Research on Data Governance for Maximizing Enterprise Efficiency

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Abstract. In an era where organizations are increasingly relying on data to perform their business, the ability of different companies to manage and analyze data will have a significant impact on their efficiency. In this paper, we develop a model to measure the current level of maturity of ICM's data and analytics (D&A) systems and optimize it to maximize the potential of its data assets. Based on the three critical components of personnel, technology, and process, we take ICM requirements as the starting point. After comprehensively considering the current situation of the industry and enterprise needs, an indicator system is built to measure the D&A system. Then, it is used AHP-CRITIC subjective and objective comprehensive empowerment, which determines the weight of each index accordingly. It is carried out the evaluation and analysis of the maturity of the D&A system and finally concluded that the maturity of the system is 0.879, and technology is the key influencing factor. Then this paper uses the System Readiness Level Index from a technical point of view, which includes the Technology Readiness Level index to measure the technological maturity and the integration readiness of the technology integration index, which can comprehensively optimize technical indicators. To maximize the potential of digital assets, we built the SRLmax model under resource-related constraints, equipped with a business process performance management (BPM) indicator system that comprehensively considered people and process components. Finally, we passed the SRLmax-BPM model to the D&A system. After comprehensive optimization, the optimized score is 25.16% higher than the original model.

Keywords: Data Governance, D&A system, AHP-CRITIC, SRLmax-BPM model.

1. Introduction

People are increasingly aware of the difficulty of data utilization and the great value behind it. In any country with a coastline, port logistics plays an important role in developing the national economy [2]. As a system for integrating and analyzing data, D&A can effectively help companies that regard data as a strategic resource obtain value and bring competitive advantages through effective management [3]. To maximize the value of these valuable resources, systematic evaluation and optimization are of great significance [4].

In this paper, we develop a model to measure the current level of maturity of ICM's data and analytics (D&A) systems and optimize it to maximize the potential of its data assets. It can also effectively help companies regard data as a strategic resource to obtain value and bring competitive advantages through effective management.

2. Establishment Of Models

2.1. AHM-CRITIC Empowerment Model

When evaluating the maturity of the D&A system, it is necessary to consider all the criteria [5] comprehensively. In order to avoid the defects of the traditional single weighting method, this paper adopts the weighting evaluation method combining the subjective weight of AHM and the objective weight of CRITIC [6].

2.1.1. AHM Empowerment

AHM (Attribute Hierarchical Model) is an algorithm based on the Analytic Hierarchy Process [7], which has the advantages of AHP and is simple and fast, without the need to calculate eigenvectors and check the consistency [8].

Determine the weight of evaluation indicators

In this paper, the Saaty scale is used as the main method, and the n-order AHP discriminant matrix is obtained by the method of expert scoring:

$$K = (k_{ij})_{n\times n} \tag{1}$$

Where, k_{ij} represents the importance of the ielement compared to the jelement.

Construct attribute discriminant matrix

In AHM, the relative attribute l_{ij} constitutes the n-order attribute discrimination matrix $L = (l_{ij})_{n\times n}$, and the relative attribute l_{ij} and the scale k_{ij} have the following conversion relationship:

$$l_{ij} = \begin{cases} \frac{2m}{2m+1} & k_{ij} = m, i \neq j \\ \frac{1}{2m+1} & k_{ij} = 1/m, i \neq j \\ 0.5 & k_{ij} = 1, i \neq j \\ 0 & k_{ij} = 1, i = j \end{cases} \tag{2}$$

Where m is a positive integer not less than 2.

Calculate the relative attribute weight of each indicator

According to the AHM calculation steps, the relative attribute weight W_{AHM} formula of each indicator is as follows.

$$W_{AHM} = \frac{2}{n(n-1)} \sum_{j=1}^{n} l_{ij} \tag{3}$$

Where i=1, 2, n, n is the number of indicators; $\sum_{i=1}^{n} w_{AHM} = 1$.

2.1.2. CRITIC weight assignment

CRITIC weight assignment method (Criteria Importance Through Inter-criteria Correlation), compared with other methods, this method is more objective, considering the influence of the index variation and the conflict between each other on the weight, making the results more realistic.

Calculate the standard deviation

$$\sigma_j = \sqrt{\frac{1}{m-1} \sum_{i=1}^{m} \left(x_{ij} - \bar{x}_j\right)^2} \tag{4}$$

where $\bar{x}_j$ is the average value of an index X_j in m schemes; σ_j is the standard deviation of X_j.

Build the Correlation Coefficient Matrix

$$r_{ij} = \frac{\sum_{i=1}^{n} (x_i - \bar{x}_i)(x_j - \overline{x_j})}{\sqrt{\sum_{i=1}^{n} (x_i - \bar{x}_i)^2 \sum_{j=1}^{n} \left(x_j - \overline{x_j}\right)^2}} \tag{5}$$

Where $\bar{x}_i$ is the average value of all schemes in the index X_i; $\bar{x}_j$ is the average value of all schemes in the index X_j; r_{ij} is the correlation coefficient between index X_i and index X_j.

Find the comprehensive weight of each indicator W_{CRI}

$$\begin{cases} W_{CRI} = \frac{C_j}{\sum_{i=1}^{n} C_j} \\ C_j = \sigma_j \sum_{j=1}^{n} (1 - r_{ij}) \end{cases} \tag{6}$$

2.1.3. Coupling weights

After determining the subjective weight W_{AHM} and the objective weight W_{CRI} The multiplier synthesis normalization method effectively reflects the relative weight relationship of each indicator and the weight proportion on the whole. The coupling weight is obtained as follows.

$$W_{AHM-CRI} = \frac{W_{AHM}W_{CRI}}{\sum_{j=1}^{n} W_{AHM}W_{CRI}} \tag{7}$$

2.2. SRLmax-BPM optimization model

With the development of intelligent shipping, freight ships will become unmanned, ports will become fully automated, the object of supervision and security will gradually change from humans to intelligent machines, and data resources will become more and more digitized. In the next 15 years, the global key schedule for the development of intelligent shipping, so our optimization model will mainly start with technical indicators.

Some manageable are useful and meaningful. The measurements are much better than 50 or 100, which does not provide much insight into how the system operates and whether its goals are met.

Many U.S. government agencies and their contractors use the normative measure of technology readiness level (TRL) to measure the maturity of individual technologies, but moving from a single abstraction to the context of a whole system requires more careful and comprehensive consideration.

2.2.1. SRL Index

Two scholars, Jose Emmanuel Ramirez-Marquez and Brian J. Sauser proposed the System Readiness Level (SRL) index, which includes the current TRL scale and IRL (Integrated Readiness Level), and proposed a method to determine the current and future readiness of a system.

For technology i, the indicator SRL_i has the following relationship.

$$SRL_i = f(TRL_j, IRL_{ij}) \tag{8}$$

Based on such an indicator SRL_i, SRL provides a system-level measure of readiness, expressed as a function of SRL that covers each technology. Suppose the system contains n technologies:

$$SRL = f(SRL_1, SRL_2, \dots, SRL_n) \tag{9}$$

From this, it can be seen that SRL is a normalized matrix of pairwise comparisons of TRL and IRL, constructed from the elements of each constituent technique. From an integration perspective, SRL quantifies the readiness of a particular technology relative to other technologies in the system, and TRL also illustrates the development status of each technology. Although both TRL and IRL can use the original (1, 9) rank measure, using normalized numerical values allows for a more accurate assessment when comparing the use of competing techniques. Therefore, in the following calculation of SRL, the values of TRL and IRL in the matrix are normalized to (0,1).

$$[SRL] = \begin{bmatrix} SRL_1 \\ SRL_2 \\ \dots \\ SRL_n \end{bmatrix} = \begin{bmatrix} IRL_{11}TRL_1 + IRL_{12}TRL_2 + \cdots + IRL_{1n}TRL_n \\ IRL_{21}TRL_1 + IRL_{22}TRL_2 + \cdots + IRL_{2n}TRL_n \\ \dots \\ IRL_{n1}TRL_1 + IRL_{n2}TRL_2 + \cdots + IRL_{nn}TRL_n \end{bmatrix} \tag{10}$$

Where, $IRL_{ij} = IRL_{ji}$

For technology i, its corresponding SRL_i is divided byn_i (n_i refers to the number of integrations of technology i with itself and each other technology specified by the system structure) to obtain its value between (0, 1), The normalized value, whereas the SRL of the entire system is the average of the SRL values of all these normalized techniques, expressed as a maturity index between 0 and 1 applied at the system level.

$$SRL = \frac{\frac{SRL_1}{n_1} + \frac{SRL_2}{n_2} + \cdots + \frac{SRL_n}{n_n}}{\mathrm{n}} \tag{11}$$

2.2.2. SRLmax model

Based on resource allocation, the SRL index is optimized to improve the management ability in the system development cycle, and the SRL_{max} model is proposed. The goal is to maximize the SRL under the constraints related to resources and to provide the highest system maturity. The model recognizes that technology competes for resources, and SRL can be improved through the optimal allocation of these resources. The general form of the SRL_{max} model is as follows.

$$MaxSRL(\text{TRL}, \text{IRL}) \tag{12}$$

$$s.t.\begin{cases} R_1(TRL, IRL) \le r_1 \\ \dots \\ R_H(TRL, IRL) \le r_H \end{cases} \tag{13}$$

The matrices TRL and IRL contain decision variables, each of which is an integer value bounded by (TRL_i, 9) and (IRL_i, 9) respectively, that is, the TRL/IRL of thei-th component cannot below At its current level, it cannot exceed the best-case scenario of technological development or integration.

SRL_{max} model allows project managers to understand how resources (i.e., budget, schedule, etc.) are being consumed as different IRL/TRL levels of different system components increase and the total amount available for a particular resource.

2.2.3. SRLmax-BPM model

SRL_{max} model is a good comprehensive optimization of the technical level, but does not consider "is a product a single or a set," "which product attributes are the most important" and more comprehensive questions about people and processes so that this article will be in the Based on the SRL_{max} model, a BPM index system that can solve the defects as mentioned above in the original model is introduced.

Business process performance management (BPM) applies to the control of all business processes. It is the main line of enterprise output value and the key to whether the enterprise can operate successfully. Its indicator system includes seven aspects: quality, cost, delivery, service, technology, assets, personnel.

This paper compiles the BPM scale through these seven aspects, with 9 levels shown in Table 1. BPM is correlated with TRL and IRL indicators through technical indicators, and a positive correlation is constructed. With the gradual maturity of technology and the gradual improvement of integration preparation, BPM is gradually more ideal. Maximize the potential of digital assets.

According to the above nine-level dimension table of BPM, establish the $SRL_{max} - BPM$ model: For technology i, the indicator SRL_i has the following relationship:

$$SRL_i = f(TRL_j, IRL_{ij}, BPM_i) \tag{14}$$

Combine the SRL formula (10) (11) to get the final SRL_{max}-BPM model:

$$MaxSRL(\text{TRL}, \text{IRL}, \text{BPM}) \tag{15}$$

$$s.t.\begin{cases} R_1(TRL, IRL, BPM) \le r_1 \\ \dots \\ R_H(TRL, IRL, BPM) \le r_H \end{cases} \tag{16}$$

Table 1 Digital assets Settings

BPM	***Definition***	***Description***
9	The BPM system has been fully built and far exceeds the standard line	Achieve the highest standards for business process performance management and maximize the use of data to maximize the potential of digital assets
8	Establish a BPM system in an all-round way, use the data proficiently, and select the optimal situation	Based on level 7, the ability to utilize digital assets is improved
7	Build a BPM system in an all-round way, and try to use the data in it to increase returns for the enterprise	Comprehensive consideration of each indicator of the BPM system and attention to the value of digital assets
6	Fully build BPM system	The BPM system is mature and perfect, ignoring the large amount of data generated in the process
5	Further establishment of the BPM system	Compared with level 4, the measurement of each indicator is sufficient and more comprehensive
4	Preliminary establishment of BPM system	Find the internal connection of the seven indicators, which can be used more systematically
3	The seven indicators of quality, cost, delivery, service, technology, assets, and personnel are all on the horizontal line	Start focusing on service metrics that add value to business processes
2	Added consideration of three indicators: technology, assets, and personnel	Based on Level 1, the importance of the three soft indicators of technology, assets and personnel have been noticed, and the management level has been improved
1	Only the quality, cost, and delivery in the indicators are guaranteed to meet the standards	The minimum level of business process performance management

3. Analysis of results

According to the Saaty scale, using the expert scoring method, a 6×6 AHP discriminant matrix is constructed, and then the matrix is converted into an attribute discriminant matrix by the conversion formula, and the attribute weights of each evaluation index are calculated as shown in Table 2, and the AHM comprehensive weighting result is obtained W_{AHM}.

By the method as mentioned above, the correlation coefficient matrix is constructed, the weight of each indicator W_{CRI} is obtained, and the W_{AHM} and W_{CRI} are coupled to obtain the following coupling weight of AHM-CRITIC, and the results are shown in Table 3.

As can be seen from Figure 1, the maturity of the D&A system is 0.879. Compared with other standard layers, the weight value of the evaluation index of technology is the most prominent, and the three

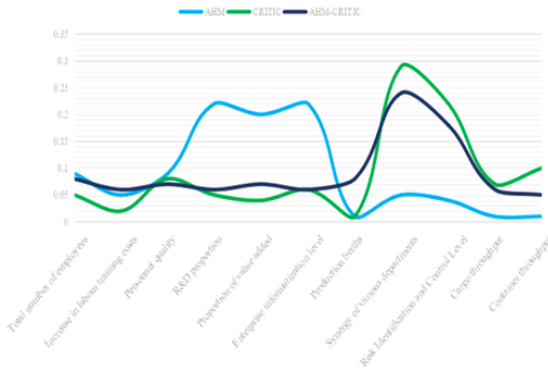


Figure 1 Coupling

Evaluation methods have obtained the same result. The second most important indicator obtained by the AHM method is inter-departmental collaboration. It can be seen that in the evaluation of professionals, more emphasis is placed on the ability of

Table 2 AHP factor Settings

Evaluation factor	***Person attributes***	***personnel training***	***Technological innovation***	***operational data***	***Data Security***	***Cross-departmental collaboration***
Person attributes	1	1/2	1/6	1/3	1/5	1/5
personnel training	2	1	1/5	3	1/2	1/3
Technological innovation	6	5	1	2	3	4
operational data	3	1/3	1/2	1	3	1/4
Data Security	5	2	1/3	1/3	1	1/3
Cross-departmental collaboration	5	3	1/4	4	3	1

Table 3 Coupling Settings

Arial Unicode MS	***Evaluation factor***					
	Person attributes	personnel training	Technological innovation	operational data	Data Security	Cross-departmental collaboration
Arial Unicode MS	11.562%	11.425%	44.795%	4.759%	12.218%	15.241%
Arial Unicode MS	5.29%	2.03%	37.57%	10.20%	5.44%	5.95%
Arial Unicode MS	0.121	0.084	0.437	0.044	0.089	0.225

The inter-departmental communication and collaboration in the process. The second important index obtained by the CRITIC method is the operation data. It is determined by the objectivity of the

sample data that the data generated in the daily operation process of the enterprise in the D&A system is relatively important. The AHM-CRITIC method selected in this paper is the second most important. The weighting of cross-departmental collaboration and operational data is included in the indicator, giving it more advantages and specifying more deficiencies, resulting in more accurate results.

According to the above formula, we calculate the $SRL_{max} - BPM$ value of the D&A system. Suppose the system is composed of four technologies and two integrated and two preselected BPM systems:

$$[TRL] = \begin{bmatrix} TRL_A \\ TRL_B \\ TRL_C \\ TRL_D \end{bmatrix} = \begin{bmatrix} 9 \\ 6 \\ 6 \\ 7 \end{bmatrix} = \begin{bmatrix} 1.00 \\ 0.67 \\ 0.67 \\ 0.78 \end{bmatrix} \tag{17}$$

$$[IRL] = \begin{bmatrix} IRL_{AA} & IRL_{AB} & IRL_{AC} & IRL_{AD} \\ IRL_{BA} & IRL_{BB} & IRL_{BC} & IRL_{BD} \\ IRL_{CA} & IRL_{CB} & IRL_{CC} & IRL_{CD} \\ IRL_{DA} & IRL_{DB} & IRL_{DC} & IRL_{DD} \end{bmatrix} \tag{18}$$

Since technology A and technology C are not integrated, technology A and technology D are not integrated, and IRL_{AC} and IRL_{AD} are 0.

$$[IRL] = \begin{bmatrix} 9 & 1 & 0 & 0 \\ 1 & 9 & 7 & 1 \\ 0 & 7 & 9 & 6 \\ 0 & 1 & 6 & 9 \end{bmatrix} \tag{19}$$

$$[BPM] = \begin{bmatrix} BPM_A \\ BPM_B \end{bmatrix} = \begin{bmatrix} 7 \\ 6 \end{bmatrix} = \begin{bmatrix} 0.78 \\ 0.67 \end{bmatrix} \tag{20}$$

$$[SRL_{max} - BPM] = [BPM] \times [IRL] \times [TRL] = \begin{bmatrix} 7.5426 & 9.75 & 12.012 & 12.012 \\ 6.7489 & 8.375 & 10.318 & 10.318 \end{bmatrix} \tag{21}$$

$$[SRL] = [9.67 \quad 12.5 \quad 15.4 \quad 11.71] \tag{22}$$

$$SRL_{max} - BPM = 7.71 \tag{23}$$

$$SRL = 6.16 \tag{24}$$

It can be seen that the score of $SRL_{max} - BMP$ is improved by 25.16% compared with SRL after optimization. Based on achieving the optimal allocation of existing resources under the constraints related to resources, including related products, personnel, and processes, the BPM that is more comprehensive and applicable to all business processes is incorporated into the model through the correlation of technical indicators. The optimized model can be considered more comprehensive, more suitable for ICM companies to measure the needs of the D&A system, and can also be well extended to other ports and other industries.

4. Conclusion

This paper conducted a maturity measurement of the D&A model currently in use by ICM companies. We have developed a measurement model based on a system of people, technology, and process indicators. Through data processing and empowerment, we believe that the system currently used by ICM is relatively mature and can withstand the test of some big data. In order to obtain better services, we subsequently optimized the system. After comprehensive optimization, the optimized score is 25.16% higher than the original model. The AHP method relies on the evaluator's experience and subjective judgment to assign the weight level, and the reliability is not stable. In contrast, the CRITIC method completely starts from the sample data and uses the objectivity of the data to judge the importance of each indicator but does not consider the importance of each index. Information

outside the data is limited mainly by the sample data itself. The AHP-CRITIC combination of subjective and objective methods used in this paper for weighting can well complement the above defects.

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