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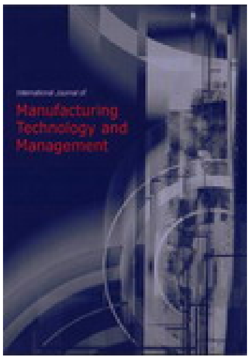

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Yi Zhou

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The dynamic multi project human resource allocation method of manufacturing industry based on multidimensional model

Yi Zhou

Business College,
Hunan International Economics University,
Changsha 410205, China
Email: yizhou@mls.sinanet.com

Abstract: In order to overcome the problems of low allocation accuracy and long allocation time, this paper designs a dynamic multi project human resource allocation method in manufacturing industry based on multidimensional model. First, the total number of talents, workload and utilisation efficiency are determined. Then, a fuzzy set of human resources indicators is built, and the different hierarchical weights of each indicator calculate are calculated. Finally, fuzzy comprehensive evaluation method is used to construct the index comprehensive evaluation matrix, the PCA interval model in the multi-dimensional model is used to orthogonalize each index, and the multilateral convex set model in the model is used to realise the intersection of index parameters in different regions, so as to realise the rational allocation of human resources. The experimental results show that the proposed method improves the accuracy of dynamic multi project human resources allocation in manufacturing industry, and the allocation time is short.

Keywords: multidimensional model; PCA interval model; human resource allocation; fuzzy sets.

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Biographical notes: Yi Zhou received her Master of Laws in Sociology from Hunan Normal University in 2007. Currently, she is an Associate Professor in the Business College of Hunan International Economics University. Her research interests include public administration and allocation of human resources.

1 Introduction

With the continuous development of social industry, the development of manufacturing enterprises has entered a new era. In the context of rapid economic development, the human resource allocation of manufacturing industry is very key, which is the key to the stable operation of an enterprise. The requirements of human resource allocation are constantly improved (Zhao et al., 2020a). Dynamic multi project in manufacturing enterprises is a project integrating science, technology and knowledge. The emergence of the project is both a challenge and an opportunity for the manufacturing industry. Dynamic multi project in manufacturing industry is a new trend of enterprise project construction and development. There are certain fluctuations and periodicity in the development of the project. It is necessary to continuously adjust the dynamic allocation of human resources in the manufacturing industry (Xu and Lei, 2021). However, in the actual work, the allocation of enterprise human resources needs to go through various processes such as continuous evaluation and selection, and also needs to constantly arrange talents to combine them with the reality of enterprise development. This process is complex and affects the normal operation of dynamic multi projects in the manufacturing industry (Bayat et al., 2021). Therefore, how to meet the requirements of various stages of dynamic multi project in manufacturing industry, improve the project interests of enterprises and complete the rational allocation of human resources has become the key at present. Therefore, a lot of research has been done on the allocation methods of human resources, and some results have been achieved.

Liu et al. (2021) designed a human resource allocation model based on cyclic neural network. The model design considers the deficiencies of human resource allocation in different fields, analyses the deficiencies in the current resource allocation methods, analyses the characteristics of the allocated resource data, and introduces the cyclic convolution neural network algorithm to reasonably match the personnel in different fields, so as to complete the human resource allocation model design. The rationality of the configuration in this paper is verified by the calculation of F value. The operation process of this method is simple, but less configuration parameters are considered in the configuration process, which has some shortcomings. Ye and Chen (2022) proposed a method for evaluating and selecting human resource demand in cloud manufacturing environment, which can realise the rational allocation of human resources. In the research of this method, the evaluation index system of personnel ability in different positions is determined, and the personnel demand ability is obtained through the constructed variable precision rough model. According to the different needs of ability, the matching degree of ability is calculated, and the personnel are reasonably allocated according to the calculation results to realise the research of the method. This method has high accuracy in calculating personnel capacity and can reasonably allocate personnel to corresponding posts, but this method has a certain randomness and has the problem of large allocation error. Fu et al. (2022) proposed a human resource decision-making system based on multidimensional data management and control. Firstly, this method constructs the feature space to determine the feature data of different post needs, then determines the multi-dimensional data by recursive analysis and fusion method, reduces the dimension of the determined data, determines the decision function of human resource allocation by using correlation tools, constructs the decision model of human resource allocation, and completes the research purpose. The accuracy of this method is high, but the amount of data determined in the distribution is less, which needs to be further improved.

In view of the shortcomings of the above methods, this paper designs a dynamic multi project human resource allocation method in manufacturing industry based on multidimensional model. The main technical route of this paper is as follows:

Firstly, the index comprehensive evaluation matrix is constructed. Determine the reasonable matching index, workload index and utilisation efficiency index of the total number of talents, determine the calculation formula of each index, and determine the allocation of human resources; by determining the fuzzy sets of different human resources indicators and calculating the different grading weights of each indicator, the fuzzy comprehensive evaluation method is introduced to construct the index comprehensive evaluation matrix to realise the index evaluation.

Then, multi project human resource allocation is realised. The PCA interval model in the multidimensional model is used to orthogonalize each index, and the intersection domain of index parameters in different regions is realised through the multilateral convex set model in the model, so as to realise the rational allocation of human resources.

Finally, through the accuracy and time-consuming of human resource allocation, the effect of human resource allocation is verified and a conclusion is drawn.

2 Construction of index comprehensive evaluation matrix

2.1 Determination of dynamic multi project human resource allocation index in manufacturing industry

In the dynamic multi project human resource allocation of manufacturing industry, the key factors affecting its allocation need to be considered. Every influencing factor in human resource allocation will have a key impact on the result of allocation. In order to realise the maximum benefit of enterprise economic development, we need to allocate reasonable resources and clarify the relationship between each allocation index element. Therefore, this paper first analyses the index factors of human resource allocation. It mainly includes the following aspects:

1 Analysis of reasonable matching indicators of the total number of talents. The total number of people in the dynamic multi project human resource allocation of manufacturing industry is an important index to be considered first. For a manufacturing enterprise, the actual workload of an engineering project determines how many personnel are needed to complete it. The actual workload is also migrated according to the continuous changes of specific external and internal factors. When the dynamic multi project development trend of the manufacturing industry is good, more personnel are needed to work at this time; when it is poorly managed or develops slowly, it needs relatively few human resources (Nobar et al., 2020). Therefore, in the dynamic multi project human resource allocation of manufacturing industry, we should fully understand the actual total amount of work, and then make reasonable allocation according to the actual number of people. The allocation proportion can be calculated according to formula (1), that is:

$$A_i = \sum_{i=1}^{n} b_i \times \frac{c_i}{b_i} \tag{1}$$

Among them, A_i represents the actual allocation proportion of the number of people, b_i represents the total amount of dynamic multi project work in the actual manufacturing industry, and c_i represents the predicted demand for project personnel.

2 Dynamic multi project workload index analysis of manufacturing industry. Workload is an important indicator to measure employees' satisfaction with dynamic multi projects in the manufacturing industry, and it is also an indicator to measure whether the human resource allocation of manufacturing enterprises is reasonable. Reasonable allocation of human resources should not only give full play to the

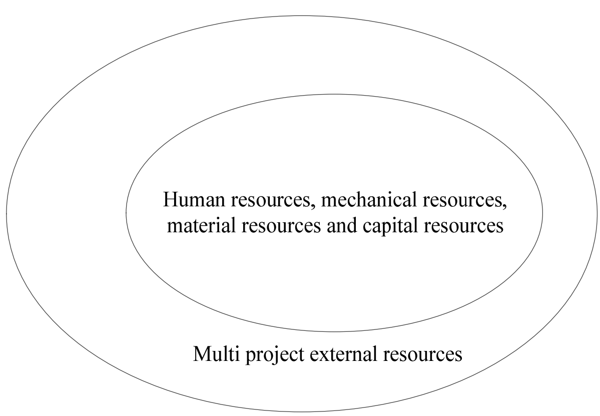
talents of staff, but also take into account that the workload corresponds to personal affordability. Manufacturing dynamic multi project is a special industry. In the working process, it is very necessary to reasonably arrange the work intensity and time (Rehman et al., 2020), which cannot exceed the limit value of personnel. While ensuring personnel efficiency, it is also necessary to ensure personnel mental health. In the process of dynamic multi project allocation in the actual manufacturing industry, when the workload of a certain post is too large, it is necessary to appropriately increase the number of workers to adjust this pressure: when the total amount of work of a post is relatively small, it is necessary to appropriately increase the work content, or try to merge some posts in some time periods. Such a reasonable arrangement can give full play to the ability of employees. Among them, the calculation formula of manufacturing dynamic multi project workload is:

$$S = \frac{(d_i + f_i \_ h_i)}{t_{all}} \times u \tag{2}$$

Among them, S represents the maximum workload actually carried by employees, d_i represents the number of project work, f_i represents the project work intensity value, h_i represents the increased workload of project work, and t_{all} represents the total length of work.

3 Analysis of utilisation efficiency index of limited resources. In the dynamic multi project work of manufacturing industry, it mainly includes internal resources and external resources of the enterprise. In its staffing, the workload and work efficiency of different resources should be considered (Salehim et al., 2021). Multi project resource allocation is a careful and efficient organisation and coordination of various resources in the construction process. For large engineering enterprises, thanks to the mature management system and long development history, both internal and external resources are at a relatively high level. Therefore, the efficiency of resource allocation needs to be considered (Zhao et al., 2020b). In the dynamic multi project human resource allocation of manufacturing industry, it is necessary to manage the constraints of multi project human resources and improve the utilisation efficiency of human resources. The main types of allocation are shown in Figure 1.

Figure 1 Core resource types of multi project human resources



4 In the process of determining the dynamic multi project human resource allocation index of manufacturing industry, this paper first determines the reasonable matching index of the total number of talents, workload index and utilisation efficiency index, and determines the calculation formula of each index to provide index data for subsequent research.

2.2 *Evaluation of dynamic multi project human resource allocation index in manufacturing industry*

Based on the determination of the above-mentioned dynamic multi project human resource allocation indicators of the manufacturing industry, in order to improve the effectiveness of human resource allocation, it is necessary to evaluate the above-mentioned determined human resource allocation indicators to determine the effectiveness of the dynamic multi project human resource allocation indicators of the manufacturing industry. In this paper, the fuzzy comprehensive evaluation method is used for evaluation (Al, 2021). The fuzzy comprehensive evaluation process of manufacturing dynamic multi project human resource allocation indicators is shown in Figure 2.

Step 1 Determine the priority evaluation set of dynamic multi-project human resource allocation indicators in the manufacturing industry. Set the collection to:

$$P = \{P_1, P_2, \ldots P_x \ldots P_n\} \tag{3}$$

Among them, P_x represents the x re-evaluation index of the index priority evaluation, and n represents the number of indicators in the set.

In order to improve the effectiveness of the evaluation of dynamic multi project human resource allocation indicators in manufacturing industry, the evaluation indicators are divided into two categories, and a reasonable number is set under each level. Determine the priority index evaluation set of multi project human resource allocation indicators. Determine the real evaluation set according to the authenticity of the evaluation to the greatest extent (Khabir et al., 2020). The set of evaluation levels is:

$$Y = \{Y_1, Y_2, \ldots Y_m \ldots Y_i\} \tag{4}$$

Among them, Y_i represents the results of the i index evaluation, and m represents the number of evaluations.

Then the fuzzy comprehensive matrix of priority evaluation is constructed. The constructed fuzzy comprehensive matrix is:

$$W = \begin{bmatrix} \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_n} \\ & \cdots & \\ \frac{w_1}{w_n} & & \frac{w_n}{w_n} \end{bmatrix} \begin{bmatrix} W_1 \\ \cdots \\ W_n \end{bmatrix} n \times h \tag{5}$$

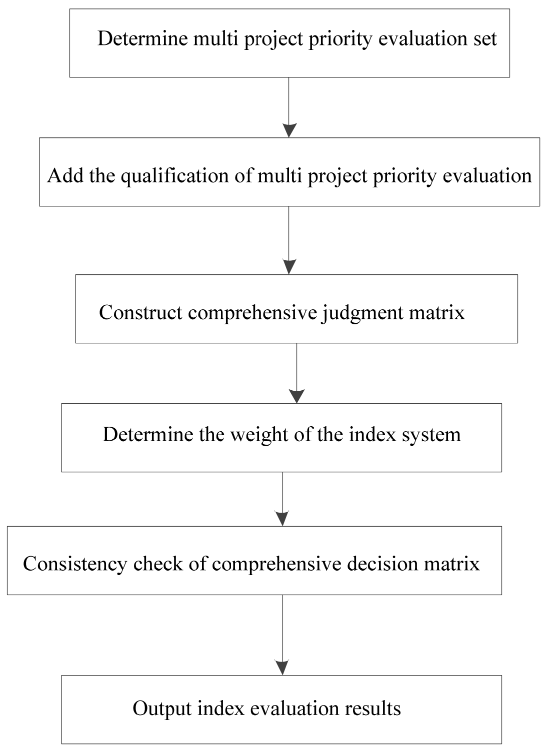
where W represents the fuzzy composite matrix, and h represents the graded weights for different indicators.

The weight vector of the evaluation index is determined according to the determined fuzzy comprehensive matrix. Set the vector of weight distribution as:

$$V = \{v_1, v_2, \dots v_m\} \tag{6}$$

Among them, v_m represents the weight of the index, and V is all the index weights meet the calculation results of the formula.

Figure 2 Fuzzy comprehensive evaluation process of dynamic multi project human resource allocation index in manufacturing industry



Finally, through the establishment of relationship matrix, the evaluation of dynamic multi project human resource allocation index in manufacturing industry is realised. The evaluation results are as follows:

$$B = g\begin{bmatrix} B_{11} & \dots & B_{1n} \\ & \dots & \\ B_{1n} & & B_{nn} \end{bmatrix}\begin{bmatrix} \frac{w_1}{w_2} & \dots & \frac{w_1}{w_n} \\ & \dots & \\ \frac{w_1}{wn} & & \frac{w_n}{w_n} \end{bmatrix} \tag{7}$$

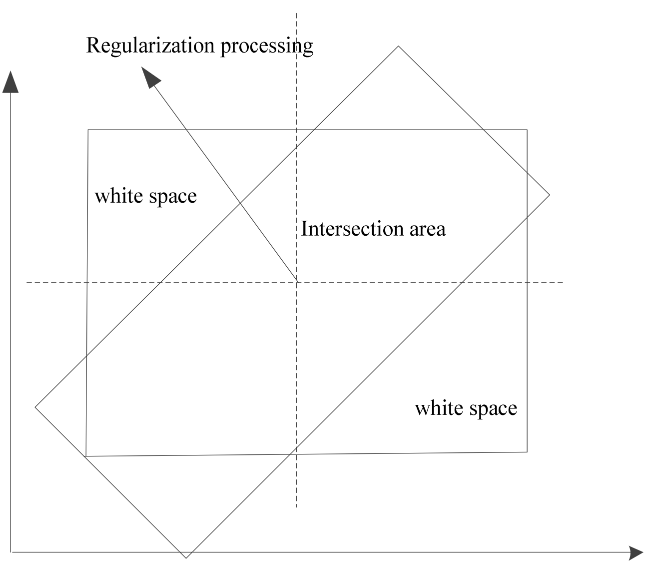
Among them, g represents the influence factor of the judgment matrix, and B represents the evaluation results of the human resource allocation indicators.

In the evaluation of manufacturing dynamic multi project human resource allocation indicators, by determining the fuzzy sets of different human resource indicators and calculating the different hierarchical weights of each indicator, the fuzzy comprehensive evaluation method is introduced to construct the index comprehensive evaluation matrix to realise the evaluation of manufacturing dynamic multi project human resource allocation indicators.

3 Dynamic multi project human resource allocation in manufacturing industry based on multidimensional model

Based on the above-mentioned dynamic multi project human resource allocation indicators of manufacturing industry, this paper uses multidimensional model to realise the effective allocation of human resources. Multidimensional model is an interval model. With the help of the uncertain parameters of the research object, the boundary value is set in the Cartesian coordinate system for uncertainty modelling, and the constructed multidimensional model is used as the uncertain area of uncertainty modelling. At this time, there is a certain connection between the uncertain parameters of the research object and reduce the blank area in the multidimensional body. By reducing the blank area, the chance of the research object in the blank area is reduced (Hidayat et al., 2021). Therefore, in the human resource allocation, this paper puts the dynamic multi project human resource allocation index of manufacturing industry into the multidimensional model, uses the PCA interval model in the multidimensional model to orthogonalize each index, and realises the intersection field of index parameters in different regions through the multilateral convex set model in the model, so as to realise the rational allocation of human resources. The basic structure diagram of the model is shown in Figure 3.

Figure 3 Basic structure diagram of multilateral convex set model



In Figure 3, the rectangular area is a compact area without any sample data. Through the reasonable allocation of human resources in different regions, put the reasonable allocation of human resources in a variety of human resources data.

The multi project human resource allocation problem is a personnel scheduling optimisation problem. The data in the multi-dimensional indicator data set is transformed into a two-dimensional model to obtain the multi project human resource allocation objective optimisation function. The weak learner is used to obtain the sample weights, the correlation degree is calculated through the multi-dimensional model, and the grey correlation method is used to optimise the output results of the human resource allocation objective optimisation function.

Assuming that there are m sample points in the *N*-dimensional uncertainty parameter domain, the human resource allocation index data is expressed as:

$$Q = \left(q_1^j, q_2^j, \dots q_n^j\right)^T \tag{8}$$

Transform the data in the determined multi-dimensional indicator dataset into a two-dimensional model to obtain the multi project human resource allocation objective optimisation function X:

$$X \in X^i = \left\{X \mid X^L \leq X^U Y^L\right\} \tag{9}$$

Among them, X^i represents the PCA transformation matrix, X^L represents the upper and lower boundary values of different parameter coordinate systems in the blank area, and X^U represents the characteristic change value in the transformation.

After transforming the human resource allocation indicator data, classify the allocated indicators, and calculate the sample weight in consideration of the different post capacity needs, so as to obtain:

$$\gamma_{(N+1)}\left(x_i\right) = Q\frac{\gamma_N \exp\left(-a_m y_i h_n\left(X_i\right)\right)}{d_m} \tag{10}$$

Among them, $\gamma_{(N+1)}(x_i)$ represents the weight value of the index data, a_m represents the classification factor, y_i represents the proportion coefficient, $h_n(X_i)$ represents the weak learner output result, d_m represents the normalisation constant.

On this basis, the grey correlation degree is used to determine the correlation degree of the blank area in the multi-dimensional model, and the correlation degree is analysed for the time series, index series and horizontal series of configured indicators (Ahmad and Jasimuddin, 2021). The behaviour sequence for setting HR allocation indicators is:

$$E = \begin{bmatrix} e_0(1), & e_0(2) & \dots & e_0(n) \\ e_1(1), & e_1(2) & \dots & e_1(n) \\ & \dots & & \\ e_m(1), & e_m(2) & \dots & e_m(n) \end{bmatrix} \tag{11}$$

The association degree of human resources in the blank area of the multidimensional model is determined according to the set behaviour sequence. The calculation formula is:

$$\delta(E) = \frac{\min \mid e_1(1) - e_m(1) \mid x(k)}{\varphi \max \mid e_1(1) - e_m(1) \mid x(k)} \tag{12}$$

Among them, φ represents the degree of association between the index data, and $x(k)$ represents the degree of correlation.

According to the determined correlation degree and the characteristic attribute requirements of multi project human resources, the fuzzy relationship of human resources allocation in China is set, and the logical relationship of human resources allocation attributes is calculated to obtain:

$$R(X_i) = \left\{ (x_s, x_t) \in u \times u \frac{1}{m} \sum \delta(E) \right\} \tag{13}$$

Among them, u represents the Haiming distance, s represents the flexible resource object similarity in multi-project human resource allocation, and t represents the fuzzy similarity relationship.

On this basis, the dependence of human resource allocation of multi-project in multidimensional model is set, and the manufacturing dynamic multi-project human resource allocation (Wu et al., 2021) based on multi-dimensional model is completed. When setting $R \in C$ represents the multi-item key HR allocation set C, the dependency in its assignment is expressed as:

$$\rho_i(X) \frac{\sum_{i=1}^{n} R_i(X_i)}{|U|} \tag{14}$$

Among them, $\rho_i(X)$ represents the obtained dependence, U representing the dependence between indicators in resource allocation.

Finally, set the indicator set cluster of multi project human resource allocation as follows:

$$F = \left\{ f_1, f_2, \dots f_n \left(U = \vec{U}_{\rho_i}(X) \right) \right\} \tag{15}$$

where $\vec{U}$ represents a theoretic domain, and f_n represents indicators on a subset of properties.

The dynamic multi project human resource allocation model of manufacturing industry based on multidimensional model is as follows:

$$r_i(F) = \sum_{i=1}^{n} \frac{F\left|B - (XX_i)\right|}{|U|} P \tag{16}$$

where $r_i(F)$ represents the final configuration result, XX_i represents the proportion of multidimensional body model, and P represents the probability of configuration.

In the dynamic multi project human resource allocation of manufacturing industry based on multidimensional model, the PCA interval model in multidimensional model is used to orthogonalize each index, and the intersection domain of index parameters in different regions is realised through the multilateral convex set model in this model, so as to realise the rational allocation of human resources.

4 Experimental analysis

4.1 Experimental design

In the experiment, a large manufacturing enterprise is selected as the research object. The company has 20 branches, and one of the companies with relatively small business scale is selected as the experimental sample data. The main parts of the company include production department, sales department and personnel department. The subsidiary operates more than 50 types of electrical appliances. In the experiment, the human resources allocation of the sales department is the main one, and the human resources are reasonably allocated according to different sales types and market sales. There are 100 people in the sales department of the company and five groups in total. According to the sales performance in recent half a year, the human resources will be allocated in proportion. Pre-process the allocated HR data group to determine whether the HR allocation is reasonable.

4.2 Experimental index design

In order to highlight the effectiveness of this method, the experiment is carried out by comparing the methods in this paper, the methods in Ye and Chen (2022) and the methods in Fu et al. (2022). The experimental results meet the experimental requirements. The experimental data take SPSS software as the experimental data analysis software.

1 Human resource allocation accuracy

The higher the accuracy of human resource allocation, the more reliable the evaluation results are. On the contrary, the lower the accuracy of human resource allocation, the less reliable the evaluation results of innovation ability evaluation model are. The evaluation accuracy P_o formula of human resource allocation is:

$$P_o = h_s / j_s \tag{17}$$

In the above formula, h_s indicates the number of relevant evaluation information detected, and j_s indicates the total number of all relevant evaluation information detected by evaluation.

2 Indicator configuration time overhead

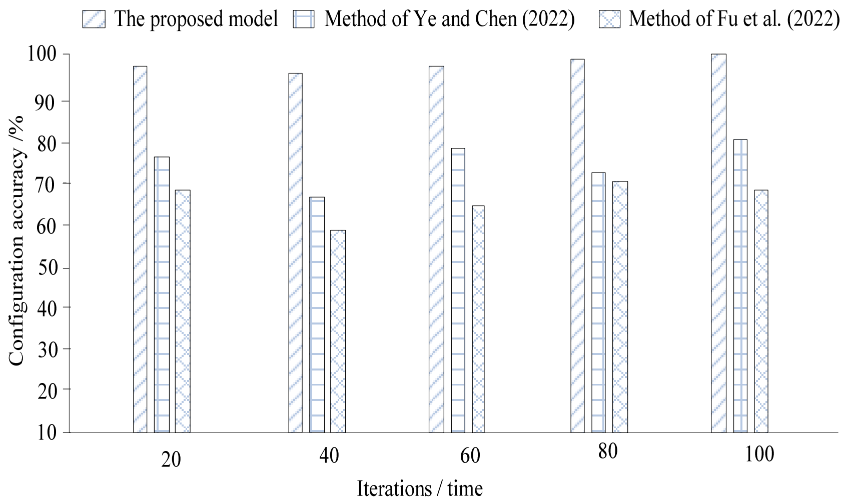
The shorter the time of human resource allocation, the higher the evaluation efficiency. On the contrary, the longer the time of human resource allocation, the lower the evaluation efficiency.

4.3 Analysis of experimental results

4.3.1 Accuracy of human resource allocation

The accuracy of human resource allocation is related to the realisation of the maximisation of economic benefits of enterprises. It is a key index to measure whether the personnel allocation is reasonable or not. Therefore, the accuracy of reasonable allocation of sample personnel data by this method, Ye and Chen (2022) method and Fu et al. (2022) method is experimentally analysed. The results are shown in Figure 4:

Figure 4 Human resource allocation accuracy analysis of different methods (see online version for colours)



By analysing the experimental results in Figure 4, it can be seen that there are certain differences in the accuracy of the reasonable allocation of sample personnel data by using the methods in this paper, Ye and Chen (2022) and Fu et al. (2022). When the number of experiments is 20, the human resource allocation accuracy of the method in Ye and Chen (2022) is 76.2%, the human resource allocation accuracy of the method in Fu et al. (2022) is 68.9%, and the human resource allocation accuracy of the method in this paper can reach 98.0%; When the number of experiments is 80, the human resource allocation accuracy of the method in Ye and Chen (2022) is 73.8%, the human resource allocation accuracy of the method in Fu et al. (2022) is 72.6.9%, and the human resource allocation accuracy of the method in this paper can reach 99.2%; the configuration accuracy of this method is always higher than 90%, and the configuration accuracy of the other two methods is lower than this method, which verifies the effectiveness of the proposed method.

4.3.2 Indicator configuration time cost

The experiment further analyses the method in this paper, the method in Ye and Chen (2022) and the method in Fu et al. (2022) to analyse the allocation time in the sample staffing, so as to improve the effectiveness of staffing. The experimental results are shown in Table 1.

By analysing the experimental results in Table 1, it can be seen that there is a certain difference in the time of personnel allocation by the three methods. When the number of iterations is 20, the configuration index configuration time cost of the method in YE and Chen (2022) is 4.2 s, the configuration index configuration time cost of the method in Fu et al. (2022) is 4.6 s, and the configuration index configuration time cost of the method in this paper is only 3.2 s; when the number of iterations is 100, the configuration index configuration time cost of the method in Ye and Chen (2022) is 5.9 s, the configuration index configuration time cost of the method in Fu et al. (2022) is 5.6 s, and the configuration index configuration time cost of the method in this paper is only 3.3 s; the time cost of the other two methods is always higher than that of this method. This is because this method uses the PCA interval model in the multi-dimensional model to orthogonalize the indicators. Through the multilateral convex set model in this model, the intersection fields of indicator parameters in different regions are realised, and the reasonable allocation of human resources is realised, which improves the effectiveness of the proposed method.

Table 1 time cost of different method configuration indicators (s)

Number of iterations/times	*The method of this paper*	*Ye and Chen (2022)*	*Fu et al. (2022)*
20	3.2	4.2	4.6
40	3.3	4.6	4.8
60	3.5	5.2	5.0
80	3.4	5.6	5.3
100	3.3	5.9	5.6

5 Conclusions

This paper proposes a dynamic multi project human resource allocation method for manufacturing industry based on multidimensional model. Determine the reasonable matching index, workload index and utilisation efficiency index of the total number of talents, and determine the allocation of human resources. By confirming the fuzzy set of resource indicators, calculate the different hierarchical weights of each index, introduce the fuzzy comprehensive evaluation method to construct the index comprehensive evaluation matrix, orthogonalize each index by using the PCA interval model in the multi-dimensional model, and realise the intersection of index parameters in different regions through the multilateral convex set model in the model, so as to realise the rational allocation of human resources. The experimental results show that:

1 The allocation accuracy of this method is always higher than 90%, which shows that the proposed method can improve the allocation effect of multi project human resources allocation.

2 The time-consuming change of this method is small, about 3.5 s, which shows that this method can effectively improve the efficiency of multi project human resource allocation.

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