An AHP-based Decision Support System for Personnel Selection for Manager Position in Businesses

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Abstract—**Humanity is one of the most important resources for businesses. Because, with human resources, the data of the institution can be obtained and information can be produced by processing. Thus, human resources make the business a learning and dynamic organization and ensure its continuity. In enterprises, personnel selection (in terms of quantity or quality) is carried out within the scope of Human Resources Management. This selection process usually takes place when a group of decision makers evaluates the candidates according to some criteria and their own opinions. However, this situation prevents an objective and fair selection. For this reason, in this study, a decision support system (DSS) has been developed by using the Analytical Hierarchy Process (AHP), one of the Multi-Criteria Decision Making (MCDM) methods, to ensure objectivity and to select the most suitable personnel for the job description. The said DSS provides the selection of the marketing manager among the personnel working in an enterprise. For this, the 10 employees working in the marketing department of the enterprise for the longest time were taken into account. When the results are examined, it is seen that the most qualified personnel can be selected successfully in cases where customer satisfaction, performance value, and number of projects are prioritized.**

Index Terms—**Personnel Selection, Human Resources Management, Analytical Hierarchy Process, Decision Support Systems, Business.**

I. Introduction

TODAY, the survival of businesses depends on keeping up with the competitive environment and using their resources effectively. Human resource is one of these resources. It is necessary to manage it in order to benefit from the resource in question and to use it effectively. In this context, human resources management is the dynamic and systematic management of human resources in a way that will increase their contribution to the business. Businesses need to analyze their conditions and situations, make appropriate workforce planning, and integrate this planning into their management systems. According to this planning, finding the right employees for the desired positions is described as a "personnel selection problem" [1].

Personnel selection is the selection of the most suitable candidate for the job from the candidate pool formed by qualified candidates. According to another definition, personnel selection is the management process in which the candidate personnel potential created at the end of the personnel recruitment process is evaluated according to the nature of the job and the decision is made whether to hire candidates or not [2]. From the point of view of the company, if the right person is not recruited for the right job, the de-

crease in productivity, conflict, loss of work day or increase in work accidents and ultimately dismissal will be inevitable due to incompatibility between people [3]. Wrong decisions made in personnel selection and subsequently hiring unqualified candidates create a serious problem for the institution. However, this misbehavior may cause the institution to lose important values such as money, time, business, reputation and customers [4]. Personnel selection problem is a decision-making problem like other selection problems. Decision-making problems like this pose significant risks in ensuring the accuracy of the solution, as it is affected by personnel judgment [2]. For a correct decision-making process, the problem must be well understood and examined in detail. For this, information about all the details of the problem should be reached and experienced. The easiest and most effective way to do this is to benefit from DSS [5].

In recent years, the use of DSS has become very common in the decision-making process of decision makers. DSS, which has been developed and made available to decision makers, enables end-users to easily access data inside or outside organizations or institutions. In this way, fast and timely access to the needed information increases the efficiency and the quality of the decisions taken by helping organizations make decisions on time [6]. Decisions made during personnel selection have a complex structure and are often made in an uncertain environment. Decision makers may have to examine conflicting criteria simultaneously. It may be difficult to evaluate personnel candidates using exact numbers. At this point, MCDM methods come to the fore. This method, especially in the face of uncertainty in the decision-making point of enterprises, helps them to solve the decision-making problem to a large extent [1]. MCDM is a difficult task to carry out with tools, methods and algorithms because it is a human functional mandate. By determining the criteria related to the problem, the measurement differences between the criteria, if any, are tried to be eliminated [2].

MCDM is a method used to determine the most suitable solution according to the selected criteria, when there are many conflicting criteria. The method allows us to analyze the factors, to rank the alternatives according to the results obtained, to compare, to classify and to choose the best alternative, in case of considering a large number of factors that are independent of each other and expressed in different ways. MCDM methods have been successfully applied in many areas. Many techniques are used such as Electre, Fac-

TABLE I. Dataset

Column Name	Description
Satisfaction_level	The average service satisfaction of the customers served by the personnel.
Last_evaluation	The result of the personnel's last performance evaluation
Number_project	The number of marketing projects implemented by the personnel
Time_spend_company	The number of days per week that the personnel does not work in the home-office and comes to the workplace

TABLE II. Data of Employees

Personnel No	K1 (Satisfaction_level)	K2 (Last_evaluation)	K3 (Number_project)	K4 (Time_spend_company)
1	0.4	0.54	2	3
2	0.84	0.85	4	6
3	0.11	0.77	6	4
4	0.11	0.87	6	4
5	0.84	0.88	4	5
6	0.39	0.5	2	3
7	0.11	0.91	6	4
8	0.45	0.56	2	3
9	0.37	0.52	2	3
10	0.4	0.52	2	3

tor Score Method, Analytical Network Process, AHP etc. which uses quantitative and qualitative data in calculations that take into account different performance criteria and weights [7]. In this context, the AHP technique was also used in the study. Because AHP is a decision-making method used in solving complex problems involving many criteria. Thanks to AHP, decision makers can incorporate both their objective and subjective thoughts into the decision process by logically combining their knowledge, experiences and intuitions [8].

In this study, it is aimed to select the marketing manager by using the AHP method, which is one of the MCDM methods, to decide to recruit and select more objective and more accurate personnel in the private sector as an alternative to traditional personnel selection methods. All details of the study are given in the following sections.

II. Materials and Methods

In this section, the the materials and methods of the study are given. The study aims to create a DSS that can effectively select the most authoritative and correct personnel among the personnel (manager position) that can be used in the authorization process in the enterprises. The AHP method, which is one of the MCDM techniques, was used in the study.

A. Dataset

The dataset was obtained from Kaggle with the name "HR_comma_sep.csv". The data in question were collected from a private enterprise registered by the Public Relations Department. The data covers all departments of the business and since it is aimed to select the marketing manager in this study, the lines other than the marketing department were not used in the study. The importance levels of the criteria used in personnel selection were determined based on the data of the employees in the marketing department. The columns that cannot be used in the study were removed in order to make a sound decision, and 4 criteria were taken into account, namely the level of satisfaction, the final evaluation score, the number of projects, and the time spent in the company (Table I).

Information about 450 employees remained when irrelevant data were removed from the dataset created by the Public Relations Department. They were evaluated as alternative personnel to be used in this study, the first 10 of the marketing department employees. It is aimed to determine as the marketing manager the person with the highest score by ranking these employees. The decision process was carried out using the AHP method. In Table II, the information of 10 personnel involved in the sorting process is given.

B. Obtaining Criterion Weights

The first step in applying the AHP method is to create the Comparison Matrix (Pair Wise). The creation and calculation of the matrices were carried out using the MS Excel program. There are a total of 4 columns in the created matrix, one for each criterion. The Comparison Superiority Matrix shows the comparison of criteria among themselves. The general rule is that the diagonal is "1". A scale of 1-5 was used when making comparisons. "1" means I totally

TABLE III. Normalized Binary Comparative Superiority Matrix

	Satisfaction_level	Last_evaluation	Number_project	Time_spend_company
	C1	C2	C3	C4
C1	0,46	0,62	0,31	0,38
C2	0,15	0,21	0,46	0,25
C3	0,23	0,07	0,15	0,25
C4	0,15	0,10	0,08	0,13

disagree, while "5" means I totally agree. In the part above the diagonal, starting from the first cell of the second column, the criteria are compared according to their level of importance. The part under the diagonal is formed by dividing the above values by 1. After the Binary Comparative Superiority Matrix called A matrix was created and column totals were taken, the normalization process was performed. The second case of matrix A after the normalization process is given in Table III.

After the matrix was normalized, criterion weights were found. For this, the rows in the normalized matrix were summed one by one and the results were divided by the number of criteria. In this study, since the number of criteria is 4, the row totals are divided into 4. The criterion weights for each criterion are given in Table IV.

TABLE IV
Criterion Weights

Criterion Number	Criterion Name	Criterion Weight
C1	Satisfaction_level	0.44
C2	Last_evaluation	0,27
C3	Number_project	0,18
C4	Time_spend_company	0,11

After the criterion weights are found, it is necessary to test the consistency of these values and the rate of giving correct results. Randomness analysis was used to test the consistency ratio. The $A. w = \lambda_{max}. w$ formula was used to test the accuracy of the criterion weights. That is, the numbers in the A matrix (the numbers in the first matrix created) are multiplied by the criterion weight of the relevant column. After the multiplications were completed, the values in each row were summed. Table V shows the final state and total values of the matrix.

First of all, the criterion weight of the criterion is divided by the total values of the criterion in Table 4 in order to find out whether the criterion weights are consistent, and after, the average of the 4 criteria is taken. The consistency Index value was found to calculate the consistency. In the study, the Consistency Index value was obtained as 0.0861053 when 4 was subtracted from the lambda max value, which was found to be 4.258316, and divided by 3.

Finally, while determining the consistency ratio, randomness index criteria were used to determine how many the Consistency Index should be divided. Since the Randomness index, which varies according to the number of criteria, is 0.882 for 4 criteria, the Consistency index value is divided by 0.882 and the value of 0.0976251 is obtained. Since this value is less than 0.10, it can be said that the weights of the 4 criteria used in the study are consistent. Consistency of the criteria values ensures correct results in ordering the personnel. Therefore, the criteria weight values given in Table IV are usable and consistent.

C. Getting Weights of Personnel Data

The same process should be applied to 10 alternative personnel after the weights of the criteria are found. The data of each employee was evaluated under the heading of each criterion, respectively. By taking the diagonals as "1" again, pairwise comparison matrices are started to be formed.

The process of examining the personnel data according to the criteria started with the first criterion, the satisfaction criterion, and the personnel data were grouped and sorted within itself. The same values were accepted as a single number and the operation was carried out, and "1" was written in the cells where they coincided with each other. After grouping, the numbers were sorted from largest to smallest and started from the line of the relevant criterion. The largest value is given as "1" and the number of values after grouping is written in the relevant cells up to that number.

TABLE V. The Multiplication and Sum of "A" Matrix and Criterion Weights

	Satisfaction_level	Last_evaluation	Number_project	Time_spend_company	
	C1	C2	C3	C4	Total
C1	0,44	0,80	0,35	0,34	1,93
C2	0,15	0,27	0,53	0,23	1,18
C3	0,22	0,09	0,18	0,23	0,72
C4	0,15	0,13	0,09	0,11	0,48

TABLE VI
PERSONNEL DECISION MATRIX BY NORMALIZED SATISFACTION

P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	Average
0,09	0,08	0,12	0,12	0,08	0,11	0,12	0,07	0,12	0,09	0,10
0,26	0,24	0,18	0,18	0,24	0,23	0,18	0,28	0,20	0,26	0,23
0,02	0,04	0,03	0,03	0,04	0,02	0,03	0,03	0,02	0,02	0,03
0,02	0,04	0,03	0,03	0,04	0,02	0,03	0,03	0,02	0,02	0,03
0,26	0,24	0,18	0,18	0,24	0,23	0,18	0,28	0,20	0,26	0,23
0,04	0,06	0,09	0,09	0,06	0,06	0,09	0,05	0,08	0,04	0,07
0,02	0,04	0,03	0,03	0,04	0,02	0,03	0,03	0,02	0,02	0,03
0,17	0,12	0,15	0,15	0,12	0,17	0,15	0,14	0,16	0,17	0,15
0,03	0,05	0,06	0,06	0,05	0,03	0,06	0,03	0,04	0,03	0,04
0,09	0,08	0,12	0,12	0,08	0,11	0,12	0,07	0,12	0,09	0,10

Decision matrices were created by dividing the opposite part of the table by 1. The column totals of the created matrices are shown in the bottom rows of the tables. The values in Table VI show the normalized version of the decision matrix resulting from the weighting of the personnel data according to the satisfaction criterion and the averages of the rows.

The values given in Table VII show the normalized version of the decision matrix obtained by taking the weights of the personnel data according to the last evaluation criterion and the averages of the rows.

The values in Table VIII show the normalized version of the decision matrix obtained by taking the weights of the personnel data according to the number of projects criteria and the averages of the rows.

The values in Table IX show the normalized version of the decision matrix obtained by taking the weights of the personnel data according to the number of days criterion and the averages of the rows.

After examining all personnel data according to the criteria, normalizing the data and finding the mean of the rows, the results are shown in Table X.

After obtaining the average values given in Table X, the final action to be taken is to multiply the data in each row with the weights of the criteria listed in Table IV, by the weight of the relevant criterion, to get the row total. The last personnel weight values found are shown in Table XI.

TABLE VII. PERSONNEL MATRIX BY NORMALIZED LAST EVALUATION

P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	Average
0,03	0,02	0,02	0,03	0,03	0,06	0,05	0,02	0,05	0,05	0,04
0,14	0,09	0,12	0,06	0,07	0,13	0,08	0,13	0,13	0,13	0,11
0,10	0,04	0,06	0,04	0,05	0,11	0,07	0,09	0,11	0,11	0,08
0,17	0,17	0,18	0,13	0,10	0,15	0,11	0,18	0,16	0,16	0,15
0,20	0,26	0,24	0,26	0,21	0,17	0,17	0,22	0,19	0,19	0,21
0,01	0,01	0,01	0,02	0,03	0,02	0,04	0,01	0,01	0,01	0,02
0,24	0,34	0,30	0,39	0,41	0,19	0,34	0,27	0,21	0,21	0,29
0,07	0,03	0,03	0,03	0,04	0,09	0,06	0,04	0,08	0,08	0,05
0,02	0,02	0,02	0,02	0,03	0,04	0,04	0,01	0,03	0,03	0,03
0,02	0,02	0,02	0,02	0,03	0,04	0,04	0,01	0,03	0,03	0,03

TABLE VIII. PERSONNEL DECISION MATRIX BY NORMALIZED NUMBER OF PROJECTS CRITERIA

P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	Average
0,06	0,05	0,06	0,06	0,05	0,06	0,06	0,06	0,06	0,06	0,05
0,11	0,10	0,09	0,09	0,10	0,11	0,09	0,11	0,11	0,11	0,10
0,17	0,19	0,18	0,18	0,19	0,17	0,18	0,17	0,17	0,17	0,17
0,17	0,19	0,18	0,18	0,19	0,17	0,18	0,17	0,17	0,17	0,17
0,11	0,10	0,09	0,09	0,10	0,11	0,09	0,11	0,11	0,11	0,10
0,06	0,05	0,06	0,06	0,05	0,06	0,06	0,06	0,06	0,06	0,05
0,17	0,19	0,18	0,18	0,19	0,17	0,18	0,17	0,17	0,17	0,17
0,06	0,05	0,06	0,06	0,05	0,06	0,06	0,06	0,06	0,06	0,05
0,06	0,05	0,06	0,06	0,05	0,06	0,06	0,06	0,06	0,06	0,05
0,06	0,05	0,06	0,06	0,05	0,06	0,06	0,06	0,06	0,06	0,05

TABLE IX. PERSONNEL DECISION MATRIX BY NORMALIZED NUMBER OF DAYS CRITERIA

P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	Average
0,06	0,07	0,05	0,05	0,05	0,06	0,05	0,06	0,06	0,06	0,05
0,22	0,27	0,29	0,29	0,32	0,22	0,29	0,22	0,22	0,22	0,26
0,11	0,09	0,10	0,10	0,08	0,11	0,10	0,11	0,11	0,11	0,10
0,11	0,09	0,10	0,10	0,08	0,11	0,10	0,11	0,11	0,11	0,10
0,17	0,13	0,19	0,19	0,16	0,17	0,19	0,17	0,17	0,17	0,17
0,06	0,07	0,05	0,05	0,05	0,06	0,05	0,06	0,06	0,06	0,05
0,11	0,09	0,10	0,10	0,08	0,11	0,10	0,11	0,11	0,11	0,10
0,06	0,07	0,05	0,05	0,05	0,06	0,05	0,06	0,06	0,06	0,05
0,06	0,07	0,05	0,05	0,05	0,06	0,05	0,06	0,06	0,06	0,05
0,06	0,07	0,05	0,05	0,05	0,06	0,05	0,06	0,06	0,06	0,05

TABLE X. AVERAGES OF PERSONNEL BY CRITERIA

	K1 (Satisfaction_level)	K2 (Last_evaluation)	K3 (Number_project)	K4 (Time_spend_company)
Personnel 1	0,10	0,04	0,05	0,05
Personnel 2	0,23	0,11	0,10	0,26
Personnel 3	0,03	0,08	0,17	0,10
Personnel 4	0,03	0,15	0,17	0,10
Personnel 5	0,23	0,21	0,10	0,17
Personnel 6	0,07	0,02	0,05	0,05
Personnel 7	0,03	0,29	0,17	0,10
Personnel 8	0,15	0,05	0,05	0,05
Personnel 9	0,04	0,03	0,05	0,05
Personnel 10	0,10	0,03	0,05	0,05

III. RESULTS & DISCUSSION

Although the criteria weight values are fixed, choosing which of the criteria in the application is more important varies from person to person. The result obtained when the first criterion, "customer satisfaction", is placed in the first place in priority is given in Table XII.

As can be seen in Table XII, the personnel who can be concluded to be the most qualified in cases where the "customer satisfaction" criterion is in the first place is Personnel 2 with a rate of 18.86%. Personnel in the last place is Personnel 9 with 4.58%.

The result when the second criterion, the "performance evaluation" criterion, is put in the first place in priority, is given in Table XIII.

As can be seen in Table XIII, the personnel who can be concluded to be the most qualified in cases where the performance value criterion is in the first place is Personnel 2 with a rate of 19.64%. Personnel in the last place is Personnel 9 with a rate of 4.65%. The result when the number of projects, which is the third criterion, is put first in priority, is given in Table XIV.

TABLE XI
DISPLAY OF WEIGHTS OF PERSONNEL BY CRITERIA IN DECIMAL AND PERCENTAGE

	Decimal Notation	Percentage Notation
Personnel 1	0,070089	7,01%
Personnel 2	0,174937	17,49%
Personnel 3	0,075072	7,51%
Personnel 4	0,09486	9,49%
Personnel 5	0,192656	19,27%
Personnel 6	0,049808	4,98%
Personnel 7	0,132125	13,21%
Personnel 8	0,097251	9,73%
Personnel 9	0,041871	4,19%
Personnel 10	0,066776	6,68%

TABLE XII. OUTPUT WHEN "SATISFACTION_LEVEL" IS PRIORITY CRITERIA

(C1) Satisfaction_level: 1 (C2) Last_evaluation: 2 (C3) Number_project: 3 (C4) Time_spend_company: 4									
Results									
%5.32	%18.86	%10.95	%12.07	%16.28	%4.71	%14.33	%5.96	%4.58	%5.16
Personnel 1	Personnel 2	Personnel 3	Personnel 4	Personnel 5	Personnel 6	Personnel 7	Personnel 8	Personnel 9	Personnel 10
0.40	0.84	0.11	0.11	0.84	0.39	0.11	0.45	0.37	0.40
0.54	0.85	0.77	0.87	0.88	0.50	0.91	0.56	0.52	0.52
2	4	6	6	4	2	6	2	2	2
3	6	4	4	5	3	4	3	3	3

TABLE XIII. OUTPUT WHEN "LAST_EVALUATION" IS PRIORITY CRITERIA

(C1) Satisfaction_level: 2 (C2) Last_evaluation: 1 (C3) Number_project: 3 (C4) Time_spend_company: 4									
Results									
%5.71	%19.64	%10.62	%11.29	%16.41	%5.03	%12.64	%6.61	%4.65	%5.61
Personnel 1	Personnel 2	Personnel 3	Personnel 4	Personnel 5	Personnel 6	Personnel 7	Personnel 8	Personnel 9	Personnel 10
0.40	0.84	0.11	0.11	0.84	0.39	0.11	0.45	0.37	0.40
0.54	0.85	0.77	0.87	0.88	0.50	0.91	0.56	0.52	0.52
2	4	6	6	4	2	6	2	2	2
3	6	4	4	5	3	4	3	3	3

TABLE XIV. OUTPUT WHEN "NUMBER_PROJECT" IS PRIORITY CRITERIA

(C1) Satisfaction_level: 2 (C2) Last_evaluation: 3 (C3) Number_project: 1 (C4) Time_spend_company: 4									
Results									
%5.53	%19.82	%8.99	%10.93	%18.4	%4.49	%14.81	%6.61	%4.28	%5.25
Personnel 1	Personnel 2	Personnel 3	Personnel 4	Personnel 5	Personnel 6	Personnel 7	Personnel 8	Personnel 9	Personnel 10
0.40	0.84	0.11	0.11	0.84	0.39	0.11	0.45	0.37	0.40
0.54	0.85	0.77	0.87	0.88	0.50	0.91	0.56	0.52	0.52
2	4	6	6	4	2	6	2	2	2
3	6	4	4	5	3	4	3	3	3

As seen in Table XIV, the personnel who can be concluded to be the most qualified in cases where the number of projects criterion is in the first place is Personnel 2 with a rate of 19.82%. Personnel in the last place is Personnel 9 with a rate of 4.28%. Table XV gives the result when the fourth criterion, the number of days spent in the company, is put first in priority.

As seen in Table XV, in cases where the number of days spent in the company is the first criterion, the most qualified personnel is Personnel 7 with a rate of 17.4%. Personnel in the last place is Personnel 9 with a rate of 4.28%. Since the number of criteria is 4, 4! (factorial), that is, there are 24 alternative possibilities.

IV. CONCLUSION AND RECOMMENDATIONS

In this study, a decision support system that selects personnel for the Manager position was developed using AHP, one of the MCDM methods. The dataset required for per-

TABLE XV. OUTPUT WHEN "TIME_SPEND_COMPANY" IS PRIORITY CRITERIA

(C1) Satisfaction_level: 2 (C2) Last_evaluation: 3 (C3) Number_project: 4 (C4) Time_spend_company: 1									
Results									
%5.53	%13.91	%11.58	%13.52	%15.81	%4.49	%17.4	%6.61	%4.28	%5.25
Personnel 1	Personnel 2	Personnel 3	Personnel 4	Personnel 5	Personnel 6	Personnel 7	Personnel 8	Personnel 9	Personnel 10
0.40	0.84	0.11	0.11	0.84	0.39	0.11	0.45	0.37	0.40
0.54	0.85	0.77	0.87	0.88	0.50	0.91	0.56	0.52	0.52
2	4	6	6	4	2	6	2	2	2
3	6	4	4	5	3	4	3	3	3

sonnel selection was obtained from Kaggle. Criteria such as customer satisfaction, final performance evaluation, number of projects and number of days spent in the company were used. The characteristics sought in personnel and the order of importance of these features may be different for each business. Although it seems that the employer makes the decision, since the AHP method, which is one of the MCDM methods, was used in this study, it can be said that objective judgments have a share in the selection of personnel as well as subjective. In other words, although the user makes the order of importance, the weights of the criteria and alternative personnel are ensured to maintain their real importance. Therefore, decisions with both objective and subjective dimensions could be taken. Although the impact of the criteria in the selection of personnel is different from each other, this difference can provide an advantage in choosing the most suitable marketing manager by adapting to the needs of the private enterprise where personnel will be recruited.

When the results are examined, it is seen that the most qualified personnel are Personnel 2 in cases where satisfaction_level, last_evaluation and number_project are prioritized. It would be a good decision for an employer who cares about these criteria to choose Personnel 2. When the alternatives are examined in general, it is seen that Personnel 2 has the highest score and Personnel 9 has the lowest score.

Finally, more detailed information on the personnel can be obtained by selecting a different dataset. Names and even photos of personnel can be added, criteria can be increased. Gender, age, graduated school, work experience, etc. factors can be included in the decision. This study is expected to set an example for AHP, one of the MCDM techniques.

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