Measuring the Intellectual Capital Performance Based on 2-tuple Fuzzy Linguistic Information

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Abstract

Nowadays, knowledge has become a determinant capital for enterprise to retain and improve competitive advantage. In other words, knowledge and intellectual capital are crucial intangible resources and also need to be emphasized and manage appropriately. Because knowledge is abstract, intangible, and difficult to measure, it becomes an important issue to evaluate intellectual capital for business managers. However, only tangible factors are considered in the evaluation process and the lack of experience may hinder the intellectual capital evaluation. A more realistic approach should consider both tangible and intangible factors and use the linguistic variables instead of numerical values simultaneously. Therefore, this paper proposes a suitable model for intellectual capital performance evaluation by combining 2-tuple fuzzy linguistic approach with multiple criteria decision-making (MCDM) method. Finally, a case study is implemented for a high-technology company in Taiwan at the end of this paper.

Keywords: intellectual capital, multiple criteria decision-making, linguistic variable, 2-tuple fuzzy linguistic approach.

1. Introduction

In a new knowledge-based economy era, knowledge has replaced machine, land, labor and physical or financial capital gradually, and become a determinant capital for enterprise to retain and improve competitive advantage [6][12]. In other words, how to accumulate and apply knowledge appropriately has become a crucial issue for business managers. Generally speaking, knowledge management (KM) is regarded as a systematic process to create, identify, collect, adapt, apply, share and store knowledge effectively and efficiently. Enterprises acquire and reuse knowledge to create the benefit of products and services through the effective management of knowledge [1][5][28][36].

Intellectual capital is one of the business capitals. Although, intellectual capital refers to capital, its implication is different from the accounting term. Some authors use it "to refer to the knowledge and knowing capability of a social collectivity, such as an organization, intellectual community, or professional practices" [31]. The traditional capital such as land, labor and machine can be measured in accordance with financial reports. However, intellectual capital is more intangible and difficult to measure the performance effectively [14][27][33][36]. In fact, the performance evaluation of intellectual capital should consider multiple dimensions or factors which are evaluated by multiple decision-makers or experts. Thus, the performance evaluation of intellectual capital should be regarded as a group multiple-criteria decision-making (GMCDM) problem. In formal terms, GMCDM problems may be described by means of the following sets:

(i) a set of k experts called $E = \{E_1, E_2, \cdots, E_k\}$;
(ii) a set of n criteria, $C = \{C_1, C_2, \cdots, C_n\}$, with which performances are measured;
(iii) a set of performance ratings of evaluation items with respect to criteria.

In general, it is assumed that there are no interactions between any two criteria within a multiple criteria decision-making problem. Therefore, the linear combination form is usually used as the mathematical model to approximate the human decision-making process. These methods include the Simple Weight Additive (SWA) method, the ELECTRE method and the PROMETHEE method [3][25]. However, these criteria often are not quite independent in dealing with the multiple criteria decision making problems. Due to imprecise and subjective information that often appears in evaluation process, crisp values are inadequate for solving the decision problems. A more realistic approach may be to use linguistic assessments instead of numerical values [2][7][9][15][18][24]. Thus, this so-called linear model is obviously inadequate since human subjective evaluation does not always hold linearity [8][13].

Nevertheless, most of intellectual capital evaluation methods obtain the performance evaluation results using the traditional SWA or similar methods [11][26][33]. In fact, many qualitative factors and subjective judgment of experts will be considered in the evaluation process of intellectual capital. The SWA method is easy to calculate the performance ratings, but the evaluation result of performance level may not be consistent with the expectation of evaluators. Thus, a suitable model based on 2-tuple fuzzy linguistic information is proposed to evaluate the intellectual capital. The 2-tuple fuzzy linguistic approach not only inherits the existing characters of fuzzy linguistic assessment but also overcomes the problems of loss information of other fuzzy linguistic approaches [23].

This paper is structured as follows. Section 2 introduces the concept and scheme of intellectual capital. In Section 3, the basic definitions and notations of the fuzzy number, 2-tuple fuzzy linguistic representation and operation are introduced. In Section 4, a systematic method based on 2-tuple fuzzy linguistic information is presented to solve the evaluation problem for intellectual capital. In Section 5 the proposed method is illustrated with a case study for a high-technology company in Taiwan. Finally, some conclusions are stated at the end of the paper.

2. Meanings of Intellectual Capital

The value of enterprise contains not only its financial capital but also intellectual capital. Financial capital represents the enterprise's book value and includes the value of its financial and physical assets [26]. On the other hand, intellectual capital consists of assets created through intellectual activities ranging from acquiring new knowledge (learning) and inventions to creating valuable relationships [37]. Stewart [32] characterizes intellectual capital as "intellectual material – knowledge, information, intellectual property, experience – that can be put to use to create wealth". Brooking [4] thinks that the intellectual capital can be divided into four categories:

i. Assets which give the company power in the marketplace such as trademarks, customer loyalty, routine processes and so on.
ii. Assets representing property of the mind-intellectual property such as patents, trademarks, copyright and so on.
iii. Assets which give the organization internal strength, such as corporate culture, management and business processes, and strength derived from IT systems and so on.
iv. Assets derived from the people who work in the organization, such as their knowledge, competencies, work related know-how, networking capability and so on.

Sveiby [34] proposed that intellectual capital includes employee competence, internal structure, and external structure. Stewart [32] identifies human capital, structure capital and customer capital. Edvisson [10] divides structure capital into organization capital and customer capital. And then, Liebowitz and Wright [29] divide intellectual capital into four unique categories such as human capital, customer capital, process capital and innovation capital (shown in Table 1). Bukh et al., [5] identify the most model of intellectual capital classify intellectual resource into human capital, customer capital and organization capital (shown in Fig. 1).

According to the classification of intellectual capital, we can understand that intellectual capital includes many intangible factors and items. Therefore, it is difficult to evaluate intellectual capital performance using traditional crisp value directly. Under this situation, linguistic variables are suitable used by experts to evaluate the ratings of intellectual capital. The 2-tuple fuzzy linguistic approach applies linguistic variable to represent the difference of degree and carry out processes of computing with words easier and without loss information [23]. In other words, decision makers and experts can apply linguistic variable to evaluate items and obtain the final evaluation result with appropriate linguistic variable. It is an effective method to reduce the time and mistakes of information translation and avoid information loss through computing with words.

Table 1. The categories of capital assets [29]

Capital asset	Example cost indicators
Human	Replacement and acquisition costs, generalized training and employee costs, percentage of outsourced personnel resource, development of cross-function team structure, internal control and ethics
Customer	Creation and development of external relationship, brand loyalties, customer service expectations, market share
Process	IT and communications infrastructure, logistical efficiencies, administrative procedures
Innovation	Renewal and development costs, change in product development and delivery cycle, adoption of industry quality standard

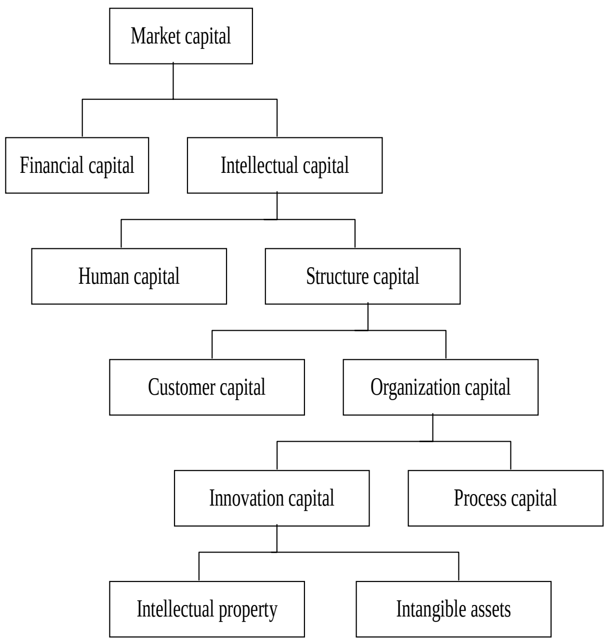

Fig. 1. The model of intellectual capital [5]

3. Basic Definitions and Notations

Fuzzy set theory is a very feasible method to handle the imprecise and uncertain information in a real world [38]. Especially, it is more suitable for subjective judgment and qualitative assessment in the evaluation processes of decision making than other classical evaluation methods applying crisp values [30][35].

3.1. Fuzzy set and fuzzy number

A fuzzy set $\tilde{A}$ in a universe of discourse X is characterized by a membership function $\mu_{\tilde{A}}(x)$, which associates with each element x in X a real number in the interval [0,1]. The function value $\mu_{\tilde{A}}(x)$ is termed the grade of membership of x in $\tilde{A}$ [39]. A fuzzy number is a fuzzy subset in the universe of discourse X that is both convex and normal [41].

Definition 1. A positive triangular fuzzy number (PTFN) $\tilde{T}$ can be defined as $\tilde{T} = (l, m, u)$, where $l \le m \le u$ and $l > 0$, shown in Fig. 2. The membership function, $\mu_{\tilde{T}}(x)$, is defined as [41]

$$\mu_{\tilde{T}}(x) = \begin{cases} \dfrac{x-l}{m-l} & , l < x < m \\ \dfrac{u-x}{u-m} & , m < x < u \\ 0 & , otherwise \end{cases} \quad (1)$$

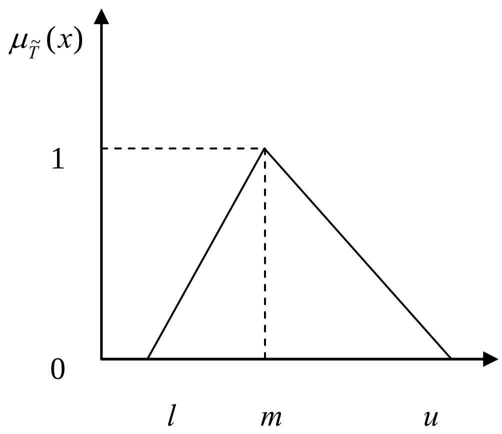

Fig. 2. Triangular fuzzy number $\tilde{T}$.

Definition 2. A linguistic variable is a variable whose values are expressed in linguistic terms. In other words, variable whose values are not numbers but words or sentences in a nature or artificial language [21][40]. For example, "weight" is a linguistic variable whose values are very low, low, medium, high, very high, etc. These linguistic values can also be represented by fuzzy numbers. It is suitable to represent the degree of subjective judgment in qualitative aspect than crisp value.

3.2. The 2-tuple fuzzy linguistic approach concept

There are several linguistic terms $\{s_0,\ldots,s_g\}$which are aggregated in a special term set S to represent the difference of degree in a qualitative aspect [38]. In order to identify the diversity of each evaluation item and facilitate to compute, these linguistic term sets often possess some characters like finite set, odd cardinality, semantic symmetric, ordinal level and compensative operation [22]. Additionally, it is feasible to represent the diversity of degree instead of traditional crisp value in qualitative evaluation processes [35]. In the other hand, it is also can be regarded as a linguistic variable set in fuzzy set concept. For example, a linguistic term set S contains five linguistic terms, '*Very Poor*', '*Poor*', '*Fair*', '*Good*', and '*Very Good*', which are denotes s_0, s_1, s_2, s_3, and s_4, respectively. Each of the linguistic term is assigned one of five triangle fuzzy numbers whose fuzzy number interval [0, 1] as shown in Fig. 3:

Definition 3. A value β whose value belongs to interval [0, 1] will be obtained after aggregating the result of evaluation using the linguistic variable set S [16][17][20]. Then the symbolic translation process is applied to translate β into a 2-tuple linguistic variable. The generalized translation function (Δ)can be represented as

$$\Delta : [0,1] \rightarrow S \times [-\frac{1}{2g}, \frac{1}{2g})$$

$$\Delta(\beta) = (s_i, \alpha) \text{ with } \begin{cases} s_i & i = round(\beta \bullet g) \\ \alpha = \beta - \dfrac{i}{g} & \alpha \in [-\dfrac{1}{2g}, \dfrac{1}{2g}) \end{cases} \quad (2)$$

where $\beta \in [0,1]$

A value β is translated into the closest linguistic term s_i in S with a value α through the symbolic translation. The 2-tuple fuzzy linguistic approach applies the concept of symbolic translation to represent the linguistic information using 2-tuples (s_i, α), $s_i \in S$. The interval of value α is derived from the number of linguistic terms. For example, if S contains five linguistic terms then $g = 4$ and $\alpha \in [-0.125, 0.125)$.

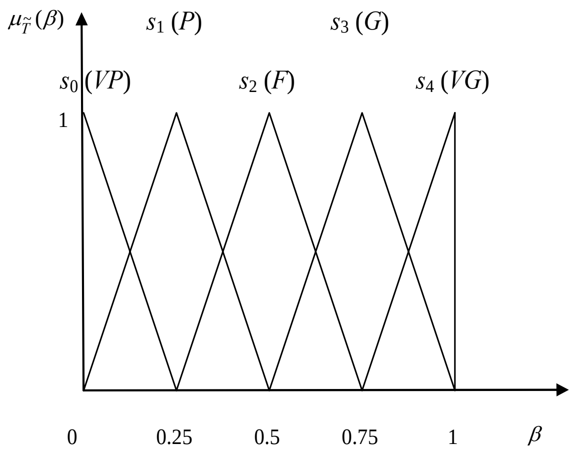

Fig. 3 A set of five linguistic terms with its semantics

Definition 4. A reverse equation Δ^{-1} is necessary to return an equivalent numerical value $\beta \in [0, 1] \subset \Re$ from a 2-tuple linguistic information (s_i, α). According to the concept of symbolic translation, an equivalent numerical value β is computed as

$$\Delta^{-1}(s_i, \alpha) = \beta = \frac{i}{g} + \alpha \; . \tag{3}$$

3.3. Operation of 2-tuple linguistic information

The 2-tuple linguistic computational model is based on the concept of computing with words [21]. Both of comparison and aggregation operators for 2-tuple linguistic computation are descried as follows [23].

3.3.1. Comparison of 2-tuples fuzzy linguistic information

If (s_i, α_i) and (s_j, α_j) are two 2-tuples fuzzy linguistic information, the comparison of both linguistic information are[19]:

i. When $i < j$, (s_i, α_i) is worse than (s_j, α_j)

ii. When $i = j$,

(i) If $\alpha_i = \alpha_j$ then (s_i, α_i) is equal to (s_j, α_j) in the view of linguistic information,

(ii) If $\alpha_i < \alpha_j$ then (s_i, α_i) is worse than (s_j, α_j),

(iii) If $\alpha_i > \alpha_j$ then (s_i, α_i) is better than (s_j, α_j).

3.3.2. Aggregation operators of 2-tuples fuzzy linguistic information

In the processes of information aggregation, both functions of symbolic translation Δ and.Δ^{-1} are applied to ensure the aggregation of 2-tuple fuzzy linguistic information can be a 2-tuple without any information loss [23].

Definition 5. When $x = \{(r_1, \alpha_1),\ldots,(r_n, \alpha_n)\}$ are a 2-tuples fuzzy linguistic information set, their arithmetic mean $\overline{X}$ is computed as,

$$\overline{X} = \Delta\left(\frac{1}{n}\sum_{i=1}^{n}\Delta^{-1}(r_i, \alpha_i)\right) = \Delta\left(\frac{1}{n}\sum_{i=1}^{n}\beta_i\right) = (s_m, \alpha_m) \tag{4}$$

Definition 6. When $x = \{(r_1, \alpha_1),\ldots,(r_n, \alpha_n)\}$ are a 2-tuples fuzzy linguistic information set, and $W = \{w_1,\ldots, w_n\}$ are the set of weight of each x_i. Their 2-tuple fuzzy linguistic weighted average $\overline{X}^w$ is

$$\overline{X}^w = \Delta\left(\frac{\sum_{i=1}^{n}\Delta^{-1}(r_i, \alpha_i) \bullet w_i}{\sum_{i=1}^{n} w_i}\right) = \Delta\left(\frac{\sum_{i=1}^{n}\beta_i \bullet w_i}{\sum_{i=1}^{n} w_i}\right) = (s^w, \alpha^w) \tag{5}$$

Definition 7. When $x = \{(r_1, \alpha_1),\ldots,(r_n, \alpha_n)\}$ are a 2-tuples fuzzy linguistic information set, and $W = \{(w_1, \alpha_{w1}),\ldots,(w_n, \alpha_{wn})\}$ are the set of weight of each x_i. This linguistic weighted average operator is extended from weighted average operator and computed as

$$\overline{X}^w = \Delta\left(\frac{\sum_{i=1}^{n}\beta_i \bullet \beta_{w_i}}{\sum_{i=1}^{n}\beta_{w_i}}\right) = (s^w, \alpha^w) \tag{6}$$

with $\beta_i = \Delta^{-1}(r_i, \alpha_i)$ and $\beta_{w_i} = \Delta^{-1}(w_i, \alpha_{w_i})$

4. The Proposed Model

In this paper, a suitable evaluation model is proposed to measure the level of intellectual capital in a company. In a real business environment, most of intellectual capital are intangible and lack of precise value to measure their performance. Under this situation, linguistic variables are suitable for experts to evaluate the level of intellectual capital. Therefore, linguistic variables are applied to describe the importance of all criteria and ratings of evaluation items with respect to each criterion in this paper.

Assume that there are n criteria $C_i\,(i = 1,2,\ldots,n)$ and each criterion contains several items in an evaluation framework of intellectual capital (shown in Fig. 4). The procedures of this proposed method (shown in Fig. 5) are summarized as follows.

Step 1. Each expert uses the linguistic importance variables (shown in Table 2) to represent the weight of each criterion and uses the linguistic rating variables (shown in Table 3) to evaluate the performance of items with respect to each criterion.

Step 2. Combining the fuzzy evaluation values of K experts as follows:

$$\overline{X}_{ij} = \Delta\left(\frac{1}{K}\sum_{k=1}^{K}\Delta^{-1}(s_{ijk},\alpha_{ijk})\right) = \Delta\left(\frac{1}{K}\sum_{k=1}^{K}\beta_{ijk}\right) = (s_{ij},\alpha_{ij}) \quad (7)$$

$$\overline{W}_{ij} = \Delta\left(\frac{1}{K}\sum_{k=1}^{K}\Delta^{-1}(s_{wijk},\alpha_{wijk})\right) = \Delta\left(\frac{1}{K}\sum_{k=1}^{K}\beta_{wijk}\right) = (s_{wij},\alpha_{wij}) \quad (8)$$

$$\overline{W}_{i} = \Delta\left(\frac{1}{K}\sum_{k=1}^{K}\Delta^{-1}(s_{wik},\alpha_{wik})\right) = \Delta\left(\frac{1}{K}\sum_{k=1}^{K}\beta_{wik}\right) = (s_{wi},\alpha_{wi}) \quad (9)$$

where, r_{ijk} is the fuzzy rating of item j with respect to C_i of the k-th expert, w_{ijk} is the fuzzy importance of item j with respect to C_i of the k-th expert, $\overline{W}_{ik}$ is the fuzzy importance of C_i of the k-th expert.

Step 3. Applying Equation (6) to obtain the fuzzy rating of C_i ($\overline{X}_i$).

$$\overline{X}_i = \Delta\left(\frac{\sum_{j=1}^{l_i}\beta_{ij}\bullet\beta_{w_{ij}}}{\sum_{j=1}^{l_i}\beta_{w_{ij}}}\right) = (s_i^w,\alpha_i^w) \quad (10)$$

with $\beta_{ij} = \Delta^{-1}(r_{ij},\alpha_{ij})$ and $\beta_{w_{ij}} = \Delta^{-1}(w_{ij},\alpha_{w_{ij}})$

Step 4. Computing the overall performance level of intellectual capital (P), the linguistic term s_T, can be applied to represent the management performance level of intellectual capital directly.

$$P = \Delta\left(\frac{\sum_{i=1}^{n}\beta_i\bullet\beta_{w_i}}{\sum_{i=1}^{n}\beta_{w_i}}\right) = (s_T,\alpha_T) \quad (11)$$

with $\beta_i = \Delta^{-1}(r_i,\alpha_i)$ and $\beta_{w_i} = \Delta^{-1}(w_i,\alpha_{w_i})$

Table 2. Linguistic variables of the importance

Linguistic label	Linguistic term	Triangular fuzzy number
s_{w4}	Very Important (VI)	(0.75, 1.0, 1.0)
s_{w3}	Important (I)	(0.5, 0.75 , 1.0)
s_{w2}	Fair (F)	(0.25, 0.5, 0.75)
s_{w1}	Unimportant (U)	(0, 0.25, 0.5)
s_{w0}	Very Unimportant (VU)	(0 ,0 , 0.25)

Table 3. Linguistic variables for the ratings

Linguistic label	Linguistic term	Triangular fuzzy number
s_4	Very Good (VG)	(0.75, 1.0, 1.0)
s_3	Good (G)	(0.5, 0.75 , 1.0)
s_2	Fair (F)	(0.25, 0.5, 0.75)
s_1	Poor (P)	(0, 0.25, 0.5)
s_0	Very Poor (VP)	(0 ,0 , 0.25)

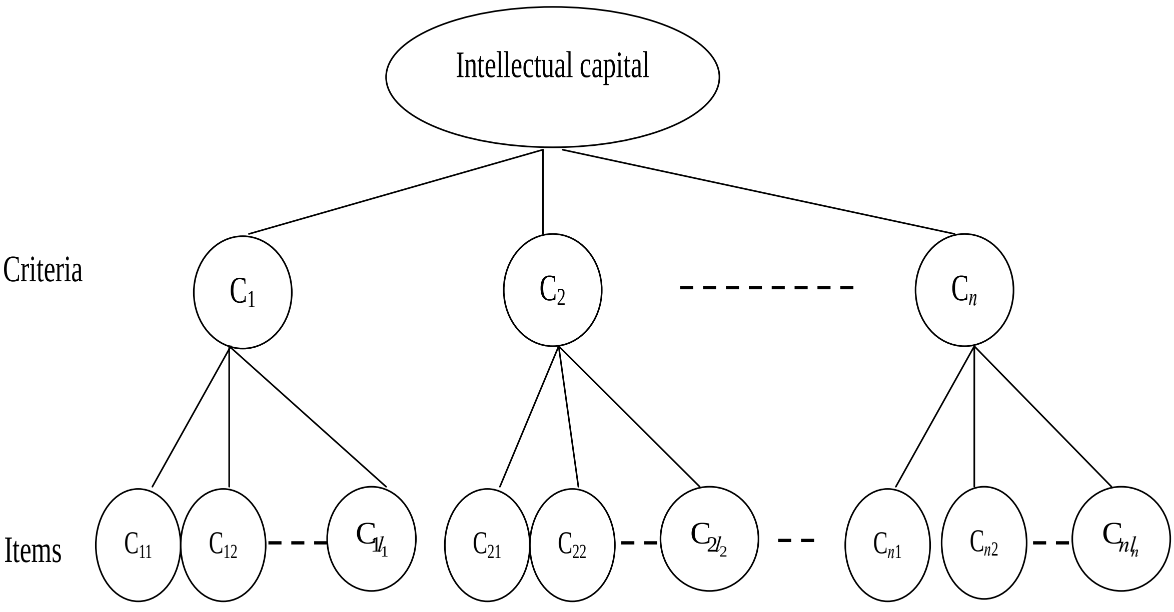

Fig. 4. The evaluation framework of intellectual capital

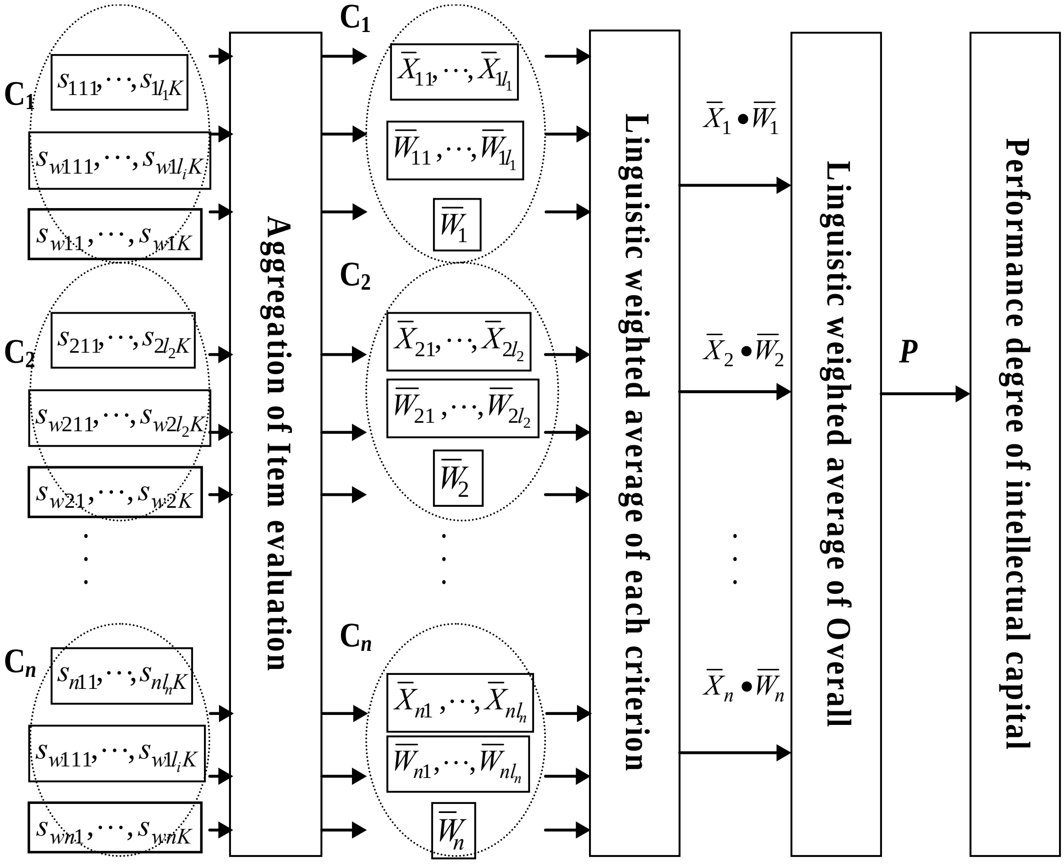

Fig. 5. The procedure of intellectual capital evaluation

5. Case Study

In this case, the proposed method is applied to evaluate the management performance of intellectual capital for a high technology company H in Taiwan. There are three experts who are invited to join the process of management performance evaluation of intellectual capital for company H. Initially, each expert uses the linguistic variables (shown in Table 3) to describe the overall performance level of intellectual capital for company H. The evaluation results by three experts are ‘Good’ (G), ‘Good’ and (G) ‘Good’ (G), respectively. According to the proposed method, the computational procedure of intellectual capital evaluation is presented as follows:

Step 1. Experts use the linguistic variables to (shown in Table 2) to determine the importance of each criterion and importance of each item with respect to each criterion (shown in Tables 4 and 5). And then, each expert uses the linguistic variables (shown in Table 3) to determine the performance rating of each evaluation item with respect to each criterion (shown in Table 4).

Step 2. Applying the 2-tuple fuzzy linguistic aggregation method to compute fuzzy evaluation and weighting value of each item. For example, fuzzy evaluation and weighting value of item “Market share” with respect to criterion “Customer capital” are computed as

$$\bar{X}_{11} = \Delta\left(\frac{1}{3}\sum \Delta^{-1}(s_4,0),\Delta^{-1}(s_2,0),\Delta^{-1}(s_3,0)\right)$$

$$= \Delta\left(\frac{1}{3}(1.0+0.5+0.75)\right) = \Delta(0.75) = (s_3,0)$$

$$\bar{W}_{11} = \Delta\left(\frac{1}{3}\sum \Delta^{-1}(s_4,0),\Delta^{-1}(s_4,0),\Delta^{-1}(s_4,0)\right)$$

$$= \Delta\left(\frac{1}{3}(1.0+1.0+1.0)\right) = \Delta(1.0) = (s_4,0)$$

Step 3. Computing the 2-tuple fuzzy linguistic weighting value of criterion “Customer capital” as

$$\bar{W}_1 = \Delta\left(\frac{1}{3}\sum \Delta^{-1}(s_3,0),\Delta^{-1}(s_3,0),\Delta^{-1}(s_4,0)\right)$$

$$= \Delta\left(\frac{1}{3}(0.75+0.75+1)\right) = \Delta(0.83) = (s_3,0.08).$$

Step 4. Applying the 2-tuple fuzzy linguistic weighted average method to compute fuzzy rating value. For example, the fuzzy rating value of in criterion “Customer capital” can be computed as

$$\bar{X}_1 = \Delta\left(\frac{\sum \Delta^{-1}(s_3,0)\bullet\Delta^{-1}(s_4,0),\Delta^{-1}(s_3,0)\bullet\Delta^{-1}(s_3,0.08),\Delta^{-1}(s_4,-0.08)\bullet\Delta^{-1}(s_3,0.08),\Delta^{-1}(s_3,-0.08)\bullet\Delta^{-1}(s_3,0)}{\sum \Delta^{-1}(s_4,0),\Delta^{-1}(s_3,0.08),\Delta^{-1}(s_3,0.08),\Delta^{-1}(s_3,0)}\right)$$

$$= \Delta\left(\frac{0.75*1.0+0.75*0.83+0.92*0.83+0.67*0.75}{1.0+0.83+0.83+0.75}\right) = \Delta(0.77) = (s_3,0.02)$$

Step 5. According to fuzzy rating and weighting value of each criterion to compute the overall performance level of intellectual capital as

$$P = \Delta\left(\frac{\sum\Delta^{-1}(s_3,0.02)\bullet\Delta^{-1}(s_3,0.08),\Delta^{-1}(s_3,-0.02)\bullet\Delta^{-1}(s_4,-0.08),\Delta^{-1}(s_3,0.11)\bullet\Delta^{-1}(s_4,-0.08),\Delta^{-1}(s_3,0.08)\bullet\Delta^{-1}(s_4,-0.08)}{\sum\Delta^{-1}(s_3,0.08),\Delta^{-1}(s_4,-0.08),\Delta^{-1}(s_4,-0.08),\Delta^{-1}(s_4,-0.08)}\right)$$

$$= \Delta\left(\frac{0.77*0.83+0.73*0.92+0.86*0.92+0.83*0.92}{0.83+0.92+0.92+0.92}\right) = \Delta(0.80) = (s_3,0.05)$$

Step 6. The result of performance evaluation of intellectual capital P is 2-tuple fuzzy linguistic information, and its mapping linguistic term is ‘Good’ according to the linguistic term set S. The evaluation result by this proposed method is consistent with the overall performance evaluation by three experts.

Table 4. The fuzzy evaluation value of each item

Criteria	Item	Linguistic rating			Linguistic importance		
		E_1	E_2	E_3	E_1	E_2	E_3
Customer capital	Market share rate	VG	F	G	VI	VI	VI
	Number of major customer	G	VG	F	I	VI	I
	Customer loyalty	VG	G	VG	I	I	VI
	Customer satisfaction	F	F	VG	VI	F	I
Organization capital	Company brand	F	G	VG	VI	F	VI
	Trademark	VG	F	G	F	I	I
	Information system	G	G	G	VI	I	F
	Index of productivity	F	F	VG	I	F	VI
Innovation capital	Number of new product or process	G	VG	VG	VI	I	VI
	Number of patent	VG	F	VG	I	I	F
	Fee of research/ fee of total	VG	G	G	VI	I	I
Human capital	Ratio of employee leave	VG	VG	G	I	F	VI
	Output value of each employee	VG	F	VG	VI	I	VI
	Training hour of each employee	F	G	VG	I	I	I

Table 5. The weight and rating of each criteria, and overall performance

Criterion	Linguistic importance			Weighted rating	Aggregated weighting	Overall performance
	E_1	E_2	E_3			
Customer capital	VI	I	VI	(s_3, 0.02)	(s_3, 0.08)	(s3, 0.05) or (G, 0.05)
Organization capital	VI	VI	I	(s_3, -0.02)	(s_4, -0.08)	
Innovation capital	I	I	VI	(s_3, 0.11)	(s_4, -0.08)	
Human capital	VI	I	VI	(s_3, 0.08)	(s_4, -0.08)	

6. Conclusions

As the trend of knowledge economy, more and more enterprises identify intangible factors, like knowledge, brand and other intellectual capital, have replaced traditional tangible asset and become the major resource of benefit making gradually. In the strategy direction making, intellectual capital evaluation model should be a feasible tool for enterprise to discover the core competitive advantage and plan the direction of business development in the future. Furthermore, managers can handle and improve existing intellectual capital effectively and efficiently in accordance with different performance level of each item and criterion.

In this paper, a feasible enterprise intellectual capital evaluation model by means of 2-tuple fuzzy linguistic approach is proposed to assist managers understand the performance of intellectual capital for their enterprises. In this proposed model, linguistic variables are applied to express the level of qualitative evaluation items and criteria of expert's subjective judgment. And then, 2-tuple fuzzy representation and operation method is applied to deal with the aggregation of rating and weighting among items and criteria effectively. Significantly, the proposed model provides enterprise a flexible mean to deal with performance evaluation of intellectual capital in a real business environment. It is helpful for enterprise managers to handle and understand the status of intellectual capital more efficiently and effectively.

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