SUPPLIER SELECTION PROBLEM WITH USING MULTI-CRITERIA DECISION MAKING METHODS: A CASE STUDY IN A GAS MASK FACTORY

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Abstract: Thisstudy aims to find a suitable supplier for buying an equipment which are very important and using to produce a gas mask. The company wants to work with only one supplier in 14 different alternative suppliers. The research provides a great help for selection of supplier to the company with prioritizingsome factors, and to find the most suitable supplier for the company.This case study is implemented in a gas mask factory in Turkey.Based on the literature review and interviews with experts, the main criteria are deduced asPrice, Quality & Safety, Delivery Time, Flexibility of Supplier, Performance History, Reputation in Industry and Technical Capability of the Firm.The problem is solved with using AHP and PROMETHEE methods. Analytic Hierarchy Process (AHP) method is used for weightingand PROMETHEE method is used for ordering all suppliers. The findings of the case study will reveal the preferences of company for supplier selection according to importance of criteria.

Keywords: Multi-Criteria Decision Making, Supplier Selection, AHP, PROMETHEE.

I. INTRODUCTION

It is a difficult decision to choose supplier companies from among a group of candidates [1]. Within these conditions supplier selection is vital for companies. As we have seen in previous years of work, determining the best suppliers has been the key to success for companies in a strategic sense [2 - 4]. One of the facts that companies have realized in recent years is; Low price, high quality product or service, on-time delivery, flexible product quantity and so on. The fact that they will not be able to optimize such factors alone. To achieve the desired results, it is necessary to examine the processes of the suppliers directly or indirectly involved in the company's processes and to work with those that are appropriate for the company. Manufacturer, distributor, wholesaler, supplier etc.

The main objective of the supply chain management, which is the work of managing a structure formed by independent actors; To reduce costs, to help increase productivity, to improve customer satisfaction and improve delivery times. If the supply chain is in good working order, it is very important to identify the right suppliers to work with. Because the choice of the right supplier is important in securing and strengthening the competitive power that other firms have in reaching the company's goals [5]. Many studies have been put forward in the literature as multi-criteria decision-making methods. Analytical Hierarchy Process (AHP), Analytic Network Process (ANP), TOPSIS, ELECTRE, PROMETHEE and VIKOR methods are the most frequently used multi-criteria decision making methods.

Implementation was carried out in an enterprise operating in the defense industry. The enterprise has been operating in the defense industry since years. This enterprise has more than 780 employees in Turkey. One of the most important parts of the gas mask production is NBC Filter. In practice, the criteria will be determined first and then the most appropriate one among the alternative suppliers will be selected. AHP and PROMETHEE methods will be used when making this selection. The weights obtained from the results of the AHP method will be used in the PROMETHEE method and a ranking for suppliers will be obtained.

II. MULTI-CRITERIA DECISION MAKING

2.1. Analytic Hierarchy Process Method

AHP is a mathematical technique that can evaluate both quantitative and qualitative variables considering the priorities of the group or individual in decision making [6 - 8]. AHP, developed by Saaty, is a structurally quantitative and qualitative method, helping decision makers' experience, knowledge and intuition in decision making under uncertainty in Multi-Criteria Decision Making (MCDM) problems [9]. AHP simplifies complex problems. The decision maker improves his understanding of the definition and elements of the problem. AHP probing allows both objective and subjective considerations to be included in the decision process. In addition, it is more suitable for group decisions than other methods [10].

2.2. PROMETHEE Method

The PROMETHEE method is one of the most recently developed methods of MCDM methods and has been licensed by Brans in 1982 [11] and developed by Brans and Vincke [12]. The basic features of the PROMETHEE method are simplicity, openness and balanced formation. The method uses preference functions when it forms a sequence. With the PROMETHEE method, it is possible to perform

both partial ordering (PROMETHEE I) and full ordering (PROMETHEE II) on the final number of alternatives [13]. With the PROMETHEE method, the decision process starts with the decision matrix formed by the alternatives (a1, a2, ..., an) and the criteria (q1, q2 ..., qk). After the method decision-maker decision matrix is created, PROMETHEE presents the results of partial and partial ranking at the end of the following five steps.

III. SUPPLIER SELECTION PROBLEM

Today, thanks to the developing technology, the quantity and variety of the products that the producers have started to increase. Due to the variety of products, it is both costly and time-consuming for manufacturers to produce all their products and the parts that make up these products themselves. One of the right decisions to make is the choice of the supplier that is appropriate for the firm. In the right place, choosing the supplier that provides the best quality or service at the right time and quantity is crucial to the success of supply chain management. The choice of the right supplier and the quality of the supplier are an important step to be successful in the long term [14]. The problem of supplier selection can be defined as the determination of who and how much of the materials, semi-finished products and other materials required for production [15]. The purpose of choosing a supplier is in the simplest sense, the choice of people who will meet the company's need at an affordable cost. Organizations should work with many suppliers to be able to continue their operations. The problem of choosing a company to make production suitable for itself can be referred to as the supplier selection problem, among the other manufacturer companies that produce the specifications and standards of the manufacturer companies.

In the supplier selection problem, many questions such as determining the number of suppliers to work with and deciding on the product to be received from the supplier are searched. According to Ghodsypour and O'Brien's [16] approach, we mainly focus on the problem of choosing two types of suppliers. These;

- Non-Constrained Supplier Selection: In other words, a supplier choice that all suppliers' producers meet all their needs, such as demand, quantity and delivery.
- Selection of Suppliers with Constraint in Capacity, Quality, etc. It is a choice with constraints

IV. LITERATURE REVIEW

In the literature, it is possible to find many studies related to supplier selection problem. In the first studies to solve the supplier selection problem, it is seen that many factors such as quality, performance, term and flexibility have been used in the studies done in recent years while investigating the effects on a single element and the company [17]. Ghodsypour and O'Brien [16] talked about the qualitative and quantitative concepts used for the criteria set for the solution of the problem of supplier selection problem in their work. A model that minimizes purchasing value and maximizes profitability is solved by using AHP and Linear Programming techniques together. In his work, Badri [18] created an integrated model combining the AHP method and the Target Programming techniques. Dağdeviren and Eren [1] set up a new model by combining Analytical Hierarchy Process and 0-1 Goal Programming techniques when choosing suppliers. The authors used the AHP technique to determine the order of preference of suppliers for the selection and then to the target programming technique, considering these priorities. The authors also questioned the effectiveness of using these methods together. Palaz and Kovancı [19] used the AHP method to make the appropriate submarine selection for the Turkish Navy. Aydın [20] used Fuzzy AHP to select the hospital location for Ankara. Keçek and Yıldırım [21] have selected the enterprise resource planning system with AHP method for a company operating in the automotive sector. Kazançoğlu and Ada [22] made supplier selection with the fuzzy AHP method in the retail sector. Razmi and Rafiei [23] have integrated Analytic Network Process (ANP) and Mixed Integer Nonlinear Programming methods into the problem of supplier selection in their work. Supçiller and Çapraz [24] have combined AHP and TOPSIS methods and made supplier selection using key criteria such as cost, delivery, and service quality, which are often mentioned in supplier selection problem studies. They used computer programs to implement the AHP and TOPSIS steps, and eventually they chose the appropriate supplier for the company. Baynal and Yüzügüllü [25] stated that today's rapid technological developments and globalization are increasing competition, which in turn has forced businesses to produce better quality, lower cost and timely products/services. For this reason, they evaluated the performance of the suppliers and emphasized that the selection of the most suitable suppliers is a serious problem. The authors defined 7 sub-criteria and 15 sub-criteria in their studies and these criteria were evaluated according to their performances by ANP method and a decision sub-structure for sequential and decision-makers was established. Çakın [26] used a combination of ANP and ELECTRE methods in supplier selection. The author determined 5 sub-criteria and 15 sub-criteria for a company operating in the machinery sector and weighted these criteria with ANP. Later, with the ELECTRE method, the suppliers that are suitable for the company were selected from 12 suppliers. Özbek and Eren [27] developed a model using Analytic Network Process method in their studies and made a suitable third party logistics firm for a firm. The authors used the

network structure of the decision-making model to review the notifications, articles published in international symposia, and the opinions of experts in the field. This information has set some criteria for applying the ANP method in the light. Gökbek [28] mentioned that the choice of supplier is a difficult and time-consuming process that needs to consider many factors.

To create a solution to the supplier selection process problem, the business created a model in which the AHP, TOPSIS and ELECTRE methods are used together and implemented in an electronics company. In the study, the criteria weights were determined with the help of AHP, and the selection and sorting were done by TOPSIS and ELECTRE methods. In this way, he has analyzed the decision-making process in detail. Bedir et al. [29] have chosen a third-party logistics company for a firm in their work. They used AHP and PROMETHEE techniques together. Özder and Eren [17] used ANP and Goal Programming techniques together for supplier selection in their studies. Özder and Eren [30] used AHP and Goal Programming techniques together in supplier selection studies. Özder et al. [31-32] have chosen a supplier of a firm with analytical Network Process and Goal Programming techniques from their collateral-based decision-making techniques. Özder et al. [33] used the ANP and PROMETHEE techniques to solve the problem of academic staff selection.

V. CASE STUDY

Implementation was carried out in an enterprise operating in the defense industry sector. The business has been operating in this sector for many years. NBC Filter is one of the most important pieces used by company in producing gas masks.The problem addressed in this paper, corresponds to the supplier selection problem as defined in the literature. The business supplies NBC Filter materials externally. Then they use it. The selection application for this material, which is vital for the company, is addressed in this study.

The NBC Filter material is selected from 14 suppliers (S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S13, S14).It is mentioned in the previous chapters that there are a lot of studies on supplier selection in the literature. Ten of these criterions were chosen in the long-term result literature. These selection criteria, which were available after the election, were decided to be reduced to 7 criteria after the opinions of the experts and engineers in the company's procurement, logistics, after-sales services and engineering departments were taken. All criteria can be seen in **Table 1**. When these criteria are set, the criteria that the company needs are included in the model.

CRITERIA
1. Price (P)
2. Quality & Safety (Q&S)
3. Delivery Time (DT)
4. Flexibility of Supplier (FOS)
5. Performance History (PH)
6. Reputation in Industry (RII)
7. Technical Capability (TC)

Table1: Supplier selection criteria determined within the scope of implementation

VI. RESULTS AND DISCUSSION

In the application of the information to be considered, the Analytical Hierarchy Process result is given in **Table 2**.

Weight	%	Supplier	
0,0056	5,65	6	S1
0,0122	1,22	12	S2
0,1922	19,22	2	S3
0,1201	12,01	5	S4
0,1223	12,23	4	S5
0,2102	21,02	1	S6
0,1336	13,36	3	S7
0,0495	4,95	7	S8
0,0269	2,69	8	S9
0,0185	1,85	9	S10
0,0115	1,15	14	S11
0,0166	1,66	11	S12
0,0121	1,21	13	S13
0,0178	1,78	10	S14

Table 2: AHP result

The results given in the Visual Promethee program with given weights are given in **Table 3.**

Supplier	Phi	Phi+	Phi-
S6	0,9670	0,967	0
S3	0,7912	0,8681	0,0769
S7	0,7033	0,8132	0,1099
S5	0,5714	0,7363	0,1648
S9	-0,0220	0,4176	0,4396
S10	-0,1538	0,3846	0,5385
S14	-0,1648	0,3297	0,4945
S11	-0,2088	0,3077	0,5165
S8	-0,2637	0,3077	0,5714
S1	-0,3516	0,2637	0,6154
S12	-0,3736	0,2198	0,5934
S4	-0,4835	0,1978	0,6813
S2	-0,4835	0,1538	0,6374
S13	-0,5275	0,1538	0,6813

Table 3:PROMETHEE application results

According to the results obtained, the S6 supplier concluded as the first supplier to work together after each calculation. It can be said that the outcome is expected because the company experts have already stated that the performance of the S6 supplier is higher than other suppliers. Because MCDM methods

generally involve decision makers' decisions, it is also normal and straightforward for the S6 supplier to rank first in their ranking practices and to have the first weight in their weighting methods.

CONCLUSIONS

In today's market conditions, firms should act rationally and consistently in every decision they make, other than to protect their competitive positions against their competitors in which they operate to be successful. While the right decisions made by decision makers in the decision-making process bring one step forward against the firms, the wrong decisions are given by the firms. In the study, a supplier selection problem was addressed for NBC Filter material for a gas mask factory. Two different multi-criteria decision making techniques have been used to select the supplier firm that is appropriate for the firm. This study proposes an integrated approach to supplier selection decision which is an important aspect of supply chain management that has been recognized by all to be important in recent years and which significantly impacts the competitive power of companies and attempts to show the results of the proposed approach combined with actual business data.

Further work can involve the use of other multi-criteria decision making techniques and this work can be further extended.

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