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Evaluation and Selection of Supplier Using Analytic Network Process (ANP) and Taguchi Method in Ahvaz's Ramak Dairy Factory

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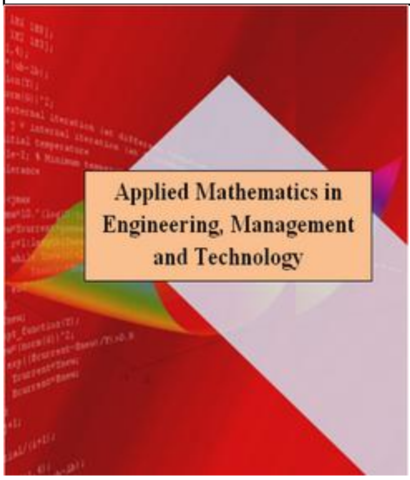

Abstract:

Purchasing directly affect the company's competitive ability. Purchasing managers need to evaluate periodicals performance of suppliers to meet their needs in a timely manner. Suppliers are a critical component of an organization that can have many effects on organizational performance. Through these various effects, a review of the selection of suppliers is essential. Effective factors on the selection process of supplier can be referred to quality, timely delivery, price and service. This article aims to provide a combined approach using analytic network process and Taguchi loss function. The mentioned model is divided into two parts. In the first part, the weight of each indicator using the analysis process and in the second part, damages (losses) related to the quality using Taguchi loss function are specified and identified. Finally, the mathematical model to select and evaluate the best suppliers will be provided by combining two approaches. The purpose of the present paper is combining different levels of indicators for selecting the better supplier. In this context, a practical case will be offered. Finally, the result of the research indicated that the supplier (e) with estimated losses of 34.4056 has selected as the best supplier

Keywords: Supplier Selection, Analytic Network Process, Taguchi Loss Function, Ahvaz's Ramak Dairy Factory.

1. Introduction

One of the most essential factors for survival in today's competitive environment is reducing production costs and increasing its quality. Selecting the right suppliers can substantially reduce purchasing costs and increase the competitive ability. As in many industries, the cost of raw materials and the components of products include the bulk of the cost of the product. Recently, supply chain management and supplier selection process in the context of management has been paid attention. Today, many factories are looking at ways to collaborate with suppliers to improve management performance and their competitiveness. In such circumstances, the purchasing department can play a key role in the efficiency and effectiveness of the organization and have a direct impact on a company's profitability and flexibility, because selecting the right supplier can also reduce the cost of materials as well as increase the company's competitive power. That's why; experts believe that today, choosing a supplier is the most important activity of the purchasing part of any organization. In the choice of supplier, price can't be considered as only criterion for selecting suppliers but also supplier selection is a multi-criteria decision making, which includes qualitative and quantitative variables such as price, quality of goods, timely delivery, etc. (Pi & Low, 2005).
Supplier selection is a process that identified through evaluating and investigating different suppliers using different criteria, and finally the best option to supply materials needed to the organization. Today, organizations reduce the number of their suppliers and in some cases; they prefer to provide their requirements from only a single source (Shin et al., 2000). One of the reasons can be derived from reducing costs of economies of scale and cash discounts to buy. Also, the variety of suppliers may result in lower quality materials because the quality of the material is different among different suppliers (Azizi, 2011). According to this, the purpose of the present article is presenting a new mathematical model for supplier selection and tries to answer two questions in Ramak dairy factory that:
How does the status of the components of supplier selection in Ahvaz's Ramak dairy factory?

How does the current status of each supplier in front of the presented components?

2. Research background:

In choosing a supplier, a lot of research was done. Some of them are mentioned below:
Scott et al (2014) in a research have studied the A decision support system for supplier selection and order allocation in stochastic, multi-stakeholder and multi-criteria environments. This paper proposes an integrated method for dealing with such problems using a combined Analytic Hierarchy Process–Quality Function Deployment (AHP–QFD) and chance constrained optimization algorithm approach that selects appropriate suppliers and allocates orders optimally between them. The effectiveness of the proposed decision support system has been demonstrated through application and validation in the bioenergy industry.
Dargi et al (2014) in a research have studied the Supplier Selection: A Fuzzy-ANP Approach. The main goal of this paper is to develop a framework to support the supplier selection process in an Iranian automotive industry. Although numerous criteria are being used for the selection of suitable supplier, selection of the critical factors in conformance to the specification of the automotive industries is less investigated. In order to fill this gap, this research was carried out to systematically propose a framework comprising of the most critical factors for the aim of supplier selection. A literature survey was conducted and measures for assessing the suppliers were extracted. Nominated Group Technique (NGT) was deployed to extract the most critical performance measures from the initial list. Seven measures were found to be proper for the supplier selection process. A Fuzzy Analytical Network Process (FANP) was then proposed to weight the extracted measures and determine their importance level. The model was then implemented to assist an automotive company for the aim of its supplier selection.
Mani et al (2014) in a research have studied the Supplier selection using social sustainability: AHP based approach in India. This research mainly focuses on socially sustainable supplier selection through social parameters by using the analytic hierarchy process (AHP) in decision making. This methodology demonstrates the development of social sustainability indicators, including equity, health, safety, wages, education, philanthropy, child and bonded labour which are validated by experts. The study also describes how the above mentioned metrics may be used to prioritize alternatives for decision making using AHP. The study further demonstrates practical applications of social sustainability dimensions in selecting suppliers for manufacturers operating in emerging economies. Three case studies illustrating this methodology have also been included. The case studies further analyses the results of the methodology along with the tradeoffs supply chain managers make. Findings show that manufacturers of electrical, automotive and cement industries were able to select suppliers based on the social sustainability score. This study helps supply chain managers integrate various social dimensions into the supply chain function. The results of the study draw the attention of all stakeholders towards social dimensions by necessitating the importance of social conditions upon suppliers.
Kumar Kar & Pani (2014) in a research have studied the Exploring the importance of different supplier selection criteria. The study has been conducted in India, while focusing on Indian manufacturing industries. Similar study conducted in developed economies may produce different results. Findings will be useful for practitioners for benchmarking supplier selection processes, not only in India, but also in similar emerging economies. Also, the outcome will provide insights for suppliers for developing systemic improvements.
Rajesh and Malliga (2013) in a research have studied the Supplier Selection Based on AHP QFD Methodology. In this paper an integrated approach, combining Analytic Hierarchy Process (AHP) and Quality Function Deployment (QFD) is developed to select suppliers strategically. When the House of Quality (HOQ) is used in supplier selection, the company begins with the features that the purchased product must have in order to meet certain requirements that the company has established and then tries to identify which of the supplier's attributes have the greatest impact on the achievement of its established objectives. QFD provides the importance weightings of evaluating criterion, which are derived by the importance ratings of stakeholder requirements together with the relationship weightings between stakeholder requirements and evaluating criterion. Based on the ranked criteria, alternative suppliers are evaluated and compared with each other using AHP again to make an optimal selection. A case study of a Precision Machined High Pressure Die Casting components company in selecting its supplier by using the proposed AHP QFD technique is presented.

3. Research method:

This study is a practical research in terms of purpose. In the literature to collect the content has been used library method and experts were questioned in determining criteria weighting that in this regard, field study and questionnaires have been applied. On the other hand, given the fact that this study is based on statistical analyses, there is no need to determine the society and statistical sample.

3.1. The Presented Innovative Models:

Figure 1 shows an outline of the hybrid model of supplier selection. According to previous studies in the field of supplier selection, four key criteria were identified. For each of these devices was considered evaluated supplier, quality, timely delivery, price and service. All the mentioned factors were used to calculate the analytic network process and Taguchi loss function. Due to the characteristics of the criteria in this regard whether lower or higher values are better, Taguchi loss function is determined and the total losses will be calculated by any means. Losses calculated for criteria and compare the two of them formed a matrix and using analytic network process is given weight to these criteria. Then, to create the appropriate field in order to use the model of supplier selection, analytic network process and Taguchi loss function have been described (Fig. 1).

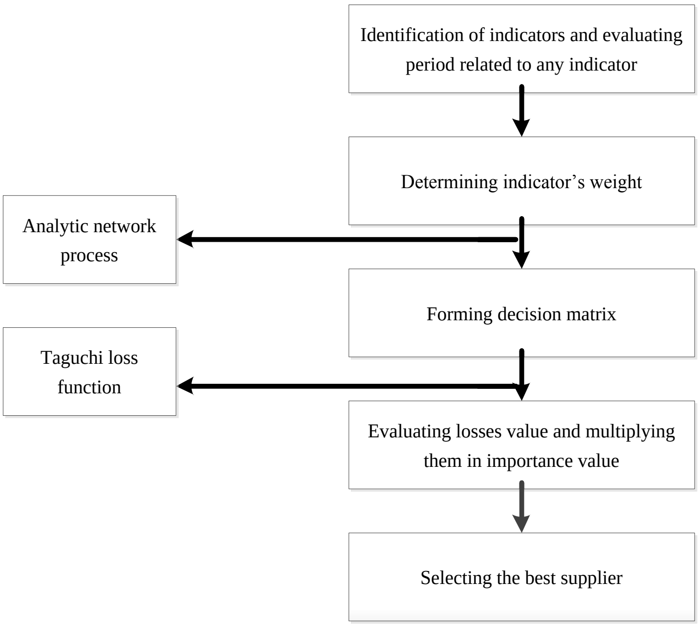

Figure 1: The process of selecting supplier using ANP-Taguchi method

3.1.2. Analytic network Process:

The analytic network process (ANP) was proposed by Saaty (1996) for extending the AHP to release the restrictions of the hierarchical structure, which indicates that the criteria are independent from each other. By raising the supermatrix into the limiting powers, the global priority vectors can be obtained with the specific network structure for determining dependence and feedback problems among the criteria.

The first step of the ANP is to compare the criteria in the whole system to form the supermatrix. This is done through pairwise comparisons by asking "How much importance does a criterion have compared to another criterion, with respect to our interests or preferences?" The relative importance value can be determined using a scale from 1 to 9 for representing equal importance to extreme importance (Saaty, 1996). The general form of the supermatrix can be described as Figure 2.

$$W = \begin{array}{cc} & \begin{array}{cccc} \quad C_1 & \quad C_2 & \cdots & \quad C_m \\ e_{11} \cdots e_{1n_1} & e_{21} \cdots e_{2n_2} & \cdots & e_{m1} \cdots e_{mn_m} \end{array} \\ \begin{array}{cc} C_1 & \begin{array}{c} e_{11} \\ e_{12} \\ \vdots \\ e_{1n_1} \end{array} \\ C_2 & \begin{array}{c} e_{21} \\ e_{22} \\ \vdots \\ e_{2n_2} \end{array} \\ \vdots & \vdots \\ C_m & \begin{array}{c} e_{m1} \\ e_{m2} \\ \vdots \\ e_{mn_m} \end{array} \end{array} & \begin{bmatrix} W_{11} & W_{12} & \cdots & W_{1m} \\ W_{21} & W_{22} & \cdots & W_{2m} \\ \vdots & \vdots & \vdots\vdots\vdots & \vdots \\ W_{m1} & W_{m2} & \cdots & W_{mm} \end{bmatrix} \end{array}$$

Figure 2. Super Matrix

Where *Cm* denotes the *m*th cluster, *emn* denotes the *n*th element in the *m*th cluster, and ***Wij*** is the principal eigenvector of the influence of the elements compared in the *j*th cluster to the *i*th cluster. In addition, if the *j*th cluster has no influence on the *i*th cluster, then ***Wij*** =0.

Therefore, the form of the supermatrix depends heavily on the variety of the structure. After forming the supermatrix, the weighted supermatrix is derived by transforming all column sums to unity exactly. This step is very similar to the concept of a Markov chain for ensuring the sum of these probabilities of all states is equal to 1. (Tzeng and Huang , 2011)

Next, we raise the weighted supermatrix to limiting powers such as Equation (1) to get the global priority vectors or so-called weights:

$$\lim_{k\to\infty} W^k \qquad (1)$$

In addition, if the supermatrix has the effect of cyclicity, the limiting supermatrix is not the only one. There are two or more limiting supermatrices in this situation and the Cesaro sum would be calculated to get the priority. The Cesaro sum is formulated as Equation (2):

$$\lim_{k\to\infty}\left(\frac{1}{N}\right)\sum_{r=1}^{N} W_r^k \qquad (2)$$

To calculate the average effect of the limiting supermatrix (i.e., the average priority weights) where ***Wr*** denotes the *r*th limiting supermatrix. Otherwise, the supermatrix would be raised to large powers to get the priority weights.

3.1.3. Taguchi Loss Function:

According to Taguchi, the meaning of quality is minimizing loss of product on people of society after delivering them to the costumers, except for losses resulting from natural performance of products (Ross, 2005). The goal is to minimize the standard deviation from both sides for desired features of product. Losses can be calculated using a quadratic function (Taguchi et al., 1989). Taguchi loss function is classified into three main types:

1- Features that are smaller are better.
2-Features that are nominal (median) are better.
3-Features that are higher are better.
Nominal is best loss function:

In this kind of function, which is also called bidirectional function, the deviation from both sides of nominal value (m) is possible. Profile of this function can be seen in figure3. As the distance of calculated feature (y) from nominal value increases, imposed loss (L) also increases equal with square of y from m. L(y) = k (y-m)2 (3) Where K is constant of formula and obtained through following relation: K = A0/Δ02 (4)

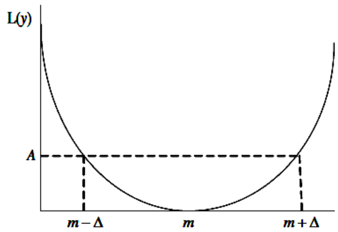

Figure 3 : Nominal-is-best Loss Function (recourse: Chin Nang Liaho, Hessing P Kahoo, 2010)

Smaller is better loss function:
In this function, which is also called unidirectional minimal function, deviation is only possible in positive direction. The nominal value is usually considered zero in this kind of function (figure 4).
The amount of loss is obtained through following relations

$$\begin{cases} L = Ky^2 \\ K = A_0/\Delta_0^2 \end{cases}$$

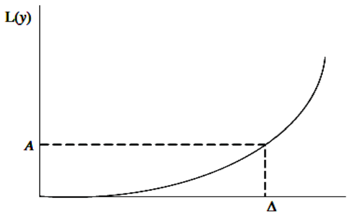

Figure4: Smaller-is-better Loss Function (recourse: Chin Nang Liaho, Hessing P Kahoo, 2010)

Higher is better loss function:
The other name of this function is unidirectional maximal function. Like previous function, deviation is only possible in negative direction (left side) of nominal value. The profile of this function and its respected relations can be seen in figure 5.

$$\begin{cases} L = k/y^2 \\ K = A\Delta^2 \end{cases}$$

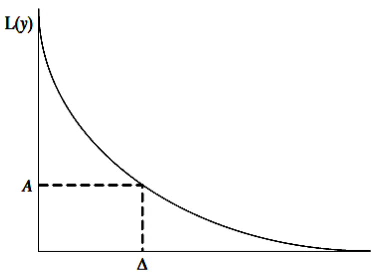

Figure5 : Higher-is-better loss function (recourse: Chin Nang Liaho, Hessing P Kahoo, 2010)

A is average loss of quality. Therefore, related function is calculated by using mentioned functions. Then this value is multiplied by all numbers of related column and in this way, loss matrix is formed for decision making.

4. Investigating Supplier selection by ANP – TAGUCHI innovative method (Finding):

Usually, the most important objective of the supplier selection is identifying suppliers that continually have the highest potential to meet the needs of a company with an acceptable cost. This selection is conducted through

extensive comparison of the suppliers and based on a set of criteria and benchmarks. However, the review and evaluation of potential suppliers may vary depending on the needs of the company. The overall objective of selection is identifying high-potential suppliers for selecting potential suppliers, we can use the appropriate criteria and benchmarks and evaluate the ability of any supplier to meet the needs continually and effectively (in terms of cost). Criteria and benchmarks established for all suppliers are applicable and show needs of enterprises and supply strategies and its technology (Kettabi et al., 2008).
Due to the above, this paper aims to according to the criteria of quality, timely delivery, and price and service offer premier supplier between seven suppliers to propose to Ramak Company as a leading supplier that with regard to the model is as follows:

4.1. The first phase of the research to output of the criteria weighting are as follows:

The input and output are given below. The findings of this study consisted of two phases: the first stage, the weight of the indicator extracted using analytic network process and then using Taguchi loss function, the ranking based on less to more loss rate is ranked. Super decision software output or final matrix from the couple comparison that form the weight of the components: In this section that related to first part of the article (the extraction of component weight), the purpose is estimating the weight of each component, which according to experts is shown in table 1:

Table 1: Weight Of criteria

component	resource	Component weight
price	(Liao & kao, 2010)	0,201256
quality	(Liao & kao, 2010)	0,307487
service	(Pi & Low, 2005)	0,267496
Timely delivery	(Pi & Low, 2005)	0,221780

4.2. Supplier evaluation and selection:

In the second stage, Taguchi loss matrix is calculated using factory's conditions and then by combining weights obtained from the analysis process, we select an option that have the lowest cost. To provide an answer to the best option from the perspective of the loss function, four stages should be done:
1) To determine the appropriate function: in the first step, we identified the appropriate function for each of indicators. The selection was done according to the nature of each indicator that is as follows:
1) Quality (maximum one-way function (the more the better))
2) Price (minimum one-way function (the lower the better))
3) Services (maximum one-way function (the more the better))
4) Timely delivery (maximum one-way function (the more the better))
2) Calculate K for each indicator
According to interview conducted from experts from the suppliers department, the range has been determined the Taguchi target range: Target range for timely delivery indicator will be around zero and we consider a maximum of 2% deviation from the target. So, zero loss occurs exactly in target value and 100% of the losses will occur in 2% deviation from the target. In price, zero losses occur for items that have the lowest price and the upper limit will be equal to 15% increase in costs, i.e. 100% of loss in the 15% increase in price will be relative to the lowest price. Similarly, to quality indicator, 100% losses are considered in the 60% appropriateness and zero loss is at 100% appropriateness. In the case of services, loss of zero is100% and the loss of 100% in services level is 85%, that is, this criteria has a range of 85% to 100%.
$k = 1 * 0.0004 = 0.0004$(timely delivery)
$\mathrm{k} = \frac{1}{.0225} = 44.44$(price)
$k = 1 * .36 = .36$ (quality)
$\mathrm{k} = 1 * .7225 = .7225$ (services)

3) The calculation of the loss for each raw value: After identifying the formula obtained, the raw values (decision matrix values) put in the formula for each indicator to be converted into loss amounts. The results of this step can be seen in the table below.
Obtain losses Matrix: L

Table 2: The results of the experts in relation to each supplier

supplier	Timely delivery	price	quality	services
Supplier (a)	3.8	6.8	3.2	3.8
Supplier (b)	3.9	6.2	3.6	3.9
Supplier (c)	4.6	5.8	3.9	4.9
Supplier (d)	6.1	5.1	5	6.1
Supplier (e)	7.2	3.6	7.1	7.3
Supplier (f)	4.5	3.9	6.2	7.1
Supplier (g)	6.1	4.2	6.1	5.7

Table 3: Estimation of L

supplier	Timely delivery	price	quality	services
Supplier (a)	0.0000277	2054.906	0.035156	0.050035
Supplier (b)	0.0000263	1708.274	0.027778	0.047502
Supplier (c)	0.0000189	1494.962	0.023669	0.030092
Supplier (d)	0.0000107	1155.884	0.0144	0.019417
Supplier (e)	0.0000077	575.9424	0.007141	0.013558
Supplier (f)	0.0000198	675.9324	0.009365	0.014332
Supplier (g)	0.0000107	783.9216	0.009675	0.022238

Integrating the loss of each option: to obtain the total loss an option, we can use the weight of each indicator. Here, the weight of which is derived from the ANP method used. (Table 4)

Table 4: Integrated of ANP & TLF

supplier	Timely delivery	price	quality	services	Loss related to each supplier
Weight related to each component	0,221780	0,201256	0,307487	0,267496	
Supplier (a)	0.0000061	413.562	0.01081	0.013483	413.5865
Supplier (b)	0.0000058	343.8	0.008541	0.012801	343.8217
Supplier (c)	0.0000042	300.87	0.007278	0.008109	300.8855
Supplier (d)	0.0000024	232.629	0.004428	0.005232	232.6383
Supplier (e)	0.0000017	115.912	0.002196	0.003654	115.9177
Supplier (f)	0.0000044	136.035	0.00288	0.003862	136.0422
Supplier (g)	0.0000107	783.9216	0.009675	0.022238	157.7779

According to Table 6 the order of suppliers is as follow that come in the table below:

Table 5: Final Ranking of supplier

suppliers	Ranking related to each supplier
Supplier (a)	7
Supplier (b)	6
Supplier (c)	5
Supplier (d)	4
Supplier (e)	1
Supplier (f)	2
Supplier (g)	3

5. Conclusion:

Many experts and scholars have established the benefits of supply chain management. To enhance competitive advantage, many companies feel that having a supply chain system that is well designed and implemented, is a very important tool in the field. In these circumstances, the use of the near and long-term relationships between buyers and suppliers is a critical success factor for supply chain system. So, the selection of suppliers is the most important issue to implement a supply chain.

In innovative approach proposed, subjective judgments of decision-makers used in paired comparison process and applied by combining AHP and TAGUCHI methods to decide on the best supplier that on the basis of it, Supplier (e) has selected as the best supplier. With regard to the made comparison, the use of the conceptual model for the study in Ramak factory is very helpful in making the right decision in this case.

As a result, high-level supplier also should develop appropriate strategies to maintain its position and low-level supplier use of data from the study to reduce the gap with the top supplier.

The proposed model can use to select vendor and choose a location for the establishment of housework and warehouse and other similar problems, it is recommended that TAGUCHI method is combined with other weighting methods and results are compared with this approach that are other suggestions for future research.

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