Applying Fuzzy Theory to the Management Competency Assessment for Middle Managers

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Abstract: Middle managers act as a role of changing agent, focus on strategy implementation, and bridge the senior management level and the front lines. The purposes of this study are to assess the management competencies for middle managers; and to evaluate, from the point of view of supervisors, the candidates for middle managers by Fuzzy Analytic Hierarchy Process (FAHP). This study found that after data collected from field expert questionnaire survey and analyzed by FAHP the result provides ranking for the management competency assessment for middle managers.

Key-Words: - Management Competency, Fuzzy Theory, Fuzzy Analytic Hierarchy Process

1. Introduction

To be a successful corporation, the precondition is to have outstanding talents. Especially in technology-intensive and capital-intensive industries, managers bear increasingly large responsibilities. Katz [1] indicated that an outstanding manager should possess the following three management skills, the percentages of which are adjustable according to positions and responsibilities in the management level. The three skills are Technical Skill, Human Skill and Conceptual Skill. Middle manages usually plays the roles in between the top management and the subordinates.

Carolyn R. Farquhar, Principal Associate Research of Centre for Management Effectiveness of the Conference Board of Canada, expressed that in a company the most critical management processes, initiatives, pursuing new strategic directions, and implementing changes are mostly contributed from middle managers. Thus, middle managers act as a role of changing agent, focus on strategy implementation, and bridge the upper management level and the front lines. For the unique position of the middle managers in an organization, therefore, it is critical and necessary to an organization to evaluate the management competency for managers.

Since human thinking usually involve many psychological factors, for examples, preference, emotion, presentiment and obscurity etc., thus uncertainty—vagueness of description, incompleteness of information and vagueness of the object itself [2] -- occures. In the process of evaluating of management competency, if qualitative criteria are involved, the assessment indexes will result in subjectivity. In addition, difference in personal cognition and value-concept would further adverse the fairness of performance assessment.

Fuzzy theory is a theory about vagueness and uncertainty, and enables us to use non-precise, ill-defined concepts and yet to work with these in a mathematically strict sense [3, 4]. The theory provides a proper expression for the vagueness and works well for many applications [5].

2. Literature Review

2.1 Meaning of Competency

Competency was first brought up by Harvard University professor D. McClelland [6]. In the early time, "competency" was studied as "personal trait". After thorough study, researchers started questioning the correlation between personal trait and work performance, which led to diversified study. Parry [7] distinguished the definition among traits, competency, skills and value. He views traits and characteristics refer to description of personality, including cooperation, aggressiveness, and decisiveness et al., which have already been defined since the early time of human life and do not have training effect. But skills and ability are formed both naturally and afterward. Skills are generated during solving special issues. As for value and style, researchers believe they are formed in the early age and develop into a role model because of environment and social authority. Both value and style can affect the management behavior for a manager. Competency and skills are frequently misused for the similar subject. Parry argues that skills tend to be situated and specific, while competency tends to be generalized and extensive. Parry notes that competency is: 1) a cluster of related knowledge, attitudes and skills that affects the major part of one's job; 2) that correlates with performance on the job and can be measured against well-accepted standards; and 3) that can be improved via training and development.

Boyatzis [8] states that competency is an underlying characteristic of an individual, which is causally related to effective or superior performance in a job. Chisholm [9] thought professional core competency contains three elements: knowledge, skills and attitudes. The three elements interact concurrently in a practical scenario

2.2 Management Competency

For the definition of management capability, although researchers have different views there are three types of study: trait approach, functional approach and situation approach.

2.2.1 Trait Approach

Personal trait refers to any persistent psychological characteristic, whether it is explicit behavior or inner personality, as long as it is unique. These researchers believe a successful manager has unique personal traits. The approach is to find what personal traits would affect management performance. This approach was popular between 1940 and 1950.

Stogdill [10] found a leader should possess seven traits: figure, look, confidence, social ability, will, management ability and active spirits (including style of conversation, expression ability, creativity). Davis [11] summarized many traits as four items: wisdom, social maturity and extensiveness, inner motive and accomplishment, social relationship attitude.

2.2.2 Functional Approach

Researchers taking functional approach focus on "the required abilities for a manager to accomplish the work in the highest performance level". The most well-known theory was proposed by Katz in 1955 for the three required skills for a manager: professional skills, interpersonal skills and concept skills. Moravec and Trucker [12] note that management skill matrix should replace traditional job description. The management skill matrix is composed of the following seven skills: 1) Technical Expertise, 2) Business Awareness, 3) Communication & Interpersonal, 4) Decision making & Initiative, 5) Leadership & Guidance, 6) Planning & Organizational Ability, 7) Problem Solving.

Moulton [13] argues that a manager should have the following five management capabilities: 1) environment awareness: understanding of global view and different cultures, 2) leadership: active attitude, value concept and ethics, 3) general management: integration ability, technical ability and flexibility, 4) interpersonal relationship: negotiation and communication abilities, 5) ability to accomplish assignment: strategic planning, policy development, functional orientation and micro-economic knowledge.

2.2.3 Situational Approach

Researchers taking situational approach believe there is not much difference in personality, traits or capability for successful managers, and the key to success lies in the situation a manager faces. They think personality, traits, and capabilities are not essential to management success, but more emphasize the importance to cope with the situation. Because situational approach considers the whole environment and involves too many factors, so it has difficulty in practical application and fails to control the actual situation facing a manager.

This study adopts the eight dimensions as criteria for management competency developed by Yian-Hui Wu [14] according to theory from Sandwith [15] and Reilz [16] on functional approach and trait approach. They are concept skill, interpersonal skill, leadership skill, administrative skill, professional skill, personal trait, ability and motive and will be used as criteria for assessment.

2.3 Fuzzy Analytic Hierarchy Process

The Fuzzy set theory, proposed by Zadeh(1965) with the objective of providing a mathematical tool for imprecise information treatment. The theory uses membership function to handle uncertain data. After systematic fuzzy operation, data are quantified and become useful information. The Analytic Hierarchy Process [AHP], proposed by Saaty [17], is a mathematical decision making technique that allows consideration of both qualitative and quantitative aspects of decisions. It reduces complex decisions to a series of one-on-one comparisons, then synthesizes the results, which is applicable to multiple criteria decision making.To overcome the uncertinty and vagueness of subjective perception in evaluation procedure , Buekley(1985) integrates the AHP with fuzzy theory to improve the uncertailty.

3. Research Method

First phase is setting the expert linguistic fuzzy numbers based on nine conversion scales and then setting membership function. The second phase is to calculate the fuzzy weight for each criterion.

Phase 1:

A. Setting Expert Linguistic Membership Functions:

Table 1. Linguistic Fuzzy Numbers

	Linguistic Term	Triangular Fuzzy Number
1	Equally important, or good	(1, 1, 2)
2	Between 1 and 3	(1, 2, 3)
3	Moderately important, or good	(2, 3, 4)
4	Between 3 and 5	(3, 4, 5)
5	Important, or good	(4, 5, 6)
6	Between 5 and 7	(5, 6, 7)
7	Very important, or good	(6, 7, 8)
8	Between 7 and 9	(7, 8, 9)
9	Extremely important, or good	(8, 9, 9)

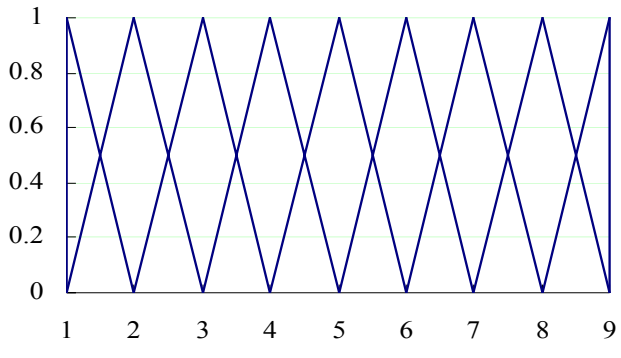

Fig. 1. Linguistic Fuzzy Numbers

B. Developing pairwise Comparison Questionnaire:

Two types of fuzzy pairwise comparison questionnaire developed. One is the pairwise comparison questionnaire for the middle managers under each criterion; the other is the comparison for the relative importance among different criteria.

C. Convert Expert Linguistic Term to Fuzzy Positive Reciprocal Matrix:

Converting linguistic terms of pairwise comparison questionnaire into fuzzy positive reciprocal matrix by m decision makers towards four manager candidates under k criteria.

Phase 2:

A. Consistency Test for Fuzzy Positive Reciprocal Matrix of Expert:

$$C.I. = (\lambda_{\max} - n)/(n-1) \quad (1)$$

$$C.R. = C.I./R.I. \quad (2)$$

$\lambda_{\max}$: maximum eigenvalue; N: matrix order

When $CR = 0$ there is complete consistency; $CR < 0.1$ it is tolerable error.

Random Index (RI) value are shown in Table 2, which are randomly generated C.I. values under different orders and according to the positive reciprocal matrix from assessment scale 1~9.

Table 2. Random Index Value

N	1	2	3	4	5	6	7
RI	0	0	0.58	0.9	1.12	1.24	1.32

N	8	9	10	11	12	13	14	15
RI	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.58

B. Integration of Group Positive Reciprocal Matrix:

To integrate expert questionnaire data with the minimum value as the lower limit, geometric mean as the intermediate, the maximum value as the upper limit. It can derive the integration value for expert group decision. The operation equations are as follows:

Triangular fuzzy number $\tilde{a}_{ij}^{m} = (\alpha_{ij}, \beta_{ij}, \delta_{ij})$, $\alpha_{ij} \le \beta_{ij} \le \delta_{ij}$ and $\alpha_{ij}, \beta_{ij}, \delta_{ij} \in [1/9,1] \cup [1,9]$.

The minimum for all assessment values by m experts for mutual assessment of the i and the j

$$\alpha_{ij} = \min(B_{ij}^m) \quad (3)$$

The geometric mean for all assessment values by m experts for mutual assessment of the i and the j

$$\beta_{ij} = (\prod_{k=1}^{n} B_{ij}^m)^{\frac{1}{n}} \quad (4)$$

The maximum for all assessment values by m experts for mutual assessment of the i and the j

$$\delta_{ij} = \max(B_{ij}^m) \quad (5)$$

C. Calculating and adjusting Fuzzy Weight:

$$Q_l^k = \min\left(\frac{W_{im}^k}{W_{il}^k}\right), \ 1 \le i \le n \quad (6)$$

$$Q_u^k = \max\left(\frac{W_{im}^k}{W_{iu}^k}\right), \ 1 \le i \le n \quad (7)$$

$$W_{il}^{k'} = Q_l^k \times W_{il}^k \quad (8)$$

$$W_{iu}^{k'} = Q_u^k \times W_{iu}^k \quad (9)$$

D. Defuzzy and Weight Normalization:
relative distance

$$r_{wi} = d(\widetilde{W}_i,0)/(d(\widetilde{W}_i,0) + d(\widetilde{W}_i,1)) \quad i = 1,2,...,n \quad (10)$$

$$d(\widetilde{W}_i,0) = \sqrt{\frac{1}{3}((W_{il}-0)^2 + (W_{im}-0)^2 + (W_{iu}-0)^2)} \quad (11)$$

$$d(\widetilde{W}_i,1) = \sqrt{\frac{1}{3}((W_{il}-1)^2 + (W_{im}-1)^2 + (W_{iu}-1)^2)} \quad (12)$$

E. Integrating Criterion Weights:
To provide overall scores by combining the calculated result for the relative weight among all criteria and the four candidate's weights and ranking on overall scores with the equations as follows. The higher overall score puts the candidate the frontier.
$R = C \otimes W$, R is the final overall score, C is criterion weight, W is the relative weight for each criterion.

4. Data Analysis

The study is to use the assessment of management competency by four decision makers towards four middle managers. The criteria are eight indexes: concept skill, interpersonal skill, leadership, administrative skill, professional skill, personal trait, ability and motive. The questionnaire result is analyzed by FAHP and starts with calculation of criteria' fuzzy weights.

A. Consistency Test for Questionnaire Result:
The study conducts consistency test on the intermediate values of fuzzy positive reciprocal matrix. Through geometric mean, weight, new vector and characteristic value, it can find whether the questionnaire has consistency as shown in Table 3. If not, the questionnaire will be repeated until no consistency problem.

Table 3. Consistency for Capability Trait M1 intermediate value

	A	B	C	D	GM	W	NV	λ
A	1	1/6	1/2	1/2	0.452	0.077	0.322	4.173
B	6	1	7	5	3.807	0.650	2.665	4.101
C	2	1/7	1	1/3	0.551	0.094	0.398	4.232
D	2	1/5	3	1	1.047	0.179	0.745	4.171
				SUM	5.857			16.676

$\bar{\lambda}$ =4.169, GM= geometric value; W= weight; NV= new vector.

Values of rank A is obtained as following geometric value:
0.452= (1x1/6x1/2x1/2) ^ (1/4)
Weight: 0.077 = 0.452/5.857
New vector: 0.322 = 1×0.077+1/6×0.650+1/2×0.094+1/2×0.179
λ : 4.173 = 0.322/0.077
values of B, C and D obtained by the same operation.
$C.I. = (\lambda_{\max} - n)/(n-1) = 0.056$,
$C.R. = C.I./R.I. = 0.062$
$RI = 0.9$, $CR < 0.1$ means consistency is satisfied.

B. Integration of Group Positive Reciprocal Matrix:

The procedure is to integrate four decision makers' data with the minimum value as the lower limit, geometric mean as the intermediate, the maximum value as the upper limit.

C. Calculating Fuzzy Weight:

To calculate the integrated weight for group positive reciprocal matrix according to geometric mean calculation. Table 4, Table 5 and Table 6 show the Lower coefficient, middle coefficient and upper coefficient.

Table 4. Lower Coefficient

	A	**B**	**C**	**D**	**GM**	**W**
A	1	1/9	1/6	1/5	0.247	0.064
B	5	1	2	4	2.515	0.657
C	1	1/8	1	1/4	0.423	0.111
D	1	1/6	1	1	0.639	0.167
				SUM	3.825	1

Table 5. Middle Coefficient

	A	**B**	**C**	**D**	**GM**	**W**
A	1	1/7	1/3	3/7	0.385	0.068
B	7	1	4	5	3.546	0.624
C	2	2/9	1	2/3	0.801	0.141
D	7/9	2	1/5	1	0.953	0.168
	3/8		3/4			
				SUM	5.684	1

Table 6. Upper Coefficient

	A	**B**	**C**	**D**	**GM**	**W**
A	1	1/5	1	1	0.669	0.083
B	9	1	8	6	4.559	0.567
C	6	1/2	1	1	1.316	0.164
D	5	1/4	4	1	1.495	0.186
				SUM	8.039	1

D. Adjusting the Fuzzy Weight:

To adjust and assure the calculated fuzzy weight be triangular fuzzy number. The results is shown in Table 7

Table 7. Adjusting Fuzzy Weight

				Low Coef.	**Upper Coef.**
w	lower	middle	upper	0.949	1.100
A	0.064	0.068	0.083	1.049	0.814
B	0.657	0.624	0.567	0.949	1.100
C	0.111	0.141	0.164	1.269	0.860
D	0.167	1.168	0.186	1.003	0.901

Adjusting Weight		
Lower	Middle	Upper
0.061	0.068	0.092
0.624	0.624	0.624
0.105	0.141	0.180
0.159	0.168	0.205

E. Defuzzy and Weight Normalization:

To convert the adjusted fuzzy weight into a crisp value. The result is shown in Table 8

F. Integrating Criterion Weights:

To integrate the weight for each criterion and provide overall score based on the weights of eight assessment criteria and ranking according to overall score. The result is shown in Table 9. Weight for Each Candidate, Table 10: Weights for Eight Criteria, Table 11: Overall Score.

Table 8. Weight Normalization

$r_{wi} = d(\tilde{W}_i,0)/(d(\tilde{W}_i,0) + d(\tilde{W}_i,1))$

	$d(\tilde{W}_i,0)$	$d(\tilde{W}_i,1)$	relative distance	normalization
A	0.075	0.927	0.075	0.073
B	0.624	0.376	0.624	0.611
C	0.145	0.858	0.145	0.142
D	0.178	0.823	0.178	0.174
		SUM	1.021	1

Table 9. Candidates' Weight

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
A	0.272	0.392	0.301	0.291	0.252	0.071	0.073	0.197
B	0.297	0.149	0.205	0.236	0.268	0.602	0.611	0.198
C	0.205	0.245	0.317	0.282	0.251	0.154	0.142	0.382
D	0.226	0.215	0.177	0.190	0.230	0.173	0.174	0.223

Table 10. Weights for Eight Criteria

C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
0.054	0.066	0.322	0.048	0.178	0.110	0.137	0.085

Table 11. Overall Score

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	Score	Rank
A	0.015	0.026	0.097	0.014	0.045	0.008	0.010	0.017	0.231	3
B	0.016	0.010	0.066	0.011	0.048	0.066	0.084	0.017	0.318	1
C	0.011	0.016	0.102	0.014	0.045	0.017	0.019	0.032	0.256	2
D	0.012	0.014	0.057	0.009	0.041	0.019	0.024	0.019	0.195	4

5. Conclusions

This study found that by FAHP the result provides ranking for the management competency assessment for middle managers. This is not only for assessing the management competency for middle managers; upper managers can also use the result in internal selection for manager candidates. This decision tool

is very simple and effective for assessing management capability.

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