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Research Article

Analysis of an Enterprise Human Resource Management Performance Evaluation Model Based on the DEA Method

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Performance evaluation is an important sand central part of the human resource management system and the process of assessing performance and documenting performance with uniform criteria. Based on the hypothesis of high-performance work systems and HRM effectiveness, this paper proposes a DEA model for evaluating the performance of HRM in enterprises through case studies, field interviews, and questionnaires and tests the validity of the model, by establishing an evaluation index system with HRM in large enterprises as the core, orders and customers as output indicators, and the number of personnel and total costs as input indicators and using the AHP method to optimise the DEA model applied to specific cases for testing. At the same time, the degree of variation between technical level, professional level, and strategic HRM gradually narrows as the HRM performance of the enterprise increases. Finally, targeted solution suggestions are given in relation to the actual situation.

1. Introduction

As we all know, the human resources system in China was established relatively late, and the overall performance of human resource management in enterprises is relatively lagging behind, but the performance itself is a very important part of the process of human resources development in enterprises. For the purpose of further improving the overall economic efficiency of enterprises, scientific research must be conducted on the performance evaluation system, in addition to this, the objective requirements of the times should be fully integrated with theory and practice, and the relevant research content should be put into practice from the practical point of view, in order to achieve the premise of further improving the overall economic efficiency of enterprises and to realise the system performance and human resource management-related theory. This is also vital for the long-term development of the enterprise.

Performance evaluation plays a very important role in the development of human resources. There is a strong link between work, pay, training, and performance, and the performance system is also the type of system that has a direct link with the employees of the company [1]. It is also a fundamental type of system that is directly linked to the employees. The performance system determines to a large extent the effectiveness of the company's own operations. Firstly, the determination of remuneration must be based on performance assessment. The basic principle of distribution according to work in China must be based on performance appraisal, which is also the basis for the reasonable distribution of the remuneration package of the enterprise's employees, or the most important basis for determining the wages of the enterprise's employees, especially the floating wages [2, 3]. Through the application of the performance evaluation system, it not only is possible to improve the basic state of the employees' work to a large extent but also has a very important role in cultivating the overall enthusiasm and initiative of the employees. Secondly, the placement and promotion of staff are based on performance appraisal. The placement of staff should be adjusted on the basis of the performance appraisal of the staff concerned. In addition, in the actual job transition process, the staff's own

Table 1: Main items and contents of performance appraisal.

Tier 1 indicators	Tier 2 indicators	Tier 3 indicators
Product indicators	Number of orders	Number of standing orders
		Number of random orders
	Number of clients	Long-term clients
		Random clients
Input indicators	Costs	Advertising costs
		Other costs
	Personnel	Company staff
		Other staff

Table 2: Quarterly performance indicators.

Decision-making units	Input indicators		Output indicators	
	Number of employees	Total costs	Number of orders	Number of customers
DMU (1)	32	50	72	40
DMU (2)	24	64	6	8
DMU (3)	60	24	46	40
DMU (4)	56	50	16	20
DMU (5)	18	30	44	16
DMU (6)	76	56	20	40

working ability must be determined by means of performance appraisal, so that the deployment of staff can be completed better [4]. Thirdly, the planning of employees' future careers must be based on performance appraisals. Performance appraisals can provide a more accurate understanding of the employee's own abilities, so as to plan the future career direction for the employee, and it is also vital to maximise the effect of future training for the employee [5]. Fourthly, the motivation of the employees themselves must be mobilised through performance appraisal. By linking the performance appraisal system to rewards and introducing a system of rewards and penalties [6, 7], it is also important for employees to be motivated to excel in the future.

Gronroos [8] proposed the concept of customer-perceived service quality (CPQ) or service performance as a tool to measure the extent to which the service level of an enterprise can meet customer expectations. Parasuraman et al. [9–11] viewed service performance as the difference between the level of service performance perceived by customers and the level of service performance expected and proposed the SERVQUAL model to evaluate service performance. Subsequently, the SERVQUAL scale has been widely used in service industries such as retail, catering, IT services, banking, insurance, transport, and libraries [12–15]. In addition to performance management methods for tangible products and services, internal corporate management has also applied performance management theories and methods such as internal customer service performance and satisfaction to improve effectiveness or efficiency, and service processes and standards have been developed in the professional fields of accounting, auditing, training, and IT services. For example, in the 1980s, the UK National Computer and Telecommunications Agency (CCTA) proposed a set of IT service management standards library—the IT Infrastructure Library (ITIL) [16]. The library of standards was applied and recognised in UK businesses and became a common international standard in the field of IT services. In the three major international performance awards such as the Malcolm Baldrige National Performance Award in 1987, the European Performance Award in 1992, and the Deming Award in Japan in 1951, human resource management constitutes a performance indicator for evaluation [17]. In August 2004, the Chinese National Standard GB/T19580-2004 also contains performance indicators for human resource management. This set of standards has gradually been applied and promoted in enterprises such as Haier.

In the existing quality award evaluation guidelines, the quality standards of HRM focus on process records, control standards, and documentary evidence in HRM processes, such as training time and operational documentation records. There is a lack of quality theories and methods for corporate HRM and a lack of frameworks and standards for judging the quality of corporate HRM. At the same time, the human resource management (HRM) theory and practice have long focused on the enhancement of job performance by individual factors. Researchers in the fields of selection, performance, and compensation management have based their management decisions primarily on the assessment of individual differences, and an underlying logical assumption of these studies is that individual characteristics can determine changes in job performance. However, researchers who view HRM as a system have proposed concepts and theories such as high-performance work systems [18], HRM best practices [19], and HRM control systems [20], which suggest that there are several best HR practices or work systems that will have a direct impact on organisational performance to such an extent that they can affect organisational performance regardless of changes in organisational conditions or circumstances that can affect organisational performance [21, 22]. Among these, Waldman [23] argues that systemic factors can have an impact on job performance, whereas previously systemic factors were treated as uncontrollable factors.

In recent years, human resource management theory and many enterprises are studying the methods and implementation of performance appraisal, and the performance appraisal of enterprise marketing personnel is particularly

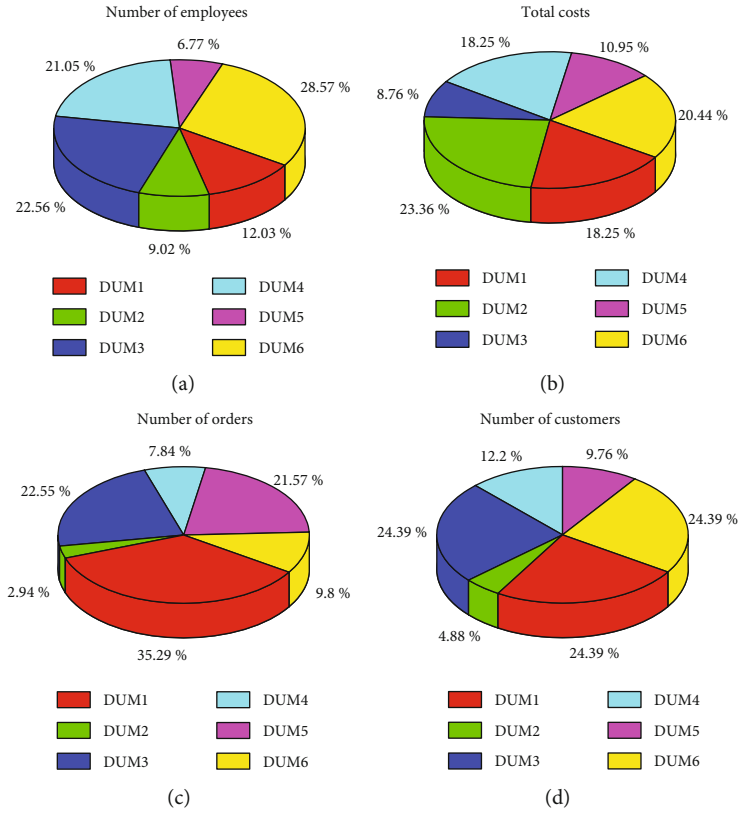

Figure 1: Comparison of pie charts of performance input and output parameters across the six divisions. (a) Number of employees. (b) Total costs. (c) Number of orders. (d) Number of customers.

Table 3: Selected Input index.

DMU (*i*)	Input1/10 thousand	Input2/person
DMU (1)	8.36	8
DMU (2)	10.64	11
DMU (3)	8.15	5
DMU (4)	6.68	4
DMU (5)	18.26	9
DMU (6)	15.70	12

important. However, there are currently some problems in the performance appraisal of marketing personnel in enterprises, such as the lack of performance appraisal indicators and standards and neglect of the performance appraisal of the team. In practical application, there are many methods of performance evaluation concerning human resource management. For example, Argenti (1976), kravarthy (1986) established a multifactor evaluation model, but because the weight of the evaluation model is difficult to determine, it is more difficult to operate in the practical application; the same traditional AHP method is also due to the determination of the weight, so that the model and method increase the subjectivity of people leading to inaccurate assessment results; from 1978, the DEA method is used in domestic and foreign decision-making. Since 1978, the DEA method has been widely used in the field of decision-making at home and abroad, but as it tends to lose potential optimal combinations when used alone, on this basis, many scholars have proposed improved algorithms for DEA, and thus, the DEA/AHP model was created.

2. The Complexity of Enterprise HRM Performance Evaluation and the Issues It Should Address

Performance evaluation is a very important part of an enterprise's human resource management system and is one of the most critical indicators for managers to evaluate performance. However, at present, the construction of performance evaluation systems in domestic HRM systems is still in its infancy, with many companies relying on performance evaluation for systematic alignment and overall evaluation. However, as the most important application of performance evaluation is to analyse the relevant data in the evaluation system, which is done within a specific time frame, a complete evaluation system has not yet been formed from the perspective of the long-term application, and the most important reason for the above problems is that many enterprises in China currently have a large lack of knowledge about the performance evaluation system; the importance attached to the evaluation system is also the most important reason for the above problems that many enterprises in China are not aware of the performance appraisal system, and the degree of importance they attach to it is also clearly insufficient.

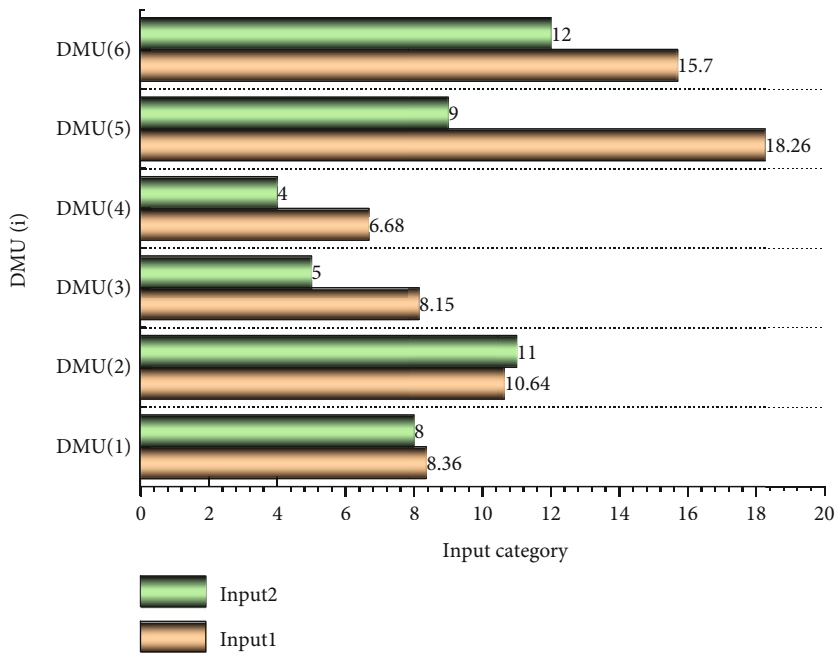

Figure 2: Comparison of the two input value tables.

Table 4: Output statistic data.

DMU (*i*)	Business ratio	Operating cost	Quality of work life	Satisfaction	Cycle efficiency	Utilisation	Organisational efficiency	Equipment	Efficiency
DMU (1)	78.00	0.51	0.68	0.78	17.14	0.75	0.82	0.73	0.86
DMU (2)	68.82	0.42	0.75	0.85	20.80	0.83	0.86	0.70	0.83
DMU (3)	76.67	0.64	0.70	0.75	17.70	0.78	0.79	0.78	0.87
DMU (4)	72.50	0.77	0.73	0.71	14.30	0.85	0.90	0.86	0.93
DMU (5)	86.25	0.81	0.82	0.84	12.50	0.89	0.85	0.83	0.92
DMU (6)	84.00	0.47	0.66	0.70	15.98	0.73	0.72	0.72	0.79

Performance evaluation is one of the most crucial components in the development of human resources in enterprises, but it has been a relatively short period of time since the performance evaluation system was adopted as a management system in China, and therefore, there is relatively little research on it [24]. Based on this, the problems related to the performance evaluation of human resource management systems in domestic enterprises are addressed, and the performance evaluation of enterprise human resource management is targeted to achieve the purpose of better human resource management.

The evaluation process of HRM performance should pay attention to the following issues: (1) The implementation of HRM will have an impact on all aspects of enterprise operations, and the evaluation of HRM performance cannot only evaluate the performance of the business process itself [25]. (2) The HRM proposed in the paper is on the basis of a system, which is an input-output system, so the performance evaluation has multiple input and output evaluation issues. It shows that HRM performance has measurability, and the most accurate evaluation of HRM implementation can be achieved by integrating all input and output indicators and establishing a complete indicator system. (3) HRM is a long-cycle process, and the evaluation indicators that enterprises pay attention to at different stages of HRM implementation are also different.

2.1. Determination of an Enterprise HRM Performance Evaluation Index System. HRM has an important relationship with the internal support system, the capability support system, and the resource input support system, and each support system has an independent contribution to HRM performance. Among them, each variable in resource input can be regarded as HRM input, and all of them can be used

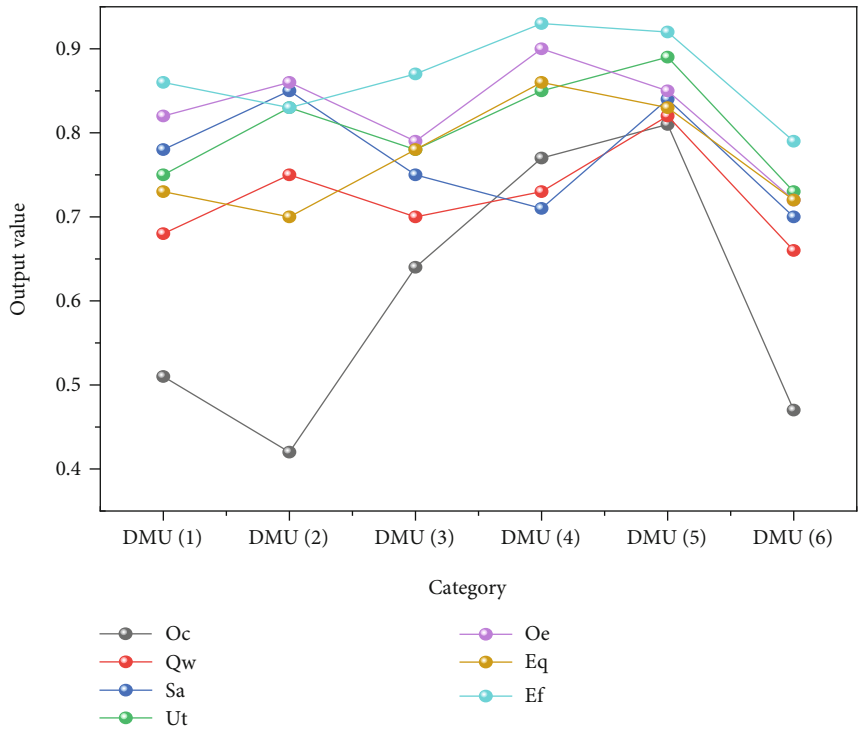

Figure 3: Comparison of output data for the two output indicators.

Table 5: Valid values for the 6 decision units.

DMU (i)	1	2	3	4	5	6
DMU (1)	0.2145	0.3210	0.2070	0.2461	0.1949	0.1772
DMU (2)	0.0579	0.0872	0.1035	0.1146	0.0740	0.1497
DMU (3)	0.2145	0.1743	0.2071	0.2282	0.1950	0.1995
DMU (4)	0.1073	0.0937	0.1117	0.1232	0.1461	0.1578
DMU (5)	0.1908	0.0918	0.1636	0.1233	0.1949	0.1577
DMU (6)	0.2146	0.2295	0.2070	0.1642	0.1949	0.1577

as input indicators for HRM performance evaluation, while the indicators of HRM implementation effect can be used as output indicators [26]. The input-output indicator system of HRM performance evaluation is established by considering the input of enterprises to the implementation of HRM and the complexity of HRM performance evaluation. In order to improve the overall competitiveness of the company, the business processes of the company are redesigned in order to obtain an improvement in performance in terms of costs, etc. This improvement is mainly reflected in the economic benefits achieved by the company and the increase in organisational efficiency. In this paper, we use effectiveness and efficiency to measure the economic and organisational value of HRM. The performance appraisal of HRM must be carried out in order to achieve the enterprise's goals, so the development of its appraisal index system also needs to reflect the long-term and short-term goals of the enterprise, so the performance appraisal index can be determined to objectively reflect both the short-term and long-term benefits of the enterprise. The indicators for performance appraisal are shown in Table 1.

3. Construction of the DEA/AHP Model

3.1. Introduction to the DEA Model. The method and model were developed by the famous American operations researchers W. W. Cooper, A. Charner, and others as a way to evaluate efficiency [27]; it is a useful method to study the relative effectiveness between decision units with the same type of decision; here, the C2R model is introduced, and the model is as follows.

Suppose there are n DMUs, each using m inputs x_i $(i = 1, 2 \cdots \cdots, m)$ to produce s output y_r $(r = 1, 2, \cdots, s)$. represents the potential amount by which DMU_k all input terms can be scaled down in equal proportions; the weights $\lambda = (\lambda_1, \lambda_2 \cdots\cdots, \lambda_n)$ represent a polyhedral vector linking all information, and the C^2R model can then be expressed as

$$\begin{aligned} &\max \left[\theta - \varepsilon\left(\hat{e}^T s^- + e^T s^+\right)\right] \\ &\text{s.t.} \sum_{j=1}^{n} x_j \lambda_j + s^- = \theta x_{j0} \sum_{j=1}^{n} y_j \lambda_j - s^+ = y_{j0} \end{aligned} . \quad (1)$$

$\lambda_j \geq 0\,; j = 1, 2, \cdots, n$, s^- is the slack variable, and s^+ is the residual variable.

$\hat{e}$ and e are m-dimensional and s-dimensional column vectors with component 1, respectively; ε is a non-Archimedean infinitesimal quantity (a quantity smaller than any quantity greater than zero).

3.2. Optimising DEA Models Using AHP. In this paper, a modified DEA/AHP method is used to divide all the decision-making units (DMUs) into two groups and compare them with each other using the traditional DEA

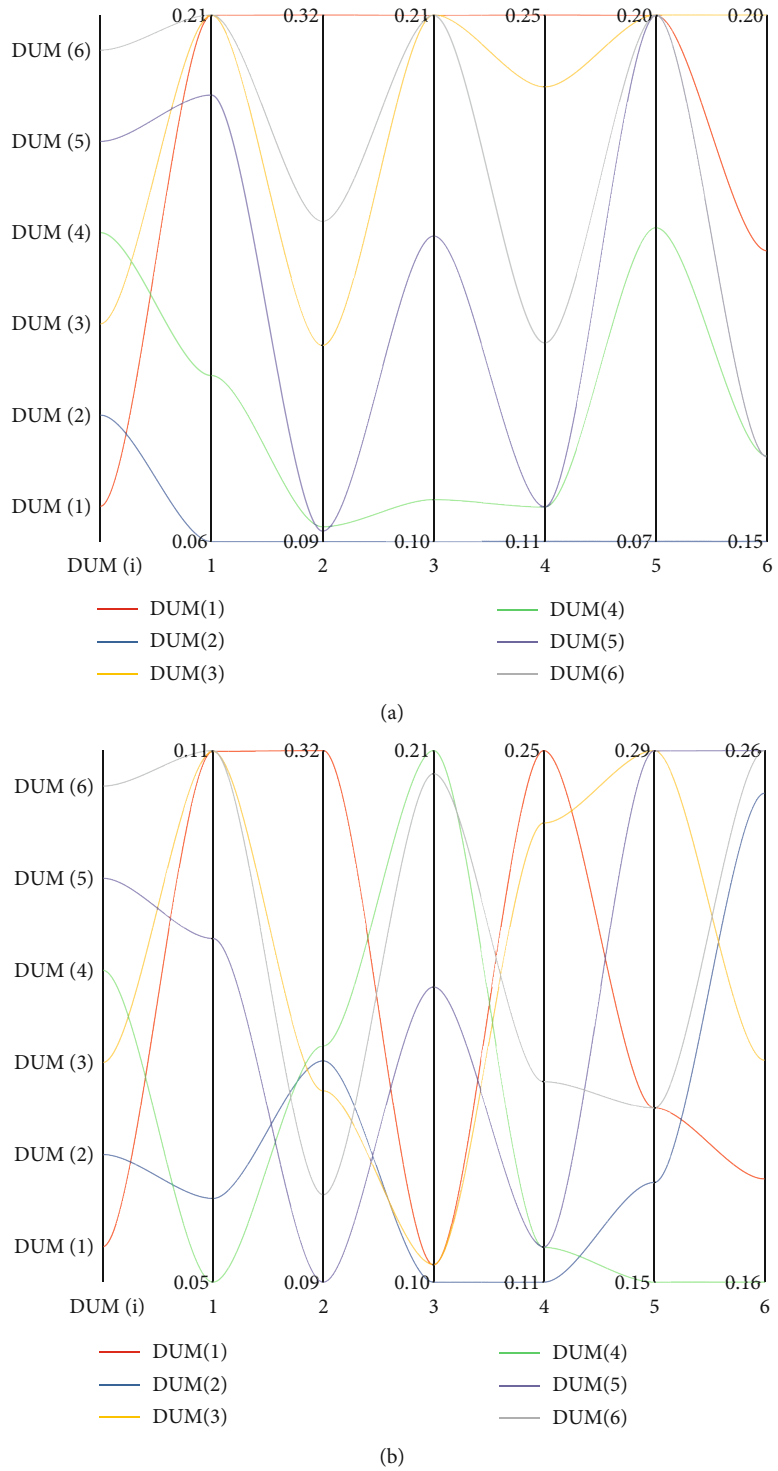

Figure 4: Comparison of the effective values of the 6 decision units (a) Output1. (b) Output2.

method. As the AHP here has only one level, the size of the eigenvector at position i here reflects the priority of the ith decision unit.

3.3. Constructing Judgement Matrices Using the DEA Method. If there are a total of n decision units, each with a total of m input indicators and s output indicators, any two decision units are divided into a group, assumed to be 1 and 2, and their RMS values are calculated separately. Since even decision units with a relative validity value of 1 are not necessarily all good in overall performance, in order to be able to distinguish whether a decision unit is better overall, we use cross-efficiency to evaluate it, a way of providing the cross-efficiency of a decision unit under the most

Table 6: Ranking of weight values for the six divisions.

DMU (i)	DEA/AHP calculated value (weight)	Rank
DMU (1)	0.2364	1
DMU (2)	0.1018	6
DMU (3)	0.1710	3
DMU (4)	0.1283	5
DMU (5)	0.2026	2
DMU (6)	0.1599	4

favourable weighting of the other decision units. The specific model is as follows.

$$\begin{gathered}\max = h_{11} = \sum_{r=1}^{s} U_r y_{r1} \\ \text{s.t.} \sum_{r=1}^{m} U_r y_{rj} - \sum_{i=1}^{m} V_i x_{ij} \le 0 \text{j} = 1, 2, \\ \sum_{i=1}^{m} V_i x_{i1} = 1 \\ \text{Ur} \ge \varepsilon > 0, \text{r} = 1, 2, \cdots, \text{s}, \\ \text{Vi} \ge \varepsilon > 0 \text{i} = 1, 2, \cdots, \text{m},\end{gathered} \quad , \tag{2}$$

$$\begin{gathered}\max = h_{21} = \sum_{m^r}^{s} U_r y_{r2} \\ \text{s.t.} \sum_{r=1}^{m} U_r y_{r1} - \sum_{i=1}^{m} V_i x_{i1} = 0 \text{j} = 1, 2, \\ \sum_{i=1}^{m} V_i x_{i2} = 1 \\ \sum_{r=1}^{s} U_r y_{r2} \le 1 \\ \text{U}_\text{r} \ge \varepsilon > 0, \text{r} = 1, 2, \cdots, \text{s},\end{gathered} \quad , \tag{3}$$

where m is the number of input indicators, s is the number of output indicators, n is the number of decision units, and v_i is the weight of input indicator i. u_r is the weight of output indicator r. X_{ij} is the value of input indicator i for the jth decision unit. y_{rj} is the value of output indicator r for the j th decision unit. And so on, hab and h_{bb} can be derived.

The ratio of the efficiency of decision unit 1 to decision unit 2 is

$$a_{12} = (h_{11} + h_{12})/(h_{22} + h_{21}). \tag{4}$$

In general, for n decision units, their two-by-two efficiency ratio is

$$\begin{gathered}a_{ij} = \left(h_{ij} + h_{ji}\right)/\left(h_{ji} + h_{jj}\right), \\ a_{ji} = 1/a_{ij}, \\ a_{ii} = 1.\end{gathered} \tag{5}$$

Using the DEA method above, a judgement matrix can be constructed. Moreover, the matrix constructed by this method does not contain subjectivity and does not require a consistency test.

3.4. Sorting by the AHP Method. Using the judgement matrix derived from the DEA method above, the AHP method is applied to solve for the maximum eigenvalue of the judgement matrix and its eigenvector [28]. Since the AHP in the above algorithm has only one level, the eigenvector ranked in the jth position is also the priority of the jth decision unit.

4. Empirical Analysis

4.1. Example. A large enterprise completes its sales tasks for the year and has an existing department divided into six divisions (DMU1-DMU6). The quarterly performance of its six teams is evaluated, and the evaluation indicators are divided into the number of employees, total costs, number of orders, and number of customers according to the nature of the inputs and outputs, as shown in Table 2.

A pie chart of the input and output indicators is given in Figure 1.

4.2. Calculation of Input Indicators

(1) Capital input indicator: HRM consulting cost is borne by these 6 DMUsi on average; the labour cost of personnel is calculated by multiplying the number of personnel directly involved in HRM in each department by the average labour cost; the training cost is calculated by multiplying the number of personnel involved in relevant training in each department by the average training cost per person; the equipment cost is calculated by combining the costs of relevant equipment purchased for each department. In other words, capital investment = HRM consulting fee + labour cost of personnel + training cost + equipment cost

(2) The input of the number of personnel is determined by the sum of the number of employees and leaders of the department who directly participate in HRM

(3) The input of staff participation and support is calculated by summing fuzzy mathematical methods

(4) The time commitment indicator is the sum of the time spent on training by each subdepartment

The sum of the time spent on the implementation of the HRM project is calculated. The data for the input indicators are shown in Table 3.

A visual comparison histogram of the two input indicators is given in Figure 2.

4.3. Calculation of Output Indicators. The evaluation indicators of both effectiveness and organisational efficiency are multi-indicator comprehensive evaluation problems, and the nature of each subindicator varies greatly, so the efficacy coefficient method is used in this paper to process these 2

Table 7: Synthetic efficacy coefficients of benefit and organisational efficiency.

Serial number	Comprehensive efficacy coefficient								
	DMU (1)	DMU (2)	DMU (3)	DMU (4)	DMU (5)	DMU (6)	DMU (7)	DMU (8)	DMU (9)
Output1	70.00	68.56	71.59	73.56	79.25	69.89	76.52	78.36	72.33
Output2	72.06	75.63	73.45	75.98	73.42	67.84	79.65	76.32	72.16

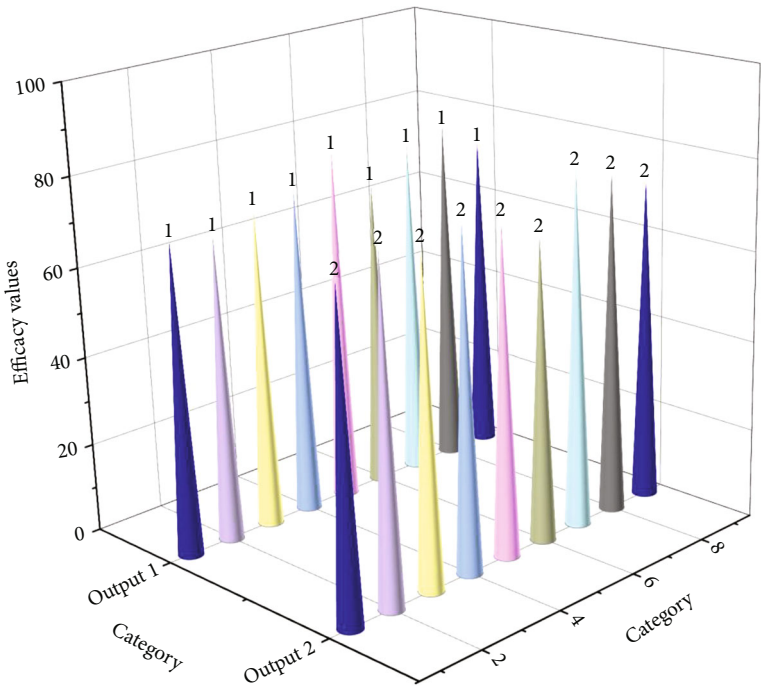

Figure 5: Comparison of data by division for the two outputs.

output indicators [29]. Table 4 shows the output indicator data.

In Figure 3, a visual comparison of the output data obtained by processing the two output indicators is presented.

4.4. Finding the Valid Values of the Decision Cells. Using Equations (2) and (3), the valid values of each decision cell in each group were solved using the operations research software QM, and the valid values were obtained as in Table 5.

A comparison of the decision values for the six cells of the two outputs is shown in Figure 4.

Some of the indicators are given in Table 6 in order to compare values for each component of the data using the fuzzy integrated judgement method. The utilisation rate of human resources is the ratio of the number of personnel used to the total number of employees on the rolls. Cost ratio of business process value-added activities and process activity cycle efficiency were calculated by the job cost method in the literature [30]. The paper's algorithm assigns a weight of 3 to the more important indicators, followed by a value of 2. The others are sufficient to distinguish the relative quantitative degree of each evaluation indicator, and the efficacy coefficients are shown in Table 7.

A comparison of the two outputs is shown in Figure 5.

4.5. The Final Judgement Matrix A of the DEA Model Is Obtained by a Two-by-Two Comsssparison.

$$A = \begin{bmatrix} 1 & 3.704 & 1 & 2 & 1 & 1.124 \\ 0.2698 & 1 & 0.498 & 0.930 & 0.380 & 0.950 \\ 1 & 2 & 1 & 0.852 & 1 & 1.266 \\ 0.5 & 1.075 & 0.540 & 1 & 0.749 & 1 \\ 1 & 2.632 & 1 & 1.333 & 1 & 1 \\ 0.889 & 1.053 & 0.791 & 1 & 1 & 1 \end{bmatrix}. \quad (6)$$

4.6. AHP Ranking. The decision unit weights were derived using the known AHP method of ranking, which resulted in the performance of the six divisions of 0.2364, 0.1018, 0.1710, 0.1283, 0.2026, and 0.1599. The ranking of the weight values is as follows.

The ranking using the AHP method yields the weight pairs of decision units as shown in Figure 6.

As can be seen from Table 6, the AHP optimization DEA method has been used to rank the performance of each department using a complementary approach and to further differentiate the process decision units with a valid value of 1

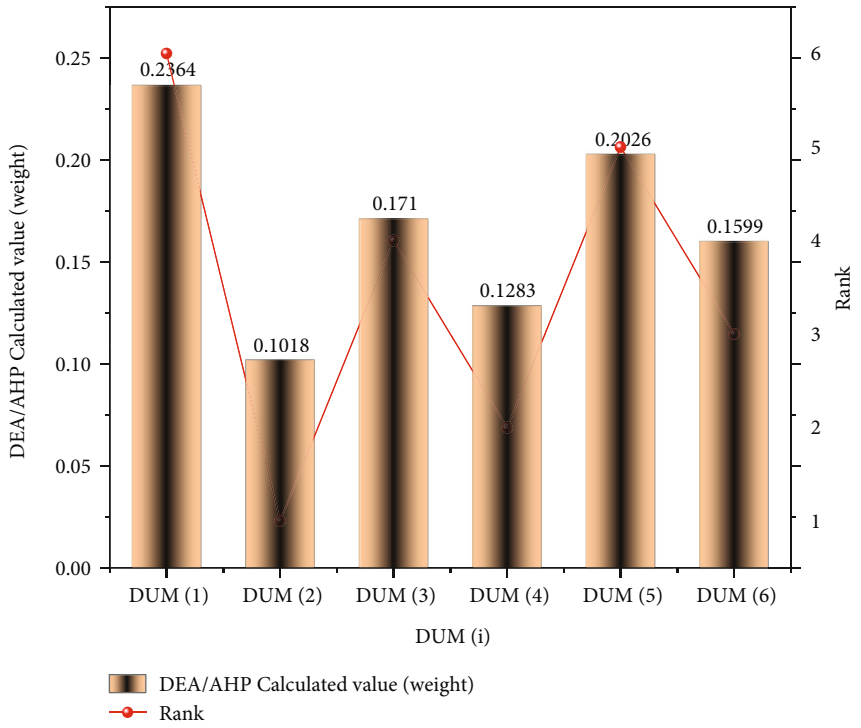

Figure 6: Comparison of the weights of the decision units from ranking using the AHP method.

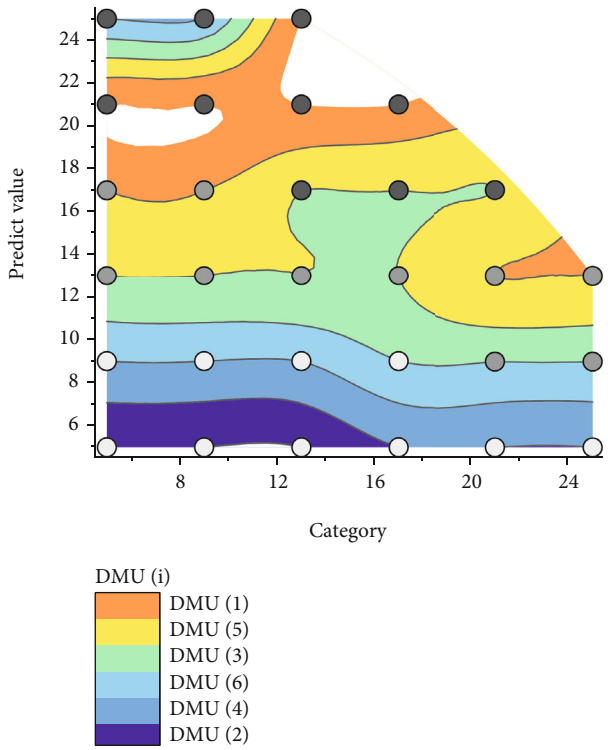

Figure 7: Results of the six divisional forecasts.

in the DEA. The objective judgement matrix used in the AHP method reduces the difficulty of making judgements on process performance.

The company uses the proposed superefficient DEA model to evaluate the performance of HRM and refine the results of HRM performance evaluation according to each stage. After refinement, the company then selects HRM performance evaluation indicators that meet the objectives of the next phase and uses the abovementioned method to evaluate HRM performance and identify weaknesses and opportunities for improvement, forming a cycle of continuous improvement so that corporate strategy can be achieved through HRM.

Finally, the kernel was used to make predictions about the future development of the six divisions, the results of which are shown in Figure 7.

5. Conclusion

The role played by a scientific human resource management performance evaluation system is crucial to the overall development of domestic enterprises, and by building a high-quality, systematic corporate HR performance evaluation system, it is equally crucial to the better future development of domestic enterprises. The use of the AHP-optimised DEA model to evaluate the performance of corporate HRM in the article is reflected in the following three main aspects. On the one hand, the new method realises the problem that the original DEA method cannot be fully ranked and further distinguishes the decision units with an effective value of 1 in DEA. On the other hand, the new method still retains the characteristics of the original DEA, i.e., the analysis of the economic significance of some indicators when evaluating the performance of decision units with multiple inputs and outputs. Finally, the new method compensates for the shortcomings of the traditional AHP method, which is too

subjective and dependent, by using data to analyse the validity of the proposed model.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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