Application of the Fuzzy Delphi Method and the Fuzzy Analytic Hierarchy Process for the Managerial Competence of Multinational Corporation Executives

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***Abstract*—The purpose of this study is to evaluate the important indicators of managerial competences for MNC executives. This research attempts to construct the initial indicators of managerial competence for MNC executives. Then, a focus group of MNC experts was established to discover the managerial competences relating to the job extent of MNC executives. The procedure of adopting the Fuzzy Delphi Method (FDM) and the Fuzzy Analytic Hierarchy Process (Fuzzy AHP) are applied to evaluate the structure of managerial competences for MNC executives. The research results indicate that the most important indicators of managerial competence were professional knowledge and leadership, which could not only provide MNCs a guidance to select higher managerial competence of MNC executives, but also select appropriate MNC executives to carry out global business successfully.**

***Index Terms*—Fuzzy analytic hierarchy process (fuzzy ahp), fuzzy delphi method (fdm), managerial competence.**

I. Introduction

With the trend of globalization in the new century, Multinational Corporations (MNCs) confront world intense competition. To pursue the business growth, increase competitive capability and expand world market, MNCs vigorously establish overseas subsidiaries to enhance their international competitive advantages in the trend of globalization [1]. The main reasons why MNCs decide to establish overseas operations are listed as follows: (1) limitation in host country's raw material, higher labor cost, and strict government regulations; (2) Incentives provided by foreign countries' preferential investment program, potential development market, and raw material accessibility. MNCs engage in different overseas strategic operations for the following four types: ethnocentric, polycentric, regiocentric, and geocentric [2]. Thus, well human resources arrangement and appropriate selection of MNC executives in overseas are essential for MNC to execute overseas business. Few researches focus on the evaluations of selecting high-tech executives for foreign assignments. This research intends to evaluate the selection of MNC managers for foreign assignment as the following steps. First, this research attempts to construct the initial indicators of managerial competence for high-tech MNC executives. Second, a focus group of high-tech MNC experts was established to discover the managerial competences relating to the job extent of MNC executes. Third, the quality factors related to the evaluation criteria are selected by using Fuzzy Delphi method. Fourth, Fuzzy AHP is applied to determine the important indicators of managerial competences for MNC executives. The research results not only provide MNCs a valuable guidance to improve the selection model of MNC executives, but also select appropriate executives to carry out overseas business successfully.

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II. The Conceptual Framework of the Research

To assure the accuracy of selection process, this study combined with several research methods, including both qualitative and quantitative research methods to evaluate the selection of the managerial competences for MNC executives. The Focus Group method and Fuzzy Delphi Method (FDM) were used to select appropriate indicators of the managerial competences for MNC executives. Then, the Fuzzy AHP was applied to selecting the important indicators**.** The whole research processes of this study were divided into the following four steps:

A. Step One: Establishing the Initial Indicators of Managerial Competence

The first step was to construct the structure of initial indicators of managerial competence for MNC executives.

B. Step Two: Focus Group Method

A focus group composed by MNC managerial experts was established to define the managerial competence indicators of MNC executives. A focus group method was employed to develop and construct the essential indicators of managerial competences related to the professional management job of MNC executives [3].

C. Step Three: Fuzzy Delphi Method (FDM)

The FDM was developed to 1) build the structure of managerial competences; 2) set up the evaluations of weights; and 3) select the important criteria of managerial competences for MNC executives [4].

D. Step Four: Fuzzy Analytic Hierarchy Process (Fuzzy AHP)

The Fuzzy AHP was applied to 1) build the hierarchical structure; 2) set up the pairwise comparative matrixes; 3) generate group integration; (4) construct the fuzzy judgment matrices; 5) calculate the fuzzy weight; 6) defuzzify a triangular fuzzy number into a crisp number; and 7) rank the defuzzified numbers [5].

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III. Constructing the Initial Indicators of Managerial Competence

This research attempts to discover the initial indicators of managerial competence for high-tech MNC executives. Based on previous literature review, the structure of initial managerial competence for MNC executives are illustrated as the following 4 main aspects: (1) conceptual skills, (2) social skills, (3) technical skills, and (4) personality. This study both applied qualitative and quantitative approaches to integrate the advantages of each research approach.

IV. Focus Group

After constructing the managerial competence criteria for high-tech MNC executives, a focus group of high-tech MNC experts was established to discover the managerial competences relating to the job extent of MNC executes. The focus group could provide positive suggestions for the adjustment to the structure of initial managerial competence criteria. To ensure that the invited experts actually realize the operation of multinational management, 16 experts from various industries, governments, and academic organizations in Taiwan were invited to participate in the focus group. The experts were required to have more than 15 years of multinational managerial experience and invited from well-known multinational corporations or organizations.

V. Fuzzy Delphi Method

After studying the opinions collected via the focus group for the adjustments on the indicators and aspects of managerial competences for MNC executives, this research proposed to adopt group-decision methods for the confirmation of those managerial competence indicators. Among the group-decision methods, Delphi Method is one of the most used methods that have usually been applied. The group-decision method is frequently used approach to survey the opinions of experts in the specific fields with questionnaires. If there is no consensus or exchange of ideas among experts, the negotiator will integrate the opinions from the experts and select the average or 50% of the result as the collective opinion. If the result does not satisfy the standard of convergence, the survey must be repeated until the standard is satisfied. Therefore, the problems of the traditional Delphi Method are that opinions from the experts might not easily satisfy the standard of convergence; the survey would often need to be repeated several times until the acceptable standard is reached, which might result in high expenses of the capital and time; and with the decrease of response rate, the negotiator's subjective opinions might affect the result. Therefore, if the Fuzzy theory could be applied to the Delphi Method, not only the merit that the result obtained could be similar to that obtained by the traditional Delphi Method, but also the repeating time for survey could be reduced and the cost could be decreased. In particular, the individual features of each expert could be reflected and the professional knowledge of each expert would be applied more reasonably and suitably [6].

Therefore, this study adopts the reformed Fuzzy Delphi Method (FDM) which is based on triangular fuzzy numbers. The FDM method was applied to select the competence of managers, because it not only solved the disadvantages resulting from the conventional Delphi Method, but also because its results would not easily be affected by extreme opinions. The questionnaires for the survey on Fuzzy Delphi Methods were sent to the recipients, who were members of Managers Association of Taiwan's high-tech industries in Taiwan, and the experts invited for the focus group. Finally, the procedure of the FDM for the structure of managerial competences for MNC executives is described as follows:

A. Step One: Building the Structure of Managerial Competences for MNC Executives.

The initial setting of managerial competences for MNC executives could be discussed from 4 dimensions, including conceptual skills, social skills, technical skills, and personality.

B. Step Two: Setting up the Evaluations of Fuzzy Weights.

By using the triangular fuzzy numbers to integrate the opinions from experts, the problems of fuzzy human thoughts and inaccuracy were reduced. Additionally, the decision maker's real attempt could be more clarified. The approaches to integrating the group opinions were average numbers, total numbers, the maximum, the minimum, and the hybrid method of averaging the maximum and the minimum. As pointed by Saaty (1999) [7], the expert opinions would be better presented using the geometric average method, which has been applied frequently in practical studies. Moreover, because the result from the geometric average method would be suitable for defining the fuzzy judgment matrix, this study used geometric averages to obtain the collective opinions from experts. Hence, the triangular fuzzy numbers, which are the fuzzy numbers most often used, were adopted, to set up the fuzzy membership function of the experts' opinions, which is shown in the Fig. 1. This chart presents the minimum of the experts' common consensuses as point l_{ij}, and the maximum as point $\boldsymbol{u_{ij}}$. Accordingly, the satisfaction degree to these two extremes would be presented as 0, while the segments between l_{ij} and u_{ij} would be given the satisfaction degree between 0 and 1. Hence, this study demonstrates the fuzzy number of all expert opinions, which is represented as $\tilde{W}_{ij} = (l_{ij}, m_{ij}, u_{ij})_{L-R}$, whereas the fuzzy weight number of the indicator for the managerial competence indicator j by an individual expert i would be $\tilde{W}_{ij} = (l_{ij}, m_{ij}, u_{ij})_{L-R}$. Consequently, the approach described above could prevent information being deleted, as happened in the traditional Delphi Method, and the common consensuses included as many experts as possible.

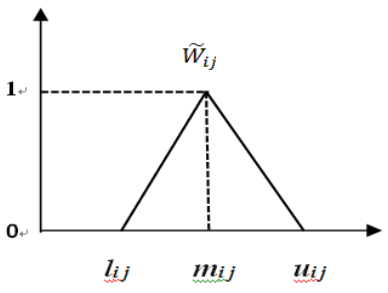

Fig. 1. The fuzzy delphi method.

The evaluations of fuzzy weights from the experts were therefore obtained from the survey of Fuzzy Delphi Method. Hence, the fuzzy weight number of expert *i* on managerial competence indicator *j* could be presented as follows:

$$\tilde{W}_{ij} = (l_{ij}, m_{ij}, u_{ij})_{L-R} \quad (1)$$

$$l_j = Min\,(l_{ij}),\ i = 1, 2, \cdots, n;\ j = 1, 2, \cdots, m \quad (2)$$

$$m_j = \left(\prod_{i=1,j=1}^{n,m} m_{ij}\right)^{\frac{1}{n}},\ i = 1, 2, \cdots, n;\ j = 1, 2, \cdots, m \quad (3)$$

$$u_j = Max\,(u_{ij}),\ i = 1, 2, \cdots, n;\ j = 1, 2, \cdots, m \quad (4)$$

Where *n* stands for the numbers of experts, and m represents the numbers of indicators for managerial competences.

C. Step Three: Selecting the Criteria of Managerial Competences for MNC Executives.

The fuzzy weight number $\tilde{W}_{ij}$ generated from Step Two could not be used for direct comparison. Therefore, this study employed the fuzzy mean and spread method [8], [9], transforming the result into a crisp number S_j.

$$S_j = \frac{l_j + m_j + u_j}{3} \quad (5)$$

The crisp numbers of indicators were ranged in order from the largest to the smallest. The difference of every two crisp numbers was calculated. Based on the largest value of the difference, the threshold of managerial competence indicators was set as *r*, which was used to select appropriate managerial competences indicator. The following operational formulas between a crisp number S_j and the threshold of managerial competence indicators *r* are shown as the following features:

If $\boldsymbol{S_j} \geq r$, the managerial competence indicator should be selected.

If $\boldsymbol{S_j} < r$, the managerial competence indicator should be deleted.

VI. Selecting the Important Criteria Using Fuzzy AHP

According to Saaty's AHP, Laarhoven and Pedrycz (1983) [10] proposed the Fuzzy AHP to solve vague problems under the analysis of criteria and the process of decision making. The Fuzzy AHP method adopted the pairwise comparison matrix of the AHP, which is based on the triangular fuzzy number of the fuzzy set theory. Due to the problems of subjective estimation and group consensus in the traditional AHP [11], this research applied the revised model of Fuzzy AHP proposed by Buckley (1985) [12] to solve the problems in the traditional AHP and determine the important indicators of managerial competences for MNC executives. The survey questionnaires of the Fuzzy AHP were processed from January to February, 2013. The participants include the executives of Taiwan exchange listed companies that manages production establishments or delivers services in at least two countries. A total of 50 questionnaires were distributed and 16 valid responses received with the valid response rate 32 %. The research procedures of Fuzzy AHP are presented as follows:

A. Step One: Building the Hierarchical Structure

A hierarchy structure was formed by using the structure of managerial competences for MNC executives and constructed in Fuzzy Delphi Method.

B. Step Two: Setting up the Pairwise Comparative Matrixes

According to 5-level evaluation scale suggested by Saaty (1999) [7], the questionnaires were designed to obtain the results of comparative importance between each pair of indicators in experts' pairwise comparison [13]. The survey results were transformed into fuzzy numbers, and the fuzzy pair comparative matrixes were constructed [4].

C. Step Three: Generating Group Integration

The geometric average method was applied for group integration [12].

The formula is presented as follows:

$$\widetilde{M}_{ij} = \left(\prod_{i=1,j=1}^{N} m_{ij}\right)^{\frac{1}{N}}\ i = 1, 2, \cdots, N \quad (6)$$

$\widetilde{M}_{ij}$ denotes the triangular fuzzy number generated from group integration.

$\tilde{m}_{ij}^{N}$ denotes the expert N's pair comparison of indicator *i*'s and *j*'s importance.

N indicates the numbers of experts.

D. Step Four: Constructing the Fuzzy Judgment Matrices.

The group integrated triangular fuzzy numbers were obtained from the previous step. Then the triangular fuzzy numbers were employed to obtain the fuzzy weight by constructing the fuzzy judgment matrix, which is shown as follows:

$$M = \left[\widetilde{M}_{ij}\right],$$

$$\widetilde{M}_{ij} = \left(l_{ij}, m_{ij}, u_{ij}\right), \widetilde{M}_{ij} = \frac{1}{\widetilde{M}_{ij}}, \forall i, j = 1,2, \cdots, n \quad (7)$$

l_{ij} denotes the lower value in triangular fuzzy membership function of the experts' opinions on the indicator *j* in managerial competences aspect *i*.

m_{ij} denotes the median value in triangular fuzzy membership function of the experts' opinions on the indicator j in managerial competences aspect *i*.

u_{ij} denotes the upper value in triangular fuzzy membership function of the experts' opinions on the indicator *j* in managerial competences aspect *i*.

E. Step Five: Calculating the Fuzzy Weight

The calculation of fuzzy weight method proposed by Buckley (1985) [12] was adopted in this research. The calculation method of fuzzy weight is shown as follows:

$$\tilde{Z}_i = (\tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes \cdots \tilde{a}_{in})^{1/n},\ \forall_i \quad (8)$$

$$\widetilde{W}_i = \tilde{Z}_i \otimes \left(\tilde{Z}_1 \oplus \tilde{Z}_2 \oplus \cdots \oplus \tilde{Z}_n\right) \quad (9)$$

$\tilde{Z}_i$ denotes the geometric average of the triangular fuzzy number.

$\tilde{a}_{ij}$ denotes the triangular fuzzy number in row *i* and column *j* in the fuzzy judgment matrix.

$\tilde{W}_i$ denotes the fuzzy weight of the indicator i.

F. Step Six: Defuzzification

The fuzzy number can be defuzzified into a crisp number by using the Center of Area Method (COA) modified by Tzeng and Teng (1993) [14]. The COA method was designed to prevent the prejudices of the decision maker. The following formula provides an equation to defuzzify a triangular fuzzy number $\tilde{a}_{ij}$ into a defuzzified number DF_{ij}.

$$DF_{ij} = \left[\left(u_{ij} - l_{ij}\right) + \left(m_{ij} - l_{ij}\right)\right]/3 + l_{ij} \qquad (10)$$

G. Step Seven: Ranking the defuzzified Numbers DFij

The COA method was applied to defuzzify a triangular fuzzy number $\tilde{a}_{ij}$ into a defuzzified number DF_{ij}, which is used to rank all criteria and select the important criteria of managerial competence.

VII. Applications of Fuzzy Delphi Method and Fuzzy AHP

After establishing the structure of initial indicators of managerial competence for MNC executives, a focus group method was employed to develop and construct the essential indicators of managerial competences related to the professional managerial job of MNC executives, which method could gave constructive suggestions to the structure of the initial indicators in this research.

The Fuzzy Delphi Method was then developed to identify the important criteria of managerial competences for MNC executives.

Then experts provided a threshold. Among the crisp number $\boldsymbol{S_j}$, the largest value of the difference was 0.025. Hence, the threshold of managerial competence indicators was set as $r = 0.79$. Referring to previous studies on managerial competences, the threshold was set as $r = 0.79$, which was used to select appropriate managerial competences indicator.

If $\boldsymbol{S_j} \geq 0.79$, then the managerial competence indicator should be selected;

If $\boldsymbol{S_j} < 0.79$, then the managerial competence indicator should be deleted.

As shown in Table I, the calculated result of the Fuzzy Delphi Method was obtained. The analytical results demonstrated that the experts considered the following four elements to be important dimensions of managerial competence: conceptual skills, social skills, technical skills, and personality. Most of the managerial competence indicators in these four dimensions were retained. However, two indicators were deleted from the dimension of conceptual skills, including A1 Decision Making and A3 Crisis Management. There was only one indicator deleted in each of the other three dimensions, including B3 Negotiation in the dimension of social skills, C3 Time Management in the dimension of technical skills, and D4 Extraversion in the dimension of personality. After deleting the above 5 less important indicators, the initial 20 indicators of managerial competences were reduced to 15 indicators.

This research applied the Fuzzy AHP to identify the important indicator of managerial competence for MNC executives. The analytical result of the Fuzzy AHP demonstrated that the fifteen indicators from the most to the least important were listed as follows:

TABLE I: The Calculated Result of the Fuzzy Delphi Method

Main Dimension Indicators		l_j m_j u_j	S_j	Select/Delete
A Conceptual skills	A1 Decision Making	0.6 0.80 0.9	0.77	Delete
	A2 Transnational Execution	0.8 0.82 1	0.87	
	A3 Crisis Management	0.6 0.77 0.9	0.76	Delete
	A4 Analysis Capabilities	0.7 0.77 0.9	0.79	
	A5 Adaptation	0.7 0.81 1	0.84	
B Social Skills	B1 Communication	0.8 0.88 0.9	0.86	
	B2 Foreign Language	0.7 0.83 1	0.84	
	B3 Negotiation	0.5 0.73 1	0.74	Delete
	B4 Coordination	0.7 0.81 1	0.84	
	B5 Leadership	0.8 0.92 1	0.91	
C Technical Skills	C1 Stress Management	0.8 0.86 1	0.89	
	C2 Professional Knowledge	0.7 0.83 1	0.84	
	C3 Time Management	0.5 0.66 1	0.72	Delete
	C4 Operational Management	0.8 0.87 1	0.89	
	C5 Goal Management	0.7 0.81 1	0.84	
D Personality	D1 Integrity	0.7 0.84 1	0.85	
	D2 Neuroticism	0.7 0.86 0.9	0.82	
	D3 Self-Independence	0.7 0.82 0.9	0.81	
	D4 Extraversion	0.5 0.82 0.9	0.72	Delete
	D5 Loyalty	0.7 0.82 1	0.84	

As shown in Table II, the defuzzified number DF_{ij} were obtained from the previous step and ranked in order. 1) Among the dimension of conceptual skills, the indicators were listed from the most to the least important as follows: A2 Transnational Execution (0.039), A4 Analysis Capabilities (0.021), and A5 Adaptation (0.016). 2) Among the dimension of social skills, the indicators were ranked from the most to the least important as follows: B5 Leadership (0.155), B4 Coordination (0.151), B2 Foreign Language (0.061), and B1 Communication (0.029). 3) Among the dimension of technical skills, the indicators were shown from the most to the least important as follows: C2 Professional Knowledge (0.268), C5 Goal Management (0.098), C1 Stress Management (0.063), and C4 Operational Management (0.042). (4) Among the dimension of personality, the indicators were displayed from the most to the least important as follows: D5 Loyalty (0.025), D3 Self-Independence (0.023), D1 Integrity (0.021), and D2 Neuroticism (0.017).

TABLE II: RANK OF MANAGERIAL COMPETENCE INDICATORS

Dimensions		l_{ij}	m_{ij}	u_{ij}	DF_{ij}	Sub-Ranking	Total Ranking
A Conceptual skills	A2 Transnational Execution	0.023	0.033	0.062	0.039	1	8
	A4 Analysis Capabilities	0.013	0.022	0.028	0.021	2	12
	A5 Adaptation	0.004	0.016	0.028	0.016	3	15
B Social Skills	B1 Communication	0.024	0.027	0.036	0.029	4	9
	B2 Foreign Language	0.052	0.060	0.071	0.061	3	6
	B4 Coordination	0.136	0.154	0.163	0.151	2	3
	B5 Leadership	0.136	0.155	0.174	0.155	1	2
C Technical Skills	C1 Stress Management	0.034	0.071	0.083	0.063	3	5
	C2 Professional Knowledge	0.229	0.266	0.309	0.268	1	1
	C4 Operational Management	0.018	0.023	0.087	0.042	4	7
	C5 Goal Management	0.063	0.081	0.150	0.098	2	4
D Personality	D1 Integrity	0.002	0.010	0.052	0.021	3	13
	D2 Neuroticism	0.007	0.010	0.033	0.017	4	14
	D3 Self-Independence	0.007	0.024	0.037	0.023	2	11
	D5 Loyalty	0.004	0.024	0.048	0.025	1	10

As shown in Table III, the most important indicators of managerial competence were listed as follows: C2 Professional Knowledge (0.268), B5 Leadership (0.155), B4 Coordination (0.151), C5 Goal Management (0.098), and C1 Stress Management (0.063).

TABLE III: THE IMPORTANCE OF MANAGERIAL COMPETENCE INDICATORS

The Importance	Indicators	DF	Ranking
The most	C2 Professional Knowledge	0.268	1
importance	B5 Leadership	0.155	2
	B4 Coordination	0.151	3
	C5 Goal Management	0.098	4
	C1 Stress Management	0.063	5
The second	B2 Foreign Language	0.061	6
importance	C4 Operational Management	0.042	7
	A2 Transnational Execution	0.039	8
	B1 Communication	0.029	9
	D5 Loyalty	0.025	10
The least	D3 Self-Independence	0.023	11
importance	D1 Integrity	0.021	12
	A4 Analysis Capabilities	0.021	13
	D2 Neuroticism	0.017	14
	A5 Adaptation	0.016	15

The second important indicators were displayed as follows: B2 Foreign Language (0.061), C4 Operational Management (0.042), A2 Transnational Execution (0.039), B1 Communication (0.029), and D5 Loyalty (0.025).

The least important indicators were shown as follows: D3 Self-Independence (0.023), D1 Integrity (0.021), A4 Analysis Capabilities (0.021), D2 Neuroticism (0.017), and A5 Adaptation (0.016).

Therefore, this study concluded that MNC executives should strengthen their managerial competences in the indicators of professional knowledge, leadership, and coordination to carry out their global business successfully...

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