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Coping with Imprecision in Strategic Planning: A Case Study Using Fuzzy SWOT Analysis

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ABSTRACT

In this article, it is shown that using the conventional SWOT analysis in the vicinity of strategic regions in the matrix of internal and external factors, ambiguity can exist in defining final strategies. To cope with this difficulty and to enhance the accuracy of the underplaying decision process, a straightforward fuzzy SWOT analysis is presented and exemplified by extracting and analyzing strengths, weaknesses, opportunities and threats in a company known as KPPP. The analysis is performed based on actual field data using 90 external and 85 internal factors and a group of 12 experts. Next to the identification of the fuzzy SWOT matrix, it is shown that the external threats and internal weaknesses of KPPP can have stronger effects compared to its external opportunities and internal strengths.

Keywords: *Fuzzy Applications, Internal and External Factors, Strategic Planning, SWOT Analysis*

1. Introduction

It is well known that a company's success in today's competitive business environment requires its ability to create and update strategic plans [1-6]. While various management analysis techniques such as the Total Quality Management (TQM) [7-10] and Re-engineering [2,4] have proven to be beneficial for meeting organizational specific objectives, strategic planning remains the single most important element for companies' overall success. Reported case studies indicate that organizations using the principles of strategic planning are by far in better condition in marketing, profitably and beneficiation [2,4,11,12].

Earlier studies have been performed on improving the classical strategic planning methods such as the strengths, weaknesses, opportunities, and threats (SWOT) analysis. Ghazinoory *et al.* [13] applied a fuzzy set approach to both the internal and external factors using conventional membership functions. The algorithm prioritizes and extracted the most significant strategies based on intensity of effects. Kuo-liang and Lin Shu-chen [14] proposed a fuzzy SWOT method to evaluate the competitive environment of different transshipment locations as international distribution centers (IDC) in the Pacific-Asian region. Their work suggested that the fuzzy method identifies more competitive locations as compared to the conventional SWOT. Zhangjiajie [15] presented a new fuzzy decision-making tool for small and medium enterprises (SMEs) under a set of ambiguous strategic policies. The model can assist SMEs to train their own core strengths and gradually explore their ideal strategies. Lee *et al.* [16] presented a mechanism for integrating a fuzzy cognitive map (FCM) within strategic planning simulations, where FCM helps decision makers understand complex dynamics between a certain strategic goal and related environmental factors. Wang and Chang [17] investigated the properties of fuzzy scenario analysis to cope with the issue of data shortage and the linguistic expression of experts. Their study successfully incorporated the fuzzy set theory into the scenario analysis such that uncertainties are accounted for. Kahraman1 *et al.* [18] proposed a method to evaluate different alternative strategies for an e-government application in Turkey. They used the SWOT approach in conjunction with the analytic hierarchy process (AHP) to prioritize their strategies. Shuliang *et al.* [19] proposed a hybrid approach for integrating a group Delphi, fuzzy sets and expert systems in developing marketing strategies. The method was specifically employed to help groups of managers undertake SWOT analysis. It is worth adding that next to the strategic planning area, fuzzy sets have been widely used in a range of applications including

linear and nonlinear control, pattern recognition, financial systems, etc [13,18,20].

This article is intended to first indentify a potential imprecision problem in the use of conventional SWOT analysis for particular strategic planning problems, and then present an application of a fuzzy SWOT method to resolve the problem. The method has been exemplified via a case study on the strategic planning of the KPPP company. The case is based on actual field data, collected from 12 experts based on 90 external and 85 internal decision factors. Section 2 reviews the basics of the conventional SWOT analysis. Section 3 identifies the potential problem with the conventional SWOT matrix and extends the analysis to the fuzzy method. Section 4 presents the KPPP's case study and discusses the results using a quantitative measure for determining the total distance between the obtained fuzzy internal and external factors. Section 5 concludes the article.

2. Basic SWOT Analysis

Strategic planning in an organization can involve making decisions on allocating resources such as capital and people. During strategic planning, main objectives are often presented as vision and mission statements and subsequently the company's strengths, weaknesses, opportunities, and threats (SWOT) are assessed [21-31]. The vision statement is an image or state to which the company aspires. It emphasizes the desire of where the company would be at a specific time. The nature of a business is often expressed in terms of its mission indicating the purpose of the business; for example, to design, develop, manufacture and market specific product lines for sales based on certain features to meet the identified needs of specific customer groups via certain distribution channels in particular geographic areas. Having built up a picture of the company's past and current achievements, the SWOT analysis can commence. The following four steps are considered for analyzing the internal factors:

1) All internal factors are scored based on their existing status in the company. The scores are crisp values and usually range from −2 to 2 as shown in **Figure 1**.

2) An overall importance coefficient/weight of 1 to 100 is assigned to each internal factor based on the viewpoints of experts. The weights are then normalized such that their sum is one.

3) The weighted score of each factor is calculated by multiplying the corresponding normalized importance coefficient by the score of the factor from Step 1.

4) The summation of the weighted scores is considered as the overall score of internal factors.

The external opportunities and threats to the company can fall in the areas such as customers, distribution channels, identities, substitute products, etc. The same procedure used for scoring the internal factors can be employed to evaluate the external factors; i.e., eventually an overall weighted score for the external factors is estimated.

Next, the company's overall internal and external scores are used to locate its position in a SWOT matrix as shown in **Figure 2**. The two overall internal and external scores define the coordinates of a strategic point that fall in one of the matrix cells. The matrix cells normally indicate known strategies for the managers. For example, if a company's position is located in cell #1, growth strategies for adding new products are proposed; for cell #9, divestiture strategies are considered and so on.

3. A Fuzzy SWOT Analysis

Whilst a list of strategies should be suggested based on the final position of a company in the SWOT matrix, the crisp division of two adjacent cells may be a methodological limitation. This can be especially problematic when most of the data collected during the scoring process are qualitative. For instance, assuming a company with a total external score of 1.5 and a total internal factor of 1.001, the company's position is then placed in cell #1 in **Figure 2** and therefore, growth strategies for adding new products would be proposed. In a very similar case, assuming the same external score of 1.5 but with an internal score of 0.999, the company's position would be placed in cell #2 and consequently, a different strategy such as keeping existing situation would be proposed.

Hence, in such cases, *two close internal or external scores can cause a major difference in the dictated*

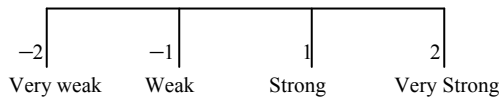

Figure 1. Scoring of the internal (or external) factors based on their importance.

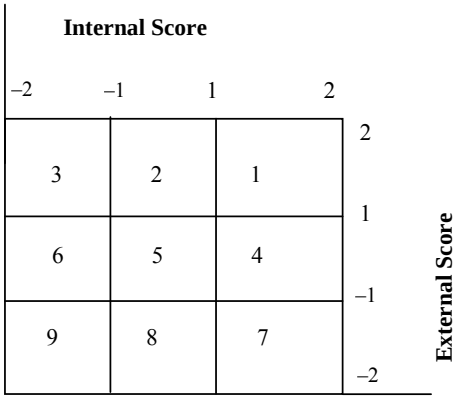

Figure 2. Matrix of internal and external scores.

strategies, while practically there are no large differences between the companies' ability and status with respect to the internal and external factor values (in the presence example, 0.999 vs. 1.001).

To overcome the above difficulty, a fuzzy scale (**Figure 3**) for scoring the internal and external factors may be considered and consequently, the evaluation matrix can compass fuzzy regions as shown in **Figure 4**. Using this fuzzy approach, the likelihood of a company's strategic point falling in a weak/medium or medium/strong state in the vicinity of two adjacent cells varies gradually (with a reasonable slope of the membership function). As a result, a sudden change from the weak to medium or from the medium to strong state is avoided. For example, recalling **Figure 4**, internal scores of 0.999 or 1.001 would both be considered within the intersection of the weak and medium states.

The following steps are proposed within the fuzzy SWOT framework:

1) Analyze the background data and define company's vision.

2) List the company's all external environment factors, including political, economical, social and technological factors. For each factor, its sub-factors/attributes can also be defined.

3) List the company's all internal environment factors, including those related to the marketing, functional sources, employee, general management, information and quality management. For each internal factor, its attributes can also be defined.

4) List the effective internal and external factors based on the company's main objectives and activities.

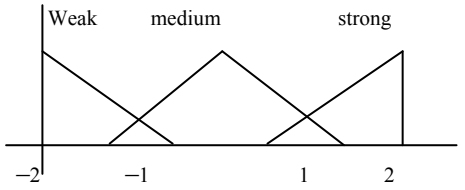

Figure 3. Triangular fuzzy numbers for scoring internal and external factors of the company.

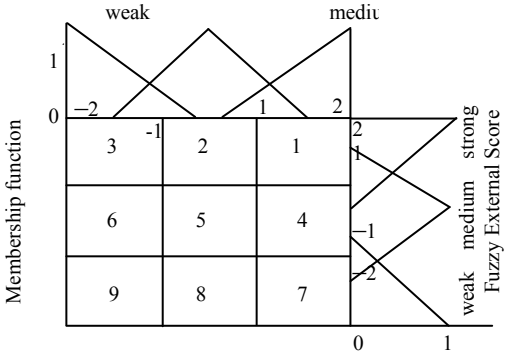

Figure 4. Fuzzy matrix of the internal and external factors.

5) Considering a factor (e.g., the *j*-th factor), define a triangular fuzzy number (A_{jk}, B_{jk}, C_{jk}) for each of its attribute values (e.g., the *k*-th attribute) based on a scale of −2 to +2, where −2: complete threat/weakness, −1: weak threat/weakness, + 1: weak opportunity/strength, + 2: complete opportunity/strength. B_{jk} is the most probable (average) value, A_{jk} is the minimum and C_{jk} is the maximum (note that $A_{jk} \le B_{jk} \le C_{jk}$). If *N* experts ($i = 1, \cdots, N$) are employed during data collection, each expert may define a fuzzy number such as $(A_{jk}^i, B_{jk}^i, C_{jk}^i)$. Averaging these fuzzy numbers for the *j*-th factor, *k*-th attribute gives [32]

$(A_{jk}, B_{jk}, C_{jk}) = \frac{1}{N}\left(\sum_{i=1}^{N} A_{jk}^i, \sum_{i=1}^{N} B_{jk}^i, \sum_{i=1}^{N} C_{jk}^i\right)$. The process can be repeated for all attributes of external and internal factors.

6) Define a weight, w_{jk}, for each attribute based on its influence on the company's activities and objectives by using a scale of 1 to 100 (subsequently the weights can be normalized to one). Weights may be found by brain storming among experts or by averaging individual weights from the experts.

7) Calculate an average fuzzy numbers C_j for each factor based on its attribute values and weights:

$$A_j = \sum_{k=1}^{n_j} w_{jk} A_{jk}\ ,\ B_j = \sum_{k=1}^{n_j} w_{jk} B_{jk}\ ,\ \ C_j = \sum_{k=1}^{n_j} w_{jk} C_{jk}\ ;$$

where n_j is the number of attributes for the *j*-th factor.

8) Calculate a total score of the internal factors (*FIF*) and a total score of the external factors (*FEF*) by summing the corresponding fuzzy scores (A_j, B_j, C_j) from the previous step. Note that *FIF* and *FEF* will also be fuzzy numbers.

9) Locate the company's position in a fuzzy SWOT matrix based on the *FIF* and *FEF* values. The located coordinates should indicate a fuzzy triangular region, instead of a single point that would normally be obtained using the conventional SWOT.

4. Case Study

Due to the confidentiality reasons, let us name the company under study 'KPPP'. KPPP carried out various national and international activities. The IT department of KPPP has the role of facilitating the technology integration and IT service development towards integrated solutions. This department manages KPPP's electronic services and internal information systems. In the beginning of 2011, KPPP made the decision that it should revisit its strategic planning for a better performance.

The company's vision during strategic planning is defined, e.g., based on a better control over its future, the

need for better circulation, environmental alterations, opportunities and threats and also cultural modifications. Considering the opportunity for a strategic evaluation of the company's production and service, the vision and objective of KPPP were defined as follows. "The company is capable of continuing the production and service with a high level of quality and quantity and with a stable progress, and it can aim at becoming the source of better services for other related industries. "

To apply the fuzzy SWOT method of Section III, data for both internal and external environmental factors were collected from a committee of 12 experts in the area. In doing so, the company's general background and its condition relative to the nation's activities were accounted for; e.g., the company's share in job security and employment.

1) All potential internal and external factors on KPPP's activities and aims were listed.

2) The effective factors were short-listed, regardless of their form of influence (positive or negative effect). It was recognized that an exact analysis of internal environment is essential in confronting weaknesses by utilizing strengths. Internal factors were classified into marketing, money, employees, general management, etc. The main external factors were grouped into political, social, economical, technological, etc. In total, 5 external and 7 internal factors were used (to be discussed for **Tables 3** & **4**).

3) The attributes of each factor in Step 2 were identified. For instance, for the 'Economical' factor (**Table 1**), attributes were chosen as: more predictable cash flow,

Table 1. Fuzzy external factors (sample data for the "Economical" factor).

fuzzy number			Priorities (weights)		Factor and its Attributes	
A_1^m	B_1^m	C_1^m	on scale of [1-100]	Normalized value		
1	1.2	1.5	65	0.030	More predictable cash flow	Economical
−1.6	−1.3	−1	80	0.035	Breakability to natural disaster	
0.1	0.2	0.4	77	0.034	Gaining financial knowledge	
0.2	0.5	1.1	80	0.035	Minimum salary	
−0.8	−0.4	−0.1	49	0.023	Rate of bank interest	
...	....	.....	....	....	....(total of 28 attributes)	

Table 2. Fuzzy internal factors (sample data for the "Employee" factor).

Factor conditions			Priorities		Factor and its Attributes	
Minimum amount	Most possible amount	Maximum amount	0-1	1-100		
0.2	0.3	0.6	0.067	81	Happy employees	Employee
−1.5	−1	−0.5	0.053	70	Employee union	
−1	−0.6	−0.2	0.068	83	Employee shortage	
1.1	1.2	1.5	0.066	80	Employee with high performance	
0	0.5	1	0.069	84	Low level of employee payment	
0	1	1.9	0.053	70	Skilled employee	
....	....	....	....	....	(total of 15 attributes)	

Table 3. Fuzzy external environmental factor analysis of KPPP.

Final Score (fuzzy average)			Number of factors	External Group Title	#
Minimum amount	Most possible amount	Maximum amount			
−0.0072	0.005	0.0213	24	Political	1
−0.0133	−0.0065	0.0075	28	Economical	2
−0.045	−0.027	0.0091	20	Social	3
−0.062	−0.025	0.002	12	Technological	4
0.103	−0.041	0.018	6	Others	5
−0.23	**−0.11**	**0.034**	90	***FEF***	

Table 4. Fuzzy internal environmental factor analysis of KPPP.

Final Score (fuzzy average)			Number of Attributes	Factor Group Title	#
Minimum amount	Most possible amount	Maximum amount			
−0.0745	−0.0451	−0.011	8	Marketing	1
−0.0638	−0.023	−0.0214	5	Money	2
−0.0061	0.02	0.063	11	Activities	3
−0.044	−0.0243	−0.0183	15	Employee	4
−0.0167	−0.0149	−0.0008	21	General management	5
−0.0362	−0.0173	−0.0016	10	Information	6
−0.0251	−0.0002	−0.0043	15	Quality management	7
−0.27	**−0.11**	**−0.018**	**85**	***FIF***	

breakability to natural disaster, gaining financial knowledge, minimum salary, and rate of bank interest.

4) Fuzzy numbers using the linguistic scale of **Figure 3** were assigned by each expert and an average score was found for each attribute of a factor as (A_{jk}, B_{jk}, C_{jk}). Sample results are included in **Tables 1** and **2** for the external 'Economical' and internal 'Employee' factors, respectively. The weight of each attribute within each factor category (e.g., political) was also determined contingent to its influence on the KPPP activities. A scale of 1 to 100 was used and the final weights were normalized.

1) The attribute scores within each factor group were averaged and a total score for the factor was calculated as (A_j, B_j, C_j); $j = 1, \cdots, 12$. Complete results are shown in **Tables 3** and **4**. For instance, the weighted average of attribute scores in Table 1 for the 'Economical' factor resulted in (−0.0133, −0.0065, 0.0075) as indicated in **Table 3.**

To locate the strategic position of KPPP in a SWOT matrix, the *FEF* and *FIF* values were calculated by summing the fuzzy number in **Tables 3** and **4**, respectively. It was found that *FEF*= (−0.23, −0.11, 0.034) and *FIF*= (−0.27, −0.11, 0.018). Consequently, the locations of the best, most probable, and worst strategic points were shown in **Figure 5**.

4.1. Determining a Distance between the Internal and External Factors - a Decision-Making Case:

Managers often intend to know which factors (external or internal) are more influential in their strategic decision making. The distance between the two fuzzy numbers of *FIF* (a_1, a_2, a_3) and *FEF* (b_1, b_2, b_3) can be calculated as:

$$d\left(FIF, FEF\right) = \frac{\left(a_1 + 2a_2 + a_3\right) - \left(b_1 + 2b_2 + b_3\right)}{4}$$

In the KPPP case this gives:

$$d\left(FIF, FEF\right) = \frac{\left[-0.27 + 2(-0.11) + 0.018\right] - \left[-0.23 + 2(-0.11) + 0.034\right]}{4} = -0.014$$

Considering a negative distance (*FIF-FEF<0*), it could be recommended that the total effect of the internal (strengths/ weaknesses) factors is greater than the total effect of the external (opportunities/threats) factors and therefore, more focus should be made on reducing the company's weaknesses and strengthening its strengths.

Finally, of the three strategic points in the Fuzzy SWOT matrix in **Figure 5**, two points have been located in the threatening area; *i.e.*, emphasizing sizable external threats and internal weaknesses of KPPP. Therefore, close attention should be paid to the external threats and internal weaknesses in making strategies for this company. The only point located in the desirable area with positive factor values is point 1 (with the least possible external threats and internal weaknesses). Nevertheless, considering the minimum likelihood of this point, no strategy would be taken up on point 1. In fact, only a small area portion (< 25%) of the overall triangle has fallen in the positive region. Both points 2 and 3 belong to a strategic cell with a score between 0 and −1 (medium-to-week).

5. Conclusions

Internal strengths and weaknesses are vital for strategic planning of companies to cope with the external threats and benefit from the external opportunities. One of the potential shortcomings of the conventional SWOT matrix was shown and a simple fuzzy SWOT approach was suggested to overcome the problem. The method was exemplified using a case study in the KPPP company. It was shown that the current strategic position of the KPPP company is identifiable as a three-point region by means

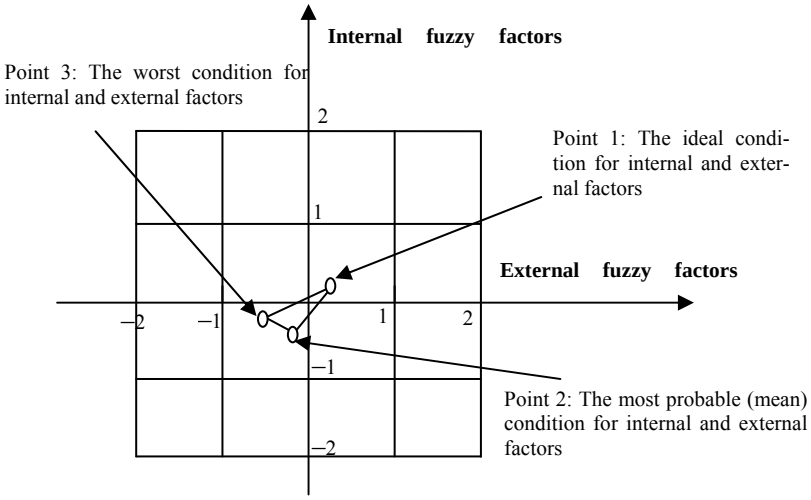

Figure 5. Strategic position of KPPP in the fuzzy SWOT matrix.

of the coordinates of *FIF* and *FEF* fuzzy numbers. In particular, the position of the ideal point with the least possible external threats and the least possible internal weaknesses, or the most external opportunities and the most internal strengths was revealed. Similarly, strategic points corresponding to the most probable (mean) and the worst condition were located. Eventually, based on the general position of the strategic triangle (relative position of the three points), a realistic strategy can be chosen. In the conventional SWOT analysis, only one point is identifiable and it may cause a decision ambiguity, specially in the vicinity of adjacent cells in the SOWT matrix. Further research is worthwhile to extend the fuzzy approach to more complex strategic planning models (e.g., TOWS [33]) where interactions among decision factors may also be included.

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