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MULTI-CRITERIA DECISION MAKING METHODS ANALYTIC HIERARCHY PROCESS AND IT'S APPLICATIONS

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Dokuz Eylul University

Faculty of Science

Department of Mathematics

Project Report

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REPORT EVALUATION FORM

A report titled '**MULTI-CRITERIA DECISION MAKING METHODS ANALYTIC HIERARCHY PROCESS AND IT'S APPLICATIONS**' prepared by **Bahar Ece YALCIN, Hande GOKMEN** under the management of **Prof. Dr. Ozlem Ege ORUC** has been read from our side.

Prof. Dr. Ozlem Ege ORUC

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ABSTRACT

The choice of the most appropriate bank based on its own criteria is a very complex decision-making process because the evaluation process involves a large number of criteria, and this process requires a compromise between the overlapping criteria. Multi-criteria decision-making methods have been developed to assist decision-makers or organizations in the decision-making process. The AHP method is used where the decision maker evaluates qualitative and quantitative factors together. In this study, it was tried to be determined by the AHP method according to its criteria for bank selection. In the study, 5 banks were compared according to 3 different criteria and the most suitable bank was decided. The payment history among the criteria according to the AHP method was the most important criterion affecting the appropriate bank. The eligible bank was selected as the Vakif Bank. During the research period, it was stated to the experts that the interest rate applied by each bank on loan was constant.

Keywords: Analytic Hierarchy Process, Decision, Criteria, Bank, Multi-Criteria Decision Making.

ÖZET

Bireyin kendi kriterlerine bağlı en uygun bankayı seçmesi, değerlendirme süreci çok sayıda ölçüt içermesi nedeniyle çok karmaşık bir karar verme sürecidir ve bu süreç çakışan ölçütler arasında bir uzlaşmaya ihtiyaç duyar. Karar verme sürecinde karar vericilere veya kuruluşlara yardımcı olmak için çok kriterli karar verme yöntemleri geliştirilmiştir. AHP yöntemi, karar vericinin niteliksel ve niceliksel faktörleri birlikte değerlendirdiği benzer durumlarda kullanılır. Bu çalışmada, en uygun banka, seçim kriterlerine göre AHP yöntemi ile belirlenmeye çalışılmıştır. Çalışmada 5 bankanın, 3 farklı kritere ve kriterlere bağlı alt kriterlere göre karşılaştırmaları yapılarak en uygun bankaya karar verilmiştir. AHP yöntemine göre kriterler arasında ödeme geçmişi, uygun bankayı etkileyen en önemli ana kriter olmuştur. Yapılan çalışma sonucunda en uygun banka Vakıf Bankası olarak belirlenmiştir. Araştırma döneminde uzmanlara her bankanın kredi verirken uyguladıkları faiz oranının sabit olduğu koşulu belirtilmiştir.

Anahtar Kelimeler: Analitik Hiyerarşi Prosesi, Karar, Kriterler, Banka, Çok Kriterli Karar Verme.

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CHAPTER ONE

INTRODUCTION

Today's rapidly changing and increasingly difficult living and working conditions force people, institutions or businesses to consistently make "good" and "successful" decisions. Healthy decision-making is a requirement to cope with such an environment, to gain competitive advantage and to sustain it. Traditionally, when a decision is reached, the relevant data are collected and analyzed as "intuitive" to arrive at the conclusion. However, in many cases, alternative ways of behaving in order to be able to make successful decisions are judged by the support of scientific decision making techniques.

Problems of decision making in real life become complicated due to various factors. These reasons are that multiple factors and objectives must be evaluated together, that the objectives generally conflict with each other, The difficulties of measuring their attainment rates, the uncertainties involved in decision cases, the involvement of more than one actor in the decision making process, the consequences of the decision being of interest to many people and of vital importance.

Multiple-criteria decision-making (MCDM) is a procedure that combines the performance of decision alternatives across several, contradicting, qualitative and/or quantitative criteria and results in a compromise solution. Multi-criteria decision making is the best choice among multiple and the same criteria. In a rational decision-making environment, it is limited in the direction of the most preferred choice and management objectives. Multi-criteria decision making; In terms of its theoretical development and practical applications, has shown a very rapid development in the field of decision analysis. It has a strong logic structure and has a wide range of applications, which has been recognized by its success in decision making.

This study will use the analytical hierarchy process, which is a multi-criteria decision making method. In this way, individuals will be made to decide which bank is suited to them for their criteria when applying for a consumer loan.

Firstly, the definition of multi-criteria decision making will be studied, followed by the AHP method and its application which are used to solve multi-criteria decision making problems.

CHAPTER TWO

MULTI-CRITERIA DECISION MAKING

2.1 MULTI-CRITERIA DECISION MAKING

2.1.1 Definition

MCDM or MCDA are well-known acronyms for multiple-criteria decision-making and multiple-criteria decision analysis. MCDM is concerned with structuring and solving decision and planning problems involving multiple criteria. The purpose is to support decision makers facing such problems. Typically, there does not exist a unique optimal solution for such problems and it is necessary to use decision maker’s preferences to differentiate between solutions.

T. L. Saaty divides his decision (decision making processes) into two: "intuitive" and "Analytical". Intuitive decisions are not supported, and are usually given arbitrarily. In some simple, non-depth decision situations, an intuitive approach can be successful. But, When conflicting decision situations are encountered that require information, the decision makers can see that the decisions they ultimately deviate from their value judgments. It "Good judgment" is used for situations where deviations are not observed. Good decision-making in the sense of emphasizing the intuitive power of the person is seen as an "art".

Today, decision-making has become a "science" rather than an "art" as opposed to believing for a long time. In order for a decision to be successful, it is often necessary to evaluate the various actors and factors that conflict with one another, to reach the results that satisfy them, and to preserve the validity of these results over time. For this reason, approaches have been developed that bring together people's value judgments with objective and analytical methods.

Although MCDM problems could be very different in context, they share the following common features.

- **Multiple attributes/criteria often form a hierarchy.**

Almost any alternatives, such as an organization, an action plan, or a product of any kind, can be evaluated on the basis of attributes. An attribute is a property, quality or feature of alternatives in question. Some attributes may break down further into lower levels of attributes, called sub-attributes. To evaluate an alternative, a criterion is set up for each attribute. Because of the one to one correspondence between attribute and criterion, sometimes attributes are also referred to as criteria and used interchangeably in the MCDM context.

- **Conflict among criteria**
- **Hybrid nature**
  1. Incommensurable units.
  2. Mixture of qualitative and quantitative attributes.
  3. Mixture of deterministic and probabilistic attributes.
- **Uncertainty**
  1. Uncertainty in subjective judgments.
  2. Uncertainty due to lack of data or incomplete information
- **Large Scale**
- **Assessment may not be conclusive**

2.1.2 Steps of Decision Making

A decision making process involves the following steps to be followed:

1) Identifying the objective/goal of the decision making process

2) Selection of the Criteria/Parameters/Factors/Decider

3) Selection of the Alternatives

4) Selection of the weighing methods to represent importance

5) Method of Aggregation

6) Decision making based on the Aggregation results

2.1.3 Working Principle

The MCDM process follows a common working principle as described below:

- **Selection of Criteria**

Selected criteria must be:

- Coherent with the decision ,
- Independent of each other ,
- Represented in same scale,
- Measurable Not Unrelated with the alternatives.

- **Selection of Alternatives**

Selected alternatives must be:

Available Comparable Real not Ideal Practical/Feasible .

- **Selection of the Weighing Methods to Represent Importance**

The weight determination methods can be either compensatory or outrankable.

- **Method of Aggregation**

- Can be a Product ,
- Can be an Average,
- Can be a Function ,

- The result of this aggregation will actually separate the best alternative from the available options.

CHAPTER THREE
ANALYTICAL HIERARCHICAL PROCESS

3.1. Analytical Hierarchical Process (AHP)

Consideration of human judgment in the decision-making process may increase effectiveness. The judgment level of decision criteria for each person in the same decision problem and judgments about judging decision options can vary. AHP can be used to solve such decision problems. The Analytic Hierarchy Process was first proposed by Myers and Alpert in 1968. In 1977, it was developed by Professor Thomas L. Saaty and is a decision-making method used to solve complex problems involving multiple criteria. The AHP allows modeling in a hierarchical structure that shows the relationship between the decision makers' complex problems, the main objective of the problem, criteria, sub-criteria and alternatives. The most important feature of the AHP is that the decision maker can incorporate both objective and subjective considerations into the decision process. In other words, AHP is a method in which knowledge, experience, individual thoughts and precepts are logically combined.

In this way, in this method, a hierarchical structure can be understood as the name implies and the best solution for the problem is found. In this structure, the problem to be solved is divided into parts, namely purpose, criteria and alternatives. The gradual division of the problem in this way makes the event clearer and simpler. All of the divided parts are firstly assessed within themselves and then the probing aims to produce a whole solution by combining the decision mechanisms in these parts. A configuration that will be done in this way in the system also ensures that the ideas of many experts can be included in the solution process as well. In the AHP technique, it was stated that knowledge and experience should have some characteristics in order to be able to incorporate the problem into the solution process and it was collected in the following titles (Saaty, 1996);

The steps to be taken in order to solve a decision making problem with AHP are described as follows:

1. Defining Decision Making Problem:
   Decision points are first identified in defining the decision making problem. In the second stage, factors affecting decision points are identified.
2. Identification of Expert Persons:
   After defining the decision-making problem, expert persons are identified, their aims and opinions are recorded and the factors that will affect the result are revealed.
3. Creating the Hierarchy:
   A hierarchical structure is established in line with the opinions of the experts and the factors affecting the result and the items are sorted according to their importance.
4. Binary Comparisons:

According to the criterions to be evaluated of the decision options, the person or persons are making the decision will make binary comparisons with each other.

The factorial comparison matrix is a square matrix of nxn dimensions. The matrix components on the diagonal of this matrix take the value 1.

$$A = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix}$$

$[\,a_{ij}\,]$ where $i, j = 1,2,\dots,n$, $a_{ij}=1$ for $i=j$,

$$a_{ij} = \frac{1}{a_{ji}} \quad \text{for } i \neq j.$$

The comparison of the factors is made one to the other and mutually according to the importance values they have according to each other. In the interrelated comparison of the factors, the importance scale in Table 3.1, created by Saaty, is used. (Saaty, 1980)

Table 3.1 Scale of Importance

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favour one activity over another
5	Strong importance	Experience and judgment strongly favour one activity over another
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2,4,6,8		Intermediate values

For example, if the first factor is more important than the third factor by the comparator, then the first row of the comparison matrix will take the value 3 of the third column component. Otherwise, if the first factor is compared to the third factor, the more important choice is to use the third factor, in this case the first row of the comparison matrix will take the value of the third column component1/3. In the comparison of the first factor with the third factor in the same comparison, if the preference is that the factors have an equal value, then the component will have value 1.

6. Normalize Operation:

As a result of this evaluation, a matrix A is obtained in binary comparisons of decision options and decision options according to each decision criterion. This matrix is

normalized. The column sums are computed for this operation and divided by the sum of its own column for each value. The normalized C matrix is found at the end of the operation.

$$C = \begin{bmatrix} c_{11} & c_{12} & \dots & c_{1n} \\ c_{21} & c_{22} & \dots & c_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ c_{n1} & c_{n2} & \dots & c_{nn} \end{bmatrix}$$

By using the matrix C, the percentage significance distributions can be obtained which show the significance values of the factors with respect to each other. For this, as shown in (2.1), the arithmetic mean of the row components forming the C matrix is taken and the W column vector called criteria weight vector W is obtained.

$$w_i = \frac{\sum_{j=1}^{n} c_{ij}}{n} \qquad (3.1)$$

The W vector,

$$W = \begin{bmatrix} w_1 \\ w_2 \\ . \\ . \\ . \\ w_n \end{bmatrix}$$

7. Measurement of Consistency in Factor Benchmarks:

Once the priority vectors have been calculated, the consistency of the comparison matrix has to be checked. Although the AHP has a coherent system in itself, the realism of the results will depend on the consistency of the decision maker's comparison between the factors. If the comparison matrix is not correct, the resulting weights cannot be used. The calculation of the reliability ratio (CR) is based on a comparison of the number of factors and a coefficient (λ) that is the maximum Eigenvalue of the judgment matrix. For the calculation of λ, the matrix A is multiplied by the matrix of the criteria weight vector W, and the column vector D is obtained.

$$D = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix} x \begin{bmatrix} w_1 \\ w_2 \\ \cdot \\ \cdot \\ \cdot \\ w_n \end{bmatrix}$$

The λ for each evaluation factor is obtained by dividing the D column vector and the W column vector by their reciprocal elements. (3.2)

$$E_i = \frac{d_i}{w_i} \quad (i = 1,2,...,n) \qquad (3.2)$$

The arithmetic mean of these values gives λ for comparison.

$$\lambda = \frac{\sum_{i=1}^{n} E_i}{n} \qquad (3.3)$$

Once the λ has been calculated, the Consistency Indicator (CI) can be calculated using formula (3.4)

$$CI = \frac{\lambda - n}{n - 1} \tag{3.4}$$

In the last stage, CI is obtained by dividing the CI by the standard correction value, which is called Random Indicator (RI) and shown in Table 3.2. (3.5)

Table 3.2 Random Indicator (RI)

N	RI	N	RI
1	0	8	1,41
2	0	9	1,45
3	0,58	10	1,49
4	0,90	11	1,51
5	1,12	12	1,48
6	1,24	13	1,56

$$CR = \frac{CI}{RI} \tag{3.5}$$

A CR of less than 0,10 indicates that the decisions made by the decision maker are consistent. A value greater than 0,10 indicates that there is a calculation error in the AHP or that the decision maker is inconsistent with the comparisons.

8. Finding Percent Significance Distributions of Decision Points for Each Factor:

This step is as described above, but this time, the percentage distribution of the decision points is determined for each factor. That is, the comparisons and matrix operations are repeated as many as the number of factors (n times). After each comparison operation, S column vectors are obtained which represent the percent distributions of the dimension and evaluated factor according to the decision points.

$$S_i = \begin{bmatrix} s_{11} \\ s_{21} \\ . \\ . \\ . \\ s_{m1} \end{bmatrix}$$

9. Finding the Distribution of Results at Decision Points.

In this stage, first, an mxn dimensional K decision matrix is formed, which is formed from n mx1 dimensional S column vectors described above.

$$K = \begin{bmatrix} s_{11} & s_{12} & \cdots & s_{1n} \\ s_{21} & s_{22} & \cdots & s_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ s_{m1} & s_{m2} & \cdots & s_{mn} \end{bmatrix}$$

Finally, when the decision matrix is multiplied by W column vector (criteria weight vector) as follows, the L column vector of m elements is obtained. The L column vector gives the percentage distribution of decision points.

$$L = \begin{bmatrix} s_{11} & s_{12} & \cdots & s_{1n} \\ s_{21} & s_{22} & \cdots & s_{2n} \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ s_{m1} & s_{m2} & \cdots & s_{mn} \end{bmatrix} x \begin{bmatrix} w_1 \\ w_2 \\ \cdot \\ \cdot \\ \cdot \\ w_n \end{bmatrix} = \begin{bmatrix} l_{11} \\ l_{21} \\ \cdot \\ \cdot \\ \cdot \\ l_{m1} \end{bmatrix}$$

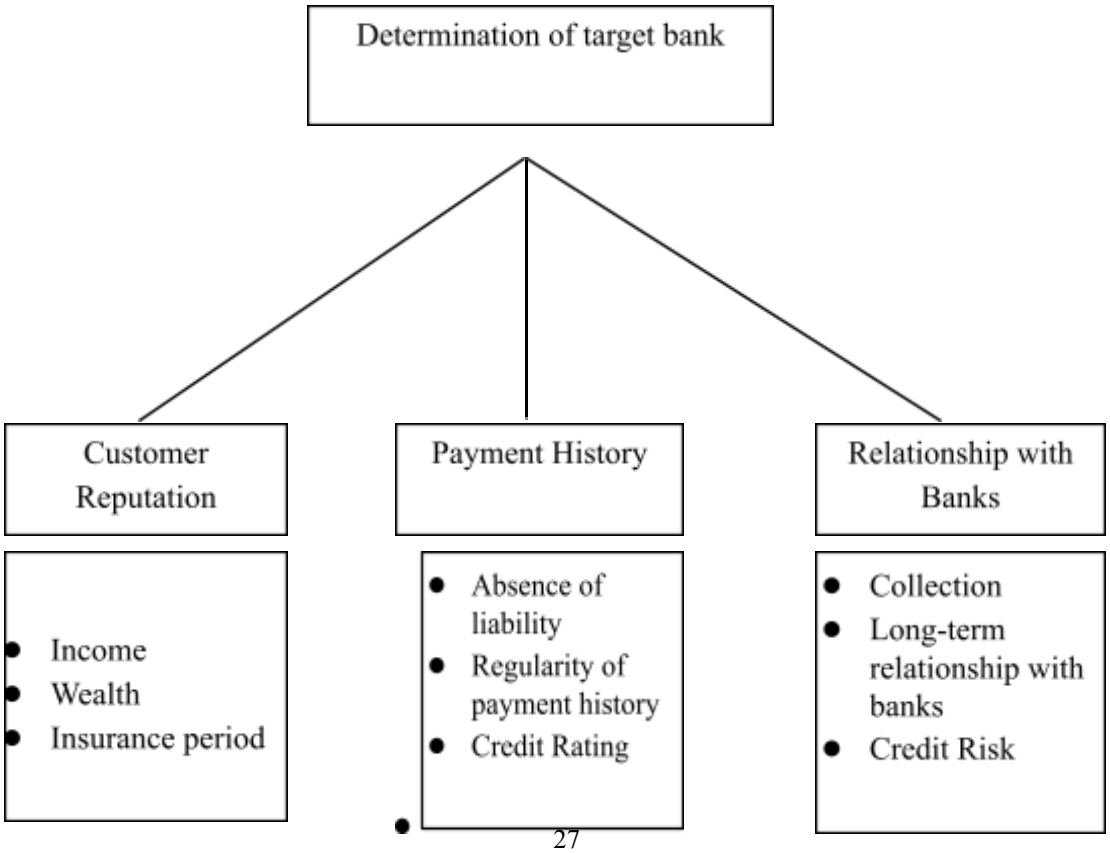
This distribution also shows the order of importance of the decision points.

CHAPTER FOUR

APPLICATION

4.1. APPLICATION ANALITIC HIERARCHY PROCESS

In this study, it was targeted that an individual who needs a loan should select the most suitable bank for his / her conditions while receiving a loan. Concepts were created in accordance with individual conditions and they were divided into 3 groups as customer reputation, payment history and relationship with banks. The identified key criteria and their sub-criteria may have different effects on each bank. The AHP method was used when evaluating with the help of the criteria and sub criteria set in a hierarchical structure.


Determination of target bank
Customer Reputation
Payment History
Relationship with Banks
Income
Wealth
Insurance period
Absence of liability
Regularity of payment history
Credit Rating
Collection
Long-term relationship with banks
Credit Risk

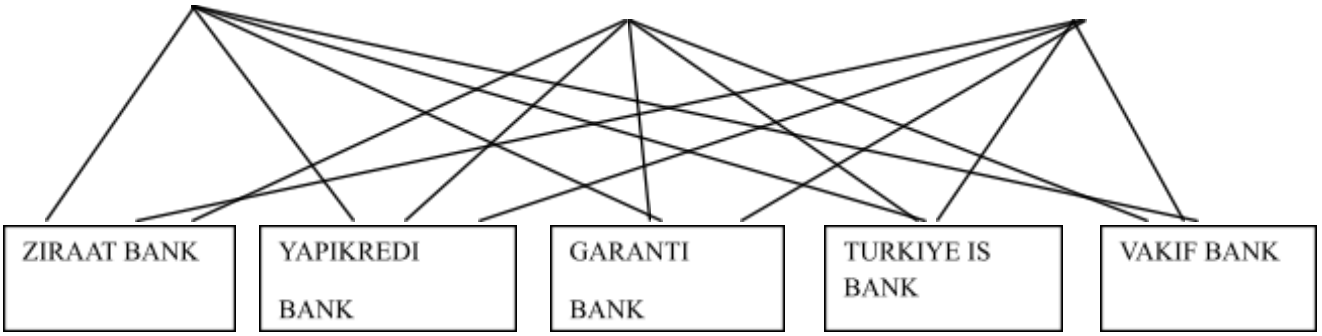


Figure 4.1 Hierarchical Structure

When the main and sub criteria were determined in the study, information was obtained from the banks and a comprehensive questionnaire including all the criteria was prepared and the criteria were weighted.

Ziraat Bank	YapiKredi Bank	Garanti Bank	TurkiyeIsBank	Vakif Bank
1)Insurance period	1) Collection	1)Insurance period	1) Credit rating	1) Regularity of payment history
2) Collection	2) Regularity of payment history	2) Collection	2) Income	2) Income
3) Income	3) Credit rating	3) Regularity of payment history	3)Credit risk	3) Insurance period
4) Credit rating	4)Credit risk	4) Income	4) Regularity of payment history	4)Absence of liability
5) Regularity of payment history	5)Absence of liability	5)Credit risk	5)Absence of liability	5)Credit risk

6)Credit risk	6) Income	6)Absence of liability	6) Wealth	6) Collection
7)Long-term relationship with banks	7)Long-term relationship with banks	7)Long-term relationship with banks	7) Collection	7) Credit rating
8)Absence of liability	8) Wealth	8) Wealth	8) Insurance period	8) Wealth
9)Wealth	9)Insurance period	9) Credit rating	9)Long-term relationship with banks	9)Long-term relationship with banks

Figure 4.2 Criteria Ranking According To Experts

In the examination conducted by specialists, the payment history, which is the main criterion, was rated higher than the other important criteria, customer reputation, in terms of importance. Then,

The main criterion of customer reputation is more important than the criteria of the relationship with banks.

The main criteria of the problem and the sub-criteria for them have been determined. When these criteria were determined, they were interviewed by experts in the banks and 5 banks agreed to participate in the evaluation by approaching positively.

After this process is done, there is a process of determining the importance of the criteria according to the purpose. Firstly, after the objective is determined, the following Table 3.1 appears with the help of binary comparisons.

Table 4.1 The Binary Comparison Matrix of the Main Criteria

Criteria	Customer Reputation	Payment History	Relationship with Banks
Customer Reputation	1	0,143	3
Payment History	7	1	9
Relationship with Banks	0,333	0,111	1
SUM	8,333	1,254	13

In order to calculate the importance of the main criteria, the first thing to do is normalize the previous Table 4.1 matrix. For this normalization the values of each column in Table 4.1 are summed. Then, each value in the columns is normalized by dividing it into its own column sum. Table 4.2 shows the normalized binary comparison matrix of the main criteria according to the purpose. It is necessary to calculate the consistency ratio in order to be able to determine whether the normalized binary comparison matrix generated by the experts is consistent.

For this purpose λ is calculated. Then, λ=3,081694723. And then the consistency index is calculated.

$$CI = \frac{\lambda - n}{n-1} \qquad (4.1)$$

CI= 0, 0408473615

After this process it is checked whether the matrix is consistent. The consistency ratio must be calculated for this. It is necessary to find the random index in Table 3.2 to calculate the consistency ratio as shown below.

$$CR=\frac{CI}{RI}=0,0704264854 \qquad (4.2)$$

It can be said that the judgment matrix is consistent within itself because this value is less than 0,1.

Table 4.2 Normalized Binary Comparison Matrix the Main Criteria

Criteria	Customer Reputation	Payment History	Relationship with Banks	W	Aw	Aw/w
Customer Reputation	0,120	0,114	0,231	0,155	0,471	3,042
Payment History	0,840	0,797	0,692	0,777	2,477	3,190
Relationship with Banks	0,040	0,0885	0,077	0,068	0,206	3,013
SUM	1,000	1,000	1,000	1,000		

According to this result, importance orders have emerged according to the purpose of the main criteria. Since a judge matrix has consistency in itself, we can obtain the order of importance of sub-criteria using this matrix in order to reach the final result. Criteria weight vector w= (0,155, 0,777, 0,068) gives priority order according to the purpose of the criteria.

The criterion with the highest value of 0.777 is the Payment History. Then the criterion with the value of 0,155 is the Customer Reputation, the criterion with the value of 0,068 is the Relationship with Banks, respectively.

In this section, importance ranks of sub criteria are calculated according to each upper criterion. First, binary comparison matrices must be established. From these matrices, a multiple comparison matrix is obtained. Comparison matrices are created by experts who assist in the study of each of the main criteria and sub-criteria based on this main criterion. The order of importance obtained here determines which sub-criterion has priority criteria that the when individual choosing the most suitable bank.

First, a binary comparison matrix will be made for the criterion with Payment History, which is ranked first in importance. Subsequent criterion will be listed after the remaining two main criteria.

Table 4.3 Binary Comparison Matrix of Payment History Sub-criteria

Sub-criteria	Absence of Liability	Regularity of Payment History	Credit Rating
Absence of Liability	1	0,111	0,333
Regularity of Payment History	9	1	7
Credit Rating	3	0,143	1
SUM	13	1,254	8,333

In the examination conducted by specialists, the Regularity of Payment History, which is the sub-criterion, was rated higher than the other sub-criterion Credit Rating, in terms of importance.

Then, the sub-criterion of the Credit Rating is more important than the criteria of the Absence of Liability.

In order to calculate the importance of the sub criteria, the first thing to do is normalize the previous Table 4.3 matrix.

Table 4.4 Normalized Binary Comparison Matrix of Payment History Sub-criteria

Subcriteria	Absence of Liability	Regularity of Payment History	Credit Rating	W	Aw	Aw/w
Absence of Liability	0,077	0,089	0,034	0,068	0,206	3,013
Regularity of Payment History	0,692	0,797	0,840	0,777	2,477	3,190
Credit Rating	0,231	0,114	0,120	0,155	0,471	3,042
SUM	1,000	1,000	1,000	1,000		

Then we have to find λ for this purpose. Then, λ=3,081694723. And the consistency index is calculated.

$$CI = \frac{\lambda - n}{n - 1}$$

CI=0.0408473615 As in the above process (4.2)

CR=$\frac{CI}{RI}$= 0,0704264854

It can be said that the judgment matrix is consistent within itself because this value is less than 0,1.

Secondly, a binary comparison matrix will be made for the criteria with Customer Reputation, which is ranked second in importance.

Table 4.5 Binary Comparison Matrix of Customer Reputation Sub-criteria

Sub-criteria	Income	Wealth	Insurance period
Income	1	9	3
Wealth	0,111	1	0,143
Insurance period	0,333	7	1
SUM	1,444	17	4,143

In this matrix, the sub-criterion Income was rated higher than the other sub criterion Insurance Period, over the significance level. After, the sub-criterion of the Insurance Period is more important than the Wealth sub-criterion.

In order to calculate the importance of the sub-criteria, then we have to normalize the previous Table 4.5 matrix.

Table 4.6 Normalized Binary Comparison Matrix of Customer Reputation Sub-criteria

Sub-criteria	Income	Wealth	Insurance Period	W	Aw	Aw/w
Income	0,693	0,529	0,724	0,649	2,043	3,150

Wealth	0,077	0,059	0,0345	0,057	0,171	3,012
Insurance Period	0,231	0,412	0,241	0,295	0,908	3,081
SUM	1,000	1,000	1,000	1,000		3,081

Same process is applied. Then, λ= 3,081694723. And then the consistency index is calculated.

$$CI = \frac{\lambda - n}{n - 1}$$

CI= 0,0404318782 As in the above process, (4.2)

CR=$\frac{CI}{RI}$= 0,0697101349

It can be said that the judgment matrix is consistent within itself because this value is less than 0,1.

Finally, binary comparison matrices will be created with sub-criterion of Relationship with Banks criteria. So that the order of importance will be established.

Table 4.7 Binary Comparison Matrix of Relationship with Banks Sub-criteria

Sub-criteria	Collection	Long-term Relationship with Banks	Credit Risk
Collection	1	9	3

Long-term Relationship with Banks	0,111	1	0,143
Credit Risk	0,333	7	1
SUM	1,444	17	4,143

In the above comparison matrix, the sub-criterion Collection is rated higher than the other sub-criteria Credit Risk, relative to the rating level. Subsequently, the sub-criterion for Credit Risk is more important than the sub-criterion for a Long-term Relationship with Banks.

In order to calculate the importance of the sub-criteria, same process as above, the first thing to do is normalize the previous Table 4.7 matrix.

Table 4.8 Normalized Binary Comparison Matrix of Relationship with Banks Sub-criteria

Subcriteria	Collecton	Long-term Relationship with banks	Credit Risk	W	Aw	Aw/w
Collection	0,693	0,529	0,724	0,649	2,043	3,150
Long-term Relationshi pwith banks	0,077	0,059	0,034	0,057	0,171	3,012
Credit Risk	0,231	0,412	0,241	0,295	0,908	3,081
SUM	1,000	1,000	1,000	1,000		3,081

For this purpose, λ is calculated. Then, λ= 3,081694723. And then the consistency index is calculated.

$$CI = \frac{\lambda - n}{n - 1}$$

CI= 0,0404318782

As in the above process, (4.2)

CR=$\frac{CI}{RI}$= 0,0697101349

It can be said that the judgment matrix is consistent within itself because this value is less than 0,1.

According to this result, it is found that the criterion having the highest priority for the most suitable bank selection for the 3 sub-criteria under the Payment History main criteria is the Regularity of the Payment History. Followed by Collection and Income according to their importance.

Table 4.9 Importance Ratings of Sub-criteria

Absence of Liability	0,06846714
Regularity of Payment History	0,77659649
Credit Rating	0,15493637
Income	0,64868183

Wealth	0,05673646
Insurance Period	0,29458170
Collection	0,64868183
Long-term Relationship with Banks	0,05673646
Credit Risk	0,29458170

For the five banks, the number of superiority will be determined based on the questionnaire results.

Table 4.10 Binary Comparison Matrices for Decision Alternatives for Absence of Liability

Absence of Liability	ZIRAAT BANK	TURKIYE IS BANK	GARANTI BANK	VAKIF BANK	YAPIKREDI BANK
ZIRAAT BANK	1	0,143	0,2	0,111	0,143
TURKIYE IS BANK	7	1	3	0,333	1
GARANTI BANK	5	0,333	1	0,2	0,333
VAKIF BANK	9	3	5	1	3
YAPIKREDI BANK	7	1	3	0,333	1
SUM	29	5,48	12,2	1,977	5,476

In order to calculate the importance of the decision alternatives, then we have to normalize the previous Table 4.10 matrix.

Table 4.11 Normalized Binary Comparison Matrix for Decision Alternatives

	ZIRAAT BANK	TURKIYE IS BANK	GARANTI BANK	VAKIF BANK	YAPIKREDI BANK	W	AW	AW/W
ZIRAAT BANK	0,035	0,0261	0,016	0,056	0,026	0,032	0,161	5,051
TURKIYE IS BANK	0,241	0,183	0,246	0,168	0,183	0,204	1,072	5,251
GARANTI BANK	0,172	0,061	0,082	0,101	0,061	0,095	0,484	5,067
VAKIF BANK	0,310	0,548	0,410	0,506	0,548	0,463	2,453	5,283
YAPIKREDI BANK	0,241	0,183	0,246	0,168	0,183	0,204	1,072	5,251
SUM	1,000	1,000	1,000	1,000	1,000			5,181

Now, applied same process and λ is calculated. Then, λ= 5,1807618201. And then the consistency index is calculated.

$$CI = \frac{\lambda - n}{n - 1}$$

CI= 0,0451904550 As in the above process, (4.2)

CR=$\frac{CI}{RI}$= 0,0403486206 < 0,10

It can be said that the judgment matrix is consistent within itself because this value is less than 0,1 .

Table 4.12 Binary Comparison Matrices for Decision Alternatives for Regularity of Payment History

Regularity of Payment History	ZIRAAT BANK	TURKIYE IS BANK	GARANTI BANK	VAKIF BANK	YAPIKREDI BANK
ZIRAAT BANK	1	0,333	0,2	0,111	0,143
TURKIYE IS BANK	3	1	0,333	0,143	0,2
GARANTI BANK	5	3	1	0,2	0,333
VAKIF BANK	9	7	5	1	3
YAPIKREDI BANK	7	5	3	0,333	1
SUM	25	16,333	9,533	1,787	4,676

In order to calculate the importance of the decision alternatives, we need to do is normalize the previous Table 4.12 matrix.

Table 4.13 Normalized Binary Comparison Matrix for Decision Alternatives

	ZIRAAT BANK	TURKIYE IS BANK	GARANTI BANK	VAKIF BANK	YAPIKREDI BANK	W	AW	AW/W
ZIRAAT BANK	0,040	0,020	0,021	0,062	0,0306	0,035	0,177	5,092
TURKIYE IS BANK	0,120	0,061	0,035	0,080	0,0428	0,068	0,341	5,029
GARANTI BANK	0,200	0,184	0,105	0,112	0,071	0,134	0,699	5,203

VAKIF BANK	0,360	0,429	0,524	0,560	0,642	0,503	2,743	5,455
YAPIKREDI BANK	0,280	0,306	0,315	0,186	0,214	0,260	1,413	5,432
SUM	1,000	1,000	1,000	1,000	1,000			5,242

For this purpose λ is calculated. Then, λ=5,2421937289. And then the consistency index is calculated.

$$CI = \frac{\lambda - n}{n - 1}$$

CI= 0,0605484322

After this process it is checked whether the matrix is consistent. The consistency ratio must be calculated for this. It is necessary to find the random index in Table 3.2 to calculate the consistency ratio as shown below.

CR=$\frac{CI}{RI}$= 0,0540611002 < 0,10

It can be said that the judgment matrix is consistent within itself because this value is less than 0,1 .

Table 4.14 Binary Comparison Matrices for Decision Alternatives for Credit Rating

Credit Rating	ZIRAAT BANK	TURKIYE IS BANK	GARANTI BANK	VAKIF BANK	YAPIKREDI BANK

ZIRAAT BANK	1	0,2	7	5	0,333
TURKIYE IS BANK	5	1	9	7	3
GARANTI BANK	0,143	0,111	1	0,333	0,143
VAKIF BANK	0,2	0,143	3	1	0,2
YAPIKREDI BANK	3	0,333	7	5	1
SUM	9,343	1,787	27	18,333	4,676

In order to calculate the importance of the decision alternatives, the first thing to do is normalize the previous Table 4.14 matrix.

Table 4.15 Normalized Binary Comparison Matrix for Decision Alternatives

	ZIRAAT BANK	TURKIYE IS BANK	GARANTI BANK	VAKIF BANK	YAPIKREDI BANK	W	AW	/W
ZIRAAT BANK	0,107	0,112	0,259	0,273	0,071	0,164	0,884	5,378
TURKIYE IS BANK	0,535	0,560	0,333	0,382	0,642	0,490	2,792	5,694
GARANTI BANK	0,015	0,062	0,037	0,018	0,033	0,033	0,167	5,118
VAKIF BANK	0,021	0,080	0,111	0,055	0,043	0,062	0,313	5,051
YAPIKREDI BANK	0,321	0,186	0,259	0,273	0,214	0,251	1,446	5,767

SUM	1,000	1,000	1,000	1,000	1,000			5,402

Now, applied same process and λ is calculated. Then, λ = 5,4017389710. And then the consistency index is calculated.

$$CI = \frac{\lambda - n}{n - 1}$$

CI=0,100434743

After this process it is checked whether the matrix is consistent. The consistency ratio must be calculated for this. It is necessary to find the random index in Table 3.2 to calculate the consistency ratio as shown below.

CR=$\frac{CI}{RI}$=0,0896738775<0,10

It can be said that the judgment matrix is consistent within itself because this value is less than 0,1.

Table 4.16 Binary Comparison Matrices for Decision Alternatives for Income

Income	ZIRAAT BANK	TURKIYE IS BANK	GARANTI BANK	VAKIF BANK	YAPIKREDI BANK
ZIRAAT BANK	1	0,333	3	0,333	7

TURKIYE IS BANK	3	1	5	1	9
GARANTI BANK	0,333	0,2	1	0,2	5
VAKIF BANK	3	1	5	1	9
YAPIKREDI BANK	0,143	0,111	0,2	0,111	1
SUM	7,476	2,644	14,2	2,644	31

In order to calculate the importance of the decision alternatives, we have to do is normalize the previous Table 4.16 matrix.

Table 4.17 Normalized Binary Comparison Matrix for Decision Alternatives

	ZIRAAT BANK	TURKIYE IS BANK	GARANTI BANK	VAKIF BANK	YAPIKREDI BANK	W	AW	AW/W
ZIRAAT BANK	0,134	0,126	0,211	0,126	0,226	0,165	0,870	5,288
TURKIYE IS BANK	0,401	0,378	0,352	0,378	0,290	0,360	1,910	5,306
GARANTI BANK	0,045	0,076	0,070	0,076	0,161	0,086	0,434	5,073
VAKIF BANK	0,401	0,378	0,352	0,378	0,290	0,360	1,910	5,306
YAPIKREDI BANK	0,019	0,042	0,014	0,042	0,032	0,030	0,150	5,034
SUM	1,000	1,000	1,000	1,000	1,000		$\lambda\_MAX=$	5,201

For this purpose λ is calculated. Then λ=5,2011008146. And then the consistency index is calculated.

$$CI = \frac{\lambda - n}{n - 1}$$

CI=0,050275204

After this process it is checked whether the matrix is consistent.The consistency ratio must be calculated for this. It is necessary to find the random index in Table 3.2 to calculate the consistency ratio as shown below.

CR=$\frac{CI}{RI}$=0,044888575<0,10

It can be said that the judgment matrix is consistent within itself because this value is less than 0,1.

Table 4.18 Binary Comparison Matrices for Decision Alternatives for Wealth

Wealth	ZIRAAT BANK	TURKIYE IS BANK	GARANTI BANK	VAKIF BANK	YAPIKREDI BANK
ZIRAAT BANK	1	0,111	0,333	0,333	0,333
TURKIYE IS BANK	9	1	5	5	5
GARANTI BANK	3	0,2	1	1	1
VAKIF BANK	3	0,2	1	1	1

YAPIKREDI BANK	3	0,2	1	1	1
SUM	19	1,711	8,333	8,333	8,333

In order to calculate the importance of the decision alternatives, the first thing to do is normalize the previous Table 4.18 matrix.

Table 4.19 Normalized Binary Comparison Matrix for Decision Alternatives

	ZIRAAT BANK	TURKIYE IS BANK	GARANTI BANK	VAKIF BANK	YAPIKREDI BANK	W	AW	AW/W
ZIRAAT BANK	0,053	0,065	0,040	0,040	0,040	0,047	0,238	5,008
TURKIYE IS BANK	0,474	0,584	0,600	0,600	0,600	0,572	2,903	5,079
GARANTI BANK	0,158	0,117	0,120	0,120	0,120	0,127	0,638	5,022
VAKIF BANK	0,158	0,117	0,120	0,120	0,120	0,127	0,638	5,022
YAPIKREDI BANK	0,158	0,117	0,120	0,120	0,120	0,127	0,638	5,0223
SUM	1,000	1,000	1,000	1,000	1,000		λ_MAX	5,031

Same process is applied. Then, λ = 5,0307964880. And then the consistency index is calculated.

$$CI = \frac{\lambda - n}{n - 1}$$

CI=0,0076991220

After this process it is checked whether the matrix is consistent. The consistency ratio must be calculated for this. It is necessary to find the random index in Table 3.2 to calculate the consistency ratio as shown below.

CR=$\frac{CI}{RI}$=0,006874216 < 0,10

It can be said that the judgment matrix is consistent within itself because this value is less than 0,1.

Table 4.20 Binary Comparison Matrices for Decision Alternatives for Insurance Period

Insurance period	ZIRAAT BANK	TURKIYE IS BANK	GARANTI BANK	VAKIF BANK	YAPIKREDI BANK
ZIRAAT BANK	1	7	1	3	9
TURKIYE IS BANK	0,143	1	0,143	0,2	3
GARANTI BANK	1	7	1	3	9
VAKIF BANK	0,333	5	0,333	1	7
YAPIKREDI BANK	0,111	0,333	0,111	0,143	1
SUM	2,587	20,333	2,587	7,343	29

In order to calculate the importance of the decision alternatives, we need to do is normalize the previous Table 4.20 matrix.

Table 4.21 Normalized Binary Comparison Matrix for Decision Alternatives

	ZIRAAT BANK	TURKIYE IS BANK	GARANTI BANK	VAKIF BANK	YAPIKREDI BANK	W	AW	AW/W
ZIRAAT BANK	0,387	0,344	0,387	0,409	0,310	0,367	1,951	5,312
TURKIYE IS BANK	0,055	0,049	0,055	0,027	0,103	0,058	0,292	5,028
GARANTI BANK	0,387	0,344	0,387	0,409	0,310	0,367	1,951	5,312
VAKIF BANK	0,129	0,2466	0,129	0,136	0,241	0,176	0,930	5,277
YAPIKREDI BANK	0,043	0,016	0,043	0,019	0,034	0,031	0,157	5,037
	1,000	1,000	1,000	1,000	1,000			5,193

For this purpose λ is calculated. Then, λ =5,1930858437. And then the consistency index is calculated.

$$CI = \frac{\lambda - n}{n - 1}$$

CI=0,048271461

After this process it is checked whether the matrix is consistent. The consistency ratio must be calculated for this. It is necessary to find the random index in Table 3.2 to calculate the consistency ratio as shown below.

CR=$\frac{CI}{RI}$=0,043099519 < 0,10

It can be said that the judgment matrix is consistent within itself because this value is less than 0,1.

Table 4.22 Binary comparison matrices for decision alternatives for Collection

Collection	ZIRAAT BANK	TURKIYE IS BANK	GARANTI BANK	VAKIF BANK	YAPIKREDI BANK
ZIRAAT BANK	1	7	1	5	0,333
TURKIYE IS BANK	0,143	1	0,143	0,333	0,111
GARANTI BANK	1	7	1	5	0,333
VAKIF BANK	0,2	3	0,2	1	0,143
YAPIKREDI BANK	3	9	3	7	1
SUM	5,343	27	5,343	18,333	1,92

In order to calculate the importance of the decision alternatives, the first thing to do is normalize the previous Table 4.22 matrix.

Table 4.23 Normalized Binary Comparison Matrix for Decision Alternatives

	ZIRAAT BANK	TURKIYE IS BANK	GARANTI BANK	VAKIF BANK	YAPIKREDI BANK	W	AW	AW/W
ZIRAAT BANK	0,187	0,259	0,187	0,273	0,173	0,216	1,137	5,266
TURKIYE IS BANK	0,027	0,037	0,027	0,018	0,058	0,033	0,168	5,056
GARANTI BANK	0,187	0,259	0,187	0,273	0,173	0,216	1,137	5,266
VAKIF BANK	0,037	0,111	0,037	0,055	0,074	0,063	0,317	5,028
YAPIKREDI BANK	0,561	0,333	0,561	0,382	0,521	0,472	2,508	5,316
SUM	1,000	1,000	1,000	1,000	1,000			5,187

For this purpose λ is calculated. Then, λ =5,1865317842. And then the consistency index is calculated.

$$CI = \frac{\lambda - n}{n - 1}$$

CI=0,046632946

After this process it is checked whether the matrix is consistent. The consistency ratio must be calculated for this. It is necessary to find the random index in Table 3.2 to calculate the consistency ratio as shown below.

CR=$\frac{CI}{RI}$=0,041636559<0,10

It can be said that the judgment matrix is consistent within itself because this value is less than 0,1.

Table 4.24 Binary Comparison Matrices for Decision Alternatives for Long-term Relationship with Banks

Long-term Relationship with Banks	ZIRAAT BANK	TURKIYE IS BANK	GARANTI BANK	VAKIF BANK	YAPIKREDI BANK
ZIRAAT BANK	1	7	1	7	1
TURKIYE IS BANK	0,143	1	0,143	1	0,143
GARANTI BANK	1	7	1	7	1
VAKIF BANK	0,143	1	0,143	1	0,143
YAPIKREDI BANK	1	7	1	7	1
SUM	3,286	23	3,286	23	3,286

In order to calculate the importance of the decision alternatives, the first thing to do is normalize the previous Table 4.24 matrix.

Table 4.25 Normalized Binary Comparison Matrix for Decision Alternatives

	ZIRAAT BANK	TURKIYE IS BANK	GARANTI BANK	VAKIF BANK	YAPIKREDI BANK	W	AW	AW/W
ZIRAAT BANK	0,304	0,304	0,304	0,304	0,3044	0,304	1,522	5,001
TURKIYE IS BANK	0,044	0,043	0,044	0,043	0,044	0,044	0,218	5,001

GARANTI BANK	0,304	0,304	0,304	0,304	0,304	0,304	1,522	5,001
VAKIF BANK	0,044	0,043	0,044	0,043	0,044	0,044	0,218	5,001
YAPIKREDI BANK	0,304	0,304	0,304	0,304	0,304	0,304	1,522	5,001
SUM	1,000	1,000	1,000	1,000	1,000			5,001

For this purpose λ is calculated. Then, λ=5, 0011997122. And then the consistency index is calculated.

$$CI = \frac{\lambda - n}{n - 1}$$

CI=0,0002999280

After this process it is checked whether the matrix is consistent.The consistency ratio must be calculated for this. It is necessary to find the random index in Table 3.2 to calculate the consistency ratio as shown below.

CR=$\frac{CI}{RI}$=0,0002677929 < 0,10

It can be said that the judgment matrix is consistent within itself because this value is less than 0,1.

Table 4.26 Binary Comparison Matrices for Decision Alternatives for Credit Risk

Credit Risk	ZIRAAT BANK	TURKIYE IS BANK	GARANTI BANK	VAKIF BANK	YAPIKREDI BANK

ZIRAAT BANK	1	0,111	0,333	0,333	0,2
TURKIYE IS BANK	9	1	5	5	3
GARANTI BANK	3	0,2	1	1	0,333
VAKIF BANK	3	0,2	1	1	0,333
YAPIKREDI BANK	5	0,333	3	3	1
SUM	21,000	1,844	10,333	10,333	4,866

In order to calculate the importance of the decision alternatives, the first thing to do is normalize the previous Table 4.26 matrix.

Table 4.27 Normalized Binary Comparison Matrix for Decision Alternatives

	ZIRAAT BANK	TURKIYE IS BANK	GARANTI BANK	VAKIF BANK	YAPIKREDI BANK	W	AW	AW/W
ZIRAAT BANK	0,048	0,060	0,032	0,032	0,041	0,043	0,216	5,060
TURKIYE IS BANK	0,428	0,543	0,483	0,484	0,617	0,511	2,645	5,174
GARANTI BANK	0,143	0,108	0,097	0,097	0.068	0,103	0,516	5,024
VAKIF BANK	0,143	0,108	0,097	0,097	0,068	0,103	0,516	5,024
YAPIKREDI BANK	0,238	0,181	0,291	0,290	0,206	0,241	1,241	5,148
SUM	1,000	1,000	1,000	1,000	1,000			5,087

For this purpose λ is calculated. Then, λ=5,0864390575. And then the consistency index is calculated.

$$CI = \frac{\lambda - n}{n - 1}$$

CI=0, 021609764

After this process it is checked whether the matrix is consistent. The consistency ratio must be calculated for this. It is necessary to find the random index in Table 3.2 to calculate the consistency ratio as shown below.

CR=$\frac{CI}{RI}$=0,019294432 < 0,10

It can be said that the judgment matrix is consistent within itself because this value is less than 0,1.

Binary comparisons of all the main and sub-criteria have been made and the result has been consistent for all of them. In order to find out which bank is more appropriate for the next transaction importance ratings of sub-criteria and the weight vector of the sub-criteria will be multiplied.

Table 4.28 Importance Ratings of Sub-criteria and Weight vectors of Sub-criteria

Importance ratings of sub-criteria	Sub-criteria	Ziraat Bank	Turkiye Is Bank	Garanti Bank	Vakif Bank	Yapikredi Bank
0,068	Absence of liability	0,032	0,204	0,095	0,464	0,204
0,777	Regularity of payment history	0,035	0,068	0,134	0,503	0,260
0,155	Credit Rating	0,164	0,490	0,033	0,062	0,251
0,649	Income	0,165	0,360	0,086	0,360	0,030

0,057	Wealth	0,048	0,572	0,127	0,127	0,127
0,295	Insurance period	0,367	0,058	0,367	0,176	0,031
0,649	Collection	0,216	0,033	0,216	0,063	0,472
0,057	Long-term relationship with banks	0,304	0,044	0,304	0,044	0,304
0,295	Credit Risk	0,043	0,511	0,103	0,103	0,241

Table 4.29 Importance ratings of sub-criteria* Sub-criteria weight vector

Importance ratings of sub-criteria* Sub-criteria weight vector	**Ziraat Bank**	**TurkiyeIs Bank**	**Garanti Bank**	**Vakif Bank**	**Yapikredi Bank**
0,068* Sub-criteria weight vector	0,002	0,014	0,007	0,032	0,014
0,777* Sub-criteria weight vector	0,027	0,053	0,104	0,390	0,202
0,155* Sub-criteria weight vector	0,025	0,076	0,005	0,010	0,039
0,649* Sub-criteria weight vector	0,107	0,234	0,055	0,233	0,019
0,057* Sub-criteria weight vector	0,003	0,032	0,007	0,007	0,007
0,295* Sub-criteria weight vector	0,108	0,017	0,108	0,052	0,009
0,649* Sub-criteria weight vector	0,140	0,022	0,140	0,041	0,306
0,057* Sub-criteria weight vector	0,017	0,002	0,017	0,002	0,017
0,295* Sub-criteria weight vector	0,013	0,150	0,030	0,030	0,071
Sum	0,442	0,600	0,474	0,798	0,685

4.2. CONCLUSION

In this study, it was aimed that a person who needs a loan should select the most suitable bank for his / her circumstances when he / she obtains a loan. The AHP method is used for solving this multi-criteria decision making problem. The concepts are formed in a hierarchical structure in accordance with Customer reputation, Payment history and Relationship with banks. They are divided into three criteria. The sub-criteria related to these criteria were established, the experts made scoring and the order of priority was determined as a result of the transactions made according to these scores. All of the main criteria and the sub-criteria have been compared with each other and the importance ratings have been determined. During the research period, the interest rates of the experts needed to be kept constant by each bank. As a result of these transactions, the Vakif Bank became the most suitable bank for the individual's own criteria.

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