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Ruiqing Hao (ruiqinghao@outlook.com)
Xi'an Technological University
Qian Ren

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Research On the Evaluation Model Construction of Manufacturing Project Management Capability Under the Background of Big Data

Ruiqing Hao[1,2,*], Qian Ren[3]
[1]Xi'an Technological University, School of Mechatronic Engineering, Xi'an, Shaanxi,710021, China
[2]Xi'an Aeronautical Polytechnic Institute, Xi'an, Shaanxi,710089, China
[3]Shaanxi Aerospace Pump &Valve Technology Group Co., Ltd., Xi'an, Shaanxi,710200, China
*Corresponding author email: ruiqinghao@outlook.com

Abstract: In order to improve the manufacturing project management ability, from the perspective of project management ability evaluation, this paper analyzes the manufacturing project management ability combined with big data technology, and constructs the project management ability evaluation model. Moreover, this paper designs a manufacturing project management maturity evaluation model based on fuzzy mathematics. In addition, this paper analyzes manufacturing project management and capability maturity evaluation models and related theories of fuzzy mathematics, and focuses on the management process and knowledge system of manufacturing projects. Through simulation research, it can be known that the evaluation model of manufacturing project management capability based on big data technology proposed in this paper has good practical effects. Moreover, the implementation of effective research and development project management can increase the success rate of research and development, reduce waste of resources, improve innovation capabilities, and ultimately enhance the core competitiveness of the enterprise.

Keywords: big data; manufacturing; project management; capability evaluation; model

1 Introduction

With the acceleration of economic globalization, China's market economy is gradually improving. If Chinese companies want to participate in international competition as soon as possible and remain invincible in international competition, the first thing to do is to strengthen their internal management and continuously enhance their core competitiveness. This puts forward higher and newer requirements for modern enterprise management. Moreover, while enterprises emphasize the improvement of management personnel's ability to innovate, practice, and dialogue with the world, they also need to strengthen resource integration and personnel deployment in project management, and project management process reengineering is also an indispensable and important content. In addition, the establishment of a project to promote better and faster economic development is a new type of enterprise organization and management mode generally recognized by contemporary professional managers.

With the intensification of market competition, improving the core competitiveness of enterprises with the help of information construction has become a key issue for enterprises, and it is also a necessary means and only way for enterprises to develop healthily and quickly. In recent years, the company has attached great importance to informatization construction and investment, but the current informatization level still has a gap with the rapid development and refined management of the enterprise, which restricts the continuous improvement of management in certain procedures. The company's internal project management and daily leave reimbursement and other processes mainly use paper documents for circulation approval. The process is time-consuming and has low office efficiency. The goal of supporting the rapid development of the company and the realization of strategic goals with information construction has not yet been achieved. Information integration and sharing support There is still a big gap to achieve the value target. Information construction is managed around the project management process, and has not yet achieved an effective connection with enterprise operations, and manual methods are still used in all aspects.

Manufacturing enterprises play a pivotal role in promoting my country's economic development. Therefore, researching the R&D project management of manufacturing enterprises can effectively promote economic development and improve the innovation capability of the manufacturing industry. Effective R&D project management helps to enhance the R&D capability of the enterprise, stimulate the innovation consciousness of R&D personnel, and change the R&D performance of the enterprise. In recent years, with the rapid development of information technology and increasingly fierce competition, new R&D management models have emerged in the process of R&D management practices of global enterprises. Domestic enterprises should also explore R&D project management models that are in line with my country's manufacturing industry.

This article combines big data technology to analyze the manufacturing project management capabilities, and builds a project management capability evaluation model to improve manufacturing related management capabilities.

2 Related work

In literature [1], in the process of systematically comparing successful companies and failed companies in innovation in each industrial sector, 41 factors that significantly affect the success of R&D projects were screened out according to the statistical results, including the process management of R&D projects. Good R&D project process management can improve the probability of R&D project success. In the study of literature [2], good process planning and execution are included as one of the eight conditions for the success of new product development, which further verifies the importance of R&D project process management. Literature [3] divides project management into four stages: definition, planning, management, review and summary, and emphasizes that the end of a project does not mean the end of all projects. The problems are sorted out and summarized to prepare for the improvement of the project management process in the future. The R&D project process needs to be matched with the project management ability. The project management ability first needs high-quality managers and enterprise organizations, and secondly, it needs a reasonable management and control system.

Literature [4] compared the critical chain with the traditional critical path, and pointed out that the progress of the critical chain is that it believes that resources are limited, and resources are scarce in the multi-project management environment, which is different from the critical path method. is sufficient, so the critical chain is more practical. Literature [5] studied the development process of the theory of constraints, and proved that the critical chain is more advanced than the critical path and plan review technology, which can significantly shorten the construction period and will be the mainstream research direction and management method of multi-project management in the future. Literature [6] studies why the theory of constraints can be applied in project schedule management, and explores whether the theory of constraints can be used for cost and risk management. Literature [7] focuses on the calculation method of time difference, and proposes new concepts of total time difference and free time difference. The literature [8] proposes the hierarchical equilibrium boundary HBC theory, which believes that Goldratt's constraint theory is imperfect, and proposes the evolution from constraint management to critical management. Literature [9] believes that even though CCPM technology has been extensively studied, there are still controversial parts, such as buffer estimation, which is too complicated. Literature [10] studies the organizational forms and control methods in multi-project management. In the project life cycle, each project stage needs to have a clear and definite person in charge, so as to ensure the smooth progress of the project at each stage. Literature [11] studies that the three roles of PMO as coordinator, controller and supporter are the key to the success of multi-project management. Literature [12] believes that PMO plays the role of knowledge broker in project-based organizations. Literature [13] believes that organizational characteristics will affect PMO characteristics, and analyzes the correlation between the two in project-based organizations.

Literature [14] introduced the critical chain theory and its application in project management. Literature [15] conducted a comparative study of critical chain and critical path and plan review technology, and explained the advantages and disadvantages of critical chain, but the view that critical chain is the direction of future project management research is clear. Literature [16] mainly studies the progress problems existing in multi-project management, and proposes that the use of critical chain theory for progress management can effectively solve the problem. Literature [17] uses the critical chain theory to optimize the management problems in non-standard equipment manufacturing projects, thereby improving the efficiency of multi-project management. The main research contents are: how to identify constrained resources, how to identify critical chains and optimize them, and how to establish buffer mechanisms. Establish a multi-project management method suitable for solving pressure vessel manufacturing enterprises. And apply this theory and method to the actual project to verify that the critical chain is an effective method to solve the multi-project management problem of non-standard equipment manufacturing enterprises. Literature [18] mainly analyzes and researches from the aspects of time-constrained type, resource-constrained type and resource allocation under resource constraints, explores how to solve the problem of resource conflict, and proposes methods and steps for resource optimization. Literature [19] expounds the critical chain theory, establishes a multi-project management model under resource constraints, and uses the constraint theory to solve problems such as serious resource conflicts and low utilization efficiency in a multi-project environment. First, determine the bottleneck resources, Then use the key chain to optimize the allocation of resources, so as to solve the problems of low resource utilization efficiency and schedule delay in the enterprise. Literature [20] studies the correlation between PMO and project success, reveals the impact of using PMO, and shows whether PMO can be added as a new element to the CSFs model of critical success factors identified by Pinto earlier. In the study of strategic planning, the five-stage capability development model of PMO is proposed, and how the organization establishes and uses PMO is summarized and described. Literature [21] proposes that a project management office (PMO) should be established for project management, and expounds the main functions of PMO in the enterprise. Aiming at the problem of resource conflict, this paper proposes that it is necessary to establish a theoretical system of resource management using critical chains in PMO, and illustrates how PMO uses critical chains to manage resource conflicts through examples.

3 Fuzzy evaluation of manufacturing project management ability based on big data

In fuzzy mathematics, in addition to fuzzy meaning, "fuzzy" also has meanings such as "unclear". Some people argue that it should be translated as "lack of clarity" with both sound and meaning. However, none of them has a profound meaning of "vagueness". Fuzzy mathematics is a mathematical theory and method for studying and dealing with fuzzy phenomena.

Fuzzy relations occupies an important position in fuzzy set theory. When the domain of theory is limited, fuzzy matrices can be used to express fuzzy relations.

The fuzzy matrix can be regarded as an extension of the ordinary relational matrix. The function of fuzzy matrix in fuzzy mathematics is similar to that of matrix in classical mathematics. It is an important tool for studying fuzzy phenomena and has a wide range of applications in cluster analysis and pattern recognition.

Theorem 1: If R 1 and R 2 are two fuzzy relations on domain $U \times V$, then:

$\forall x \in U, \forall y \in U, R1 \subseteq R2$ is equivalent to $\mu_{R1}(x, y) \le \mu_{R2}(x, y)$;

$\forall x \in U, \forall y \in U, R1 = R2$ is equivalent to $\mu_{R1}(x, y) = \mu_{R2}(x, y)$;

$\forall x \in U, \forall y \in U, R1 \cup R2$ is equivalent to $\mu_{R1} \cup R2(x, y) = \vee\left(\mu_{R1}(x, y), \mu_{R2}(x, y)\right)$;

$\forall x \in U, \forall y \in U, R1 \cap R2$ is equivalent to $\mu_{R1} \cup R2(x, y) = \wedge\left(\mu_{R1}(x, y), \mu_{R2}(x, y)\right)$;

$\forall x \in U, \forall y \in U, R1'$ is equivalent to $\mu_{R1}(x, y) = 1 - \mu_{R}(x, y))$;

Theorem 2: If R 1 is the fuzzy relationship on the domain $U \times V$ and R 2 is the fuzzy relationship on the domain $V \times W$W, then R 1 and R 2 are the fuzzy relations on domain $U \times W$, and the membership function is defined as:

$$\mu_{R1} \cdot R2(x, z) = \vee\left(\mu_{R1}(x, y) \wedge \mu_{R2}(y, z)\right) \quad (1)$$

Theorem 3: If the composite operation of fuzzy relations satisfies the associative law, that is, $\mathrm{A, B, C}$ is the fuzzy relation on the domain $U \times V$, then:

$$(\mathrm{A}\ \grave{o}\ \mathrm{B}) \ldots \mathrm{C} = \mathrm{A}\ \grave{o}\ (\mathrm{B}\ \grave{o}\ \mathrm{C}) \quad (2)$$

Theorem 4: If R is a fuzzy relationship on domain $U \times V$, then:

If $\forall x \in U$, and $\mu_{R1}(x, x) = 1$, R satisfies reflexivity;, if $\forall x \in U$, and $\mu_{R1}(x, x) = 0$, R satisfies anti-reflexivity;

If $\forall (x, y), (x, z), (y, z) \in U \times V$, and $\mu_R(x, z) \ge \psi\mu(R, x) \wedge \left(\mu_R y\right) z$, then R satisfies transitivity.

Definition 1: If the universe of discourse is $U = \{x_1, x_2, \ldots, x_n\}$ and the fuzzy set is A、$\mathrm{B} \in F(U)$, then:

$$d(A, B) = \left[\sum_{k=1}^{n} \left|A\left(x_k\right) - B\left(x_k\right)\right|^p\right]^{1/p} \quad (3)$$

Among them, P is a positive real number, when $\mathrm{p} = 1^{k=1}$, $\mathrm{d(A, B)}$ is called the Hamming distance, and when $\mathrm{p} = 2$, $\mathrm{d(A, B)}$ is called the Euclidean distance.

In fuzzy mathematics, what kind of indicator is used to describe the fuzzy degree of a fuzzy set is very important. A natural idea is that the ordinary set is not vague, and "0" can be used to describe its vagueness. For the fuzzy set A, when $x \in U$, if $\mathrm{A(x)} = 0.5$, then $\mathrm{A}^{'}(\mathrm{x})$ is also equal to 0.5, this time is the most difficult decision. At this time, the fuzzy degrees of A and A^{2} are equal.

In addition, the ambiguity of the sign fuzzy set A should also have the following properties: the farther $\mathrm{A(x)}$ is from 0.5, the smaller the ambiguity, and vice versa, the greater the ambiguity.

Definition 2: If the mapping $d: F(U) \to [0,1]$ satisfies:

(1) $d(A) = 0 \Leftrightarrow A \in P(U)$;

(2) $d(A) = 1 \Leftrightarrow A(x) \equiv 0.5$;

(3) If there is $A(x_i) \geq B(x_i) \geq 0..$ or $A(x_i) \leq B(x_i) \leq 0\ldots$ for any $x_i \in U$, then $d(A) \leq d(B)$;

(4) $\mathrm{d(A)} = \mathrm{d}\left(\mathrm{A}^{'}\right)$.

Then, $\mathrm{d(A)}$ is the ambiguity of A.

Definition 3: A matrix in which all elements in a matrix take values in the closed interval [0,1] is called a fuzzy matrix. Union, intersection, complement operations: The operations of taking the larger (smaller, complement) corresponding elements of two fuzzy matrices as new elements are called their union (intersection, complement) operations, such as:

$$\mathrm{R} = \begin{bmatrix} 0.7 & 0.5 \\ 0.9 & 0.2 \end{bmatrix} \quad \mathrm{B} = \begin{bmatrix} 0.4 & 0.3 \\ 0.6 & 0.8 \end{bmatrix}$$

$$\mathrm{R} \cup \mathrm{B} = \begin{bmatrix} 0.7 \vee 0.4 & 0.5 \vee 0.3 \\ 0.9 \vee 0.6 & 0.2 \vee 0.8 \end{bmatrix} = \begin{bmatrix} 0.7 & 0.5 \\ 0.9 & 0.8 \end{bmatrix}$$

$$\mathrm{R} \cap \mathrm{B} = \begin{bmatrix} 0.7 \wedge 0.4 & 0.5 \wedge 0.3 \\ 0.9 \wedge 0.6 & 0.2 \wedge 0.8 \end{bmatrix} = \begin{bmatrix} 0.4 & 0.3 \\ 0.6 & 0.2 \end{bmatrix}$$

$$\mathrm{R}^{\mathrm{C}} = 1 - \begin{bmatrix} 0.7 & 0.5 \\ 0.9 & 0.2 \end{bmatrix} = \begin{bmatrix} 0.3 & 0.5 \\ 0.1 & 0.8 \end{bmatrix}$$

The fuzzy matrix cut-off matrix is similar to the cut-off set of the fuzzy set, for example:

$$R = \begin{bmatrix} 0.7 & 0.8 \\ 0.9 & 1 \end{bmatrix}$$

The cut-off matrix of 0.7 is:

$$R_{0.7} = \begin{bmatrix} 0 & 1 \\ 1 & 1 \end{bmatrix}$$

It can be seen that the cut-off matrix of the fuzzy matrix must be a Boolean matrix.

The synthesis operation of the fuzzy matrix is similar to the multiplication operation of the ordinary matrix, only the multiplication operation and the addition operation in the ordinary matrix are changed to the small and large operations respectively. For example:

$$Q = \begin{bmatrix} 0.2 & 0.5 \\ 0.7 & 0.1 \end{bmatrix} \quad R = \begin{bmatrix} 0.6 & 0.5 \\ 0.4 & 1 \end{bmatrix}$$

$$Q^\circ R = \begin{bmatrix} (0.2 \wedge 0.6) \vee (0.5 \wedge 0.4) & (0.2 \wedge 0.5) \vee (0.5 \wedge 1) \\ (0.7 \wedge 0.6) \vee (0.1 \wedge 0.4) & (0.7 \wedge 0.5) \vee (0.1 \wedge 1) \end{bmatrix} = \begin{bmatrix} 0.4 & 0.5 \\ 0.6 & 0.5 \end{bmatrix}$$

Based on the management of the manufacturing project development process, the primary indicator system for capability maturity evaluation has been obtained. We can see that in the huge process of software development, a large amount of personnel management, project management and industrial process management are involved, and the amount of data is huge. If we take all the indicator systems involved as the content of the evaluation model, it is conceivable that the workload will be very huge, which will affect the rapid and effective progress of the entire evaluation process.

Therefore, we have to screen the established primary indicator system. At the same time, according to different types of manufacturing enterprises and different types of development projects, we need to modify and filter the evaluation model with theoretical knowledge of fuzzy mathematics to obtain the most important and concise evaluation indicator system.

Next, we will introduce the selection process of the evaluation indicator system:

(1) First, we compare the internal similarity of the indicators of each indicator system. For example, we compare the similarity between the programming and coding management capability indicator system and the code review management capability indicator system. The similarity matrices F1 and F2 are obtained, respectively, as follows:

$$F1 = \begin{bmatrix} 1 & 0.4 & 0.2 & 0.1 & 0.2 & 0.4 & 0.5 & 0.4 \\ 0.4 & 1 & 0.6 & 0.8 & 0.6 & 0.7 & 0.4 & 0.9 \\ 0.2 & 0.6 & 1 & 0.3 & 0.8 & 0.2 & 0.2 & 0.3 \\ 0.1 & 0.8 & 0.3 & 1 & 0.3 & 0.2 & 0.1 & 0.8 \\ 0.2 & 0.6 & 0.8 & 0.3 & 1 & 0.2 & 0.3 & 0.4 \\ 0.4 & 0.7 & 0.2 & 0.2 & 0.2 & 1 & 0.7 & 0.8 \\ 0.5 & 0.4 & 0.2 & 0.1 & 0.3 & 0.7 & 1 & 0.4 \\ 0.4 & 0.9 & 0.3 & 0.8 & 0.4 & 0.8 & 0.4 & 1 \end{bmatrix}$$

$$F2=\begin{bmatrix} 1 & 0.7 & 0.6 & 0.8 & 0.6 & 0.9 & 0.9 \\ 0.7 & 1 & 0.4 & 0.7 & 0.3 & 0.2 & 0.8 \\ 0.6 & 0.4 & 1 & 0.2 & 0.4 & 0.6 & 0.3 \\ 0.8 & 0.7 & 0.2 & 1 & 0.2 & 0.2 & 0.7 \\ 0.6 & 0.3 & 0.4 & 0.2 & 1 & 0.4 & 0.5 \\ 0.9 & 0.2 & 0.6 & 0.2 & 0.4 & 1 & 0.4 \\ 0.9 & 0.8 & 0.3 & 0.7 & 0.5 & 0.4 & 1 \end{bmatrix}$$

Definition 1: If $R=\left(r_{ij}\right)\in\mu_{m\times n}$, then it is called:

$$R_{\lambda}=\left(r_{ij}(\lambda)\right)_{m\times n} \quad (4)$$

is the transposed matrix of R.

Among them, r_{ji} is denoted as $r_{ij}^{T}(i=1,\mathrm{L}\ ,m,j=1,\mathrm{L}\ ,n)$.

Definition 2: When $R=\left(r_{ij}\right)\in\mu_{m\times n}$, if $R^{T}=R$, then R is a symmetric matrix.

According to definition 2, we know that F1 and F2 above are symmetric matrices, and each indicator is compared with other indicators for similarity. The similarity on the diagonal is 1 because the similarity between itself and itself is 1. After completing the above steps, we proceed to the next step:

(2) By using the principle of fuzzy matrix to delete indicators with greater similarity, the goal of slimming can be achieved. In this process, we need to pay attention to the determination of the deletion principle.

Definition 3: We set $R=\left(r_{ij}\right)_{m\times n},\forall\lambda\in[0,1]$ and $R_{\lambda}=\left(r_{ij}(\lambda)\right)_{m\times n}$.

Among them,

$$R_{\lambda}=\left(r_{ij}(\lambda)\right)_{m\times n} \quad (5)$$

Then R_{λ} is called the λ-cut matrix of R.

According to Definition 3, when we take λ=0.7, we get the following matrix:

$$F1_{0.7}=\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 & 0 & 1 \end{bmatrix}$$

$$F2_{0.7} = \begin{bmatrix} 1 & 1 & 0 & 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 1 & 0 \\ 1 & 1 & 0 & 1 & 0 & 0 & 1 \end{bmatrix}$$

After getting the result matrix, we filter out the indicators whose result is 1 and get the following results:

F1'={(indicator 2, indicator 4), (indicator 2, indicator 6), (indicator 2, indicator 8), (indicator 3, indicator 5), (indicator 4, indicator 8) (indicator 6, indicator 7) , (indicator 6, indicator 8)};

F2'={(indicator 1, indicator 2), (indicator 1, indicator 4), (indicator 1, indicator 6), (indicator 1, indicator 7), (indicator 2, indicator 4) (indicator 4, indicator 7) };

After obtaining the above indicator screening set, we must eliminate the repetitive indicators with greater similarity to achieve the goal of slimming the indicator system.

Here we only introduce two of the many indicator systems. After all the indicator systems have been screened, the algorithm can enter the next step:

(3) The indicator system obtained after screening is further screened. Moreover, the similarity is judged for every two screened indicator systems. For example, we will judge the similarity of the indicator system generated in the previous step. We will generate a similarity matrix for the two indicator systems after screening with the indicator as the row and column, and get the following matrix according to the similarity:

$$FF = \begin{bmatrix} 0.1 & 0.9 & 0.3 & 0.6 \\ 0.7 & 0.5 & 1 & 0.3 \\ 0.2 & 0.8 & 0.2 & 0.7 \\ 0.8 & 0.7 & 0.7 & 0.5 \end{bmatrix}$$

The cut-off matrix of the matrix being calculated. Among them, when $\lambda = 0.7$, the matrix is as follows:

$$FF_{0.7} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 \end{bmatrix}$$

The set of screening indicators is as follows:

FF'={(indicator 1, indicator two), (indicator 2, indicator one), (indicator 2, indicator three), (indicator 3, indicator two), (indicator 3, indicator four), (indicator 4, indicator one), (indicator 4, indicator two), (indicator 4, indicator three)};

According to the above-mentioned screening indicator set, we can remove the repeated indicator with higher similarity again to obtain a new indicator set. At the same time, we can combine these two indicators into one part and name it set 1. The system of the filtered set 1 is shown in Figure 1.

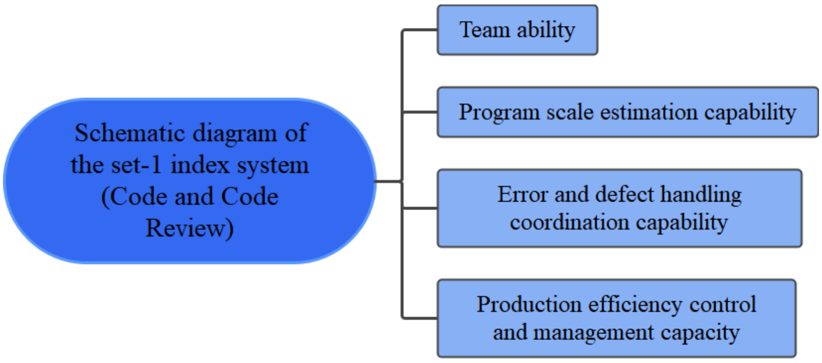

Figure 1 Schematic diagram of indicator screening results

We perform pairwise detection on the indicator system after screening, use similarity judgment to obtain a similarity matrix, take a cut-off matrix of 0.7, and then perform indicator screening. In this way, after several judgments, an indicator screening system will be formed, which is the indicator screening system required by the evaluation model in this paper. The algorithm flow chart of this part of the function is shown in Figure 2.

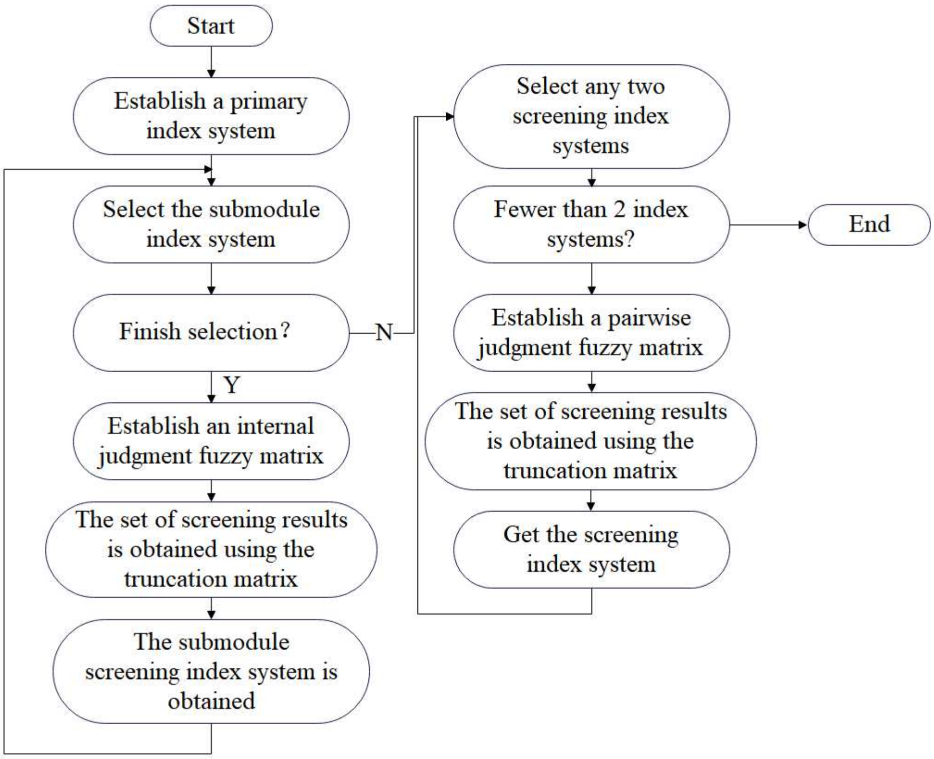

Figure 2 Flow chart of screening of evaluation indicators for manufacturing project management capabilities based on fuzzy mathematics

Based on the above results, we filter and integrate the indicator screening system earlier in this chapter, and obtain a manufacturing project management capability evaluation indicator system based on fuzzy mathematics, as shown in Figure 3.

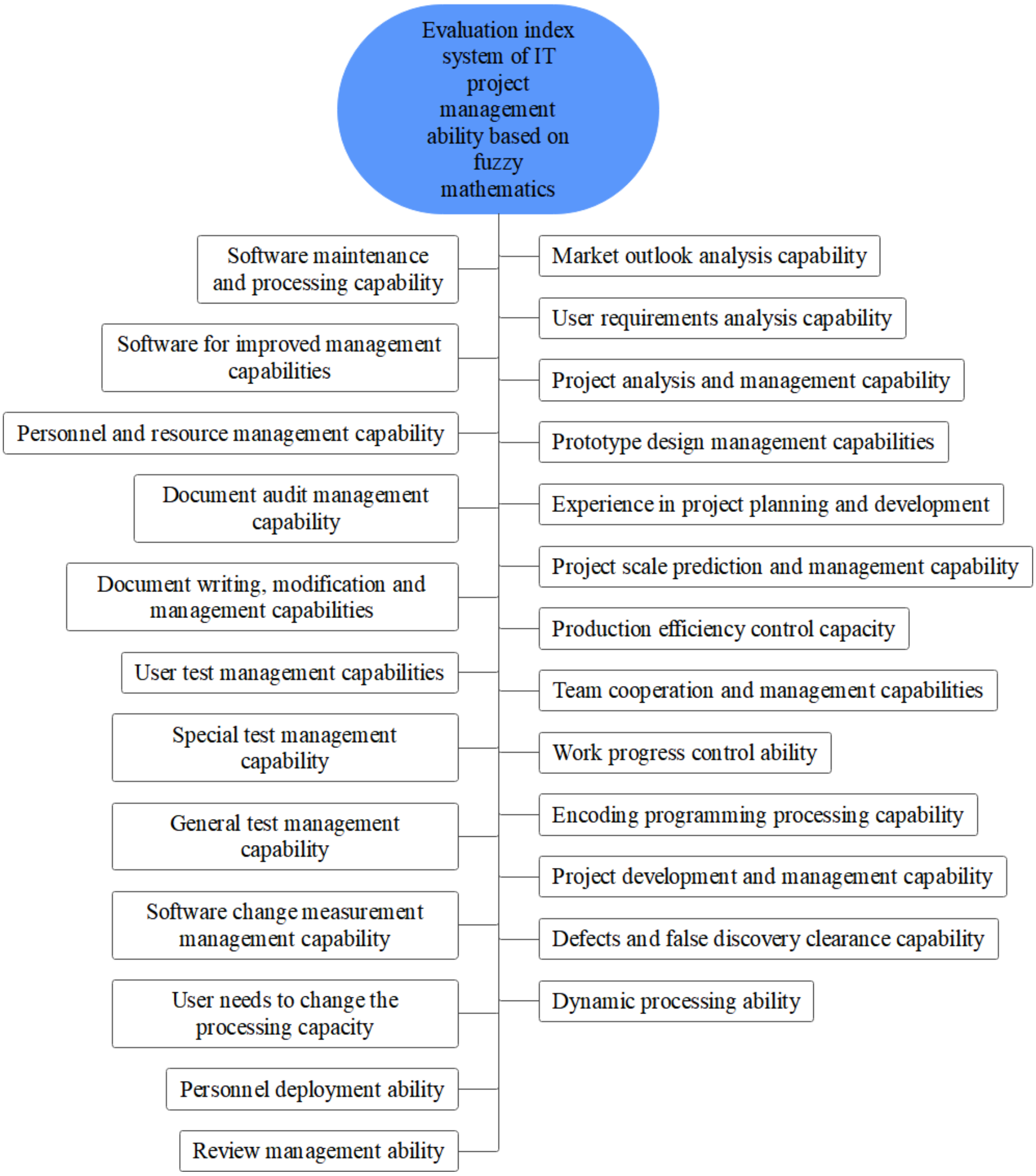

Figure 3 The evaluation indicator system of manufacturing project management ability based on fuzzy mathematics

The manufacturing project management capability maturity model is a model system that comprehensively evaluates the management capability of a manufacturing enterprise. Therefore, the management level of the manufacturing enterprise should be obtained based on the evaluation results. The manufacturing project management capability maturity model based on fuzzy mathematics designed in this paper is divided into four levels in total:

(1) Management disorder level

The management of manufacturing enterprises at this level is chaotic and disorderly. From market analysis to project establishment, development and final testing and delivery, the process is carried out under a chaotic management order. Moreover, the software development cycle has been extended indefinitely, causing the cost to be greater than expected. In order to reverse the loss situation, cutting corners are often carried out in the later testing and maintenance stages, resulting in the failure of project development and seriously affecting the reputation and image of the company. This type of manufacturing companies are often individual small companies, and they don't even have a fixed organization and development team. They belong to guerrilla management.

(2) Management qualification level

Manufacturing companies at this level have fixed organizations and development teams that can formulate relevant management regulations. In the software development stages such as talent introduction, project establishment, research, development, testing and maintenance, reasonable management can be implemented, so that the entire development process can be carried out more effectively. It is eager, and the products produced basically meet the needs of users, which is a relatively qualified form of management. This type of manufacturing enterprises are often small and medium-sized enterprises that can achieve marginal management and have a set of management systems. Although it is not very mature, it can meet the standardized management of the key steps of the development process.

(3) Management standard level

Manufacturing enterprises at this level have a set of standardized personnel, management, and development systems and regulations, which can standardize and rationalize the effective management of the entire process of project development. In particular, it has standardized working methods for the application and management of some advanced tools and methods. During the development of many projects, it strictly abides by user needs and project development goals. In the subsequent testing and maintenance, analysis and testing are repeated, and the user is the starting point, benign interaction is carried out, and timely and effective after-sales service is provided. This type of enterprise is generally a large-scale manufacturing enterprise, has a larger staff team and relatively fixed investment funds, and can undertake some large-scale projects.

(4) Management maturity level

Manufacturing companies at this level often have a very planned management system. Has very mature management experience and management methods in personnel management systems such as talent introduction, assessment and management. In the process of project development, in addition to strengthening management in core links such as design, coding, and testing, it also pays special attention to pre-market research, user demand analysis, and project discussion management. For later maintenance and software upgrades, it is regarded as the lifeline of an enterprise, and quality and reputation are regarded as strategic resources for development and survival. Such manufacturing companies are large companies with many subsidiaries, and many of them are joint-stock companies with multinational companies. At the same time, they have strong funds and strict management, and occupy a large user group and market share in the market.

Figure 4 shows the grade division of the manufacturing management capability maturity evaluation model based on fuzzy mathematics.

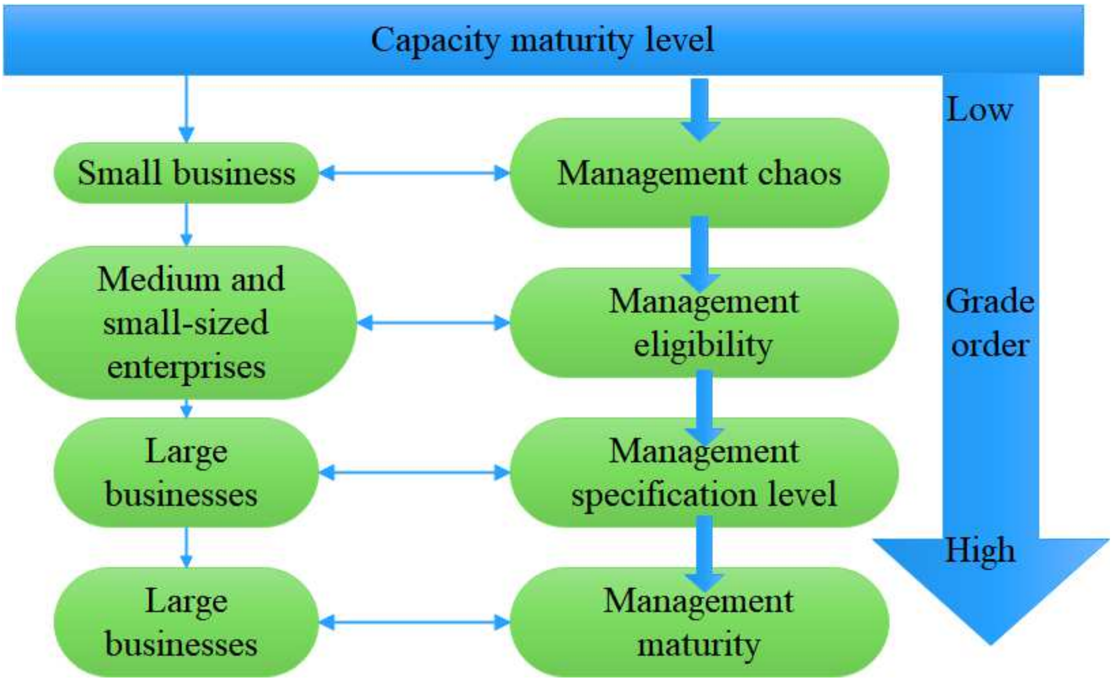

Figure 4 The classification of the maturity evaluation model of manufacturing project management capability based on fuzzy mathematics

In the process of grading, in fact, the boundaries are not very obvious, and some manufacturing enterprises at the qualified level will also have standardized management activities. However, it is also possible that some management is in a state of chaos and disorder. Therefore, attention should be paid to the understanding of the concept of classification. The classification of levels is not a strict definition of an enterprise, but a conclusion drawn from an overall assessment of its management capabilities, which can only reflect the overall situation. It should be said that this is a statistical estimation model based on a large amount of evaluation data.

During the construction of the evaluation model, there are some principles that need to be determined. Because there are not only a large number of manufacturing companies at present, but also their types and functions are not all the same. In order to enable the evaluation model to accurately and objectively reflect the management capabilities of the evaluated manufacturing enterprise, we need to proceed from reality and conduct a reasonable and effective evaluation based on the characteristics of the enterprise. Therefore, the following principles need to be followed:

(1) Evaluation based on the scale of the enterprise to be evaluated

We know that there are countless manufacturing companies, but they are classified into several categories according to their scales, and the management and operation models of manufacturing companies of different sizes are definitely different. If we use the same standard to measure these evaluation objects, it will cause big errors.

(2) Evaluation based on the business operation direction of the evaluation object

We know that different types of manufacturing companies may be engaged in development and services in different directions. Generally speaking, evaluations should be made according to the characteristics of the enterprise, and classifications should be made for specific project practices.

Here we use the knowledge of fuzzy mathematics to construct the capability maturity evaluation model.

First, we assign a weight to the importance of a code for each indicator of the indicator evaluation system according to the characteristics of the enterprise. The range is [0,1], where the 1 code is the most important. We assign weights to indicators based on the characteristics of the company. Moreover, we know that the fuzzy degree defined in fuzzy mathematics is between [0,1]. Therefore, we can establish a fuzzy relationship between various indicators and their importance. According to the evaluation index system in Chapter 3, we will get an evaluation set $U_m = \{u_1, u_2, \ldots, u_m\}$ of indicators, where the value of m is the number of indicators. The set of importance assigned to each weight is $I_m = \{i_1, i_2, \ldots, i_m\}$, then we can get a set $A_m = \{a_1, a_2, \ldots, a_m\}$ of fuzzy relations.

$$Am = \frac{i_1}{u_1} + \frac{i_2}{u_2} + \ldots + \frac{i_m}{u_m}$$

Next, we explain the evaluation result set $V_m = \{v_1, v_2, \ldots, v_m\}$, where the value range of V is [1,4], which respectively represent the four levels of evaluation. In this way, we select any evaluation index, such as $u_x (1 \le x \le m)$, then there is a fuzzy membership relationship between it and these four levels, and a fuzzy relationship set V can be formed.

$$Ax = \frac{r_{x1}}{(u_x, v_1)} + \frac{r_{x2}}{(u_x, v_2)} + \ldots + \frac{r_{xn}}{(u_x, v_n)}$$

If we connect all the indicators, we will get a fuzzy matrix F of $m \times n$.

$$F = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ . & . & . & . \\ . & . & . & . \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix}$$

After getting the fuzzy matrix, we can proceed to the final fuzzy judgment. We can see through observation that each column element in the matrix F1 is the level membership of m index elements, and the value of each row is the ambiguity between each index element and the value of each level. Therefore, we add up each row of data and take the average to get:

$$R1 = \frac{\sum_{i=1}^{n} r_{1i}}{n};$$

$$R2 = \frac{\sum_{i=1}^{n} r_{2i}}{n};$$

$$\cdots\cdots\cdots$$

$$Rm = \frac{\sum_{i=1}^{n} r_{mi}}{n}.$$

The obtained set v is the evaluation result of $R = \{R1, R2, \ldots, Rm\}$ evaluation indicators. Combining the indicator importance set we got, we can get the final evaluation result, and we use the averaging method to calculate it, namely:

$$X = \begin{bmatrix} R1 & R2 & \ldots & Rm \end{bmatrix}$$

$$Y = \begin{bmatrix} a_1 \\ a_2 \\ \cdot \\ \cdot \\ a_m \end{bmatrix}$$

We calculate:

$$X \times Y = \begin{bmatrix} R1 & R2 & \ldots & Rm \end{bmatrix} \times \begin{bmatrix} a_1 \\ a_2 \\ \cdot \\ \cdot \\ a_m \end{bmatrix}$$

$$= R1 \times a_1 + R2 \times a_2 + \ldots + Rm \times a_m$$

We calculate the weighted average:

$$Z_{\text{ave}} = \frac{\sum_{i=1}^{m} Ri \times a_i}{m}$$

After the above result Z_{are} is obtained, the evaluation level of its management ability can be judged.

In addition to the weighted average method mentioned above, we can also take other methods:

(1) Maximum membership method;

(2) Fuzzy distribution calculation method.

Through the above introduction, we can see the brief construction process of an evaluation indicator system, which involves the establishment and calculation of some fuzzy matrices. Figure 5 shows the construction flow chart of the capability maturity evaluation model.

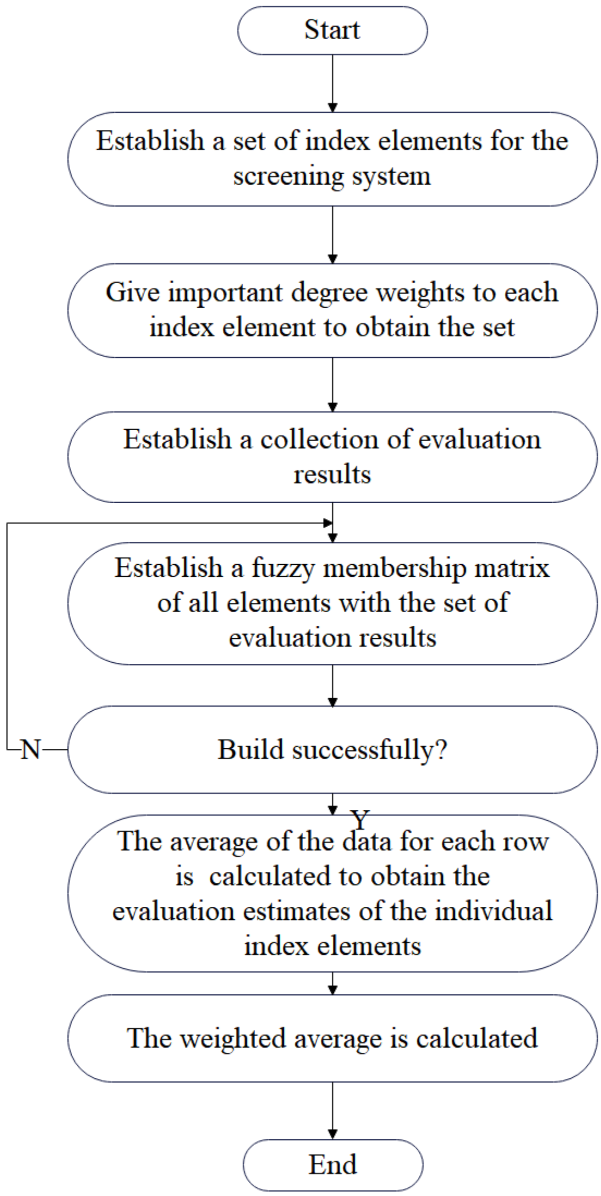

Figure 5 The data flow chart of the construction of a manufacturing project management capability maturity evaluation model based on fuzzy mathematics

4 Evaluation model of manufacturing project management capability based on big data and fuzzy evaluation

The system is a three-tier B/S architecture, which is a data persistence layer, a business logic layer, and a presentation layer, as shown in Figure 6.

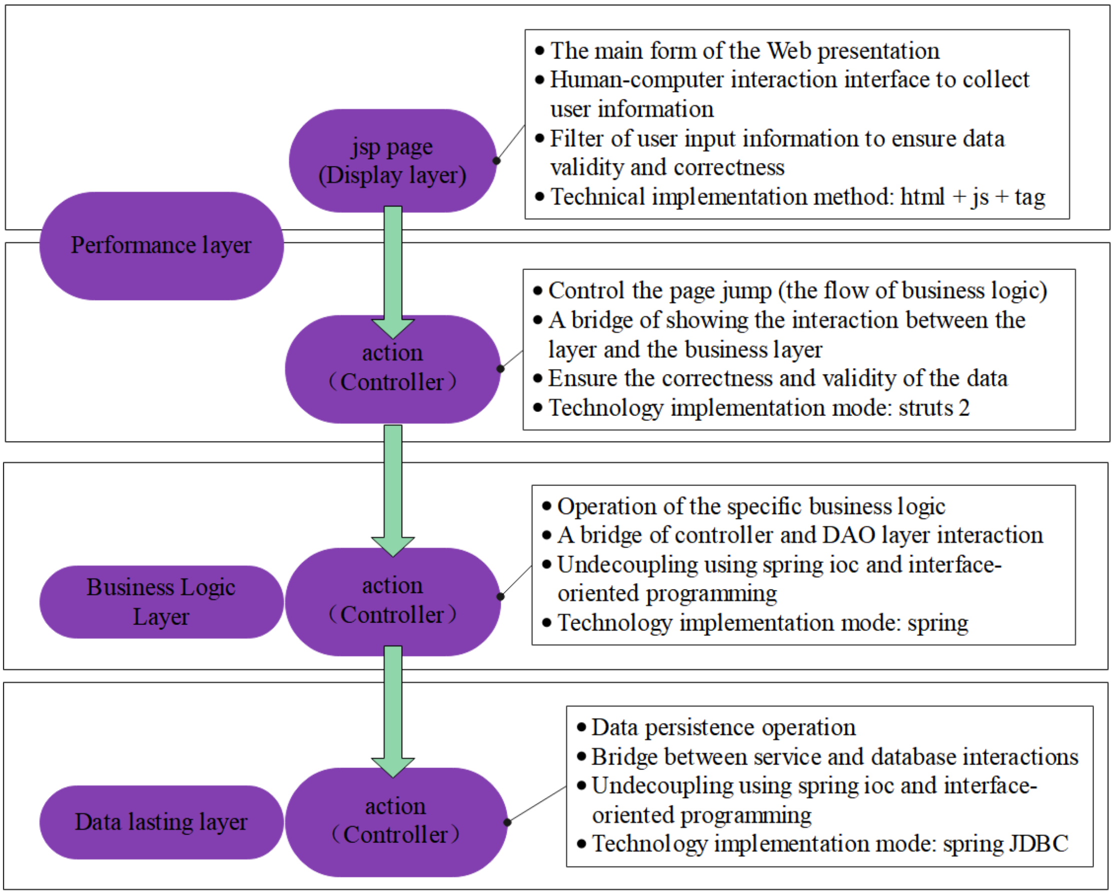

Figure 6 System architecture design

The network boundary of the system is divided into two types: Internet and Baijian DMZ, self-built DMZ and self-built intranet. Between the Internet and the self-built DMZ, the system uses the real name of the network to access the gateway, and the system issues terminal identity certificates for terminals accessing the system to prevent illegal terminal access. At the same time, the system uses the secure transmission channel provided by HTTPS for Internet and self-built DMZ information transmission.

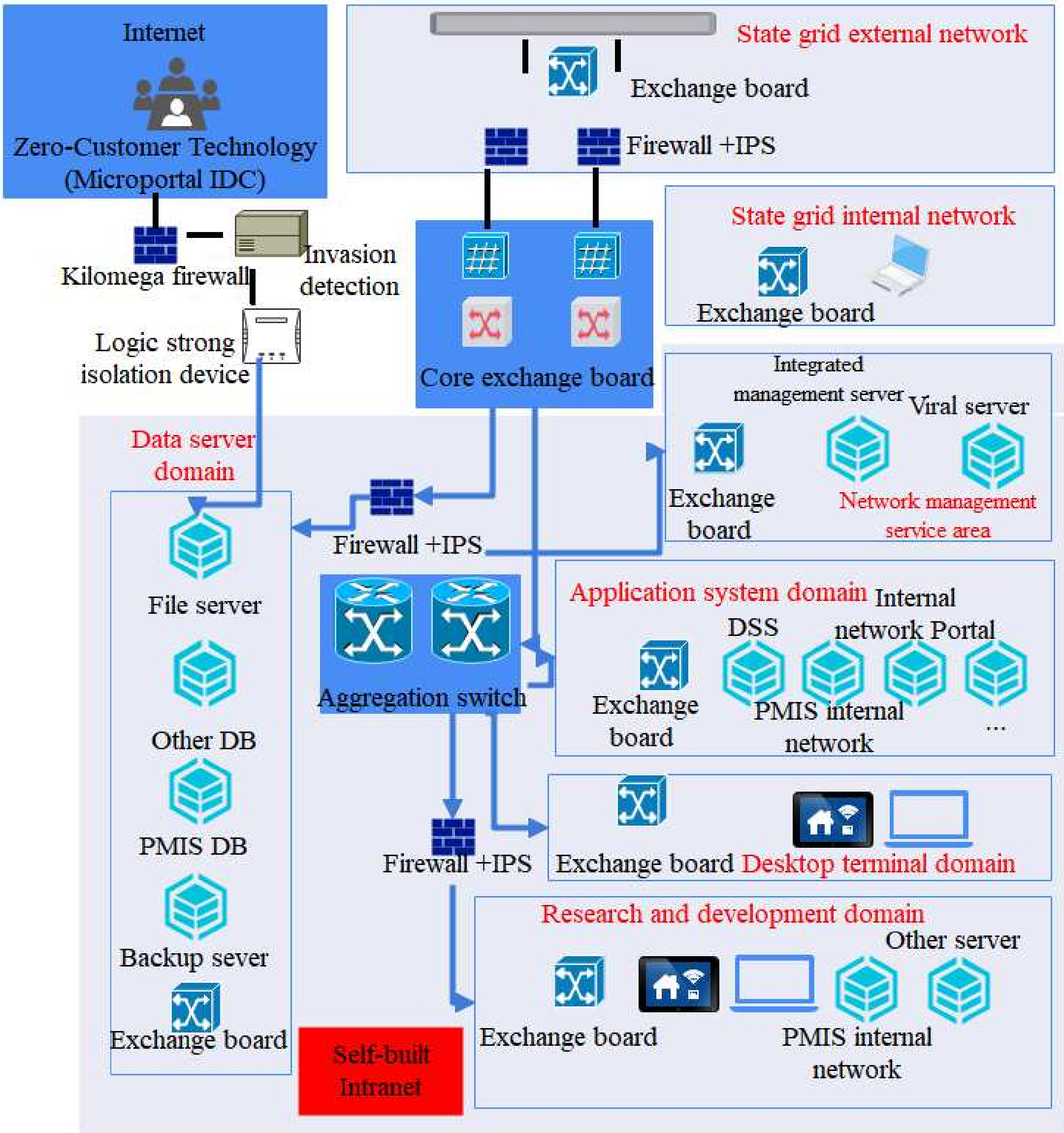

Figure 7 System deployment topology

The manufacturing project management system includes ten business modules: project management, human resources management, contract management, financial management, decision support, planning and planning, production management, operation management, public information management, and comprehensive query. Among them, project management is the main line, based on human resources management, contract management and financial management. The system business architecture is shown in Figure 8.

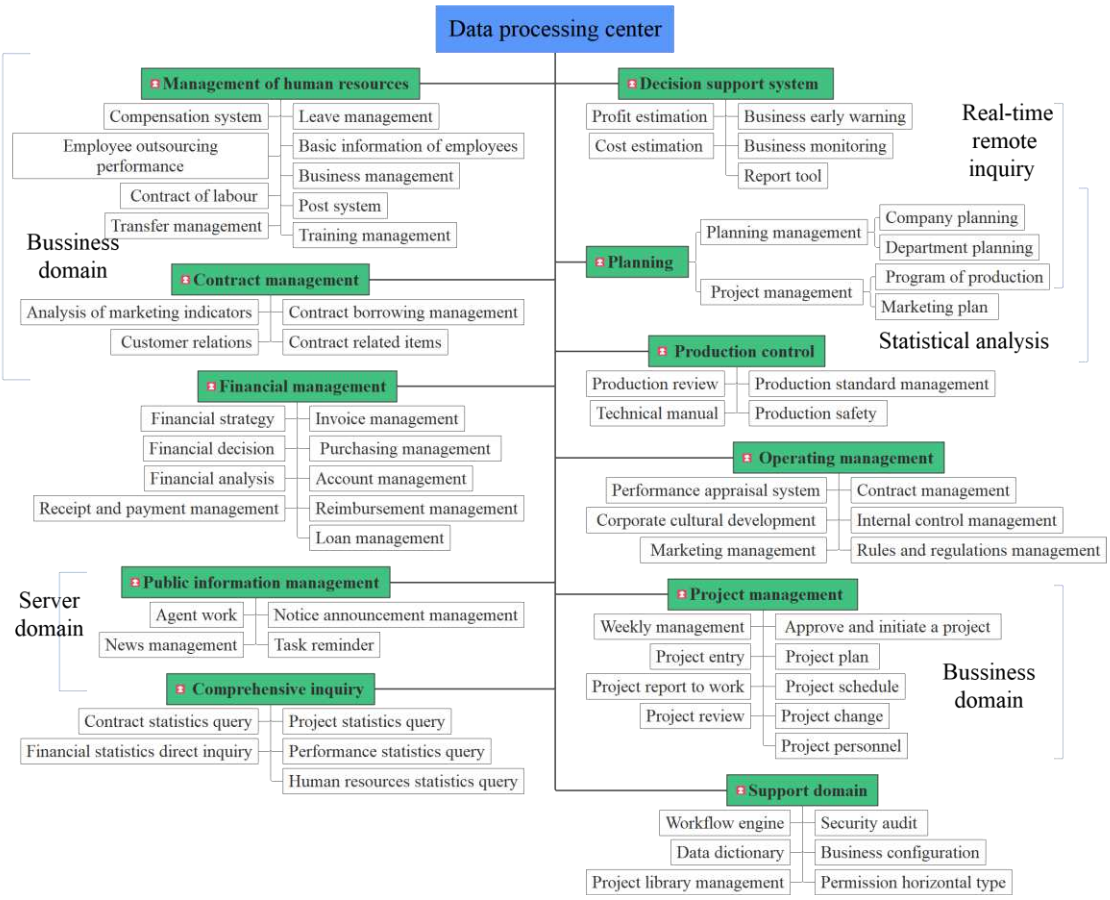

Figure 8 Business architecture diagram of manufacturing project management system

On the basis of the above research, the model of this paper is studied through the clustering simulation mode. The structure of the clustering model proposed in this paper is shown in Figure 9.

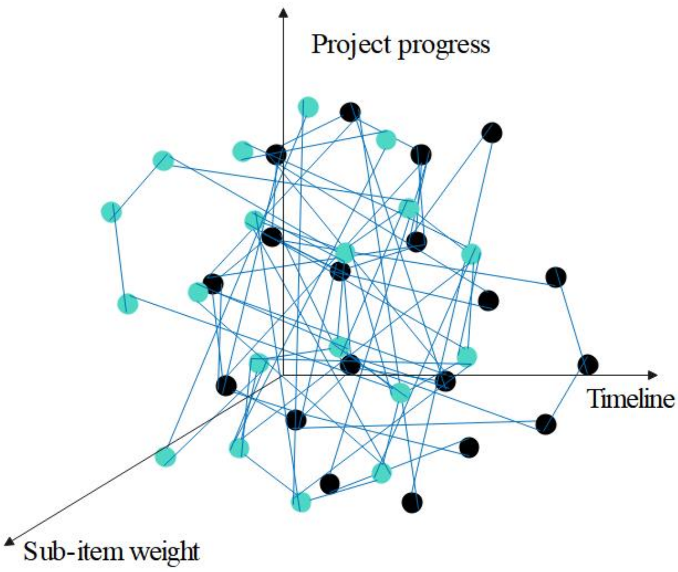

Figure 9 Clustering model structure

On the basis of the above model structure, the intelligent evaluation effect of the model in this paper is compared with the actual evaluation effect, and the results shown in Table 1 are obtained.

Table 1 Comparison of intelligent evaluation effect and actual evaluation effect

Number	System assesment	Actual evaluation	Number	System assesment	Actual evaluation
1	81.71	84.72	17	85.32	88.65
2	86.95	87.11	18	78.82	82.07
3	81.34	85.08	19	89.93	90.61
4	90.41	94.66	20	80.20	80.29
5	88.57	88.71	21	80.59	80.00
6	88.04	89.13	22	86.17	87.55
7	81.47	84.48	23	80.08	77.71
8	81.35	80.69	24	84.34	88.03
9	91.84	89.32	25	85.66	86.17
10	86.61	89.96	26	87.36	83.56
11	85.58	89.05	27	83.37	81.80
12	80.87	84.22	28	91.31	86.80
13	89.25	92.50	29	89.09	91.12
14	87.97	83.88	30	88.98	85.26
15	89.79	88.83	31	88.87	91.69
16	91.54	87.90	32	81.01	83.99

It can be seen from Table 1 that the manufacturing project management capability evaluation model based on big data technology proposed in this paper has good practical effects.

5 Conclusion

The extensive development model of the manufacturing industry has created pressures on energy, resources, and the environment, and has restricted the development of the manufacturing industry. The most important thing is that China's manufacturing industry has insufficient R&D capabilities and low added value of products. At present, it is urgent to rely on the improvement of independent innovation capabilities to accelerate the transformation and upgrading of the manufacturing industry. Due to the differences in the culture, technological level and ability of enterprises in different countries, the position of the industrial chain, the development stage, etc., the requirements for the cultivation of enterprise R&D capabilities are different. Therefore, it is necessary to explore suitable R&D project management methods according to the actual situation of the enterprise. This article combines big data technology to analyze the manufacturing project management ability and constructs a project management ability evaluation model. Through simulation research, it can be known that the manufacturing project management ability evaluation model based on big data technology proposed in this paper has good practical effects.

Declarations

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Code availability: Not applicable.

Authors' Contributions: Ruiqing Hao, is responsible for designing the framework, analyzing the performance, validating the results, and writing the article. Qian Ren, is responsible for collecting the information required for the framework, provision of software, critical review, and administering the process.

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