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Selection of the Best Customer using a Combination of Rank Order Centroid and Grey Relational Analysis

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Abstract
A customer is an individual or entity that purchases goods or services from a company or organization. They play an important role in business success, as customer satisfaction and loyalty can determine a company's reputation and sustainability in the marketplace. One of the main challenges is collecting and analyzing accurate and comprehensive data regarding purchase behavior, transaction frequency. Other challenges include keeping customer data confidential and ensuring that the selection process is fair and transparent. The ROC method is used in the initial stage to determine the importance weight of each criterion based on the subjective ranking of the decision makers, which is then converted into numerical weights systematically and consistently, the GRA method is applied to calculate the relational proximity between each customer's alternative to the ideal solution based on their performance values on each criterion.The purpose of this study is to develop and implement a comprehensive framework for the selection of the best customers by combining ROC weighting and GRA methods, and provide practical recommendations for companies in managing and utilizing the best customer relationships, in order to improve customer loyalty and long-term profitability. By combining these approaches, businesses can effectively prioritize customers based on their significance and potential to build long-term relationships and maximize profitability, thus enabling more targeted marketing strategies and better resource allocation. The best customer ranking results were obtained by Customer I with a final GRG value of 0.1792 for the 1st rank, Customer D with a final GRG value of 0.1683 for the 2nd rank, and Customer K with a final GRG value of 0.1505 for the 3rd rank.

Keywords: Customer Loyalty; GRA; Recommendations; ROC; Selection

1. INTRODUCTION

A customer is an individual or entity that purchases goods or services from a company or organization. They play an important role in business success, as customer satisfaction and loyalty can determine a company's reputation and sustainability in the marketplace. Customers are not only looking for high-quality products or services, but also expect a pleasant experience and responsive service. The best customers are those who not only consistently buy products or services from a company, but also show high loyalty and satisfaction. Selecting the best customers is a critical challenge in the competitive business world, especially in the context of customer relationship management (CRM) that demands companies to allocate resources efficiently and retain high-value customers.The selection of the best customers involves a process of identification and evaluation based on a number of criteria, such as purchase frequency, transaction value, loyalty, and their contribution to business development through useful feedback. The best customers are those who not only consistently shop but also become brand advocates, promote products or services to others, and actively participate in loyalty programs or customer communities. Problems in selecting the best customers often arise from the complexity and subjectivity of the identification process. One of the main challenges is collecting and analyzing accurate and comprehensive data regarding purchase behavior, transaction frequency. Errors in data processing or interpretation can lead to bias in judgment, neglect potential customers, or reward less deserving customers. Other challenges include keeping customer data confidential and ensuring that the selection process is fair and transparent.

Decision support systems (DSS) have significant benefits in the selection of the best customers, because they are able to analyze various data and information quickly and accurately[1]–[3]. DSS assists companies in collecting and processing customer data, such as purchase history, satisfaction levels, and interactions with the company. Using multi-criteria analysis methods, DSS can provide an objective assessment of each customer based on various performance indicators[3]–[5]. This allows companies to identify the most valuable and potential customers for business growth, as well as design more effective and efficient marketing strategies. In addition, DSS can also help reduce subjective judgment in the decision-making process, resulting in more fair and transparent decisions. By leveraging technology, DSS can identify trends and patterns that may not be visible to conventional analysis, providing deeper insights into customer behavior. In addition, DSS can be integrated with CRM (Customer Relationship Management) systems to provide a more holistic picture of customers, so that every department in the company can work synergistically in providing superior service. In the end, the use of DSS in the selection of the best customers not only improves the company's operational efficiency, but also encourages sustainable business growth through increased customer satisfaction and loyalty.

Grey Relational Analysis (GRA) is a method of multi-criteria decision making that overcomes uncertainty and ambiguity in data. Based on the concept of gray degrees, GRA allows evaluation and ranking of alternatives based on the gray relationship between the analyzed variable[6]–[8]. With measures such as data normalization, gray degree formation, and alternative ratings, GRA provides a suitable systematic framework for dealing with complex informational conditions. GRA's strength lies in its ability to handle uncertainty, making it relevant in sectors such as management, engineering, economics and the environment. The flexibility of GRA, which does not require probability distributions or absolute

precision, expands the scope of its use[8]–[10]. With careful implementation of GRA, organizations can improve the quality of their decisions, responsiveness to the changing dynamics of the environment. One of the main advantages of GRA is its ability to handle uncertainty and ambiguity in data. The GRA allows performance evaluation and ranking alternatives even when the available data is incomplete or inaccurate.

Rank Order Centroid Weighting (ROC) is a method used in multi-criteria decision making to determine the relative weights of each criterion and rank alternatives based on those criteria[11]–[13]. In the ROC method, the process begins by assigning a rating to each alternative related to each criterion. Then, the center of mass or centroid of the rating of each criterion is calculated. The relative weight of the criterion is measured based on the distance between the alternate rating and the center of mass. Alternatives with closer proximity to the center of mass are considered better overall. The ROC method combines elements of rank and distance to provide a holistic view of relative preferences between alternatives. Thus, ROC becomes an effective tool in overcoming the complexity of directly weighting criteria, while still providing informative solutions in multi-criteria decision making.

The combination of the Centroid ROC and GRA Rank Order methods is seen as appropriate to overcome problems in selecting the best customers because each method has specific advantages that complement each other. The ROC method offers a simple yet systematic criterion weighting solution, by converting the subjective ranking of the decision-maker into a proportionate and consistent numerical weight. Meanwhile, the GRA method has the power to analyze the proximity relationship between an ideal alternative and a solution, especially under conditions of uncertain or incomplete data—a condition that is often encountered in customer evaluations. GRA enables quantitative evaluation of customer performance even if the data is heterogeneous or scales differently. When integrated, the ROC ensures that the weighting of criteria is done objectively and efficiently, while the GRA processes that information to produce thorough and accurate customer ratings. This combination creates a decision-making framework that is resilient, adaptive, and fits the needs of the dynamic modern business world. The combination of these two methods allows the best customer selection process to be carried out quantitatively, efficiently, and supports data-driven decision-making. The final results of this research can be used by companies to improve the effectiveness of business strategies through the management of priority customers who make the greatest contribution.

Research from [14] Determination of the best customers using the SAW method to identify customers who deserve awards based on various criteria such as purchase frequency and transaction value. Research from [15] to help overcome the problem of selecting the best customer by using a decision support system applying the Weighted Product method, with a decision support system determining the best customer with a weighted product method, Subur Graphic Printing can easily select the best customer. Research from [16] the use of the Analytical Hierarchy Process (AHP) method in selecting the best customers can overcome multi-criteria and complex problems into a hierarchy, with the concept of converting qualitative values into quantitative values through the process of weighting criteria, so that the results can be more objective. Research from [17] the best customer decision support system by applying the profile matching method, the results of determining the best customer rank 1 were obtained by a customer named Sri Widianingsih with a final score of 3.04. The difference with previous research is that this study applies criteria weighting using the ROC method, and for the selection of the best customers apply the GRA method, complementary approaches in producing more objective and robust customer evaluations. The uniqueness of this approach lies in the use of ROC that simplifies the weighting process based on ratings without losing consistency, and the GRA that is able to process complex and heterogeneous data to comprehensively generate customer ratings.

The purpose of this study is to develop and implement a comprehensive framework for the selection of the best customers by combining ROC weighting and GRA methods, and provide practical recommendations for companies in managing and utilizing the best customer relationships, in order to improve customer loyalty and long-term profitability. This research makes a significant contribution to the development of a decision support system (DSS) through a combination of ROC and GRA methods for the selection of the best customers. By integrating ROC for weighting criteria based on objective priority order and GRA for analyzing the relationship between criteria, this study improves objectivity, transparency, and reliability in the customer selection process. Another contribution is the application of this combined methodology in relevant business contexts, providing an effective solution for companies to evaluate customers based on criteria such as loyalty, long-term value, and satisfaction. The research also enriches the development of more sophisticated DSS that can be applied in various industries, opening up the potential for the development of more efficient and structured customer evaluation algorithms.

2. RESEARCH METHODOLOGY

2.1 Research Stages

Research stages are systematic steps followed to achieve research objectives and obtain valid and reliable results. By following this stage systematically can ensure that the research carried out has a clear structure, valid results, and meaningful contributions to the field of science studied[18]–[20]. Figure 1 is the stage of research conducted.

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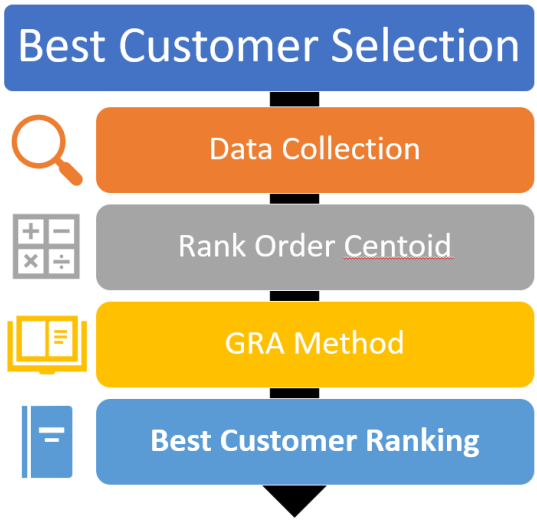

Figure 1. Research Stages

The research stage of Figure 1 is a research process to determine the best customers, the stages carried out start from collecting data, using ROC and GRA methods, and ranking the best customers.

2.2 Data Collection

Data collection is an important step in the process of ranking the best customers, the criteria data used are transaction value, purchase frequency, loyalty, positive feedback, and loyalty program participation. The collected data will be ready for further analysis in the process of ranking the best customers. Systematic and accurate data collection is the key to obtaining reliable analysis results that are beneficial to business decisions.

2.3 Rank Order Centroid (ROC) Method

Centroid Rank Order (ROC) methods provide flexibility in handling situations where preference and criteria weights may be difficult to measure or express explicitly. ROC also has the ability to handle criteria with different measurement scales, since the ratings given are relative and independent of absolute scales. ROC is calculated using equation (1).

$$w_k = \frac{1}{2}\sum_{i=1}^{k}\frac{1}{k} \quad (1)$$

w_k is the weight of the criteria for k criteria, while the k indicates the position or ranking order of the criteria based on the decision maker's assessment (the smaller the k value, the higher the priority).

2.4 Grey Relational Analysis (GRA) Method

The stages of Grey Relational Analysis (GRA) take us into methods designed to address uncertainty and complexity in multi-criteria decision making. The GRA provides a systematic approach involving a structured set of steps to evaluate and rank alternatives based on predetermined criteria.
Data Normalization: A normalization process is applied to transform raw data into a comparable form. This is usually done to overcome differences in scale or units between variables so that they can be processed more accurately. Normalization is calculated using equation (2).

$$X_{ij} = \frac{x_{ij} - x_{\min ij}}{x_{\max ij} - x_{\min ij}} \quad (2)$$

X_{ij} is the original value of the i alternative on the j criterion, while $x_{\max ij} and\ x_{\min ij}$ are the maximum and minimum values of all alternatives on the same criterion, respectively.
Weight Multiplication: weight multiplication in the GRA method based on criteria weights with matrix normalization results. Weight multiplication is calculated using equation (3).

$$V_{ij} = x_{i,j}.w_j \quad (3)$$

V_{ij} is a weighted value that reflects the relative contribution of each alternative to each criterion, while w_j is the weighting of the criteria
Grey Relation Value: the grey relation value is calculated for each variable based on the result of the overall weight multiplication that has been created. Grey relation value is calculated using equation (3).

$$GRG_i = \frac{1}{n}\sum_{j=1}^{n} V_{ij} \quad (4)$$

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GRG_i represents the degree to which the overall proximity of the second alternative is to the ideal solution, the higher the GRG value, the better the overall performance of the alternative.

2.4 Best Customer Ranking

Best customer ranking is an evaluation and assessment process to determine the customers who provide the highest value to the business based on various relevant criteria. These rankings help companies identify and reward their most valuable customers, and direct more effective marketing and service strategies.

3. RESULT AND DISCUSSION

The selection of the best customers is an important step for businesses that want to optimize resources and increase profitability. Combining ROC methodology and Grey Relational Analysis (GRA) provides a solid framework for this task. ROC analysis facilitates the measurement of customer attribute uncertainty, allowing businesses to identify the most influential factors in customer selection. On the other hand, GRA establishes relationships between these attributes, providing insight into their relative importance and interconnectedness. By combining these approaches, businesses can effectively prioritize customers based on their significance and potential to build long-term relationships and maximize profitability, thus enabling more targeted marketing strategies and better resource allocation.

3.1 Data Collection

Data collection for the analysis of the combination of ROC and GRA in the selection of the best customers can be done through several steps. Identify relevant customer attributes, such as purchase history, transaction frequency, transaction value, and customer feedback. Collect data for each attribute from a variety of sources, such as internal sales databases, customer surveys, and third-party data where needed. Table 1 is the assessment data for customers.

Table 1. Customer Rating Data

Customer Name	Loyalty Transaction	Purchase Frequency	Value Positive	Feedback Loyalty	Program Participation
Customer A	4	3	5	2	4
Customer B	2	4	3	3	4
Customer C	3	2	4	4	3
Customer D	5	3	5	4	5
Customer E	2	3	3	2	3
Customer F	3	4	2	4	3
Customer G	4	3	4	3	4
Customer H	4	3	4	3	2
Customer I	5	4	3	5	5
Customer J	3	3	4	3	3
Customer K	4	4	4	4	4
Customer L	2	3	2	3	2

Table 1 assessment data is obtained from the administration in collecting assessment data from customers. This data will be used in this study to determine the best customers, so that companies can make a decision based on the results of the recommendations provided in this study.

3.2 Calculation of Criteria Weights Using ROC Method

The ROC method in calculating the weight of criteria is one approach that can be used in multi-criteria decision making. This method allows decision makers to determine the weight of criteria based on the relative ranking of existing criteria. The result of calculating the ROC criteria boobt using equation (1).

$$w_1 = \frac{1 + {}^1/_2 + {}^1/_3 + {}^1/_4 + {}^1/_5}{5} = \frac{2.283}{5} = 0.457$$

$$w_2 = \frac{0 + {}^1/_2 + {}^1/_3 + {}^1/_4 + {}^1/_5}{5} = \frac{1.283}{5} = 0.257$$

$$w_3 = \frac{0 + 0 + {}^1/_3 + {}^1/_4 + {}^1/_5}{5} = \frac{0.783}{5} = 0.156$$

$$w_4 = \frac{0 + 0 + 0 + {}^1/_4 + {}^1/_5}{5} = \frac{0.45}{5} = 0.09$$

$$w_5 = \frac{0 + 0 + 0 + 0 + {}^1/_5}{5} = \frac{0.2}{5} = 0.04$$

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The results of the calculation of the weight of the criteria will be used in the GRA method in determining the best customer.

3.3 Best Customer Assessment Using GRA Method

The GRA method can be effectively applied to assess the best customers based on several criteria. By calculating the Grey Relational Coefficient (GRC) between each customer and the reference series for each criterion, and calculating the Grey Relational Value (GRG) for each customer, customers can be ranked based on their GRG value. The customer with the highest GRG value is considered the best customer based on the criteria and data analyzed. The normalization of the matrix in the GRA method is calculated based on the assessment data of table 1 using equation (2).

The following are the results of the normalization matrix calculation for the transaction value criteria from the existing alternative assessment data.

$$x_{11} = \frac{x_{11} - x_{\min 11;112}}{x_{max\ 11;112} - x_{\min 11;112}} = \frac{4-2}{5-2} = 0.667$$

The normalization process is carried out to change the initial assessment data into a uniform scale so that it can be objectively compared between criteria. Each value in the normalization matrix reflects the proportion of alternative contributions to each predetermined criterion. The results of the normalization matrix calculation for all criteria based on alternative assessment data are shown in Table 2.

Table 2. Normalization Results

Customer Name	Loyalty Transaction	Purchase Frequency	Value Positive	Feedback Loyalty	Program Participation
Customer A	0.667	0.500	1.000	0.000	0.667
Customer B	0.000	1.000	0.333	0.333	0.667
Customer C	0.333	0.000	0.667	0.667	0.333
Customer D	1.000	0.500	1.000	0.667	1.000
Customer E	0.000	0.500	0.333	0.000	0.333
Customer F	0.333	1.000	0.000	0.667	0.333
Customer G	0.667	0.500	0.667	0.333	0.667
Customer H	0.667	0.500	0.667	0.333	0.000
Customer I	1.000	1.000	0.333	1.000	1.000
Customer J	0.333	0.500	0.667	0.333	0.333
Customer K	0.667	1.000	0.667	0.667	0.667
Customer L	0.000	0.500	0.000	0.333	0.000

The result of weight multiplication in the GRA method is calculated based on the normalization result with weight multiplication from the ROC method using equation (3).

$$V_{11} = w_1 * x_{11} = 0.457 * 0.667 = 0.3047$$

This multiplication aims to exert an influence according to the level of relative importance of each criterion to the alternatives assessed. The results of the multiplication between the normalization matrix and the weighting criteria are presented in Table 3.

Table 3. Weight Multiplication Results

Customer Name	Loyalty Transaction	Purchase Frequency	Value Positive	Feedback Loyalty	Program Participation
Customer A	0.3047	0.1285	0.1560	0.0000	0.0267
Customer B	0.0000	0.2570	0.0520	0.0300	0.0267
Customer C	0.1523	0.0000	0.1040	0.0600	0.0133
Customer D	0.4570	0.1285	0.1560	0.0600	0.0400
Customer E	0.0000	0.1285	0.0520	0.0000	0.0133
Customer F	0.1523	0.2570	0.0000	0.0600	0.0133
Customer G	0.3047	0.1285	0.1040	0.0300	0.0267
Customer H	0.3047	0.1285	0.1040	0.0300	0.0000
Customer I	0.4570	0.2570	0.0520	0.0900	0.0400
Customer J	0.1523	0.1285	0.1040	0.0300	0.0133
Customer K	0.3047	0.2570	0.1040	0.0600	0.0267
Customer L	0.0000	0.1285	0.0000	0.0300	0.0000

The final result of the GRG value in the GRA method is calculated using equation (4).

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$$GRG_1 = \frac{1}{5} * (V_{11} + V_{21} + V_{31} + V_{41} + V_{51})$$
$$GRG_1 = \frac{1}{5} * (0.3047 + 0.1285 + 0.1560 + 0 + 0.0267)$$
$$GRG_1 = \frac{1}{5} * (0.6158) = 0.1232$$

This final value is obtained by calculating the average of all coefficients of proximity owned by each alternative. The results of the calculation of the final GRA score for each alternative are shown in Table 4.

Table 4. Final Value GRA

Customer Name	Final Value
Customer A	0.1232
Customer B	0.0731
Customer C	0.0659
Customer D	0.1683
Customer E	0.0388
Customer F	0.0965
Customer G	0.1188
Customer H	0.1134
Customer I	0.1792
Customer J	0.0856
Customer K	0.1505
Customer L	0.0317

The result of the final GRG value is the final result of applying the GRA method in calculating the best customer selection.

3.4 Best Customer Ranking

The ranking of the best customers can be done using the GRA Method, Customers are then ranked based on GRG values with the highest value indicating the best customers in the context of the criteria set. This method allows the company to objectively assess and select the best customers based on relevant criteria. Figure 2 is the result of ranking the best customers using the GRA method.

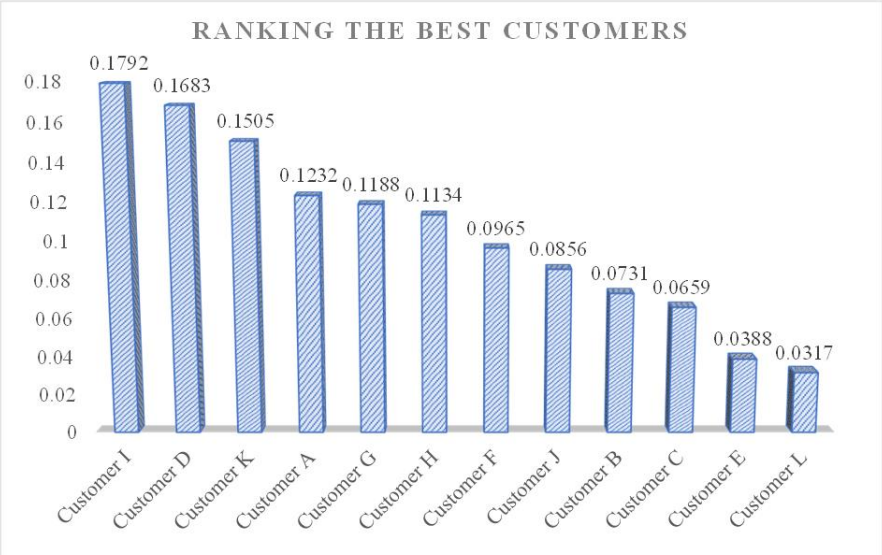

Figure 2. Ranking the Best Customer

The ranking results show that Customer I obtained the highest final score of 0.1792, thus ranking first as the best customer. This shows that Customer I makes the most significant contribution to the company, both in terms of transaction value, loyalty, and purchase frequency. Followed by Customer D and Customer K with values of 0.1683 and 0.1505, respectively, which also showed a high contribution in supporting the company's revenue growth and stability. Meanwhile, Customer A, Customer G, and Customer H are in the middle position with values between 0.1232 to 0.1134, which reflects a contribution that is still quite good even though it is not dominant. On the other hand, the customer with the lowest final score was Customer L with a score of 0.0317, which ranks last and shows a relatively small contribution

to the overall performance of the company. This sequence shows that the higher the final GRA value, the greater the customer's contribution in creating value for the company.

This research makes a significant contribution to the development of decision support systems by applying ROC and GRA methods to identify the best customers based on various assessment criteria. With this approach, companies can conduct a more objective and systematic evaluation of customer performance, so that marketing and service strategies can be focused on the segments that provide the highest value. In addition, the results of this research can be the basis for strategic decision-making related to customer retention, loyalty programs, and resource allocation more efficiently and on target.

4. CONCLUSION

The selection of the best customers is an important step for businesses that want to optimize resources and increase profitability. Combining ROC methodology and Grey Relational Analysis (GRA) provides a solid framework for this task. ROC analysis facilitates the measurement of customer attribute uncertainty, allowing businesses to identify the most influential factors in customer selection. On the other hand, GRA establishes relationships between these attributes, providing insight into their relative importance and interconnectedness. By combining these approaches, businesses can effectively prioritize customers based on their significance and potential to build long-term relationships and maximize profitability, thus enabling more targeted marketing strategies and better resource allocation. The best customer ranking results were obtained by Customer I with a final GRG value of 0.1792 for the 1st rank, Customer D with a final GRG value of 0.1683 for the 2nd rank, and Customer K with a final GRG value of 0.1505 for the 3rd rank. This research makes a significant contribution to the development of a decision support system (DSS) through a combination of ROC and GRA methods for the selection of the best customers. By integrating ROC for weighting criteria based on objective priority order and GRA for analyzing the relationship between criteria, this study improves objectivity, transparency, and reliability in the customer selection process. Another contribution is the application of this combined methodology in relevant business contexts, providing an effective solution for companies to evaluate customers based on criteria such as loyalty, long-term value, and satisfaction. The research also enriches the development of more sophisticated DSS that can be applied in various industries, opening up the potential for the development of more efficient and structured customer evaluation algorithms.

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