

Evaluation Model and Promotion of Logistics Transportation D&A System based on AHP

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Abstract. To maximize the potential and value of enterprise data assets, this paper analyzes and evaluates the data asset management and analysis (D&A) system for logistics enterprises. A relatively complete system is put forward for enterprise data asset management, and a comprehensive evaluation model based on the Analytic Hierarchy Process (AHP) is constructed. The Key Performance Indicator (KPI) is determined by the key success factor method, and the right is further quantified. The comprehensive score of key indicators is obtained by expert score and linear weighted average method. It expounds on the connection and importance between internal personnel, technology and the data management process, the calculation is simple and the results are clear. By simulating the relevant situation of the enterprise, the effectiveness of the model is proved, which is strong, and the combination of qualitative and quantitative, can deal with many practical problems that cannot be started with the traditional optimization technology.

Keywords: Logistics Industry; KPI; AHP; Data Assets.

1. Introduction

With the rapid development of big data, data assets have created more value for enterprises even more than physical assets [1], and their value in business activities cannot be ignored, data has become a strategic asset and production factor for logistics enterprises, and many companies regard data as a strategic asset. And now global logistics management information is replacing physical resources as an important resource for logistics economic activities, and more and more famous producers in the world are paying more and more attention to data processing and information system utilization. Therefore, many logistics enterprises have established a comprehensive data analysis system [2] to mine the potential value of data. The in-depth understanding of the current management and application status of a logistics company's data assets requires the evaluation of the key performance indicators in the D&A system. This paper considers the feedback and dependence characteristics of factors, determines the weight information of all indicators of the D&A system, namely key performance indicators [4], on the basis of the hierarchical analysis [3], and uses the coefficient of variation method to process the data, and uses the linear weighting algorithm [5] to score the D&A system, optimize the system, and maximize its asset potential. The results are used by decision makers of logistics companies to measure the maturity of their current D&A systems and to optimize their data asset management and analysis capabilities. p is second-order indicators. P is Weight of second-order indicators. c is primary, M is System Maturity, CER is System Maturity score. detailed descriptions are discussed below.

2. Background and Related Work

The concept of data assets was first introduced by Richard E. Peters in 1974, and data assets include assets such as bonds held by individuals, enterprises or institutions ; the 2019 White Paper on Big Data explains that the concept of "data assets" evolved from the concepts of information resources and data resources [7]. Data asset management is a set of business functions that plan, control, and provide data and information assets [8]. At present, data management has formed a theoretical system

represented by DAMA, IBM and DGI [10]. Foreign countries as a whole started early and the system is relatively complete and mature [11]. However, no attention has been paid to data asset management and data value release, more to meet regulatory requirements and enterprise assessment [10]. Ming Zhao (2020) et al. proposed a new model of data asset management based on blockchain, which combines the application of each level in the blockchain system and improves the efficiency compared to the traditional method more than twice the efficiency compared to the traditional method [9]; Minzhen Huang (2022) integrated the concept of data asset management into the project management system to improve the management and application capabilities of enterprise data assets[12].

Under the double blow of the 2020 epidemic crisis and reverse globalization, the disappearance of offline scenes makes the information digitization process more and more important [13]. Digital investment in logistics enterprises is still at a low level. For data asset management in logistics industry, some scholars put forward corresponding research: Qi Hu (2020) and others provided the basis for advanced application management of operation data through the design of ship operation data extraction and analysis scheme [14]; Yami Li (2021) studied the application of BIM technology in railroad signaling equipment data management to achieve efficient management of railroad signaling equipment data management [15].

To this end, the purpose of this study is to build a model to optimize the analytical capability of the D&A system, measure the maturity of the D&A system, and provide a reliable plan to optimize the D&A capability.

3. Theory and Method

3.1. Determination of Structural Composition of D&A System based on CSF Method

In this paper, the KPIs of D&A system of logistics enterprises are effectively extracted by the critical success factor method, and people *C1*, technology *C2* and process *C3* are used as the assessment objects to determine professional competence *P1*, work attitude *P2*, age *P3*, technical error rate *P4*, data information security degree *P5*, technical improvement cost reduction rate *P6*, technical intelligence degree *P7*, business understanding degree *P8*, efficiency of operation *P9* and maintenance rate *P10* as key performance indicators to measure the maturity level of D&A system of related logistics companies.

3.2. Empowering Key Performance Indicators for Logistics D&A Systems through AHP

After determining the structural composition of the D&A system, the goal of decision making, the factors considered and the decision object are divided into the highest level, the middle level (*C*) and the lowest level (*P*) according to their interrelationships, and the hierarchical structure of the system is shown in Figure 1. In the scientific data evaluation system, the highest level, the middle level and the lowest level correspond to the goal level, the first and second level indicators, respectively.

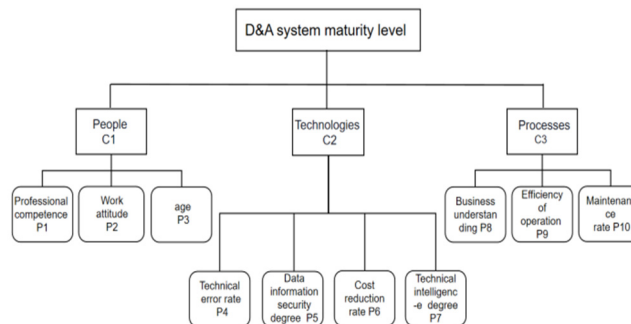


Fig 1. The hierarchical structure of the system

We first construct the judgment matrix M-C and compare the three elements $C1$, $C2$, $C3$ in the benchmark layer C two by two, and we get the matrix M-C through the indexes searched in the literature of the search, which passed the consistency test and proved that it worked. And we find the weights according to three methods, such as the arithmetic mean method for finding the weights.

Step 1: Normalize the judgment matrix (each element divided by the sum of its columns) .

Step 2: Add up the normalized columns (sum by rows).

Step 3: Divide each element of the summed vector by n to get the weight vector.

Assume that the judgment matrix

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \quad (1)$$

Then the weight vector obtained by the algorithmic averaging method is

$$w_i = \frac{1}{n} \sum_{j=1}^n \frac{a_{ij}}{\sum_{k=1}^n a_{kj}} (i = 1, 2, \dots, n) \quad (2)$$

The results of the weights are obtained, and to ensure the robustness of the results, the weights are then obtained according to the geometric mean method and the eigenvalue method, and the average of the three methods are taken, and the results are obtained. method and the eigenvalue method, and the average of the three methods is taken, and the results are obtained.

Then construct the judgment matrices $C1-P$, $C2-P$, and $C3-P$, the same method as above, and calculate the weight results for the 10 KPIs in the system.

3.3. Comprehensive Evaluation of D&A System Maturity Level

For the evaluation of each secondary index, multiple experts scoring method is used. Due to the influence of experts' level and understanding of domain. The use of removing the highest and lowest scores and then averaging them may cause. The use of removing the highest and lowest scores and then averaging them may cause data distortion, so we use the coefficient of variation method for processing. When the coefficient of variation reaches a certain value, n experts are asked to re-investigate the research, understand the knowledge related to the index, and finally score it. After removing the effects of large fluctuations, the evaluation results of the 10 The evaluation results of the 10 evaluation indexes are evaluated in total, and the linear weighted comprehensive evaluation method is applied to obtain the comprehensive score of system maturity. The formula is

$$CER = \sum_{i=1}^n p_i \times \bar{X}_i \quad (3)$$

Then the D&A system is divided into five stages according to the scoring criteria, shown in Table 1: Initial, Planning, Strategic, Predictable, and Optimization, and the system maturity level is used as a scale to further evaluate the maturity level and feasibility of the D&A system so that decision makers can make further optimization and improvement.

Table 1. Phase diagram of the system

Maturity level	Initial level	Planning level	Strategic level	Predictable level	Optimization level
Maturity score	<60	60-70	70-80	80-90	90-100

3.4. D&A System Effectiveness Analysis

In this paper, we review the extensive literature and learn that there is a strong correlation between the maturity of a system and its effectiveness, and that the more mature a system is, the more effective we can assume it to be. We can then accurately measure the effectiveness of a system by its maturity.

We divide it into three stages, when the system is in the maturity score is below 60, we think the validity of the system is 0, when the system is in the maturity score is above 90, we think the validity of the system is 1, when in between, we can understand that when the system is more mature, we will more think the validity of the system is higher, with exponential growth rate, we get the following maturity and the functional relationship between system validity.

$$V = \begin{cases} 1 & M > 90 \\ e^{-90} e^M & 90 \geq M \geq 60 \\ 0 & M < 60 \end{cases} \quad (4)$$

4. Result and Discussion

By processing the data, we obtained a system maturity score of 79.9, which is at the Predictable level, and learned that the system is highly effective.

4.1. Data Simulation

Because of the subjectivity of the above data, in order to illustrate the feasibility of the model, we needed to simulate some data to test it. We performed discrete random number simulation, and for generating a large number of random numbers for each indicator, we set certain constraints and set each indicator to be simulated randomly in different ranges to show the reliability of the. We generated 1000 random numbers by Matlab and formed a matrix of order 100×10 . There are 10 evaluation metrics and 100. These numbers were standardized to values between $[60, 100]$, and these values can indirectly represent the score of the indicator. These numbers were standardized to values between $[60, 100]$, and these values can indirectly represent the score of the indicator.

It's worth noting that P3 and P4 are interval indicators and extremely small indicators respectively, in order to make their range are also between $[60, 100]$, we apply the following formulas to find their scores for normalization to eliminate the effect of magnitude.

$$\begin{aligned} M &= \max\{a - \min\{x_i\}, \max\{x_i\} - b\} \\ \bar{x}_i &= \begin{cases} 100 - 40 \frac{x_i - b}{M}, & x_i > b \\ 1 & , \quad a \leq x_i \leq b \\ 100 - 40 \frac{a - x_i}{M}, & x_i < a \end{cases} \end{aligned} \quad (5)$$

Among the parameters $M = 10, a = 25, b = 30$.

$$\bar{x}_i = \max - x \quad (6)$$

Among them $\max = 100$, The normalized matrix is denoted as X , where each element is x_{ij} .

$$\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} (n=1,2,\dots,10, m=1,2,\dots,100) \quad (7)$$

Finally, we average the 100 evaluation scores for each indicator as $\bar{X}_i$ and use it as the rating value after performing a large number of simulations.

We present the scores of the ten indicators as shown in Table 2.

Table 2. Index scores for the random simulation

Index	P1	P2	P3	P4	P5
Score	81.25	80.69	86.89	82.23	79.56
Index	P6	P7	P8	P9	P10
Score	79.03	79.93	78.23	80.09	81.53

We then use the formula, linearly weighted to calculate the score CER :

$$CER = \sum_{i=1}^n p_i \times \bar{X}_i \quad (8)$$

Calculated to obtain $CER_1 = 76.51$.

This is also at the Predictable level, so a large number of simulations were performed to make the model applicable to a more comprehensive situation and to show the feasibility of our model.

4.2. Sensitivity Analysis

In order to apply the system to a wide range of material flows, we need to perform sensitivity analysis on the above important parameters to determine the stability of the model.

For the professional competence indicators, we weighted them separately $\pm 5\%$ change, then the function at this time:

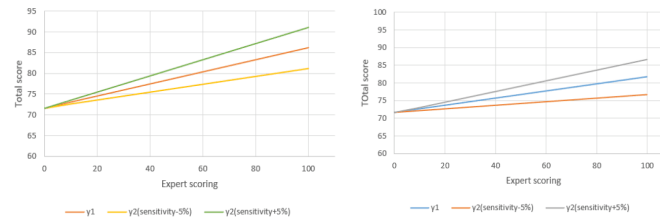
$$y = 0.1012 \times (1 \pm 5\%)x_1 + \sum_{i=2}^{10} x_i p_i \quad (9)$$

When a 5% change in the weights occurred, the maturity score y changed by 5.16% accordingly at this point.

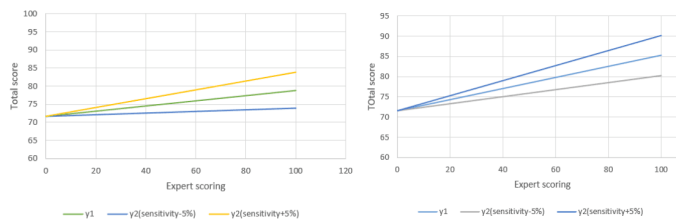
When a -5% change in the weights occurred, the maturity score y changed by -5.16% accordingly at this point.

Then it shows that y is not sensitive to the weight of $P1$, indicating that the model is stable and can be applied to the case of changing material flow.

The robustness of the model can be observed visually in the figure. 2

**Fig 2.** Sensitivity analysis of P1 and P4

In addition, we examined the three metrics of Technical error rate P4, Technical intelligence P7 and Efficiency of operation P9, as shown in the figure.3

**Fig 3.** Sensitivity analysis of P7 and P9

We can understand that the magnitude of change is small and the model can be well applied in the case of changing material flow.

Therefore, through our extensive data simulation of the model and sensitivity analysis of important indicators, we have obtained the desired results, which fully demonstrate the feasibility and robustness of the evaluation model.

5. Conclusion

Data assets are gradually becoming invisible strategic assets in many industries such as logistics and transportation. Therefore, it is necessary to make a maturity and effectiveness evaluation of the D&A system formed by the interconnection between the logistics enterprise's data management talents, related technologies and processes, in order to maximize the potential of data assets. This paper constructs an evaluation model of D&A system of logistics enterprises based on hierarchical analysis, which is divided into three stages of determining system KPIs, assigning weights and scoring to make a comprehensive evaluation of D&A system. The main research points can be summarized as follows: the model proposed in this paper is applicable to logistics and transportation and other related industries, and based on hierarchical analysis, the data asset management of enterprises is regarded as a system for decomposition, comparison and comprehensive judgment; it is more practical, combining qualitative and quantitative, and can deal with many practical problems that cannot be started with traditional optimization techniques; at the same time, the calculation is easy and the results are clear, which can be applied directly by decision makers. This also increases the effectiveness of decision making. Finally, we performed sensitivity analysis on the model, and when the weights changed by 5%, the corresponding change in maturity score y did not exceed 6%, and the model stability was good. In future work, we aim to reduce the subjectivity of the model, integrate the idea of cluster analysis into the clustering AHP method, and determine the weights of experts according to the size of the category capacity of each category, in an effort to improve the accuracy of the evaluation of D&A systems.

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