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THE PROMOTION FACTORS OF MANAGEMENT INNOVATION BASED ON GRAY-DEMATEL METHOD

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Abstract. *In order to clarify the promotion factors of management innovation, this paper combs the dynamic factors of enterprise management innovation firstly, and then analyzes the promotion factors quantitatively by the Gray-DEMATEL method. We get the reason degree and centrality degree of the factors. The results show that the level of education, organizational scale, and diversity of management team professional background are the most important reason factors; market orientation, centralization, organizational cohesion and management intensity are the most important result factors; position power, organizational specialization, centralization and overall view of the manager are the most important centrality factors.*

Keywords: Private enterprises in manufacturing industry, Management innovation, Gray-DEMATEL, Promotion factors

1. **Introduction.** The implementation of technological innovation and management innovation is an important response for the rapidly changing market environment for the enterprises. However, in the management practice, enterprises always pay more attention to technological innovation, not management innovation. In the financial crisis of the year 2008, enterprises found that US companies with the advantage of technological innovation have not survived; technological innovation cannot sustain the development of enterprises, and concerning about the management innovation may be a better way. Management innovation has an irreplaceable role in overcoming organizational inertia and ossification, and improving organizational performance. It is an important way for enterprises to gain sustained competitive advantages.

Scholars began to focus on the factors that can promote management innovation [1-4]. And in order to find out the relationship between them, structural equation modeling was the common method to use [5-11]. However, structural equation modeling can only tell the corresponding relationship between variables, and it is difficult to distinguish the nature of the variable itself. Meantime, the practice showed that the success rate of innovation is still very low. BPR (Business Process Reengineering) had 50-70% of the effort that cannot meet the target [12] and 80% of total quality management activities failed [13]. This requires us not only to find the factors that can affect management innovation, but also to know which factors can play a fundamental role, which factors can play the most direct role and which factors have the largest effect. And then we can guide business practice at the target.

2. Analysis of the Promotion Factors of Management Innovation.

2.1. The definition of management innovation.

At present, the non-technical attributes of management innovation have been widely accepted, but the definition of management innovation is quite different in different researches. Generally speaking, the definition of management innovation can be divided into two types: one type is that the management innovation only contains several areas, such as organizational and cultural innovation [1] and organizational structure, management processes, and human resources [2].

The other is that management innovation is all innovation except technological innovation. For example, Damanpour and Evan argued that management innovation refers to innovation in organizational structure and management processes and is not directly related to the organization's basic work activities [3]. Birkinshaw et al. [1] defined management innovation as a new practice, process, or structure implemented by an organization that has led to significant changes in management activities and the achievement of organizational goals by extending management innovation to all non-technical innovation. The definition of Damanpour and Evan [3] is used more extensively, so we adopt it.

2.2. Promotion factors of management innovation.

In recent years, the study of contributing factors is mainly concentrated on the individual and organizational level. In the individual level, the researchers study the object by the view of managers and employees. From the perspective of managers, the overall view and educational level have significant positive effects on the promotion of management innovation [4]. The more diverse the professional background is, the more obvious it is to promote managerial innovation [4]. The position power and managerial strength have a significant positive correlation with managerial innovation [5]. From the perspective of employees, the professionalism of employees can promote organizational management innovation [6].

In the organizational level, the contributing factors mainly contain organizational structure, organizational resources and organizational strategy orientation. (1) Organizational structure. The high degree of organizational centralization can promote organizational management innovation [7]. Because of the scale economy, the organizational innovation increases as the size of the organization increases. Organizational specialization has a significant positive impact on management innovation [7]. (2) Organizational resource. The internal social capital has a positive impact on management innovation, that is, management innovation needs the promotion of internal social capital [8]. And marketing capabilities have a significant positive effect on organizational innovation [9]. (3) Strategic orientation. Learning orientation emphasizes that organizations acquire new knowledge, and organizational innovation emphasizes the infusion of new ideas and behaviors. Therefore, the establishment of organizational learning mechanism can stimulate the innovation. Learning orientation is an important antecedent of management innovation [12]. In the different backgrounds, scholars have found that market orientation has a significant positive impact on organizational innovation [10,11].

In summary, the contributing factors of organizational management innovation include the following 14 variables: (a1) managers overall view, (a2) managers education level, (a3) diversity of management team professional background, (a4) position power, (a5) management intensity, (a6) staff professionalism, (a7) organization cohesion, (a8) organizational scale, (a9) centralization, (a10) organizational specialization, (a11) internal social capital, (a12) learning orientation, (a13) market orientation, and (a14) marketing ability.

3. Empirical Research.

DEMATEL (Decision-Making Trial and Evaluation Laboratory) method was developed by the Bastille National Laboratory of the United States in

the mid-1970s. This method uses graph theory and matrix theory principle to analyze system factors. Through the calculation, we can get the centrality and reason degree, and thus can conclude which category the factors belong to (fundamental drivers and direct drivers). Gray number refers to an interval or a certain number of uncertain values. For the problems with ambiguity, to make the data collected gray will be more able to make the results accurate. Therefore, based on the DEMATEL method, increasing the gray number is a good idea. According to the research content, we need to apply Gray-DEMATEL method by doing the following five steps for data processing.

(1) Determine the factors and their relationship. Each factor in the indicator system is regarded as a factor that directly or indirectly affects the indicator attribute; let the managers in the private enterprise in manufacturing industry analyze directly effect between two factors. The managers have more than 3 years of experience in the enterprise, and are responsible for management. 65 valid questionnaires were collected. The questionnaire can truthfully reflect the practical status in the enterprise.

(2) Construct the matrix by gray system theory. There are five levels to get gray-matrix conversion, a weak influence $[0, 0.25]$, a moderate effect $[0.25, 0.5]$, a strong influence $[0.5, 0.75]$, and very strong influence $[0.75, 1]$. And then we get the 14×14 gray matrix x, and its diagonal values are $[0, 0]$. According to the size of the enterprise and the number of management innovation, we give different enterprises different weights.

(3) We use Formulas (1)-(3) to clarify the questionnaire. k is the number of the sample. The gray number refers to the interval gray number; it is denoted by $\otimes x$ which belongs to $[\underline{\otimes} x, \overline{\otimes} x]$, $\underline{\otimes} x$ is the lower limit and $\overline{\otimes} x$ is the upper limit of the gray number.

$$\begin{aligned}
\underline{\otimes}\tilde{x}_{ij}^{k} &= \left(\underline{\otimes} x_{ij}^{k} - \min\underline{\otimes} x_{ij}^{k}\right) \Big/ \triangle_{\min}^{\max} \\
\overline{\otimes}\tilde{x}_{ij}^{k} &= \left(\overline{\otimes} x_{ij}^{k} - \min\overline{\otimes} x_{ij}^{k}\right) \Big/ \triangle_{\min}^{\max} \\
\triangle_{\min}^{\max} &= \max\overline{\otimes} x_{ij}^{k} - \min\underline{\otimes} x_{ij}^{k} \qquad (1)
\end{aligned}$$

$$Y_{ij}^{k} = \frac{\left(\underline{\otimes}\tilde{x}_{ij}^{k}\left(1 - \underline{\otimes}\tilde{x}_{ij}^{k}\right) + \left(\overline{\otimes}\tilde{x}_{ij}^{k} \times \overline{\otimes}\tilde{x}_{ij}^{k}\right)\right)}{\left(1 - \underline{\otimes}\tilde{x}_{ij}^{k} + \overline{\otimes}\tilde{x}_{ij}^{k}\right)} \qquad (2)$$

Calculate a clear value:

$$z_{ij}^{p} = \min_{j} \underline{\otimes} x_{ij}^{p} + Y_{ij}^{p} \Delta_{\min}^{\max} \qquad (3)$$

(4) Use Formula (4) to calculate the weight matrix Z of each sample. The normalized matrix N is obtained by using Formulas (5) and (6), and z_{ij} is the element of the ith row and jth column in the matrix. s is the normalization coefficient and p is the number of samples. At the same time, use Formula (7) to calculate the comprehensive influence matrix T ($T = [t_{ij}]n \times n$).

$$z_{ij} = w_1 z_{ij}^{1} + w_2 z_{ij}^{2} + \cdots + w_p z_{ij}^{p}, \quad \sum_{i=1}^{p} w_i = 1 \qquad (4)$$

$$N = s \cdot Z \qquad (5)$$

$$s = \frac{1}{\max\limits_{1 \le i \le n} \sum\limits_{j=1}^{n} z_{ij}}, \quad i, j = 1, 2, \ldots, n \qquad (6)$$

$$T = N + N^2 + N^3 + \cdots = \sum_{i=1}^{\infty} N^i = N(I - N)^{-1} \quad \text{When } |\lambda_i| < 1, \lim_{i \to \infty} N^i = [0]_{n \times n} \qquad (7)$$

(5) In the comprehensive influence matrix T, we use Formulas (8) and (9) to calculate the reason degree E_i and the centrality degree P_i. The result is shown in Table 1.

$$R_i = \sum_{j=1}^{n} t_{ij} \quad \forall i \qquad D_j = \sum_{i=1}^{n} t_{ij} \quad \forall j$$

$$E_i = \{R_i - D_j | i = j\} \tag{8}$$

$$P_i = \{R_i + D_j | i = j\} \tag{9}$$

The reason degree $E_i > 0$ indicates that the element has a great influence on other factors, and we call it reason factors; on the contrary, it is influenced by other factors, and we call it the result factors. The centrality degree P_i means the influence strength. The higher P is, the higher the effect it has on innovation. R_i is the sum of the elements in each row, it means the effect the ith dynamic factor has on the other dynamic factors, and it is the degree of influence. D_j is the sum of the column elements, it is the effect that the jth dynamic factor has on the other dynamic factors, and it is the degree of being influenced.

TABLE 1. The degree of reason and centrality of factors

Factors	R (sum)	D (sum)	E_i $(R-D)$	P_i $(R+D)$
a1	4.2052	3.8168	0.3884	8.0220
a2	3.8248	2.6610	1.1638	6.4858
a3	3.5938	2.8920	0.7018	6.4858
a4	4.7355	4.2132	0.5223	8.9488
a5	3.6737	4.2227	−0.5490	7.8964
a6	3.7318	3.4289	0.3029	7.1607
a7	3.3996	3.9029	−0.5034	7.3025
a8	4.2171	3.3835	0.8336	7.6006
a9	3.8409	4.2712	−0.4303	8.1121
a10	4.2771	3.9505	0.3266	8.2276
a11	3.4756	4.1080	−0.6324	7.5836
a12	3.4189	4.2292	−0.8103	7.6482
a13	3.8405	4.1305	−0.2899	7.9710
a14	3.4215	4.4456	−1.0241	7.8671

4. **Results and Analysis.** According to the reason and the centrality degree of each factor, the Cartesian coordinate is established, and the position of each influencing factor in the coordinate is marked, where the ordinate represents the reason degree and the abscissa represents the centrality degree (Figure 1).

4.1. **Analysis of reason degree.** (1) Analysis of reason factors. The reason factors are the most fundamental factors, which can not only promote the management innovation directly, but also influence other factors. It is the key factor to establish the long-effect mechanism. In Table 1 and Figure 1, the most fundamental motivators for the promotion of organizational management innovation are the level of education (a2, 1.1638), organizational scale (a8, 0.8336), diversity of management team professional background (a3, 0.7018) and position power (a4, 0.5223). As a supplement, managers overall view (a1, 0.3884), organizational specialization (a10, 0.3266) and staff professionalism (a6, 0.3029) are also the important reason factors.

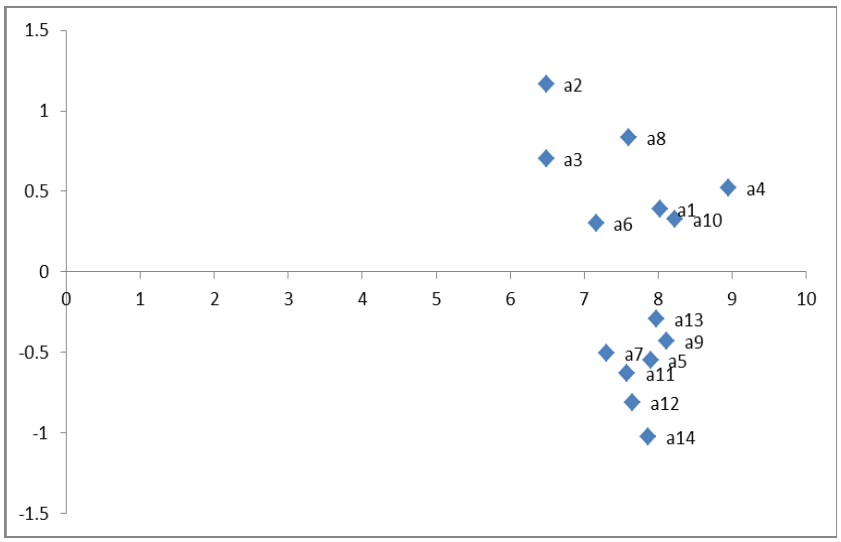

FIGURE 1. Reason-result

If the organizations want to enhance management innovation, they need to mainly focus on the manager and organizational characteristics. On the whole, it is necessary to enhance the manager's own educational level, to increase the professional background of the management team and to enhance the overall view of the managers. At the same time, larger scales are more likely to increase other factors to promote the level of organizational management innovation; the division of the department and enhancing the professional ability of the staff can increase the management innovation.

(2) Analysis of result factors. The result factors are the most direct factors to promote the management innovation. They are easy to be influenced by the other factors, so they are the most obvious promotion factors to the management innovation in the short term. In Table 1 and Figure 1, the most direct motivating factor is market orientation (a13, −0.2899). Centralization (a9, −0.4303), organizational cohesion (a7, −0.5034), management intensity (a5, −0.5490) and internal social capital (a11, −0.6324) take the second place. Learning orientation (a12, −0.8103) and marketing ability (a14, −1.0241) are the weak factors.

The most direct way to promote management innovation is to adopt market-oriented strategy. The enterprise should according to the market requirements adjust management functions. Meantime, increase the concentration of organizational decision-making authority, enhance the organization's attraction to employees and the centripetal force, enhance the strength of unity and cooperation among members, and increase the intensity of management to promote management innovation.

4.2. **Analysis of centrality degree.** The centrality degree represents the strength of the effect on management innovation. The higher the centrality degree is, the more important the factor is. From Table 1 and Figure 1, we can see that position power (a4), organizational specialization (a10), centralization (a9) and overall view of the manager (a1) have the strongest impact on the management innovation.

According to the result, we should enhance the position power and their overall view to promote the management innovation. Meantime, when organizational specialization and the specialization are enhancing, we need a new way to manage the organization, and the management innovation is shown up.

It can be seen from Table 1, (a2) education level and (a3) diversity of management team professional background are the lowest two variables in the centrality degree factors, but

the two factors are the highest factors in reason factor. This indicates that although a2 and a3 have a weak promotion effect on organizational innovation, it is the further promotion factor of organizational innovation, which can promote the other factors and make the organization maintain the management innovation. If we want to improve the management innovation in a short time, we can achieve it by enhancing the higher degree of central variables. However, if we want to fundamentally improve the management innovation, we should pay attention to the reason factors.

5. **Sensitivity Analysis.** Based on the sensitivity analysis, we can see the influence of a particular sample with potential bias on the results. If the weight of the sample has little influence on the case, it shows that the sensitivity is small and has high reliability. In order to facilitate the analysis, only the maximum weight of the sample questionnaire changes. The gray weight of the sample is $[0.7, 1]$ (very important), and then we make the gray weight of this sample $[0.5, 0.9]$ (more important), $[0.4, 0.7]$ (significant) and $[0.3, 0.5]$ (less important), and other sample weights are constant. Using the Gray-DEMATEL method to repeat the calculation three times, we can get three reason-result graphs (Figures 2-4). We can see the position of the reason and the centrality degree factors almost has no change, so the result has passed the sensitivity test.

6. **Conclusions.** This paper uses the Gray-DEMATEL method to analyze the promotion factors of management innovation, and identifies the reason factors and the result factors; at the same time get the center of each factor. In order to avoid the subjectivity of the evaluation, we analyzed the sensitivity of the results. The results show that: in the process of management innovation, the level of education, organizational scale, and diversity of management team professional background are the most basic promotion factors, and they can fundamentally guarantee the enterprise management innovation; market orientation, centralization, organizational cohesion and management intensity can provide the most direct impetus for enterprise management innovation; if you need quick results, you should pay attention to these factors. The most powerful factors in organizational management innovation are position power, organizational specialization, centralization and overall view of the manager, which can give the strongest impetus to management innovation. Enterprises can match the requirements with the characteristics of the factors to achieve

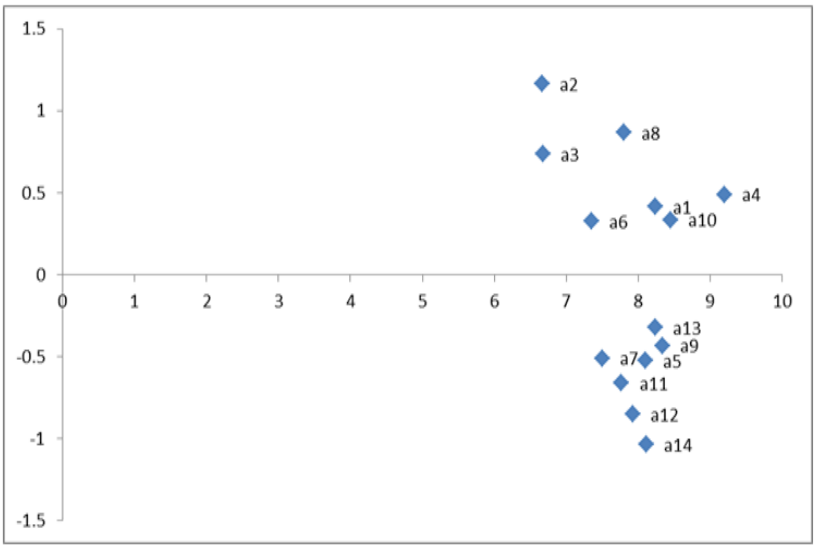

FIGURE 2. Reason-result ($[0.5, 0.9]$)

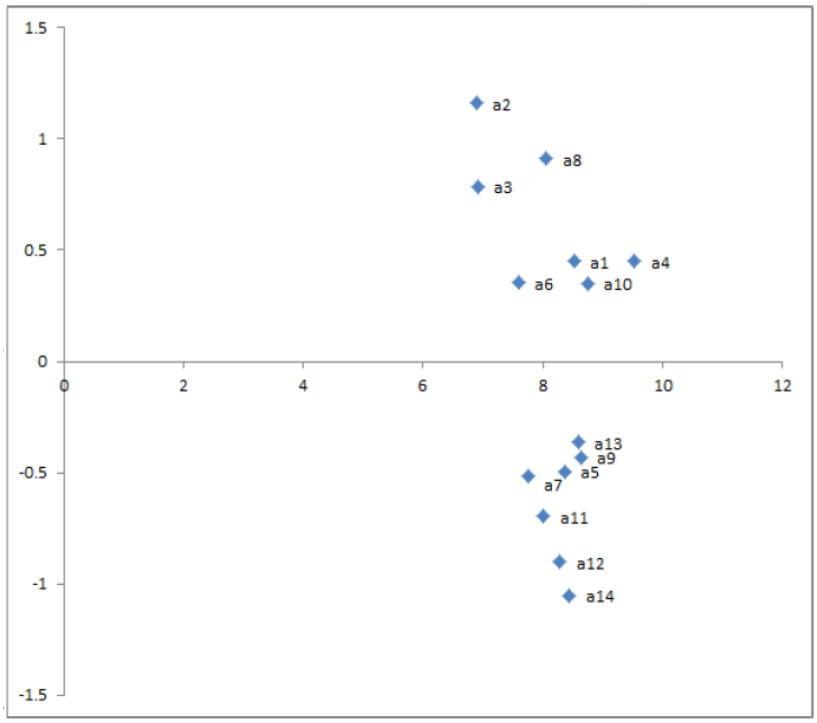

FIGURE 3. Reason-result ($[0.4, 0.7]$)

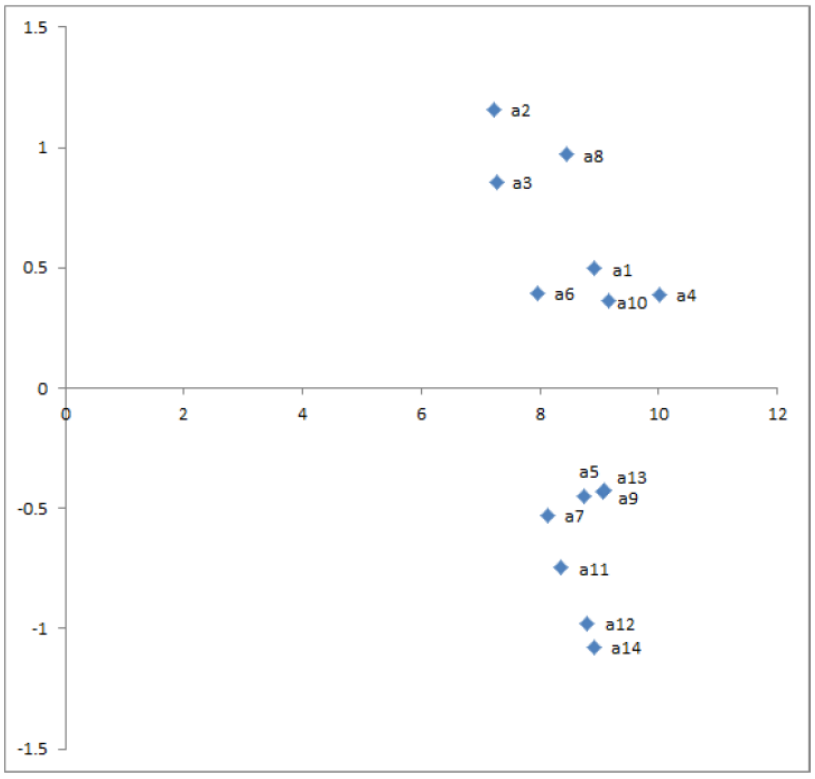

FIGURE 4. Reason-result ($[0.3, 0.5]$)

enterprise management innovation. This paper does not take account of the different roles of promoters on management innovation in different stages of enterprise development. Future research can do comparative analysis in different stages.

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