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Using Fuzzy Analytic Network Process (FANP) in a SWOT Analysis

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The present research in terms of purpose was an applied research; it was also considered as a descriptive research. In this research for determining importance weight, fuzzy analytic network process was used.

Keywords : *strategic planning, SWOT matrix, analytic network process, fuzzy analytic hierarchy process, chang's extent analysis method, triangular fuzzy numbers.*

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The present research in terms of purpose was an applied research; it was also considered as a descriptive research. In this research for determining importance weight, fuzzy analytic network process was used. The used fuzzy method was Chang's extent analysis method (EA). Excel software had been used in calculations for analytic network process through using extent analysis method for determination of importance weights and MATLAB software had been used for reaching final results.

Research results showed that when dependence exists among SWOT factors, this dependence could change weight and priority of strategy alternative and eventually WO strategy with the final weight of 0.317 was selected as the best strategy.

Keywords : strategic planning, SWOT matrix, analytic network process, fuzzy analytic hierarchy process, chang's extent analysis method, triangular fuzzy numbers.

I. Introduction

Now a day quantity methods are more valuable and managers organization are interests on acquiring and utilizing those techniques and methods in encounter with their difficulties and problems organizations to ease. Chose a suitable strategy according to abilities and environmental conditions organization is the most important that a organization encounter with it.

Organizations have to chose of strategies which certify survivability them in competitions and it is possible only by strategic planning. In other words, 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 analyze capability and environmental condition and in accordance with its specific available goals and 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 [4]. 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 the 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 organization and another one is external environment of the organization [8]. The data from environmental analysis can be shown systematically in a matrix [6]. 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 [12]. Routinely, this method does not specify quantitatively the amount of influence of each of these factors on the proposed program or the chosen strategy [11].

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 while SWOT matrix should be able to specify quantitatively in the analysis the precise impact of each of these factors [5]. 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 [17]. As a result of ignorance to deficiencies SWOT matrix analysis only provides a list of strategic factors or an incomplete qualitative examination of these factors.

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Due to the reasons SWOT matrix analysis could not fully and comprehensively carry out the process of strategic decision-making that enables organizations to do the right strategic decision. Kuttila and et al developed a combined technique to eliminate defects in SWOT. This technique uses AHP[1] in the SWOT analysis [7.9]

For many years the ANP[2] as a comprehensive approach, used to solve many problems of decision making. In this research FANP[3] the new and powerful tool of fuzzy analytic network process is used, which links fuzzy concepts with network analysis process. This method can be useful when the decision faced with several options and decision indicators. The theory of fuzzy system through using fuzzy logic theory and fuzzy sizes can enter parameters such as knowledge, experience and human judgment, in to the model. and in addition to creating flexibility in the model, provide a gray picture of the gray world.

Clearly, the results of such models due to providing real condition in the model, would be more accurate and practical [1]. The final output of this process, provides a method for determining importance weights of indictors and priority of options. SWOT analysis is not alone having this ability analyzing strengths, weaknesses, opportunities, threats. (SWOT) is one of the key elements of the strategic planning which is very challenging in the analytical method. Several methods are used to enhance the accuracy of results. Using the FANP in SWOT is one of the new issues which is the innovation of this research.

a) Research Question

This research has one main question as follows:

- What is the process of using FANP in SWOT?
- And how can its results be analyzed?

i. *The analysis method of data and information*

In this study in order to determine the importance weight, FANP is used. The used fuzzy method is 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 according to network analysis process technique of expansion analysis method, two computer programs are used. EXEL software is used for the calculations relating to analytic network process by using expansion analysis method for determination of importance weights, and for final results MATLAB software is used.

b) Research Method

The present research in terms of purpose is considered as an applied research. Applied research is a research that its findings could have scientific use. The subjective realm of the research is Fuzzy Analytic Network Process (FANP) and the local realm is Notashafra Company.

The reasons for the use of ANP in the SWOT matrix Although the technique of AHP eliminates the major flaws in the assessment and measurement of the SWOT matrix analysis steps, the main drawback of this method is that it couldn't measure the possible dependency between SWOT factors. In the AHP it is assumed that these factors are independent from 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 from each other and in addition, a connection may exist between some of these factors. The technique of analytical hierarchy process of SWOT factors Weights, is calculated with the assumptions that these factors are independent from each other, but it is possible that these factors are related to each other and in this situation these dependencies can affect on 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 [18]. The proposed algorithm in this research uses FANP which makes it possible for us to measure dependency among SWOT factors. In many issues the favorable decision is the one that link real world; we can imagine the interrelationships among criteria. Being a powerful tool of FANP approach available modeling of SWOT factors for the decision –makers is why it became an attractive multi-criteria decision making tool. Dependence among SWOT factors affect both on the weights of SWOT factors branches and the weights of strategy options and may also change the priority of the strategy options. In summery this study shows the process for quantifying SWOT matrix analysis in the situation that there is dependence among SWOT factors.

i. *Analytic Network Process (ANP)*

Saaty in 1996, presented a method for multi criteria, this method is called analytic network process and the aim of its presentation is designing a model through which complex issue of multi decision is analyzed into smaller pieces and by reasonable value analyze them in to simpler components and then integrates these values to a final decision.

[1] . Analytical Hierarchy Process
[2] . Analytic Network Process
[3] .Fuzzy Analytic Network Process

ANP is a developed form of AHP which is able to model the correlations and feedbacks among effective elements during a decision-making process. Furthermore, it considers all influences of internal effective components in a decision-making process which are subsequently entered into estimations. Therefore, the technique may be considered as a superior and distinctive model compared to previous ones [2, 15]. Thus, hierarchical up-down structure is not suitable for a complicated system. A feedback system can be shown as a network.

Structural difference between a network and a hierarchy is shown in the following figure. Elements in a cluster can affect the elements in other branches. A network can be organized as source cluster, intermediate clusters and sink clusters. Relationships within the network is shown with arcs and arcs direction shows the dependence [15, 2] interdependence between two cluster, which is called outer dependence and is displayed with a two-way arrow. Internal dependence among the elements of a cluster is shown by looped arcs [2, 16] (Figure1).

ANP consists of four main steps: making model and the issue structure: at first, the issue should be clearly stated and analyzed into a logical system like a network. The structure can be shown in Figure 1.

a. *Pair wise comparisons matrices and priority vector*

In network analysis process like analytical hierarchy process, decision elements in each cluster are compared in pair wisely according to their importance in that criteria and the clusters also, are compared par wisely 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 interdependent exists among elements of one part, we should specify the amount of each element effect 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 relative priority vectors should be entered in 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 tow clusters in a system. Suppose a decision system which has C_K parts and K= 1, 2, 3,.., n and each k cluster which has shown through $e_{k1}, e_{k2}, \ldots e_{kmk}$.

Priority vectors are obtained relatively in the second step; they got sectional and placed in the appropriate position in the super matrix according to the effect direction from one cluster to another. A standard for super matrix is shown in the following [15].

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

c) Select of the best position

If the former super matrix in the third step covers all net work, option weights can be found in the normalized super matrix column. On the other hand, if a super matrix contained 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.

i. *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 purpose effect on the criteria.

W32 : is a matrix which shows criteria effect on each of the sub criteria.

W43 : is a matrix which shows sub-criteria effect on any of the options.

I : is one unit matrix. (Figure2)

Figure model 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 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 purpose effect on the criteria

W_2 *:* is a matrix which shows internal dependence among SWOT factors

W_3 *:* is a matrix which shows SWOT factors effect on each of the sub branches of SWOT factors.

W_4 *:* 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 is used to show calculation details 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 degree of SWOT factors with assuming that there is no dependence between SWOT factors.(W_1, i.e. matrix calculation)

Step three: identifying interdependences between SWOT factors and based on these relationship for dependency the matrix of each of the SWOT factors with regard to other factors is formed. (W_2, i.e. matrix calculation)

Step four: Determining priority of SWOT factors, according to the dependency that exists between them. ($W_{SWOT\ factors} = W_1 \times W_2$)

Step five: Determining relative importance degree of sub branches of SWOT factors ($W_{sub\ branches\ of\ SWOT\ factors}$ i.e. calculation)

Step six: Determining general importance degree of sub branches of SWOT factors. ($W_{general\ sub\text{-}branches\ of\ SWOT\ factors} = W_{factors} \times W_{relative\ sub\ branches\ of\ SWOT\ factors}$)

Step seven: Determining importance degree of strategy options with regard to each of sub branches of SWOT factor. (W_4)

Step eight: calculation of the final priority of strategy options, with consideration to internal relations among SWOT factors. ($W_{alternatives} = W_4 \times W_{general\ sub\ branches}$)

The main inputs required in the technique of network analysis process for calculation of W1, W2, W3, W4 pair wise comparison are existed elements in each cluster which composed of a pair of wise comparison matrix. Pair wise comparisons matrices and output evaluation of them 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 in simplicity to understand and is easy to use but due to incompatibility with human mind's map cannot close us to the actual results.

This research is trying through using theoretical concepts of fuzzy sets and triangular fuzzy numbers with

the tools of analytic network process improve the results and make them closer to reality as much as possible.

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

ii. *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 method but the calculation and level 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 follow:

Consider two triangular fuzzy numbers
$M1 = (L_1, m_1, u_1)$ and $M2 = (L_2, m_2, u_2)$. (Figure3)
$M1+M2 = (l_1+l_2+m_1+m_2, u_1+u_2)$
$M1.\ M2 = (l_1l_2, m_1m_2, u_1u_2)$

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

It should be noted that product of two triangular fuzzy numbers or reverse of a triangular fuzzy number, is not a triangular fuzzy number anymore and this relationship tells only an 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 vale which is a triangular fuzzy number, is calculated as follow:

In which K present row number and I and J respectively present 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.

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

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

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

In this case we have:

$$Hgt\,(M1 \cap M2) = \frac{u1 - l2}{(u1 + l2) + (m2 - m1)}$$

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

$$V(M_1 \geq M_2, \ldots, M_k) = V(M_1 \geq M_2) \text{ and } \ldots \text{ and } V(M_1 \geq M_k)$$

Also for the calculation of indices in pair wise comparisons matrix performs the following.

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

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

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

It is the non-normalize coefficient vector of fuzzy hierarchy process [1].

Since the used numbers in change extent analysis method are triangular fuzzy numbers, so we assumed that decision-makers are set these words set for weighting, you can see its fuzzy scale and diagram in the Table below (Table1and Figure4)

II. Implement Of Decision Algorithm

a) The (First Step) Specifying organization strategic factors and determining strategy options with respect to this factors

In this study, environmental analysis should be done at 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, which did environmental analysis. After identification of strategic factors (i.e. identification of strengths (S), weaknesses (W), Opportunities (O), threats (T) we selected possible strategies through the analysis of these factors. As you can see in the Table below, the organization is faced with four strategy alternatives, which are as follow:

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 :* development 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 selection of the best strategy for the organization (Table 2).

After the identification of organization strategic factors and strategy alternatives we should convert the issue into a hierarchical, 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 of the selection of 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 organization that are in the last level of the model (Figure5).

b) The (second step) determining importance degree with assuming no dependency exist among SWOT factors

At this stage we assume that there is no dependence and interaction among SWOT factors (Strengths, weaknesses, opportunities, threats). We form pair wise comparisons matrix of SWOT factors with goal of the best strategy selection. The result of comparisons are shown in the below Table3).

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

c) The (third step) forming dependence matrix of each the SWOT factors with regard to other factors

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

Based on the dependences that exist among SWOT factors, we formed pair wise comparisons matrix based on fuzzy numbers and extent analysis method. (Table 4, 5, 6 and7).

W2 matrix is formed by the obtained vectors of each Table (WJ). This matrix shows relative importance weights of SWOT factors in the situation that we recognize the interdependence between them which is displayed in the following matrix.

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

d) The (fourth step) Priority determination of SWOT factors with the consideration of dependency among them

At this step we should calculate priority of SWOT factors according to the dependency 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 ignore inner dependence among these factors and the results have been changed respectively for strengths from 0.382 to 0.445 and for weaknesses from 0.108 to 0.153 for opportunities from 0.401 to 0.341 and for threats from 0.109 to 0.061.

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

e) The (fifth step) Determination of relative importance degree of SWOT factors on sub branches

At this stage, we should calculate the relative priority of sub branches of SWOT factors by using pair wise comparisons matrix. These matrices are as follow, respectively (Table 8, 9, 10 and 11).

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

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

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

f) The (sixth step) Determination of general importance degree of SWOT factors sub branches

Following results were obtained:

$$(W_{general\ sub\ branches\ of\ SWOT\ factors} = W_{factors} \times W_{Relative\ sub\ branches\ of\ SWOT\ factors})$$

g) The (seventh step) determining importance degree of strategy options with respect to each of the sub branches of SWOT factors

At this stage, we should calculate importance 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 (Table 13 and 14).

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:

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

h) The (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:

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

Analyzing the results of fuzzy analytic network process (FANP) shows that WO strategy with final weight of 0.317 is chosen s 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 infrastructure 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 implementing of new technologies (ST) with a final weight of 0.278
4. Cooperation and strategic partnership (WT) with a final weight of 0.123

i) Comparing the result s of fuzzy analytical hierarchy process with fuzzy analytic network process

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

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

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 the Table below. As you see when we analyze the dependence among SWOT factors, this dependence impact on the strategies weights and strategies priority compared to the state that assumed these factors are independent from each other (Table15).

III. Discussion and Conclusion

In this study the technique of fuzzy analytic network process 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 we could also identify and measure the dependence between SWOT factors and also we could 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 dependency among SWOT factors on both

the weights of SWOT factors sub branches and priority of strategy options, we also use 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, the results of these two approaches were compared in Table 15. As you observed both weights and strategies rank was different from each other in fuzzy analytical hierarchy process and fuzzy analytic network process. Although these differences are predict Table because analytical hierarchy process does not consider the dependency among SWOT factors in the analysis and sole problem with the assumption that these factors are independent from each other. While in the method of analytic network process the dependence among SWOT factors takes in to consideration and with respect to these dependencies this issue can be analyzed. For this reason, fuzzy analytic network process can be a better modeling for the real world problems in comparison with a hierarchical approach. Other organization and companies that want to use this method in their strategic planning process should pay attention to this point that dependency among SWOT factors and its sub branches are largely related to organization types and their activities. In this study we only analyze dependency among SWOT factors, but it is possible that for other organizations dependency among sub-branches of SWOT Factors is more important than dependency among SWOT factors. In general it can be concluded in the cases that there is internal interaction or dependence among SWOT factors (strengths, weaknesses, opportunities, threats) or among it s sub branches, the method of analytic network process must be used to prioritize strategic options, using these approaches and techniques enables organizations to take correct strategic decision. Also in the cases that there is no dependence among SWOT factors or among its sub branches or dependency is such that it can be ignored, the technique of analytical hierarchy process can be used.

a) 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 organization decides to implement strategic planning, by comprehensive training create necessary organizational knowledge and attitude and when running by using special structures such as self managed teams and using the methods like brainstorming pave the way for better and effective results.

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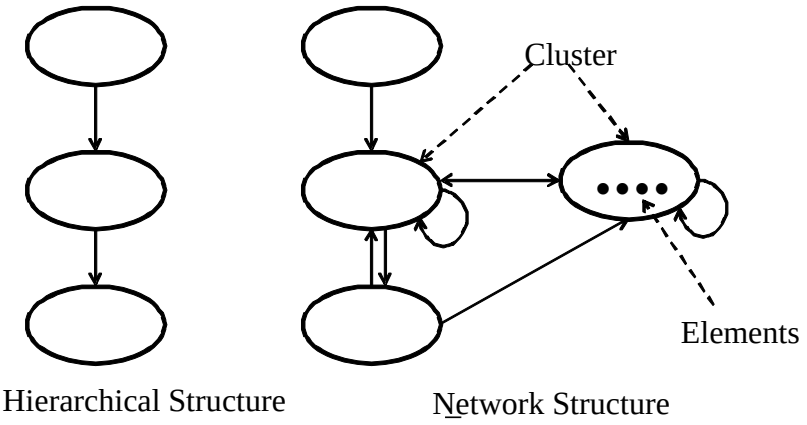

Figure 1 : The structural differences between network and hierarchy. Resources [16.2]

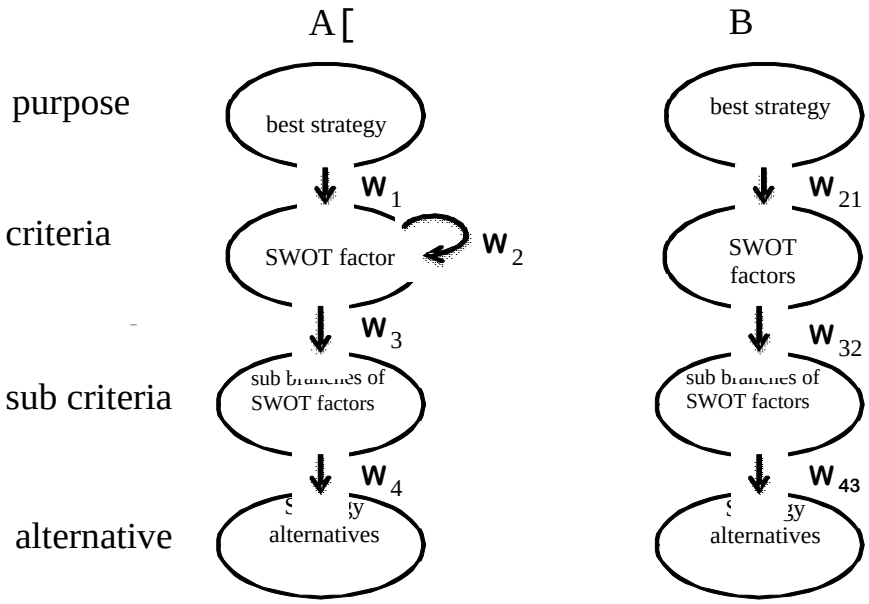

Figure 2 : Structure difference of SWOT model between a hierarchy of A and a network of B

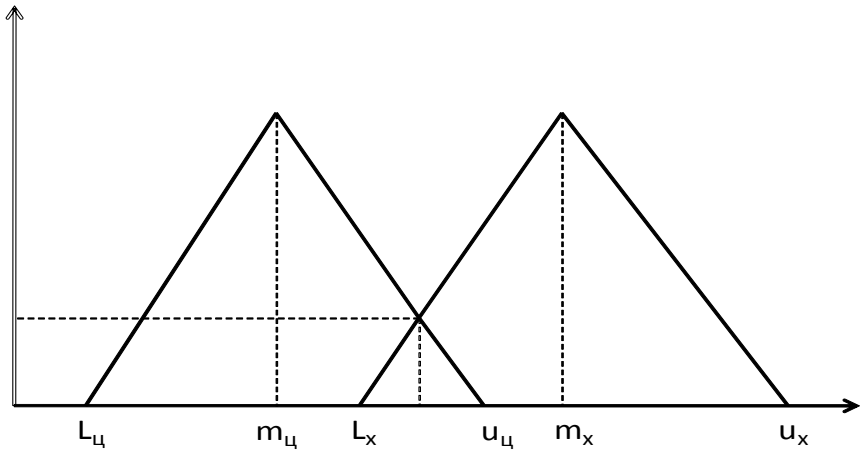

Figure 3 : Display of two triangular fuzzy numbers

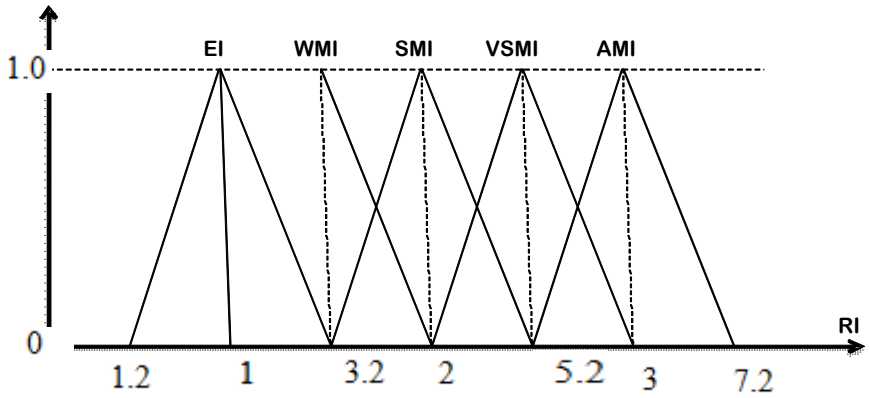

Figure 4 : Verbal scale for measuring the relative importance. Reference [3 and 14]

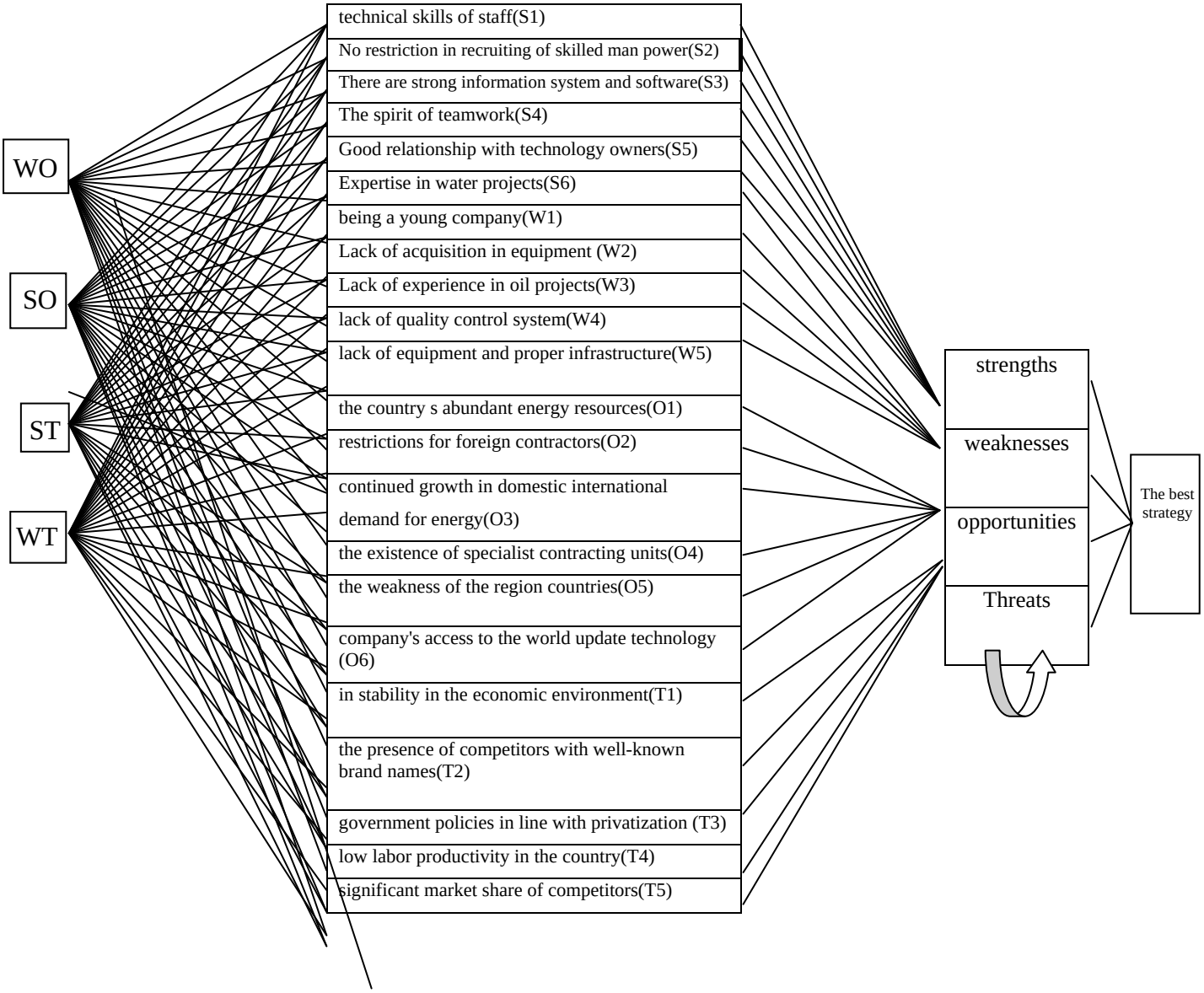

Figure 5 : Analytic network process model for SWOT matrix

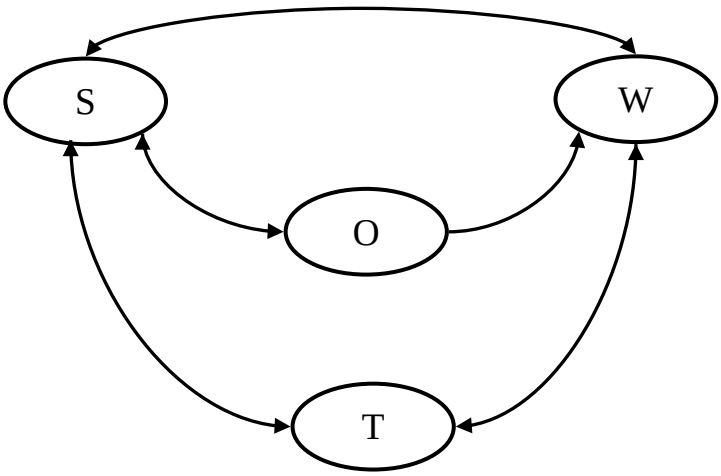

Figure 6 : The inner dependence among SWOT factors

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)

Weaknesses(W) -Being a young company (W1) -lack of acquisition in 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)	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)	Internal factor External factor
WO strategy -professional reinforcing of manpower and infrastructure in the area of thermal power plants	SO strategy -market development-the foreign goal market	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)
WT strategy -cooperation and strategic partnership	ST strategy -development and implementing of new technology	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)

Table 2 : SWOT Matrix

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)

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)

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)

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 sprit 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

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 and 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
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

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

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