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SWOT Analysis using of Modified Fuzzy QFD – A Case Study for Strategy Formulation in Petrokaran Film Factory

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Abstract

Strategy is a comprehensive program that determines main approaches of the organization and suggests proper ways for allocating resources in order to help the organization to achieve its long term objectives. Environment change, competitiveness and attitude of customers have convinced managers to have a strategic program. In strategic programming SWOT analysis is a useful method that can be used for analyzing strengths and weaknesses within the organization and opportunities and threats from outside of the organization. Although this method is very practical there are some problems in using it. For example there is no tool to determine the importance of factors and this is mostly done by personal preferences. In this paper weight of strengths, weaknesses, opportunities and threats are calculated by Fuzzy Quality Function Deployment and proper strategies for the organization are achieved by HOQ (House of Quality). Hence the customer requirements are important for the strategic planners in this approach the relations between the customer requirements and relations at the top of HOQ are numerically calculated and have impact on internal and external factors of the organization. Because of uncertainty in the decision making factors the calculations are done in a fuzzy environment. At the end this approach is applied in Petrokaran factory as a numerical case study.

Keywords: Strategic management; SWOT Analysis; Quality Function Deployment; Customer Needs; Fuzzy Set

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1. Introduction

Today world is complex with congested rivalry. Customer requirements are always changing and managers have special attention toward long term schedules. Mission change and editing new strategies are parts of manager's responsibilities.
Strategic management can be understood as the collection of decisions and actions taken by business management, in consultation with all levels within organization, to determine the long term activities of the organization [1]. Strategic management process consists of three stages: strategy formulation, strategy implementation, and strategy evaluation. SWOT analysis is important tools for strategy formulation and development [2]. The SWOT analysis is based on aggregation of the internal (Strengths, Weaknesses) and external (opportunities, Threats) factor for adapting strategies [3]. Having identified these factors strategies are developed which may build on the strengths, eliminate the weaknesses, exploit the opportunities or counter the threats [4]. Despite wide application of SWOT, it has also a number of problems [5] that 7 of them are mentioned by Hill and Westbrook [6], but most important ones are as follows:

- Usually only qualitative examination of environmental factor is considered [7].
- It considers no priority for various factors and strategies [3].
- If the numbers of factors are more, the number of adopted strategies will be increased exponentially [3].
- SWOT analysis dose not provide an analytical means to determine the relative importance of the factors [1], [8].
- Basically SWOT is based on quality analysis, capacities and personal skills in strategic planning process.

For this reason, SWOT analysis can not comprehensively appraise the strategic decision making process. In this paper we can calculate the importance of customer requirements and the situation of rivals in a numeric way by using Fuzzy QFD and SWOT analysis when we know the relations between the customer requirements, internal and external factors of the organization. In order to formulate qualitative decision making factors in an uncertain environment fuzzy logic is used for strategy making process. As a case study this approach will be examined at Petrokaran Film Factory.

The remaining part of this article is divided into six sections. Review of Literature indicates in second section. In the third section, fuzzy concept is determined, and then the research approach is defined in fourth sections, and fifth section has case study. At last, in sixth section results and conclusion are given.

2. Review of Literature

The analytic Hierarchy Process (AHP) has been implemented for this case [5], [9].hybrid method in order to improve the usage of SWOT analysis and to eliminate the deficiencies about measurement and evaluation by systematical approach applied by Kurttila et al. [9]. But in AHP approach only weights of the SWOT factors are determined [5], [8], [9], and [10].

For measurement of the dependency among strategic factors, as well as AHP, Analytic Network Process (ANP) used by Youksel and Dagdeviren [1], in this research, dependency among the SWOT factors is observed to effect the strategic and sub-factor weights, as well as to change the strategy priorities.

Quantification SWOT analytical is another approach, for help the SWOT analysis to formulate the strategies [2]. The concept of this MADM [11] is introduced into SWOT, according to four factors of decision making: alternative, criteria, performance and weight [2].

In another research, Ghazinoory et al. [3], quantified the SWOT factors through the definition of fuzzy membership functions, evaluated the factors and strategies, and both qualitative and quantitative aspect of factors are considered.

3. Fuzzy Concept

Lotfi A. Zadeh in 1965 introduced the fuzzy set theory to deal with the uncertainty due to imprecision and vagueness [12]. Since then progress to fuzzy sets and its application in various sectors of human life has been improved.

In the classical theory, an element could belong to a set or not. But fuzzy sets and membership developed this concept and introduces raised rate membership. Therefore an element could be a member of a set to a degree. In this theory membership is showed with μ(x) symbol [13]. This value is always between zero and one, as is shown:

$$\widetilde{A} = \left\{ (x, \mu_A(x)) \middle| x \in X \right\}$$

The Fuzzy numbers are in many shapes, but triangular and trapezoidal fuzzy number forms are used more. In this study we use the triangular fuzzy numbers. Membership function of triangular fuzzy numbers (a,b,c) are defined as follow:

$$\mu(x) = \begin{cases} \dfrac{x-a}{b-a} & a \le x \le b \\ \dfrac{c-x}{c-b} & b \le x \le d \\ 0 & otherwise \end{cases} \tag{1}$$

If $\widetilde{A} = (a_1, b_1, c_1)$ and $\widetilde{B} = (a_2, b_2, c_2)$ are two triangular fuzzy numbers, Algebraic mathematical operations on them are defined as follows:

$$\widetilde{A} + \widetilde{B} = (a_1 + a_2, b_1 + b_2, c_1 + c_2) \qquad \widetilde{A} - \widetilde{B} = (a_1 - c_2, b_1 - b_2, c_1 - a_2) \qquad \widetilde{A} \times \widetilde{B} = (a_1 \times a_2, b_1 \times b_2, c_1 \times c_2)$$

$$\frac{\widetilde{A}}{\widetilde{B}} = \left(\frac{a_1}{c_2}, \frac{b_1}{b_2}, \frac{c_1}{a_2} \right) \tag{2}$$

4. Research Approach

4.1. Quality Function Deployment (QFD)

Quality function deployment originated in 1972 in Japan [15], as a methodology to be adapted to improve products quality in Japanese firms, such as Mitsubishi, Toyota and their suppliers [16]. In QFD methodology, first, the application of them requires the careful consideration of customer during the

development process [17]. Second, this approach has introduced the collaboration among different business areas as a prerequisite for product design. [18].

The customer requirement planning matrix, the product characteristics deployment matrix, the process and quality control matrix and the operative instruction matrix are four successive QFD matrixes [19]. But, we only focused on the customer requirement planning matrix which has been used to weighted SWOT analysis factors. This matrix, also called "House of Quality" because of its typical shape. The HOQ is thus adopted by the design work group (here, team of experts). The HOQ can be build by eight steps process [16].but in this research we applied new procedure For HOQ buildings that used for SWOT analysis.

4.2. Methodology

The methodology of this paper (Fig. 1) (we called Modified Fuzzy QFD) is based on the following steps:

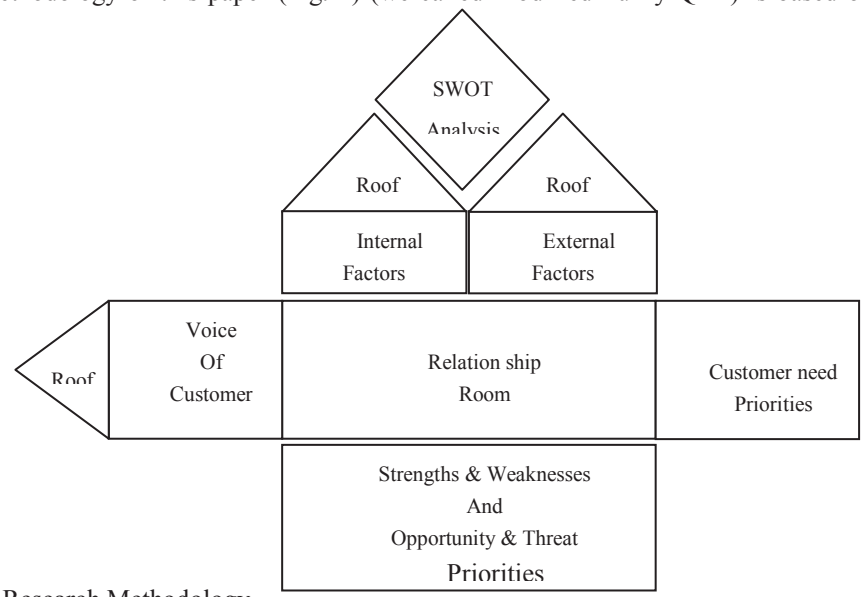

Fig. 1. Research Methodology

- Selecting the team of experts. After describing market circumstances, analyzing the situation and convincing high ranking managers of the strategic management benefits a team of experts from different branches of the organization who have a complete command on the company's internal and external situation will be selected.

- Defining the new mission of the organization by editing a new mission statement, figuring the perspective and organization values are defined by experts and will be generally announced to the managers, personnel and beneficiaries.

- Analyzing internal and external environment of the organization and detecting the organization strengths, weaknesses, opportunities and threats. One of the expert team responsibilities in Formulating strategies is analyzing internal and external environment of the organization. By a proper analysis in this step SWOT results will propose effective strategies in the organization.

- Voice of customer needs. One of our goals in this research is paying attention to the customers in the future plans of the organization, therefore detecting customer requirements is very important. If we understand the priorities and importance of these factors customers will be highly satisfied and there will be more profit for the organization. We can detect customer requirements by interviewing the customers, preparing check lists and reviewing the customer's complaints. Then the expert team uses this information and finally the customer requirements will be detected. Considering common requirements among all customers is important in detection. Regarding all the requirements will end up in huge amount of calculation but we need to use all the needs in a proper way so the requirements will be separated in different groups. But it is important to know that requirements which are in one group must have common characteristics so that we can use them in the relation matrix.

- Population and sample. Defining population and sample are two important steps for having accurate results. The population of the research is different concerning the situation and the topic.

- Distribution of questionnaire. After the customer requirements now we can measure their importance by the first questionnaire.

- Measuring the importance of customer requirements. According to equation (3) fuzzy average of each answer is the importance rating or weight of each requirement. Due to verbal and uncertain answers fuzzy spectrum in fig. 2 with seven options is proposed.

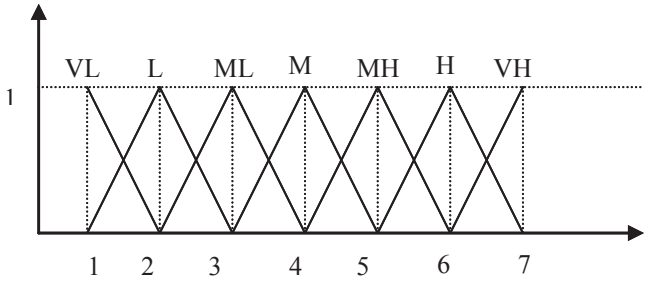

Fig. 2. Fuzzy Spectrum

$$\widetilde{W}_i = C\widetilde{I}R_i = \frac{\sum_{j=1}^{n} \widetilde{I}R_j}{n} \tag{3}$$

In Eq. (3) W is the weight or importance of each requirement from the customer perspective and CIR is the customer importance rating of each need from the questionnaire and n is the number of people who answer the questioners.

- Current customer satisfaction rating is calculated by dividing satisfaction ratio to the number of customers Eq. (4). (for rating of competitors is the same)

$$CC\widetilde{S}R_i = \frac{\sum_{j=1}^{n} \widetilde{S}R_j}{n} \tag{4}$$

- Goals/ Targets of requirements. One of the important steps in completing the House of Quality (HOQ) is defining the goals of the customer requirements. In this step the expert team defines the goals based on internal capabilities of the organization, financial resources and technological constraints. In the selection of goals it is important for the organization to select goals that are more competitive regarding its rivals.

- Improvement ratios (IMR) are achieved by dividing the goals to the current customer satisfaction ratio.

- Preliminary raw weights. The column of importance rating and improvement ratio are multiplied and Preliminary raw weights of each requirement will be calculated by Eq. (5).

$$\widetilde{PRW}_i = \widetilde{CIR}_i \otimes \widetilde{IMR}_i \tag{5}$$

- Final customer requirement weights. There are relations between the customer requirements and these relations are effective in their importance so the effect of these relations (6) declares final customer requirement weights.

$$\widetilde{FCRW}_i = \widetilde{PRW}_i \oplus \left(\sum_{u=1,u\neq i}^{N} \widetilde{PRW}_i \otimes \widetilde{X}_{iu} \right) \tag{6}$$

Xiu equals the degree of relation between ith and uth requirement. These equations are valued by the expert team according to fuzzy spectrum in fig. 3.

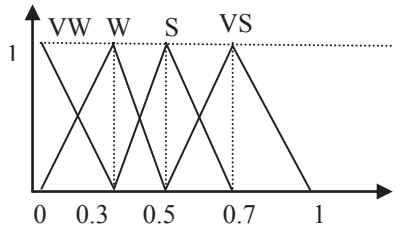

Fig. 3. Fuzzy Spectrum (VS:$\oplus$, S:+ , W: - , VS:$\ominus$)

- Customer Requirements ranking. In order to rank the requirements first we normalize final weights Eq. (7) and then we use Eq. (8) for defuzzification. Then the crisp values can be easily ranked. If we show fuzzy numbers by A (l, m, u) then we have:

$$rl_{ij} = \frac{al_{ij}}{\sqrt{\sum_{i=1}^{m} au_{ij}^2}} \qquad rm_{ij} = \frac{am_{ij}}{\sqrt{\sum_{i=1}^{m} am_{ij}^2}} \qquad ru_{ij} = \frac{au_{ij}}{\sqrt{\sum_{i=1}^{m} al_{ij}^2}} \tag{7}$$

$$A = \frac{l + 2m + u}{4} \tag{8}$$

- Clarifying the importance of strengths, weaknesses, opportunities and threats of factors. The importance of strengths, weaknesses, opportunities and threats for internal and external factors is achieved by members of the expert team ideas, fuzzy average Eq. (9) of expert ideas are used.

$$\widetilde{RWS}_i = \frac{\sum_{j=1}^{N} \widetilde{DMA}_j}{N} \tag{9}$$

Achieved weights are raw because the relations between customer requirements and internal, external factors of the organization.

- Complete relationships matrix between customer needs, internal and external factors. One of the QFD advantages is defining the relations between customer requirements and technical characters. The expert team clarifies these relations by combining different ideas.

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- Preliminary weights of internal and external factors. Preliminary weights of internal and external factors are primary raw weights added to the multiplication of final normalized weights to the relations of internal and external factors in the organization. The importance of Preliminary weights is because of considering relations of customer requirements and internal, external factors, current situation of organization, competitors and capability based goals. Preliminary weights are achieved by (10) and (11).

$$I\widetilde{FPW}_j = I\widetilde{FRW}_j \oplus (\sum_{i=1}^{m} \widetilde{R}_{ij} \otimes \widetilde{NFCRW}_I) \tag{10}$$

$$E\widetilde{FPW}_j = E\widetilde{FRW}_j \oplus (\sum_{i=1}^{m} \widetilde{R}_{ij} \otimes \widetilde{NFCRW}_I) \tag{11}$$

Eq. (10) Is for internal factors (IFPW) and (11) is for external factors (EFPW).

- Final weights of internal and external factors. In the environment analysis it is seen that there are relations between strengths and weaknesses and also opportunities and threats. This fact adds to the importance of some of the factors of SWOT analysis. Therefore the final weight of each factor is achieved by adding internal factor Preliminary weights to the summation of relations multiplied to internal factor Preliminary weights (12), (13).

$$I\widetilde{FFW}_j = I\widetilde{FPW}_j \oplus (\sum_{i=1}^{m} \widetilde{T}_{jy} \otimes I\widetilde{FPW}_j) \tag{12}$$

$$E\widetilde{FFW}_j = E\widetilde{FPW}_j \oplus (\sum_{i=1}^{m} \widetilde{T}_{jy} \otimes E\widetilde{FPW}_l) \tag{13}$$

Eq. (12) is for internal factor final weights and Eq. (13) is for external factor final weights. T is like X in both of the equations above.

After Modified Fuzzy QFD steps are finished now all of the strengths, weaknesses, opportunities and threats according to the internal external environment analysis which is achieved by the team of experts. We can apply customer requirements effect on the factors, potential capabilities of the organization and the situation of rivals in proposing new strategies.

- Ranking internal and external factors. In this part like customer requirements part and according to Eq. (7) and Eq. (8) ranking of factors are done but internal and external factors are ranked separately.

4.3. Strategy analysis by SWOT.

Regarding the method of this study in completing the top of HOQ (House of Quality) SWOT analysis is applied on the top of HOQ. This means that all of the effective factors in making strategy are located under a single roof therefore the results of this study are much more effective than the previous methods.

In this part the extent of relations between internal and external factors (Z) are defined by proposed fuzzy spectrum in fig. 2 according to the team of expert consensus so final weights are achieved by (14).

$$\widetilde{SW}_q = \widetilde{FWIF}_j \otimes \widetilde{FWEF}_l \otimes Z_{jl} \tag{14}$$

In this formula SW is the weight of strategy.

4.4. Strategic actions and their rankings in the organization.

According to the achieved weights based on SWOT analysis the organization strategies will be formulated. Since we have the weights of strategies from the previous step the strategic priorities for the organization can be well seen.

5. Case Study

Since every approach should be practical to be introduced, Petrokaran Film Factory has been chosen to perform above mentioned approach and changing its mission. Petrokaran Film Company is established in center of the Iran and produces raw film for packing polymeric products and has limited goal marketing. Regarding today's business, intense competition, and customers needs, top manager of this organization has devised new mission which based on it, company must focus on new markets inside and outside of the country. Changing mission of the organization needs a strategic program to conduct the organization towards its short term and long term goals.

According to the approach of this study, first of all strategic management team (experts team) consisting of five persons of top managers was formed. Then the strategy was explained to them by the researcher of the editing process. Afterwards it is requested from each of the team members to survey the strengths, weaknesses, opportunities, and threats of the organization individually and bring the results with themselves for the next session. At the next session every member expressed his/her case and at the end of this brain storming below mentioned items were chosen as S, W, O, and T of the organization:

S1: multi professional personnel, S2: high culture effort, S3: low cost energy, S4: simple production process, S5: over 30 type of laboratorial product, S6: low product waste, W1: centralized management, W2: frequently management changes, W3: lacking local laboratory, W4: lacking sufficient info about competitors, W5: insufficient advertisements, W6: Fewer staff, W7: lack of spare part, W8:unsuitable packing, W9:undissolve film, W10:lack of professional personnel in some department, O1:possibility of using dissolving material, O2:possibility of buying a new machine, O3:same film & product production, O4:suitable location, O5:stability spec, O6:nighbourhood to the ARPC, O7:there are many polymer plant in country, O8:possibility delivery to the Persian golf district, T1:lack of spare part in case of boycott, T2: increased cost in case of inflammation, T3:effective delivery exporting & importing law to supply feed & sell, T4:establish the law of environment ecology, T5:undissolving plastic, T6:petrochemical co investment in film production, T7: competitors new technology, T8; main competitors are near to the internal objective market.

According to the obtained information from film customers in Iran 45 of basic needs common between the all of customers were specified by the expert's team and were categorized in 9 groups(size, shape of roll, Film quality, Stamp quality, Packing, physical characteristics, Services, Sale format and Amount of waste). A questionnaire were prepared and distributed amongst organization's customers and the customer of the main competing companies', which checks requirements of the customers in two level of

importance and rate of providing requirements. Reliability of the questionnaire was measured through calculation of the Cronbach's alpha with SPSS software package.

After gathering related information House of Quality was completed based on research methodology as mentioned below (fig. 4). The importance rating is measured via results of the questionnaire and Eq. (3). Current position of the organization and its three competitors (C1, C2, and C3) was analyzed via information's of the questionnaire and the Eq. (4). With Eq. (5), (6), (7), and (8) completes Fig. 4.

PRW	FCRW	NFCRW	CRISP	RANK
(4.62, 7.65,10.77)	(9.21, 20.72, 37.79)	(0.064, 0.288, 1.159)	0.4499	5
(4.92, 8.22, 11.56)	(7.94, 16.61, 32.78)	(0.056, 0.231, 1.005)	0.3804	6
(4.81, 8.19, 11.27)	(7.18, 13.75, 27.46)	(0.05, 0.191, 0.842)	0.3186	8
(5.09, 8.27, 11.47)	(6.71, 12.84, 28.57)	(0.047, 0.179, 0.876)	0.32	7
(5.25, 8.83, 12.27)	(11.13, 25.42, 46.33)	(0.078, 0.353, 1.421)	0.5513	4
(5.37, 9.13, 13.14)	(11.92, 25.38, 47.51)	(0.083, 0.353, 1.457)	0.6615	3
(5.31, 9.36, 14.5)	(14.87, 33.72, 73.21)	(0.104, 0.469, 2.249)	0.8217	2
(5.17, 8.33, 10.46)	(6.76, 13.01, 20.61)	(0.047, 0.181, 0.632)	0.2603	9
(4.73, 7.95, 11.84)	(16.92, 38.96, 78.4)	(0.118, 0.542, 2.404)	0.9016	1

Fig. 4. Priority of needs

After specifying priorities and weight of customers requirements the weight of each of internal and external factors of the organizations are defined. For this reason first every members of the expert team should individually determine to which group of the SWOT each of the internal and external factors belongs and at the end weight of each factors calculated through Eq. (9). Then preliminary weight of internal and external factors of the organization is determined based on Eq. (10) and Eq. (11) and fuzzy spectrum of figure 2. Since there are relations between weaknesses and strengths and also opportunities and the threats, at the next stage these relations and the final weights of the interior and exterior elements are defined by the expert's team through Eq. (12) and Eq. (13) and fuzzy spectrum in fig. 3 (fig. 5). At the end of this section final weight are normalized and ranked via Eq. (7) and Eq. (8). The main point is that the internal and external factors are normalized separately.

In this section we observe that strengths, weaknesses, opportunities, and threats of the organization are weighted and prepared for analyzing the SWOT. Therefore members of the expert team in a brain storming session define the relations between internal and external factors based on table 1, so via Eq. (14) the weight of each pair could be calculated. As a result the strategy gets priority for strategy formulation.

Table 1. Priority of Strategy formulation

	S1O2	S3T1	S5O1	S5O2	S5O3	S5O4	S5O5	S5O7	S5T6	S5T7	S6T7	W2O2	W4T7
R	MH	L	L	VH	VL	VH	VH	MH	M	M	L	M	M
W	11.4	2.18	8.49	15.99	4.35	17.62	24.19	24.07	0.95	9.69	6.68	17.3	1.75
Rank	8	22	10	5	18	3	1	2	25	9	13	4	23
	W4T8	W5O4	W5O7	W5O8	W5T8	W6O3	W6T1	W7T1	W7T2	W8O8	W9T5	W9T6	W10T2
R	H	MH	H	M	VH	3	L	VH	MH	ML	VH	M	MH
W	1.52	7.09	13.22	8.11	3.94	5.68	2.85	3.04	4.67	5.68	4.71	0.23	12.9
Rank	24	12	6	11	19	14	21	20	17	15	16	26	7

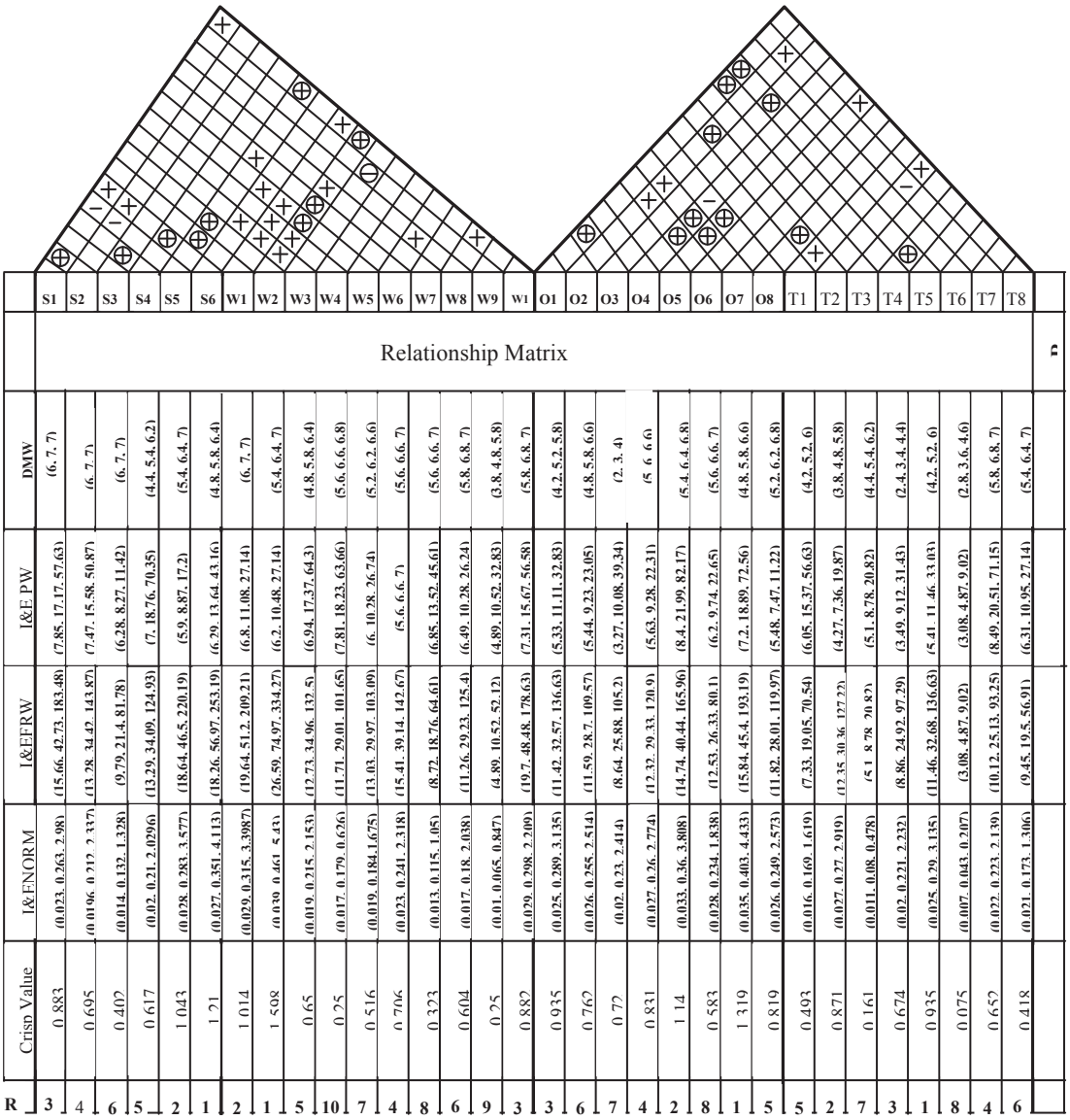

Fig. 5. Weighing of internal & external factor

6. Conclusion

Regarding performed study, above mentioned deficiencies about the SWOT analysis has been corrected through Modified Fuzzy QFD technique. The results show that making quantitative the relations between customers' requirements, internal and external factors of the organization which are not considered in QFD have influence on the weight of the elements and deliver more real results. As it is obvious because this approach considers requirements of the customers, competitors and also relations between requirements of the customers and internal and external factors in condition that customer orientation is located on the agenda and the competitions is a inseparable element of the organization's today business, gives a new perspective to the strategists and managers of the organization. Furthermore it

could be seen that for the phase of strategy implementation this approach prepares a framework based on competition and customer orientation because by specifying requirements of the customers and prioritizing them the organization concentrates its resources on elements which prepares customer's requirements more and as a result there is more profit with it for the organization.

In addition, according to final result only 26 pairs of internal and external factors get in strategy formulation. It is in condition that traditional SWOT analysis equal to 18*18=324.

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