academicJournals

Vol. 7(18), pp. 1859-1874, 14 May, 2013
DOI: 10.5897/AJBM12.381
ISSN 1993-8233 © 2013 Academic Journals
http://www.academicjournals.org/AJBM

African Journal of Business Management

Full Length Research Paper

Strategic planning with fuzzy analysis network process approach (FANP)

Farangis Siavashan[1, 2]* and Ali Khari[3]

[1]Payam- e- Noor University, Tehran branch, Tehran, Iran.
[2]No. 4, Nasim building, Esfande sharghi, Gorgan, Iran.
[3]Human Resources Management, Golestan Non Beneficial High Educational Institute, Gorgan, Iran.

Accepted 8 October, 2012

The main purpose of this research is to use a decision approach in prioritizing strategy choice for SWOT matrix analysis. This research was done in 2010, in Frab Co. which works in the field of installation of water and energy projects in Tehran. Based on the nature of the research, its statistical society was managers and experts of different units of the organization. The members of this team include the managing director, management of human resources, director of planning and project control, inspection and quality control manager, financial and administrative management and engineering management and deputy of projects affairs. The present research in terms of purpose is an applied research; it is also considered as a descriptive research. In this research for determining important weight, fuzzy analytic network process was used. The fuzzy method used was Chang's extent analysis (EA) method. Excel software was used to calculate analytic network process by using extent analysis method for determination of important weights, and MATLAB software was used to get the final results of the study. Research results showed that when dependence exists among SWOT (strengths, weaknesses, opportunities and threats) factors, this dependence could change weight and priority of strategy alternative, and eventually WO (weaknesses- opportunities) strategy with the final weight of 0.317 was selected as the best strategy.

Key words: Strategic planning, SWOT matrix, analytic network process, fuzzy analytic hierarchy process, Chang's extent analysis method, triangular fuzzy numbers.

INTRODUCTION

Nowadays, organizations are faced with restive and turbulent environment. Environmental threats from all side threaten life and survival of organizations. Organizations should identify their current position. They should precisely analyze their strengths and weaknesses; and by relying on their strengths they should use environmental opportunities and prepare themselves to face threats. If a company is not able to identify actions and strategies of its competitors, it should not be expected to win its rivals. In other words, if a company does not pay attention to its competitors, it competes blindly. Today's success can guarantee tomorrow's success.

Success always causes new and various problems. In fact, companies must choose goals and strategies that ensure their survival in competition, based on their available resource and the information from the environment. This is possible in the form of strategic planning within strategic planning framework of the organization used to analyze its capability and environmental condition based on the organization's specific available goals and

*Corresponding author. E-mail: omideparsi@gmail.com. Tel/Fax: 00981712231931.

the method for reaching them. These factors play a key and vital role in the success of the organization. Many approaches and techniques can be used in strategic analysis in the process of strategic management (Dincer, 2004) such as Boston consulting group, the porter model or GE model that was introduced by General Electric Company. But among these techniques, SWOT matrix analysis, which evaluates opportunities, threats, strength and weaknesses of an organization, is one of the most famous methods. In SWOT analysis two environments must be carefully analyzed and evaluated; one is internal environment, which requires identifying strength and weakness of an organization and the other one is external environment of an organization (Kangas et al., 2003). The data from environmental analysis can be shown systematically in a matrix (Houben et al., 1999). Various combinations from four factors of matrix if analyzed properly can be a good basis for the compilation and designing of strategy. But the analysis of SWOT has flaws in evaluation and measurement of steps (McDonald, 1993). Routinely, this method does not specify quantitatively the amount of influence of each of these factors on the proposed program or the chosen strategy (Masozera et al., 2006).

In other words, SWOT analysis is not specifically an analytical tool for determination of relative importance of each of these factors. It does not also have the ability to prioritize the options for our strategy. This method usually gives a general and brief description of the impact of each factor, and it is expected that SWOT matrix should be able to specify quantitatively in analyzing the precise impact of each of these factors (Hill and Westbrook, 1997). SWOT matrix must also be able to rank these factors in relation to a decision; in this way it provides opportunity for decision makers to analyze the importance of strategic factors in comparison with each other (Shrestha et al., 2004). As a result of ignorance of deficiencies, SWOT matrix analysis only provides a list of strategic factors or an incomplete qualitative examination of these factors.

Due to these reasons, SWOT matrix analysis could not fully and comprehensively carry out the process of strategic decision-making that enables organizations to implement the right strategic decision. Kurttila et al. (2006, 2000) and Kajanus et al. (2004) developed a combined technique to eliminate defects in SWOT. This technique uses analytical hierarchy process (AHP) in the SWOT analysis. Although AHP techniques remove main flaws in the evaluation and measurement of SWOT analysis, the drawback of this method is that it cannot measure the possible associations between SWOT factors. It is assumed that in the AHP, SWOT agents are independent in a hierarchical structure; although, this assumption may not always be correct due to the effects that both external and internal environment have on each other. So it is essential that we use SWOT analysis in a way that also measures the dependence between SWOT agents (Yuksel and Dagdeviren, 2007). The proposed algorithm in this research uses fuzzy analysis network process (FAND) which also provides the possibility of measuring the dependence between strategic factors. In many decision issues, it is desirable to imagine the interaction between criteria to be the same as the real world. NAP powerful tool with fuzzy approach gives the opportunity for decision makers to model SWOT factors. Also, it has become an attractive multi-criteria decision making tool that causes dependence among SWOT factors, affects the weight of sub-branches of SWOT agents and the weight of strategy options, and it might serve as a process for quantifying the analysis of SWOT leading dependence between SWOT factors.

Importance of the research

For many years, the process of network analysis (ANP), as a comprehensive approach, is used to solve many problems of decision making. In this research, FANP, the new and powerful tool is used, which links fuzzy concepts with network analysis process. This method can be useful when decisions with several options and indicators are to be made. With the theory of fuzzy system, fuzzy logic theory and fuzzy sizes parameters such as knowledge, experience and human judgment can be entered into the model; and by creating flexibility in the model, a gray picture of the gray world can be created.

Clearly, the results of such models, due to the availability of real condition, would be more accurate and practical (Azar and Faraji, 2008). The final output of this process provides a method for determining important weights of indictors and priority of options. SWOT analysis does not only have this ability in analyzing strengths, weaknesses, opportunities and threats, but is also one of the key elements of the strategic planning which is very challenging in the analytical method. Several methods are used in enhancing the accuracy of the results. Using the FANP in SWOT is one of the new issues, which is the innovation of this research.

Research question

This research has one main question: What is the process of using FANP in SWOT and how can its results be analyzed?

RESEARCH METHODS

In this study, in order to determine the importance of weight, fuzzy analytic network process was used. The fuzzy method used was Chang's extent analysis (EA)

method. So in the various steps, due to the extensiveness of information, on one hand, and the high volume of calculations, on the other hand, two computer programs are used based on network analysis process technique of expansion analysis method. EXEL software was used for the calculations relating to analytic network process by using expansion analysis method for determination of importance of weights, and for final results, MATLAB software was used.

The present research in terms of purpose is considered as an applied research. Applied research is a research whose findings could have scientific use. The subjective realm of the research is fuzzy analytic network process (FANP) and the local realm is Frab Company. The reason for the use of Analytic Network Process in the SWOT matrix is that it can eliminate the major flaws in the assessment and measurement of the SWOT matrix analysis steps, but the main drawback of this method is that it could not measure the possible dependence between SWOT factors. In the analytical hierarchy process, it is assumed that these factors are independent of each other in the hierarchical structure. Although the assumption is not always true in terms of effects on both internal and external environments, an organization can use internal strengths to take advantage of external opportunities; or by exploiting available opportunities in external environment it can improve internal weaknesses, or by using internal strength it can reduce the effects of threats in the environment or eliminate them. As it was said these factors are not independent of each other and in addition, a connection may exist between some of these factors. In the technique of analytical hierarchy process SWOT factors' weights are calculated with the assumptions that these factors are independent of each other; but it is possible that these factors are related to each other and in this situation these dependencies can affect SWOT factors' weights and this will ultimately change priorities of strategic options. So it is essential that we use a state of SWOT analysis which considers the possible associations between SWOT factors in decision (Yukse and Dagdeviren, 2007).

The proposed algorithm in this research uses fuzzy analytical network process (FANP) which makes it possible for us to measure dependence among SWOT factors. In many issues, the favorable decision is the one that links real world; we can imagine the inter-relationships among criteria. It became an attractive multi-criteria decision making tool because it is a powerful tool of network analysis process with fuzzy approach available modeling of SWOT factors for decision–makers. Dependence among SWOT factors affect both the weights of SWOT factors' branches and the weights of strategy options, and may also change the priority of the strategy options. In summary, this study shows the process for quantifying SWOT matrix analysis in a situation where there is dependence among SWOT factors.

Analytic Network process (ANP)

Saaty (1996) presented a method for multi criteria called analytic network process. The aim of its presentation is to design a model through which complex issue of multi decision can be analyzed into smaller pieces and using reasonable value to analyze them into simpler components and then integrate these values to get a final decision.

The method of analysis network process (ANP) is the developed form of analytical hierarchy process (AHP) that has the capacity to model the correlations and feedbacks among effective factors and also calculates the effects of decision on internal components. Therefore, due to this feature, this technique is distinctive and superior to previous model (Saaty, 1996; Chung et al., 2006). Therefore, top- down hierarchical structure is not suitable for a complex system. A feedback system can be shown as a network.

Structural difference between a network and a hierarchy is shown in Figure 1. Elements in a cluster can affect the elements in other branches. A network can be organized as source, intermediate and sink clusters. Relationships within the network is shown with arcs, and arcs direction shows the dependence (Saaty, 1996; Chung et al., 2006) and interdependence between two clusters, called outer dependence and is displayed with a two-way arrow. Internal dependence among the elements of a cluster is shown by looped arcs (Chung et al., 2006; Sarkis, 2002).

Network analysis process consists of four main steps: making model and the issue of structure: at first, the issue should be clearly stated and analyzed into a logical system like a network (Figure 1).

Pair wise comparisons matrices and priority vector

In network analysis process like analytical hierarchy process, decision elements in each cluster are compared pair wise according to their importance in those criteria, and the clusters also are compared par wise with each other according to their effects on the goal. Decision-makers are asked in terms of a series of pair wise comparisons. They were asked what effects two elements or two clusters have in comparison with each other on the above criteria.

Furthermore, if interdependence exists among elements of one part, we should specify the amount of effect of each element on the other elements by using a pair wise comparisons matrix and getting special vector of each element.

Super matrix formation

Super matrix is like Markov chain process. For obtaining global priorities in the mutual influence system, the

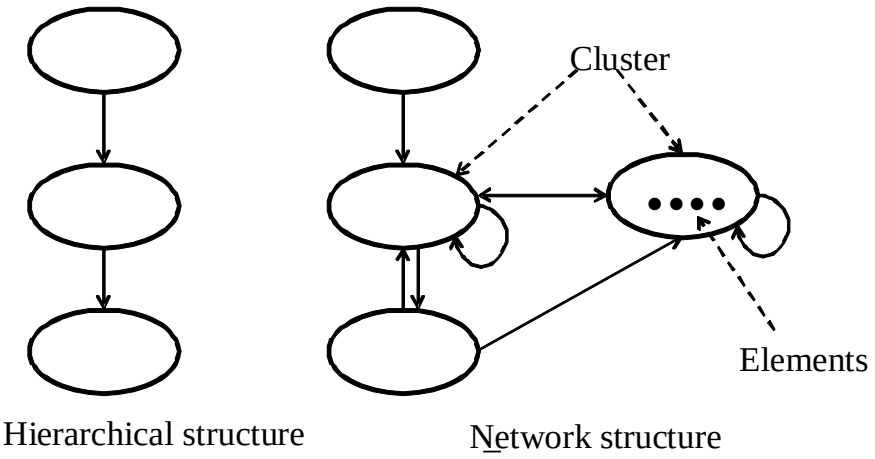

Figure 1. The structural differences between network and hierarchy (Sarkis, 2002; Chung et al., 2006).

relative priority vectors should be entered into the appropriate columns of matrix. As a result, a super matrix is, in fact, a segmented matrix that each matrix part shows a relationship between two clusters in a system. Suppose a decision system which has C_K parts and K= 1, 2, 3,.., n and each k cluster is shown through $e_{k1}, e_{k2}, \ldots e_{kmk}$.

Priority vectors are obtained relatively in the second step; they were placed in sections and in the appropriate position in the super matrix according to the effect of direction from one cluster to another. A standard for super matrix is shown in the following (Saaty, 1996).

$$W = \begin{array}{c} \\ C_1 \\ \vdots \\ C_k \\ \vdots \\ C_n \end{array} \begin{array}{c} \begin{array}{cccccccccccc} C_1 & & & C_k & & & C_n & & \end{array} \\ \begin{array}{cccccccccccc} e_{11} & e_{12} & \ldots & e_{1m1} & \ldots & e_{k1} & e_{k2} & \ldots & e_{k\,mk} & \ldots & e_{n1} & e_{n2} & \ldots & e_{n\,mn} \end{array} \\ \begin{bmatrix} W_{11} & \cdots & W_{1k} & \cdots & W_{1n} \\ \vdots & & \vdots & \vdots & \vdots \\ W_{k1} & \cdots & W_{kk} & \cdots & W_{kn} \\ \vdots & & & \vdots & \\ W_{n1} & \cdots & W_{nk} & \cdots & W_{nn} \end{bmatrix} \end{array}$$

Selecting the best position

If the former super matrix in the third step covers all networks, option weights can be found in the normalized super matrix column. On the other hand, if a super matrix contains the connected parts, more calculations would be needed to achieve the overall priorities of options and finally the option which has the most weight is recognized as the best option.

The proposed algorithm for SWOT matrix

The hierarchical model and the presented network in this study are designed in a four- level analysis of SWOT matrix. Its structural difference can be seen in Figure 2. The purpose (selection of the best strategy) is placed in the first level, criteria (SWOT factor) in the second level, sub criteria (sub branches of SWOT factors) in the third level and in last level, alternative (strategy alternatives). Super matrix is a hierarchical SWOT matrix structure which is composed of four levels and is defined as follows:

W= Purpose / SWOT factors / Sub branches of SWOT factors / Alternatives

$$\begin{bmatrix} 0 & 0 & 0 & 0 \\ W_{21} & 0 & 0 & 0 \\ 0 & W_{32} & 0 & 0 \\ 0 & 0 & W_{43} & I \end{bmatrix}$$

In which:

W21: is a vector which shows effect of purpose on the criteria.
W32: is a matrix which shows effect of criteria on each of the sub criteria.
W43: is a matrix which shows effect of sub-criteria on any of the options.
I: is one unit matrix.

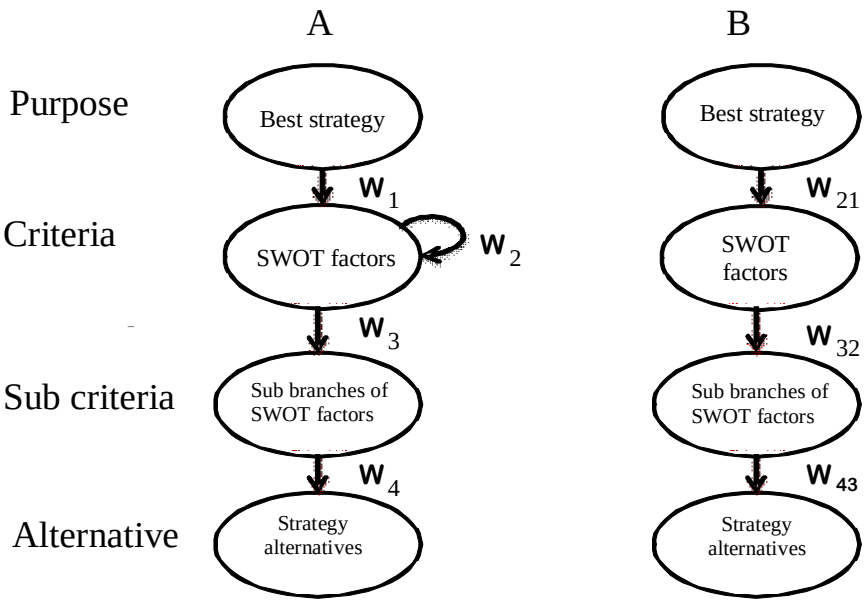

Figure 2. Structure difference of SWOT model between a hierarchy of A and a network of B.

Figure 2 shows a state of hierarchical structure with interdependence between clusters without any feedback. Here SWOT factor, sub branches of SWOT factors and strategies, respectively are put in the place of criteria, sub criteria and alternatives and there is an internal dependence among factors. Based on the design shown in Figure 2(B), the super matrix in this research which is used for SWOT is as follows:

W= Purpose / SWOT factors / Sub branches of SWOT factors / Alternatives

$$\begin{bmatrix} 0 & 0 & 0 & 0 \\ w_1 & W_2 & 0 & 0 \\ 0 & W_3 & 0 & 0 \\ 0 & 0 & W_4 & I \end{bmatrix}$$

W_1: is a vector which shows effect of purpose on the criteria
W_2: is a matrix which shows internal dependence among SWOT factors
W_3: is a matrix which shows effect of SWOT factors on each of the sub branches of SWOT factors.
W4: is a matrix which shows the effect of the sub branches of SWOT factors on any other options.

In this research for better understanding, matrix used to show calculation details of the main steps of the proposed framework can be summarized as follows:

Step one: Identifying the sub branches of SWOT factors (identification of strategic factors) and determination of strategic options with regard to the analysis of these factors.
Step two: Determining the importance of degree of SWOT factors with assumption that there is no dependence between SWOT factors (W_1, that is matrix calculation).
Step three: identifying interdependences between SWOT factors and based on these relationships for dependency the matrix of each of the SWOT factors with regard to other factors is formed (W_2, that is matrix calculation).
Step four: Determining priority of SWOT factors, according to the dependency that exists between them (W SWOT factors = W1×W2).
Step five: Determining relative important degree of sub branches of SWOT factors (W sub branches of SWOT factors, that is calculation).
Step six: Determining general important degree of sub branches of SWOT factors (W general sub-branches of SWOT factors= W factors × W relative sub branches of SWOT factors).
Step seven: Determining important degree of strategy options with regard to each sub branch of SWOT factor (W_4).
Step eight: calculation of the final priority of strategy options, considering the internal relations among SWOT factors (W alternatives= W_4 ×W general sub branches).

The main inputs required in the technique of network analysis process for calculating W1, W2, W3, W4 pair wise comparison are existed elements in each cluster composed of a pair wise comparison matrix. Pair wise comparisons matrices and output evaluation are in the fuzzy analytical hierarchy process. In analytical hierarchy process, according to the traditional method, pair wise comparisons are done based on the relative scale. Although a discrete scale has advantages of easy understanding and use, but due to incompatibility with human mind's map, cannot lead us to the actual results.

This research is studied using theoretical concepts of fuzzy sets and triangular fuzzy numbers with analytic network process, improving the results and making them closer to reality as much as possible.

In this study, fuzzy analytical hierarchy process is used based on specific model of network structure and existence of internal relationship change in fuzzy analytic network process. As we go on, we study some relationships and the main operators using triangular fuzzy numbers and we also present a method for extent analysis.

Group decision through change expansion analysis method

As previously noted, to calculate W1, W2, W3, W4, pair wise comparisons with verbal data are required. The mentioned matrices can be calculated by using fuzzy analytical hierarchy process methodology. There are several types of fuzzy analytical hierarchy process methods but the calculation and level of complexity of some of these methods are based on the least logarithmic squares method. In this research, Chang Extent Analysis method is preferred because its stages are easier than other fuzzy analytical hierarchy processes.

Concepts and definition of fuzzy analytical hierarchy process based on the Chang Extent Analysis (EA) are as follows:

Consider two triangular fuzzy numbers M1= (L_1, m_1, u_1) and M2= (L_2, m_2, u_2) (Figure 3)

M1+M2= (l_1+l_2+m_1+m_2,u_1+u_2)
M1.M2= (l_1l_2, m_1m_2, u_1u_2)

$$M^{-1} = \left(\frac{1}{u_1}, \frac{1}{m_1}, \frac{1}{l_1}\right) \qquad M^{-2} = \left(\frac{1}{u_2}, \frac{1}{m_2}, \frac{1}{l_2}\right)$$

It should be noted that product of two triangular fuzzy numbers or reverse of a triangular fuzzy number is not a triangular fuzzy number any more, and this relationship tells only of approximation of the true product of two triangular fuzzy numbers and reverse of a triangular fuzzy number. In the extent analysis method for each row of pair wise comparisons matrix, the value which is a triangular fuzzy number is calculated as follows:

In which K represents row number and I and J respectively represent options and indexes.
In this method after the calculation of S_k, you should get their largeness degree in relation with each other. In general, if M1 and M2 are two triangular fuzzy numbers, M1 largeness degree on M2 is defined as follows:

$$S_k = \sum_{i=1}^{n} M_{kj} \times \left[\sum_{i=1}^{n}\sum_{j=1}^{n} M_{ij}\right]^{-1}$$

$$\begin{cases} V(M1 \geq M2) = 1 & M1 \geq M2 \\ V(M1 \geq M2) = \mathrm{Hgt}\,(M1 \cap M2) \end{cases}$$

Otherwise, also if $L_2 \geq U_1$, put zero.

In this case, we have: Hgt (M1∩M2)= $\frac{u1 - l2}{(u1 + l2) + (m2 - m1)}$

In largeness amount of a triangular fuzzy number from k, another triangular fuzzy number is obtained from the following relationship:

$V(M_1 \geq M_2, \ldots, M_k) = V(M_1 \geq M_2)$ and … $V(M_1 \geq M_k)$.

Also, for the calculation of indices in pair wise comparisons matrix the following is performed:

$$W'(xi) = \min\{V(Si \geq Sk)\}$$
$$k = 1, 2, \ldots, n, k \neq i$$

Thus, the weight vector of indicators will be as follows:

$$W = [W'(x_1), W'(x_2), \ldots, W'(x_n)]^T$$

This is the non-normalized coefficient vector of fuzzy hierarchy process (Azar and Faraji, 2008).
Since the used numbers in change extent analysis method are triangular fuzzy numbers, so we assumed that decision-makers set these words for weighting. You can see its fuzzy scale and diagram in Table 1 and Figure 4.

Implementing decision algorithm

First step: Specifying organization's strategic factors and determining strategy options with respect to these factors

In this study, environmental analysis should be done at

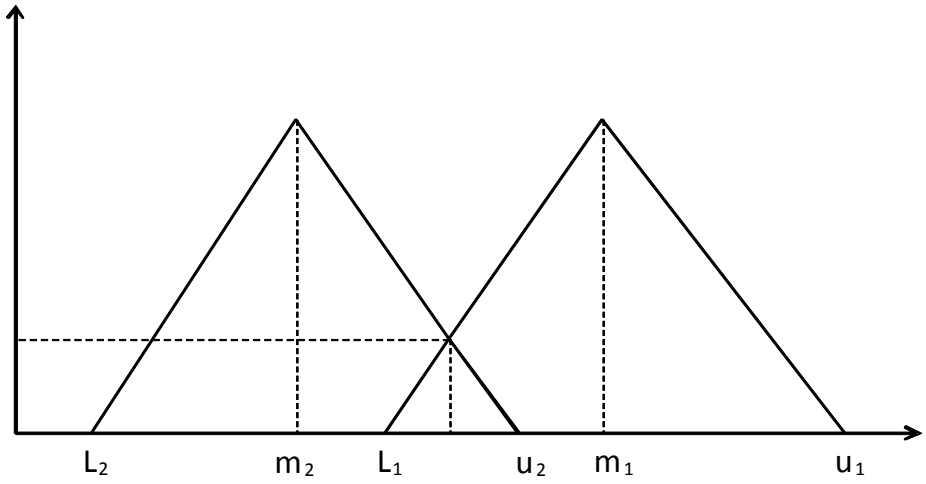

Figure 3. Display of two triangular fuzzy numbers.

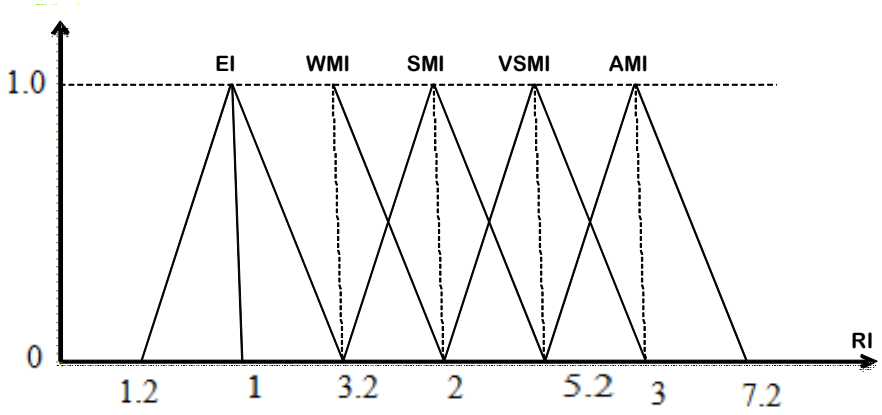

Figure 4. Verbal scale for measuring the relative importance. Chung et al (2006) and Shrestha et al (2004).

first. Analysis of external and internal environment is the first stage of algorithm implementation. A team of managers from different parts of the organization who were familiar with operation and organization environment was formed to do environmental analysis. After identification of strategic factors (that is identification of strengths (S), weaknesses (W), Opportunities (O) and threats (T), we selected possible strategies through the analysis of these factors. The organization is faced with four strategy alternatives, which are as follows:

1. SO strategy: market development- the foreign goal market
2. WO strategy: professional reinforcing of manpower and infrastructure in the area of thermal power plants
3. ST strategies: developing and implementing of new technologies
4. WO strategies: cooperation and strategic partnership

In this study, the aim of SWOT analysis is to prioritize strategy alternatives and select the best strategy for the organization (Table 2).

After the identification of the organization's strategic factors and strategy alternatives, we should convert the issue into a hierarchy, in the way that we are able to analyze it by analytic network process (ANP). This network structure is shown in Figure 5. The goal for selecting the best strategy is in the first level of analytic network process model, SWOT factors (strengths, weaknesses, opportunities, threats) are in the second level, sub branches of SWOT factors which include 6 factors for strengths, 5 factors for weakness, 6 factors for opportunities and 5 factors for threats are in the third level of the model, and according to SWOT matrix, four strategies are selected for the organizations that are in the last

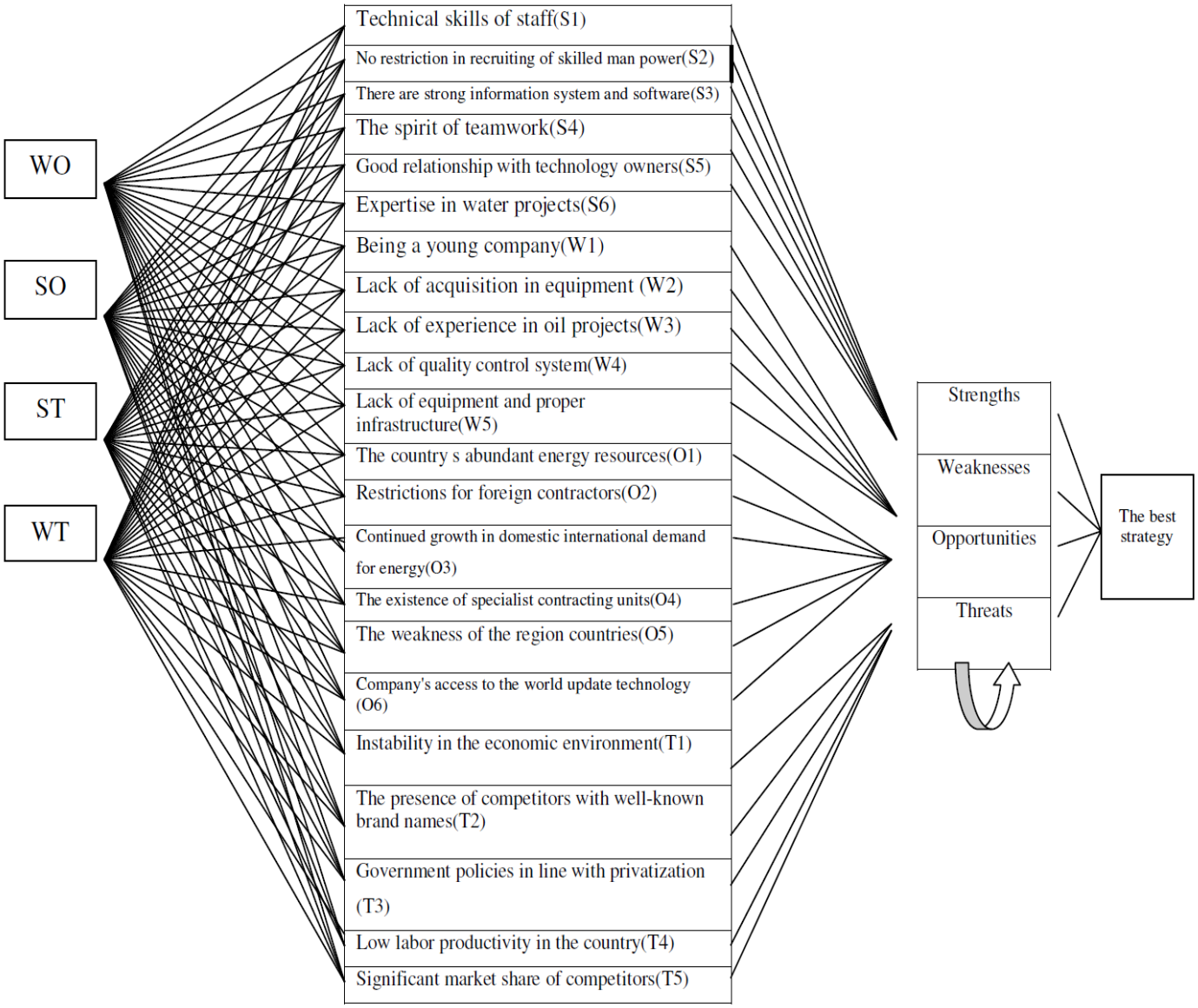

Figure 5. Analytic network process model for SWOT matrix.

level of the model (Figure 5).

Second step: Determining important degree with assumption that no dependence exists among SWOT factors.

At this stage, we assume that there is no dependence and interaction among SWOT factors (Strengths, weaknesses, opportunities and threats). We form pair wise comparisons matrix of SWOT factors with the goal of selecting the best strategy. The results of comparisons are shown in Table 3.

Third step: Forming dependence matrix of each SWOT factor with regard to other factors:

At this stage, the interdependence between SWOT factors (Strengths, weaknesses, opportunities, threats) is specified by analyzing the impact of each factor on other factors. After the analysis, these relationships were identified (Figure 6).

Based on the dependence that exists among SWOT factors, we formed pair wise comparisons matrix based on fuzzy numbers and extent analysis method (Tables 4, 5, 6 and 7).

W2 matrix is formed by the obtained vectors of each

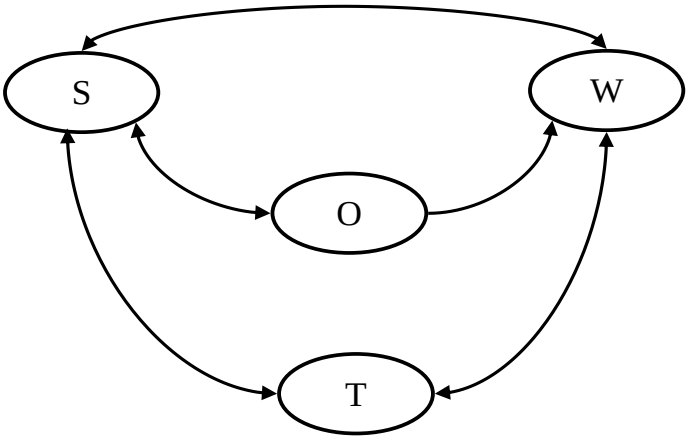

Figure 6. The inner dependence among SWOT factors.

Table 1. Verbal scale for assessing the relative importance.

Verbal scale of relative importance	Triangular fuzzy scale	Triangular fuzzy scale in the other side
Same	(1,1,1)	(1,1,1)
Equal importance	(1/2,1,3/2)	(2/3,1,2)
Relatively more important	(1,3/2,2)	(1/2,2/3,1)
More important	(3/2,2,5/2)	(2/5,1/2,2/3)
Very important	(2,5/2,3)	(1/3,2/5,1/2)
Exactly very important	(5/2,3,7/2)	(2/7,1/3,2/5)

table (WJ). This matrix shows relative important weights of SWOT factors where we recognize the interdependence between them which is displayed in the following matrices:

$$W_2 = \begin{bmatrix} 1.000 & 0.881 & 0.759 & 1.000 \\ 0.267 & 1.000 & 0.241 & 0.000 \\ 0.733 & 0.000 & 1.000 & 0.000 \\ 0.000 & 0.119 & 0.000 & 1.000 \end{bmatrix}$$

Fourth step: Priority determination of SWOT factors considering the dependence among them

$$W_{SOWAT\ factors} = W_2 \times W_1 = \begin{bmatrix} 1.000 & 0.881 & 0.795 & 1.000 \\ 0.276 & 1.000 & 0.245 & 0.000 \\ 0.733 & 0.000 & 1.000 & 0.000 \\ 0.000 & 0.119 & 0.000 & 1.000 \end{bmatrix} \times \begin{bmatrix} 0.382 \\ 0.108 \\ 0.401 \\ 0.109 \end{bmatrix} = \begin{bmatrix} 0.445 \\ 0.153 \\ 0.341 \\ 0.061 \end{bmatrix}$$

At this step, we should calculate priority of SWOT factors according to the dependence that exists between these factors; this vector is obtained from the product of W2 matrix in W1 vector.

As we see, significant differences exist between the results obtained in the weights of SWOT factors in comparison with situation which ignores inner dependence among these factors; and the results have changed respectively: strengths, from 0.382 to 0.445; weaknesses, from 0.108 to 0.153; opportunities, from 0.401 to 0.341; and threats, from 0.109 to 0.061.

Fifth step: Determination of the relative important degree of SWOT factors in sub branches

At this stage, we should calculate the relative priority of sub branches of SWOT factors by using pair wise comparisons matrix (Tables 8, 9, 10 and11).

Priority vectors obtained from the analysis of pair wise comparison matrix are as follows:

$$W_{(strength)} = \begin{bmatrix} 0.191 \\ 0.163 \\ 0.128 \\ 0.189 \\ 0.177 \\ 0.152 \end{bmatrix} \qquad W_{(weaknesses)} = \begin{bmatrix} 0.298 \\ 0.197 \\ 0.271 \\ 0.090 \\ 0.144 \end{bmatrix}$$

Table 2. SWOT matrix.

Internal factor / External factor	**Strength (S)** -staff professional skills (s1) -no restriction in recruiting of skilled manpower(S2) -there are strong information system and software (S3) -the spirit of team work(S4) - good relationships with technology owners(S5) -Expertise in water project (S6)	**Weaknesses (W)** -Being a young company (W1) -lack of acquisition of equipment and certain machinery(W2) -lack of experience in oil projects (W3) -lack of quality control system(W4) -lack of equipment and proper infrastructure(W5)
Opportunities (O) -the country's abundant energy resources(O1) -restrictions for foreign contractors(O2) -continued growth in domestic international demand for energy(o3) -the existence of specialist contracting units(O4) - the weakness of the region countries(O5) -company's access to the world update technology (O6)	**SO strategy** -market development-the foreign goal market	**WO strategy** -professional reinforcing of manpower and infrastructure in the area of thermal power plants
Threat (T) - instability in the economic environment(T1) -the presence of competitors with well-known brand names(T2) -government policies in line with privatization (T3) -low labor productivity in the country(T4) -significant market share of competitors(T5)	**ST strategy** -development and implementing of new technology	**WT strategy** -cooperation and strategic partnership

Table 3. Pair wise comparisons matrix of SWOT factors with no dependence of SWOT factors.

W_J	T	O	W	S	SWOT factors
0.382	(1,1.42,1.88)	(0.73,0.96,1.29)	(1.88,2.38,2.88)	(1,1,1)	Strength (S)
0.108	(0.75,1.17,1.63)	(0.43,0.54,0.75)	(1,1,1)	(0.35,0.42,0.53)	Weakness (W)
0.401	(1.63,2.13,3.26)	(1,1,1)	(1.33,1.85,2.35)	(0.77,1.04,0.38)	Opportunities (O)
0.109	(1,1,1)	(0.38,0.47,0.62)	(0.62,0.86,1.33)	(0.53,0.71,1)	Threat (T)

$$W_1 = \begin{bmatrix} S \\ W \\ O \\ T \end{bmatrix} = \begin{bmatrix} 0.382 \\ 0.108 \\ 0.401 \\ 0.109 \end{bmatrix}$$

Table 4. The inner dependence matrix of SWOT factors with regard to the strengths.

W_j	T	O	W	Strengths
0.267	(1.25,1.67,2.13)	(0.41,0.52,0.71)	(1,1,1)	Weakness (W)
0.733	(1.75,2.25,2.75)	(1,1,1)	(1.41,1.94,2.45)	Opportunity(O)
0	(1,1,1)	(0.36,0.44,0.57)	(0.47,0.6,0.8)	Threats (T)

Table 5. The inner dependence matrix of SWOT factors with regard to the weaknesses.

W_j	T	S	Weakness
0.881	(1.21,1.60,2)	(1,1,1)	Strengths (S)
0.119	(1,1,1)	(0.50,0.63,0.83)	Threats (T)

$$W_{(opportunity)}=\begin{bmatrix}0.245\\0.167\\0.216\\0.158\\0.085\\0.128\end{bmatrix} \qquad W_{(threats)}=\begin{bmatrix}0.431\\0.269\\0.196\\0.026\\0.078\end{bmatrix}$$

Sixth step: Determination of the general important degree of SWOT factors in sub branches

The following results were obtained:

W general sub branches of SWOT factors = W factors ×W Relative sub branches of SWOT factors (Table 12).

Seventh step: Determining important degree of strategy options with respect to each of the sub branches of SWOT factors

At this stage, we should calculate important degree of strategy options with respect to each of the sub-branches of SWOT factors. Due to the calculations volume, to illustrate how to do this stage we only calculate the first and last tables and put their resultant vectors respectively in the first and last columns of W4 matrix (Tables 13 and14).

These tables should be conducted for all of the strategic factors and W4 matrix is obtained by putting the resultant vectors from each table in the appropriate column:

$$W4=\begin{bmatrix}0.345 & 0.335 & 0.361 & 0.372 & 0.439 & 0.446 & 0.205 & 0.177 & 0.078 & 0.205 & 0.108 & 0.111 & 0.078 & 0.236 & 0.306 & 0.388 & 0.351 & 0.264 & 0.115 & 0.206 & 0.077 & 0.351\\ 0.301 & 0.286 & 0.225 & 0.266 & 0.297 & 0.281 & 0.334 & 0.333 & 0.487 & 0.357 & 0.395 & 0.375 & 0.444 & 0.324 & 0.226 & 0.327 & 0.294 & 0.241 & 0.343 & 0.346 & 0.524 & 0.260\\ 0.211 & 0.222 & 0.199 & 0.226 & 0.207 & 0.251 & 0.267 & 0.316 & 0.302 & 0.293 & 0.341 & 0.339 & 0.408 & 0.387 & 0.310 & 0.252 & 0.303 & 0.254 & 0.338 & 0.302 & 0.328 & 0.316\\ 0.134 & 0.157 & 0.215 & 0.136 & 0.057 & 0.022 & 0.184 & 0.174 & 0.133 & 0.145 & 0.156 & 0.175 & 0.070 & 0.053 & 0.158 & 0.033 & 0.052 & 0.241 & 0.204 & 0.146 & 0.071 & 0.073\end{bmatrix}$$

Eighth step: Determining the final priority of strategy alternatives

At the end, we calculate the final priority of strategy options with regard to the relationship that existed among SWOT factors, through the following way:

$$W_{\text{alternative}}=\begin{matrix}SO\\WO\\ST\\WT\end{matrix}\begin{bmatrix}\\\\\\\end{bmatrix}=W_4\times W_{\text{general sub branches of SWOT}}=\begin{bmatrix}0.282\\0.317\\0.278\\0.123\end{bmatrix}$$

Analyzing the results of fuzzy analytic network process (FANP) shows that WO strategy with final weight of 0.317 is chosen as the best strategy. Priority of strategy alternatives with regard to the method of fuzzy analytic network process is as follows in the order of priority:

1) Professional reinforcing of man power and infra-structure in the area of thermal power plants (WO) with a final weight of 0.317.
2) Market development- the foreign goal market (SO) with a final weight of 0.282.
3) Development and implementation of new technologies (ST) with a final weight of 0.278.
4) Cooperation and strategic partnership (WT) with a final

Table 6. The inner dependence matrix of SWOT factors with regard to the opportunities.

W_j	W	S	Opportunity
0.759	(1.1,1.5,1.92)	(1,1,1)	Strengths (S)
0.241	(1,1,1)	(0.52,0.67,0.91)	Weakness (W)

Table 7. The inner dependence matrix of SWOT factors with regard to the threats.

W_j	W	S	Threats
1	(1.32,1.71,2.1)	(1,1,1)	Strengths (S)
0	(1,1,1)	(0.48,0.59,0.76)	Weakness (W)

weight of 0.123.

Comparing the results of fuzzy analytical hierarchy process with fuzzy analytic network process

This case was also solved with a hierarchical structure (assuming there is no dependence between SWOT factors). In pair wise comparisons matrix, determining the final priority of strategy options in the method of fuzzy analytic network process is like that of pair wise comparisons matrix used in the fuzzy analytic network process, and the results are as follows:

$$W_{\text{alternative (FAHP)}} = \begin{bmatrix} SO \\ WO \\ ST \\ WT \end{bmatrix} = \begin{bmatrix} 0.274 \\ 0.316 \\ 0.286 \\ 0.124 \end{bmatrix}$$

In the analysis of fuzzy analytic network process, WO strategy with a final weight of 0.316 is selected as the best strategy. Also, the priority of strategy options in the order is WO, ST, SO, WT. The analysis results of fuzzy analytical hierarchy process and fuzzy analytic network process have been compared in Table 15. As you see, when we analyze the dependence among SWOT factors, this dependence impacts the weights and priority of strategies compared to the state that assumed these factors are independent of each other.

DISCUSSION AND CONCLUSION

In this study, fuzzy analytic network process technique was selected as an analysis tool according to its capabilities. Analytic network process in decision making considers some angles of the issue which does not exist in fuzzy analytical hierarchy process. Internal dependence is of the most important strategic planning issues. With this technique, we could identify and measure the dependence between SWOT factors and also specify quantitatively each of these factors' impact on the strategy alternatives. SWOT factors and strategy options changed to a model of fuzzy analytic network process. As we observed, SWOT matrix network model is designed in four levels: the purpose (the best strategy selection), SWOT factors, sub branches of SWOT factors and the strategy options. Also, to illustrate the impact of dependence among SWOT factors on both the weights of SWOT factors, sub branches and priority of strategy options, we used the method of fuzzy analytical hierarchy process in the SWOT analysis in order to compare the results of these two approaches. In both methods of fuzzy analytical hierarchy process and fuzzy analytic network process we used the same pair wise comparisons matrices; however, different results were obtained. As observed both weights and strategies rank was different from each other in fuzzy analytical hierarchy process and fuzzy analytic network process. These differences are predictable because analytical hierarchy process does not consider the dependence among SWOT factors in the analysis and sole problem with the assumption that these factors are independent of each other. While in the method of analytic network process the dependence among SWOT factors is taken into consideration and with respect to this dependence, this issue can be analyzed. For this reason, fuzzy analytic network process can be a better modeling for real world problems compared to hierarchical approach. Other organizations and companies that want to use this method in their strategic planning process should pay attention to this point that dependence among SWOT factors and its sub branches is largely related to types of organizations and their activities. In this study, we only analyzed dependence among SWOT factors, but it is possible that for other organizations dependence among sub-branches of SWOT factors is more important than dependence among SWOT factors. In general, it can be concluded in cases where there is internal interaction or dependence among SWOT factors (strengths, weaknesses, opportunities, threats) or among its sub branches, the method of analytic network process must be used to prioritize strategic options, for using these approaches and techniques enables organizations to take correct strategic decision. Also in cases where there is no dependence among SWOT factors or among its sub branches or can be ignored, analytical hierarchy process technique can be used.

In the SWOT analysis, strategic options are selected based on the strengths, weakness, opportunities and threats that organizations are facing. These factors are identified through analysis of external and internal environment of organizations. However, SWOT analysis alone is not able to quantify weights and effects of each

Table 8. Relative importance degree of the strengths.

Strengths (S)	S1	S2	S3	S4	S5	S6	W_j
Technical skills of the staff(S1)	(1,1,1)	(1.2,1.7,2.2)	(1,1.43,1.9)	(0.43,0.68,0.97)	(0.68,0.97,1.33)	(0.8,1.3,1.8)	0.191
No restriction in recruiting of skilled manpower(S2)	(0.45,0.59,0.83)	(1,1,1)	(1.08,1.5,1.93)	(0.46, 0.67,0.97)	(0.78,1.13,1.53)	(0.86,1.13,1.47)	0.163
There are strong information system and software(S3)	(0.53,0.70,1)	(0.52,0.67,0.93)	(1,1,1)	(0.73,0.91,1.17)	(0.46,0.83,1.1)	(0.46,0.83,1.1)	0.128
The spirit of team work(S4)	(1.03,1.47,2.34)	(1.03,1.5,2.17)	(0.86,1.09,1.38)	(1,1,1)	(0.65,0.98,1.33)	(0.66,1,1.37)	0.189
Good relationships with the technology owners(S5)	(0.75,1.03,1.47)	(0.65,0.88,1.28)	(0.91,1.20,1.56)	(0.75,1.02,1.55)	(1,1,1)	(0.9,1.4,1.9)	0.177
Expertise in water projects(S6)	(0.56,0.77,1.25)	(0.67,0.88,1.16)	(0.91,1.2,1.56)	(0.73,1,1.52)	(0.53,0.71,1.11)	(1,1,1)	1.52

Table 9. Relative importance degree of the weaknesses.

Weaknesses(W)	W1	W2	W3	W4	W5	W_j
Being a young company (W1)	(1,1,1)	(1.05,1.31,1.63)	(0.75,1.08,1.43)	(1.5,2,2.5)	(1.38,1.8,2.23)	0.298
Lack of a question in equipment and certain machinery (W2)	(0.61,0.76,0.96)	(1,1,1)	(0.64,0.9,1.21)	(1,1.43,1.9)	(0.68,1.1,1.53)	0.197
Lack of experience in oil projects (W3)	(0.7,0.93,1.34)	(0.82,1.11,1.57)	(1,1,1)	(1.1,1.6,2.1)	(1.5,1.93,2.4)	0.271
Lack of quality control system (W4)	(0.4,0.5,0.67)	(0.53,0.7,1)	(0.48,0.63,0.91)	(1,1,1)	(0.55,0.81,1.13)	0.09
Lack of equipment and proper infrastructure (W5)	(0.45,0.56,0.72)	(0.65,0.91,1.47)	(0.42,0.52,0.67)	(0.88,1.23,1.83)	(1,1,1)	0.1444

Table 10. Relative importance degree of the opportunities.

Opportunities	O1	O2	O3	O4	O5	O6	W_j
The country s abundant energy resources and reserves(O1)	(1,1,1)	(1.38,1.73,2.13)	(1.2,1.63,2..1)	(1.1,1.6,2..1)	(1.2,1.7,2.2)	(0.78,1.2,1.63)	0.245
Restrictions for foreign contractors (O2)	(0.47,0.58,0.72)	(1,1,1)	(0.47,0.57,1.1)	(0.86,1.13,1.47)	(1.2,1.63,2.1)	(0.87,1.28,1.7)	0.167
Continued growth in domestic and international demand for energy(O3)	(0.48,0.61,0.83)	(0.91,1.34,2.14)	(1,1,1)	(1.1,1.6,2.1)	(1.3,1.8,2.3)	(1,1.43,1.9)	0.216
The existence of specialist contracting unit(O4)	(0.48,0.63,0.91)	(0.68,0.88,1.16)	(0.48,0.63,0.91)	(1,1,1)	(1.4, 1.9, 2.4))	(0.6,1.03,1.5)	0.158
The weakness of the region countries (O5)	(0.45,0.59,0.83)	(0.48,0.61,0.83)	(0.43,0.56,0.77)	(0.42,0.53,0.71)	(1,1,1)	(0.96,1.23,1.58)	0.085
Company s access to the world update technology (O6)	(0.61,0.83,1.28)	(0.59,0.78,1.15)	(0.53,0.7,1)	(0.67,0.97,1.67)	(0.63,0.81,1.04)	(1,1,1)	0.129

strategic factor on strategy options. Some studies have used this measure; however, few studies have been able to identify and evaluate the influence of relationship and internal dependence of factors using SWOT analysis. In general, we could not assume that the SWOT factors (strengths, weakness, opportunities and threats) are independent of each other. In real world, we can observe the effects that these factors have on

Table 11. Relative importance degree of the threats.

Threats	T1	T2	T3	T4	T5	W_j
Instability in the economic environment (T1)	(1,1,1)	(1.6,2.1,2.6)	(1.3,1.8,2.3)	(1.6,2.03,2.5)	(1.3,1.8,2.3)	0.431
The presence of competitors with well-known brand names (T2)	(0.38,0.48,0.63)	(1,1,1)	(1.37,1.78,2.2)	(1.27,1.68,2.1)	(0.88,1.3,1.73)	0.269
government policies in line with privatization (T3)	(0.43,0.56,0.77)	(0.45,0.56,0.73)	(1,1,1)	(1.3,1.67,2.1)	(1.2,1.57,2)	0.196
Low labor productivity in the country(T4)	(0.4,0.49,0.63)	(0.48,0.6,0.79)	(0.48,0.6,0.77)	(1,1,1)	(0.68,1.03,1.43)	0.026
Significant market share of competitors (T5)	(0.43,0.56,0.77)	(0.58,0.77,1.14)	(0.5,0.64,0.83)	(0.7,0.97,1.47)	(1,1,1)	0.078

Table 12. General priority of SWOT factors sub branches.

SWOT factor	Factors weights	SWOT sub factors	Sub factors weight	Weights of sub factors	General priority of sub factors
Strengths(S)	0.445	Technical skills of the staff(S1)	0.191	0.085	1
		No restriction in recruiting of skilled manpower(S2)	0.163	0.072	6
		There are strong information systems and software(S3)	0.128	0.057	8
		The spirit of team work (S4)	0.189	0.084	2
		Good relationships with the technology owners(S5)	0.177	0.079	4
		Expertise in water projects(S6)	0.152	0.068	7
Weaknesses (W)	0.152	Being a young company (W1)	0.298	0.046	10
		Lack of a question in equipment and certain machinery (W2)	0.197	0.030	13
		Lack of experience in oil projects (W3)	0.271	0.042	12
		Lack of quality control system (W4)	0.090	0.014	18
		Lack of equipment and proper infrastructure (W5)	0.144	0.022	16
Opportunities (O)	0.342	The country' s abundant energy resources and reserves(O1)	0.245	0.083	3
		Restrictions for foreign contractors (O2)	0.167	0.057	8
		Continued growth in domestic and international demand for energy(O3)	0.216	0.074	5
		The existence of specialist contracting unit(O4)	0.158	0.054	9
		The weakness of the region countries (O5)	0.085	0.029	14
		Company s access to the world update technology (O6)	0.128	0.044	11

Table 12. Contd.

Threats	0.061	Instability in the economic environment (T1)	0.431	0.026	15
		The presence of competitors with well-known brand names (T2)	0.269	0.016	17
		government policies in line with privatization (T3)	0.196	0.012	19
		Low labor productivity in the country(T4)	0.026	0.002	21
		Significant market share of competitors (T5)	0.078	0.005	20

Table 13. The importance degree of strategy options with regard to the professional skills of employees.

Professional skills of employees (S1)	SO	WO	ST	WT	W_j
Market development- the foreign goal market(SO)	(1,1,1)	(1.36,1.77,2.18)	(1.08,1.43,1.83)	(0.88,3.1,1.73)	0.354
Professional reinforcing of manpower and infrastructure in the area of thermal power plants (WO)	(0.46, 0.57,0.74)	(1,1,1)	(1.2,1.7,2.2)	(1.1,1.53,2)	0.301
Development and implementing of new technologies (ST)	(0.55,0.7,0.93)	(0.45,0.59,0.83)	(1,1,1)	(1.1,1.53,2)	0.211
Cooperation and strategic partnership (WT)	(0.58,0.77,0.14)	(0.5,0.65,0.91)	(0.5,0.65,0.91)	(1,1,1)	0.134

Table 14. The importance degree of strategy options with regard to the significant market share of competitors.

Significant market share of competitors (T5)	SO	WO	ST	WT	W_j
Market development- the foreign goal market (SO)	(1,1,1)	(1.34,1.67,2.01)	(0.78,1.13,1.53)	(1.18,1.53,1.93)	0.351
Professional reinforcing of manpower and infrastructure in the area of thermal man plants (WO)	(0.5,0.6,0.75)	(1,1,1)	(0.68,1.03,1.43)	(1.2,1.63,2.1)	0.26
Development and implementing of new technologies (ST)	(0.65,0.88,1.28)	(0.7,0.97,1.47)	(1,1,1)	(1.5,2,2.5)	0.316
Cooperation and strategic partnership (WT)	(0.52,0.65,0.85)	(0.48,0.61,0.83)	(0.4,0.5,0.67)	(1,1,1)	0.073

each other. In this research, through one example, we showed that where there is dependence between SWOT factors, we can make a quantity analysis of SWOT. In this thesis, fuzzy network analysis technique was selected due to its capabilities as an analytical tool. Network analysis is used in making decision and considers issues which are not feasible in the analytical hierarchy process. This technique enables us to measure the dependence between SWOT factors and identify the impact of each of these factors on strategy options. Internal dependence exists in the majority of problems related to strategic planning.

Combining fuzzy logic with the ANP was a new point considered in this study. Using fuzzy logic to reduce the ambiguity of words played a significant role in doing the required comparison.

SWOT agents and strategy options were

Table 15. Strategies weight and priorities in FANP and FAHP.

	SO	WO	ST	WT
Weights in FAHP	0.274	0.316	0.286	0.124
Rank in FAHP	3	1	2	4
Weights in FANP	0.282	0.317	0.278	0.123
Rank in FANP	2	1	3	4

changed into a model for fuzzy network analysis process. Network analysis process model in order includes purpose (the selection of the best strategy), SWOT agents, sub-branches of SWOT agents and strategy option.

Fuzzy analytical hierarchy process method (FAHP) was used in SWOT factors analysis in order to compare the effect of dependence between SWOT factors in the weight of sub-branches of SWOT factors and also the prioritization of strategy options.

Although we used similar paired comparison matrices in both FAHP and FANP methods, we observed different results. These differences are predictable because FAHP does not consider the dependence between the agents and it is assumed that SWOT factors are independent of each other while FANP brings this dependence into account. Because of this, the fuzzy network analysis process can model real world issues better compared to hierarchical methods.

In this study, we represented that the dependence between SWOT factors are different in the weights of strategy options and also in the priority of effective strategy options obtained through FANP and FAHP methods.

PRACTICAL PROPOSALS

1. It is recommended that the management of Frab Company focus on its goals and resources on WO strategy which is professional reinforcing of manpower and infrastructure in the area of thermal power plants.
2. It is recommended that before organizations decide to implement strategic planning, by comprehensive training create necessary organizational knowledge and attitude and using special structures such as self managed teams and using the methods like brainstorming pave the way for better and effective results.

REFERENCES

Azar A, Fraji H (2008). Fuzzy management sciences, pressed by book institute of Mehran nashar.

Chung SH, Lee AHL, Pearn WL (2006). Analytic network process (ANP) approach for product mix planning in semiconductor fabricator, Int. J. Prod. Econ. 96:15-36.

Dincer O (2004). Strategy Management and Organization Policy, Beta Publication, Istanbul.

Hill T, Westbrook R (1997). SWOT analysis it's time for a product recall, Long Range Plann. 30:46-52.

Houben G, Lenie K, Vanhoof K (1999). Aknowledge-based SWOT-analysis system as an instrument for strategic planning in small and medium sized enterprises, Decis. Support Syst. 26:125-135.

Kajanus M, Kangas J, Kurttila M (2004). The use of value focused thinking and the A'WOT hybrid method in tourism management, Tourism Manage. 25:449-506.

Kangas J, Kurttila M, Kajanus M, Kanga A (2003). Evaluating the management strategies of a forestland estate-the S-O-S approach, J. Environ. Manag. 69:349-358.

Kurttila M, Kangas J, Kajanus M, Leskinen LA, Leskinen P (2006). Adapting modern strategic decision support tools in the participatory strategy process-a case study of a forest research station, Forest Policy Econ. 8:267-278.

Kurttila M, Pesonen M, Kangas J, Kajanus M (2000). Utilizing the analytic hierarchy process (AHP) in SWOT analysis-a hybrid method and its application to a forest-certification case, Forest Policy Econ. 1:41-52.

Masozera MK, Alavalapati JRR, Jacobson SK, Shresta RK (2006). Assessing the suitability of community-based management for the Nyungwe Forest Reserve, Rwanda, Forest Policy Econ. 8:206-216.

McDonald MHB (1993). The Marketing Planner, Butter-worth-Heinemann, Oxford pp.234-247.

Saaty TL (1996). Decision Making with Dependence and Feedback: The Analytic Network Process, RWS Publications, Pittsburgh.

Sarkis J (2002). A model for strategic supplier selection, J. Supply Chain Manage. 38:18-28.

Shrestha RK, Alavalapat JRR, Kalmbacher RS (2004). Exploring the potential for silvopasture adoption in South-central Florida: an application of SWOT-AHP method, Agric. Syst. 81:185-190.

Yuksel I, Dagdeviren M (2007). Using the analytic process (ANP) in a SWOT analysis- A case study for a textile firm, Inform. Sci. 177(16):3364-3382, Turkey.