greater accuracy, efficiency, and objectivity while improving the quality of services provided.

II. METODE

This research method begins with observations to understand existing needs and problems, followed by an in-depth literature review on DSS based on AHP as the primary framework [13], and then continues with a literature review on SAW and WP.

A. 1. Conceptual Framework

The following figure presents the conceptual framework, outlining the stages of this research.

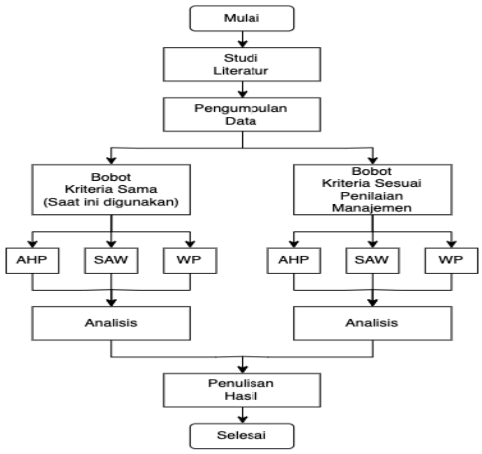

Figure 1. Metodh

A.2. Pusat Bisnis UT

Pusat Bisnis UT has the primary responsibility of managing, developing, and utilizing the economic potential of all assets, facilities, and resources within Universitas Terbuka. It operates in two service areas, namely the Service and Facilities Division, which includes accommodation, meeting room rentals, public hall rentals, office space rentals, and convention center rentals, and the Business Development and Investment Division, which offers training programs, distance education consulting, instructional material development, IT solutions, primary clinic development, café and catering services, and studio development [14].

A.3 Analytic Hierarchy Process (AHP)

AHP is a method used in decision support systems to assist decision-making that involves multiple criteria or alternatives. This method is particularly useful when decisions require the consideration of multiple complex factors simultaneously. AHP simplifies complex problems by structuring them into a hierarchy that consists of objectives, criteria, sub-criteria, and alternatives. Decision-makers evaluate each element within the hierarchy based on their preferences and relative importance. The AHP process then calculates comparisons between elements to derive priority values, ultimately aiding in selecting the best alternative. Generally, AHP is conducted through several steps: first, establishing a decision hierarchy by creating a structure that places the main objective at the top, followed by criteria and sub-criteria, with decision alternatives at the bottom. Second, conducting pairwise comparisons where users compare criteria or alternatives in pairs to assess their relative importance, often using a numerical scale to indicate the significance of one element over another. Lastly, calculating priority values, where AHP determines the relative weights and priorities of each alternative based on the pairwise comparisons.

A.4 Simple Additive Weighting (SAW)

Simple Additive Weighting (SAW) is one of the methods used to solve multi-attribute decision-making problems. The fundamental concept of SAW is to calculate the weighted sum of performance ratings for each alternative based on all the given attributes [3].

The SAW method requires a normalization process of the decision matrix (X) into a scale that allows comparisons between all ranked alternatives.

$$r_{ij} = \frac{x_{ij}}{Max(x_{ij})} \quad (1)$$

$$r_{ij} = \frac{Min(x_{ij})}{x_{ij}} \quad (2)$$

If j is a benefit attribute, the first formula is used. However, if j is a cost attribute, the second formula is applied.

$$w = \frac{C1}{C1+\cdots+Cn} x\ 100\% \quad (3)$$

$$v_i = \sum_{j-1}^{n} w_j r_{ij} \quad (4)$$

The weights of all criteria are obtained using the third formula, where r_{ij} represents the normalized performance rating of alternative A_i with respect to attribute C_i where $i = 1,2,3 \ldots, n$ dan $j = 1,2,3, \ldots, n$. The preference value for each alternative is calculated using the fourth formula.

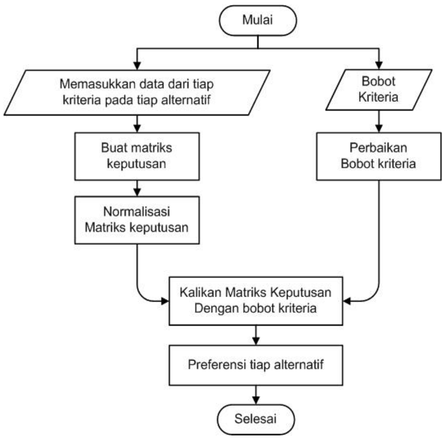

Figure 2. Flowchart Diagram of SAW Method Calculation [3]

A.5. Weighted Product (WP)

The WP method is a popular multi-criteria decision analysis technique and is one of the multi-criteria decision-making methods, like all FMADM methods. The selection of the WP method is also based on its ability to provide optimal solutions in ranking systems. This method is chosen due to its relatively low computational complexity, which allows for quick calculations (Ahmadi and Wiyanti, 2014). The WP method has also been widely used as a reference in ranking systems and Decision Support Systems (DSS) [DSS Module]. The calculation flow of the WP method can be seen in the following diagram:

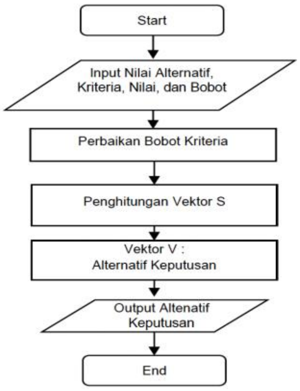

Figure 3. Flowchart Diagram of WP Method Calculation [3]

Steps in Implementing the WP Method for Alternative Selection:

1. Determine the alternative choices and criteria that will be used as the basis for decision-making.
2. Input the alternative values, criteria importance levels, values, and weights for each criterion.
3. Adjust the weight of each criterion by summing up all the criteria weights, followed by dividing each initial criterion weight by the total sum of the criteria weights.
4. Determine the S vector value for each alternative by multiplying the value data:
   a) Raised to the positive power of the adjusted weight if the criterion is a Benefit.
   b) Raised to the negative power of the adjusted weight if the criterion is a Cost.
5. Determine the V vector value used for ranking.
6. Generate the final decision alternative.

A.6. Data and Criteria

The alternatives, criteria, and assessment data used can be seen in Table 1, Table 2, and Table 3 below:

Table 1. Alternatif

Alternatif	Insisial
A1	Vendor 1
A2	Vendor 2
A3	Vendor 3
A4	Vendor 4
A5	Vendor 5
A6	Vendor 6
A7	Vendor 7
A8	Vendor 8
A9	Vendor 9
A10	Vendor 10
A11	Vendor 11
A12	Vendor 12

There are five (5) relevant criteria: (1) Time, which includes service speed and punctuality in fulfilling orders, (2) Taste, which refers to the quality and deliciousness of the food served, (3) Presentation, which involves the appearance and aesthetics of the food, (4) Interest, which reflects the catering service's ability to attract attention through menu variety and choices that align with trends or customer needs, and (5) Administration, which assesses how efficiently and professionally order management, logistics, and financial administration are handled.

Table 2. Criteria

Criteria	Description
Time (K1)	Punctuality of arrival
Taste (K2)	Flavor of the dish
Presentation (K3)	User appeal
Interest (K4)	Food presentation method
Administration (K5)	Administration process

Table 3. Expert Assessment Results

Alternatif	Criteria					Rata2	Rank
	K1	K2	K3	K4	K5		
A1	80	75	75	70	90	78	11
A2	90	90	90	100	100	94	1
A3	90	90	90	100	100	94	1
A4	85	90	90	90	100	91	3
A5	80	75	80	70	90	79	9
A6	70	80	80	70	85	77	12
A7	90	90	80	70	100	86	7
A8	90	85	85	80	100	88	6
A9	80	90	90	70	100	86	7
A10	90	85	85	90	100	90	5
A11	80	75	80	70	90	79	9
A12	90	85	90	90	100	91	3

A.7. Determining Criteria Weights

To ensure the validity of the comparative results between the AHP, SAW, and WP methods, the determination of weights must be conducted consistently and systematically. One approach used is the AHP pairwise comparison method to obtain the criteria weights, which are then uniformly applied across all three methods. Additionally, a consistency ratio (CR) check must be performed. If the CR value is ≤ 0.1, the pairwise comparison is considered consistent, and the resulting weights can be reliably used. With this approach, the comparison results between the methods will be more credible and valid [10].

IV. RESULT

The discussion aims to address the research problems, interpret findings, connect them with existing knowledge, and develop or modify existing theories [15]. The discussion is divided into two parts: uniform weighting for all criteria and weighting based on expert preferences at the UT Business Center.

A. Pembobotan Seragam Untuk Semua Criteria

A.1. AHP

The first step in using the AHP method is to establish a decision hierarchy, starting with defining the main goal, which is selecting the best catering service.

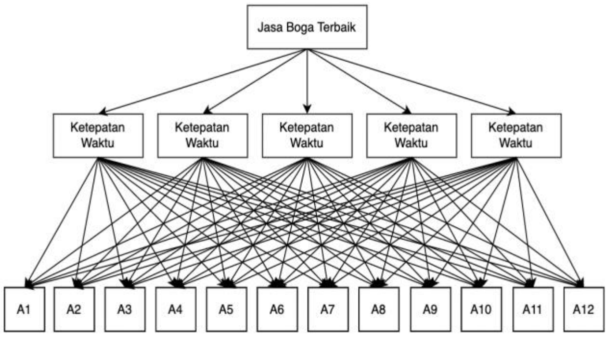

Figure 4. Hierarchy Diagram

The next step is to determine the criteria comparisons using a scale of 1 to 5, where a value of 1 means both criteria have equal importance, and a higher value indicates a more important criterion.

Table 4. Matrix P of Pairwise Comparisons

Criteria	K1	K2	K3	K4	K5
K1	1.00	1.00	1.00	1.00	1.00
K2	1.00	1.00	1.00	1.00	1.00
K3	1.00	1.00	1.00	1.00	1.00
K4	1.00	1.00	1.00	1.00	1.00
K5	1.00	1.00	1.00	1.00	1.00
Jumlah	5.00	5.00	5.00	5.00	5.00

The next step is to calculate Matrix Q by normalizing it using the following formula [16]:

$$q_{ij} = \frac{p_{ij}}{\sum_{j=1}^{n} a_{ij}} \quad (5)$$

$$q_{11} = \frac{1}{5} = 0{,}20$$

Normalization is performed on all columns to ensure that each column is on a uniform scale, resulting in the following matrix:

Table 5. Normalization

Criteria	K1	K2	K3	K4	K5
K1	0.20	0.20	0.20	0.20	0.20
K2	0.20	0.20	0.20	0.20	0.20
K3	0.20	0.20	0.20	0.20	0.20
K4	0.20	0.20	0.20	0.20	0.20
K5	0.20	0.20	0.20	0.20	0.20

Then, the weight/priority for each criterion is calculated using the following formula:

$$K_i = \frac{1}{n}\sum_{j=1}^{n} q_{ij} \quad (6)$$

$$K_1 = \frac{0{,}20 + 0{,}20 + 0{,}20 + 0{,}20 + 0{,}20}{5} = 0{,}12$$

The following are the weight/priority results obtained for each criterion, including Time (K1), Taste (K2), Interest (K3), Presentation (K4), and Administration (K5). Each weight reflects the importance of the respective criteria in the decision-making process, calculated through a specific analytical method to determine priority and its contribution to the final outcome.

Table 6. Criteria Priorities

Criteria	K1	K2	K3	K4	K5
Prioritas	0.20	0.20	0.20	0.20	0.20

After obtaining the priority values for each criterion, the consistency ratio is calculated by multiplying the elements in the matrix by their corresponding priority values. The results can be seen in the following table [3]:

Table 7. Matrix of Each Element's Weight with Its Priority Value

Criteria	K1	K2	K3	K4	K5	Jml
K1	0.20	0.20	0.20	0.20	0.20	1.00
K2	0.20	0.20	0.20	0.20	0.20	1.00
K3	0.20	0.20	0.20	0.20	0.20	1.00
K4	0.20	0.20	0.20	0.20	0.20	1.00
K5	0.20	0.20	0.20	0.20	0.20	1.00

Then, each weighted sum element is divided by its corresponding priority for each criterion (Table 5). Next, the average value is calculated to obtain λmax (Lambda Max) [17][18].

$$\lambda max = \frac{Jumlah}{Jumlah\ Kriteria} \quad (7)$$

Table 8. Menghitung LamdaMax

K1	1.00	/	0.20	=	5.00
K2	1.00	/	0.20	=	5.00
K3	1.00	/	0.20	=	5.00
K4	1.00	/	0.20	=	5.00
K5	1.00	/	0.20	=	5.00
			Jumlah	=	25.00

$$\lambda\text{max} = \frac{25.00}{5} = 5.0000$$

Next, we calculate the consistency index (CI) using the following formula [18]:

$$CI = (\lambda\max - n)\ /\ (n-1) \quad (8)$$

$$CI = (5.0000 - 5)\ /\ (5-1) = 0.0000$$

Next, we calculate the Consistency Ratio (CR) using the following formula [18]:

$$CR = CI/RI \quad (9)$$

RI is the consistency index of a random matrix, where for n=5n = 5n=5, the RI value is 1.12. Therefore, the CR value is:

$$CR = \frac{0.0000}{1.12} = 0.0000$$

With a CR value of 0.0000 or below 0.1, we can assume that the assessment matrix is consistent, allowing us to proceed with the decision-making process using AHP [19]. The next step is to determine the priority and CR for each alternative based on the criteria.

A comparison matrix of alternatives based on criteria is constructed to compare the 12 (twelve) given alternatives, where each alternative is evaluated based on its relative importance to others [18]. Each element in the matrix represents a comparison between two alternatives, where a value greater than one indicates that the first alternative is superior to the second, while a value less than one indicates the opposite.
The comparison of the importance of alternatives based on time considerations produces the following priorities:

Table 9. Priority Values Based on Criteria Per Alternative

Alternatif	Nilai Prioritas				
	K1	K2	K3	K4	K5
A1	0.0788	0.0743	0.0739	0.0722	0.0779
A2	0.0887	0.0743	0.0887	0.1031	0.0866
A3	0.0887	0.0743	0.0887	0.1031	0.0866
A4	0.0837	0.0743	0.0887	0.0928	0.0866
A5	0.0788	0.0743	0.0788	0.0722	0.0779
A6	0.0690	0.0743	0.0788	0.0722	0.0736
A7	0.0887	0.0743	0.0788	0.0722	0.0866
A8	0.0887	0.0743	0.0837	0.0825	0.0866
A9	0.0788	0.0743	0.0887	0.0722	0.0866
A10	0.0887	0.0743	0.0837	0.0928	0.0866
A11	0.0788	0.0743	0.0788	0.0722	0.0779
A12	0.0887	0.0743	0.0887	0.0928	0.0866
CR	0.0113	0.0000	0.0000	0.0000	0.0000

After processing all the alternative importance comparison matrices, the local priority values are obtained. The next step is to perform a multiplication operation between the matrices containing local priorities, ultimately resulting in a global priority [18].

Table 10. Global Priority Values and Ranking

Criteria	K1	K2	K3	K4	K5	Prioritas Global	Rank
Bobot	0.2000	0.2000	0.2000	0.2000	0.2000		
A1	0.0788	0.0743	0.0739	0.0722	0.0779	0.061	11
A2	0.0887	0.0743	0.0887	0.1031	0.0866	0.100	1
A3	0.0887	0.0743	0.0887	0.1031	0.0866	0.100	1
A4	0.0837	0.0743	0.0887	0.0928	0.0866	0.088	5
A5	0.0788	0.0743	0.0788	0.0722	0.0779	0.063	9
A6	0.0690	0.0743	0.0788	0.0722	0.0736	0.058	12
A7	0.0887	0.0743	0.0788	0.0722	0.0866	0.069	7
A8	0.0887	0.0743	0.0837	0.0825	0.0866	0.079	6
A9	0.0788	0.0743	0.0887	0.0722	0.0866	0.068	8
A10	0.0887	0.0743	0.0837	0.0928	0.0866	0.088	4
A11	0.0788	0.0743	0.0788	0.0722	0.0779	0.063	9
A12	0.0887	0.0743	0.0887	0.0928	0.0866	0.090	3

Based on the total value calculation, A2 and A3 each have a score of 0.100, making them the best alternatives.

A.2. SAW

The chosen alternatives and criteria used as the basis for decision-making are taken from Table 1 and Table 2. The criteria weights are based on Table 5, and the values assigned to each alternative for the respective criteria are from Table 3. Next, normalization is performed using Formula (1):

$$r_{ij} = \frac{x_{ij}}{Max(x_{ij})}$$

Since all criteria are benefit criteria, the normalization results are shown in the following table:

Table 11. Normalization Results

Alternatif	Criteria				
	K1	K2	K3	K4	K5
A1	0.89	0.83	0.83	0.70	0.90
A2	1.00	1.00	1.00	1.00	1.00
A3	1.00	1.00	1.00	1.00	1.00
A4	0.94	1.00	1.00	0.90	1.00
A5	0.89	0.83	0.89	0.70	0.90
A6	0.78	0.89	0.89	0.70	0.85
A7	1.00	1.00	0.89	0.70	1.00
A8	1.00	0.94	0.94	0.80	1.00
A9	0.89	1.00	1.00	0.70	1.00
A10	1.00	0.94	0.94	0.90	1.00
A11	0.89	0.83	0.89	0.70	0.90
A12	1.00	0.94	1.00	0.90	1.00

The ranking process is carried out based on the weights assigned by experts and using Formula (4). The results are as follows:

Table 12. SAW Ranking Results

Alternatif	Prioritas	Rank
A1	0.8311	11
A2	1.0000	1
A3	1.0000	1
A4	0.9689	3
A5	0.8422	9
A6	0.8211	12
A7	0.9178	7
A8	0.9378	6
A9	0.9178	7
A10	0.9578	5
A11	0.8422	9
A12	0.9689	3

From these results, the highest values are A2 and A3, making them the best alternatives.

A.3. Weighted Product (WP)

The selected alternatives and criteria used as references for decision-making are based on the data in Table 1 and Table 2. The weight criteria are taken from Table 5. The values for each alternative correspond to the relevant criteria, as shown in Table 3. The importance level of each criterion is rated using a scale from 1 to 5:

5 = Very Important
4 = Important
3 = Moderately Important
2 = Less Important
1 = Least Important

Next, the weight values use the data from Table 5, or they are uniformly assigned a weight of 4 for each criterion:

Table 13. Weight Values for Each Criterion

Criteria	Bobot	Level of Importance
K1	4	Important
K2	4	Important
K3	4	Important
K4	4	Important
K5	4	Important

Next, the weight adjustment for each criterion is carried out by summing the weights of all criteria, then dividing each initial criterion weight by the total weight sum, resulting in the following:

Table 14. Adjusted Weights for Each Criterion

W1	W2	W3	W4	W5
0.20	0.20	0.10	0.20	0.20

Next, the S vector value for each alternative is determined by multiplying the suitability rating values. If the criterion is of the Benefit type, the value is raised to a positive exponent using the adjusted weight. Conversely, if the criterion is of the Cost type, the value is raised to a negative exponent using the adjusted weight. The final results are presented as follows [3].

Table 15. Determining the S Vector

						Vektor S
A1	2.40	2.37	2.37	2.34	2.46	77.72
A2	2.46	2.46	2.46	2.51	2.51	93.87
A3	2.46	2.46	2.46	2.51	2.51	93.87
A4	2.43	2.46	2.46	2.46	2.51	90.87
A5	2.40	2.37	2.40	2.34	2.46	78.73
A6	2.34	2.40	2.40	2.34	2.43	76.76
A7	2.46	2.46	2.40	2.34	2.51	85.38
A8	2.46	2.43	2.43	2.40	2.51	87.75
A9	2.40	2.46	2.46	2.34	2.51	85.38
A10	2.46	2.43	2.43	2.46	2.51	89.84
A11	2.40	2.37	2.40	2.34	2.46	78.73
A12	2.46	2.43	2.46	2.46	2.51	90.87

Next, the V vector will be used for ranking, which can be calculated by dividing each S Vector value by the total of all S Vector values, resulting in the following:

Table 16. V Vector and Ranking

Alternatif	Vektor V	Ranking
A1	0.2928	11
A2	0.3536	1
A3	0.3536	1
A4	0.3423	3
A5	0.2966	9
A6	0.2892	12
A7	0.3216	7
A8	0.3305	6
A9	0.3216	7
A10	0.3384	5
A11	0.2966	9
A12	0.3423	3

It is evident that the highest values are A2 and A3, making them the best alternatives.

B. Weighting Based on Expert Preferences

B.1. AHP

The decision hierarchy follows Figure 4. The values used for each alternative in the corresponding criteria are taken from Table 3. The next step is to determine the pairwise comparison of criteria using a scale from 1 to 5, where a value of 1 indicates that both criteria are equally important, and a larger value signifies a more important criterion.

Table 17. Pairwise Comparison Matrix

Criteria	K1	K2	K3	K4	K5
K1	1.00	0.33	2.00	0.33	2.00
K2	3.00	1.00	2.00	1.00	3.00
K3	0.50	0.50	1.00	0.50	2.00
K4	3.00	1.00	2.00	1.00	3.00
K5	0.50	0.33	0.50	0.33	1.00
Total	8.00	3.17	7.50	3.17	11.00

The next step is to calculate normalization using formula (5). Normalization is performed on all columns to ensure that each column is on a uniform scale, resulting in the following matrix [3]:

Table 18. Normalisasi

Criteria	K1	K2	K3	K4	K5
K1	0.13	0.11	0.27	0.11	0.18
K2	0.38	0.32	0.27	0.32	0.27
K3	0.06	0.16	0.13	0.16	0.18
K4	0.38	0.32	0.27	0.32	0.27
K5	0.06	0.11	0.07	0.11	0.09

Then, the weight/priority for each criterion is calculated using the formula (5), resulting in the obtained weight/priority for each criterion, which includes Time (K1), Taste (K2), Interest (K3), Presentation (K4), and Administration (K5). Each weight reflects the importance of each criterion in the decision-making process, which is calculated through a specific analytical method to determine its priority and contribution to the final outcome.

Table 19. Criteria Priorities

Criteria	K1	K2	K3	K4	K5
Prioritas	0.16	0.31	0.14	0.31	0.09

After obtaining the priority values for each criterion, the consistency ratio (CR) is then calculated by first multiplying the matrix elements by their corresponding priority values. The results can be seen in the following table [3]:

Table 20. Matrix of Each Element's Weight with Its Priority Value

Criteria	K1	K2	K3	K4	K5	Jml
K1	0.16	0.10	0.28	0.10	0.17	0.81
K2	0.47	0.31	0.28	0.31	0.26	1.62
K3	0.08	0.15	0.14	0.15	0.17	0.70
K4	0.47	0.31	0.28	0.31	0.26	1.62
K5	0.08	0.10	0.07	0.10	0.09	0.44

Next, each element's total weight is divided by its corresponding priority for each criterion (Table 18). Then, the average value is calculated to obtain λmax based on formula (7).

Table 21. Calculating LambdaMax [17][18]

K1	0.81	/	0.16	=	5.18
K2	1.62	/	0.31	=	5.25
K3	0.70	/	0.14	=	5.04
K4	1.62	/	0.31	=	5.25
K5	0.44	/	0.09	=	5.11
			Jumlah	=	25.84

$$\lambda max = \frac{25.84}{5} = 5.1672$$

Next, we calculate the consistency index (CI) using formula (8) as follows:

$$CI = (5.1672 - 5) / (5 - 1) = 0.0418$$

Then, we compute the Consistency Ratio (CR) using formula (9). The RI value, which represents the consistency index for a random matrix, is 1.12 for n=5n = 5n=5. Therefore, the CR value is:

$$CR = \frac{0.0418}{1.12} = 0.0372$$

With a CR value of 0.0372, which is below 0.1, we can assume that the assessment matrix is consistent, allowing us to proceed with the decision-making process using AHP [19].

The next step is to determine the priority and CR of each alternative based on the criteria [3]. The alternative comparison matrix is constructed to compare the 12 (twelve) given alternatives, with each alternative evaluated based on its relative importance to the others. Each element in the matrix represents a comparison between two alternatives, where a value greater than one indicates that the first alternative is superior to the second, while a value less than one indicates the opposite.

The comparison of alternative importance based on time considerations results in the following priorities:

Table 22. Priority Values Based on Criteria for Each Alternative

Alternatif	Nilai Prioritas				
	K1	K2	K3	K4	K5
A1	0.08	0.07	0.07	0.07	0.08
A2	0.09	0.07	0.09	0.10	0.09
A3	0.09	0.07	0.09	0.10	0.09
A4	0.08	0.07	0.09	0.09	0.09
A5	0.08	0.07	0.08	0.07	0.08
A6	0.07	0.07	0.08	0.07	0.07
A7	0.09	0.07	0.08	0.07	0.09
A8	0.09	0.07	0.08	0.08	0.09
A9	0.08	0.07	0.09	0.07	0.09
A10	0.09	0.07	0.08	0.09	0.09
A11	0.08	0.07	0.08	0.07	0.08
A12	0.09	0.07	0.09	0.09	0.09
CR	0.0113	0.0000	0.0000	0.0000	0.0000

After processing the alternative comparison matrix, the local priorities obtained are then multiplied to generate the global priorities.

Table 23. Global Priority Values and Ranking

Criteria	K1	K2	K3	K4	K5	Prioritas Global	Rank
Bobot	0.16	0.31	0.14	0.31	0.09		
A1	0.08	0.07	0.07	0.07	0.08	0.0700	12
A2	0.09	0.07	0.09	0.10	0.09	0.0885	1
A3	0.09	0.07	0.09	0.10	0.09	0.0885	1
A4	0.08	0.07	0.09	0.09	0.09	0.0845	5

A5	0.08	0.07	0.08	0.07	0.08	0.0753	9
A6	0.07	0.07	0.08	0.07	0.07	0.0734	11
A7	0.09	0.07	0.08	0.07	0.09	0.0776	7
A8	0.09	0.07	0.08	0.08	0.09	0.0814	6
A9	0.08	0.07	0.09	0.07	0.09	0.0774	8
A10	0.09	0.07	0.08	0.09	0.09	0.0846	4
A11	0.08	0.07	0.08	0.07	0.08	0.0753	9
A12	0.09	0.07	0.09	0.09	0.09	0.0853	3

Berdasarkan perhitungan nilai total, alternatif dengan nilai tertinggi adalah A2 dan A3 dengan total nilai sebesar 0,0885, sehingga A2 dan A2 menjadi alternatif terbaik.

B.1. SAW

Based on the total score calculation, the alternatives with the highest values are A2 and A3, each with a total score of 0.0885, making them the best alternatives.

2) SAW Method

The chosen alternatives and criteria used as a reference in decision-making are based on the data in Table 1 and Table 2. The values for each alternative according to the corresponding criteria are provided in Table 3. The assessment data for each alternative based on the relevant criteria from Table 3 is used for further processing.

Next, normalization is performed using Formula (1):

$$r_{ij} = \frac{x_{ij}}{Max(x_{ij})}$$

Since all criteria are benefit criteria, the results of the normalization are presented in the following table:

Table 24. Normalization Results

Alternatif	Criteria				
	K1	K2	K3	K4	K5
A1	0.89	0.83	0.83	0.70	0.90
A2	1.00	1.00	1.00	1.00	1.00
A3	1.00	1.00	1.00	1.00	1.00
A4	0.94	1.00	1.00	0.90	1.00
A5	0.89	0.83	0.89	0.70	0.90
A6	0.78	0.89	0.89	0.70	0.85
A7	1.00	1.00	0.89	0.70	1.00
A8	1.00	0.94	0.94	0.80	1.00
A9	0.89	1.00	1.00	0.70	1.00
A10	1.00	0.94	0.94	0.90	1.00
A11	0.89	0.83	0.89	0.70	0.90
A12	1.00	0.94	1.00	0.90	1.00

The ranking process is carried out based on the weights assigned by experts and using Formula (4). The results of this ranking process are presented in the following table:

Table 25. SAW Ranking Results

Alternatif	Prioritas	Rank
A1	0.8066	12
A2	1.0000	1
A3	1.0000	1
A4	0.9604	3
A5	0.8143	9
A6	0.8097	11
A7	0.8918	7
A8	0.9133	6
A9	0.8898	8
A10	0.9442	5
A11	0.8143	9
A12	0.9519	4

From the above calculations, it is evident that the highest values are **A2** and **A3**, making them the best alternatives.

B.2. WP

The selected alternatives and criteria used as the basis for decision-making are based on Table 1 and Table 2. The values used for each alternative in the corresponding criteria are obtained from Table 3.

The weight of the criteria is based on Table 19. Next, the S vector value for each alternative is determined by multiplying the compatibility rating values as follows:

(a) Raised to a positive power based on the corrected weight if the criterion is Benefit.

(b) Raised to a negative power based on the corrected weight if the criterion is Cost.

The results are shown in the following table [3]:

Table 26. Determining the S Vector

						Vektor S
A1	1.99	3.80	1.82	3.72	1.47	75.34
A2	2.03	4.02	1.87	4.15	1.49	93.83
A3	2.03	4.02	1.87	4.15	1.49	93.83
A4	2.01	4.02	1.87	4.02	1.49	90.01
A5	1.99	3.80	1.84	3.72	1.47	76.01
A6	1.95	3.88	1.84	3.72	1.47	75.57
A7	2.03	4.02	1.84	3.72	1.49	82.67
A8	2.03	3.95	1.85	3.88	1.49	85.36
A9	1.99	4.02	1.87	3.72	1.49	82.49
A10	2.03	3.95	1.85	4.02	1.49	88.52
A11	1.99	3.80	1.84	3.72	1.47	76.01
A12	2.03	3.95	1.87	4.02	1.49	89.23

Next, the V vector, which will be used for ranking, can be calculated by dividing each S Vector value by the total sum of all S Vector values. The results are as follows [3]:

Table 27. V Vector and Ranking

Alternatif	Vektor V	Ranking
A1	0.2865	12
A2	0.3568	1
A3	0.3568	1
A4	0.3423	3
A5	0.2890	9
A6	0.2873	11
A7	0.3143	7
A8	0.3246	6
A9	0.3137	8
A10	0.3366	5
A11	0.2890	9
A12	0.3393	4

It is evident from the above calculations that the highest values are A2 and A3, making them the best alternatives.

III. DISCUSSION

A. Weight Equality

This accuracy test was conducted by

comparing the results of calculations using the AHP, SAW, and WP methods with the data in Table 3. The purpose of this accuracy test is to determine the degree of similarity between the system's decision results and the company's decision results. The number of matches will determine the system's accuracy level. The accuracy calculation formula is given by the following equation:

$$Akurasi = \frac{JNumber\ of\ Matches}{Total\ Rangking} X\ 100\% \quad (10)$$

Below is the comparison of ranking results from manual evaluation and the AHP method.

Table 28. Comparison of Expert, AHP, SAW, and WP Rankings

Alternatif	Expert	AHP	SAW	WP
A1	11	11	11	11
A2	1	1	1	1
A3	1	1	1	1
A4	3	4	3	3
A5	9	9	9	9
A6	12	12	12	12
A7	7	7	7	7
A8	6	6	6	6
A9	7	7	7	7
A10	5	4	5	5
A11	9	9	9	9
A12	3	3	3	3
Jumlah Yang Sama		10	12	12
	Akurasi	83.33%	100%	100%

The priority value comparison between AHP, SAW, and WP for each alternative (where the priority values from SAW and WP have been normalized beforehand) is shown in the following figure:

Figure 4. Comparison of Priority Values

The correlation coefficient between Expert Evaluations, AHP, SAW, and WP is calculated using the following formula:

$$r = \frac{\sum(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum(X_i - \bar{X})^2} \cdot \sqrt{\sum(Y_i - \bar{Y})^2}} \quad (11)$$

dimana

X_i, Y_i= individual data points

$\bar{X}, \bar{Y}$= mean values of X and Y

$\sum$ = summation over all data points

The correlation coefficient results are presented in the following table:

Table 29.
Correlation Between Expert, AHP, SAW, and WP

	Expert	AHP	SAW	WP
Expert	1			
AHP	0.9899	1		
SAW	0.9999	0.9884	1	
WP	0.9996	0.9927	0.9993	1

The correlation coefficient between SAW and AHP is 0.93, indicating a strong correlation between the two methods. Similarly, the correlation coefficient between WP and AHP is 0.96, and between WP and SAW is 0.99.

The Mean Absolute Error (MAE) measures the average error between the predicted values and actual values [21]. It is calculated by summing the absolute differences of each data pair and dividing by the total number of data points.

Table 30. MAE

	Expert	AHP	SAW	WP
Expert	0			
AHP	0.0018	0		
SAW	0.0001	0.0018	0	
WP	0.0001	0.0018	0.0002	0

The MAE table above shows the average error rate between predicted values and actual values for four evaluation methods: Expert, AHP (Analytic Hierarchy Process), SAW (Simple Additive Weighting), and WP (Weighted Product). The MAE value is calculated for each pair of methods, providing insight into how similar different methods are compared to the reference or each other. From the table, it can be observed that the SAW and WP methods produce results that are very close to the Expert values (each with an error of only 0.0001), making them more suitable for this case. Meanwhile, the AHP method has a slightly higher error rate compared to the Expert, making its results slightly less suitable than those of SAW and WP.

Root Mean Square Error (RMSE) is a statistical measure used to evaluate the level of error between predicted values and actual values in a model [21]. RMSE is calculated by taking the square root of the average squared difference between predicted and actual values, which places greater emphasis on larger errors.

Table 31. RMSE

	Expert	AHP	SAW	WP
Expert	0			
AHP	0.0022	0		
SAW	0.0001	0.0021	0	
WP	0.0002	0.0021	0.0003	0

The RMSE table shows the average error rate between predicted values and actual values for four evaluation methods: Expert, AHP (Analytic Hierarchy Process), SAW (Simple Additive Weighting), and WP (Weighted Product). Unlike MAE, RMSE places greater emphasis on significant errors by using the squared differences. From the table, it can be seen that SAW has the highest alignment with the Expert values, followed by WP. The very small RMSE value of SAW (0.0001) indicates that its prediction results are almost identical to the actual Expert values. The WP method also shows good alignment with the Expert values, although slightly less than SAW. The AHP method has a higher error compared to SAW and WP concerning the Expert values, indicating a more significant difference.

B. Weights Based on Expert Preferences

This accuracy test was conducted by comparing the results of calculations using the AHP, SAW, and WP methods with data obtained from the UT Business Center. The purpose of this accuracy test is to determine how closely the system's decision-making results match the company's actual decision-making data. The degree of matching determines the system's accuracy level. The accuracy calculation formula follows equation (10).

Below is the comparative ranking data between the manual assessment rankings and the AHP method rankings.

Table 32. Comparison of Expert, AHP, SAW, and WP Rankings with Uniform Criterion Weights

Alternatif	Expert	AHP	SAW	WP
A1	11	12	12	12
A2	1	1	1	1
A3	1	1	1	1
A4	3	5	3	3
A5	9	9	9	9
A6	12	11	11	11
A7	7	7	7	7
A8	6	6	6	6
A9	7	8	8	8
A10	5	4	5	5
A11	9	9	9	9
A12	3	3	4	4
Number of Matches		7	8	8
Akurasi		58.83%	66.67%	66.67%

The comparison of priority values between AHP, SAW, and WP for each alternative (where the priority values of SAW and WP were first normalized) can be seen in the following figure:

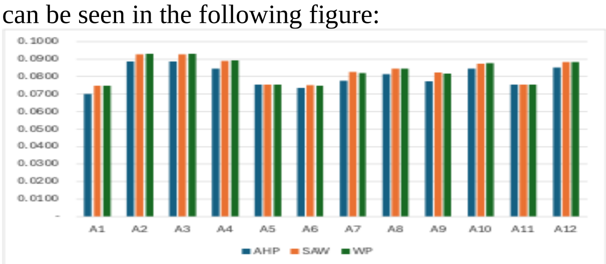

Figure 4. Comparison of Priority Values

The correlation coefficients between Expert Assessment, AHP, SAW, and WP were calculated using formula (11), with the results shown below:

Table 33. Correlation Between Expert, AHP, SAW, and WP

	Expert	AHP	SAW	WP
Expert	1			
AHP	0.9603	1		
SAW	0.9947	0.9694	1	
WP	0.9915	0.9743	0.9991	1

With a value of 0.9947, the SAW method has the highest correlation with the Expert, indicating that its results are almost identical. It is followed by the WP method with a correlation value of 0.9915 and AHP with 0.9603. For the correlation analysis between methods, it can be observed that SAW and WP produce nearly identical results. Compared to all comparisons with the AHP method, SAW and WP yield almost the same results, whereas AHP differs slightly from the other two methods. The table analysis concludes that the SAW method has the highest correlation with the Expert, making it the most suitable method to approximate the Expert's evaluation results.

Table 34. Table MAE

	Expert	AHP	SAW	WP
Expert	0			
AHP	0.0032	0		
SAW	0.0009	0.0032	0	
WP	0.0011	0.0032	0.0003	0

From the MAE table above, it can be analyzed that the SAW method has the highest compatibility with the Expert, followed by the WP method, while the AHP method has a greater degree of deviation. The SAW and WP methods also produce very similar results, whereas AHP shows more variation compared to both. If selecting a method based on compatibility with the Expert, the SAW method is the best choice, with the lowest MAE value of 0.0009, followed by the WP method, while AHP is less suitable in this case.

Table 35. RMSE Table

	Expert	AHP	SAW	WP
Expert	0			
AHP	0.0036	0		
SAW	0.0010	0.0036	0	
WP	0.0012	0.0036	0.0003	0

The RMSE table above shows the average error level between predicted values and actual values for four evaluation methods: Expert, AHP (Analytic Hierarchy Process), SAW (Simple Additive Weighting), and WP (Weighted Product). Unlike MAE, RMSE places greater emphasis on significant errors by squaring the differences. From the table, it can be observed that SAW has the highest compatibility with the Expert's values, followed by WP. RMSE provides larger error values compared to MAE since it assigns higher weights to large errors. The pattern of results is similar to MAE, but RMSE further highlights that AHP has the largest error, while SAW and WP are more accurate.

IV. CONCLUSION

The comparison of AHP, SAW, and WP methods under two weighting scenarios shows that SAW and WP have advantages when criteria weights are uniform, whereas AHP experiences a decrease in accuracy under expert preference-based weights. In the uniform weight scenario, the accuracy of the SAW and WP methods reaches 100%, while AHP only achieves 83.33%. However, when weights are determined based on expert preferences, AHP's accuracy drops to 58.83%, while SAW and WP maintain higher accuracy at 66.67% each. These findings indicate that structured summation-based methods (SAW and WP) are more stable against weight changes compared to hierarchical methods like AHP. This result aligns with research by [22], which states that linear aggregation-based methods like SAW tend to be more adaptive to weight variations compared to pairwise comparison-based methods like AHP.

In terms of correlation with expert evaluation, the SAW method shows the most consistent results, with a correlation coefficient of 0.9999 in the uniform weight scenario, followed by WP at 0.9996 and AHP at 0.9899. Meanwhile, in the expert preference-based weight scenario, the correlation between SAW and expert evaluation remains high at 0.9947, whereas WP scores 0.9915, and AHP declines to 0.9603. This indicates that SAW and WP align more closely with expert assessments than AHP under various weighting scenarios. A study by [23] also confirms that linear calculation-based methods have a higher level of agreement with human evaluations compared to pairwise comparison-based methods.

From the MAE and RMSE analysis, it can be concluded that SAW and WP methods have lower error rates compared to AHP. Under uniform weights, the MAE between SAW and expert evaluation is 0.0001, while WP has the same value of 0.0001, whereas AHP has a higher MAE of 0.0018. A similar trend is observed in RMSE, where SAW and WP have RMSE values of 0.0001 and 0.0002, respectively, while AHP has an RMSE of 0.0022. In the expert preference-based weight scenario, AHP's error increases more significantly compared to SAW and WP, demonstrating that pairwise comparison-based methods are more vulnerable to changes in weight criteria. This is supported by the study [24], which indicates that comparison-based methods like AHP tend to become unstable when significant weight changes occur.

These findings suggest that in multi-criteria decision-making, SAW and WP outperform AHP in terms of stability and accuracy, particularly when weights are uniformly assigned. However, even when weights are customized based on decision-makers' preferences, these methods still perform better than AHP in terms of agreement with expert evaluations. The advantage of SAW and WP lies in their linear aggregation approach, which is more resistant to weight variations, whereas AHP, based on pairwise comparison, is more sensitive to changes in preference scales. Therefore, in decision support system implementation, method selection should consider the nature of weight variations and the needs of decision-makers. This study provides in-depth insights into the efficiency and reliability of each method under various weight scenarios and its implications for real-world decision support system applications. Ultimately, it is expected to offer more objective and efficient recommendations and improve service quality at the UT Business Center.

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Unggul Utan Sufandi is a Head of Universitas Terbuka Business Center and a lecturer at the Department of Information Systems, Faculty of Science and Technology, Terbuka University, Indonesia. (email: unggul@ecampus.ut.ac.id)

Mayang Anglingsari Putri author is a lecturer at the Department of Information Systems, Faculty of Science and Technology, Terbuka University, Indonesia. (email: mayang.anglingsari@ecampus.ut.ac.id)

Mochamad Bagoes Satria Junianto, author, is a lecturer at the Department of Information Systems, Faculty of Science and Technology, Terbuka University, Indonesia. (email: mochamad.bagoes@ecampus.ut.ac.id)

Minrohayati author is a lecturer at the Department Faculty of Economic and Business, Terbuka University, Indonesia (email: minrohayati@ecampus.ut.ac.id)