

## Using Fuzzy TOPSIS to Determine Strategy Priorities by SWOT Analysis

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**Abstract.** Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis does not provide an analytical means to determine the importance of the identified factors or the ability to assess decision alternatives according to these factors. In this paper, we use TOPSIS method to determine strategies priority as a novel innovation. Strengths and opportunities are considered as positive criteria and weaknesses and threats are considered as negative criteria in TOPSIS method. In addition, in order to deal with uncertainty and vagueness of human mind, we incorporate fuzzy logic in the proposed method. Then strategies are prioritized based on the TOPSIS method.

**Keywords:** SWOT analysis, TOPSIS, Fuzzy logic, Strategy analysis.

### 1. Introduction

Determining strategy is one of the most important activities to ensure the survival of an organization in current competitive market. Strengths, weaknesses, opportunities and threats (SWOT) analysis is a useful tool for the planning development and decision making and has widely been applied as a means to systematically analyze an organization's internal and external environments management (Yuksel and Dagdeviren, 2007; Diamantopoulou and Voudouris, 2008). When used properly, SWOT can provide a good basis for strategy formulation. Strengths and weaknesses constitute factors within the system that enable and hinder the organization from achieving its goal, respectively. Opportunities and threats are considered as exogenous factors that facilitate and limit the organization in attaining its goals, respectively (Tahernejad et al. 2011). A variation of SWOT analysis is the TOWS matrix. In the TOWS matrix the various factors are identified and these are then paired e.g. an opportunity with a strength, with the intention of stimulating a new strategic initiative (Dyson, 2004).

Although SWOT analysis is not without deficiencies and weaknesses, literature review shows its extensive use in different cases. Tahernejad et al. (2011) used SWOT-AHP (Analytic hierarchy process) approach to define dimensional stone mines decision process in a hierarchical structure of factors. He then quantified the relative importance of each factor to the decision and determined the priorities of the strategies for these mines. Lee et al. (2009) utilized quantitative SWOT analytical method to locate the competitive relation of global logistics hub. Yuksel and Dagdeviren (2007) performed SWOT analysis using the analytical network process (ANP) to determine the most suitable strategies for a textile firm. Kurtilla et al. (2000) utilized AHP in SWOT analysis to a forest certification case.

In this paper, TOPSIS method is used to determine strategies priority as a novel innovation. Strengths and opportunities are considered as positive criteria and weaknesses and threats are considered as negative criteria in TOPSIS method. In addition, in order to deal with uncertainty and vagueness of human mind, we

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incorporate fuzzy logic in the proposed method. Using the case study from the research paper of Yuksel and Dagdeviren (2007) efficiency and usefulness of a proposed method is surveyed.

## 2. Fuzzy Set Theory

Fuzzy sets are sets whose elements have degrees of membership. Fuzzy sets have been introduced by Zadeh(1965) as an extension of the classical notion of set. A fuzzy set is an extension of a crisp set. Crisp sets only allow full membership or non-membership, whereas fuzzy sets allow partial memberships (Torlak et al., 2010).

Among various shapes of fuzzy numbers, we use triangular fuzzy number (TFN), because of its simplicity and popularity. Triangular fuzzy numbers can be defined as a triplet (a, b, c) where the parameters of a, b, and c, respectively indicate the smallest possible value, the most promising value, and the largest possible value that describe a fuzzy event. If we consider two fuzzy numbers, A (a<sub>1</sub>, b<sub>1</sub>, c<sub>1</sub>) and B (a<sub>2</sub>, b<sub>2</sub>, c<sub>2</sub>), important operations used in this study are as below:

$$(a_1, b_1, c_1) \pm (a_2, b_2, c_2) = (a_1 \pm a_2, b_1 \pm b_2, c_1 \pm c_2) \quad (1)$$

$$(a_1, b_1, c_1) \times (a_2, b_2, c_2) = (a_1 \times a_2, b_1 \times b_2, c_1 \times c_2) \quad (2)$$

## 3. TOPSIS

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution), proposed by Hwang and Yoon (1981). The basic principle of TOPSIS is that, chosen alternatives should have the shortest distance from the ideal solution and the farthest distance from the negative-ideal solution. FTOPSIS is TOPSIS extended to fuzzy environment. According to Shih et al. (2007), some advantages of TOPSIS are as follows:

- A sound logic that embodies the rational of human choice,
- A simple computation process that can be easily programmed into a spreadsheet,
- A scalar value that accounts for both the best and worst alternative at the same time.

To deal with the supplier selection problems, according to Chen et al. (2006), FTOPSIS can be outlined as following steps:

Step1: Choose appropriate linguistic variables for the importance weight of criteria and linguistic ratings for suppliers.

Step2: Aggregate the weight of criteria to get aggregated fuzzy weight  $\tilde{W}_{ij}$  of criterion  $C_j$ , and pool DMs' ratings to get aggregated fuzzy rating  $\tilde{x}_{ij}$  of alternative  $A_i$  under criterion  $C_j$ .

Step4: Construct fuzzy-decision matrix and normalized fuzzy-decision matrix.

Step5: Construct weighted normalized fuzzy decision matrix.

Step6: Determine fuzzy positive ideal solution (FPIS) and fuzzy negative ideal solution (FNIS).

Step7: Calculate the distance of each alternative from FPIS and FNIS, respectively.

Step8: Calculate closeness coefficient of each supplier.

Step9: According to the closeness coefficient, we can understand the assessment status of each alternative and determine the ranking order of them.

## 4. Methodology

This section presents an illustration of the proposed approach summarized in the previous section. In order to test the proposed method, we make use of case study from Yuksel and Dagdeviren (2007) to show efficiency of our proposed method. Table 1 shows the internal and external factors and alternative strategies based on the sub-factors. It can be seen from Table 1 that the organization has four alternative strategies. The strategy identified as SO concerns making good use of opportunities by using the existing strengths of the organization. The WO strategy seeks to gain benefit from the opportunities appeared by the external environmental factors by taking into account the weaknesses of the organization. Similarly, ST is the strategy related to the organization's strengths to remove or reduce the effects of threats. The fourth and last strategy is WT, in which the organization aims to reduce the effects of its threats by taking its weaknesses into

account. The aim of this study is to prioritize strategies by using fuzzy TOPSIS method. Positive and negative criteria are determinant in deciding about final ranking or priority of alternatives. In this method, strengths and opportunities are considered as positive criteria and weaknesses and threats are considered as negative criteria. It is important to note that we use the same weight for criteria as used in the work of Yuksel and Dagdeviren (2007).

Step 1: In order to construct decision matrix, a linguistic scale should be defined. Each strategy is evaluated by the triangular numbers according to the linguistic scale. Fig. 1. Shows the linguistic scale used to evaluate alternative strategies.

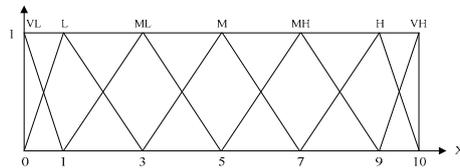


Fig. 1. A linguistic scale

Table 1: SWOT matrix (Yuksel and Dagdeviren, 2007)

External factors	Internal factors	
	<b>Strengths (S)</b>	<b>Weaknesses (W)</b>
	– Intellectual capital (S1)	– Weak image of Turkish products (W1)
	– Expert management staff (S2)	– Energy costs (W2)
	– Technically qualified workforce (S3)	– Distance to market (W3)
	– Quality of the product (S4)	
<b>Opportunities (O)</b>		
– Liberalization of Turkey (O1)	SO Strategy	WO Strategy
– New foreign markets (O2)		
– Investment incentives (O3)	Working with strong suppliers	Making joint investments with EU suppliers
<b>Threats (T)</b>		
– Threat of China (T1)	ST Strategy	WT Strategy
– Too high value of YTL (T2)		
– Economic and political uncertainty in Turkey (T3)	Investing in former east-bloc countries	Subcontracting
– Current and possible problems in Middle East (T4)		

Step 2: Decision makers use Delphi method to reach consensus for evaluation of strategies with linguistic scale. Table 2 shows the decision matrix. Table 3 shows the importance weight of criteria based on the work of (Yuksel and Dagdeviren, 2007).

Step 3: using fuzzy TOPSIS method, closeness coefficient is calculated for each strategy and priority of each strategy is determined. The closeness coefficient is between 0 and 1. The largest the  $CC_i$  is, the better the alternative  $A_i$  is. Results are shown in Table 3. According to the computations, the priority of strategies are WT, ST, SO and WO respectively.

Table 2: rating of strategies based on SWOT analysis

Strategies	Strength				Opportunity			Weakness			Threat			
	S1	S2	S3	S4	O1	O2	O3	W1	W2	W3	T1	T2	T3	T4
SO	MH	ML	M	H	L	ML	MH	VH	MH	ML	VL	H	M	MH
ST	H	M	L	L	H	ML	H	M	M	VH	MH	M	MH	L
WO	L	VL	M	H	VH	H	ML	H	L	MH	ML	ML	L	M
WT	H	H	VH	VH	MH	MH	ML	H	VH	H	M	VL	M	H

	Strength				Opportunity			Weakness			Threat			
	S1	S2	S3	S4	O1	O2	O3	W1	W2	W3	T1	T2	T3	T4
Importance weight	0.196	0.143	0.047	0.086	0.041	0.016	0.176	0.102	0.039	0.022	0.034	0.02	0.055	0.013

Table 3: computations of  $CC_i$

Strategy	$CC_i$	Priority
SO	0.489	3
ST	0.552	2
WO	0.368	4
WT	0.595	1

## 5. Discussion

In this study, a common strategic planning tool, SWOT, was used. The objective of this paper was to present that SWOT can be used more effectively. This was done by linking SWOT with TOPSIS method. SWOT can benefit from advantages of TOPSIS. In TOPSIS, scalar values account for both the best and the worst alternative simultaneously. Therefore, it can be fitted with SWOT. Strengths and opportunities are considered as positive and weaknesses and threats are considered as negative. TOPSIS provides quantitative priorities to be used in decision support. It does not, however, include statistical assessment of the uncertainty of the results. By incorporating fuzzy logic, this deficiency can be minimized. Using case study from research of Yuksel and Dagdeviren (2007), the proposed method determined the priority of strategies. As we see, subcontracting is the most important strategy for the current situation with these criteria. In order to avoid complexity in organizations, subcontracting is crucial in many aspects. Investing in former east-bloc countries has the second priority. Globalization necessitates constructing relationship with others. Working with strong supplier is also important issue that has third priority in our proposed approach. Partner selection is very important in constructing a powerful supply chain. Select the right partner to make strategic and long term relationship is important. Making joint investments with EU suppliers is the last important strategy in this study. Sharing resources and benefit is another issue that recently attracted attentions.

As we see, all strategies are important and deal with different aspects of an organization, but by proposed method, considering the priorities of these strategies will ensure the successfulness of an organization. Given these priorities, managers will be confident of the appropriateness of the strategy being used.

## 6. Conclusion

In SWOT analysis, strategic alternatives are selected in the light of the strengths, weaknesses, threats and opportunities of the organization as determined through internal and external environment analysis. The objective of this study was to present an application where some of these weaknesses can be avoided, and thereby SWOT can be used more effectively. This was done by linking SWOT with a decision analysis method (TOPSIS). Fuzzy logic is also used to deal with uncertainty and vagueness of human mind. The factors from the SWOT analysis and the alternative strategies based on these factors were transformed into TOPSIS model.

Result is the priority of strategies according to the SWOT factors. The main characteristics and innovations of the proposed model can be listed as below:

- Proposing a method that consider positive and negative criteria to determine strategies priority based on SWOT,
- Taking into account the internal and external factors,
- Applying fuzzy logic to deal with uncertainty of human's opinions.

Further research may seek to incorporate ANP to determine weight of SWOT factors with fuzzy numbers. Also, instead of using fuzzy logic in constructing decision matrix, AHP method can be utilized to evaluate strategies based on these factors via pairwise comparison. Comparative research with other works that used AHP or ANP with SWOT will be useful to explore the validity of proposed method.

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