Chapter 11
Competency Evaluation Engineering of R&D Personnel based on Rough Set

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Abstract Competency model as the emerging matter in the field of human resource management has been greatly concerned. As companies realize the high performance that is produced by talent-post matching, enterprise managers think that competency model is an urgent need to implement competitive advantage. This paper studies the characteristics of R&D personnel, and uses interviews, questionnaires, and behavioral event interviews and other methods to build competency model, then determines the R&D personnel's competency appraisal index, combines with expert evaluation and rough set theory to determine the weight factor of the evaluation, so weight distribution is more scientific and rational to improve the reliability and accuracy of the evaluation.

Keywords Competency · R&D personnel · Rough set

11.1 Introduction

In the era of globalization and knowledge-based economy, the speed of the industrial environment changes gradually accelerated. In order to survive in the globalization system, the enterprises mainly depend on the continuous innovation, and the development of new products relies on the personnel's unique knowledge, skills and professional attitude. Domestic enterprises face the competitive environment of liberalization, and the basic wage continues to rise, and the requirements of transition, continuous innovation for enterprises grow surge. Therefore,

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how to obtain and retain excellent human resources for enterprises have become the most important issue, and R&D personnel even are the key for enterprises to own competitive advantage.

For R&D personnel, traditional human resource management based on job analysis has become increasingly inadequate. In the recruitment process, we always consider how to select personnel who truly has the research and development ability, especially in the same extrinsic factors like qualifications, experience. In the performance management process, in order to promote personnel's research and development capabilities, we often consider how to reasonably evaluate the R&D personnel (Kang and Niu 2008). Professor McClelland of Harvard University had made a series of studies for this phenomenon and found there had some crucial factors behind a superior performance, such as attitude, personal qualities, knowledge, and these factors are called "competence" (Mengna 2006). This management model which think the competence as a starting point is different from traditional job analysis methods, which more fit the personnel's work and environment, further convergence with the company's strategy to assist enterprises effectively manage the staff from human resource management and various aspects, improve core competitiveness.

Since McClelland proposed the concept of competence, domestic and foreign scholars had been mainly studied the competency model of corporate middle-and top-level managers or other related personnel. In recent years, the theoretical system of competency continually improves, and the application object and scope constantly expand. The recruitment, talent planning, training and development, career design, performance evaluation and compensation management based on competency also show great effects (Hu 2011). But so far the competency model about R&D personnel is little studied.

This paper hopes to use competency model to explore the construction and evaluation of R&D personnel competency, and use rough set to determine the weight of appraisal factors, and expect to provide a reference for future research and practices.

11.2 The Characteristics of R&D Personnel

Competency model is a high-end human resource management mode in corporation. Its core purpose is to achieve the best match between post and personnel. As competency needs to be reflected in our daily behavior, in order to bring value, the enterprises should define each competency and summarize key behavior which can act as a reference to judge the proficiency of competency model. The competency model of iceberg model is shown in Fig. 11.1. In this model, the underwater part of iceberg is the "potential" that we usually refer, the depth from top to bottom are different, then the difficulty levels of excavated and perception are also different. Relative to the knowledge and skills, the potential part of the competency elements are more difficult to evaluate and train (Peng and Pao 2003).

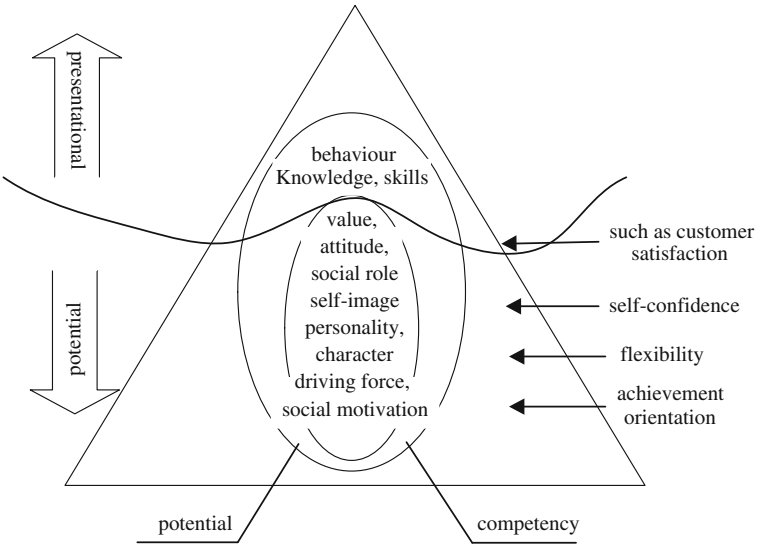

Fig. 11.1 Iceberg model

Compared with the ordinary employees, the work R&D personnel's is the most creative. They primarily explore new areas and create new products in the independent and autonomous environment, and their work is mental work-based, no specific job description, nor a fixed workflow. At the same time, the knowledge and skills which required for research and development work are also professional. With strong specialization, R&D personnel need to keep learning, training and continuing education to maintain their human capital value (Shahhosseini and Sebt 2011).

In addition, the labor achievements of R&D personnel are often new technology, new products and new services, and they are switched into economy profits but are subject to other internal and external resources. Therefore, performance appraisal cycle of R&D personnel will be longer. Also, research and development activities are often used by team work, and the innovation achievements are the fruit of team members' wisdom, so sometimes it is difficult to monitor R&D personnel's work, and accurately measure the level of effort or members' contribution. Therefore, it often results in greater difficulty for performance evaluation of R&D personnel.

11.3 The Construction of R&D Personnel's Competency Model

According to the needs of enterprises' actual situation and business management, and refer to the competency model in similar industry, we can divide the structure of competency into explicit and implicit ability. Among them, the elements of

explicit ability include: professional qualifications, expertise, work history and title and so on. Knowledge elements include: expertise, management expertise, production knowledge and company knowledge. The elements of implicit ability include management skills and basic quality. Professional skills and basic quality can form the initial competency project, and define the common quality of R&D personnel based on the organizational culture and values.

The components, design sources, methods and processes of competency model are show in Table 11.1.

The construction of competency model for R&D personnel mainly combines four methods of the interview, questionnaire, behavioral event interview and expert panel discussion.

In the process of structuring R&D personnel's competency model, first of all, we should define the performance standards. For the evaluation object, clear and definite standards can be used to determine and measure which kind of performance is good, which kind of performance is poor. Because of the specificity of R&D personnel's work, the performance standards of this group are mainly based on job analysis. We can refine and decompose the excellent performance standards into some specific tasks, identify and summarize the characteristic of behavior which may promote R&D personnel high performance.

Second, it can use the interviews to understand the comments and suggestions about the construction of R&D personnel's competency model from senior leadership. Before the interview, we should write the interview outline, arrange and analyze the interview content to obtain the major elements constituted competency, namely explicit ability and implicit ability.

Furthermore, on this basis, using a structured questionnaire to conduct behavioral event interview from merit and general incumbent, and through the methods like job analysis, interviews with experts or an expert database to compare and analyze the

Table 11.1 Structure of competency model

Ability category	Definition	Design source	Design methods and processes
Management skills	Engage in management or the work with nature of management should have the common ability	Theory with actual	Design questionnaire by post sequence, count and analyze combined with Interview of benchmarking characters
Common quality	Require common moral character and attitudes of employees	Organizational culture values	Research cultural systems, understand the leadership's management intent
Professional quality	Position require the employee's personality, moral character and attitude	Departmental responsibilities Job responsibilities	Design questionnaire by post sequence, count and analyze combined with Interview of benchmarking characters

key behavioral characteristics of performance differences between two groups, thereby obtaining the competency characteristics which R&D personnel must be had, and combining the collected and classified information to standardization define and classify each competency, and making a behavioral description for different competency levels. Then it will structure the R&D personnel's competency model initially. After, the enterprises should form a group constituted by some experts, discuss the competency elements which belong to R&D personnel's competency model library, and make the appropriate adjustments.

To ensure the rationality of competency model, it is necessary to establish the model testing, and count the frequency that competency project has appeared, then do significant difference test to compare the frequency of elements indicators and related degree statistical indicators between merit and general group, finally identify the similarities and differences characteristics between two groups. Through the construction and validation of R&D personnel's competency model, we determine seven R&D personnel's competency indicators: security awareness, creative awareness, and teamwork, problem-solving skills, communication skills, learning ability, succeed desire. Enterprises can combine questionnaires and expert scoring views to set weights for R&D personnel's competency indicators.

Rough set is a new mathematical tool to deal with fuzzy and uncertain knowledge (Zhu 2007). The essence of multi-index evaluation method based on rough set is trans-forming the problem of weights determining into the evaluation of properties importance of rough set. In the context of data-driven, through the analysis of objects support and importance, we can determine the weights value with comprehensive evaluation model, and the weights are entirely decided by the law of data itself. It uses the evaluation indicators as the condition property, and sets the set of condition property, and the set of decision property. There are 16 experts involved in the evaluation scoring table, and the objects for evaluation are, so the two-dimensional information table formed by is the relational data model on the evaluation objects. The results of pretreatment and discrete data are shown in Tables 11.2 and 11.3.

Table 11.2 Results of pretreatment data

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	D
E_1	0.80	0.67	0.64	0.56	0.80	1.00	0.70	0.83
E_2	0.56	0.33	0.52	0.45	0.60	0.67	0.76	0.68
E_3	0.67	0.47	0.57	0.42	0.69	0.79	0.83	0.76
E_4	0.76	0.69	0.63	0.33	0.78	0.83	0.89	0.72
E_5	0.83	0.67	0.59	0.67	0.88	0.86	0.83	0.75
E_6	0.78	0.84	0.74	0.59	0.78	0.78	0.81	0.86
E_7	0.58	1.00	1.00	0.89	1.00	0.94	0.94	0.77
E_8	0.66	0.37	0.67	0.39	0.64	0.83	0.73	0.78
E_9	0.61	0.47	0.30	0.36	0.67	0.73	0.74	0.77
E_{10}	0.59	0.38	0.59	0.45	0.71	0.86	0.76	0.73
E_{11}	0.68	0.89	0.42	0.33	0.68	0.68	0.76	0.68
E_{12}	0.82	0.64	0.89	0.56	0.86	0.85	0.86	0.83
E_{13}	0.59	0.43	0.39	0.41	0.96	0.69	0.73	0.67
E_{14}	1.00	0.88	0.79	0.85	0.89	0.99	1.00	0.84
E_{15}	0.58	0.47	0.46	1.00	0.62	0.69	0.78	0.72
E_{16}	0.74	0.65	0.72	0.36	0.81	0.89	0.90	0.85

Table 11.3 Results of discrete data

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	D
E_1	2	2	2	2	2	3	1	3
E_2	1	1	1	1	1	1	1	1
E_3	1	1	2	1	1	2	2	2
E_4	2	2	2	1	2	2	2	2
E_5	2	2	2	2	2	2	2	2
E_6	2	3	2	2	2	2	2	3
E_7	1	3	3	3	3	3	3	2
E_8	1	1	2	1	1	2	1	2
E_9	1	1	1	1	1	1	1	2
E_{10}	1	1	2	1	1	2	1	2
E_{11}	1	3	1	1	1	1	1	1
E_{12}	2	2	3	2	2	2	2	3
E_{13}	1	1	1	1	3	1	1	1
E_{14}	3	3	3	3	3	3	3	3
E_{15}	1	1	1	3	1	1	1	1
E_{16}	2	2	2	1	2	3	2	3

Calling MATLAB solver to calculate the set of equivalence classes:

$$
\begin{aligned}
U/ind(D) &= \{E_1, E_6, E_{12}, E_{14}, E_{16}), (E_2, E_{10}, E_{11}, E_{13}, E_{15}), \\
&\quad (E_3, E_4, E_5, E_7, E_8, E_9)\} \\
U/ind(C) &= \{E_1, (E_2, E_9), E_3, E_4, E_5, E_6, E_7, (E_8, E_{10}), \\
&\quad E_{11}, E_{12}, E_{13}, E_{14}, E_{15}, E_{16}\} \\
U/ind(c_2, c_3, c_4, c_5, c_6, c_7) &= \{E_1, (E_2, E_9), E_3, E_4, E_5, E_6, (E_7, E_{14}), (E_8, E_{10}), \\
&\quad E_{11}, E_{12}, E_{13}, E_{14}, E_{15}, E_{16}\} \\
U/ind(c_1, c_3, c_4, c_5, c_6, c_7) &= \{E_1, (E_2, E_9, E_{11}), E_3, E_4, (E_5, E_6), E_7, (E_8, E_{10}), \\
&\quad E_{12}, E_{13}, E_{14}, E_{15}, E_{16}\} \\
U/ind(c_1, c_2, c_4, c_5, c_6, c_7) &= \{E_1, (E_2, E_9), E_3, E_4, (E_5, E_{12}), E_6, E_7, (E_8, E_{10}), \\
&\quad E_{11}, E_{13}, E_{14}, E_{15}, E_{16})\} \\
U/ind(c_1, c_2, c_3, c_5, c_6, c_7) &= \{(E_1, E_{16}), (E_2, E_9, E_{15}), E_3, (E_4, E_5), E_6, \\
&\quad E_7, (E_8, E_{10}), E_{11}, E_{12}, E_{13}, E_{14}\} \\
U/ind(c_1, c_2, c_3, c_4, c_6, c_7) &= \{E_1, (E_2, E_9, E_{13}), E_3, E_4, E_5, E_6, E_7, \\
&\quad (E_8, E_{10}), E_{11}, E_{12}, E_{14}, E_{15}, E_{16}\} \\
U/ind(c_1, c_2, c_3, c_4, c_5, c_7) &= \{(E_1, E_5), (E_2, E_9), (E_3), (E_4, E_{16}), E_6, E_7, \\
&\quad (E_8, E_{10}), E_{11}, E_{12}, E_{13}, E_{14}, E_{15}\} \\
U/ind(c_1, c_2, c_3, c_4, c_5, c_6) &= \{E_1, (E_2, E_9), (E_3, E_8, E_{10}), E_4, E_5, E_6, E_7, \\
&\quad E_{11}, E_{12}, E_{13}, E_{14}, E_{15}, E_{16}\}
\end{aligned}
$$

Exporting the positive field of the set of condition property as follows:

$$
\begin{aligned}
&pos_c(D) = \{E_1, E_3, E_4, E_5, E_6, E_7, E_{11}, E_{12}, E_{13}, E_{14}, E_{15}, E_{16}\} = 12\\
&pos_{c-|c_1|}(D) = \{E_1, E_3, E_4, E_5, E_6, E_{11}, E_{12}, E_{13}, E_{15}, E_{16}\} = 10\\
&pos_{c-|c_2|}(D) = \{E_1, E_3, E_4, E_7, E_{12}, E_{13}, E_{14}, E_{15}, E_{16}\} = 9\\
&pos_{c-|c_3|}(D) = \{E_1, E_3, E_4, E_6, E_7, E_{11}, E_{13}, E_{14}, E_{15}, E_{16}\} = 10\\
&pos_{c-|c_4|}(D) = \{E_1, E_3, E_4, E_5, E_6, E_7, E_{11}, E_{12}, E_{13}, E_{14}, E_{16}\} = 11\\
&pos_{c-|c_5|}(D) = \{E_1, E_3, E_4, E_5, E_6, E_7, E_{11}, E_{12}, E_{14}, E_{15}, E_{16}\} = 11\\
&pos_{c-|c_6|}(D) = \{E_1, E_3, E_5, E_6, E_7, E_{11}, E_{12}, E_{13}, E_{14}, E_{15}\} = 10\\
&pos_{c-|c_7|}(D) = \{E_1, E_4, E_5, E_6, E_7, E_{11}, E_{12}, E_{13}, E_{14}, E_{15}, E_{16}\} = 11
\end{aligned}
$$

Calculating the dependence that decision property towards the set of evaluation indicators, using the formula:

$$r_{c-|c_i|}(D) = \frac{card(pos_{c-|c_i|}(D))}{card(U)} \tag{11.1}$$

The results are as follows:

$$
\begin{aligned}
&r_c(D) = 12/16 = 0.7500; r_{c-|c_1|}(D) = 10/16 = 0.6250;\\
&r_{c-|c_2|}(D) = 9/16 = 0.5625; r_{c-|c_3|}(D) = 10/16 = 0.6250;\\
&r_{c-|c_4|}(D) = 11/16 = 0.6875; r_{c-|c_5|}(D) = 11/16 = 0.6875\\
&r_{c-|c_6|}(D) = 8/16 = 0.6250; r_{c-|c_7|}(D) = 11/16 = 0.6875
\end{aligned}
$$

Further, calculating the importance of the condition property towards the decision property, using the formula:

$$\sigma(c_i) = r_C(D) - r_{C-|c_i|}(D) \tag{11.2}$$

The results are as follows:

$$
\begin{aligned}
\sigma(c_1) &= 0.7500 - 0.6250 = 0.1250;\\
\sigma(c_2) &= 0.7500 - 0.5625 = 0.1875\\
\sigma(c_3) &= 0.7500 - 0.6250 = 0.1250;\\
\sigma(c_4) &= 0.7500 - 0.6875 = 0.0625\\
\sigma(c_5) &= 0.7500 - 0.6875 = 0.0625;\\
\sigma(c_6) &= 0.7500 - 0.5000 = 0.1250\\
\sigma(c_7) &= 0.7500 - 0.6875 = 0.0625
\end{aligned}
$$

Calculating the weight of each evaluation indicator:

$$\omega_i = \frac{\sigma(c_i)}{\sum_{j=1}^{n} \sigma(c_i)} \tag{11.3}$$

Calculating the normalized weight of each evaluation indicator based on the above formula (11.3):

$$\omega_1 = 0.1667; \omega_2 = 0.2500;$$
$$\omega_3 = 0.1667; \omega_4 = 0.0833;$$
$$\omega_5 = 0.0833; \omega_6 = 0.1667;$$
$$\omega_7 = 0.0833$$

Competency model describes the company's core capabilities and personnel's core competencies and skills. These will be applied to recruitment selection, potential evaluation and the final appointment or removal decisions to provide more personnel's support for enterprises' better development.

11.4 Conclusion

With the gradually in-depth study of competency, the new human resources management mode based on competency will further enhance the core competitiveness of enterprises and provide a solid basis for enterprises in the fierce market competition. In this paper, it started from the characteristics of R&D personnel, combining with various methods to structure the R&D personnel's competency model, and forming its evaluation indicators system, further based on rough sets determining the weight of the evaluation indicators to ensure the rationality of evaluation system, then future providing reference for in-depth study of R&D personnel's competency. But, in the process of doing empirical research, the test methods of competency model need to be further expanded.

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