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Combination of Composite Performance Index and Rank Order Centroid Methods for Selecting Financial Applications

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Abstract−In the current digital era, the selection of an effective financial management application poses a significant challenge due to the extensive variety of available options. Manual selection processes are often time-consuming and labor-intensive, requiring users to individually research and compare different applications based on limited and sometimes incomplete information. This research endeavors to develop a Decision Support System (DSS) employing a combined approach of the Composite Performance Index (CPI) and Rank Order Centroid (ROC) methods to streamline the selection of financial management applications. The CPI method integrates various performance dimensions into a single comprehensive index, facilitating a holistic evaluation of each candidate. Simultaneously, the ROC method is used to assign weights based on the ranking of criteria, thereby reducing subjectivity in determining the importance of each criterion. This research has resulted in a DSS capable of managing criteria and alternative data, evaluating alternatives, performing automatic CPI calculations, and displaying the optimal choices in a ranked format. In the conducted case study, Goodbudget achieved the highest composite index score of 114.42, followed by Money Lover with a score of 112.97, TrackWallet scoring 112.75, Budget Planner with 105.22, and Bluecoins with 100. The results from the DSS matched the manual calculations, demonstrating the reliability of the system's output. Black-box testing has demonstrated that all test cases have been executed successfully and have met the predefined functions.

Keywords: Black-Box Testing; Composite Performance Index; Decision Support System; Financial Management Application;

1. INTRODUCTION

In this sophisticated digital era, the need for effective financial management is becoming increasingly important for individuals and companies. Many people have difficulty maintaining and managing their cash flow efficiently, which often ends in financial problems such as mounting debt, excessive spending, and failure to save consistently [1], [2]. Financial management applications offer technology solutions to help users manage and optimize their finances [3]. However, with the plethora of applications available on the market, selecting the application that best meets the specific needs of the user can be challenging. Manually choosing a financial management application has significant drawbacks. The manual process often requires considerable time and effort, as users must research and compare various applications individually based on limited and sometimes incomplete information. Furthermore, manual evaluations are often subjective and prone to personal bias, which can result in suboptimal decisions. In light of this situation, the need for an efficient Decision Support System (DSS) becomes crucial. A DSS can be an effective solution in selecting financial management applications because it addresses the weaknesses of the manual selection process. DSS integrates data, analytical models, and evaluation algorithms to provide more objective and data-driven recommendations [4].

Previous research on Decision Support Systems for application selection has employed various approaches. Some studies have developed decision support systems for selecting business and financial management software using the Simple Additive Weighting (SAW) method, which determines the best choice through the weighted aggregation of the existing alternatives' performance [5]. Other studies have adopted the MOORA approach for selecting digital wallet applications, aiming to provide optimal solutions in multi-criteria situations by integrating the weights and preferences of each criterion [6]. Additionally, there have been explorations of the Analytical Hierarchy Process (AHP) to determine the best Enterprise Resource Planning (ERP) application by comparing and relatively evaluating various criteria to find the most suitable option [7]. Studies on decision support systems for e-wallet applications have used the Profile Matching method, comparing candidate profiles against a defined ideal profile [8]. Lastly, research on selecting P2P lending applications using the Complex Proportional Assessment (COPRAS) approach has involved normalizing the decision matrix, with weights for criteria set to produce an aggregate score for each alternative [9].

Unlike previous research, this study focuses on financial management applications, employing a holistic and comprehensive evaluation using the Composite Performance Index (CPI) and Rank Order Centroid (ROC) techniques for weight setting. CPI was chosen for its ability to integrate various performance dimensions into a single comprehensive index, facilitating a thorough evaluation of each candidate [10]. Moreover, the CPI approach is flexible in accommodating various types of data and criteria, both quantitative and qualitative, making it applicable in diverse contexts and applications [11]. On the other hand, ROC is used to calculate weights by averaging the ranking positions of each criterion, which is particularly useful when data on relative preferences are difficult to obtain or when decision-makers struggle to express their preferences in precise numerical terms [12].

This research aims to implement a Decision Support System integrating the CPI and ROC methods to select financial management applications. This study contributes to the development of decision support systems for selecting financial management applications. By combining the Composite Performance Index (CPI) and Rank Order Centroid

(ROC), this research offers an effective framework for assessing and comparing applications based on predetermined criteria.

2. RESEARCH METHODOLOGY

2.1 Research Stages

Research stages encompass a sequence of methodological steps executed in a systematic and organized fashion with the aim of attaining research objectives [13]. The research stages serve to guarantee that the research process is conducted in a structured, methodical, and dependable manner, thereby ensuring that the obtained results possess scientific rigor and are pertinent to the specified research objectives [14]. The executed stages are depicted in Figure 1.

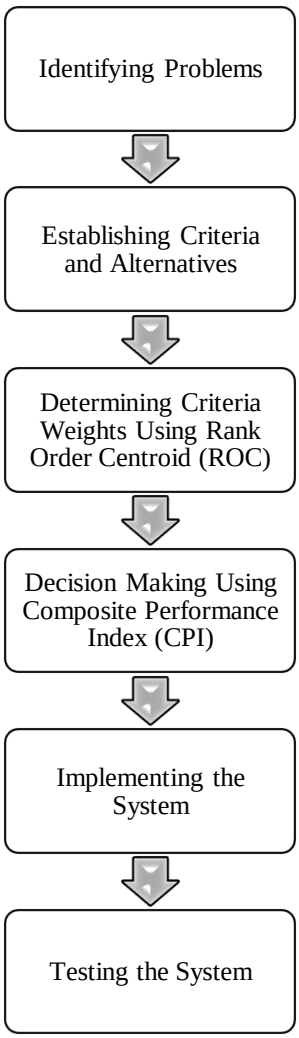

Figure 1. Applied Research Phase

Based on Figure 1, the steps of the research method carried out are explained in detail as follows.

a. Identifying Problems

This stage involves the introduction and definition of the problem to be addressed by the system [15]. In the current landscape, the vast array of available applications makes selecting the one that precisely meets a user's specific needs quite challenging. The manual process of selection is often time-consuming and laborious, requiring users to individually research and compare various applications based on information that can be limited and sometimes incomplete. Moreover, these manual evaluations are typically subjective and prone to personal biases, potentially leading to less than optimal decisions. Given these complications, the necessity for an efficient Decision Support System (DSS) becomes essential to streamline and enhance the decision-making process.

b. Establishing Criteria and Alternatives

Once the problem is identified, research continues by establishing relevant assessment criteria and identifying available alternatives. The main purpose of establishing criteria is to establish factors or standards that will be the basis for evaluating the various available alternatives [12]. The criteria considered in this case study were obtained through

recommendations from financial practitioners whose articles were published on the mybest web page [16]. The following criteria are used: features and functionality, ease of use, system security, customer support and service, and integration with other systems. Meanwhile, the alternatives used include: Budget Planner, Goodbudget, Money Lover, TrackWallet, and Bluecoins.

c. Determining Criteria Weights Using Rank Order Centroid (ROC)

At this stage, Rank Order Centroid (ROC) is used to determine the weight of the criteria. This involves ranking criteria by importance and calculating mathematical weights based on their ranking positions. ROC helps in the objectification of subjective judgments into a numerical form that is manageable and understandable in the context of further analysis.

d. Decision Making Using Composite Performance Index (CPI)

With the criteria weights established, the subsequent step involves applying the Composite Performance Index (CPI) method for decision-making. The CPI method synthesizes the individual scores of each criterion into a singular performance index for each alternative, enabling a direct comparison between the alternatives [17]. The CPI produces a ranking of alternatives based on their overall performance relative to predefined criteria.

e. Implementing the System

This stage involves the implementation process, where the model that has been designed is transformed into an operational Decision Support System (DSS). This implementation process involves using a programming language to convert logic and algorithms into code that can be executed by a computer [18]. In the context of this research, SPK was developed as a website, utilizing Komodo IDE as a code editor and MySQL as a database management system to store the required data. This coding step is crucial for transforming the system design into a functional application that can be used efficiently by users.

f. Testing the System

The testing stage is a crucial part in evaluating the model or system that has been developed, to determine its reliability and performance before it is widely implemented. The main goal of this stage is to test the main functions of the system, verify the accuracy of the results produced, and assess the performance of the system in various possible scenarios or conditions [19]. One methodology that is often used in software testing is black-box testing. In black-box testing, the system is tested without considering its internal structure or how it works [20]. This method is useful for verifying that the system operates according to expectations and meets user requirements, without needing to understand the internal technical details of the system.

2.2 Metode Rank Order Centroid (ROC)

The Rank Order Centroid (ROC) approach represents a methodology employed in multi-criteria decision-making to ascertain the weight of each criterion according to its ranked order [21]. This approach is simple but effective, providing a systematic and objective way to allocate weights that reflect the relative importance of each criterion in a decision. This method is useful in contexts where decisions must be made by considering many factors or criteria of varying importance [22]. ROC provides a systematic and objective way to allocate weights based on the preferences or rankings given to each criterion. To get the ROC weighting value, equation (1) is used.

$$w_i = \frac{1}{n}\sum_{j=r}^{n}\frac{1}{j} \qquad (1)$$

where w_i is the weight for the i-th criterion, n is the total number of criteria, r is the ranking of the i-th criterion, j is the index used in the sum and goes from the ranking of the criteria to the total number of criteria.

2.3 Metode Composite Performance Index (CPI)

The Composite Performance Index (CPI) method is a technique used in decision support systems designed to amalgamate multiple evaluation indicators into a singular composite index, which encapsulates the overall performance of an entity [23]. CPI enables decision-makers to evaluate and compare performance based on diverse and multidimensional criteria, by reducing complexity to a single, representative score [24].

The CPI method combines scores from various criteria by assigning a weight to each criterion, reflecting the importance of each criterion to overall performance. In the CPI method, the performance value for each criterion is calculated or assessed for each alternative, and then these values are integrated into a composite index by considering the predetermined weights [25]. The steps in determining decisions using the CPI approach are explained as follows:

a. Identify the trend of each criterion used, where the criteria can have a positive trend or a negative trend. Criteria with a positive trend focus on achieving the highest value, while criteria with a negative trend strive to achieve the lowest value.
b. The minimum value of each criterion with a positive trend will be changed to one hundred, while the other values will be changed proportionally in higher increments.

c. Conversely, the minimum value of each criterion with a negative trend will be changed to one hundred, but the other values will be adjusted to a lower proportion.
d. The method for calculating the alternative index value entails multiplying each criterion's value by its corresponding weight and then summing the resulting values to derive the final index score.
e. Next, the combined index will be calculated by adding up the results of each attribute for each alternative.

Based on these steps, to get the best alternative using the CPI method, the equations used in each stage are equations (2), (3), (4), and (5).

$$A_{ij} = \left(x_{ij}(min)/x_{ij}(min)\right) \times 100 \quad (2)$$

$$A_{(i+1.j)} = \left(x_{(i+1.j)}(min)/x_{ij}(min)\right) \times 100 \quad (3)$$

$$I_{ij} = A_{ij} \times P_j \quad (4)$$

$$I_i = \sum_{i=1}^{n} I_{ij} \quad (5)$$

where A_{ij} shows the value of option i on criterion j, $x_{ij}(min)$ refers to the value of option i in the initial criterion on the minimum option on j, $A_{(i+1.j)}$ describes the value of the next option on criterion j, $x_{(i+1.j)}$ shows the value of the next option in the initial criteria in j, P_j refers to the weight value of the criteria, I_{ij} shows the index value of each option, and I_i refers to the combined index value of each option.

3. RESULT AND DISCUSSION

To start the case study on selecting a financial management application, the initial task is to allocate weights for each criterion. This is imperative as each criterion holds varying degrees of significance for decision-makers. To streamline the process of determining criterion weights, the Rank Order Centroid (ROC) approach is employed. This methodology entails ranking criteria according to their perceived importance, with the highest ranking assigned to those deemed most crucial by decision-makers. In this method, decision makers are asked to give a relative ranking to each criterion based on its level of importance. Thus, decision makers only need to determine the priority order for each criterion. The criteria considered in this case study were obtained through recommendations from financial practitioners whose articles were published on the mybest web page [16]. In the context of this case study, decision-makers have established a ranking order based on the importance of various criteria which include features and functionality, ease of use, system security, customer support and service, and integration with other systems. The structured ranking of these criteria is displayed in Table 1.

Table 1. Priority Order for Each Criteria

Criteria Code	Criteria	Criterion Trends	Priority Ranking
C1	Features and Functionality	Positive	1
C2	Ease of Use	Positive	2
C3	System Security	Positive	3
C4	Customer Support and Service	Positive	4
C5	Integration with Other Systems	Positive	5

Table 1 exhibits the prioritization of each criterion under consideration. Subsequently, utilizing the priority order as a reference, the weights are ascertained employing the Rank Order Centroid (ROC) technique through equation (1). The ensuing steps detail the calculation process employed to derive the weight value:

$$w_1 = \frac{1}{5}\left(\frac{1}{1}+\frac{1}{2}+\frac{1}{3}+\frac{1}{4}+\frac{1}{5}\right) = 0.4566$$

$$w_2 = \frac{1}{5}\left(\frac{1}{2}+\frac{1}{3}+\frac{1}{4}+\frac{1}{5}\right) = 0.2567$$

$$w_3 = \frac{1}{5}\left(\frac{1}{3}+\frac{1}{4}+\frac{1}{5}\right) = 0.1567$$

$$w_4 = \frac{1}{5}\left(\frac{1}{4}+\frac{1}{5}\right) = 0.0900$$

$$w_5 = \frac{1}{5}\left(\frac{1}{5}\right) = 0.0400$$

Based on consideration of the values that have been calculated for the weight of each criterion using the ROC approach, these values are then entered into Table 2.

Table 2. Weight Values Based on Rank Order Centroid (ROC) Calculation

Criteria Code	Criteria	Criterion Trends	Value Weight
C1	Features and Functionality	Positive	0.4566
C2	Ease of Use	Positive	0.2567
C3	System Security	Positive	0.1567
C4	Customer Support and Service	Positive	0.0900
C5	Integration with Other Systems	Positive	0.0400

Table 2 displays the weights generated from the Rank Order Centroid (ROC) approach, which are subsequently utilized to determine the best alternative. The next step involves evaluating each option under consideration. For instance, in this case, five financial management applications are recommended: Budget Planner, Goodbudget, Money Lover, TrackWallet, and Bluecoins. Each option is assessed on a scale ranging from 1 to 5, where 1 indicates "Very Poor," 2 indicates "Poor," 3 indicates "Fair," 4 indicates "Good," and 5 indicates "Excellent." Decision-makers will then assess each option based on the established criteria. Using this rating scale, the values for each alternative are listed in Table 3.

Table 3. Converted Alternative Values

Alternative Code	Alternative	Criteria				
		C1	C2	C3	C4	C5
A1	Budget Planner	4	4	4	3	3
A2	Goodbudget	5	4	3	4	3
A3	Money Lover	4	5	4	3	4
A4	TrackWallet	5	4	3	3	4
A5	Bluecoins	4	4	3	3	3

Table 3 shows the assessment of each alternative which will then be calculated to obtain the best alternative using the CPI approach. To calculate it, start by looking for the A_{ij} value, taking into account the positive trend and negative trend values which have been transformed through equation (1). Based on Table 1, it can be seen that criteria C1, C2, C3, C4 and C5 are types of positive trend criteria. So, the calculation to get the A_{ij} value is as follows:

$$A_{11} = \left(\frac{4}{4}\right) \times 100 = 100$$

$$A_{21} = \left(\frac{5}{4}\right) \times 100 = 125$$

$$A_{31} = \left(\frac{4}{4}\right) \times 100 = 100$$

$$A_{41} = \left(\frac{5}{4}\right) \times 100 = 125$$

$$A_{51} = \left(\frac{4}{4}\right) \times 100 = 100$$

$$A_{12} = \left(\frac{4}{4}\right) \times 100 = 100$$

$$A_{22} = \left(\frac{4}{4}\right) \times 100 = 100$$

$$A_{32} = \left(\frac{5}{4}\right) \times 100 = 125$$

$$A_{42} = \left(\frac{4}{4}\right) \times 100 = 100$$

$$A_{52} = \left(\frac{4}{4}\right) \times 100 = 100$$

$$A_{13} = \left(\frac{4}{3}\right) \times 100 = 133$$

$$A_{23} = \left(\frac{3}{3}\right) \times 100 = 100$$

$$A_{33} = \left(\frac{4}{3}\right) \times 100 = 133$$

$$A_{43} = \left(\frac{3}{3}\right) \times 100 = 100$$

$$A_{53} = \left(\frac{3}{3}\right) \times 100 = 100$$

$$A_{14} = \left(\frac{3}{3}\right) \times 100 = 100$$

$$A_{24} = \left(\frac{4}{3}\right) \times 100 = 133$$

$$A_{34} = \left(\frac{3}{3}\right) \times 100 = 100$$

$$A_{44} = \left(\frac{3}{3}\right) \times 100 = 100$$

$$A_{54} = \left(\frac{3}{3}\right) \times 100 = 100$$

$$A_{15} = \left(\frac{3}{3}\right) \times 100 = 100$$

$$A_{25} = \left(\frac{3}{3}\right) \times 100 = 100$$

$$A_{35} = \left(\frac{4}{3}\right) \times 100 = 133$$

$$A_{45} = \left(\frac{4}{3}\right) \times 100 = 133$$

$$A_{55} = \left(\frac{3}{3}\right) \times 100 = 100$$

After all the values have been calculated (A_{ij}), then proceed with looking for alternative index values (I_{ij}). The I_ij value is obtained based on equation (3) which was discussed previously, where the A_{ij} value that has been obtained is then multiplied by each weight (weight values in Table 2). The results of all alternative index values (I_{ij}) are as follows:

$$I_{11} = 100 \times 0.4566 = 45.66$$

$$I_{21} = 125 \times 0.4566 = 57.08$$

$$I_{31} = 100 \times 0.4566 = 45.66$$

$$I_{41} = 125 \times 0.4566 = 57.08$$

$$I_{51} = 100 \times 0.4566 = 45.66$$

$$I_{12} = 100 \times 0.2567 = 25.67$$

$$I_{22} = 100 \times 0.2567 = 25.67$$

$$I_{32} = 125 \times 0.2567 = 32.09$$

$$I_{42} = 100 \times 0.2567 = 25.67$$

$$I_{52} = 100 \times 0.2567 = 25.67$$

$$I_{13} = 133 \times 0.1567 = 20.89$$

$$I_{23} = 100 \times 0.1567 = 15.67$$

$$I_{33} = 133 \times 0.1567 = 20.89$$

$$I_{43} = 100 \times 0.1567 = 15.67$$

$$I_{53} = 100 \times 0.1567 = 15.67$$

$$I_{14} = 100 \times 0.0900 = 9.00$$

$$I_{24} = 133 \times 0.0900 = 9.00$$

$$I_{34} = 100 \times 0.0900 = 12.00$$

$$I_{44} = 100 \times 0.0900 = 9.00$$

$$I_{54} = 100 \times 0.0900 = 9.00$$

$$I_{15} = 100 \times 0.0400 = 4.00$$

$$I_{25} = 100 \times 0.0400 = 4.00$$

$$I_{35} = 133 \times 0.0400 = 5.33$$

$$I_{45} = 133 \times 0.0400 = 5.33$$

$$I_{55} = 100 \times 0.0400 = 4.00$$

Based on the results of the alternative index (I_{ij}) it is then used as a reference to obtain the combined index value (I_i) which is obtained using equation (4). The summation of the I_{ij} values for each alternative yields the aggregated I_i value. The subsequent steps delineate the procedure for obtaining the combined index value (I_i):

$$I_1 = 45.66 + 25.67 + 20.89 + 9.00 + 4.00 = 105.22$$

$$I_2 = 57.08 + 25.67 + 15.67 + 12.00 + 4.00 = 114.42$$

$$I_3 = 45.66 + 32.09 + 20.89 + 9.00 + 5.33 = 112.97$$

$$I_4 = 57.08 + 25.67 + 15.67 + 9.00 + 5.33 = 112.75$$

$$I_5 = 45.66 + 25.67 + 15.67 + 9.00 + 4.00 = 100.00$$

Next, the results of the combined index are ranked from smallest to lowest value. The highest composite index (I_i) value is the best option. The ranking results for each alternative can be seen in Table 4.

Table 6. Ranking of Combined Index Values (I_i)

Alternative Code	Alternative	I_i Value	Ranking
A2	Goodbudget	114.42	1
A3	Money Lover	112.97	2
A4	TrackWallet	112.75	3
A1	Budget Planner	105.22	4
A5	Bluecoins	100.00	5

Table 6 shows that the best alternative is the Goodbudget (A2) which got a score of 114.42, followed by the Money Lover (A3) which got a score of 112.97, TrackWallet (A4) which got a score of 112.75, Budget Planner (A1) which got a score of 105.22, and the Bluecoins (A5) got a score of 100. Therefore, in this case study the best option is the Goodbudget (A2).

The next step is to implement the analysis results by developing a Decision Support System (DSS) through the coding stage. In this research, the DSS was developed as a web-based application using code editors such as Komodo IDE and MySQL for data storage. DSS designed to select financial regulatory applications include key features such as management of alternative criteria and data, evaluation of alternatives using the CPI method, and presentation of the best alternatives through a ranking process. Users of this system will be directed to the login page to access the DSS. Upon successful login, users will be taken to the main menu page, which contains the available features. The DSS dashboard interface is depicted in Figure 2.

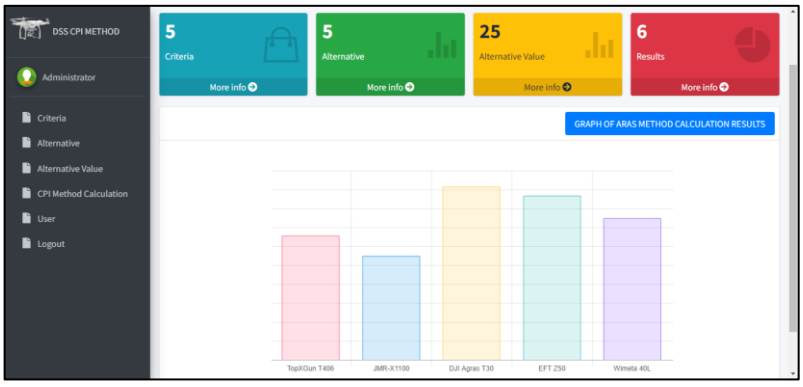

Figure 2. Main Menu Dashboard

As shown in Figure 2, the main menu dashboard of the Decision Support System (DSS) for selecting financial management applications displays the main features of the system. To make decisions regarding agricultural applications, users must first manage their criteria data. This feature provides users with accessibility to add, delete, or change criteria data. The interface for managing criteria data is illustrated in Figure 3.

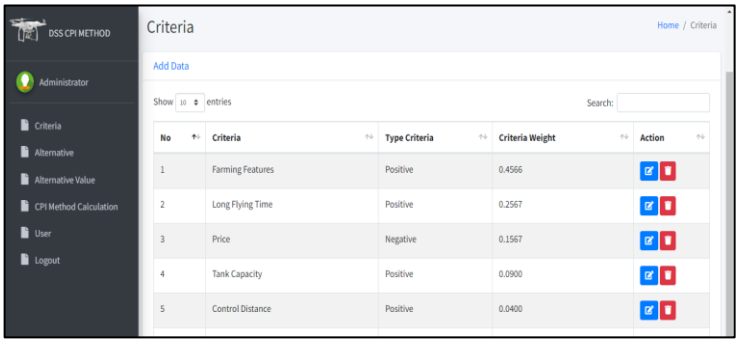

Figure 3. Features for Managing Criteria Data

After managing the criteria data as shown in Figure 3, users will proceed to manage the alternative data and provide evaluations for each alternative. The interface for adding alternative evaluation data can be seen in Figure 4.

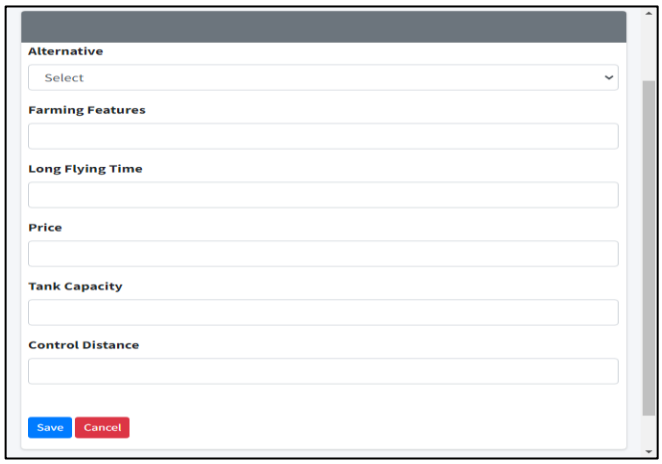

Figure 4. Feature to Add Alternative Value Data

As shown in Figure 4, the interface for adding alternative evaluation is displayed. After all alternative evaluation data has been entered, the user can continue the decision-making process using the CPI method calculation feature. On this page, users will be shown the calculation process using the CPI approach from start to finish. On this page, users can also see alternative rankings from the highest to the lowest combined index value in the form of a ranking. The CPI calculation output produced by the system is presented in Figure 5.

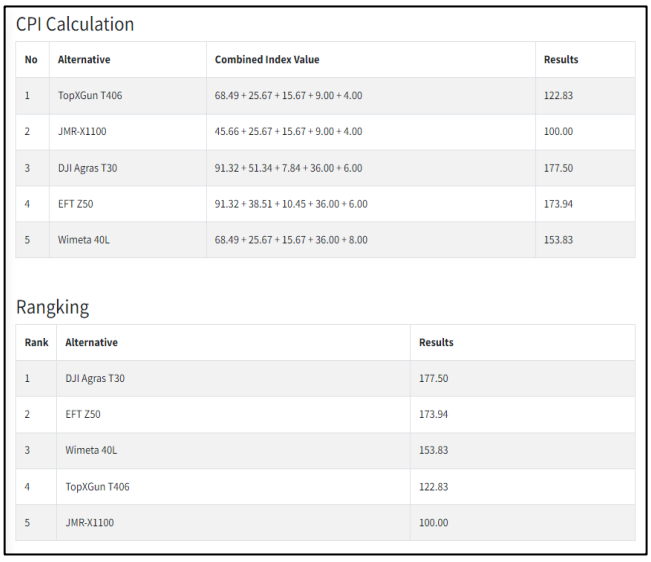

Figure 5. Output of CPI Calculation Results

Figure 4 displays the CPI method calculation output for the case study of selecting recommended financial management applications. The output from the Decision Support System (DSS) displays a composite index score for each alternative, ranking them based on their performance. Goodbudget leads with a score of 114.42, followed by Money Lover at 112.97, TrackWallet close behind with 112.75, Budget Planner at 105.22, and Bluecoin with a score of 100. The alignment of the DSS output with manual calculations confirms the system's validity.

The process continues with testing the developed DSS. This stage aims to verify the system's main functions, validate the output, and evaluate system performance under various scenarios or conditions. The approach used is black-box testing, where the system is tested without considering its internal structure or implementation. Testing is conducted by inputting data into the system and examining the output to ensure the system operates according to the specified requirements. The results of black-box testing for each system function are presented in Table 5.

Table 5. Test Results for Each Functionality

No	Functionality Function	Test Expected	Results
1	Login Menu	Users can access the system by providing their username and password.	Valid
2	Main course	The system has the ability to display the main menu or dashboard, as well as various system features.	Valid
3	Criterion Data	The system is capable of managing criteria data by allowing users to add, modify, and delete entries.	Valid
4	Alternative Data	The system can handle alternative data by enabling the addition, modification, and deletion of entries.	Valid
5	Alternative Value	The system has the capability to manage alternative values, including adding, changing and deleting alternative value data.	Valid
6	CPI calculation	The system can show the CPI method calculation process.	Valid
7	Ranking Results	The system displays alternative ranking results derived from the CPI method calculation.	Valid
8	User Data	The system has the ability to manage user data, such as adding, changing and deleting user data.	Valid

The results of the tests, as detailed in Table 5, demonstrate that all features functioned as anticipated, with each test case marked as "Valid." This indicates that the system is operating seamlessly and fulfilling its intended functionalities.

4. CONCLUSION

In this study, a combined approach has been applied using the Composite Performance Index (CPI) and Rank Order Centroid (ROC) methods in the Decision Support System (DSS) to select the best financial management application. The ROC method is employed to allocate weights based on the rank or preference assigned to each criterion. Meanwhile, the Composite Performance Index (CPI) integrates various performance dimensions into a single index reflecting overall performance. From the conducted case study, the Goodbudget achieved the highest composite index score of 114.42, followed by the Money Lover with a score of 112.97, the TrackWallet with a score of 112.75, the Budget Planner with a score of 105.22, and the Bluecoins with a score of 100. The scores generated by the manually developed DSS demonstrated consistent reliability. This DSS is designed to manage criteria and alternative data, evaluate alternatives, automatically calculate the CPI, and display the best alternatives in a ranked format. Black-box testing also indicated that the system operates effectively. However, for future research, several improvements are recommended. For instance, the determination of weights in the ROC method may be influenced by the decision maker's subjectivity; thus, integrating fuzzy logic algorithms could be considered to enhance objectivity. Additionally, further testing is recommended to evaluate the performance of the employed methods to ensure that the decisions made are of high quality and accuracy.

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