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Combination of SMART and CRITIC Methods in Decision Support Systems for Determination of Superior Products

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Abstract: Superior products are goods or services that have a higher value compared to other similar products because of their quality, innovation, or uniqueness. These products are usually produced through a standardized production process, utilizing selected raw materials, and supported by modern technology and special skills. The determination of superior products is carried out through a comprehensive analysis process to identify goods or services that have great potential to provide added value, both economically and socially. The main problem in determining superior products often arises due to the lack of accurate and comprehensive data on market potential, product quality, and consumer needs. Inaccuracies in setting evaluation criteria or weights given to each criterion can also result in bias in the selection process. This research aims to implement a combination of SMART and CRITIC methods in a decision support system to determine superior products objectively and efficiently. This combination is designed to take advantage of the advantages of the SMART method in evaluating alternatives based on multi-criteria utility, as well as the CRITIC method in determining the weight of the criteria objectively based on data variation and correlation between criteria. The results of the ranking of seven products are based on the total value that has been calculated using a certain evaluation method. Product G (D700) ranks first with the highest score of 0.78961, showing the best performance compared to other alternatives. These results provide clear information about which products are superior and can be the basis for decision-making in choosing the best product.
Keywords: Combination; CRITIC; Product; SMART; Superior;

1. INTRODUCING

Superior products are goods or services that have a higher value compared to other similar products because of their quality, innovation, or uniqueness. These products are usually produced through a standardized production process, utilizing selected raw materials, and supported by modern technology and special skills. Superior products are often the identity of a region, company, or industry because they are able to compete in local and international markets. The success of a superior product depends not only on its

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quality, but also on an effective marketing strategy, including strong branding, wide distribution, and excellent customer service. With its attractiveness and added value, superior products have the potential to support economic growth and increase competitiveness in the global market. The determination of superior products is carried out through a comprehensive analysis process to identify goods or services that have great potential to provide added value, both economically and socially. This process involves assessing various criteria, such as product quality, uniqueness, competitiveness, market demand, and its contribution to economic growth. Usually, the determination of superior products also considers local resources, available technology, and the manufacturer's innovation capabilities. Data from market surveys, product performance evaluations, and input from stakeholders are the main basis for this process. By determining the right superior products, business actors and the government can focus resources and development strategies to maximize the potential of these products in the local and international markets[1]. The main problem in determining superior products often arise due to the lack of accurate and comprehensive data on market potential, product quality, and consumer needs. Inaccuracies in setting evaluation criteria or weights given to each criterion can also result in bias in the selection process.

Decision support system (DSS) in selecting superior products is a technology-based approach to assist decision-makers in determining the best products based on various predetermined criteria[2], [3]. This DSS combines data, mathematical models, and algorithms to objectively analyze product alternatives. In the process, criteria such as quality, price, popularity, innovation, and customer reviews can be weighted according to their level of importance. By using DSS, decision-makers can reduce subjectivity, increase efficiency, and ensure that the selected product has a high competitive advantage in the market. DSS also enables the management of complex and dynamic data, such as changes in customer preferences or price fluctuations, so that decisions taken remain relevant and adaptive to market conditions. This system can be implemented in various scenarios, both to select superior products to be marketed, determine the best products for mass production, and for product procurement by companies. The main advantage of DSS is its ability to integrate various data sources, such as customer surveys, competitor analysis, and market trends, resulting in more comprehensive decisions[4]. Thus, the use of DSS in the selection of superior products not only improves the quality of decisions, but also provides added value in the form of transparency and accountability in the decision-making process[5], [6].

The simple multi-attribute rating technique (SMART) method is one of the techniques in multi-criteria decision-making that is simple, flexible, and effective. This method is used to evaluate a number of alternatives based on various criteria that have been determined, by assigning values and weights to each criterion according to its level of importance[7]–[9]. The advantage of the SMART method is its simplicity in implementation, making it suitable for use in a variety of decision-making cases[9]–[11]. However, the disadvantage is the potential for bias if the weight of the criteria is determined subjectively and the limited ability to handle data with dependencies between criteria. Nonetheless, this method can be modified or combined with other techniques to improve its accuracy.

The criteria importance through intercriteria correlation (CRITIC) method is an objective weighting technique used in multi-criteria decision-making. This method is designed to determine the weight of the criteria automatically based on the variation of the data and the relationship between the criteria, resulting in a more objective weight without subjective intervention from the decision maker[12]. In the process, the CRITIC method measures two main aspects of each criterion: contrast intensity, which reflects the degree of variation or diversity of data within the criteria, and conflict correlation, which indicates the degree of interdependence between criteria. The weight of the criteria is calculated by combining these two aspects using a mathematical approach, where the

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criteria with high variation and low correlation with other criteria will get more weight. The advantage of the CRITIC method lies in its ability to eliminate subjective bias and provide a fairer weighting based on actual data[13], [14]. Therefore, this method is often used in decision support systems for various applications, such as product selection, performance evaluation, and strategic planning. However, this method requires reliable quantitative data for reliable results.
This research aims to implement a combination of SMART and CRITIC methods in a decision support system to determine superior products objectively and efficiently. This combination is designed to take advantage of the advantages of the SMART method in evaluating alternatives based on multi-criteria utility, as well as the CRITIC method in determining the weight of the criteria objectively based on data variation and correlation between criteria. With this approach, this study aims to reduce subjectivity bias in determining the weight of criteria, produce accurate and relevant product rankings, and provide fair solutions in decision-making. In addition, this study is also to validate the effectiveness of the method combination through case studies of superior product selection and compare it with the results of conventional methods, so that it can contribute to the development of multi-criteria decision-making methods that are more adaptive, transparent, and applicable in various contexts.

2. RESEARCH METHODS

The research flow is a series of systematic steps taken to answer a research question or achieve a research goal. This flow includes stages designed to ensure the research process takes place in a structured, consistent, and logical manner. The research flow helps to stay focused and focused on the main goal. With clear steps, the risk of deviation from the original goal can be minimized. The flow of research is an important guide that ensures research is carried out carefully, planned, and produces meaningful findings. The flow of the research carried out is shown in Figure 1.

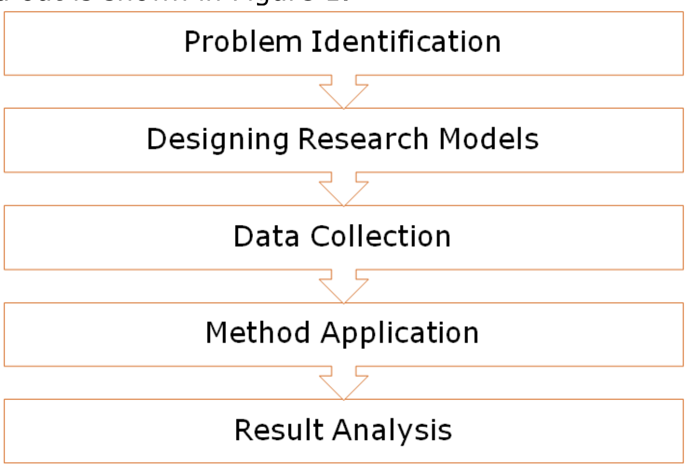

Figure 1. The Flow Research

This research begins with the problem identification stage, where the problem that is the focus of the research is the need for a decision support system that is able to determine superior products objectively and accurately, overcoming subjectivity in weighting criteria. After that, a research model design was carried out which aims to integrate the SMART method, which focuses on preference-based alternative evaluation, with the CRITIC method, which provides a weight of criteria based on data objectivity. Furthermore, the data collection stage is carried out to obtain relevant information regarding the performance of alternative products based on certain criteria. In the method application

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stage, the SMART method is used to calculate the value of alternative utilities, while the CRITIC method determines the weight of the criteria objectively. The combination of these two methods results in the final ranking of superior products. Finally, the results analysis stage is carried out to assess the performance of the model, interpret product ratings, and compare the effectiveness of the combination model with conventional methods to ensure its accuracy and reliability in supporting decision-making.

CRITIC Weighting Method

The CRITIC method is an objective weighting technique in multi-criteria decision-making that determines the weighting of criteria based on statistical analysis of the relationship between criteria[15]. This method utilizes information from data variations (standard deviations) and the level of conflict or correlation between criteria to produce more objective weights.

Compiling the decision matrix at this stage, alternative data and criteria are arranged in the form of a decision matrix. Each row in the matrix represents an alternative, while the column represents a criterion. The values in the matrix indicate alternative performance against certain criteria.

$$X = \begin{bmatrix} x_{11} & x_{21} & x_{n1} \\ x_{12} & x_{22} & x_{n2} \\ \vdots & \vdots & \vdots \\ x_{1m} & x_{2m} & x_{nm} \end{bmatrix} \tag{1}$$

Normalization of decision matrix because criteria may have different scales, the values in the decision matrix must be normalized to be on a uniform scale (usually between 0 and 1).

$$d_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} \tag{2}$$

Calculating standard deviation is used to measure the degree of variation or spread of data on each criterion.

$$\sigma_j = \sqrt{\frac{\sum_{i=1}^{j} (d_{ij} - d_j)^2}{n}} \tag{3}$$

Calculating the correlation between criteria is calculated using coefficients to determine the degree of relationship between criteria.

$$R_{ij} = \frac{\sum_{i=1}^{n} (d_{ij} - d_j) * (d_{ij} - d_h)}{\sqrt{\sum_{i=1}^{n} (d_{ij} - d_j)^2} * \sqrt{\sum_{i=1}^{n} (d_{ij} - d_h)^2}} \tag{4}$$

Calculating the information that the criteria have is calculated by combining the standard deviation and the level of conflict between the criteria.

$$C_j = \sigma_j * \sum_{j=1}^{n} (1 - R_{ij}) \tag{5}$$

Calculating the final weight of the criteria is determined by normalizing the value of the criteria information so that the total weight of all criteria is equal to 1.

$$W_j = \frac{C_j}{\sum C_j} \tag{6}$$

The CRITIC method provides objective weight and considers the complexity of the relationship between criteria, making it suitable for more data-driven decision-making.

SMART Method

The SMART method is one of the approaches in multi-criteria decision-making used to evaluate and rank a number of alternatives based on several criteria. This method is simple, intuitive, and very flexible, so it is often applied in a variety of decision support systems. Preparation of decision matrix, alternatives are evaluated based on their value or performance against each criterion. This value is arranged in the form of a decision matrix using (1).

Decision matrix normalization: the values in the decision matrix are normalized to equalize the scale between the criteria.

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$$u_{i(a_i)} = \frac{\max x_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}} \quad (7)$$
$$u_{i(a_i)} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} \quad (8)$$

Calculating the Final Score of Each Alternative by adding the result of multiplication between the normalized value and the weight of the criteria.

$$u_{(ai)} = \sum_{j=1}^{n} w_j . u_{i(a_i)} \quad (9)$$

The SMART method is perfect for decision-making that requires a simple approach but still considers the weight of the criteria.

3. RESULT AND DISCUSSION

Combining the *simple multi-attribute rating technique* (SMART) with the *criteria importance through intercriteria correlation* (CRITIC) method offers an advanced approach to decision-making in determining the best products. The CRITIC method assigns objective weights to criteria based on the variability and interdependence of data, ensuring that critical criteria with higher differentiation are prioritized. Once weights are established, the SMART method evaluates and ranks alternatives by aggregating their performance across all criteria using a straightforward and user-friendly scoring mechanism. This hybrid approach capitalizes on the objectivity of CRITIC and the simplicity of SMART, enabling decision-makers to analyze products systematically. By implementing this combination in Decision Support Systems, businesses can enhance their product evaluation processes, ensure fairness, and select superior products that align with both customer needs and organizational goals.

Alternative Assessment Data

Alternative assessment data in the determination of superior products is information collected to evaluate various product options based on a number of predetermined criteria. This assessment involves comparing different product alternatives using relevant criteria, such as price, quality, features, and performance, depending on the needs and objectives of the assessment. Each alternative is assigned a score or score based on how well the product meets the criteria that have been set. This data can be the results of surveys, product trials, or market analysis, and aims to provide a clear picture of the advantages of each product. This process is often carried out in decision support systems to assist stakeholders in selecting the best products based on multi-criteria analysis. Thus, alternative assessment data serves as an objective basis in determining superior products that meet market expectations or needs.

Table 1. Alternative Assessment Data

Product Name	Price (Cost)	Quality (Benefit)	Feature (Benefit)	Performance (Benefit)	Design (Benefit)
Product A (X100)	8	9	7	8	6
Product B (Y200)	6	8	9	7	8
Product C (Z300)	7	7	8	9	7
Product D (A400)	7	8	7	8	9
Product E (B500)	9	8	6	7	7
Product F (C600)	8	9	8	8	8
Product G (D700)	6	7	9	6	8

The best source of product assessment data comes from the company's internal data, namely sales reports and product performance test results, which are the basis for evaluating performance in the market.

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Determination of Criteria Weighting Using the CRITIC Method

The CRITIC method is one of the objective approaches used to determine the weight of criteria in multi-criteria decision-making. This method focuses on analyzing data variability and correlation between criteria to provide a weight that reflects the importance of each criterion objectively. The criterion weights in the CRITIC method are determined based on the product between the standard deviation and the independent information obtained from the correlation matrix. The end result is a weight that represents the relative significance of each criterion objectively, without relying on the subjective preferences of the decision maker. This approach is particularly useful in situations where transparent data-driven analysis is required to support more equitable and rational decisions.

The preparation of the decision matrix is the first process in the CRITIC method which shows the performance of alternatives to certain criteria made using equation (1), the general form of the decision matrix is as follows.

$$X = \begin{bmatrix} x_{1,1} & x_{2,1} & x_{3,1} & x_{4,1} & x_{5,1} \\ x_{1,2} & x_{2,2} & x_{3,2} & x_{4,2} & x_{5,2} \\ x_{1,3} & x_{2,3} & x_{3,3} & x_{4,3} & x_{5,3} \\ x_{1,4} & x_{2,4} & x_{3,4} & x_{4,4} & x_{5,4} \\ x_{1,5} & x_{2,5} & x_{3,5} & x_{4,5} & x_{5,5} \\ x_{1,6} & x_{2,6} & x_{3,6} & x_{4,6} & x_{5,6} \\ x_{1,7} & x_{2,7} & x_{3,7} & x_{4,7} & x_{5,7} \end{bmatrix}$$

The results of the decision matrix from the general form that has been made are as follows.

$$X = \begin{bmatrix} 8 & 9 & 7 & 8 & 6 \\ 6 & 8 & 9 & 7 & 8 \\ 7 & 7 & 8 & 9 & 7 \\ 7 & 8 & 7 & 8 & 9 \\ 9 & 8 & 6 & 7 & 7 \\ 8 & 9 & 8 & 8 & 8 \\ 6 & 7 & 7 & 6 & 8 \end{bmatrix}$$

Decision matrix normalization is the second process in the CRITIC method which shows that alternative performance against certain criteria must be normalized so that it is on a uniform scale calculated using equation (2).

$$d_{1,1} = \frac{x_{1,1} - \min x_{1,1;1,7}}{\max x_{1,1;1,7} - \min x_{1,1;1,7}} = \frac{8-6}{9-6} = \frac{2}{3} = 0.667$$

The results of the calculation of the overall normalization of the alternatives for each criterion that have been calculated are shown in table 2.

Table 2. The Results of the Calculation of the Overall Normalization

Product Name	Price (Cost)	Quality (Benefit)	Feature (Benefit)	Performance (Benefit)	Design (Benefit)
Product A (X100)	0.667	1.000	0.333	0.667	0.000
Product B (Y200)	0.000	0.500	1.000	0.333	0.667
Product C (Z300)	0.333	0.000	0.667	1.000	0.333
Product D (A400)	0.333	0.500	0.333	0.667	1.000
Product E (B500)	1.000	0.500	0.000	0.333	0.333
Product F (C600)	0.667	1.000	0.667	0.667	0.667
Product G (D700)	0.000	0.000	1.000	0.000	0.667

The standard deviation calculation is the third process in the CRITIC method which is used to measure the degree of variation or spread of data on each criterion calculated using equation (3).

$$\sigma_1 = \sqrt{\frac{\sum_{i=1}^{j} (d_{1,1;1,7} - d_{1,1;1,7})^2}{7}} = 0.3434$$

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$$\sigma_2 = \sqrt{\frac{\sum_{i=1}^{j}(d_{2,1;2,7} - d_{2,1;2,7})^2}{7}} = 0.3780$$

$$\sigma_3 = \sqrt{\frac{\sum_{i=1}^{j}(d_{3,1;3,7} - d_{3,1;3,7})^2}{7}} = 0.3434$$

$$\sigma_4 = \sqrt{\frac{\sum_{i=1}^{j}(d_{4,1;4,7} - d_{4,1;4,7})^2}{7}} = 0.3012$$

$$\sigma_5 = \sqrt{\frac{\sum_{i=1}^{j}(d_{5,1;5,7} - d_{5,1;5,7})^2}{7}} = 0.3012$$

The calculation of correlation between criteria is the fourth process in the CRITIC method which is used to measure the coefficient to determine the degree of relationship between criteria calculated using equation (4) are shown in table 3.

Table 3. The Results of the Calculation of Correlation between Criteria

Product Name	**Price (Cost)**	**Quality (Benefit)**	**Feature (Benefit)**	**Performance (Benefit)**	**Design (Benefit)**
Product A (X100)	1.0000	0.5503	-0.8654	0.2850	-0.4824
Product B (Y200)	0.5503	1.0000	-0.3669	0.2092	-0.2092
Product C (Z300)	-0.8654	-0.3669	1.0000	-0.2850	0.3289
Product D (A400)	0.2850	0.2092	-0.2850	1.0000	-0.2250
Product E (B500)	-0.4824	-0.2092	0.3289	-0.2250	1.0000
Product F (C600)	1.0000	0.5503	-0.8654	0.2850	-0.4824
Product G (D700)	0.5503	1.0000	-0.3669	0.2092	-0.2092

Information calculation is the fifth process in the CRITIC method which is used by combining standard deviations and the level of conflict between the calculated criteria using equations (5) are shown in table 4.

Table 4. The Results of the Calculation of Information Value Criteria

Criteria Name	C_j
Price (Cost)	1.5495
Quality (Benefit)	1.4425
Feature (Benefit)	1.7816
Performance (Benefit)	1.2094
Design (Benefit)	1.3817

The calculation of the final weight of the criterion is the sixth process in the CRITIC method which is used by obtaining the criterion weight calculated using equation (6) are shown in table 5.

Table 5. The Results of the Calculation of Final Weight Criteria

Product Name	W_j
Price (Cost)	0.2104
Quality (Benefit)	0.1959
Feature (Benefit)	0.2419
Performance (Benefit)	0.1642
Design (Benefit)	0.1876

The CRITIC method provides objective weight and considers the complexity of the relationship between criteria, making it suitable for more data-driven decision-making.

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Implementation of a Combination of SMART and CRITIC Methods

The implementation of the combination of SMART and CRITIC methods in the decision support system aims to integrate a preference-based assessment approach with objective weighting. The SMART method provides a simple and flexible structure for evaluating alternatives based on attribute values calculated through normalization scales, making it ideal for situations with multiple criteria. Meanwhile, the CRITIC method is used to objectively determine the weight of the criteria by considering the correlation between the criteria and the variability of the data. This combination results in a more balanced decision-making process, where the weights of the criteria are determined data-driven through CRITIC, and the final value of each alternative is calculated using an intuitive SMART mechanism. Thus, this approach improves the accuracy and reliability of decision results, especially in scenarios with mutually influencing criteria and requiring comprehensive analysis.

Decision matrix normalization is the values in the decision matrix normalized to equalize the scale between the calculated criteria with the equation (7) for the benefit criterion and the equation (8) for the cost criterion.

$$u_{1(a_{1,1})} = \frac{x_{1,1} - \max x_{1,1;1,7}}{\max x_{1,1;1,7} - \min x_{1,1;1,7}} = \frac{8-6}{9-6} = \frac{2}{3} = 0.6667$$

The results of the calculation of the overall normalization of the alternatives for each criterion that have been calculated are shown in table 6.

Table 6. The Results of the Calculation of the Overall Normalization

Product Name	**Price (Cost)**	**Quality (Benefit)**	**Feature (Benefit)**	**Performance (Benefit)**	**Design (Benefit)**
Product A (X100)	0.6667	0.0000	0.6667	0.3333	1.0000
Product B (Y200)	0.0000	0.5000	0.0000	0.6667	0.3333
Product C (Z300)	0.3333	1.0000	0.3333	0.0000	0.6667
Product D (A400)	0.3333	0.5000	0.6667	0.3333	0.0000
Product E (B500)	1.0000	0.5000	1.0000	0.6667	0.6667
Product F (C600)	0.0000	1.0000	0.0000	1.0000	0.3333
Product G (D700)	0.0000	1.0000	1.0000	1.0000	1.0000

Calculating the final score of each alternative by adding the result of multiplication between the normalized value and the weight of the criteria with the equation (9) for the criterion weights are taken from the weight values generated from the CRITIC method.

$$u_{(Produk\ A\ (X100))} = \sum_{j=1}^{n} w_{1;5}.\, u_{1,5(a_{1,1;5,1})} = 0.54388$$

$$u_{(Produk\ B\ (Y200))} = \sum_{j=1}^{n} w_{1;5}.\, u_{1,5(a_{1,2;5,2})} = 0.26995$$

$$u_{(Produk\ C\ (Z300))} = \sum_{j=1}^{n} w_{1;5}.\, u_{1,5(a_{1,3;5,3})} = 0.47171$$

$$u_{(Produk\ D\ (A400))} = \sum_{j=1}^{n} w_{1;5}.\, u_{1,5(a_{14;5,4})} = 0.38408$$

$$u_{(Produk\ E\ (B500))} = \sum_{j=1}^{n} w_{1;5}.\, u_{1,5(a_{1,5;5,5})} = 0.78479$$

$$u_{(Produk\ F\ (C600))} = \sum_{j=1}^{n} w_{1;5}.\, u_{1,5(a_{1,6;5,6})} = 0.42262$$

$$u_{(Produk\ G\ (D700))} = \sum_{j=1}^{n} w_{1;5}.\, u_{1,5(a_{1,7;5,7})} = 0.78961$$

Best product ranking is an evaluation process used to determine the product with the best performance based on certain criteria. This process ensures that decisions are made more

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objectively and based on systematic analysis, thus helping consumers or organizations choose the product that best suits their needs. The ranking results are shown in Figure 2.

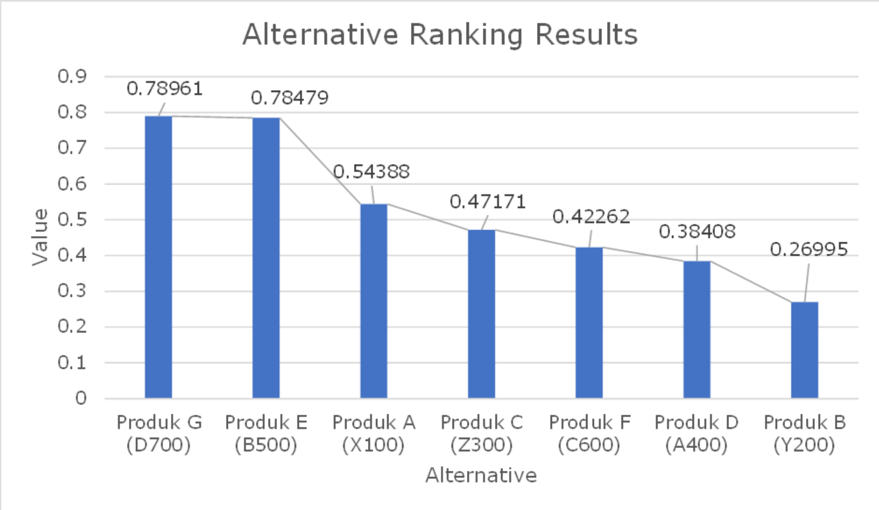

Figure 2. The Ranking Results Graph

The ranking results graph shows the ranking results of seven products based on the total value that has been calculated using a specific evaluation method. Product G (D700) ranks first with the highest score of 0.78961, showing the best performance compared to other alternatives. Product E (B500) ranks second with a value of 0.78479, which is almost close to product G, signaling competitive performance. Product A (X100) is in third place with a value of 0.54338, followed by product C (Z300) with a value of 0.47171 and product F (C600) with a value of 0.42262. Meanwhile, products D (A400) and B (Y200) took the lowest positions with values of 0.38408 and 0.26995, respectively, indicating that they did not perform as well as other alternatives. These results provide clear information about which products are superior and can be the basis for decision-making in choosing the best product.

4. CONCLUSION

This research aims to implement a combination of SMART and CRITIC methods in the decision support system to determine superior products objectively and efficiently. Combining the SMART with CRITIC method offers an advanced approach to decision-making in determining the best products. The CRITIC method assigns objective weights to criteria based on the variability and interdependence of data, ensuring that critical criteria with higher differentiation are prioritized. Once weights are established, the SMART method evaluates and ranks alternatives by aggregating their performance across all criteria using a straightforward and user-friendly scoring mechanism. This hybrid approach capitalizes on the objectivity of CRITIC and the simplicity of SMART, enabling decision-makers to analyze products systematically. By implementing this combination in Decision Support Systems, businesses can enhance their product evaluation processes, ensure fairness, and select superior products that align with both customer needs and organizational goals. The ranking results graph shows the ranking results of seven products based on the total value that has been calculated using a specific evaluation method. Product G (D700) ranks first with the highest score of 0.78961, showing the best performance compared to other alternatives. Product E (B500) ranks second with a value of 0.78479, which is almost close to product G, signaling competitive performance. Product A (X100) is in third place with a value of 0.54338, followed by product C (Z300) with a value of 0.47171 and product F

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(C600) with a value of 0.42262. Meanwhile, products D (A400) and B (Y200) took the lowest positions with values of 0.38408 and 0.26995, respectively, indicating that they did not perform as well as other alternatives. These results provide clear information about which products are superior and can be the basis for decision-making in choosing the best product.

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