Qual Quant (2011) 45:751–768
DOI 10.1007/s11135-010-9425-6

Combining the Fuzzy Analytic Hierarchy Process and the fuzzy Delphi method for developing critical competences of electronic commerce professional managers

Chih-Hung Wu · Wen-Chang Fang

Published online: 4 January 2011

Abstract This study proposes a novel approach that integrates the qualitative approach, the quantitative approach, and fuzzy set theory for developing a framework of critical managerial competences of electronic commerce (EC) professional managers. The approach combines a focus group, a fuzzy Delphi method and the Fuzzy Analytic Hierarchy Process (Fuzzy AHP) for identifying competences via experts' opinions and questionnaires for developing the framework of managerial EC professional managers. Comparing the competences of traditional managers and EC managers reveals main differences in the emphasis on EC manager professional skills. Furthermore, competency weights for EC managers lie particularly in domain knowledge and information management skills. Research results reveal that our proposed EC competence framework not only help firms in selecting/hiring high quality EC professional managers more objectively, but also in evaluating the performance of EC managers.

Keywords Competence · Electronic commerce · Fuzzy Delphi · Fuzzy Analytic Hierarchy Process (Fuzzy AHP)

1 Introduction

Over the past decades researcher's interest has grown in the use of competence-based management development (Holman and Hall 1996). Lack of understanding managerial competence is commonly believed as the primary reason for the failure of smaller companies to perform

C.-H. Wu (✉)
Department of Digital Content and Technology, National Taichung University of Education, 10F-1024, 140, Min-Shen Road, Tai Chung 40306, Taiwan, ROC
e-mail: chwu@ntcu.edu.tw

W.-C. Fang
Department of Business Administration, National Taipei University, Taipei, Taiwan, ROC
e-mail: fang@mail.ntpu.edu.tw

to their potential, and government policy. Furthermore, for the last three decades, global competition has dramatically changed. Formerly dominating firms are facing competition from nearly all over the world (Tschirky et al. 2004). Firms will have to employ electronic commerce (EC) to compete in the global competition of the twenty-first century. While electronic business related issues have been extensively study, the competences of EC professional managers have rarely been studied. The earliest investigation on competence, in the late 1960s, concentrated on the study of personality. However, few studies have attempted to develop a framework to evaluate the managerial competence of EC managers. Recent studies on competence have changed the direction from the conventional understanding of competence as the quality, knowledge and skills one possesses to the notion that competence implies not only the qualities one possesses, but also those one does not yet have and therefore needs to learn.

Competence is one's "underlying characteristic". The underlying characteristic not only is related to one's profession and position at work, but predictably or even affects his behavior and performance (Spencer 1993). Also indicated that the competence is critical to enhancing one's working performance, implying the specific basic quality in a person (Yeung 1996). Additionally, Ritter and Gemunden (2004) stated that both network competence and technological competence have a significant positive impact a company's innovation success. Mansfield (1996) added that competence reflects accuracy, skillfulness, and specific behaviors, requiring study by the staff to enhance their work performances. Therefore, in spite of the fact that scholars from each school have had different definitions on competence, most scholars confer that competence is closely related to one's profession, which is also the crucial key to one's performance and achievement at work.

Therefore, this study proposes an approach that integrated qualitative and quantitative approach for developing an evaluation framework of critical managerial competences of electronic commerce (EC) professional managers. The approach combined Focus group, Fuzzy Delphi Method and Fuzzy Analytic Hierarchy Process (Fuzzy AHP) for identifying the key competences and indicators via experts' opinions and questionnaires. Our approach and research results offer companies and industries a clear direction for training and hiring best managers, which will also provide a mechanism for evaluating performance of EC managers. Additionally, the indicators for EC professional managers can be applied as the indicators for enterprises to evaluate the competences of their managers in technology management.

The rest of this paper is organized as follows. The indicators and methods for evaluating managerial competence are discussed in Sect. 2. Section 3 details the methods of developing competence indictors for selecting and evaluating performance of electronic professional managers. In Sect. 4 reveals an application of Fuzzy Delphi and Fuzzy AHP for developing the framework of EC professional manager competences. Discussions are presented in Sect. 5 and conclusions are drawn in the final section.

2 Viewpoints and methods for evaluating managerial competence

In this section the aspects and indicators of managerial competences for EC professional managers are discussed. In the first subsection, literature review presents studies relating to various views of managerial competence. Next, the second part focuses on the methods of evaluation for competence.

2.1 Viewpoints of studies on managerial competence

Although the first study on competence appeared in the late 1960s, recent studies on competence rarely concentrate on the research of managerial competence possessed by EC managers, and fail to mention the competence indicators. Many different definitions of competences appeared in the previous literature is partly due to the fact that competences are relevant in a number of distinct research fields with different disciplinary roots (Van Loo and Semeijn 2004). Therefore, this work starts with previous studies on managerial competence and managerial skills. In this case, the managerial competence needed by EC managers must be investigated, so that the research methods and procedure can be determined. For this purpose, in this paper the contemporary studies on managerial competence are presented as follows: (1) the personality trait school; (2) the functional school; (3) the situational school, and (4) the survey school.

The personality trait school adopts "the moment of heroism" and suggests that successful managers should have some special personality characteristics in their personalities. Hence, as long as individuals have a unique personality, they could be trained and become a successful manager. In terms of personality, Gattell (1973) observed and analyzed various behaviors in daily life. The 171 personality types he identified were sorted into 16 categories according to factors that would affect people's behaviors. Robbins (1997) tended to see from the managerial perspective and asserted that a person's ability mainly comprises intellectual and physical abilities. Intellectual ability implies the ability of mind activities, including abilities relating to calculation, language, response, and logic. Physical ability denotes characteristics such as one's spirit, physical flexibility and energy. Professions of higher positions require more intellectual ability, whereas technical or mechanical jobs require people with more physical abilities. Maslow (1987) proposed the hierarchy of needs theory and suggested that each individual has five levels of needs. From the lowest-order need to the highest-order need these are: physiological need, need of safety, social need, need of self-esteem and need of self-actualization. Generally, for those who require less need in life, physical need tends to be more important, while for managers the needs of self-esteem and self-realization would be more emphasized. However, the personality theory has many problems, such as the tendency to neglect interactions between leader and staff, and the fact that personalities are too complicated and difficult to define. Hence, theories in this school have gradually tended to be ignored.

Katz, the leader of the functional school, contended that managers of various levels require different levels of skills such as following: professional skill, social skill, and technical skill (Katz 1995). These three skills would vary according to the manager's level, due to the different tasks required a fact which was also confirmed in the theory of Guglieliemino (1979). However, the situational school emphasizes the importance of circumstances, and believes that some specific situations could turn some people into heroes. Restated, they deny the importance of the manager's personality and function. They further believe that what makes an individual a successful manager is not necessarily his personality, but how he deals with the confronted situations. For instance, Fiedler (1967), a scholar of this school, proposed the leadership contingency model and suggested that the function of the leadership could be influenced by the relationship between the leader and the fellow group members, the structure of each task, and the authority of the leader. Additionally, in his path-goal theory, House (1971) added that circumstantial factors such as the structure of the work, the system of the official authority, and team involved in the work can affect a manager's behaviors. The quality of staff members, such as their ability for internal and external control, experiences, and abilities, can also affect leadership.

All these factors would have influences on the manager's performance and satisfaction with the job.

The appropriate managerial competences for the managers were discovered by survey methods in the theory of investigation. Chang (1998) surveyed managers at various levels and concluded that the important managerial competences for managers at higher positional levels are: "planning and coordination", "decision making", "management reforming", "strategies adopting", "prospect", "problem solving", "sensibility to the market", "consultation and authority", "insurance managing", "social network", "outstanding performance" and "perfectionism". The important managerial competences for managers of intermediate positional level are: "project and procedure management", "goals setting", "communication skills", "staff training and supporting", "incident managing and group constructing", "innovation" and "negotiation". The major managerial competences for managers of basic position levels are "professional skills", "efficiency", "being active and enthusiastic", "executive ability", "time management", "quality management", "reliability", "good learning attitudes", "customer services" and "emotional control". Chung (1998) studied the managerial competence of higher positional managers in the high-tech industry, focusing on 159 junior managers of higher positional level in an industrial technology research institute (ITRI). According tot their results, competences possessed by these managers were the abilities of "strategies adopting and coordinating", "problem solving", "quality control", "action directing" and "group constructing". The major competences that needed to be trained and improved are "sensibility in management", "ability of negotiation", "strategies adopting and coordinating", "inspiration on others" and "quality control". Wu (1993) asserted that managerial competence should include both personal characteristics and managerial skills. In terms of personal characteristics, Wu (1993) considered personality and motivation to be the main factors, whereas managerial skills comprise social skills (including communication skills), administrative skills (i.e. planning and coordinating), cognitive skills (such as analysis and decision-making), leadership skills (such as inspiring and tutoring) and technical skills.

Recent studies on managerial competence tend to include theories and perspectives from different scholars and have combined various methods to examine managerial competences. Ritter and Gemunden (2004) discussed and analyzed the impact of the dual nature of the key to competitiveness in the network economy. Tschirky et al. (2000) pointed out that technology marketing is a new core competence of technology-intensive enterprises. The new core competence is dependent upon new processes and concepts, because known marketing methods do not sufficiently take into account the knowledge-defined uniqueness of technologies as the object of commerce. Firms have become proficient in sourcing technologies that are either state of the art or non-available inside their boundaries or they have intensified their activities regarding the external commercialization of knowledge (mainly technological knowledge) (Tschirky et al. 2004). Lin (1996) adopted the Fuzzy theory to the evaluation models of managerial competences, considering aspects of both personal characteristics and skills. Personal characteristics include ability, personality and motivation, whereas managerial skills include technical skills, social skills and conceptual skills. Additionally, Huang et al. (2001) adopted the Fuzzy Analytic Hierarchy Process to construct the evaluation model of managerial competence and suggested that managerial competence comprises eight aspects: (1) conceptual skills, (2) social skills, (3) leadership skills, (4) administrative skills, (5) professional skills, (6) personal characteristics, (7) abilities and (8) motivations. Accordingly, the direction of his research has already covered the concepts from personal characteristic, functional and investigative theories. Chang et al. (2000) proposed a new fuzzy Delphi method and fuzzy statistics for managerial talent assessment. Their taxonomical approach was derived from the open systems view of firms. The new method was able to identify and distinguish

different aspects of organizational competence. Sanchez (2004) also developed a taxonomy of five models of competences than an organization must develop and maintain in its various activities to reach overall competence.

2.2 Methods of evaluation on competences

The various definition of competence, the context of the research and the classifying principle causes substantially different methods for measuring competence (Van Loo and Semeijn 2004). The primary methods of evaluation on competences are as follows: (1) evaluation on working ability (McClelland 1973), (2) focus group, (3) examination on competence models (Hsieh 1998), (4) peer Evaluation (Parry 1996), (1) assessment centers (Parry 1996), (5) circumstantial tests (Parry 1996), (6) evaluation tables of competence (Chuang 1997), (7) fuzzy theory (Ishikawa et al. 1993). Instead of any of these, Turley and Bieman (1995) applied the two-stage method which combines qualitative and quantitative methods for researching competencies for computer software technicians. While in the first stage qualitative study approach was adopted for detailed interviews, in the second stage quantitative analysis was used to generate the final list of competencies using Q-Sort techniques and discriminant analysis. Ishikawa et al. (1993) employed the Fuzzy theory to solve problems in the existing conventional Fuzzy Delphi Method. They used Max-Min and Fuzzy Integration to examine the Fuzzy Delphi Method's feasibility, and the result has demonstrated that the Fuzzy method has some advantages that the traditional methods lack. Therefore, increasing numbers of scholars, such as Lin (1996), have begin to adopt Fuzzy theories evaluate managerial competencies. Later, Huang et al. (1997) constructed their evaluation model of managerial competencies through the Fuzzy Analytic Hierarchy Process. Acock and Clarke (1990) first to use LISREL structured means test to evaluate the two efficacy factors correlate as expected with measures of general personal competence and political trust. Van Loo and Semeijn (2004) reviewed and pointed out the three possible important and distinguished competence concepts—the educational perspective, the labor market perspective and the human resources perspective and then apply it to the measurement of competences in the context of labor market research using graduate surveys. The competence on qualification also can be described and judge by the method which based on a cross-rating matrix of its members with specification of a calibration function (Bomze and Gutjahr 1995). Buscema et al. (2006) used Artificial Neural Networks to integrate competences and preferences for achieving the educational pathways desire and professional skills in order to increase the synergies between Knowledge Management (KM) and e-Learning.

In summary, the above literature demonstrated that in terms of competence no consensus exists between theories from different schools, and that the methods adopted vary. Therefore, an investigation should start with building a more complete managerial indictors-structure, which should also be adoptable for EC.

3 Methods of developing competence indictors for selecting and evaluating performance of electronic professional managers

Based on literature review, the initial indictors-structure for this study is illustrated in Fig. 1. This work attempts to discover the managerial competence indicators for EC professional managers. To achieve this goal, this study adopts a combined qualitative and quantitative approach, allowing the study to integrate the advantages of each approach to be, instead of relying too much on a particular approach, with the disadvantages that produces.

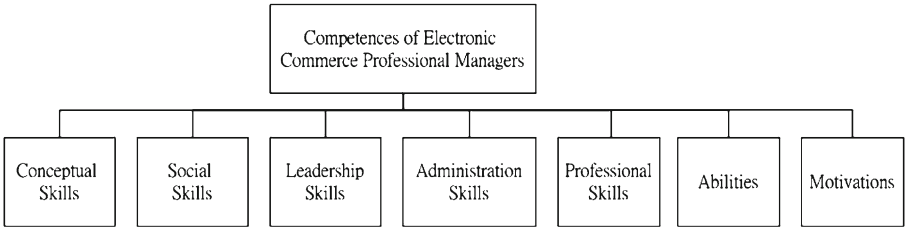

Fig. 1 The initial construct of competences for EC professional managers

To increase the accuracy of our research and to follow the tendency of studies nowadays, this work adopts several methods, combining of qualitative and quantitative methods to evaluate and improve the managerial competences for EC Managers. The Focus Group method, Fuzzy Delphi method, and Fuzzy Analytic Hierarchy Process (Fuzzy AHP) are used to choose suitable aspects and indicators of the managerial competences for EC managers. Then this study believed that the gaps between the desired/aspiration values and real performances are evaluated and improved for achieving working performance or hiring qualified EC mangers. Next, the research methods of this study are discussed in three parts: 1. Focus Group, 2. Fuzzy Delphi method, and 3. Fuzzy Analytic Hierarchy Process.

3.1 Focus group

After establishing the structure through literature review, a focus group of EC experts was established to discover the managerial competences relating to the job of EC managers. This focus group also provided some suggestions for the adjusting to the initial structure of the study. To ensure that the experts invited would be representative, 12 experts from the industrial, governmental, and academic fields of the EC in Taiwan were invited to the focus group. The experts from business were EC professional managers in famous enterprises.

3.2 Fuzzy Delphi method

After studying the opinions collected via the focus group for the adjustments on the indicators and aspects of managerial competences for EC managers, this work proposed to adopt group-decision skills for the confirmation on those competences and indicators. Among the group-decision skills, Delphi Method is the one that has usually been applied. The approach is 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 conventional 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 achieved, 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. Hence, if the Fuzzy theory could be applied to the Delphi Method, apart from the merit that the result obtained could be similar to that obtained by the traditional Delphi Method, the repeating time for survey could be reduced and the time and capital could therefore be decreased. In particular, the individual features of each expert could be reflected and the professional knowledge of each expert would be more reasonably and suitably dealt with Ishikawa et al. (1993).

Therefore, this study adopts the reformed Fuzzy Delphi Method which is based on triangular fuzzy numbers. This method was applied to confirm the managerial competences and characteristics of EC 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 on 15 June 2002 to the recipients, who were members of EC association in Taiwan, and the experts invited for the focus group. The total numbers of the questionnaires sent were 120 and 40 returned valid responses, making a valid response rate of 33%. Finally, the procedure of adopting the Fuzzy Delphi Method to the structure of managerial competences for EC managers is described as follows:

Step One: Building the structure of managerial competences for EC managers.

The initial setting of managerial competences for EC managers could be discussed from 8 aspects, which were conceptual skills, social skills, leadership skills, administrative skills, professional skills, personal characteristics, abilities and motivations.

Step Two: Setting up the evaluations of 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), 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 right chart of Fig. 2. This chart presents the minimum of the experts common consensuses as point l, and the maximum as point u. Accordingly, the satisfaction degree to these two extremes would be presented as 0, while the segments between l and u would be given the satisfaction degree between 0 and 1. Hence, this study includes the fuzzy number of all expert opinions, which is represented as $\tilde{W} = (l, m, u)_{L-R}$, whereas the fuzzy weight number of the indicator for the managerial competence indicator j by an individual expert i would be $\tilde{W}_{ij} = \left(l_{ij}, m_{ij}, u_{ij}\right)_{L-R}$. Consequently, the approach described above could prevent information being deleted (neglecting the information except those presented in $\bar{l}\bar{u}$ as shown in the left chart of Fig. 2) as happened

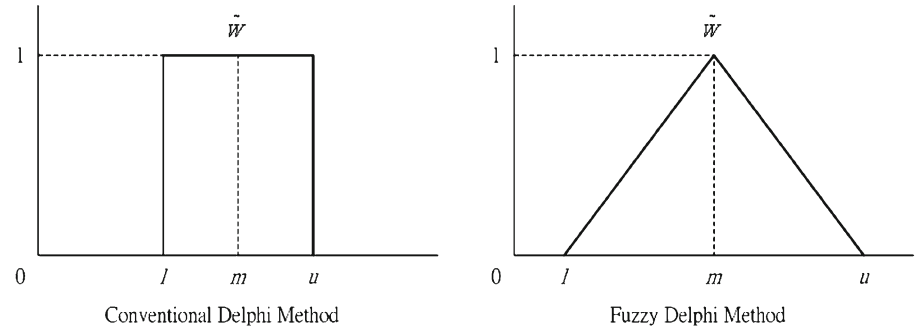

Fig. 2 Comparison of membership functions in the conventional Delphi Method and Fuzzy Delphi Method

in the conventional Delphi Method, and the common consensuses included as many expert as possible.

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:

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

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

$$m_j = \left(\prod_{i=1, j=1}^{n,m} m_{ij}\right)^{1/n}, \quad i = 1, \ldots n; \quad j = 1, \ldots m \tag{3}$$

$$u_j = Max\left(u_{ij}\right), \quad i = 1, \ldots n; \quad j = 1 \ldots m \tag{4}$$

where n stands for the numbers of experts, and m shows the numbers of indicators for managerial competences.

Step Three: Selecting the suitable indicators of managerial competences for EC managers.

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 (Lee and Li 1988; Wu et al. 2004), transforming the result into a crisp number of of_j.

$$of_j = \frac{u_j + m_j + l_j}{3} \tag{5}$$

Then experts provided a threshold. Referring to previous studies on managerial competences, the threshold was set as $r = 0.7$, and this was used to select appropriate managerial competences.

If $of_j \geq r$, then the managerial competence indicator should be selected;
If $of_j < r$, then the managerial competence indicator should be deleted.

Hence, from the three steps above, a calculated result was obtained as shown in Table 1. The initial 73 indicators of managerial competences in 8 aspects, after deleting 33 less important indicators, was reduced to 40.

3.3 Fuzzy analytic hierarchy process (Fuzzy AHP)

To solve vague problems which occur during the analysis of criteria and the judgment process, Laarhoven and Pedrycz (1983) developed Saaty's AHP into the Fuzzy AHP. The method used the triangular fuzzy number of the fuzzy set theory directly into the pairwise comparison matrix of the AHP. Due to problems in the traditional analytic hierarchy process, which tends to be over-subjective in estimation, inter-correlated between attributes of decision, problem in averaging, and problem in group consensus (Belton and Gear 1985; Buckley 1985), this study applies Fuzzy AHP to determine the important elements of managerial competences for EC managers and to solve the problems in the traditional AHP. Among the models of Fuzzy AHP, the revised model by Buckley et al. (2001) used a genetic algorithm to calculate the fuzzy weight and to develop their Fuzzy AHP model. Although that these two models are more complete, their calculation process is very complicated. Other Fuzzy AHP models, such as that based on Entropy proposed by Mon et al. (1994), combined fuzzy theory and analytic hierarchy process to build a pairwise comparative matrix with fuzzy triangular numbers, to obtain fuzzy weights through an analytic hierarchy process, then to use the center of area method (COA) to obtain the best fuzzy numbers or crisp values for further comparisons.

Table 1 Selection result of the managerial competences (Fuzzy Delphi Method)

Main aspects		Managerial competence indicators	Fuzzy calculation	
			Fuzzy numbers (l, m, u)	Defuzzification
A. Professional skills		Domain knowledge	(0.60, 0.81, 1)	0.81
	x	Foreign language(s) abilities	(0.20, 0.69, 1)	0.63*
	x	Knowledge on quality management	(0.20, 0.63, 1)	0.61*
		Knowledge on marketing	(0.40, 0.75, 1)	0.72
	x	Knowledge on financial management (fund transfer and financial analysis)	(0.20, 0.63, 1)	0.61*
	x	Professional knowledge on delivery and supply	(0.20, 0.69, 1)	0.63*
		Information Technology (IT)	(0.40, 0.73, 1)	0.71
	x	Pressure management (EQ)	(0.20, 0.63, 1)	0.61*
		Information management (data collecting, integrating and analysis)	(0.40, 0.79, 1)	0.73
		Knowledge management (KM)	(0.40, 0.73, 1)	0.71
		Enterprise resource management (ERP)	(0.40, 0.69, 1)	0.70
	x	Supplying chain management (SCM)	(0.40, 0.67, 1)	0.69*
		Customer relationship management (CRM)	(0.40, 0.75, 1)	0.71
	x	Time management	(0.20, 0.69, 1)	0.63*
	x	Information technology outsourcing (IT Outsourcing)	(0.40, 0.64, 1)	0.68*
B. Conceptual skills		Evaluating the environment and the future tendency	(0.40, 0.79, 1)	0.73
		Transforming conceptual policies into realizable strategies	(0.40, 0.72, 1)	0.71
		Being able to propose new methods and ideas, and to evaluate their feasibility	(0.40, 0.73, 1)	0.71
	x	Making objective decisions and focusing on both the morality of management and the development of team	(0.40, 0.66, 1)	0.69*
		Strategies planning and Executing	(0.40, 0.77, 1)	0.72
		Creating profitable models for the enterprise	(0.40, 0.75, 1)	0.71
C. Social skills		Communication skills	(0.40, 0.80, 1)	0.73
	x	Listening skills	(0.20, 0.68, 1)	0.63*
		Presentation skills	(0.40, 0.69, 1)	0.70
		Negotiation skills	(0.40, 0.73, 1)	0.71
		Strategic union with other industries	(0.40, 0.73, 1)	0.71

Table 1 continued

Main aspects		Managerial competence indicators	Fuzzy calculation	
			Fuzzy numbers (l, m, u)	Defuzzification
	x	Correctly interpreting other people's messages	(0.20, 0.74, 1)	0.65*
	x	Highly approachable	(0.20, 0.67, 1)	0.62*
		Incident managing skills	(0.40, 0.69, 1)	0.70
D. Leadership skills		Group-leading abilities	(0.40, 0.79, 1)	0.73
	x	Innovation	(0.20, 0.68, 1)	0.63*
		Prospect	(0.40, 0.76, 1)	0.72
		Evaluating the performance of fellow staff righteously and objectively	(0.40, 0.70, 1)	0.70
		Understanding the ability, personality and needs of each staff member	(0.40, 0.72, 1)	0.71
	x	Changing the leading style at the right moment	(0.20, 0.61, 1)	0.60*
		Training and helping other people grow	(0.40, 0.72, 1)	0.71
		To lead other people in order to accomplish the goals of the team	(0.60, 0.77, 1)	0.79
E. Administrative skills		Problem solving and evaluating	(0.40, 0.73, 1)	0.71
		To make the best use o the resources in the enterprise	(0.40, 0.73, 1)	0.71
		Setting achievable goals and standards	(0.40, 0.73, 1)	0.71
	x	Meeting-directing skills	(0.20, 0.62, 1)	0.61*
	x	Project management	(0.20, 0.69, 1)	0.63*
		Being able to authorize suitable and professional people	(0.40, 0.73, 1)	0.71
F. Personal characteristics		Being confident	(0.40, 0.77, 1)	0.72
		Being responsible	(0.60, 0.80, 1)	0.80
	x	With broad interests	(0.20, 0.57, 1)	0.59*
		Being courageous and confident to taking risks	(0.40, 0.76, 1)	0.72
		With patience	(0.40, 0.72, 1)	0.71
	x	High endurance towards pressure	(0.20, 0.74, 1)	0.65*
	x	Righteousness	(0.40, 0.68, 1)	0.69*
		With enterpriser-ship	(0.40, 0.72, 1)	0.71
	x	Sincerity and reliability	(0.40, 0.67, 1)	0.69*
		Being innovative	(0.40, 0.72, 1)	0.71
		Being decisive	(0.40, 0.71, 1)	0.70
		With strong will	(0.40, 0.73, 1)	0.71
G. Abilities	x	Calculation ability	(0, 0.55, 1)	0.52*
	x	Sensitivity to numbers	(0.20, 0.66, 1)	0.62*
	x	Expressive with words	(0.20, 0.64, 1)	0.61*

Table 1 continued

Main aspects	Managerial competence indicators		Fuzzy calculation	
			Fuzzy numbers (l, m, u)	Defuzzification
		Adapt to environment easily	(0.40, 0.75, 1)	0.72
	x	Knowing his/her own merits and short comings	(0.20, 0.70, 1)	0.63*
		To interrupt at the right moment	(0.40, 0.74, 1)	0.71
	x	With working experiences across departments	(0.20, 0.67, 1)	0.62*
	x	Good physical condition	(0, 0.63, 1)	0.54*
	x	Cross cultural understanding	(0.20, 0.64, 1)	0.61*
	x	Intelligence (IQ)	(0.20, 0.56, 1)	0.59*
H. Motivations	x	Need of high financial reward	(0.20, 0.61, 1)	0.60*
	x	Need of security of the job	(0.20, 0.50, 1)	0.57*
	x	Need of high self-esteem	(0.20, 0.64, 1)	0.61*
		Need of self-realization	(0.40, 0.76, 1)	0.72
		Need of group achievements	(0.40, 0.72, 1)	0.71
	x	Need of obtaining good social relationships at work	(0.20, 0.66, 1)	0.62*
	x	With great ambition	(0.40, 0.67, 1)	0.69*
	x	Need of social status	(0.20, 0.57, 1)	0.59*

* denotes the value of defuzzification less than 0.7. This indicators will be deleted from the managerial competence indicators

Therefore, after examining the advantages and disadvantages of the various methods proposed by previous researchers, this work adopted the approach of Buckley (1985) because it has the advantages of fuzzy theory and easy calculation. This study employed Fuzzy AHP to discover the comparative importance of each competence and indicator for EC managerial competences. The questionnaires for the survey on Fuzzy AHP were sent out on 1 July 2002, and the recipients included the members of EC association in Taiwan and the experts have been invited to the focus group. A total of 134 questionnaires were and 35 valid responses received, making the valid response rate 26%. Here, the procedure of Fuzzy AHP is presented as follows:
Step One: Building the hierarchical structure.

A structure of hierarchy was then built by using the structure of managerial competences for EC managers constructed in Fuzzy Delphi Method.
Step Two: Setting up the pairwise comparative matrixes.

Following 9-level evaluation scale (Saaty 1999), the questionnaire for the survey was designed to obtain the results of comparative importance between each pair of constructs/indicators in experts' pairwise comparison. Then the results were transformed into fuzzy numbers, and the fuzzy pair comparative matrixes were constructed using the method proposed by Huang et al. (1997).
Step Three: Group integration.

The geometric average method suggested by Buckley (1985) was adopted for the integration, and the formula could be presented as follows:

$$\tilde{M}_{ij} = \left(\prod_{i=1, j=1}^{N} m_{ij} \right)^{1/N}, \quad i = 1, \ldots N, \tag{6}$$

$\tilde{M}_{ij}$ denotes the triangular fuzzy number generated from group integration, $\tilde{m}_{ij}^{N}$ denotes the expert N's pair comparison of indicators i's and j's importances, N denotes the numbers of experts.

Step Four: Constructing the fuzzy judgment matrices.

The group integration in the previous step obtained several group integrated triangular fuzzy numbers, which could be used to construct the fuzzy judgment matrix to obtain the fuzzy weight. The fuzzy judgment matrix could be presented as follows:

$$M = \left[\tilde{M}_{ij}\right], \tag{7}$$
$$\tilde{M}_{ij} = \left(l_{ij}, m_{ij}, u_{ij}\right), \quad \tilde{M}_{ji} = 1/\tilde{M}_{ij}, \quad \forall i, j = 1, 2, \wedge, n$$

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.

Step Five: Calculating the fuzzy weight.

This study focuses on the calculation of fuzzy weight, which was adapted from the method proposed by Buckley (1985), and the calculation method is presented as follows:

$$\tilde{Z}_i = \left(\tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes \cdots \tilde{a}_{in}\right)^{1/n}, \quad \forall i \tag{8}$$
$$\tilde{W}_i = \tilde{Z}_i \otimes \left(\tilde{Z}_1 \oplus \tilde{Z}_2 \oplus \cdots \oplus \tilde{Z}_n\right) \tag{9}$$

$\tilde{a}_{ij}$ denotes the triangular fuzzy number in row i and column j in the fuzzy judgment matrix, $\tilde{Z}_i$ denotes the geometric average of the triangular fuzzy number, $\tilde{W}_i$ denotes the fuzzy weight of the indicator i.

Step Six: Defuzzification.

The fuzzy number can be defuzzified into a crisp number using many methods such as the center of gravity defuzzifier or center of area defuzzifier; mean of maxima defuzzifier; modified mean of maxima defuzzifier; modified center average defuzzifier, and modified center average defuzzifier. Among them, one of the most common methods is the center of area method (COA). Thus, this study selected the modified COA method proposed by Tzeng and Teng (1993) to defuzzify and rank the fuzzy number, because the method was simple and practical, and also could avoid the prejudices of the decision maker. The formula (Eq. 10) solves a triangular fuzzy number $\tilde{a}_{ij} = \left(l_{ij}, m_{ij}, u_{ij}\right)$ into a crisp number.

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

3.4 Process of EC competence framework development

The process of EC competence framework development (Fig. 3) can be divide into 5 steps which is discussed as follows.

Step 1: Define the competence indicators of the EC professional manager based on literature review and focus group technique.

Step 2: Selection of competence and indicators via Fuzzy Delphi technique using Eqs. (1)–(5).

Step 3: Establish a hierarchy structure for different levels with interrelated decision criteria. Establish the triangular fuzzy numbers and, then, establish the triangular fuzzy positive reciprocal matrix. Each expert makes a pair-wise comparison of the

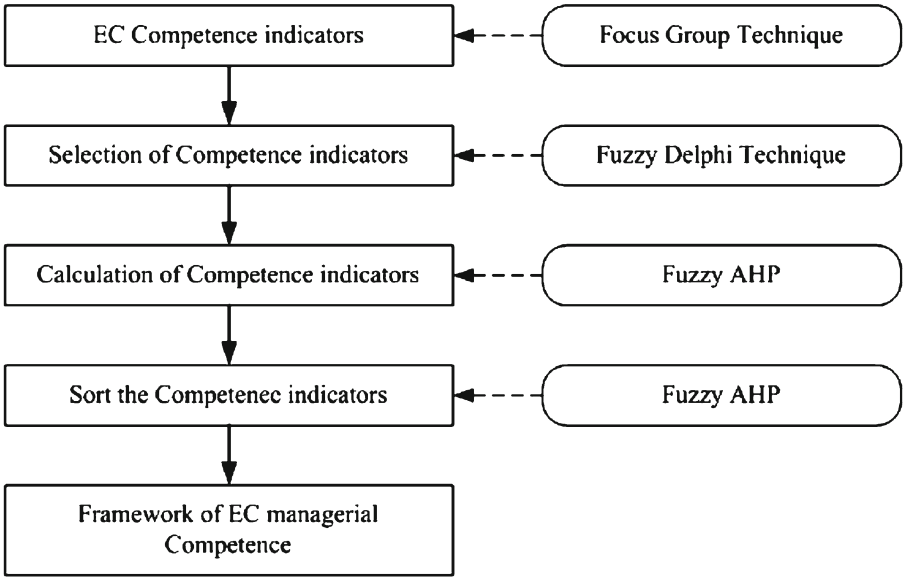

Fig. 3 Process of EC competence framework development

decision criteria and gives relative scores. Finally, calculate the fuzzy weights and defuzzification for the competence and indicators using Eqs. (6)–(10).

Step 4: Sort the competence and indicators based on the final defuzzification weight of competences and indicators.

Step 5: Conduct the framework of EC managerial competence and indicators.

4 Applications of fuzzy Delphi and fuzzy AHP for developing the framework of EC professional manager competences

After establishing the initial construct of competences for EC professional managers, a focus group method was used to discover the managerial competences related to the job of EC managers, which also gave some suggestions for the adjustment to the initial structure of our study. Fuzzy Delphi Method was then applied in our study to identify managerial competences and indicators of EC managers. The Fuzzy Delphi Methods gave a calculated result as shown in Table 1 (where 'x' mark denotes this indicator be deleted). The initial 73 indicators of managerial competences in eight aspects, after deleting 33 less important indicators, was reduced to 40, as presented in Table 2. The analytical results showed that the experts considered professional skills, conceptual skills, social skills, leadership skills, administration skills and personal characteristics to be important skills. Therefore, most of the managerial competence indicators in these aspects have been retained, whereas the indicators deleted were mostly from the aspects of abilities and motivations, which eventually contained only 2 indicators each. Hence, the analysis also suggested most experts in the survey considered that these two aspects were unimportant. Accordingly, the analysis also showed that viewpoints from the functional school and the investigation school tended to be more supported,

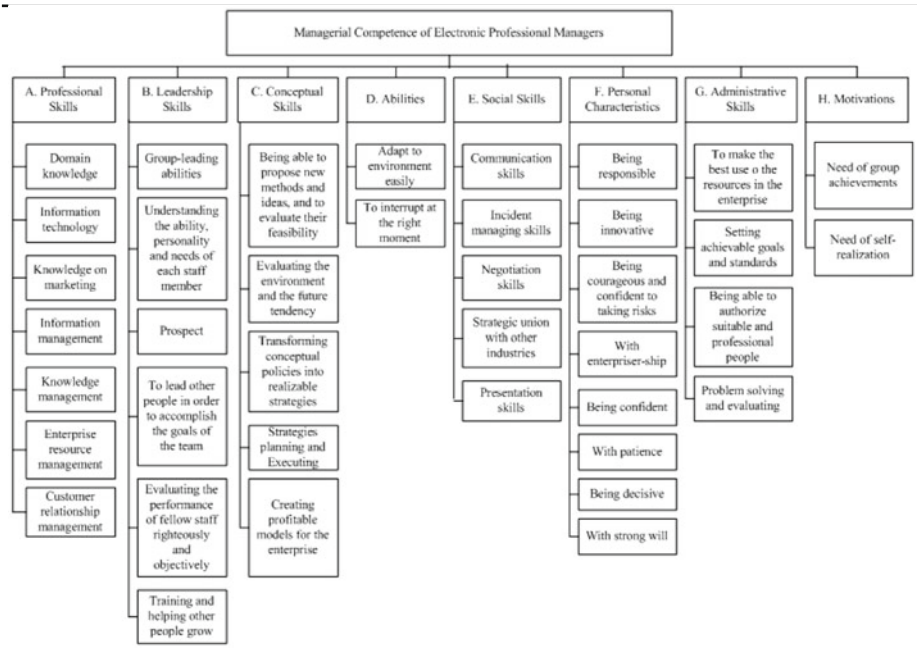

Fig. 4 Framework of managerial competence of electronic commerce professional managers

while personal characteristics and motivations were considered less important in the EC environment.

This study employs the Fuzzy Analytic Hierarchy Process (Fuzz AHP) to identify the importance of each competence indicator for EC management. The result of the Fuzzy AHP analysis revealed that the eight aspects to be listed from the most to the least important were: professional skills, leadership skills, conceptual skills, social skills, personal characteristics, administrative skills and motivations. For EC managers, professional skills aspect (0.1433) was considered to be the most important aspect of managerial competences. Among professional skills, the most important indicators were domain knowledge (0.1607), information management (0.1583) and business management (0.1511). Among leadership skills (0.1407), the most important indicators were group-leading skill (0.1862) and understanding the ability, personality and needs of each staff member (0.1818). Among conceptual skills (0.1383), the most important indicators were the ability to propose new methods and ideas and to evaluate their feasibility (0.2160), and the ability to evaluate the environment and future tendency (0.2097). Among abilities (0.1364), adapting to the new environment easily (0.54) and interrupting at the right moment (0.46) were the most important. Among social skills (0.1343), the most important indicators were communication skills (0.2415), incident management skill (0.2212) and negotiation skills (0.2135). In personal characteristics (0.1258), being responsible (0.1429), innovative (0.1370), and being courageous and confident to taking risks (0.1361) were most important indicators. Finally, the least important aspects were administrative skills (0.1036), among which to make best use of the resources in the enterprise was the most important; and motivations (0.0776), among which need of group achievements (0.6066) was the most important indicator.

Table 2 Managerial competences and indicators for EC professional managers

Main aspects	Managerial competence indicators	Weights
A. Professional skills (0.1433)	Domain knowledge	(0.1607)
	Information technology (IT)	(0.1583)
	Knowledge on marketing	(0.1511)
	Information management (data collecting, integrating and analysis)	(0.1380)
	Knowledge management (KM)	(0.1379)
	Enterprise resource management (ERP)	(0.1305)
	Customer relationship management (CRM)	(0.1235)
B. Leadership skills (0.1407)	Group-leading abilities	(0.1862)
	Understanding the ability, personality and needs of each staff member	(0.1818)
	Prospect	(0.1794)
	To lead other people in order to accomplish the goals of the team	(0.1704)
	Evaluating the performance of fellow staff righteously and objectively	(0.1629)
	Training and helping other people grow	(0.1194)
C. Conceptual skills (0.1383)	Being able to propose new methods and ideas, and to evaluate their feasibility	(0.2160)
	Evaluating the environment and the future tendency	(0.2097)
	Transforming conceptual policies into realizable strategies	(0.1997)
	Strategies planning and Executing	(0.1977)
	Creating profitable models for the enterprise	(0.1769)
D. Abilities (0.1364)	Adapt to environment easily	(0.5400)
	To interrupt at the right moment	(0.4600)
E. Social skills (0.1343)	Communication skills	(0.2415)
	Incident managing skills	(0.2212)
	Negotiation skills	(0.2135)
	Strategic union with other industries	(0.1859)
	Presentation skills	(0.1378)
F. Personal characteristics (0.1258)	Being responsible	(0.1429)
	Being innovative	(0.1370)
	Being courageous and confident to taking risks	(0.1361)
	With enterpriser-ship	(0.1268)
	Being confident	(0.1245)
	With patience	(0.1164)
	Being decisive	(0.1112)
	With strong will	(0.1050)

Table 2 continued

Main aspects	Managerial competence indicators	Weights
G. Administrative skills (0.1036)	To make the best use o the resources in the enterprise	(0.2937)
	Setting achievable goals and standards	(0.2536)
	Being able to authorize suitable and professional people	(0.2448)
	Problem solving and evaluating	(0.2079)
H. Motivations (0.0776)	Need of group achievements	(0.6066)
	Need of self-realization	(0.3934)

The numbers in the brackets show the weights which have been defuzzified with COA
The aspects and indicators in this table have been sorted by their fuzzy weights

5 Discussion

From the analytical results mentioned above, competencies for EC professional manager can be compared with the study of Chang (1998) on the managerial competences for managers, indicating that managerial competences for EC managers tend to be closer to those for the managers in the intermediate level. For instance, the managerial competences for EC managers correspond to the "professional knowledge" for managers in the basic level; similar to "communication skills", "training and supporting staff members", "incident management and group construction", "innovation" and "negotiation" for managers in the intermediate level; and closed to "strategies planning", "sensitivity to the market", "consultation and authorization" and "prospect" for the managers in the high level. Additionally, among the managerial competences for EC managers, "strategies planning", "problem solving" and "negotiation" also echo the study of Chang (1998) on the managerial competences of higher level managers in the high-tech industry. Hence, the analytical results demonstrated that in both the business and academic fields in Taiwan, EC managers were considered as "intermediate" or "high" level managers. This study suggests that one of the reasons for internet bubble economy, as our study suggests, is that the professional skill aspect had been too much emphasized in the EC. This study also points out that focusing on skill level along would not be adequate. EC managers still have to possess the thinking, leading and management skills which are in the strategic level—for example, whether they could help the enterprise or company build the prospect, plan the strategies and assign the resources; whether they are innovative; whether they could evaluate and make analysis of the environment and future tendency, and whether they have good communication skills and incident management skills. All of these are the managerial competences for a successful EC manager.

6 Conclusion

This study proposes an approach that combines focus group, fuzzy Delphi, and fuzzy AHP fuzzy for developing an evaluation framework of EC managerial competences. The complete framework is showed in Fig. 4. Result results indicate that the EC managerial competences are ranked in the following order of importance: Professional Skills, Leadership Skills, Conceptual Skills, Abilities, Social Skills, Personal Characteristics, Administrative Skills, and

Motivations. Of these, professional skills and leadership skills are considered to be the most important aspects, while administrative skills and motivations are the least important. The EC managerial competence framework/model ranks the importance that firms hold for various indicators used to compare or select/hire/evaluate the desirability of different EC managers based on these eight aspects and indicators in each aspects. The proposed model provides an objective and effective decision model for entrepreneur to implement when selecting or hiring best EC professional managers. Even for educational trainings, we believe these managerial competences and indicators would provide as a good checklist and direction in technology management.

Currently, studies on managerial competences for EC management are still quite rare, and do not mention the indicators. Future research might focus on developing a model based on competence and indicators to compare the similarities and dissimilarities among various industries or countries, which would hopefully make the result more complete. Gaps analysis can be use in minimizing gaps for increasing the EC professional competence level in manager in the future. Moreover, being limited by the contemporary EC management structure, EC managers still do not vary regarding position levels, unlike managers in general business who can be divided into different levels. Therefore, discussion of their specific managerial competences would be difficult in terms of different position levels.

References

Acock, A.C., Clarke, H.D.: Alternative measures of political efficacy: models and means. Qual. Quan. **24**(1), 87–105 (1990)

Belton, V., Gear, A.E.: The legitimacy of rank reversal—a comment. Omega **13**(3), 227–230 (1985)

Bomze, I., Gutjahr, W.: Estimating qualifications in a self-evaluating group. Qual. Quan. **29**(3), 241–250 (1995)

Buckley, J.J.: Fuzzy hierarchical analysis. Fuzzy Sets Syst. **17**, 233–247 (1985)

Buckley, J.J., Feuring, T., Hayashi, Y.: Fuzzy hierarchical analysis revisited. Eur. J. Oper. Res. **129**, 48–64 (2001)

Buscema, M., Terzi, S., Maurelli, G., Capriotti, M., Carlei, V.: The smart library architecture of an orientation portal. Qual. Quan. **40**(6), 911–933 (2006)

Chang, Y.L.: A study of developing an evaluation tool for managerial competence and reliability and validity analysis. In: A Research Report of National Science Council (in Chinese) (1998)

Chang, P.T., Huang, L.C., Lin, H.J.: The fuzzy Delphi method via fuzzy statistics and membership function fitting and an application to the human resources. Fuzzy Sets Syst. **112**(3), 511–520 (2000)

Chuang, C.C.: Developing Managerial Competencies Assessment Scale-A Case Study in High-Tech Firm. Master Thesis, National Central University (in Chinese) (1997)

Chung, P.T.: A Research on Hi-Tech Industry Managerial Competencies Resources Channel. Master Thesis, National Central University (in Chinese) (1998)

Fiedler, F.E.: A Theory of Leadership Effectiveness. McGraw-Hill Series in Management, New York (1967)

Gattell, R.B.: Personality pinned down. Psychol. Today **7**, 40–46 (1973)

Guglieliemino, P.J.: Developing the top-level executive for the 1980's and beyond. Train. Dev. **33**(4), 12–14 (1979)

Holman, D., Hall, L.: Competence in management development: rites and wrongs. British J. Manag. **7**(2), 191–202 (1996)

House, R.J.: A path goal theory of leader effectiveness. Adm. Sci. Q. **16**(3), 321–339 (1971)

Hsieh, C.C.: A Prototype of Expert System for Evaluating Managerial Competence: An Example of a High-technology Company. Master Thesis, National Central University (in Chinese) (1998)

Huang, L.C., Chang, P.T., Lin, H.J.: The fuzzy managerial talent assessment model: a pilot study. Pan Pac. Manag. Rev. **1**(1), 71–83 (1997)

Huang, L.-C., Wu, P., Jaw, B.-S., Wu, Y.-H. A study of applying fuzzy analytic hierarchy process on managementtalent evaluation model. In: Joint 9th FSA World Congress and 20th NAFIPS International Conference, vol. 3, July 25–28, 1484–1488 (2001)

Ishikawa, A., Amagasa, M., Shiga, T., Tomizawa, G., Tatsuta, R., Mieno, H.: The Max-Min Delphi method and fuzzy Delphi method via fuzzy integration. Fuzzy Sets Syst. **55**(3), 241–253 (1993)

Katz, R.L.: Skills of an effective administrator. Harv. Bus. Rev. **33**, 33–42 (1995)
Laarhoven, P.J.M., Pedrycz, W.: A fuzzy extension of Saaty's priority theory. Fuzzy Sets Syst. **11**(3), 229–241 (1983)
Lee, E.S., Li, R.L.: Comparison of fuzzy numbers based on the probability measure of fuzzy events. Comput. Math. Appl. **15**, 87–96 (1988)
Lin, H.J.: Applying Fuzzy Theory to An Assessment Model of Managerial Talent. Master Thesis, I-Shou University (1996)
Mansfield, R.S.: Building competency models: approaches for HR professionals. Hum. Resour. Manag. **35**(1), 7–18 (1996)
Maslow, A.H.: Motivation and Personality. 3rd edn. HarperCollins Publishers, New York (1987)
McClelland, D.C.: Testing for competence rather than for "Intelligence". Am. Psychol. **28**(1), 1–14 (1973)
Mon, D.-L., Cheng, C.-H., Lin, J.-C.: Evaluating weapon system using fuzzy analytic hierarchy process based on entropy weight. Fuzzy Sets Syst. **62**(2), 127–134 (1994)
Parry, S.B.: Just what is a competency? (And why should you care?). Training **35**(6), 58–64 (1996)
Ritter, T., Gemunden, H.G.: The impact of a company's business strategy on its technological competence, network competence and innovation success. J. Bus. Res. **57**, 548–556 (2004)
Robbins, S.P. : Organizational Behavior: Concepts, Controversies, Applications. Prentice Hall, Englewood Cliffs (1997)
Saaty, T.L.: Decision Making for Leaders: The Analytic Hierarchy Process for Decisions in a Complex World, New Edition 2001, 3rd edn. RWS Publications, Pittsburgh (1999)
Sanchez, R.: Understanding competence-based management Identifying and managing five modes of competence. J. Bus. Res. **57**(5), 518–532 (2004)
Spencer, S.M.: Competence at Work: Models for Superior Performance. Wiley, New York (1993)
Tschirky, H., Escher, J.-P., Tokdemir, D., Belz, C.: Technology marketing: a new core competence of technology-intensive enterprises. Int. J. Technol. Manag. **20**(3–4), 459–474 (2000)
Tschirky, H., Koruna, S.M., Lichtenthaler, E.: Technology marketing: a firm's core competence? Int. J. Technol. Manag. **27**(2–3), 115–122 (2004)
Turley, R.T., Bieman, J.M.: Competencies of exceptional and nonexceptional software engineers. J. Syst. Softw. **28**(1), 19–35 (1995)
Tzeng, G.-H., Teng, J.-Y.: Transportation investment project selection with fuzzy multiobjectives. Transp. Plann. Technol. **17**(2), 91–112 (1993)
Van Loo, J., Semeijn, J.: Defining and measuring competences: an application to graduate surveys. Qual. Quan. **38**, 331–349 (2004)
Wu, F.S.: Evaluation and selection for manager. Pers. Mon. (in Chinese) **17**(3), 21–43 (1993)
Wu, F.G., Lee, Y.J., Lin, M.C.: Using the fuzzy analytic hierarchy process on optimum spatial allocation. Int. J. Ind. Ergon. **33**(6), 553–569 (2004)
Yeung, A.K.: Competencies for human resource professionals: an interview with Richard E. Boyatzis. Hum. Resour. Manag. **35**(1), 119–131 (1996)