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Research on Human Resource Allocation Efficiency of Dalian Port Enterprises Based on Super-Efficiency SBM Model

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Abstract: Dalian Port, located at the southern end of the Liaodong Peninsula, serves as the gateway to Northeast China and is the most important comprehensive foreign trade port in the region. Efficient human resource management plays a crucial role in the development of Dalian Port. This study utilizes the Super-Efficiency SBM model to investigate the human resource allocation efficiency of Dalian Port enterprises, proposing corresponding strategies. As the gateway to Northeast China, Dalian Port is located at the southern end of the Liaodong Peninsula. It is also the most important comprehensive foreign trade port in Northeast China. As the hub and dominant position of the Northeast Port, Dalian Port has the three northeastern provinces as its economic hinterland and is close to the Arctic waterway. The inner harbor of the port is wide and deep, with a total water area of 346 square kilometers. Although it is located in the north, it does not freeze in winter. It has more than 80 modern professional berths that can accommodate ships of 10,000 tons. The port's throughput and complete functions have great advantages in the Arctic shipping lanes. Dalian Port has complete functions, such as six major functions: loading and unloading and storage, multimodal transport, transportation agency, transfer loading, communication information and daily life services. In terms of throughput: In 2018, the cargo throughput of Dalian Port exceeded 468 million tons.

1. Introduction

The allocation of human resources refers to the enterprise's allocation of human resources to corresponding social labor according to reasonable proportions, and detailed division of human resources into each department of the enterprise to ensure the efficient and smooth operation of the department, thereby improving the overall operating efficiency of the enterprise. Whether it is the internal organizational structure of the enterprise or the internal and external environment of the enterprise, they are all important factors that affect the optimal allocation of human resources of the enterprise. With the continuous development of the national economy, port enterprises have also entered a new stage of rapid development. As human resource management is the core of enterprise management, correct allocation and decision-making of human resources is extremely important for

the further development of port enterprises significance. In order to correctly allocate human resources, it is necessary to analyze the efficiency of human resource allocation in port enterprises. However, there are currently unreasonable human resource allocations in some ports, with unclear job responsibilities and insufficient personnel, resulting in a situation where one person is solely responsible for the heavy burden while many people are watching. This situation has brought a series of problems to salary distribution, performance appraisal, training, job adjustment and promotion, etc. It has had a negative impact on employees' career planning and reduced the work enthusiasm and efficiency of most employees. All these factors have adverse effects on the efficiency of human resource allocation.

The existing literature's methods for measuring the efficiency of port human resource allocation include parametric methods based on the stochastic frontier method (SFA) and non-parametric methods represented by the data envelopment analysis method (DEA). The difference between the two is that the SFA method needs to set a clear production function when describing the production process, which can easily lead to measurement errors caused by subjective selection of function forms. Furthermore, the SFA method is only applicable to production function models with a single output and multiple inputs. The DEA method is suitable for production function models with multiple inputs and multiple outputs, and does not require manual setting of weights or the need to set functional forms in advance, making the analysis results more objective.

Data Envelopment Analysis (DEA) has the characteristic of analyzing the relative effectiveness between decision-making units with multiple inputs and multiple outputs. During the calculation process, the optimal weight can be determined based on actual indicators, and its results are better than those of other methods. To be more objective, many scholars believe that the DEA model is more suitable for efficiency research, so it is widely used in port efficiency and logistics transportation measurement research. Hung et al. (2010) used the traditional CCR model and BCC model, and selected indicator data including the number of container berths, container throughput, terminal area, etc., analyzed the technology, pure technology, and scale efficiency of major container ports in Asia and proposed corresponding countermeasures. [1]. Beuren (2018) and others used BCC and CCR models to measure the efficiency of major ports in Brazil [2]. Mohsen (2022) applied the data envelopment analysis (DEA) method to assess technical efficiency and productivity changes in six of Tunisia's most important commercial seaports over a twelve-year period from 2005 to 2016 [3]. Jose et al. (2020) used DEA to analyze the operational and financial efficiency of Spanish ports, and the results showed that the overall average operating efficiency of Spanish ports was low [4].

With the further development of research, the aforementioned traditional DEA model did not consider the input-output slack variable problem and undesired output. Therefore, some scholars proposed the super-efficiency SBM model, which solved the input-output slack variable problem. Tone and Tsutsui (2009) developed the SBM-DEA model based on the DEA model, further decomposing efficiency into three parts: mixed efficiency, pure technical efficiency, and scale efficiency. This is conducive to further analysis of the specific reasons for the inefficiency of the decision-making unit [5]. Yang Lin (2019) and others used the inverse data envelopment analysis (IDEA) model, which is used to measure the efficiency of container ports, considering undesired outputs to analyze their resource consumption [6]. Taleb et al. (2022) used the super-efficiency SBM model to effectively distinguish efficient and inefficient ports in South Korea and rank their efficiency. The researchers believe that the proposed method has certain applicability to 19 ports in South Korea [7].

2. Super-Efficiency SBM Model Construction

2.1. Evaluation Indicator System

The data for this study were sourced from Dalian Port's official website, the China National Bureau of Statistics, China Port Yearbook, and statistical yearbooks of various Chinese cities. The time span covered is from 2016 to 2021. Combining literature analysis, we constructed an evaluation indicator system for the efficiency of human resource allocation in Dalian Port, as shown in Table 1.

Table 1: Evaluation Indicator System for Human Resource Allocation Efficiency in Dalian Port.

Category	Metric Name	Metric Representative
Input Indicators	Operating costs	T1
	Total number of employees per person	T2
	Labour productivity	T3
	Proportion of administrative staff (%)	T4
	Proportion of technical personnel (%)	T5
	Proportion of highly educated (bachelor degree or above) (%)	T6
Output indicators	Operating income (RMB)	C1
	Annual cargo throughput (10,000 tons)	C2
	Net profit after deducting non-recurring gains and losses/yuan	C3
	Annual container throughput (10,000 TEU)	C4

2.2 Super-Efficiency SBM Model

This study opts to establish an input-oriented Super-Efficiency SBM model. Following Tone's (2001) model for constructing an input-oriented Super-Efficiency SBM model to measure the efficiency of intelligent port logistics [8]. Assuming there are n intelligent port enterprises, each with m input indicators and q output indicators, we build an input-oriented Super-Efficiency SBM model.

$$min\theta = 1 + \frac{1}{m}\sum_{i=1}^{m}\frac{S_i^-}{T_{ik}} \tag{1}$$

$$s.t.\begin{cases} \sum_{j=1,j\neq k}^{n} T_{ij}\lambda_j - S_i^- \leq T_{ik} \\ \sum_{j=1,j\neq k}^{n} C_{rj}\lambda_j \geq C_{rk} \\ \lambda_j, S_i^- \geq 0 \\ \mathrm{i} = 1,2,3,\ldots m; \\ r = 1,2,3,\cdots q; \\ j = 1,2,3,\cdots n(j \neq k) \end{cases} \tag{2}$$

where θ stands for the logistics efficiency value of the smart port; the i-th redundant input value of each smart port's logistics is represented by S_i^-; the i-th input index value for the evaluated k smart port logistics is represented by T_{ik}; and T_{ij} stands for the i-th input index value of the j smart port logistics. j cannot be equal to k because the super-efficiency model compares the evaluated decision unit to a reference set of other decision units; C_{rk} represents the r-th output index value of the k-th smart port, while C_{rj} stands for the r-th output index value of the j-th smart port, and λ_j is a weight variable.

3. Analysis of Human Resource Allocation Efficiency in Dalian Port Enterprises

By calculating the input-oriented Super-Efficiency SBM model for input and output indicators of human resource allocation in Dalian Port, we obtain efficiency, pure technical efficiency, and scale efficiency. Scale efficiency is the ratio of intelligent port logistics efficiency to pure technical efficiency. Pure technical efficiency reflects the distance between the financial management level and the frontier face of intelligent port logistics at the optimal logistics scale, while scale efficiency reflects the gap between actual logistics scale and the optimal financing scale, jointly determining the level of enterprise logistics efficiency. Efficiency values greater than or equal to 1 indicate relative effectiveness, while values less than 1 indicate that efficiency has not reached a relatively optimal state. The efficiency values obtained from the DEA model for human resource allocation in Dalian Port are relative efficiency values, and an efficiency value greater than or equal to 1 does not necessarily indicate that the efficiency of Dalian Port has reached an optimal state; it only signifies its relative effectiveness within the sample enterprises.

We use the Super-Efficiency SBM model to analyze the efficiency of human resource allocation in Dalian Port from 2016 to 2021, employing original input and output indicators and utilizing MAXDEA software for calculations.

The Super-Efficiency values for human resource allocation in Dalian Port from 2016 to 2022 are presented in Table 2.

Table 2: Dalian Port human resources allocation super efficiency value from 2016 to 2022.

Year	Efficiency value
2016	1.03
2017	1.08
2018	1.08
2019	1.08
2020	1.39
2021	1.51
2022	0.83

Analyzing Table 2, we can assess the efficiency values of human resource allocation in Dalian Port from 2016 to 2022. These values help evaluate the efficiency of Dalian Port's human resource utilization during these years. In 2016, the efficiency value for human resource allocation in Dalian Port was 1.03, indicating that the port relatively efficiently utilized its employees and other resources in that year. In 2017 and 2018, the efficiency values were 1.08 each, showing stability and a continued high level of human resource utilization. In 2019, the efficiency value slightly decreased to 1.08 but remained at a high level, possibly influenced by seasonal or temporary factors. In 2020, the efficiency value sharply increased to 1.39, indicating a significant improvement in human resource utilization. This could be attributed to adopting more efficient technologies or processes, possibly influenced by changing demands during the COVID-19 pandemic. In 2021, the efficiency value further increased to 1.51, revealing continued improvements in human resource allocation. However, in 2022, the efficiency value dropped to 0.83, indicating significant issues affecting the utilization of human resources during that year. This could be due to internal or external challenges, such as supply chain issues, economic fluctuations, or management changes.

In summary, Dalian Port maintained a relatively high human resource allocation efficiency from 2016 to 2022, with significant improvements in 2020 and 2021. However, the drop in efficiency in 2022 requires in-depth analysis to identify the causes and take measures to enhance human resource allocation and efficiency. These data are valuable for port managers and policymakers, aiding them in better managing and planning human resources.

Next, let's analyze the redundancy values of input indicators for human resource allocation

efficiency in Dalian Port from 2017 to 2021. The specific results are presented in Table 3.

Table 3: Redundancy Values of Input Indicators for Human Resource Allocation Efficiency in Dalian Port from 2017 to 2021.

Year	T1	T2	T3	T4	T5	T6
2016	0.00	-115.29	-0.02	-0.54	0.00	-2.40
2017	0.00	0.00	-0.34	-3.23	-0.49	-0.39
2018	-1651024322.92	-589.89	0.00	0.00	-0.03	-1.86
2019	-909856788.83	-762.93	-1.12	-0.50	0.00	0.00
2020	-667287097.00	-577.91	0.00	0.00	-9.89	0.00
2021	-4782997260.97	-5319.05	-3.12	-5.74	-9.07	-16.50
2022	2607149022.89	2653.28	0.81	1.57	4.27	0.53

Through the analysis of redundant values for input variables, it was observed that when the efficiency value for a given year is greater than 1, the redundant value for input variables is negative. This implies an amount beyond the frontier that can still be expanded. When the efficiency value is less than 1, the redundant value is positive, indicating a need to reduce input.

The redundant values for input variables in 2016-2017 were relatively small, indicating high utilization of inputs. For 2018-2021, the absolute value of the redundancy for T1 was large and negative, suggesting that cost inputs in these years could continue to be invested. The redundant values for other input variables were similar to 2016-2017, with no significant changes.

In 2022, the efficiency value was below 1, and the redundant values were all positive, especially for T1, indicating excessive cost investment and low interest rates. There was significant redundancy in the number of staff, indicating wastage. Although the redundancy for other inputs was relatively small, they were all greater than 0, suggesting varying degrees of resource wastage, leading to overall low efficiency.

4. Dalian Port Human Resources Optimization Strategies

Based on the efficiency and redundancy values of Dalian Port's human resources configuration from 2016 to 2022, fluctuations in efficiency values during this period are evident.

These strategies and recommendations are comprehensive and can help Dalian Port improve human resources configuration efficiency while providing higher-quality services, enhancing competitiveness, and adapting to market changes and demand fluctuations. To implement these strategies, the port management team needs to develop detailed strategic plans and ensure effective communication and execution within the organization. Collaboration and engagement with employees and relevant stakeholders are also key factors for successful implementation.

5. Conclusion

The optimization of human resources configuration in ports is an ongoing and flexible process that requires consideration of various factors, including strategic development goals, cost control, and organizational structure. Port development must evolve with market changes, making adjustments to employee positions as needed to ensure an adequate but not excessive workforce. This can be achieved through strengthening employee professional skills through training or introducing new talent, ensuring the port has reliable human resources to meet its development needs. Through continuous and scientific human resource optimization, the port will maintain its vitality and achieve long-term sustainability in its endeavors.

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