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An improved SWOT evidential reasoning based approach for strategy evaluation under uncertainty

K. Ramooshjan, M. A. Sobhanallahi and Alireza Arshadi Khamseh*

Department of Industrial Engineering, Kharazmi University, Karaj, Iran

C H R O N I C L E

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A B S T R A C T

Formulation and evaluation of strategy play important role in the strategy management. Strength, Weakness, Opportunity and Threats (SWOT) is a famous approach to formulate strategy planning, which relies on external and internal factors. Identifying these factors precisely is very critical for any organization and manager. This study aims at providing a quantitative basis to analytically determine the ranking of the factors in SWOT analysis via Evidential Reasoning (ER) approach. This paper applies SWOT and Richard Rumelt's criteria to evaluate strategies in Evidential Reasoning approach. The ER approach has been developed to support MADA under uncertainty. It is based on Dempster's rule for evidence combination and uses belief functions for dealing with probabilistic uncertainty and ignorance. This research is the first study in the ranking the factors of SWOT and Richard Rumelt approach. An illustrative example is also presented to show the efficiency of our model.

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1. Introduction

There are some approaches to formulate strategies such as the Strength, Weakness, Opportunity and Threats (SWOT) matrix, the SPACE matrix, the BCG matrix, the IE matrix, and the Grand strategy matrix. Matching external and internal criteria factor is the key to effective strategy and SWOT depends on external and internal critical factors, which is the most well-known approach to formulate most strategies. The factors of SWOT consists of opportunity, threats, weaknesses and strength based on four types of strategies, strength-opportunity (SO), weakness-opportunity (WO), strength-threats (ST) and weakness-threats (WT). Electing critical factors and matching key external and internal factors and matching key external and internal factors are the most difficult parts of developing a SWOT matrix. Intuitive judgment is generally used in this important function. This approach requires good judgment and there may be some errors to match the factors and to formulate the strategy. Recently, quantitative approaches are used to decrease the errors and obtain approximately more precise results.

* Corresponding author.
E-mail addresses: alireza.arshadikhamseh@gmail.com (A. Arshadi Khamseh)

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Kurttila et al. (2000) used analytical hierarchy process (AHP) to formulate SWOT strategies. Chang and Huang (2006) used multiple attribute decision marking in SWOT. In another case study, Yüksel and Dagdeviren (2007) used ANP algorithm to formulate SWOT matrix as well as to assess strategy. Lee and Walsh (2011) presented an application of SWOT and AHP hybrid model to support marketing outsourcing, using a case of intercollegiate sport. However, many complex multiple attribute decision analysis problems involve both quantitative and qualitative information with various types of uncertainties such as local and global ignorance (incomplete or no information) and fuzziness (vague information). Fuzzy logic based approaches have been extensively used to consider vagueness and ambiguity but it cannot deal with uncertainties such as incomplete, imprecise and missing information (Chin et al.,2009). These complex problems can be consistently modeled using the Evidential Reasoning (ER) approach (Yang and Xu, 2002, Wang et al., 2006; Xu et al., 2006).

Also, in a newly study Massahi et al. (2012) implemented an ER and AHP to selected the most appropriate location for a bank branch. In conventional methods, a MADA problem is modeled using a decision matrix in which the related criteria are assessed at each alternative decision by using single value or assessment grades and their associated degrees of belief. In addition conventional methods provide a novel way to model MADA problems and the same framework (Chin et al., 2009). The main objective of this paper is to present a new decision making model for selecting the most important strategy on SWOT matrix. We form formulate SWOT matrix based on the organization's internal and external factors and develop the requisite strategies. Then, by taking advantage of evidential reasoning approach, we rank those strategies in the order based on factors of Rumelt criteria (Rumelt, 1998).

The rest of the paper is organized as follow: in section 2 the processes of strategic management will be explained. Section 3 presents the necessity, modeling and procedure of ER. Section 4 illustrates a numerical example. Finally, the characteristics and limitations of the proposed method are discussed in section 5.

2. Strategic management

Strategic management is the art and science of formulating, implementing and evaluating cross-functional decisions that enable organization to achieve its objectives (David, 1995). This management concentrates on integrating management, marketing, finance/accounting, production/operation, research and development and information systems through appropriate strategies to achieve organizational long-term objectives. The strategic management process consists of strategy formulation, strategy implementation and strategy evaluation. Formulation process includes developing mission, identifying external factors (opportunities and threats) determining internal factors (strengths and weaknesses), collecting and evaluating information on competitors, establishing long term objectives, generating strategies and choosing feasible strategies, based on situation and sources of organization. SWOT is a tool that helps managers develop four types of strategies including SO, WO, ST and WT. Matching key factors (external, internal) is the most important part of developing a SWOT matrix. Therefore, formulating appropriate strategies requires good judgment criteria for appropriate strategies. It is not possible to show that a particular strategy is the best one and it will work ideally. Rumelt (1998) offers four criteria that can be useful to evaluate a strategy. These criteria are as follows:

1. Consistency: the goals and policies of organization must be consistent. All departments should work together to achieve the organization’s objectives. The success for one department should not be the failure mean for another department.
2. Consonance: an appropriate strategy must represent an adaptive response to the external environment and to the critical changes occurring within it.

3. Feasibility: the strategy must be able to work within the physical, human and financial resources of the enterprise.
4. Advantage: one of the criteria for success of a strategy is to create or to maintain a competitive advantage in a selected area of activity.

In this paper ER algorithm has been used to determine the most important factors in order to formulate SWOT matrix which are based on Rumelt criteria and can be applied by almost all organizations.

3. ER algorithm

The evidential reasoning approach has recently been developed on the basis of decision theory in particular utility theory (Keeney & Raiffa, 1976) artificial intelligence in particular the theory of evidence (Shafer, 1976), statistical analysis and computer technology. It uses a belief structure to model an assessment with uncertainly, evidential reasoning algorithm (Yang & Xu, 2002) to aggregate criteria for generation distributed assessment, and the concepts of the belief and plausibility function to generate a utility interval for measuring the degree of ignorance. A conventional decision matrix used for modeling an MCDA problem is a special case of a belief decision matrix (Xu et al., 2006). The use of belief decision matrices for MCDA problem modeling in the ER approach results in the following features:

- An assessment of an option can be more reliably and realistically represented by a belief decision matrix than by a conventional decision matrix.
- It accepts data of different formats with various types of uncertainties such as inputs, single numerical values, probability distribution, and subjective judgment with belief degrees.
- It allows all available information embedded in different data formats, including qualitative and incomplete data, to be maximally incorporated in assessment and decision making processes.
- It allows assessment outcomes to be represented more informatively.

The ER approach is implemented in a software tool called intelligent Decision System.

3.1 Identification of ER evaluation criteria

Let L experts are selected to diagnosis the importance of criteria. Each expert is associated with a relative weight $\lambda_l > 0$ $(l = 1, \dots, L)$; $\sum_{l=1}^{L} \lambda_l = 1$. Let $CR_1 \sim CR_m$ are the m evaluation criteria, which are selected and analyzed by experts to identify their weights.

3.2 Identification of the weights using initiation judgment

The possible rating scale is defined based on Table 1 but other rating scale can also be defined. Our intention is not to explore which rating scale is the best or more appropriate for a specific situation, which is beyond the scope of this paper. In term of the defined rating scale, experts can explain their opinions: sometimes they may have incomplete ideas or have no ideas. For example expert CR_1 may assess a criteria to be of very important degree of 60% and moderately important to the degree of 40%. This assessment can be modeled as {(7,60%),(5,40%)}, the total degree belief must be 100%. If an expert rate the importance of criteria between very important and extremely important by belief degree of 20% and moderately important by belief degree of 70% such an assessment can be modeled as {(7-9,20%),(5,70%)}, which leads to a total belief degree of 90%. If the total belief degree of an assessment is less than 100%, the assessment is said to be incomplete; otherwise it is said to be complete. Note that the total belief degree cannot be more than 100% or the assessment makes no sense. For an incomplete assessment, the remains don’t assign any rating but it could be assigned to any single evidence (Shafer 1979). Therefore, the remaining belief degree could be assigned to any of the rating scale 0-9. If an expert J^{th} criterion such as assessment is to be called ignorance it can be characterized by {(0-9,100%)}. For example, the above three beliefs can be characterized by expected scores in the following way:

{(7, 60%),(5, 40%)}→7×60%+5×40%=6.2

{(7-9, 20%),(5, 70%)}→[7-9]×20%+5×70%+[0-9]×10% = 4.9-6.2 {(0-9,100%)} → [0-9]×100% = 0-9

If $E(S_i^l)$ be the expected score obtained from the belief structure of expert l in assessing the relative importance of criteria C_i, the total expected score from the relative importance of C_i can be expressed as the weighted sum of the expected scores of the L experts. That is

$$\mathrm{E}(S_i)=\sum_{l=1}^{L}\lambda_l E(S_i^l) \quad i=1,\dots,m \tag{1}$$

where λ_l is the relative weight of expert l. Based on EQ. (1), the relative importance of CR_i can be defined as

$$\omega_i=\frac{E(S_i)}{\sum_{k=1}^{m}E(S_k)},\quad i=1,\dots,m \tag{2}$$

In the case that some $\mathrm{E}(S_i)$ is interval, w_i $(i=1,\dots,m)$ will be normalized interval satisfying $\sum_{i=1}^{m}w_i=1$.

Table 1
Rating scales for relative importance, relationship and assessment

Rating	Definition for		
	Relative importance	Relationship matrix	Interrelationship matrix
9	Extremely important	Very strong relationship	Very strong positive correlation
7	Very important	Strong relationship	Strong positive correlation
5	Moderately important	Moderate relationship	Moderate positive correlation
3	Weakly important	Weak relationship	Weakly positive correlation
1	Very weakly important	Very weak relationship	Very weakly positive correlation
0	Not important	No relationship	No correlation

3.3 The relationship matrix between Rumelt criteria and strategies of SWOT

The relationship matrix between Rumlet criteria (David, 1999) and strategies of SWOT reflects the results of the fulfillment of Rumlet criteria in strategic of SWOT. This matrix helps experts assess the relationship to express their opinions, such pattern as 1-3 or 1-5-9 may be used to denote weak medium and strong relationship between Rumlet criteria and strategic of SWOT. In this paper, rating scale 0-9 is defined to characterize different strength of the relationship between Rumlet criteria and strategies of SWOT shown in the third column of Table 1. In the ER algorithm each member of the team explains opinion with belief structure freely and independently. Each belief structure may be complete or incomplete, precise or imprecise. Suppose there are M assessment team members and each of them is assigned a weight $\theta_k>0$ such that $\sum_{k=1}^{M}\theta_k=1$. Let $\{(H_{ij},\beta_{ij}^k),p1,\dots,N,q=i,\dots,N\}$ be the belief structure provided by team member K on the assessment of relationshipH_{ij} where H_{pp} for p=0 to N and the crisp rating defined for relationship assessment, H_{pq} for $p=0$ to N and $q=p+1$ to N are intervals between H_{pp} and H_{qq}, and β_{ij}^k are the belief degrees to which the relationship V_{ij} is assessed to interval rating H_{pq}. For the rating scale 0–9 defined in Table 1, we have six crisp ratings inclusive of zero, which are 0, 1, 3, 5, 7, 9, and fifteen possible intervals that are 0–1, 0–3, 0–5, 0–7, 0–9, 1–3, 1–5, 1–7, 1–9, 3–5, 3–7, 3–9, 5–7,5–9 and 7-9. Therefore, we have N= 5.

$$H=\left\{\begin{matrix} H_{00} & H_{01} & H_{02} & H_{03} & H_{04} & H_{05} \\ & H_{11} & H_{12} & H_{13} & H_{14} & H_{15} \\ & & H_{22} & H_{23} & H_{24} & H_{25} \\ & & & H_{33} & H_{34} & H_{35} \\ & & & & H_{44} & H_{45} \\ & & & & & H_{55} \end{matrix}\right\}=\left\{\begin{matrix} 0 & 0-1 & 0-3 & 0-5 & 0-7 & 0-9 \\ & 1 & 1-3 & 1-5 & 1-7 & 1-9 \\ & & 3 & 3-5 & 3-7 & 3-9 \\ & & & 5 & 5-7 & 5-9 \\ & & & & 7 & 7-9 \\ & & & & & 9 \end{matrix}\right\} \quad (3)$$

where H constitutes a frame of discernment in the terminology of the theory of evidence. The collective assessment of the M team members for each relationship is also a belief structure, which is denoted $\{(H_{ij}, \beta_{ij}^{k}), p1, \ldots, N, q = i, \ldots, N\}$ and determinate by

$$\beta_{pq} = \sum_{l=1}^{M} \theta_l \beta_{pq}^{(l)}\ ,\ \ p = 0, \ldots, N\ ; q = p, \ldots, N \quad (4)$$

3.4 Aggregating the belief relationship matrix using interval ER algorithm

ER algorithm provides a systematic yet rigorous way of aggregating the relationships between WHATs and HOWs. The aggregation is based on the belief relationship matrix and the combination rule of the Dempster–Shafer theory of evidence (Shafer, 1976). Various ER algorithms have been developed to handle different types of belief structures and to provide flexibility for their aggregation. If the belief structure aggregated contains no interval ratings, or$\alpha_{lp}^{(k)} = 0\ for\ p \neq q$, then a recursive or analytical ER algorithm can be adopted (Wang et al., 2006b; Yang, 2001; Yang & Xu, 2002). In this paper, the interval ER algorithm (Xu et al., 2006) will be employed to aggregate the belief relationship matrix because the belief structures in the matrix may contain interval ratings such as 7–9, 5–7, 0–9 and so on. The interval ER algorithm includes the original recursive ER algorithm as a case and is also carried out recursively. Let $V_{p_1 q} = \{(H_{ij}, \beta_{ij,p_1 q}), i = 1, \ldots, N; j = i, \ldots, N\}$ and $V_{p_2 q} = \{(H_{ij}, \beta_{ij,p_1 q}), i = 1, \ldots, N; j = i, \ldots, N\}$ be two belief structure which characterize the relationship between the Rumlet criteria and strategic of SWOT, C_1 and C_2 and S_1(Strategy No. 1), respectively and w_{i_1} and w_{i_2} be the normalized weights for C_1 and C_2. The interval ER algorithm first transforms the belief structures into basic probability masses by considering their weights and using the following equations below:

$$m_{pq} = w_{i_1} \beta_{pq}(R_{i_1 j}), p = 0, \ldots, N; q = p, \ldots, N \quad (5)$$

$$m_H = 1 - \sum_{p=0}^{N} \sum_{q=p}^{N} w_{i_1} \beta_{pq}(R_{i_1 j}) = 1 - w_{i_1} \quad (6)$$

$$n_{pq} = \beta_{pq}(R_{i_2 j}), \quad p = 0, \ldots, N; q = p, \ldots, N \quad (7)$$

$$n_H = 1 - \sum_{p=0}^{N} \sum_{q=p}^{N} w_{i_2} \beta_{pq}(R_{i_2 j}) \qquad = 1 - w_{i_2} \quad (9)$$

The above probability masses are viewed as two pieces of evidence and combined to produce a set of joint probability masses:c_{ij} (p=1,…,N ; q=p,…,N) and c_H which are computed by the following equations:

$$C_{pq} = \frac{1}{1-K}[\sum_{s=0}^{p}\sum_{t=q}^{N}(m_{st}n_{pq} + m_{pq}n_{st}) + \sum_{s=0}^{p}\sum_{t=q}^{N}(m_{st}n_{pq} + m_{pq}n_{st})] + \frac{1}{1-K}\left[m_H n_{pq} + m_{pq}n_H - m_{pq}n_{pq}\right] \quad (10)$$

$$C_H = \frac{m_H n_H}{1-K} \quad (11)$$

$$K = \sum_{p=0}^{N}\sum_{q=p}^{N}\sum_{s=0}^{p-1}\sum_{t=s}^{p-1}(m_{st}n_{pq} + m_{pq}n_{st}), \quad (12)$$

Let x_{ij} (p=1,…,N ; q=p,…,N) and x_{ij} be the final combined probability masses, then the overall assessment for S_i will be $\{(H_{ij}, \delta_{ij}), i = 0,...,N; j = i,...,N\}$ which is an aggregated belief structure and δ_{ij} is determined by

$$\delta_{pq} = \frac{x_{pq}}{1-x_H}, p = 0, \dots, N; q = p, \dots, N \quad (13)$$

Overall assessment can finally be characterized by an expected interval as follows,

$$E(DR_j) = \sum_{p=0}^{N}\sum_{q=p}^{N}\delta_{pq}H_{pq} = \left[\sum_{p=0}^{N}\sum_{q=p}^{N}\delta_{pq}H_p, \sum_{p=0}^{N}\sum_{q=p}^{N}\delta_{pq}H_q\right], \quad (14)$$

where Eq. (14) represents the interval rating $[E_j^L, E_j^U]$ of the important strategic of S_i. Other design requirements can be rated in the same way.

3.5 Optimizing the technical importance ratings of SWOT strategies

The Interval ER algorithm requires the weight of SWOT strategic to be precise and normalized, which means $\sum_{i=1}^{m} w_i = 1$ with $w_i > 0$ $(i = 1, \dots, N)$. In this case, the technical importance ratings of the Rumlet criteria can be directly determined by Eq. (14). However, if the weights of strategies cannot be precisely determined by the selected experts, they will be imprecise and uncertain. If one or more experts provide an incomplete assessment or interval belief structure, then the final weights will be intervals determined by Eq. (1) and Eq. (2). In this case, the technical importance ratings cannot be uniquely determined by Eq. (14) since precise weights are not known. They have to be optimized by solving the following pair of preference programming models:

$$\min \quad E_j^L = \sum_{p=0}^{N}\sum_{q=p}^{N}\delta_{pq}H_p \quad (15)$$

subject to

$$w_i^L \le w_i \le w_i^U, i = 1, \dots, m, \sum_{i=1}^{m} w_i = 1,$$

$$\min \quad E_j^U = \sum_{p=0}^{N}\sum_{q=p}^{N}\delta_{pq}H_q \quad (16)$$

subject to

$$w_i^L \le w_i \le w_i^U, i = 1, \dots, m, \sum_{i=1}^{m} w_i = 1,$$

Here δ_{ij} is determined by Eq. (13) is a function of $w_1, \dots, w_m$. To solve the models δ_{ij} needs to be written out, recursively. If the interval ER algorithm discussed above is implemented on Microsoft Excel worksheets, then the above pair of models can be solved on the same worksheet by Excel Solver without the need to write the expressions of δ_{ij} separately. By solving the above pair of models for each strategy, the technical importance ratings for all the design requirements can be generated.

3.6 Normalization and prioritization

The technical importance ratings determined are usually intervals due to the presence of uncertainty in initiative judgments, which are non-normalized and they can be normalized by Eq. (17),

$$N(\sup_j)\frac{E(\sup_j)}{\sum_{i=1}^{n} E(\sup_i)} = \left[\frac{\left(E(\sup_j)\right)^L}{\left(E(\sup_j)\right)^L + \sum_{i\neq j}\left(E(\sup_i)\right)^U}, \frac{\left(E(\sup_j)\right)^U}{\left(E(\sup_j)\right)^U + \sum_{i\neq j}\left(E(\sup_i)\right)^L}\right], \quad j = 1,\dots,N \tag{17}$$

Here $\left(E(\sup_j)\right)^L$ and $\left(E(\sup_j)\right)^U$ are the lower and upper bound. The normalized technical importance ratings can then be utilized to determine the priority of each strategic of SWOT. To prioritize the strategies one way is to compare the average value (i.e. midpoint value) of each interval rating to generate an average ranking order with a degree of preference indicating the extent to which one interval rating is on average preferred to another, though in general this does not provide an absolute ranking order for the strategic of SWOT. The degree of preference is calculated using the following equation below developed by Wang et al. (2005)

$$p(S_i > S_j) = \frac{\max(0, a_{i2} - a_{1j}) - \max(0, a_{1i} - a_{2j})}{(a_{2i} - a_{1i}) - (a_{2j} - a_{1j})} \quad (i, j = 1, \dots, m) \tag{18}$$

The (a_{1i}, a_{2i}) and (a_{1j}, a_{2j}) are positive interval numbers for strategies S_i and S_j, respectively.

4 An illustrative example

Suppose that internal and external factors for the hypothetical organization are defined in Table 2.

Table 2
The internal and external factors of a hypothetical organization

Internal factors	Financial	Cost control-overhead cost- capital productivity- capital cost in comparing whit competitors
	Operational	Productive- process control-technology level- capacity, automation
	marketing	Marketing system- organizing- social and customer trust- market share-packaging-efficiency of distribution system
	Human resource	Wage system- Education, experience and skill of labor-
	Management system	Responsibility for environmental change- influence power personal moral
	R & D	Facilities –access to updated-information- number and level of satisfaction
	IT	Efficiency of MIS- ERP system
External factors	Economic factors	GNP-Unemployment- tax-price change-trend of capital market-labor productivity- labor productivity-
	Social/cultural factors	Young population-education-labor combustion-
	State / political / legal factors	Labor law-international relationship- currency market-control of population regulation-oil industry regulative
	Technology factors	E-commerce-IT-ICT-E-learning-hardware product
	Environment factors	Waste management-green product-corrective active

Now let figure be the SWOT matrix for the hypothetical organization according to its strengths, weaknesses, threats and opportunities. Suppose five experts M_1 to M_5 unit weights like $\lambda_1$to λ_5 so that $\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \ \lambda_5 = 1.5$, To evaluate strategies we measure four Rumlet criteria (coordination, compatibility, conceivability and competitive advantage) in management strategic (the evaluation of Business strategy 1980) shown CR_i. This criteria are very important for the manager and strategies which are evaluated (Kawi-Sang Chin et.al 2009) with this factor. Each of external audit, which has special weight as TM_i has been shown in Table 6. Based internal and external factors these possible strategies have been identification and are shown as $S_i(i = 1,2,..)$ in Table 2.

Table 3
SWOT Matrix

	O	T
	1-young populate 2-the level of education 3-good relationship with neighbors 4-E-commerce extenuation 5-IT growth	1-tax low 2-inflation rate 3-price change 4-economic boycotting 5-currency change 6-technological change
S	SO	ST
1-high product tech 2-high product capacity 3-high market share 4- social and costumer trust 5-high quality of product 6-influncing on decision market 7-productive of new goods	1-feasibility study of export to developing countries	1-automative and using high tech to increase export power
W	WO	WT
1-weak control of cost 2-low productivity 3-lack of optimal usage of capacity 4-Efficiency of distribution system 5-lake of appropriate instrument for R & D 6- Efficiency of information system	1-developing supply chain approach and efficiency distribution method using high ICT tech	1-improving productivity and controlling cost

The rating scale defined in Table 1 is used in this numerical study. Result expected the rating scale defined in Table 1 is used in this numerical study. The expected scales of belief structure resulting from Table 4 has been collected and averaged by Eq. (1). The results are shown in the end column of Table 5 and finally normalized by Eq. (2) and Eq. (17) to generate the relative importance weights of strategies.

Table 4
Assessment the relative importance of Rumlet criteria

factors	Important degree				
	M_1 20%	M_2 20%	M_3 20%	M_4 20%	**M_5 20%**
Consistency	3	3:80% 5:20%	3:90%	3-5	Unknown
Consonance	5	5:70% 7:30%	5	5-7	5
Feasibility	9	9:90% 7:10%	9	7-9	9
Advantage	3	3:80% 5:20%	3:90%	3-5	Unknown

Table 5
Expected rating for the relative importance of Rumlet criteria

	Expected rating obtained from five manager						
$\mathbf{CR_s}$	M_1(20%)	M_2(20%)	M_3(20%)	M_4(20%)	M_5(20%)	Weighted average rating	Normalized expected rating
$\mathbf{CR_1}$	3	3*80%+5*20%	3*90%+[0-9]*10%	3-5	0-9	2.42-4.80	0.11-0.23
$\mathbf{CR_2}$	5	5*70%+7*30%	5	5-7	5	5.12-5.52	0.22-0.29
$\mathbf{CR_3}$	9	9*90%+7*10%	9	7-9	9	8.56-8.96	0.36-0.47
$\mathbf{CR_4}$	3	3*80%+5*20%	3*90%+[0-9]*10%	3-9	0-9	2.42-4.80	0.11-0.23

Table 5 shows the assessment relationships between the Rumlet criteria and strategies of SWOT matrix provided by four hypothetical assessors. The four assessor ($TM_1 \sim TM_4$) are assumed to have different importance. Table 6 shows the scale assessed by the four members of the assessed team in the relationship matrix between Rumlet criteria and strategies result from SWOT matrix. The four assessors ($TM_1 \sim TM_4$) are assumed to have different importance. The weights related to these four members are given after team members' name. Each strategy in Table 7 has been assessed by four assessors with the help of Eq. (4) for the relationship matrix and belief structure. Table 6 illustrates the collective assessed results for relationships according to their significance. These results come from integration of relationship matrix which itself is the result of Table 6. Note that the weight related to 0-9 in the Table 7 are "ignorance" information. In other words, they have no connection to the weights assessed by the four assessors.

Table 6
Assessment relationship between the Rumelt criteria and five strategies of SWOT

		S_1	S_2	S_3	S_4	S_5
CR_1	TM_1(20%)	3:80% 5:20%	0	0	7-9:90% 5-7:10%	**0**
	TM_2(30%)	3:75%	0	0	9	**0**
	TM_3(30%)	Unknown	0	0	9	**0**
	TM_4(20%)	3:80%	0	0	9	**0**
CR_2	TM_1(20%)	0	3	7-9:805	0	**7-9**
	TM_2(30%)	0	3	7-9:90%	0	**9:80%** **7:20%**
	TM_3(30%)	0	3	7-9:80%	0	**9**
	TM_4(20%)	0	3:80% 1:20%	Unknown	0	**9**
CR_3	TM_1(20%)	1	3	9	0	**9:80%**
	TM_2(30%)	1	3:80%	9	0	**7-9:75%** **5-7:25%**
	TM_3(30%)	1	3:60% 1:40%	9	0	**9:80%**
	TM_4(20%)	1	3	7-9:75% 5:25%	0	**9:80%**
CR_4	TM_1(20%)	Unknown	0	0	9:80%	**0**
	TM_2(30%)	1	0	0	9	**0**
	TM_3(30%)	1	0	0	9:90% 7:10%	**0**
	TM_4(20%)	1	0	0	7-9:85% 5-7:15%	**0**

Table 7
Belief relationship matrix between the Rumlet criteria and five strategies of SWOT

	S_1	S_2	S_3	S_4	S_5
CR_1	3:54.5% 5:4% 0-9:41.5%	0	0	9:80% 5-7:2% 7-9:18%	0
CR_2	0	1:4% 3:96%	7-9:67% 0-9:33%	0	7:6% 9:74% 7-9:20%
CR_3	1	3:82% 1:12% 0-9:6%	5:5% 9:80% 7-9:15%	0	9:56% 5-7:7.5% 7-9:22.5% 0-9:14%
CR_4	1:80% 0-9:20%	0	0	9:73% 7:3% 5-7:3% 7-9:17% 0-9:4%	0

For the belief relationship matrix, with the aid of implementing the interval ER algorithm, Eqs. (5-13), and optimizing preference programing models based on Eq. (14) and Eq. (15) for each strategies, we obtain the importance rating of the five strategies, which are shown in Table 8, in which inf and suf represent the lower and upper bounds respectively. Then, the ratings will be calculated and normalized by Eq. (16) and is shown in Table 9. We use Eq (18) to compute ranking order of the five strategies which we get $S_5^{50.98} > S_3^{100} > S_4^{53.62} > S_2^{72.37} > S_1$. It is clear that strategy S_5 comparing with other strategies possess more weigh consequently according to ER algorithm is more possible to be selected.

Table 8
Ranking generated by ER algorithm

Strategies of SWOT		S_1	S_2	S_3	S_4	S_5
Technical importance rating	INF	0.7614	1.6702	4.4806	1.2383	4.6236
	SUF	1.8750	2.5541	7.3924	3.3172	7.3831

Table 9
Normalized technical importance ratings

Strategies of SWOT		S_1	S_2	S_3	S_4	S_5
Technical importance rating	INF	0.7614	1.6702	4.4806	1.2383	4.6236
	SUF	1.8750	2.5541	7.3924	3.3172	7.3831
Normalized technical importance ratings	INF	0.0356	0.0772	0.2285	0.0606	0.2340
	SUF	0.1350	0.1870	0.4713	0.2233	0.4753
	Average	0.0853	0.1321	0.3499	0.1420	0.3546
Ranking order		5	4	2	3	1

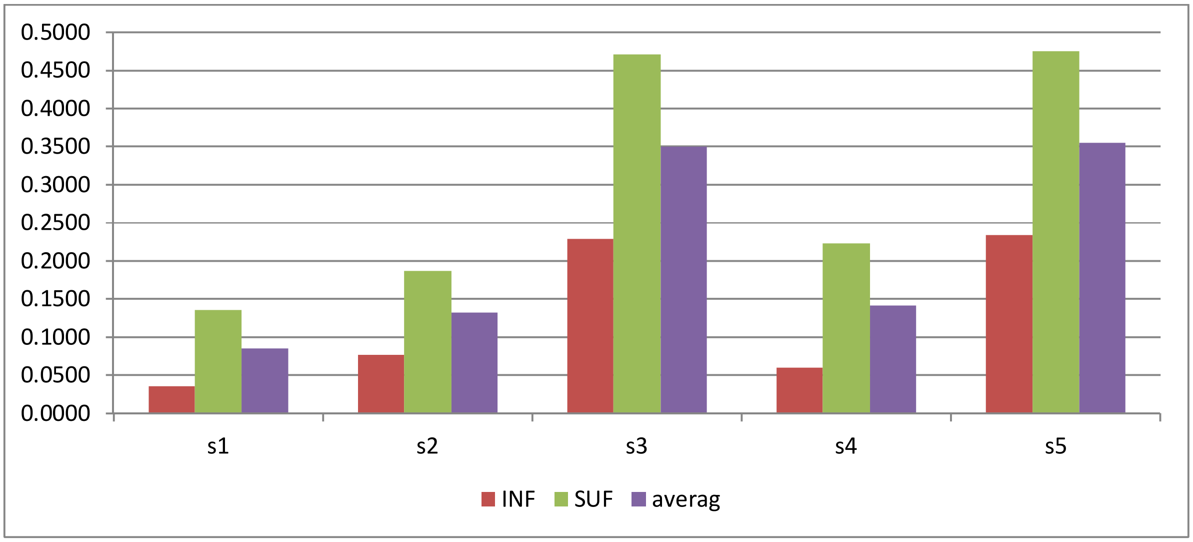

Fig.1. Normalized technical importance ratings of the five strategies

5 Conclusion

SWOT matrix identifies strategies based on external and internal factors i.e. opportunity, threats, strength and weakness. SWOT matrix cannot define the weights of strategies for selected strategy. On the other hand, uncertainty is an important subject, which cannot be eliminated from real situation, especially in group decision making. In this paper, we have focused on strategies selection and proposed a new method to rank potential strategies. One of the benefits of this method is that decision makers can present their opinions freely and independently in three types as incomplete, imprecise and ignorance. This approach applied ER algorithm to selection strategies upon "Dempster-Shafar" aggregation rule to aggregate opinions from decision maker.

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