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Supplier selection and order allocation a main factor in supply chain

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Abstract. Supplier management is one of the most important parts in supply chain management that is increasingly recognized as a critical decision in the globalization process. Most of firms have been spending considerable amount of their revenues on purchasing. Hence supplier selection is one of the most important functions of purchasing management. 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 performed in two sections and four steps. In first section in order to select the best suppliers we used an integrated AHP-TOPSIS approach. Therefore, after library studies and interview with experts, managers and specialists in supply chain management filed, decision criterion were identified through Delphi contains of main criteria and sub criteria for suppliers selection process. Then in the second section for order allocation to every selected suppliers in first section; we used a multi-objective linear programming model. Therefore objectives and subjective of suppliers and Automotive Company were identified in this section. Results show that applying a two phase AHP-TOPSIS methodology causes to select the best suppliers. Also Automotive Company's total costs will be minimized with using a MOLP model.

Keyword: Supplier selection, Analytical Hierarchy Process, Supplier evaluation, TOPSIS, MOLP.

1. Introduction

Basically the issues related to supplier selection are 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? [1]

In many cases, organizations usually choose more than one supplier for their products, until facing 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 present study we discuss solving the selection of supplier in the state of multiple sourcing. Increasingly importance of selecting appropriate supplier, as a critical decision in supply chain management, lead organizations in different industries to use systematically formed models to choose suppliers and allocate orders to them. The present study using the suggested model to answer two mains 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 section, and 4 steps that will explain more in the following.

2. Literature Review

At least four journal articles have already reviewed the literature related to suppliers' evaluation and selection models [2,3,4,5]. Ghodsypour and O'Brien (2001) suggested mixed integer non-liner programming model to solve supplier's problem with multiple criteria and suppliers capacity [6]. Choy et al (2002)[7], Choy and Lee (2003)[8], Choy et al (2003a)[9], Choy et al (2003b)[10], Choy et al (2004)[11], Choy et al (2005)[12], developed the CBR-based model to aid decision makers in the supplier selection problem. Amid et al. (2006) constructed a fuzzy multi-objective linear programming model to choose appropriate suppliers.

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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 [13]. 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 [14]. Kull & 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 was given to the suppliers and then GP model formulated to assess alternative suppliers based on the objectives of multiple risk and various hard restrictions[15].

3. Methodology

The research was carried out in automotive industry. Overall, this study is doing in four steps. In the first, 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 Delphi 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. After that, 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.

3.1. Step 1: identifying evaluation criteria and sub-criteria

Selecting criteria and indicators is for this purpose that the important aspects and characteristics of suppliers being measured. 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. In our case study, automotive company used Delphi model in order to identify criteria and sub-criteria, with regard to their strategic goals. Therefore, the automotive company-in a meeting consists of 25 managers, experts and specialists in supply chain area identified the criteria influencing on the process of appropriate suppliers selection. The criteria were identified in the form of two main criteria and 10 sub-criteria as follows in Fig. 1:

3.2. Step 2: Implementing AHP technique

AHP technique which developed by Thomas L. Saati in 1980 is a powerful tool for solving complex problems of decision-making with regard to quantitative and qualitative criteria [16]. According to the solution algorithm in this technique as shown in Fig. 1 at first, 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 parts makers who had the highest evaluation (grade A) and was able to produce four parts with codes A, B, C, and D were selected.

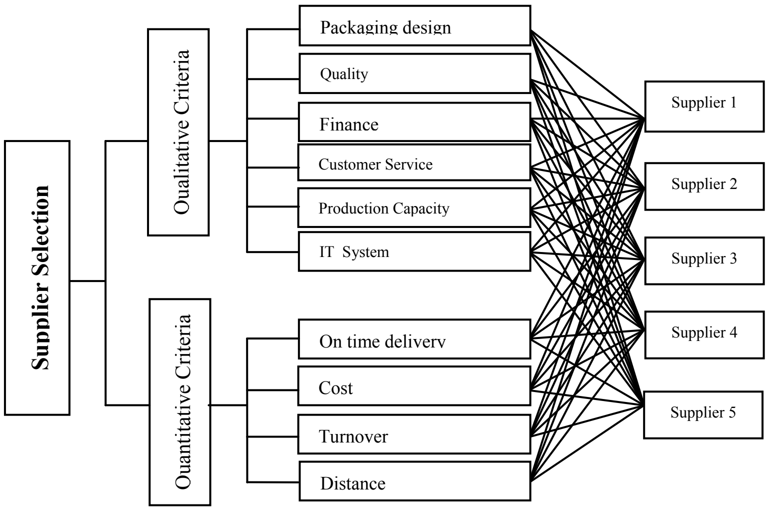

Fig. 1: "Hierarchical structure to select best suppliers"

After the hierarchical structure drew; in order to determine the criteria, and sub-criteria weights, a questionnaire concerning to pairwise comparisons matrix was given to 42 managers, experts, and specialists in the field of supply chain management. Then the data gathered from them, 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.

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
Qualitative Criteria	0.423	D1: Packaging design	0.324	0.347	0.261	0.513	0.033	0.564
		D2: Quality	0.453	0.153	0.425	0.122	0.055	0.236
		D3: Finance	0.132	0.235	0.200	0.200	0.200	0.450
		D4: Customer Service	0.259	0.134	0.555	0.267	0.140	0.174
		D5: Production Capacity	0.206	0.267	0.261	0.513	0.133	0.098
		D6: IT System	0.056	0.056	0.036	0.230	0.230	0.450
Quantitative Criteria	0.302	D7: On time delivery	0.096	0.126	0.520	0.079	0.128	0.342
		D8: Cost	0.120	0.287	0.289	0.041	0.044	0.159
		D9: Turnover	0.118	0.136	0.156	0.352	0409	0.326
		D10: Distance	0.206	0.128	0.216	0.513	0.133	0.230

3.3. Step 3: implementation of TOPSIS technique

TOPSIS is a widely accepted model that proposed by Huang and Yoon in 1981, and then in 1992 was developed by Chen and Huang. In this method, alternatives are ranking based shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution.

The weight obtained by the AHP technique converted to normalize weighted matrix By TOPSIS technique.

Then, positive and negative ideal solution is obtained. The next step of TOPSIS technique is to calculate the Euclidean distance of each alternative to the positive and negative ideals.

In the final stage, relative closeness of suppliers to ideal solution obtained and ranked according to relative approximately descending order of suppliers. Table 2 represents the ranking of suppliers based on combining two techniques of AHP and TOPSIS.

Table 2: final ranking in two-phase AHP-TOPSIS approaches

Alternatives	S1	S2	S3	S4	S5
C_j^+	0.314	0.340	0.529	0.302	0.615
Ranking	4	3	2	5	1

3.4. Step 4: Mathematical Modeling

As was observed, in the first phase of this study using 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 it was identified that how much order should be allocated to each supplier. Thus, the second phase is included designing a multi-objective linear programming model. Table 3 is briefly described to the symbols used in equations.

Table 3: introducing mathematical parameters model

	definition
Decision variables	
x_{ij}	Order quantity of the jth part from the ith supplier
parameters	
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
A_{ij}	Rate of perfect raw material i from supplier j
B_j	Purchasing budget for the jth part
D_j	demand for jth part
V_{ij}	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
z_i	Objective function

Multi-objective linear programming model was designed this way, that at first, automotive company multiple targets are formulated as three objectives function that include:

The first objective function (Z_1): purchase costs

$$MinZ_1 = \sum_i^m \sum_j^n p_{ij} * X_{ij}$$

The second objective function (Z_2): Quality

$$MaxZ_2 = \sum_i^m \sum_j^n A_{ij} * X_{ij}$$

The third objective function (Z_3): Delivery

$$MinZ_3 = \sum_i^m \sum_j^n t_{ij} * X_{ij}$$

Subject to:

Then the limitation of company's suppliers and automotive company are specified in five constraints as follows.

First limitation: shopping budget

$$\sum_{i=1}^m p_{ij} . x_{ij} \le B_j \qquad j = A, B, C, D$$

Second limitation: Buyers demand

$$\sum_{i=1}^n X_{ij} \ge D_j \qquad j = A, B, C, D$$

The third limitation: Suppliers capacity

$$X_{ij} \le V_{ij} * Y_{ij} \qquad j = A, B, C, D \qquad i = 1,2,3,4,5$$

Fourth limitation: quality control

$$\sum_{i=1}^{m} q_{ij}.x_{ij} \leq Q_j.D_j \qquad j = A,B,C,D$$

Fifth limitation: non-zero limit (integer)

$$X_{ij} = Integer \qquad j = A,B,C,D \qquad i = 1,2,3,4,5$$

After gathering data about decision variables and parameters of mathematical model, the information obtained to resolve was entered into software (LINGO). Table 4 shows that automotive company in order to minimize the purchase costs, returned rate from defects, and delivery time, must buy from any supplier in the amount specified by the model,

Table 4: the order quantity allocation

Part	A	B	C	D	Total
Alternative					
Supplier 1	1200	2850	3100	2250	9400
Supplier 2	4200	2800	3000	2500	12500
Supplier 3	4500	3700	4300	5500	18000
Supplier 4	-	1500	2000	1500	5000
Supplier 5	6200	4500	5100	1200	17000
Z1= 57167325		Z2= 74		Z3=9	

4. Conclusion

What should be considered is that the allocation order to suppliers, based on score alone, is not an appropriate method. So that the proposed model shows although supplier obtained highest score in phase (1) and also holds a high productive capacity, but because it does not meet the objectives and the priorities of automotive company; therefore, it is not a good approach that just because of a higher rank, the highest order being allocated to this supplier. These not only never results in meeting the goals of company, but also causes to waste too much 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.

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