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SUPPLIER SELECTION WITH TOPSIS AND GOAL PROGRAMMING METHODS: A CASE STUDY

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ABSTRACT
Supplier selection is an important issue in supply chain management. Generally, manufacturers spend more than 60% of its total sales on purchased items, such as raw materials, parts and components. The aim of the supplier selection is to choice of the suppliers to meet the needs of the company with reasonable cost. Organizations must work with several suppliers to continue its activities. Selection of the suppliers in a group of candidate firms is a difficult decision problem. In this study, the supplier selection problem is discussed, which is operating in the automotive production sector. Preemptive goal programming is used to solve the problem. TOPSIS methods have been used to determine the ideal solution points. In the light of these results, the structured model is solved by the help of LINGO 14.0 and best suppliers are verified for the company.
Keywords: Multi Criteria Decision Making, TOPSIS, Goal Programming, Supplier Selection

1. INTRODUCTION
Organizations must work with several suppliers to continue its activities. Selection of the suppliers in a group of candidate firms is a difficult decision problem [1]. In this circumstances, supplier selection is vital for the firms. Determining the best supplier is the key for success to the companies with respect to strategic sense [2-4]. This study has two main goals. The first one is to investigate the problem and solution method of the selected company in the light of findings to the literature. Second one is to suggest the alternative suppliers for the firms with the help of the TOPSIS Method which is a methodology of multi-criteria decision making period in the light of qualitative data and quantitative data with Goal Programming method.
In decision making processes, there are some necessities about measuring conditions and interactions between the elements which exist in supply chain. TOPSIS is a convenient technique for solving models based on the principles of a closeness to the ideal solution of decision points. Goal Programming is one of the developed models to measure the multi-objective decision-making methods. In this model, while the decision makers finding the best solutions from a group of possible solutions, decision makers is taking into consideration of many purposes [5].
A different perspective is presented about supplier selection and evaluation problem in the study for supporting the decision makers to choose and evaluate supplier. All supplier selection criteria are covered which are told in the literature. The application of the study is done to an automotive factory that is searching for a new guidance in the selection process. The criteria set for the selection of

suppliers includes numerous and conflicting situations. Therefore, in the planning supplier selection issue, usage of scientific methods is required for the accurate results [6, 7].

2. LITERATURE REVIEW

In Razmi and Rafiei's [8] study, Analytic Network Process (ANP) and Mixed Integer Nonlinear Programming Method (MINLPM) are integrated each other in supplier selection problem.
Supçiller and Çapraz [9] are used some main criteria which are frequently mentioned on the supplier selection problems like cost, quality, delivery and service. They mixed analytic hierarchy process and TOPSIS methods and chose supplier for the selected company. Baynal and Yüzügüllü's [10] study ANP method is used for decision-making. Çakın [11] is used ELECTRE and ANP methods together. Özbek and Eren [12] worked and developed a model using the Analytic Network Process method and made suitable third-party logistics company selection for a company. Gökbek [13] has been mentioned that supplier selection process which requires consideration of many factors and arduous duration. On behalf of supplier selection problem process, AHP, TOPSIS and ELECTRE methods used to create a solution for the company.

3. METHODOGOLY

In this paper, TOPSIS method and Goal Programming (GP) technique are used. All methodology will be explained on previous chapters. TOPSIS method is applied with the help of qualitative data and goal programming method is applied with the help of quantitative data. [14, 15].

3.1. TOPSIS Method

TOPSIS Method (Technique for Order Preference by Similarity to Ideal Solution) is developed by Yoon & Hwang in 1981. TOPSIS uses the similar approach with ELECTRE Method. TOPSIS includes 6 steps [16].

3.2. Goal Programming Method

In Goal Programming, objective criteria's minimization or maximization cannot be done directly. Instead of this, deviations between the goals are attempted to be minimized. Objective function is created from only the devious variables. [17-19]
Because of simultaneously both positive and negative deviations cannot occur, at least one or both devious variables deviations must be zero. After determination of unwanted variables, deviated goal programming formulation is made. Only one of these variables is desired to be minimized by decision maker. [21-23].

4. APPLICATION

In this chapter, TOPSIS and Goal Programming calculations are done in following statements. The application was carried out in a company operating in the automotive sector. The company has been operating since many years in the automotive industry. One of the most important parts are used in vehicle production car windscreen, which employs more than 1,000 people all over the Turkey. The company has been supplying the outside of these materials. Then they perform the installation on the vehicle. Vital tools for application for Windshield material selection are discussed in this study. In four important supplier for companies (x_1, x_2, x_3, and x_4) will be held for windscreen election in light of goal programming methods will be applied to the target company under certain constraints. LINGO 14.0 program is used for the calculations. Goal programming solutions built separately according to the multi-target method of equal importance methods and results have been reached.

4.1. TOPSIS Calculations

As in mentioned on previous chapters, there are lots of study about supplier selection problem. In these studies lots of selection criteria are used. After a long time period research, 24 criteria have been chosen. Purchasing department experts, engineering department deputy and managers of the company have decided to examine 4 main and 12 sub main criteria of them. These criteria determined by the needs of the carriers were included in the model. Questionnaires were filled with specialists to determine these criteria. Supplier selection criteria's are given in Table.1.

Table.1 - Supplier Selection Criteria

MAIN CRITERIA	SUB-MAIN CRITERIA
QUALITY (Q)	1. Product Performance (PP)
	2. Standards (S)
	3. Production Experiance (PE)
FIRM RATING (FR)	4. Reliabilty Score (RS)
	5. Time Period of Working With (TPWW)
	6. Location (L)
	7. Price (P)
	8. Reputation (R)
FLEXIBILTY (F)	9. Delivery Flexibilty (DF)
	10. Product Quantity Flexibilty (PQF)
LEAD TIME (LT)	11. Delivery on Time (DT)
	12. Distribution Network Extensiveness (DNE)

TOPSIS calculations are made by order.

C_1^* = (0,145503043) C_2^* = (0,959229336) C_3^* = (0,218317226) C_4^* = (0,107438828)

As it seen from the results, T2 Supplier has the biggest importance value in all suppliers. And now this supplier selection problem is solved with the help of goal programming model.

4.2. Goal Programming Calculations

There are a number of constraints that must be taken into account in establishing the model. These limitations include:

- Capacity Constraint
- Purchasing Cost Constraint
- Quality Control Time Constraint
- Supply Delay Time Constraint
- Transportation Cost Constraint
- Faulty Product Average Constraint
- Return/Change Cost Constraint

Parameters will be used on the establishment of the model are given in Table.2.

Table.2 – Goal Programming Constraints

Constraints	T1 Supplier	T2 Supplier	T3 Supplier	T4 Supplier
Production Capacity (Weekly)	550	600	525	400
Purchasing Cost (£)	10.000	14.550	7.200	7.000
Control Time (Hour)	17	20	15	14
Maximum Supply Delay Time (Day)	6	3	4	5
Transportation Cost (£)	4240	0	0	3750
Faulty Product Average (1000 Product Per)	1,448	1,0998	3,3847	3,4586
Return/Change Cost (£)	320	275	401	398

Parameters:

- x_1 = T1 Supplier, x_2 = T2 Supplier, x_3 = T3 Supplier, x_4 = T4 Supplier
- Capacity Constraint = (d_1)
- Purchasing Cost Constraint = (d_2)
- Quality Control Time Constraint = (d_3)
- Maximum Supply Delay Time Constraint = (d_4)
- Transportation Cost Constraint = (d_5)
- Faulty Product Average Constraint = (d_6)
- Return/Change Cost Constraint=(d_7)

Min Z $= d^-_1 + d^+_2 + d^+_3 + d^-_4 + d^+_4 + d^+_5 + d^+_6 + d^+_7 + d^+_8$

Constraints:

$250\ x_1 + 300\ x_2 + 225\ x_3 + 200\ x_4 + d_1^- - d_1^+ = 300$ (Demand Constraint)

$10.000\ x_1 + 14.450\ x_2 + 7.200\ x_3 + 7000\ x_4 + d_2^- - d_2^+ = 15.000$ (Purchasing Cost Constraint)

$17\ x_1 + 20\ x_2 + 15\ x_3 + 14\ x_4 + d_3^- - d_3^+ = 15$ (Quality Control Time Constraint)

$6\ x_1 + 3\ x_2 + 4\ x_3 + 5\ x_4 + d_5^- - d_5^+ = 5$ (Supply Time Const.)

$4240\ x_1 + 3250\ x_4 + d_6^- - d_6^+ = 5000$ (Transportation Cost Constraint)

$1{,}448\ x_1 + 1{,}0998\ x_2 + 3{,}3847\ x_3 + 3{,}4586\ x_4 + d_7^- - d_7^+ = 3$ (Faulty Product Const.)

$320\ x_1 + 275\ x_2 + 401\ x_3 + 398\ x_4 + d_8^- - d_8^+ = 400$ (Return/Change Cost Constraint)

$x_i = 0$ or 1 (Choosing or not the supplier) *i= 1, 2, 3, 4* $d_i^-, d_i^+ \geq 0$ *i= 1, 2, 3, 4*

After solution of the established model under the existing constraints, T2 supplier is suitable for the purchasing in all suppliers.

5. CONCLUSION

In this paper, the calculation algorithm is done properly and the results were reached within the framework of the objectives set for the supplier. In this study, two different methodology is used and results are given for the supplier selection topic which is vitally important for the company nowadays. Selection problem is solved with two different methods and same result is found for the supplier selection. TOPSIS method is used by the help of qualitative data. T2 supplier is found for the suitable supplier. Then Goal Programming method is applied with the help of quantitative data. Again T2 supplier is found for the suitable supplier. As it seen from the result, T2 supplier is the best supplier for the firm because, it is verified with two different methodology. This model also established production site selection, machinery selection, and so on. It is believed may be used in many fields. In future studies, this model can be further integration of multi-criteria decision-making techniques and extensible.

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