ICIC Express Letters
Volume **15**, Number **12**, December **2021**
 ISSN 1881-803X
pp. **1319–1327**

A STRATEGIC DECISION-MAKING INFORMATION FUSION APPROACH BASED ON KNOWLEDGE ELEMENT RELATION MINING

Lin Sun

School of Economics and Management
Dalian University
No. 10, Xuefu Street, Jinzhou New District, Dalian 116622, P. R. China
sunlin1@dlu.edu.cn

Received April 2021; accepted June 2021

Abstract. *Enterprise strategic decision-making, which has the nature of high complexity and uncertainty, needs knowledge discovery based on the competitive information and decision makers' experience to improve the capability of competitive situation assessment and business opportunity identification. In the big data era, the information and knowledge demand of strategic decisions highlight the dynamics and comprehensiveness of multi-agent and cross-industry competitive situation analysis, as well as the intellectual and forward-looking features of strategy selection and decision formulation. However, the existing studies still face some difficulties in fully utilizing competitive information to provide the instructive and operational knowledge for strategic decision-making. This paper proposes a multi-attribute fusion method and similarity analysis to deal with the comprehensive relationship between knowledge element (KE) and information element (IE) in the context of strategic decision-making, which not only helps to realize the comprehensive interpretation and objective evaluation of the competitive situation based on a standard knowledge framework, but also provides more accurate feedback of decision experience knowledge for strategic decision makers through the relation mining based on strength weakness opportunity threat (SWOT) case knowledge. The application of the proposed model is shown in the SO and WO information acquisition of an enterprise. We make an empirical analysis in the multi-attribute fusion and relation mining of the KE and IE of the enterprise's production ability for strategic decision support and further demonstrate the effectiveness of this method.*
Keywords: Multi-attribute fusion, Relation mining, Knowledge element, Information element, Strategy decision-making

1. **Introduction.** Enterprise strategic decision-making, which has a large number of unstructured problems and uncertain factors, needs efficient quantitative and qualitative methods based on competitive information and decision makers' experience. Especially in the knowledge economy and big data era, how to use cross-domain enterprise management theory, information processing technology and knowledge discovery methods to mine the implicit value of massive data through tracking and analyzing competitive information has become an issue of concern [1,2]. In the field of competitive intelligence application, many achievements have been made in the research of enterprise business relationship identification, product feature relationship mining and opinion mining [3,4].

However, how to fully identify the potential value of business information to provide intellectual support for strategic decision-making has not yet been solved well. On the one hand, there is a lack of dynamic identification and comprehensive analysis method of competitive situation information. Especially, few studies have effectively combined intelligent analysis technology with enterprise strategic analysis tools to extract high-value competitive information and generate decision knowledge, which affects the objectivity

DOI: 10.24507/icicel.15.12.1319

and scientificity of strategic decision-making. On the other hand, it is failed to supply the action-oriented knowledge in the whole process of enterprise strategic management. As a result, the reusability of strategic decision knowledge is unable to realize.

This paper explores to infer the complex relationship among information elements (IEs) to obtain the in-depth representation and analysis of enterprise competitive environment from the perspective of the information and knowledge requirements of strategic decision. Based on this, the proposed method reveals the relationship among the key elements of decision knowledge elements (KEs), so as to obtain decision experience knowledge to enhance the intelligence of decision support. It is worth noticing that, KEs of strategic decision-making are able to represent the perceptual cognition of the descriptive objects in a common knowledge framework. Besides, the information fusion that reveals the comprehensive relationships between KEs and IEs goes deep into the rational cognition level of strategic decision-making, which is conducive to the knowledge increment of strategic information.

The remainder of this paper is organized as follows. Section 2 briefly reviews the related works of KE model, a multi-attribute fusion method and similarity analysis of KE. Section 3 elaborates on the information fusion framework of strategic decisions. In Section 4 and Section 5, an attribute fusion model and the information merging approach based on KE and IE are designed respectively. Section 6 illustrates a case that fuses the information of the advantages and disadvantages of an enterprise and its competitor and furthermore, discusses the objective basis for adjustment of the strategic decision-making. Conclusions are finally drawn in Section 7, along with some future endeavors of this study.

2. Related Works.

2.1. Knowledge element model.

Knowledge element is considered as the smallest unit of knowledge and the basis of knowledge management [5]. At present, the understandings and technical methods of KE are different due to the fact that diverse application fields put forward a knowledge element model which uses triples to represent the features of things, which gets rid of the limitations of text unit and model knowledge representation, and can realize the implicit description of the association relationship between KE attributes.

Let N be the concept and attribute name of the corresponding thing, A denote the corresponding attribute state set, and R denote the mapping relation set on $A \times A$ to describe the change and interaction of attribute states. Then the framework of the knowledge element model (KEM) can be expressed as

$$K = (N, A, R) \tag{1}$$

2.2. Multi-attribute fusion method based on evidence theory.

Dempster-Shafer theory of evidence (DST) [6,7] provides an effective way to merge uncertain information without any prior probabilities. A multi-attribute integration approach proposed by Sun and Wang [8] extends classical DST to fuse combinatorial-type evidences so as to find a relative consensus on the attribute description of the object. All the attributes of an object make up the frame of discernment (FD) $\theta = \{a_1, \ldots, a_N\}$, and the power set of θ is represented as $X = \{X_1, \ldots, X_{2^N-1}\}$ where $X_1 = \{a_1\}, \ldots$, and $X_{2^N-1} = \{a_1, \ldots, a_N\}$. The proposed method deals with the combination rule as $m_\alpha(X_i) = m_{\cap f}(X_i) + q(X_i) \cdot k$, where $m_{\cap f}(X_i)$ is replaced by a new cross-fusion function as

$$m_{\cap f}(X_i) = \sum\nolimits_{SupX_i} m_1(X_1) \cdot \ldots \cdot m_r(X_r) \tag{2}$$

The purpose of this multi-attribute fusion is to find X_f satisfying

$$m_\alpha(X_f) = Max[m_\alpha(X_i)].$$

2.3. **KE and IE similarity analysis.** Data preprocessing is needed to eliminate redundant and noise data through similarity analysis to realize the content integration of incomplete IEs. Let two IEs be marked as E_1 and E_2, and their similarity $Sim(E_1, E_2)$ can be divided into two parts: similarity of KEs (marked as K_1 and K_2) and similarity of the state values of each attribute (marked as S_1 and S_2). The basic process is as follows [9]:

$$Sim(E_1, E_2) = \omega_1 Sim(N_1, N_2) + \omega_2 Sim(A_1, A_2) \cdot Sim(S_1, S_2) \tag{3}$$

where A_1 and A_2 denote the attribute name-sets, ω_1 and ω_2 denote the weight coefficients satisfying $0 < \omega_1, \omega_2 < 1$ and $\omega_1 + \omega_2 = 1$. If $Sim(E_1, E_2) \geq \mu$ where μ is the threshold of IE similarity, it is regarded that E_1 and E_2 are the same IE that can be fused.

3. **Fusion Framework of Strategic Decision Based on the Relations of KE and IE.** This paper attempts to design an information fusion framework of identifying the key features of enterprise strategic decision through exploring the relationship among objective-attributes and basis-attributes of decision KEs, which is able to help enterprises accumulate abundant and accurate decision-making knowledge and further carry out the intelligent support during the processes of enterprise's strategy analysis, decision making and effect evaluation.

As shown in Figure 1, the proposed merging computation not only uses IEs to sort out the impact of competitive environment, enterprise resources and capability on the decision implementation effect, but also verifies the fusion result by assessing the matching degree between the result and the target of the decision IE [10]. In particular, the basis/target matches the input/output features respectively in the attribute set of decision KEs.

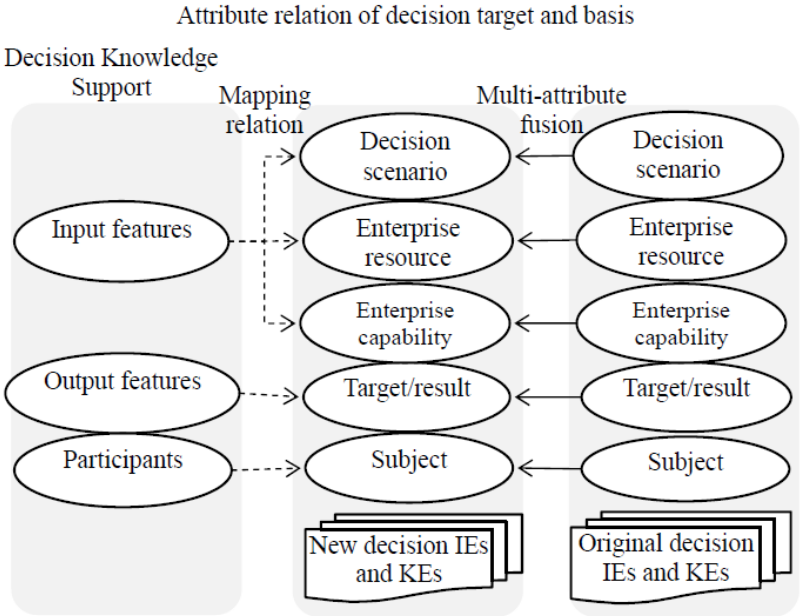

FIGURE 1. Information fusion framework of strategic decision-making

4. **Key Attribute Fusion Model for Decision-Making Based on KE and IE.** The essence of decision key feature fusion is to identify the relationship among the objective-attributes and basis-attributes of decision KE. The selection of critical features based on decision objectives is helpful to realize the integration of the implicit relationship of decision case knowledge, which is mainly realized by multi-attribute fusion of KEs. Besides, anomaly monitoring based on the key features of the IEs extracted from multiple sources can further drive the formulation and adjustment of the strategic decision, so as to help the enterprise carry out the scientific and accurate decision.

4.1. **Decision case knowledge accumulation based on IE similarity.** Strategic decision information fusion is regarded as a procedure of refining decision experience knowledge. Assume that two decision IEs $E_1 = \{c_1, P_1, t_1, B_1, [A_1, R_1]\}$ and $E_2 = \{c_2, P_2, t_2, B_2, [A_2, R_2]\}$ where c, P, t, B, A, R denote the feature elements namely decision title, subject and time, as well as the attribute-status set namely decision basis, target and result. Thus, the similarity analyzing process of two decision case knowledge fragments is as follows.

Step 1: Similarity analysis on the decision title attribute of IEs. Based on the text similarity analysis methods, if $Sim(c_1, c_2) \geq \mu_c$ where c_1 and c_2 represent the titles and μ_c is the threshold of the title similarity, go to Step 2; otherwise, the calculation ends.

Step 2: Similarity analysis on the decision target attribute of IEs. In general, decision objectives are composed of more than one business indicator and enterprise resource indicator. Although decision-making processes of enterprises are usually similar, the key indicators of individual decision might be quite different. As a result, if the computing result satisfies $Sim(A_1, A_2) \geq \mu_a$ where A_1 and A_2 represent the targets of two decision IEs, go to Step 3; otherwise, the calculation ends.

Step 3: Synthetic similarity analysis on the decision title-targets of IEs. Two IEs can be classified into the same group of decision knowledge and the computing will continue to Step 4 when satisfying $Sim_D^1 = \omega_1 Sim(c_1, c_2) + \omega_2 Sim(A_1, A_2) \geq \mu_D^1$ where ω_1 and ω_2 denote the weight coefficients and μ_D^1 denotes the threshold of the similarity comparison.

Step 4: Synthetic similarity comparison of decision IEs to remove redundancy. We conclude that these IEs have high similarity and can be combined to a single if satisfying $Sim_D^2 = \omega_3 Sim(B_1, B_2) + \omega_4 Sim(R_1, R_2) \geq \mu_D^2$ where ω_3 and ω_4 denote the weight coefficients and μ_D^2 denotes the analysis threshold. Afterwards, the reserved IEs are stored in the knowledge base for further application.

4.2. **Decision experience knowledge renewal based on KE multi-attribute fusion.** In this part, the multi-attribute method is used to update the attribute features of the original decision experience knowledge based on decision case knowledge, so as to realize empirical knowledge fusion of strategic decision based on SWOT analysis. Suppose the decision experience knowledge to be fused is $K_1 = \{B_1, P_1, A_1, R_1\}, \ldots, K_n = \{B_n, P_n, A_n, R_n\}$ where B, P, A, R are the attribute sets of basis, subject, goal and result of decision-making respectively. According to the principle that the analysis results belong to the same kind of decision case knowledge where c_0 and A_0 denote the title and target of decision respectively, the multi-attribute fusion process of decision basis based on KE without considering decision effect is described as follows.

Step 1: Eliminate the redundant attributes and define the frame of discernment of multi-attribute fusion. Take K_1 and K_2 for example, where $B_1 = \{b_1^1, \ldots, b_1^s\}$ and $B_2 = \{b_2^1, \ldots, b_2^t\}$ denote the attributes of decision case knowledge respectively. The attributes in B_2 are analyzed based on B_1. If $Sim\left(b_1^i, b_2^j\right) = 1$ $(1 \leq i \leq s, 1 \leq j \leq t)$, b_2^j will be deleted based on the processing rules of redundant IE in Sun's similarity model [9]. This computation will end until all the decision basis attributes of the experience knowledge are merged into the set $\theta = \{b_1, \ldots, b_m\}$ where $m = |\theta|$.

Step 2: In the frame of discernment 2^θ, the multi-attribute fusion analysis is carried out, in which the evidences are regarded independent and the fusion result B_f is obtained.

Step 3: The multi-attribute fusion analysis of decision-making agents is carried out based on Step 1 and Step 2, and the result P_f is obtained.

Step 4: Rebuild the common description of decision KEs. The attribute-set $A_s = \{c_0, P_f, t, B_f, [A_0, R]\}$ (c_0 corresponds to the name of the decision KE) is obtained and saved after updating the corresponding decision experience knowledge.

To sum up, the attribute relationship fusion of decision case KE is realized and the attribute description of decision experience KE is improved. In particular, the decision

case knowledge is more persuasive to revise the original decision experience knowledge, which improves the reliability and rationality of decision basis.

5. **Strategic Decision Information Fusion Based on the Relations of SWOT KE and IE.** The target of the strategic decision information fusion is to find the optimal strategy under different state combinations of SWOT factors. This paper utilizes the prior knowledge of strategic influencing factors to collect information. In addition, the positive and negative thresholds of key attributes are set to adjust the status of advantages and disadvantages timely, and the feedback mechanism is used to modify the decision experience knowledge.

5.1. **Decision experience knowledge generation based on decision attribute relations.** In this process, the optimal strategic objectives under various combinatorial features are extracted and decision basis features are merged to match relationship.

Step 1: According to the decision target G, SWOT matrix collects the corresponding decision basis attributes. For example, the decision basis case knowledge includes the N groups recorded as $A_{SO}^1 = \{S_1^1, \ldots, S_1^{n_1}, O_1^1, \ldots, O_1^{m_1}\}, \ldots, A_{SO}^N = \{S_N^1, \ldots, S_N^{n_N}, O_N^1, \ldots, O_N^{m_N}\}$.

Step 2: In the frame of discernment $\theta = A_{SO}^1 \cup \cdots \cup A_{SO}^N$, the evidence $A_{SO}^1, \ldots, A_{SO}^N$ is merged and the result $A_{SO}^f = \left\{S_f^1, \ldots, S_f^{n_f}, O_f^1, \ldots, O_f^{m_f}\right\}$ is obtained.

Step 3: According to $A_{SO}^f = \left\{S_f^1, \ldots, S_f^{n_f}, O_f^1, \ldots, O_f^{m_f}\right\}$ and the decision target G, the SO factors are stored as the decision basis and target attributes of decision KE which will be used as the decision experience knowledge in the future.

5.2. **Decision case knowledge accumulation based on decision effect attribute of IEs.**

Step 1: Collect SWOT IEs. At the beginning of the strategy implementation, record every status of factor as $E_0 = \{S_0, W_0, O_0, T_0\}$. In the assessment stage of decision G, information tracking is carried out for all strategic influencing factors, and the IE $E_1 = \{S_1, W_1, O_1, T_1\}$ is obtained through the IE ordering and reconstruction. At this point, E_1 will not be saved.

Step 2: Reevaluate the attribute status of each SWOT factor and rebuild the related IE. Select all the attributes that reach the positive threshold and update them according to S factors or O factors. Similarly, all the attributes that reach the negative threshold are renewed according to W factors or T factors.

Step 3: The latest SWOT factor and its states are stored in the IE base according to SWOT KE, which is represented as $E_2 = \{S_2, W_2, O_2, T_2\}$. After the assessment, the SWOT situation knowledge will be replaced from E_1 to E_2.

Step 4: Describe decision IE as $E_d = \{c, P, t, B_d, [A_d, R_d]\}$, and save it in the IE base. Note that, the features and their states of decision basis B_d come from E_1 and the decision target $A_d = G$, and yet the features and their states of decision result R_d derive from E_2.

Step 5: Evaluate the decision effect. Analyze the elements of A_d and R_d based on the decision experience knowledge renewal method. If anyone of them does not match the rule, it will not be marked as the decision case knowledge, and the analysis ends. Otherwise, reconstruct the decision case knowledge which is represented as $K_c = \{A_c, B_c\}$ where A_c and B_c derive from the attributes of A_d and B_d respectively.

5.3. **Decision basis revising and decision experience knowledge updating based on KEs.**

Step 1: Classify and collect all relevant decision case knowledge as evidences (represented as $K_c^1 = \{A_1, B_1\}, \ldots, K_c^n = \{A_n, B_n\}$) based on the decision target A_c.

Step 2: Build the frame of discernment $\theta = B_1 \cup \cdots \cup B_n$ and compute the multi-attribute fusion result B_f. Although many SWOT features have been integrated at this stage, the merging result is still arranged according to SWOT.

Step 3: Describe the matching relation of the decision target A_1 and the decision basis B_f of the updating decision KE.

In summary, the advantages of the proposed fusion method based on KE and IE relation are 1) it overcomes the traditional static analysis of SWOT, and 2) according to whether the decision effect achieves the decision goals, the decision experience knowledge is modified through the continuous accumulation of decision case knowledge, so that decision basis attributes tend to cover all the key features.

6. **Case Study.** Two enterprises are selected to carry out the application study of the proposed approach. Enterprise A is the main object of the strategic decision-making information fusion in this case. Enterprise B forms a competitive relationship with enterprise A. The targets of this case study include 1) strategic decision-making information fusion based on the comprehensive relationship between KEs and IEs which reflect the advantage and disadvantage factors of enterprise A, and 2) providing the objective basis for timely adjustment of strategic decision-making according to the IEs latest collected from enterprise A and its competitor B.

6.1. **Data source selection and data preprocessing.** According to Lu's study [11], the critical features, the KE attributes and the strategic influencing factors (SIF) are extracted based on the advantage and disadvantage description in the 2013 SWOT analysis of enterprise A, as shown in Table 1 and Table 2. Note that, some of the SIFs are involved in both strength and weakness analysis of the enterprise, such as R&D staff and R&D institutes mentioned in S8, S10, W7 and W9.

On this basis, the SO and WO situation of enterprise A is described respectively in Table 3 and Table 4 [11]. Note that the strategic selection of both D6 and D17 is to "improve production capacity and expand production scale", and the related SIFs and their states are listed in Table 5, which means two different opinions on the same decision target.

Table 1. SIF features of enterprise strength analysis

S	Description	Critical feature	KE-attribute				Strategic influencing factor		
...	...	...	...	...	...	...	...	...	...
8	Rich R&D and design experience	R&D and design	R&D capability	Technical resources			R&D staff	R&D results	R&D investment
...	...	...	...	...	...	...	...	...	...
10	Relatively high-quality technical team	Technical team	R&D capability	Human resources	Technical resources		R&D staff	R&D institutes	
...	...	...	...	...	...	...	...	...	...

Table 2. SIF features of enterprise weakness analysis

W	Description	Critical feature	KE-attribute			Strategic influencing factor		
...	...	...	...	...	...	...	...	...
7	Lack of R&D personnel	R&D staff	Human resources	R&D capability	Technical resources	R&D staff	R&D institutes	
...	...	...	...	...	...	...	...	...
9	Weak R&D capability of core technology	Core technology	R&D capability	Technical resources		Core technology	R&D achievements	R&D institutes
...	...	...	...	...	...	...	...	...

Table 3. Internal and external features of enterprise based on SO strategic decision

ID	Strength (S)				Opportunity (O)			Strategic decision targets description
	Internal cause 1	Internal cause 2	Internal cause 3	Internal cause 4	External cause 1	External cause 2	External cause 3	
...	...	...	...	...	...	...	...	...
D6	S1	S11	S12		O4			Further improve production capacity and expand production scale
...	...	...	...	...	...	...	...	...

Table 4. Internal and external features of enterprise based on WO strategic decision

ID	Weakness (W)		Opportunity (O)				Strategic decision targets description
	Internal cause 1	Internal cause 2	External cause 1	External cause 2	External cause 3	External cause 4	
...	...	...	...	...	...	...	...
D17	W1	W11	O5	O6			Improve production capacity and expand enterprise scale
...	...	...	...	...	...	...	...

Table 5. Different attribute-sets and IEs of the same decision target

ID	Strategic decision targets	Factor	Strategic influence factor			
			Attribute name	Symbol	2017.8	
					A	B
D6	Further improve production capacity and expand production scale	S1	Equipment	A	DXJ, DXY, PSF, ZYS; HHJ	
			Labor	**B**	Total, 701; Proportion, 49.30%	Total, 3221; Proportion, 54.54%
			Production	**C**		
		S11	Liquidity	D	116911892	1105855452
		S12	Financing mode	E		
			Financing amount	F		
		O4	Entry barrier	G	High	
D17	Improve production capacity and expand enterprise scale	W1	**Production per capita**	**H**		
		W11	Total assets	I	3090335104	16656000926
			Main business income	J	461510849	2286923955
		O5	Economy development	K	To be good	
		O6	Industry integration	L	Small business integration	

Furthermore, there is a quantitative relationship between "Labor" and "Production" of D6 and "Production per capita" of D17, but these three features appear in S factor and W factor respectively. This is the inevitable divergence in making strategic decisions artificially.

Table 3 and Table 4 show the existing decision experience knowledge. However, how to improve the accuracy of SIF selection is the key point of this case. At this point, diverse decision case knowledge about production capability has been collected from sources such as CNKI and encyclopedia website, which forms multiple evidences of this decision basis attribute shown in Table 6. The goal of this case is to find the consensus knowledge on the critical features to determine the production capacity based on case knowledge acquired.

6.2. **Result analysis.** There followed the multi-attribute fusion for five pieces of decision case knowledge of the product capability in $\theta = \{A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q\}$, as shown in Table 7. Given that $X_B = \{B, C, L\}$, the evidence with the largest

TABLE 6. Decision experience knowledge of enterprise production capability

Sample 1		Sample 2		Sample 3		Sample 4		Sample 5	
Attribute name	Symbol	Attribute name	Symbol	Attribute name	Symbol	Attribute name	Symbol	Attribute name	Symbol
Equipment	A	New product development cycle	D	Fixed assets involved	A	Fixed assets involved	A	Equipment	A
Labor	**B**	Sales ratio of new product	E	**Production Labor**	**C**	Productivity	G	Number of good products	M
Production	**C**	Procurement cost reduction rate	F	Productivity utilization rate	**B**	Quality of employees	O	**Production amount**	**C**
		Individual productivity	G	**Reject rate**	H	**Production Labor**	**C**	Type of production	Q
		Productivity utilization rate	H	Equipment utilization rate	**L**	Production process	**B**		
		Cost reduction rate	I	Production process	N	Productivity utilization rate	P		
		Rework rate	J		P		H		
		Intact rate of equipment	K						
		Fine rate	**L**						
		Number of good product	M						
		Total production	**C**						

TABLE 7. Multi-attribute fusion result of decision basis features of product capability

Random data fusion	ACMQ	**ABCHLNP**	ABCGHLNOP
Probability distribution results	0.0348	**0.5**	0.4652
mf	0.0348	**0.5**	0.4652
q	0.1675	**0.3903**	0.3903

probability distribution result (shown in bold) $X_f = \{A, B, C, H, L, N, P\}$ is regarded as a complete decision experience knowledge based on Equation (2). In view of the above, the information in Table 5 can be further enriched.

Assuming that the negative threshold of main business income is set according to 15% of enterprise B, it can be seen from Table 5 that the main business income of enterprise A in 2017 no longer constitutes the W factor, nor does it reach the threshold of S factor. Therefore, the knowledge of SWOT competition situation of enterprise A will change. On this basis, enterprise A is no longer suitable to carry out the strategy of expanding production scale due to the reversal of the state of critical feature attribute, which does not meet the decision basis feature attribute in D17.

7. **Conclusions and Future Research.** In summary, the proposed strategic decision-making information fusion study uses relation mining technology to integrate multi-attributes of KEs and IEs of enterprise's SWOT situation. In particular, the selection process of decision basis attributes breaks the absolute boundary between S/W factors and O/T factors, thus generating more objective and reasonable decision experience knowledge. Besides, the refinement and integration of IEs based on fine-grained strategic influencing factors can reflect the latest changes in the competitive situation and provide operational and instructive knowledge support for effective strategic decision-making. The visualization of strategic decision-making information based on SWOT KEs and IEs needs to be deepened in the near future.

Acknowledgment. This work is partially supported by Research on Economic and Social Development of Liaoning Province in 2020 (ID 2020lslktqn-008).

REFERENCES

[1] R. Jiwat, C. Y. Zhang and K. Andy, The implications of big data analytics on business intelligence: A qualitative study in China, *Procedia Computer Science*, vol.87, pp.221-226, 2016.

[2] Y. Yang and J. He, A novel method based on fixed point iteration and improved TOPSIS method for multi-attribute group decision making, *International Journal of Innovative Computing, Information and Control*, vol.17, no.1, pp.15-29, 2021.

[3] J. Zhao, *Research on Web Oriented Enterprise Competitive Intelligence Acquisition*, Ph.D. Thesis, University of Science and Technology of China, 2013.

[4] C. H. Sun and Y. Z. Liu, A method for combining online reviews' sentiment orientation based on recognition of relationship between product feature words, *Journal of the China Society for Scientific and Technical Information*, vol.32, pp.844-852, 2013.

[5] Y. Z. Wang, Knowledge and representation of model management, *Journal of Systems Engineering*, vol.26, pp.850-856, 2011.

[6] A. P. Dempster, Upper and lower probabilities induced by a multi-valued mapping, *Annual Mathematics and Statistics*, vol.38, pp.325-339, 1967.

[7] G. Shafer, *A Mathematical Theory of Evidence*, Princeton University Press, Princeton, 1976.

[8] L. Sun and Y. Z. Wang, A multi-attribute fusion approach extending Dempster-Shafer theory for combinatorial-type evidences, *Expert Systems with Applications*, vol.96, pp.218-229, 2018.

[9] L. Sun, Approach of multi-source competitive intelligence fragments fusion based on intelligence element similarity, *Information Theory and Application*, vol.10, pp.8-14, 2018.

[10] G. Q. Yun, X. L. Chen and Y. Z. Wang, Distance entropy based decision-making information fusion method, *Systems Engineering – Theory & Practice*, vol.35, pp.216-227, 2015.

[11] K. Lu, *Research on the Development Strategy of TQ Company Based on SWOT Analysis*, Master Thesis, Hunan University of Technology, 2013.