Development of a Model for Evaluating and Ranking Gas Stations Using Analytic Hierarchical Process

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Abstract: In the present research, a model is presented using the Analytic Hierarchical Process (AHP) for evaluating and ranking gas stations. First, some indicators were identified by reviewing the literature of this field and interviewing the experts in National Iranian Oil Company (NIOC). Then, pairwisecomparisons were made between the indicators by taking the views of experts into account. Due to the large number of indicators, a different approach to the typical AHP was taken where instead of two-by-two comparisons between alternatives based oneach indicator, a rating scale was used at one level of the hierarchy. Thus, the relative weight of each indicator was calculated with respect to the aboveelement and finally, by multiplying the local weight related to the rating scale acquired for each indicator, the total weight and score of each index was calculated. Finally, by adding all the scores, the score of the evaluated gas station was calculated. To calculate these scores, a program was written using EXCEL software so that NIOC could easily evaluate and calculate the scores of stations and rank them.

Key words: Analytic Hierarchical Process, ranking, evaluation, gas station.

INTRODUCTION

In the contemporary world, numerous transformations can be observed along with the growing competition in various areas, in particular markets. Change is a familiar word which along with the opportunities and threats that each society and profession faces, at times leads to growth and development and at times leads to apprehension, bewilderment and failure. Countries and companies that have set dynamism as their goal find construction and development in change.

On the other hand, competition is a word that has more than anything else dominated the world and its different forms have made administrative, commercial and industrial teams react. The competition process is the force that steers economic progress.

Therefore, competitive forces and change processes must be used for progress in the economic arena (improving customer service). But customer satisfaction depends on two factors-product performance in providing value for customers (with respect to purchase expectation) and product quality. If product performance is lower than customer expectation, the purchaser will be dissatisfied and if performance is the same as what is expected, the customer will be satisfied. A satisfied customer repeats their purchase and informs others of their good experiences with the product - the key is that customer expectations correspond to product performance (Brent, A. et al., 2006).

This issue is evident in all organizations including service and manufacturing. One of the organizations that are of utmost important in supplying the fuel required for various organizations of the country is National Iranian Oil Company (NIOC). This company is particularly important in that it is the only organization responsible for fuel supply in Iran. Management of gas stations is one of the most important duties of this company which has occupied much of its responsibilities, duties and decisions. Thus, the changing economic conditions and the changing factors of the external environment (competitors, customer satisfaction, etc.) have made the managers of NIOC make decisions about paying incentive fees to gas stations.

Although the production and supply of oil products in Iran are exclusive to NIOC and gas station proprietors practically play no role in producing or improving the quality of their product, they do play a role in improving customer service, supply conditions, production environment, supply-related personnel, etc.

National Iranian Oil Product Distribution Company (NIOPDC) is responsible for the allocation of licenses to the private sector for establishing and administering gas stations with limited liability and through this process, this company pays wage to gas stations. This company, like any other public organization that are responsible for monitoring the performance of their organization, enforces a set of rules and regulations on the gas stations in order to protect the reputation of the company and to control and guide the gas station toward better customer service and customer satisfaction. Thus, the present research presents a scientific model which is imperative for improving the fair evaluation of how the rules and regulations are observed by the company (NIOC); a model that can identify the indicators, weigh them using the view of experts and determine and rank their priority using MCDM models (AHP and the like), so as to direct gas stations toward better customer service and customer satisfaction through fair payment of wage and bonus.
Importance and Purpose of the Research:

Trade globalization (WTO) and the macro policies of the government for bringing gasoline prices to international rates as included in the future plans and the 20-Year Outlook Document, as well as the exclusivity of production and distribution of oil products to NIOC and the fixed price of oil in all the gas stations has led to decreased competition among these businesses for providing better customer service.

Thus, the present research aims to obtain strategies for National Iranian Oil Product Distribution Company (NIOPDC) for guiding and persuading gas stations to provide better services and improve customer orientation using leverages such as paying incentive fees based on the degree to which the regulations and standards (measures and criteria) of NIOC are observed. Another reason for the necessity of the present research is that so far there has not been any research that would scientifically study the evaluation indicators of gas stations.

Considering the mentioned necessity, the purpose of the research can be outlined as follows:

- Study, identification and ranking of criteria for evaluating fuel supply channels.
- Providing a scientific model for ranking and improvement of customer service in NIOC gas stations.
- Evaluation and ranking the gas stations in Qazvin Province.
- Increasing confidence in ranking the gas stations.

Some of the research purposes are:

- Improvement of fuel supply services.
- Customer orientation and public satisfaction.
- Improvement of the physical condition and making use of state-of-the-art technologies in fuel supply.
- Acceleration of fuel supply process.
- Improving the financial position and satisfaction of the proprietors of gas stations.
- Preparing the ground for competition for a more desirable product supply and services.

Problem Statement:

How are the gas stations evaluated and ranked for fair payment of incentive fees in order to improve customer services?

Following the mentioned primary questions, the secondary questions are outlined below:

- What criteria can be used for evaluation of gas stations?
- How is the priority of those criteria?
- How can a model be developed for such an evaluation using multi-criteria decisionmaking techniques?

Research Hypotheses:

- Ranking the gas stations will lead to fair payment of wages by the NIOPDC.
- Ranking gas stations will increase and improve services and customer satisfaction.

Analytical Hierarchy Process:

As the name of this technique suggests, it is used for solving problems in which the goal is at the toplevel and the alternatives are the bottomlevel. In the medial levels, there are factors which are on one hand related to the goal and on the other hand related to the alternatives and are somehow intermediaries between the top and the bottomlevel. An instance of such a problem is when a goal has several criteria each of which has its own subcriteria. The number of these elements differs in different problems, but the overall shape of these problems leads to a decision tree and when this tree is formed, the procedures of AHP for problem solving proceeds as discussed below.

First Step: Pairwise Comparisons:

The alternatives at each level of the decision tree must be judged by the decisionmaker based on pairwise comparisons; that is, the individual prefers an alternative over the other and assigns a degree of importance to this preference. This is referred to as the marginal rate of substitution which starts with equal preference with a numerical value of 1 and continues until extreme importance with a value of 9.

For instance, if element A is strongly preferred to element B, the marginal rate of substitution of A for B will be 5 and the marginal rate of substitution of B for A will be 0.2. Thus, if the elements in each level of the decision tree are placed in the row and column of a matrix, the result will be a positiveinverse matrix. This matrix is named matrix A and its entries are named $a_{ij}$ (Azar, A. and M. Momeni, 2001):

$$a_{ij} = \frac{1}{a_{ji}}$$  \hspace{1cm} (1)

\(\alpha_{ii} = 1\)  \hspace{2cm} (2)

Table 1: Intensity of importance and the marginal rate of substitution in pairwise comparisons.

<table>
<thead>
<tr>
<th>Intensity of Importance</th>
<th>Numerical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equal</td>
<td>1</td>
</tr>
<tr>
<td>Equal to Relative Importance</td>
<td>2</td>
</tr>
<tr>
<td>Relative Importance</td>
<td>3</td>
</tr>
<tr>
<td>Relative Importance to Strong Importance</td>
<td>4</td>
</tr>
<tr>
<td>Strong Importance</td>
<td>5</td>
</tr>
<tr>
<td>Strong Importance to Very Strong Importance</td>
<td>6</td>
</tr>
<tr>
<td>Very Strong Importance</td>
<td>7</td>
</tr>
<tr>
<td>Very Strong Importance to Extreme Importance</td>
<td>8</td>
</tr>
<tr>
<td>Extreme Importance</td>
<td>9</td>
</tr>
</tbody>
</table>

That is because the result of comparing each element with itself leads to equal preference whose numerical value is 1. If there are \(n\) factors at a specific level of the decision tree, the rank of matrix A will be \(n \times n\) and to complete it, \(\frac{n(n-1)}{2}\) comparisons have to be made by the decisionmaker.

If the number of decisionmakers is more than one, a group matrix will be obtained by combining individual matrices. Then each entry of this matrix will be equal to the geometric mean of the corresponding entries in the individual matrices:

\[a_{ij} = \left( \prod_{k=1}^{n} a_{ijk} \right)^{\frac{1}{n}}\]  \hspace{2cm} (3)

If the weight of decisionmakers is not equal, one can even attribute a specific weight \(w_i\) to each and use the following geometric-harmonic mean to obtain the group matrix:

\[a_{ij} = \left( \prod_{k=1}^{n} a_{ijk}^{w_i} \right)^{\frac{1}{w_i}}\]  \hspace{2cm} (4)

The necessary condition for using each group matrix is that it has an acceptable consistency rate.

**Second Step: Calculation of the Importance Coefficient of Each Matrix:**

As for this step, matrices are first normalized using the following relation:

\[\tau_{ij} = \frac{s_{ij}}{\sum_{i=1}^{n} s_{ij}}\]  \hspace{2cm} (5)

In this relation, the entries of the normalized matrix are shown as \(\tau_{ij}\). Then, one can find the importance of each element using the mean of each row in the normalized matrix. Obviously, the sum of all the weights in each matrix is equal to 1. The prioritization of the alternatives in the last row is obtained by multiplying the weight of each alternative by the weight of the related elements in the higher levels until reaching the top level. The alternatives can be ranked by calculating their final weight (Azar, A. and M. Momeni, 2001).

**Third Step: Calculating the Consistency Rate:**

This step is for problems in which a group decisionmaking matrix is used. In other words, the reliability of the method for such problems is measured by the inconsistency rate. What is meant by consistency in this method is that if the alternative \(i\) is preferred to alternative \(j\) with a rate of substitution of \(a_{ij}\) and if alternative \(j\) is preferred to alternative \(k\) with a rate of substitution of \(a_{jk}\), the decisionmaker is expected to prefer alternative \(i\) to alternative \(j\) with a rate of substitution of \(a_{ik}\) (Azar, A. and M. Momeni, 2001):

\[a_{ij} \times a_{jj} = a_{ij}\]  \hspace{2cm} (6)

But in reality, this is not the case and there is some kind of inconsistency between the comparisons. By calculating the inconsistency rate it is revealed whether or not the error is insignificant. The steps for calculation of the inconsistency rate are as follows:

1. Calculating the weighted sum vector:

\[wsv = W \times A\]  \hspace{2cm} (7)
2. Calculating the consistency vector:
\[ CV = \frac{w_i}{w_j} \]  

(8)

3. Calculating the eigenvalue \( \lambda_{max} \):
\[ \lambda_{max} = \frac{\sum CV_i}{n} \]  
where \( n \) is the number of options.  

(9)

4. Calculating the consistency index (CI):
\[ CI = \frac{\lambda_{max} - n}{n-1} \]  
in case of individual decision making \( (10) \)

\[ CI = \frac{\lambda_{max} - n}{n-1} \]  
in case of group decision making \( (11) \)

5. Calculating the consistency ratio (CR):
\[ CR = \frac{CI}{RI} \]  

(12)

In the above relation, RI denotes random index which is extracted from table 2 with respect to the number of options:

<table>
<thead>
<tr>
<th>n</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI</td>
<td>0</td>
<td>0</td>
<td>0/58</td>
<td>0/9</td>
<td>1/13</td>
<td>1/24</td>
<td>1/32</td>
<td>1/41</td>
<td>1/45</td>
<td>1/49</td>
<td>1/51</td>
<td>1/48</td>
<td>1/56</td>
<td>1/57</td>
<td>1/59</td>
</tr>
</tbody>
</table>

If the consistency rate is less than 0.1, pairwise comparisons have acceptable consistency; otherwise, the pairwise comparisons must be reconsidered.

**Literature:**

Many studies have been carried out on evaluating and ranking using multi-criteria decision making techniques, especially on Analytical Hierarchy Process (AHP) and some of these studies are mentioned in this section.

Leung and colleagues carried out a research in 1998 and mentioned the application of AHP with regards to the multiple objectives related to fishery management that have created a complicated decision-making environment. In this paper, AHP is used for evaluating four alternatives for limiting entry of longliners into the Hawaii pelagic fishery (Nydick, R.L., R.P. Hill, 1992). In 2006, a research was carried out by Shyura and colleagues using multi-criteria decision making techniques in which a hybrid model was presented for supporting the vendor selection process. First, the problem of vendor evaluation was formulated using MCDM approach and a multi-step hybrid process that incorporates ANP. Then, the modified TOPSIS was adopted for rank competing products in terms of their overall performance (Shyura, H., S. Shih, 2005). Sólnes (2003) presents another application of AHP. In this article, he seeks to choose one alternative from 3 options for building an aluminum smelter using analytical hierarchy process (Sólnes, J., 2003). Mau-Crimmins and colleagues used AHP as a means for improving public participation. In this study, the university students who had enrolled for a course in natural resources economics and management at the University of Arizona tested the application of the multi-criteria decision making method (AHP) to a national forest planning situation (Qodsipour, S.H., 2004). In 2007, a research was carried out by Jabeur and colleagues regarding an ordinal sorting method for group decision making. This paper focuses on methods for ranking separate alternatives when their values are precisely evaluated by multi-criteria indices (Najafi, K., 2002). Kang and Lee (2007) used fuzzy AHP ranking and presented a hybrid planning model for semiconductor fabrication (Nili-Ahmadiabadi, M., 2003). Ravi and Ready (1999) used fuzzy MADM for ranking Indian coals (Saaty, T.L., L.G. Vargas, 1994). Chan et al., (2004) presented and implemented another application of AHP for determining priority in a safety management system (Jabeur, K., J. Materal, 2007). Wijnmalen (2007) studied an analytical framework of benefits, opportunities, costs and risks (BOCR) using an AHP-ANP approach in a critical validation case (Wijnmalen, D.J.D., 2007). Gerdari and Kocaoglu (2007) showed an application of AHP in developing a strategic framework for a roadmap technology (Mau-Crimmins, T. et al., 2003). Bozbura and Beskese used fuzzy AHP to prioritize organizational capital measurement indicators (Chiu, Y., Y. Chen, 2007). In another study, an application of AHP to patent validation was presented by Chen and Chiu (Leung, P. et al., 1998).
Brent and colleagues presented another application of AHP to establish health care waste management systems that minimize infection risks in developing countries (Gersri, N., D. Kocaoglu, 2007). Wang and Chang used TOPSIS for evaluating initial training aircraft (Wang, T., T. Cheng, 2007). Chang and colleagues presented an application of MCDM to military officer performance appraisal system (Kang, H., A.H.I. Lee, 2007). In another study, Chang and colleagues used MCDM for an optimization-based evaluation of development strategies for the air cargo industry (Kotler, P. and G. Armstrong, 1999). In their research, Chiu and colleagues compared among three MCDM analytical techniques for knowledge communities group-decision analysis (Leung, P. et al., 1998). Nydick and Hill applied AHP to the problems of supplier selection. They stated that AHP, due to its innate capability, uses qualitative and quantitative indicators in supplier selection (Ravi, V., P.J. Ready, 1999) and in addition, it can easily be understood and applied by operational level managers (Tam, M.C.Y., V.M.R. Tummala, 2001). Moreover, AHP can help improving the decisionmaking process. Due to its hierarchical structure, all the members of the evaluation team are able to systematically observe the criteria and sub-criteria. Further, if necessary, the team can modify this hierarchical structure by adding some criteria. They can also use AHP to make systematic comparisons and determine the priority of the criteria and sub-criteria (Tam, M.C.Y., V.M.R. Tummala, 2001).

In a thesis, the factors affecting the clientele of IranRefah Bank were studied using AHP. In this study, the factors affecting customer satisfaction were identified and the most important ones were selected using statistical techniques. Then, they were ranked using multi-criteria decisionmaking (MCDM) techniques including TOPSIS, AHP and LINAMP (Chang, Y. et al., 2006). In another study, the performance of the factories of ETKA Company was evaluated using AHP and TOPSIS techniques. In this research, based on Kaplan and Norton’s Evaluation Model, evaluation indices in the structure and processes were identified and by collecting information, the alternatives of interest were evaluated using the mentioned techniques (Chang, J. et al., 2006). Tam and Tummala studied the applicability of AHP to vendor selection of a telecommunication system for improving group decisionmaking using a more systematic and logical approach. In this study, they took a different approach to AHP where a rating scale was used in the decision hierarchy and they calculated the overall weights and chose the best option without recourse to pairwise comparisons. This method is applied in most cases where there are a large number of indices and alternatives; to overcome the problem of innumerable pairwise comparison, the present research too uses this method.

**Methodology:**
Since the present research is mainly descriptive and comparative, statistical tests will seldom be used for data analysis and instead, the analysis is mainly done on the collected qualitative and quantitative data by transforming qualitative data to quantitative, using frequency, Delphi technique and feedback from surveys regarding indices; experts confirmed the importance of the criteria and finally arrived at a consensus regarding these criteria. Thus, by a review of the extant literature in this field and interviewing experts of the area, the criteria were identified and a questionnaire was used to get feedback from the expert regarding the importance of each in evaluating and ranking gas stations. Then, using the number of experts’ views (M) regarding the number of indices (N), the mean importance of each index was obtained and using statistical hypothesis testing, the mean importance of each was tested. Then, the important indices were identified and culturally adapted and the views of experts were collected through an interview and a questionnaire. Regarding the necessity of the criteria and their level of significance (weight), based on Likert scale, the experts were asked to add any indices and criteria that have been overlooked to the end of the questionnaire. The added criteria would be included in the subsequent questionnaires and would be distributed among some of the experts so that they would arrive to a consensus regarding their necessity and importance. Finally, after determining the criteria that affect the evaluation process and their importance, secondary measures and parameters that are needed for determining each criterion were identified and categorized. After identifying the criteria, weighing and ranking were done using MCDM techniques (MADM, AHP, etc.). In fact, this evaluation is meant to help the manager in making decisions regarding the ranking of gas stations (Sarmad, Z. et al., 2006).

1. Designing and modeling using the tree model or analysis of variance.
2. Experimental implementation of the model and interpretation of the results of comparisons with the mentioned methods.
3. Suggesting the model and presenting the strengths and weaknesses.

**RESULTS AND DISCUSSIONS**

**Data Collection:**
By defining the research problem and considering its hypotheses, the present research is descriptive-survey. Considering the nature of the research, library method was used for identification of the criteria and field method was applied for the final identification of criteria and their confirmation by the experts.
Population and Sample:
The indices were identified based on the views of professors and experts and were categorized into three
categories each of which had one addressee; indices related to technical properties concerned the managers and
experts of NIOC, indices related to services and facilities which concerned the customers and indices related to
fuel suppliers which concerned the drivers. Thus, three different groups were identified.

To increase the validity and reliability of the research and make it more applicable, the population of the
research for surveying and identification of the evaluation indices include managers, customers and fuel
supplying drivers and who are the contractors of Qazvin Oil Company. On average, each station receives 120
customers, the total number of managers in NIOC is 40 and the number of fuel supplying drivers is 60.

To determine sample size, the following relation can be used based on statistical texts (A collection of
articles for the first international project management conference, 2004):

\[ n = \left( \frac{z_{\alpha/2} \sigma}{\varepsilon} \right)^2 \]

Where \( z_{\alpha/2} \) denotes the statistic related to confidence percentage and \( \varepsilon \) and \( \sigma \) are the level of standard error
and standard deviation respectively. After consulting the statistics experts, the best value was set as 2% of
standard deviation. Since the value of the test statistic at the 95% confidence level is 1.96, the sample size for
managers, customers and drivers were calculated as 28, 58 and 37 respectively. On the other hand, because of
research limitations such as time, costs and other issues, the questionnaire return rate was X for managers, 48 for
customers and all the 37 questionnaires distributed among the drivers.

Validity and Reliability of the Questionnaire:
Validity and reliability are two of the technical properties of the measurement material. Reliability refers to
how much the material yields equal results in similar situations. Validity refers to how much the material can
measure the consistent characteristics of the subjects or their changing and temporary characteristics
(Ashgharpour, M.J., 2007).

Reliability was calculated for the first questionnaire - i.e. criteria identification questionnaire - using
Cronbach’s alpha with the following formulation which was done in SPSS software for each of the sub-criteria
questions.

\[ \alpha = \frac{1}{j-1} \left( 1 - \frac{\sum S_j^2}{S^2} \right) \]

Where \( j \) denotes the number of sub-questions of the questionnaire or the test, \( S_j^2 \) is the variance of the \( j \)th
subtest and \( S^2 \) is the total variance of the test; the results are as follows:
- Questionnaire of the managers: \( \alpha = 0.7059 \)
- Questionnaire of the customers: \( \alpha = 0.7207 \)
- Questionnaire of the drivers: \( \alpha = 0.7302 \)
- Total mean: \( \alpha_{\text{Ave}} = 0.7189 \)

These values were verified by statistical experts.

The second questionnaire deals with identifying the weight of the criteria using pairwise comparisons and
according to the conventions, its reliability is measured using the inconsistency rate; that is, this rate has to be
less than or equal to 0.1. If the inconsistency rate is less than 0.1, the questionnaires will have to be modified
and redistributed until this rate arrives at the level of interest for all the pairwise comparisons.

Conclusion and Discussion:
In the present study, the criteria for evaluating and ranking gas stations were clearly defined by applying an
AHP approach and the problem was systematically structured. This approach enables the decisionmaker to take
the strengths and weaknesses of the conventional evaluation systems into account and thus, it will help the
evaluation team to arrive at a conscious decision. In this research, a general model was presented for evaluating
and ranking gas stations with all the 90 described criteria and in this method, the overall priorities of the criteria
of interest were calculated. Based on these total weights, 5 gas stations in Qazvin Province were ranked as a case
study. It can be concluded that the AHP model can facilitate decisionmaking and considerably decrease the time
of evaluation and ranking of gas stations. Hopefully, the success of this approach will encourage the regional oil
companies of the country, especially National Iranian Oil Company (NIOC), to apply the model in their future
decisions regarding evaluation of gas stations. All the evaluators who engaged in pairwise comparisons were
satisfied with the ranks in the case study and supported them. The officials of the Qazvin Oil Company were also satisfied with application of this model. To describe the results of this research, it is imperative to pay heed to the following issues:

1. Using this approach, the criteria for evaluating and ranking the gas stations were explicitly defined and the problem of interest was systematically structured. This enables decisionmakers to investigate into the weaknesses and strengths of gas stations by comparing them using proper criteria and sub-criteria.

2. Moreover, using AHP for this problem can considerably save time and efforts related to evaluation and the program written in EXCEL software facilitates computations.

3. The model presented in this research can be considered as a basis for evaluating and ranking gas stations throughout the country.

4. The five-point rating scale used in this model helps decisionmakers to avoid time consuming pairwise comparisons. If a new sub-criterion is of interest of some decisionmakers, it can easily be added to the model and be used in the selection process.

5. Further, if the number of evaluators increases, they can also be incorporated into the model easily and the evaluation and ranking of a gas station can be done through a more straightforward method.

6. It must be noted that with the increase in the number of criteria and sub-criteria and as well the number of alternatives, data collection and calculations increases and this was one of the reasons why only 5 alternatives were incorporated in the AHP model.

7. Moreover, as observed in the present research, the criteria and sub-criteria were categorized to reduce their number and then they were incorporated in the model.

REFERENCES


