Using Fuzzy MCDM to Evaluate Index and Benefit Preference on Communities of Practice

M. T. Chu, J. Z. Shyu
Institute of Management of Technology, University of National Chiao-Tung, Taiwan

Abstract—Benefit preference and index evaluation on Communities of Practice (CoP) will profoundly impact on the competitive advantage of knowledge management (KM) total solutions and specific problems. As enterprises grow in size, scope, and complexity, implementation of CoP on members who regularly engage in sharing and learning based on common interests, can improve organizational performance. The purpose of this research is to use the fuzzy Multi-Criteria Decision Making (MCDM) method to identify index priority and to measure the four-benefit preference of CoP. In survey case were given fifty-seven questionnaires about their priorities towards sixteen different pairs of criteria. Additionally, they were also asked to estimate their four highest achievable benefit utility preferences. These evaluation criteria include satisfying multi-dimensions to capable operators. Under each of the four first-tier dimensions, four second-tier criteria are used to assess and echo their first-tier dimensions. The survey results have three parts. First, the four dimensions are weighted, dimension of Member Interaction is heavily weighted, Incentive Mechanism is the next, and Locus of Leadership is the least. Second, the sixteen criteria are prioritized, Emphasize Cross-Field Sharing is highest prioritized, Achievement Appraisal Basis is next, and Bottom-Up Teaming and Independent IT Platform are the lowest. Third, the four benefit alternatives are scored; Increase Core Competency has the highest utility score in satisfying the multiple-dimensions while Promoting Responsiveness is the last. The findings of this paper can promote performance value of implementing knowledge management and references of competitive strategies for CoP.

Keywords—Benefit Preference, Communities of Practice (CoP), fuzzy Multi-Criteria Decision Making (MCDM)

I. INTRODUCTION

CoP simultaneously emphasizes storage and dissemination of explicit and tacit knowledge. CoP promotes member interaction and knowledge sharing, enables organization learning, and induces innovation to maximize the value of knowledge management.

Global enterprises, such as IBM, 3M, Xerox, Cisco, and Dell, intensely condense members' centripetal force to activate enterprise's innovation. Company management organizes and maintains knowledge sedulously and systematically. Therefore CoP structure has taken a new central role in the value chain. As knowledge complexity increases, and specialization and cooperation grow, the knowledge lifecycle also shorten. Therefore, CoP must concentrate focus in important field to meet the fast changes.

II. METHODOLOGY

In the pure environment, or simple appraisal index, a method such as cost minimization, profit maximization, or cost effect analysis to evaluate different plans can be used. However, a complex situation with multi-goals has too much interdependent information to analyze. The traditional analysis method is not suitable to find the solution. Therefore this research used fuzzy MCDM to evaluate each of the possible benefit preference. The inconsistent environment is due to the multi dimension. During the process, all participants' linguistic opinion is not absolute and unique. This research uses fuzzy linguistic cognition to express varying degree of value to the quantity criteria and to discuss each kind of benefit preference in CoP. The following explains the related procedure and steps. Constructing a Multi-Criteria Decision-Making Model, Fig.1 shows the appraisal hierarchy system.
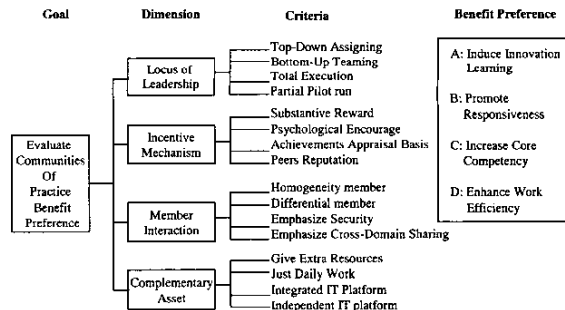

Fig 1. The Hierarchy System of Evaluation Indexes of CoP Benefit Evaluation

The evaluation of the related hierarchy system and weights comes from a pair wise comparison of AHP method; each factor's importance within the hierarchy is determined by their weights. The observed evaluation system and indexes in the hierarchy of each dimension in Fig.1 are used as a template on the questionnaire. First, we sought to discover the participants' recognition of the relative importance (weights) between the main four

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dimensions of **Locus of Leadership, Incentive Mechanism, Member Interaction** and **Complementary Asset**. Second, the template was used to find out the interviewee's recognition of the relative importance (weights) of the evaluation indexes below each dimension. In doing so, participants can easily understand the problem and analyze the relationship between each evaluation index. This result can reflect the true aspect of each opinion towards the relative importance of the evaluation index in the questionnaire.

This research carries out the ANOVA test from the contents of the questionnaire. The goal is to examine the differences in opinion towards the weights of CoP benefit performance between individuals from different groups. For any significant difference between groups, the Least Significant Difference (LSD) is employed to conduct all pair wise comparison on means between groups.

This research uses triangle fuzzy theory to value the four-benefit preference in view of sixteen criteria. Experts have chosen a fuzzy value region in their questionnaire to show their priority setting. Using Center of Area (COA) solutions to transfer fuzzy linguistic expression (very important, important, ordinary, unimportant, and very unimportant) to Best Non-fuzzy Performance (BNP). These BNP represent the participant's comment on the quantity criteria effective value regarding the four kinds of benefits and sixteen criteria. These effective values form this participant's effective matrix, and U participants represent the 1st participant's effectiveness matrix.

III. RESULTS

After collecting sixty-two questionnaires, and deleting five invalid volumes, fifty-seven effective questionnaires are used, a returns-ratio of approximately 76%.

A. Opinion of All Groups

Table 1. Dimension and Criteria Weight of all Groups

Dimension/Criteria	Weight	Weight of Each dimension	Weight of Inter dimension	Weight of cross dimension (Ranking)
Locus of Leadership		0.215		
Top-Down Assigning			**0.348 (1)**	0.075 (4)
Bottom-Up Teaming			0.174 (4)	0.037 (15)
Total Execution			0.204 (3)	0.044 (13)
Partial Pilot run			0.274 (2)	0.059 (9)
Incentive Mechanism		0.264		
Substantive Reward			0.280 (2)	0.074 (5)
Psychological Encourage			0.158 (4)	0.042 (14)
Achievements Appraisal Basis			**0.361 (1)**	0.095 (2)
Peers Reputation			0.201 (3)	0.053 (11)
Member Interaction		**0.287**		
Homogeneity member			0.190 (4)	0.055 (10)
Differential member			0.236 (2)	0.068 (6)
Emphasize Security			0.233 (3)	0.067 (7)
Emphasize Cross-Domain Sharing			**0.341 (1)**	**0.098 (1)**
Complementary Asset		0.234		
Give Extra Resource			0.285 (2)	0.067 (7)
Just Daily Work			0.191 (3)	0.045 (12)
Integrated IT Platform			**0.367 (1)**	0.086 (3)
Independent IT platform			0.157 (4)	0.037 (15)

The priority result of all Groups showed the weighting order by all experts in dimension: (1) **Member Interaction** (0.287); (2) **Incentive Mechanism** (0.264); (3) **Complementary Asset** (0.234); (4) **Locus of Leadership** (0.215). As for **Member Interaction** dimension score: (1) **Emphasize Cross-Domain Sharing** (0.341); (2) **Differential member** (0.236);(3) **Emphasize Security** (0.233); (4) **Homogeneity member** (0.190). Other various dimensions and criteria priority are listed in table 1.

B. Average Utility Value and Ranking

The cross dimension weights derived from Table 1. $\bar{W}$ =(0.075, 0.037, 0.044, 0.059, 0.074, 0.042, 0.095, 0.053, 0.055, 0.068, 0.067, 0.098, 0.067, 0.045, 0.086, 0.037). By multiplying U_i with, participant's utility scores for the four benefits are derived.

The averages of the all-participant utility scores for the four benefits can be seen in table 2. From that table, we can see all Groups prefer benefit of **Increasing Core Competency**.

Table 2. Average utility scores towards the four benefits for all Groups

Benefit Preference	Average Utility Scores (Ranking)
A. Induce Innovation Learning	71.36 (3)
B. Promote Effectiveness	70.16 (4)
C. Increase Core Competency	**73.52 (1)**
D. Enhance Work Efficiency	73.38 (2)

C. Variation Analysis of All Groups

SPSS was used to calculate the variation analysis toward benefit weight. The four criteria have apparent different weights between the various groups: **Top-Down Assigning, Emphasize Security, Integrated IT Platform**, and **Independent IT Platform**. LSD to do T-test is used to determine the mean value of pair difference comparison during groups used.

D. Equations

The following is a mathematical formula given offers hope to compare standard set with n standards, according to its relative importance weights. Suppose the standard for comparison is $c_1, c_2... cn$, and the weights of each is $w_1, w_2... w_n$, and assuming $w = (w_1, w_2,..., w_n)'$, then the pair wise comparison can be represented by formula of matrix A'

$$(A - \lambda_{max} I) W = 0$$

(1)

Formula (1) shows how A is a pair wise comparison matrix sorted in order by instinct and judgment. In order to come up with the priority Eigenvector, we must satisfy the Eigenvector of every w of $Aw = \lambda_{max} w$, the λ_{max} is the maximum eigenvalue of A. The sorting judgment of the order of pair wise comparison is observed and examined

for consistency because an $n \times n$ matrix A includes n independent feature $*_j$ moreover, $j=1,2...n$, also ranks aspects in order according to dimension (the same as the concept of main component analysis), $\sum_{j=1}^{n} \lambda_j$ is the Diagonal Element of matrix A and $\sum_{j=1}^{n} \lambda_j = \text{tr } (A)$ is the total. The diagonal factor line of matrix A is 1, so the total of the diagonal line factor of matrix A is n, therefore, only one $\lambda_j = 0$ ($\lambda_j \neq \lambda_{max}$) from the middle of $C.I. = (\lambda_{max} - n)/(n - 1)$ ' $(C.I.)$. The latter deviation value is what evaluates consistency.

As an example: $C.I. = (\lambda_{max} - n)/(n - 1), (C.I.)$ is close to the consistency index, so it's deemed consistent. Generally speaking, only a value smaller than 0.1, can satisfy our judgment. In this problem, the participant doing the strategic analysis must take four dimensions into consideration as shown in Fig. 1.

IV. DISCUSSION

The results of this research show the overall weights of CoP benefit preference index and the differences between each group. Surveyed case plays an important role in the development of Taiwan's KM. The results of this research could be referenced by other R&D organizations. If enterprise have already started to impel KM, and progressed to the stage of organization learning or encourage innovation, they should specially emphasize CoP related execution.

Proper mechanism and strategy will enable successful knowledge sharing. CoP as one promotion approach, provides infrastructure of creating value and promote organizational intellectual capital value. Only by well-defined concrete goal can CoP devote their resources to overcome the inherent problems and realize their contribution. If organizations have not established a measurement standard, CoP will be unable to control their impact and outcome.

As for the criteria evaluation, **Emphasize Cross-Domain Sharing, Achievements Appraisal basis,** and **Integrated IT platform** score the highest. Therefore we suggest the above three indexes should be the improvement targets. Taking into consideration future innovation benefit instead of present will increase core competency benefit, and then can maintain global competition superiority.

In a knowledge economy era, tangible assets do not lead to the biggest competitive advantage for enterprises. The scholars mostly thought CoP will become effective approach in learning organization, and the benefit of Cop will become the organizations achievement. They believe that this will become the method to develop and maintain long-term organization memory. After realizing organization knowledge creation and sharing is the source of competitive advantage, Enterprise must establish an

infrastructure to enable knowledge exchangeable and shareable through CoP implementation. An organization's best results come from maintenance, strength, creating dialogues between people, and sharing information and knowledge. To cultivate CoP successfully, organizations must embrace dynamic and flexible viewpoints and facilitate core members sharing. Facilitate personnel's participation, simultaneously develop interaction space, contains physical and virtual environment, also watch continually value generation or not, and establish mutual trust and innovation training.

V. CONCLUSION

CoP enhances knowledge sharing and avoids resource overlapping. The conclusions are based on research of practical case where CoP is acknowledged for creating value. CoP is regarded as an important tool to integrate cross-domain energy. Creating mutually a beneficial and valuable infrastructure to connect knowledge owners and demanders is crucial. To realize the target, CoP should focus on locus of leadership, incentive mechanism, member interaction, and complementary asset. Real case implementation provides precious experience towards CoP. Therefore; priority about each dimension and criteria of CoP benefit preferences should be planned before construction. The interview and survey process reveal that all knowledge worker are concerned with the benefit preference. This research purpose was to make an objective evaluation through Taiwan's case study, by investigating various CoP experts' opinion, and to provide a reference about CoP benefit preferences.

Enterprises have considerable differences in preference due to their different missions. These preferences are shown by the expected benefit assessment weights. A major motive of this research is to determine if each group has distinct CoP index of benefit preferences. Rather, an evaluation should be derived from the index weights agreed upon by groups of similar natures.

A. Results Analysis of Dimension and criteria

All participants' top weighting is **Member Interaction** (28.7%). **Incentive Mechanism** (26.4%) is second and **Locus of leadership** (21.5%) third. Among the sixteen criteria, **Emphasize Cross-Domain Sharing** receives top weighting at 0.098. **Achievement Appraisal Basis** is second at 0.995, and **Bottom-Up Teaming** and **Independent IT Platform,** with weighting 0.037, achieve the lowest score. For dimension of member interaction, **Emphasize cross-domain sharing** (0.341) relative importance is highest, obviously CoP experts hope to break boundaries through new thought and working patterns, and enlarge cross field synergy, by way of

mutual exchange and integration. Each kind of participants chooses four kinds of goals dimension importance.

B. Perception of CoP benefit preference

R&D organizations are usually comprised of a system of divisions, each with distinct research programs aimed at an assortment of industries and customers. This mix accounts for the lack of any common model or mechanism of evaluation to help CoP in either meeting institutional goals or enhancing performance. At the beginning of implementing CoP, varying degrees of cognition and preference regarding management issue often lead to transformation obstruction. Difference between locus of leadership, incentive mechanism, member interaction, and complementary asset, where discover. In addition, the operating mode and achieved benefits were also found to be different. Dividing cognition and benefit into two layers may differentiate CoP's four benefits. Most of group experts rank **Increase core competency** (73.52) and **Enhance Working Efficiency** (73.38) higher, and **Induce innovation learning** (71.36) and **Promotion responsiveness** (70.16) lower, because KM goal is to increase core competitive ability by the CoP approach. This research analysis result confirms present situation

First, this research constructs a multi-criteria model for CoP benefit reference (see Fig.1), from interview and questionnaire data conducted to experts in order to collect their priority settings.

Then, pair wise comparison in the first level by the participant four kind of goals constructions relative importance, as well as in the second level respectively to comment the quantity criteria relative importance, and therefore calculates various goals AHP weight.

Each participant expresses fuzzy linguistic expression denoted by: very important, important, ordinary, unimportant, and very unimportant. The COA method is used to calculate best non-fuzzy performance (BNP). These BNP represent the participants' utility value regarding the four benefits and sixteen criteria. Then multiple cross-goal ranking are used to get the priority and obtain average utility value. Table 1 collects entire average utility value and ranking of CoP benefit reference by four groups.

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