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Full Length Research Paper

A new methodology for suppliers selection and order allocation

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One of the main factors in competitive environment is to reduce production costs. Selecting the right suppliers significantly reduces the purchasing costs and improves corporate competitiveness. That is why the cost of raw materials and components part constitutes the main cost of a product and most of the firms have to spend considerable amount of their sales revenue on purchasing. The aim of this research is to introduce an integrated model for supplier's selection and order allocation in an automotive company. Therefore, the research was divided into two phases (conceptual modeling and mathematical modeling) with four steps. In conceptual modeling, in order to select the best suppliers, an integrated, Analytic Hierarchy Procees and Technique for Order Preference by Similarity to Ideal Solution (AHP-TOPSIS) approach was used. Hence, after library studies and interview with experts, managers and specialists in the supply chain management field, decision criteria were identified through brain storming which contains the main criteria and sub criteria of the selection process for suppliers. Then in mathematical modeling in order to allocate every selected supplier in conceptual modeling, a Multi-Objective Linear Programming (MOLP) model was used. As such, the objectives and subjectives of suppliers and the Automotive Company were identified. Results show that applying a two phase AHP-TOPSIS methodology aided the selection of the best suppliers. Also Automotive Company's total costs were minimized with using a MOLP model.

Key words: Supply chain, analytical hierarchy process, supplier evaluation, technique for order preference by similarity to ideal solution (TOPSIS), multi-objective linear programming (MOLP).

INTRODUCTION

Increasing customer demands and diversity, technological advances in communications and information systems, competition in the global environment, reducing government regulations and increasing environmental awareness, have forced companies to accurately focus more on supply chain management. The term "chain management" is defined as an integration of activities related to preparation of raw materials, its conversion to intermediate goods and final products, and its final delivery to customers (Cebi and Bayraker, 2003). Generally, the primary goal of supply chain managment will be to reduce supply chain risk, production costs, making the maximum revenue, improve customer's service, optimize inventory levels, improve business processes which ends in increasing competitiveness, customer satisfaction and profitability (Boran and Genc, 2009). This chain started with the production of raw materials, equipment and components by suppliers and finally ends with consumption by consumers which will then create a strong relationship between suppliers, manufacturers and consumers (Chan, 2008). Since in many industries, more than 70% of the total cost to organizations is related to the cost of raw materials (Chuan, 2009) and companies are forced to spend a major portion of their revenues on buying raw materials, supply management is one of the most important issues of supply chain management.

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Consequently, selection of appropriate supplier can significantly reduce purchase cost and improve companies' competitive position (Cebi and Bayraker, 2003).

Basically, the issues related to supplier selection are of two types. The first type (single sourcing), in which a supplier is able to meet all buyers' needs including demand rate, quality, and delivery time. In this condition, the management should just decide which supplier is the best? In type II (multiple sourcing) a supplier alone is not able to meet all needs of buyer and buyer must meet their demands through several suppliers. In this case, management should take two types of decisions: first, which suppliers are the best? And second, how much should be purchased from each supplier? (Demirtas and Ustun, 2008; Ting and Cho, 2008).

In many cases, organizations usually choose more than one supplier for their products, when faced with non-competence of one supplier to ensure continuity of supply. They can also compare prices and services from various suppliers during the period of time. Hence, in the present study, we discussed solving the selection of supplier in the state of multiple sourcing. Increasingly, the importance of selecting appropriate supplier, as a critical decision in supply chain management, lead organizations into different industries to use systematically formed models to choose suppliers and allocate orders to them. One of these industries is automobile manufacturing industry which had been significant progress in Iran during the recent years. The study is doing an automobile manufacturing company which despite spending energy, time and cost to select the appropriate suppliers, unfortunately, is faced with deficiencies and drawbacks in its supply chain. The main problems can be listed as following:

1. Assessment process in the company is being done step by step. In other words, it is not given an equal opportunity to suppliers in order to demonstrate their competency in all stages and if a supplier fails to obtain the required score in the first stage, it will be removed from competition cycle, while it may have high capability in later stages or vice versa.
2. All suppliers, regardless of the product type they produce; are being assessed together, while the determining factor varies from each product to the other (such as quality for product A and price for product B and so on).
3. Finally, the order rate to each selected supplier, is being determined solely based on scores earned during the assessment process in the sense that a supplier which obtains the highest score, and the highest amount of order will be assigned to it, while the supplier may not have the capacity to produce that order which in this case, they change the amount of order manually.

Therefore, the present study using the suggested model is done to remove these deficiencies and to answer two main research questions:

How to select suitable suppliers in order to meet company's need?
How to determine the optimal amount of order to each selected supplier?

The research is done in the two phases, (conceptual modeling and mathematical modeling) and four steps that will explain more in the following.

LITERATURE REVIEW

Nowadays, supply chain management tries to obtain the long-term participation with suppliers and use fewer numbers but more reliable suppliers. Therefore, to choose appropriate suppliers is something more than just looking at the list of suppliers' suggested prices and suppliers selection depends on to many qualitative and quantitative factors. Thus, wide multiple criteria decision-making approaches (MCDM) proposed for suppliers selection such as: Analytic Hierarchy Process (AHP), the process of network analysis (ANP), Artificial Neural Networks (ANN), Case-Based Reasoning (CBR), Data Envelopment Analysis (DEA), Genetic Algorithm (GA), Fuzzy Set Theory, Mathematical Programming (MP), Simple Multi–Attribute Rating Technique (SMART) and mixed technique. At least four journal articles have already reviewed the literature related to suppliers' evaluation and selection models (Weber et al., 1991; Degraeve et al., 2000; De Boer et al., 2001; Ho et al., 2010).

Talluri and Narasimhan (2004) applied DEA model for sourcing effective suppliers. The approach was the same with the works of Narasimhan et al. (2001) except that they had used a simple efficiency index while Talluri and Narasimhan (2004) used statistical models and cross-efficiencies indicator in the classification of the various categories. Hong et al. (2005) formulated a mixed integer linear programming to solve supplier's selection problem. This model was determined by the optimal number of suppliers and optimal order quantity which could maximize an income. In addition, changes in the supplier's supply capacities and needs of customers during a period of time were studied. Percin (2006) proposed an integrated, Analitical Hierarchy prosess and Goal Programming (AHP-GP), approach to assess and select suppliers. At first, AHP was used to measure the relative importance of potential suppliers according to 20 criteria. Then, the weights were used as coefficients of five objective functions in GP model. This model also determined the optimal order quantity from the best suppliers; while supplier's productive capacity was also examined. Amid et al. (2006) constructed a fuzzy multi-objective linear programming model to choose appropriate suppliers. This model was able to control the ambiguity and inaccuracy of the input data, and help decision-makers to find the optimal order quantity of each supplier. In this model, three objective functions with different weights and one algorithm was developed to solve the model. Ramanathan (2007) reported that DEA can be used to evaluate supplier's performance apprai-sals using qualitative and quantitative information obtained by Total Cost of Ownership (TCO) and AHP technique. More exactly, the cost based on the concepts total cost of ownership was used as the input, and weights obtained by AHP model considered as output in DEA model. Lau et al. (2006) developed an integrated ANN and GA approach for supplier selection. ANN was used for benchmarking the potential supplier with respect to the four evaluating factors. After that, GA was deve-loped to determine the best combination of suppliers. The four evaluating criteria were used again in the fitness function of GA. Saen (2007) suggested an integrated AHP-DEA approach to evaluate and select suppliers that somewhat were inconsistent. The experts stated that many of the suppliers are not using their entries and inputs completely to supply and produce outputs. In this approach, AHP was used to determine the relative weight of each supplier. Then DEA was applied to calculate the relative efficiency of each supplier. Kull and Talluri (2008) developed an integrated AHP-GP approach to evaluate and select suppliers according to risk indexes and product life cycles. In the proposed model, AHP was used to evaluate suppliers according to the risk factors, and according to this; some scores were given to the suppliers and then GP model formulated to assess alter-native suppliers based on the objectives of multiple risk and various hard restrictions. Ho lin (2009) proposed an integrated Fuzzy Analytic Network Process (FANP) approach and multi-objective linear programming for suppliers selection and order allocation. In this approach, four criteria including quality, price, delivery, and technology were considered. Then, ANP specified the priority option of suppliers with the study of interde-pendence between criteria and its effect on the evaluation and selection of suppliers. Because ANP was just able to calculate definite data, the fuzzy set theory was also used. In the last step, multi-objective programming model were identified to determine the amount of order according to the restriction of suppliers and buyers.

There are also several articles that used the two techniques of AHP and TOPSIS simultaneously (Onut and Selin, 2008; Percin, 2008; Dagdeviren et al., 2009; Gumus, 2009; Torfi et al., 2010). In all of the earlier mentioned articles, researchers first designed their hierarchical tree and then using the AHP technique deter-mined the relative weights of indices and eventually using TOPSIS technique dealt with rank available alternatives in their model. Using a two-phase AHP and TOPSIS methodology comes with several advantages. First, the AHP technique is able to evaluate the hierarchical structure, performing pairwise comparisons and consis-tency ratio (CR) to determine correct judgments, while TOPSIS does not provide such a possibility. In contrast, TOPSIS technique is able to consider distances from the best and worst answers due to relative proximity to the optimal answer simultaneously and in addition find the answer and prioritize other options, respectively. As a result, first combining of these two models means to benefit from both techniques (Dagdeviren et al., 2009). Secondly, the speed of decision-making using two techniques of the AHP and TOPSIS is higher as compared to the other mathematical models such as DEA, ANP, fuzzy logic, and genetic algorithm. Thus, the proposed combination technique is a flexible and convenient tool for decision-making under different conditions (Gumus, 2009).

METHODOLOGY

The research was carried out in automotive industry. Overall, this study was conducted in two phases (conceptual and mathematical modeling) and four steps. In the first phase (conceptual modeling), in order to answer the first question of the research, concerning how to select best supplier(s), after reviewing the research literature, interview with the experts, and survey the managers, in a company custodian to automotive supply chain management group, decision-making criteria were identified using brainstorming method including criteria and sub-criteria affecting on suppliers selection. Then, in order to calculate the weight of each indices and final ranking of desired parts suppliers, integrated AHP-TOPSIS techniques were used. In the second phase (mathematical modeling), in order to answer the second question of the research concerning allocation quantity of orders to each supplier, multi-objective linear programming model (MOLP) was used. First, the multi-objectives of the company were identified then suppliers' and buyers' constraints were considered. Finally the equations solved by LINGO software and the optimum amount of order to each supplier identified. Figure 1 shows the process of the research. The first phase (conceptual modeling) includes three steps.

Conceptual modeling

Step 1: Identifying evaluation criteria and sub-criteria

In decision-making models, one of the most important parts is to determine the criteria and measuring indicators. The selected criteria and indicators for this purpose are important aspects considered in measuring the characteristics of suppliers. In fact, suppliers' selection indices indicate the present status and present/future supplier's performance. Therefore, the design and selection of indices as the input of decision-making model has a direct impact on model efficiency. As in companies and organizations, the criteria and sub-criteria affecting suppliers' selection processes differs based on their objectives. In our case study, automotive company used brainstorming in order to identify criteria and sub-criteria, with regard to their strategic goals. Therefore, the automotive company–in a meeting consists of 32 managers, experts and specialists in supply chain area identified the criteria influencing the process of appropriate suppliers selection due to their industry targets by using brain-storming method. The criteria were identified in the form of three main criteria and 10 sub-criteria as follows:

C1: Quality

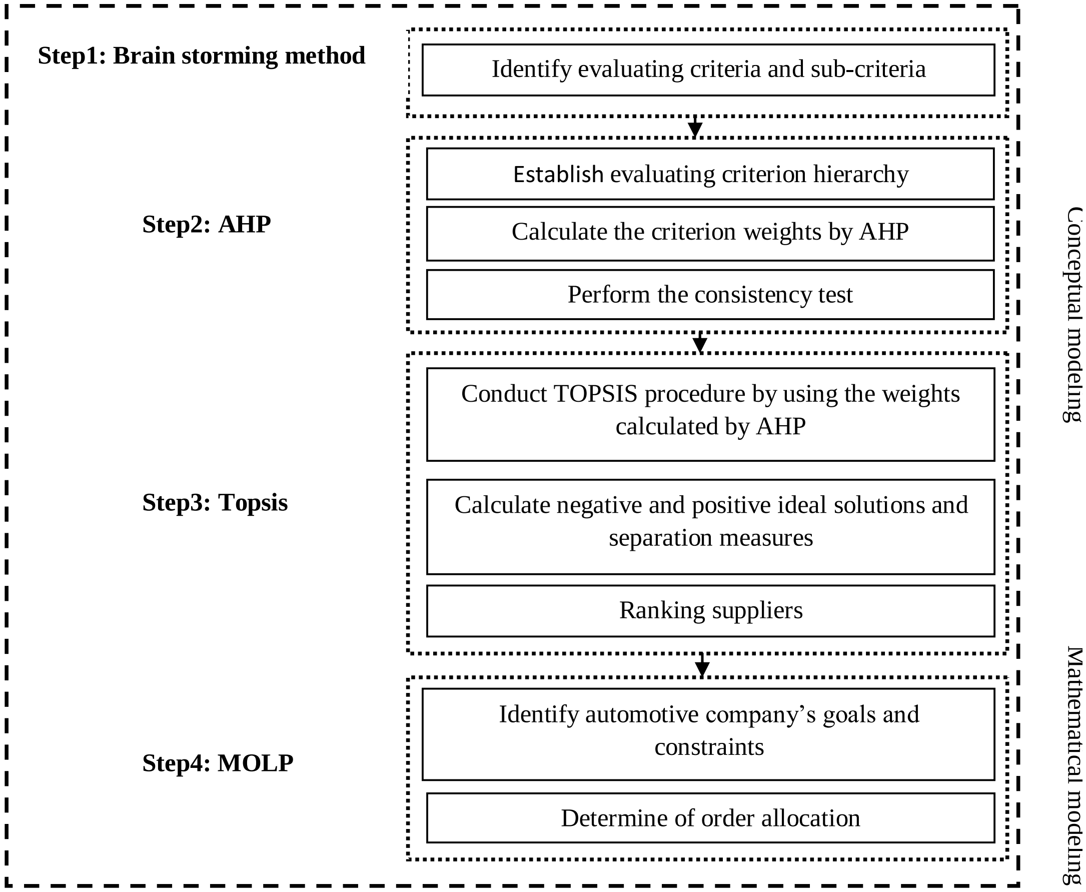

Figure 1. The overall research processes.

D1: Standardization: To standardize the maker production process, as the first step to improve production process and to form process control program
D2: Packaging design: Projects for the first time are prepared or revised with the aim of increasing customer satisfaction.
D3: PPM (Part Per Million) customers: Measuring the number of returned parts per million delivered parts which is returned by automobile-maker.
D4: PPM after sales services: Measuring the number of returned parts per million delivered parts which returned by the final customer.
C2: Cost
D5: Price reduced rate: Ability of suppliers to reduce products prices at lower prices than the year before the contract or if possible maintaining proposed price in the current year.
D6: transportation cost: An expense related to transport products from origin to destination.
D7: Order cost
C3: Delivery
D8: On time delivery: Product delivery in time and date specified in the amount determined by the procurement unit.
D9: achieving over-supply: The ability to increase production because of the sudden increase in customer's demands.
D10: percentage of performance realization: Measuring the rate of realization of customer needs (automotive).

Step 2: Implementing AHP technique

AHP technique which was developed by Thomas (1980) is a powerful tool for solving complex problems of decision-making with regard to quantitative and qualitative criteria (Ting and Cho, 2008). According to the solution algorithm in this technique as shown in Figure 2, decision-making hierarchical structure is determined to simplify supplier selection. It should be noted that despite the frequency of the number of suppliers and parts, in order to test the model, some part makers who had the highest evaluation (grade A) was able to produce four parts with codes A, B, C, and D was selected.

After the hierarchical structure was drawn; in order to determine the criteria, and sub-criteria weights, a questionnaire concerning pairwise comparisons matrix was given to 42 managers, experts, and specialists in the field of supply chain management. Then, the data gathered from them was entered into specialized software of expert choice to calculate the weight of suppliers indices and to ensure the accuracy of judged and inconsistency rate. Because of smaller inconsistency rate from 0.1, the accuracy of judgments were confirmed. Table 1 shows the weights obtained for each of the criteria, sub-criteria, and the decision-making alternatives using the AHP technique.

Step 3: Implementation of TOPSIS technique

TOPSIS is a widely accepted model that was proposed by Huang and Yoon (1981), and was developed by Chen and Huang (1992). In this method, alternatives are ranked based on the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution. In this step, TOPSIS technique

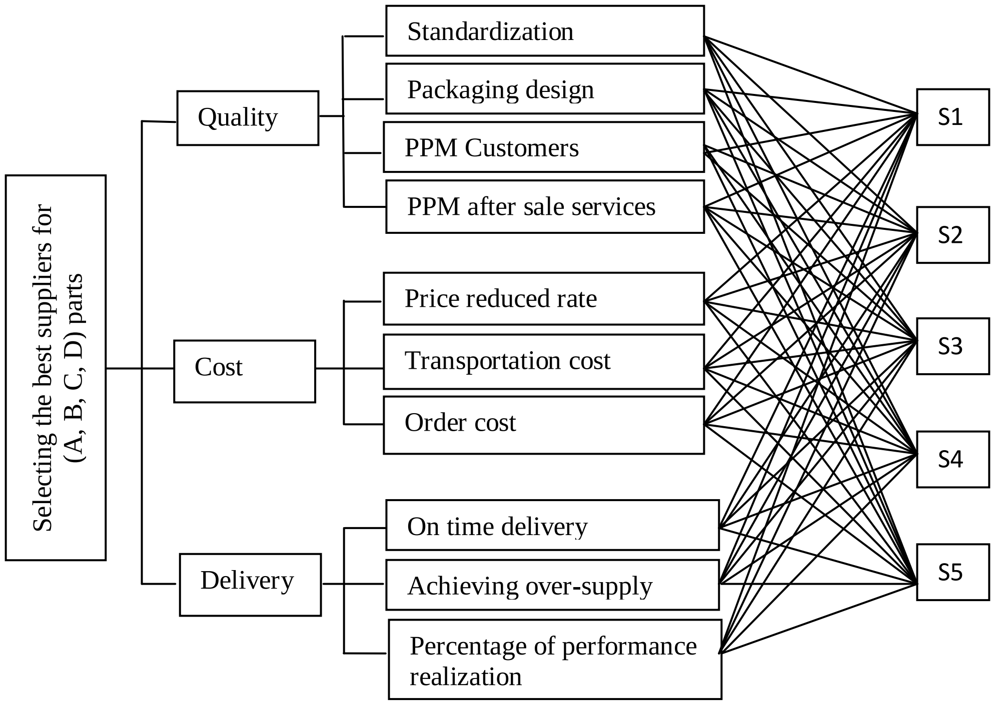

Figure 2. Hierarchical structure to select best suppliers.

play its role. The weight obtained by the AHP technique using Equations 1 and 2 as shown in Table 2 is converted to normalized weighted matrix. Equations 1 and 2 can be summarised as:

$$n_{ij} = \frac{r_{ij}}{\sqrt{\sum_{i=1}^{m} r_{ij}^2}} \quad (1)$$

$$V = N_D \times w_{n\times n} \quad (2)$$

Then, using Equations 3 and 4, positive and negative ideal solution is obtained in the results as shown in Table 3. Equations 3 and 4 are highlighted thus:

$$A^+ = \{(\max V_{ij} \mid j \in J), (\min V_{ij} \mid j = \in J^{`})\} = \{V_1^+, V_2^+, ..., V_n^+\} \quad (3)$$

$$A^- = \{(\min V_{ij} \mid j \in J), (\max V_{ij} \mid j = \in J')\} = \{V_1^-, V_2^-, ..., V_n^-\} \quad (4)$$

The next step of TOPSIS technique is as shown in Table 4 and is used to calculate the Euclidean distance of each alternative, the positive and negative ideals using Equations 5 and 6 summarized as:

$$d_i^+ = \{\sum_{j=1}^{n} (V_{ij} - V_j^+)^2\}^{0.5} \quad (5)$$

$$d_i^+ = \{\sum_{j=1}^{n} (V_{ij} - V_j^+)^2\}^{0.5} \quad (5)$$

$$d_i^- = \{\sum_{j=1}^{n} (V_{ij} - V_j^-)^2\}^{0.5} \quad (6)$$

In the final stage, relative closeness of suppliers to ideal solution using Equation 7 is obtained and ranked according to the relative descending order of suppliers. Table 5 represents the ranking of suppliers based on the combination of the two techniques of AHP and TOPSIS. Equation 7 is thus highlighted:

$$CL_i^+ = \frac{d_i^-}{(d_i^+ + d_i^-)}$$

$$0 \le CL_i^+ \le 1$$

$$i = 1,2,\ldots,m \quad (7)$$

Table 6 defines all of symbols used in Equations 1 to 7.

Mathematical modeling

As was observed, in the first phase of this study using the two techniques of AHP and TOPSIS in integrated form, suppliers were classified with regard to criteria and sub-criteria. While in the second phase, using a mathematical model, how much order should be allocated to each supplier was identified. Thus, the

Table 1. Final weights of criteria and sub-criteria and alternatives.

Criteria	Weights of criteria	Sub-criteria	Weights of sub criteria	S1	S2	S3	S4	S5
Quality	0.330	D1: Standardization	0.231	0.513	0.261	0.129	0.163	0.033
		D2: Packaging design	0.189	0.122	0.425	0.280	0.055	0.055
		D3: Customers PPM	0.198	0.200	0.200	0.200	0.200	0.200
		D4: After sale customers PPM	0.238	0.267	0.555	0.124	0.254	0.140
Cost	0.250	D5: Price reducced rate	0.268	0.513	0.261	0.129	0.063	0.133
		D6: transfer cost	0.091	0.230	0.036	0.476	0.036	0.230
		D7: Order cost	0.096	0.079	0.520	0.298	0.074	0.128
Delivery	0.230	D8: On time delivery	0.153	0.041	0.512	0.144	0.260	0.044
		D9: Achieving over-supply	0.149	0.352	0.156	0.057	0.029	0409
		D10: Percentage of performance realization	0.203	0.513	0.216	0.129	0.163	0.133

Table 2. The weighted normalized decision matrix.

Variable	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
S1	4.256	2.168	0.700	1.658	3.771	3.397	0.231	7.316	1.564	0.506
S2	2.165	10.089	0.310	0.131	1.118	0.523	8.106	1.948	0.689	1.892
S3	1.070	5.391	0.113	0.589	0.202	6.898	4.645	0.560	3.272	3.504
S4	0.523	1.059	0.052	0.131	1.118	0.532	1.154	3.482	0.294	0.246
S5	0.276	0.558	0.814	0.287	0.525	3.397	0.436	7.419	0.174	0.506

Table 3. the ideal solution and negative solution.

Variable	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
A^+	4.256	10.089	0.052	0.131	0.202	6/896	0.231	0.560	1.564	3.504
A^-	0.276	0.558	0.814	1.658	3.771	0.523	8.106	7.419	0.294	0.246

Table 4. Separation of each alternative to positive and negative solution.

Variable	S1	S2	S3	S4	S5
d^+	16.196	9.935	12.175	15.884	15.997
d^-	9.224	15.869	13.676	8.191	11.152

Table 5. Final ranking in two-phase AHP-TOPSIS approaches.

Alternatives	S1	S2	S3	S4	S5
C_j^+	0.363	0.615	0.529	0.340	0.413
Ranking	4	1	2	5	3

second phase is included in designing a multi-objective linear used in the equations. Multi-objective linear programming model was designed this way, that at first, automotive company multiple programming model. Table 7 is briefly described to the symbols

Table 6. Description of symbols in first phase.

Symbol	Definition
r_{ij}	Value of the ith Alternative according to jth crieteria
n_{ij}	Normalized matrix of ith alternative according to jth crieteria
V	Normalized weighted matrix
$W_{n\times n}$	A matrix with original diameter of non- zero
A^{+}	Positive ideal solution
A^{-}	Negative ideal solution
J	Related to profit criteria
J'	Related to cost criteria
d_i^{-}	Edclidean distance to negative ideals
d_i^{+}	Edclidean distance to positive ideals
CL_i^{+}	Relative closeness to positive ideal solution

targets are formulated as three objectives function that include:

The first objective function (Z_1): Purchase costs

$$Minz_1 = \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}.x_{ij}$$

$$c_{ij} = p_{ij} + f_{ij} + o_{ij}$$

The first objective function (Z_1) which is expressed as the minimum indicates the minimization of the costs of buying its pieces from suppliers. These costs include the pure price of product (piece), transportation costs and the cost of ordering.

The second objective function (Z_2): Quality

$$Minz_2 = \sum_{i=1}^{m}\sum_{j=1}^{n} d_{ij}.x_{ij}$$

The second objective function (Z_2) expressed minimizing of the amount due to defects and disadvantages in the parts.

The third objective function (Z_3): Delivery

$$Minz_3 = \sum_{i=1}^{m}\sum_{j=1}^{n} t_{ij}.x_{ij}$$

The third objective function (Z_3) expressed the minimizing of total deviation from the delivery date which is determined according to the contract.

Limitation of conceptual and mathematical modeling

The limitation of company's suppliers and automotive company are specified in seven constraints as follows:

First limitation: Shopping budget

$$\sum_{i=1}^{m} p_{ij}.x_{ij} \leq B_j$$

$$j = A, B, C, D \quad i = 1,2,3,4,5$$

The first limitation represents budget constraints of purchase by the company automotive. This limitation is as ≤ because the total payments to buy parts to suppliers should not be higher from the set budget.

Second limitation: Product demand (pieces)

$$D_j \leq \sum_{i=1}^{m} x_{ij} \leq D'_j$$

$$j = A, B, C, D \quad i = 1,2,3,4,5$$

Table 7. Introducing mathematical parameters model.

Decision variables	Definition
x_{ij}	Order quantity of the jth part from the ith supplier
Parameter	
c_{ij}	Purchasing cost of jth part from the ith supplier
d_{ij}	Average defect rate of jth part from the ith supplier
t_{ij}	Average delivery delay of the jth part from the ith supplier
p_{ij}	The price of jth part that be suggested by ith supplier to automotive company
f_{ij}	Transportation cost of jth part that be suggested by ith supplier to automotive company
o_{ij}	Ordering cost of jth part that be suggested by ith supplier to automotive company
B_j	Purchasing budget for the jth part
D_j	Lowest demand for jth part
D'_j	Highest demand for jth part
S_{ij}	Lowest quantity supply of jth part from the ith supplier
S'_{ij}	Highest quantity supply of jth part from the ith supplier
q_{ij}	Average defect percent of jth part from the ith supplier
Q_j	Maximum acceptable scarp rate of the jth part
L_j	Lead time of the jth part be delivery by ith supplier to automotive company
A_j	Average consumption quantity of the jth part
z_i	Objective function
K_j	Capacity of a vehicle for carried the jth part in terms of kg
u_{ij}	Weight of the jth part that bought from the ith supplier
K'_j	Capacity of a vehicle for carried the jth part in terms of m^3
v_{ij}	Volume of the jth part that bought from the ith supplier

The second restriction indicated limits of demand for the product by automotive company. This restriction shows that how much should be the highest and lowest demand for concerned parts.

Third limitation: Production capacity

$$S_{ij} \le x_{ij} \le S'_{ij}$$

$$j = A, B, C, D \quad i = 1,2,3,4,5$$

This restriction shows that how much the highest and lowest production which supplier is able to meet it.

Fourth limitation: Quality control

$$\sum_{i=1}^{m} q_{ij} . x_{ij} \le Q_j . D_j$$

Table 8. The order quantity allocation.

Part	A	B	C	D	Total
Alternative					
Supplier 1	2500	3000	5200	1600	12300
Supplier 2	6200	3700	6800	4100	20800
Supplier 3	4500	4800	6200	6000	21500
Supplier 4	2100	□	2000	1500	5600
Supplier 5	3800	4500	3500	1200	13000
$Z_1 = 681562500$		$Z_2 = 93$		$Z_3 = 11$	

Table 9. Model credit assessment in first phase.

Suppliers	Final ranking by AHP	Final ranking by topsis	Final ranking by AHP-TOPSIS	Final ranking of company
S1	3	4	4	5
S2	1	2	1	1
S3	2	1	2	2
S4	4	4	5	4
S5	5	5	3	3

$$j = A, B, C, D \quad i = 1,2,3,4,5$$

This restriction shows that the total amount of deficiency for each piece should not be higher from the maximum acceptable rate of defects for each piece, so it is express as ≤.

Fifth limitation: Vehicle weight capacity

$$\sum_{i=1}^{m} u_{ij} . x_{ij} \leq K_j$$

$$j = A, B, C, D \quad i = 1,2,3,4,5$$

This restriction indicates constraints in available transportation capacity. In the above limitation, KJ is expressed in terms of kilogram (kg), so weight of customized parts should be less than or equal to vehicle capacity in terms of kg.

Sixth limitation: Vehicle volume capacity

$$\sum_{i=1}^{m} V_{ij} . x_{ij} \leq K'_j$$

$$j = A, B, C, D \quad i = 1,2,3,4,5$$

These limitations indicate the limitations of vehicle capacity. In the above limitation, K'_j is expressed the capacity of a vehicle in terms of m^3. This restriction should be considered in system because it is possible that the cargo which is carried is in high volume relative to its weight. This limitation is written as ≤.

Seventh limitation: Non-zero limit (integer)

$$X_{ij} = Integer$$

$$j = A, B, C, D \quad i = 1,2,3,4,5$$

After gathering data about decision variables and parameters of mathematical model, the information obtained was entered into a software (LINGO). Table 8 shows that in order for the automotive company to minimize purchase costs, returned rate from defects and delivery time, she must buy from any supplier at the amount specified by the model.

MODEL CREDIT ASSESSMENT

In phase 1 of the research's aim to select and rank suppliers for the four parts A, B, C, D, a two-phase AHP and TOPSIS approaches was used in the integrated form. It should be noted that though each of these two techniques alone can also evaluate and rank suppliers, however, combining the two, caused the weaknesses of each model covered by the strengths of other models. Therefore, to measure the proposed model, one with the approach of AHP and the other with TOPSIS approach was used in single form to solve the decision model, and then the results along with the results of integrated model was provided for managers, experts and specialists in supply chain management area. The results expressed from the integrated AHP-TOPSIS model is closer to the actual results of the company as shown in Table 9 in which model credit was confirmed in the first phase.

In phase II, after determining the position of the suppliers to identify the optimum amount of order to each of them, a linear programming model with three

Table 9. Model credit assessment in first phase.

Suppliers	Final ranking by AHP	Final ranking by topsis	Final ranking by AHP-TOPSIS	Final ranking of company
S1	3	4	4	5
S2	1	2	1	1
S3	2	1	2	2
S4	4	4	5	4
S5	5	5	3	3

Table 10. Saving in purchase cost after applying suggested model.

Part	Real purchasing cost	Optimize purchasing cost	Saving
A	36800000	31452500	5347500
B	11400000	8910000	2490000
C	782000000	641200000	140800000
D	6500000	5250000	1250000
Total cost	836700000	658512500	149887500

Units are according one thousand Rials- Iran.

Table 11. Optimization results of quality and delivery functions.

Part	Defect rate (number) before	Defect rate after	Delivery delay (day) before	Delivery delay after
A	35	12	25	20
B	22	8	30	30
C	42	12	45	30
D	36	10	45	30

objective function and 7 constraints was used. According to this, the amount of order that must be allocated to each supplier determined. Then the results were compared to documents available in the company. To run the proposed mathematical model and order allocation given to each supplier as seen in Table 10, purchase costs were minimized. Table 10 shows the amounts saved by applying the (MOLP) model for the first objective function and Tabel 11 shows the amounts for other objective functions (Quality and delivery).

Conclusion

In this study, what should be considered is that the allocation order to suppliers, based on score alone is not an appropriate method. So the proposed model which shows that the supplier obtained the highest score in phase (1) and also holds a high productive capacity is the appropriate method. However, if the supplier does not meet the objectives and priorities of the automotive company, it is therefore not a good approach for the highest order to be allocated to this supplier just because of a higher rank. This not only results in meeting the goals of the company, but also causes too much waste of time and cost. While executing the proposed model causes to save energy, cost and time. It is a great privilege for large organizations and industries that seek competitive advantage in global markets to adopt this model.

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