

A model for measuring D&A systems and their applications

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Abstract. Data is an indispensable strategic asset for various incorporations. In this paper, we deeply explore the model for evaluating the R&D and system of ICM company and effects on different scales and industries. we build a D&A system maturity evaluation model through the fuzzy analytical hierarchy process and recommend changes to the company system based on this model. The current D&A system maturity level of ICM company include key performance indicators of the success of staff, technology and processes, so as to obtain the quantitative evaluation index of the company's D&A process and technology level. we use the model at ICM to determine their current D&A maturity level and demonstrate how they use the model to optimize the system, allowing companies to maximize the potential of their data assets. It is of great essence to establish a goal programming model to optimize the indicators again, so as to formulate specific strategies. At last, we also summarize the strengths and weaknesses and provide insights to ICM customers about the D&A system.

Keywords: D&A system maturity level; a goal programming model; fuzzy analytical hierarchy process.

1. Introduction

Nowadays, various companies have regarded data as an indispensable part of strategic asset. Proper management of this valuable resource can bring competitive advantage. In order to further explore maximization the potential of its data assets, it is necessary to establish an integrated data and analysis (D&A) system to quantify special strategies.

2. Problem Restatement and Analysis

Task 1 requires us to build a D&A system maturity evaluation model and recommend changes to the company system based on this model. The key to this problem is to define an indicator to measure the current D&A system maturity level of ICM company, including key performance indicators of the success of staff, technology and processes, so as to obtain the quantitative evaluation index of the company's D&A process and technology level.

Task 2 requires us to use the model at ICM to determine their current D&A maturity level and demonstrate how they use the model to optimize the system, allowing companies to maximize the potential of their data assets. It is of great essence to establish a goal programming model to optimize the indicators again, so as to formulate specific strategies.

Task 3 requires us to suggest ICM should develop an agreement to measure the effectiveness of its D&A system. We plan to establish the exponential function model so that ICM ensure the accuracy of the results as much as possible.

Task 4 requires us to get a further insight into the applicability of the model for different scales and industries according to the D&A system maturity evaluation model established by us. Besides we should also analyze the benefits of ICM customers (such as freight companies) using our metrics.

3. Assumptions and notations

Notation	Meaning
A, B, C	Evaluation indicators
i	
i	
W	Normalized determination matrix maximum feature root lambda max's eigenvector
CI	Consistency metrics
RI	Stochastic consistency indicator
CR	Consistency ratio
R	One-factor judgment matrix
B	Fuzzy vectors
S	Hierarchical hierarchical vectors
H	Scoring results of the subsystem Fuzzy Hierarchy Analysis Comprehensive
i	Evaluation Analysis Method
y, w	A weight vector composed of the weights of each indicator of a first-level indicator
Y	The final fuzzy hierarchy analysis of the total evaluation system is the score result of the comprehensive evaluation analysis method
y	Business Maturity Index
p'	The total cost that the company can afford
i, h	Percentage increase in scores for all assessment indicators in the previous period
f	effectiveness
ρ	Maturity level

4. Assumptions and notations

4.1. Measure the establishment and solution of D&A system maturity model

In order to establish a maturity model of the D&A system that includes talents, technologies, and processes, we have established an evaluation index system from these three aspects. Take the enterprise talent assessment level system as an example: we divide the enterprise talent assessment level system into talent attributes, company team attributes, enterprise and talent attributes 3 secondary indicators. From the perspective of talent's own attributes, the professional ethics, learning ability, innovation ability, job adaptability, technical skill level, communication ability, and work performance level of the talent team are all within the scope of consideration, and for the company's talent team, it is necessary to consider the vacancy situation, team leadership ability, team collaboration ability, personnel utilization rate, personnel counterpart, and the enterprise and talent attributes include the satisfaction of the talent with the company, the sense of belonging of the talent to the company, and the loyalty of the talent to the company.

From the problem analysis can be obtained, for the company's evaluation, we decided to establish the following indicator system:

Table 1. Measurement of D&A system maturity indicator system

	Enterprise talent assessment rating systemA1	
Talent properties B1	First Stage	Professional ethics C1
	Second Stage	Ability to learn C2
	Third Stage	The ability to innovate C3
	Fourth Stage	Job adaptationC4
	Fifth Stage	Technical competence levelC5
	Sixth Stage	Level of work performanceC6
	Seventh Stage	Communication skillsC7
Company Team Attributes B2	First Stage	VacanciesC8
	Second Stage	Team leadership skillsC9
	Third Stage	Teamwork skillsC10
	Fourth Stage	Personnel utilizationC11
	Fifth Stage	Professional counterpart situationC12
The relationship between talent and company B3	First Stage	Talent recognition of the companyC13
	Second Stage	Talent has a sense of belonging to the companyC14

Starting from the first-level indicators, the entire index system is decomposed into three parts, and the three parts are independently fuzzy hierarchical analysis comprehensive evaluation method and scored. In view of the limitation of the length of the article, only the fuzzy hierarchical analysis comprehensive evaluation method and scoring process of the enterprise talent assessment hierarchy are given here.

The above three subsystems all use the fuzzy hierarchical comprehensive analysis method to score and give different weights to the three subsystems according to the expert scoring method, and the final calculated score is used as the final evaluation score of the system.

4.2. Hierarchical single ordering and its consistency test

The eigenvector corresponding to the lambda max, the maximum eigentogen of the judgment matrix, is normalized (so that the sum of the elements in the vector is 1) and w. The element of W is the sort weight of the element of the same level for the relative importance of a factor in the previous level, a process called hierarchical single sorting.

Consistency testing refers to the permissible range for determining inconsistencies in the judgment matrix. The only non-zero feature root of the nth-order conjunctigenic array is n, and when the largest feature root of the nth-order positive and reciprocal array, $\lambda_{\max} \geq n$, A is the non-consistent matrix, the ratio The larger the n, the more inconsistency A becomes, and if and only if $\lambda_{\max} = n$, A is the consistent matrix. Therefore, it is possible to test whether matrix A is a consistent matrix by whether $\lambda_{\max}$ is equal to n.

Since in practice it is impossible to satisfy many of the above equations when constructing pairwise comparison matrices. Therefore, it is required that the pairwise comparison matrix have

a certain degree of consistency, that is, it can allow a certain degree of inconsistency in the pairwise comparison matrix. From the analysis, it can be seen that for pairwise comparison matrices that are perfectly consistent, the largest eigenvalue of absolute value is equal to the dimensionality of the matrix. The consistency requirement for pairwise comparison matrices translates into requirements: the largest eigenvalue of absolute value and the dimensionality of the matrix are not much different.

The steps to test the consistency of the pairwise comparison matrix A are as follows: Define the consistency indicator :

$$CI = (\lambda_{\max} - n) / (n - 1)$$

CI = 0 CI=0CI=0 with full consistency;

CI is close to 0, with satisfactory consistency;

The larger the CI, the more serious the inconsistencies.

To measure the size of the CI, the stochastic consistency indicator RI is introduced, according to the average stochastic consistency indicator given by Saaty:

Table 2. Average stochastic consistency indicator

n	1	2	3	4	5	6	7	8	9	10	11
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51

Define the consistency ratio:

$$CR = CI / RI$$

It is generally believed that when the consistency ratio $CR < 0.1$, it is believed that the degree of inconsistency of A is within the allowable range, and there is satisfactory consistency, which passes the consistency test. Its normalized feature vector can be used as a weight vector, otherwise it is reconstructed into a pairwise comparison matrix A.

Here the complex computation process with the help of the Python language

Table 3. Weight score table

Guideline layer		Factor layer	
criterion	weight	factor	weight
Talent and company relationships	0.63698557	Talent recognition of the company	0.12972062
		Talent has a sense of belonging to the company	0.13784873
		Talent loyalty to the company	0.73243065
Company team evaluation	0.25828499	Vacancies	0.04888029
		Team leadership skills	0.26536396
		Teamwork skills	0.39433519
		Personnel utilization	0.15222443
		Professional counterpart situation	0.13919613
Talent attributes	0.10472943	Professional ethics	0.1208006
		Ability to learn	0.08279641
		The ability to innovate	0.25692845
		Job adaptation	0.09133562

	Technical competence level	0.08279641
	Level of work performance	0.09133562
	Communication skills	0.27400687

The evaluation set is the set of various results that the evaluator may make to the evaluation object, which is represented here in V, and here is taken in five grades, which mean "excellent, good, average, poor, and very poor".

10 experts are invited to score the enterprise talent assessment system, and the final summary results are as follows:

Table 4. Expert scoring table

Talent attributes	Professional ethics	0.1	0.4	0.3	0.2	0
	Ability to learn	0.5	0.3	0.2	0	0
	The ability to innovate	0.2	0.3	0.2	0.1	0.2
	Job adaptation	0	0.2	0.3	0.3	0.2
	Technical competence level	0.2	0.2	0.3	0.2	0.1
	Level of work performance	0.5	0.3	0.2	0	0
	Communication skills	0.1	0.3	0.3	0.2	0.1
Company team evaluation	Vacancies	0.1	0.1	0.4	0.2	0.2
	Team leadership skills	0	0.1	0.3	0.3	0.3
	Teamwork skills	0.2	0.3	0.4	0.1	0
	Personnel utilization	0.1	0.3	0.5	0.1	0
	Professional counterpart situation	0.2	0.5	0.3	0	0
Talent and company relationships	Talent recognition of the company	0.3	0.3	0.3	0.1	0
	Talent has a sense of belonging to the company	0.1	0.3	0.3	0.2	0.1
	Talent loyalty to the company	0.1	0.1	0.5	0.2	0.1

After determining the one-factor evaluation matrix R and the factor weight vector A, the fuzzy vector A on U is changed to the fuzzy vector B on V by fuzzy change. Finally the fuzzy vector is obtained

$$B = (0.15, 0.24, 0.36, 0.16, 0.09)$$

In the example, the excellent grade score is definitely the highest, followed by good, and then down, the grading score is $S = (1, 0.8, 0.6, 0.4, 0.2)$, in order

Then the result $H1 = B * S$ (matrix multiplication) The final system score is 0.6400 (out of 1). Based on the above process, the total scores of the fuzzy hierarchical analysis comprehensive evaluation method of the enterprise technical assessment grade system and the enterprise process system are calculated, respectively $H2 = 0.6008$ 、 $H3 = 0.7468$. Given the weights of three subsystems by an expert scoring method, note the weight vector $Wy = (W1, W2, W3)$, then $Wy = (0.4, 0.2, 0.4)$. $Y = H1 * W1 + H2 * W2 + H3 * W3 = 0.4 * 0.6400 + 0.2 * 0.6008 + 0.4 * 0.7468$. The final calculated total system score is $Y = 0.6749$.

4.3. Model Optimization

The above analysis gets the company's current D&A maturity level, and the above indicators can be optimized again under the company's current conditions, but all the optimization is inseparable from the support of cost, so in order to maximize the potential of its data assets within the effective conditions, we choose to establish a target plan to develop a specific strategy.

According to the above analysis, the percentage increase in the score of all the assessment indicators in the previous period is h_i ($i=1, 2, 3... m$) m indicates a total of m three-level indicators, and the cost required for each indicator to increase by 1% is p_i ($i=1, 2, 3, \dots, m$) The model for measuring the maturity of the D&A system established by us above is available. When p and h_i are known, an optimal change strategy is available within the company's reach, enabling the company to maximize the potential of its data assets.

4.4. Develop protocols that measure the effectiveness of their D&A systems

According to the D&A system maturity assessment scale, we consider it valid after maturity reaches a certain value s_1 , and we consider it invalid until maturity reaches a certain value s_2 . When the maturity boundary is bounded to $[s_2, s_1]$ make the effectiveness gradually increase with the increase of maturity. Based on the above analysis, we have established the following model f , which makes it effective and ρ mature:

$$f = \begin{cases} 1, & \rho \geq s_1 \\ f(\rho), & \rho \in [s_2, s_1] \\ 0, & \rho < s_2 \end{cases} \quad (1)$$

By consulting the relevant information, it $f(\rho)$ is generally an exponential function, then the exponential function is used in this article:

$$f = \begin{cases} 1, & \rho \geq s_1 \\ \alpha e^{\rho}, & \rho \in [s_2, s_1] \\ 0, & \rho < s_2 \end{cases} \quad (2)$$

$$\rho = s_2, f = 1, \text{ then, } \alpha e^{s_2} = 1 \quad \alpha = \frac{1}{e^{s_2}}, \quad (3)$$

$$f = \begin{cases} \frac{1}{e^{s_2}} e^{\rho}, & \rho \in [s_2, s_1] \\ 0, & \rho < s_2 \end{cases} \quad (4)$$

Based on this, we plot an image of the function as shown in the following figure: The image can be intuitively seen: The protocol that ICM should develop is: When $\rho \in [s_2, s_1]$, its D&A system is valid.

5. Strengths and Weaknesses

5.1. Strengths

Effective models: For different problems, we build several models including the D&A system maturity evaluation model, the goal programming model which makes the analysis of each problem de-tailed and convincing.

Consistency tests: Instead of simply comparing the value, we apply consistency tests to make our conclusions are reliable.

Vivid visualizations: We use many figures to show our results, make it easier to capture the key information.

5.2. Weaknesses

The analytic hierarchy process can only be selected from the original scheme, but cannot provide decision-makers with a new scheme to solve the problem.

The goal programming model has high requirements for the accuracy of work summary design and data statistics, otherwise it is easy to lead to inaccurate evaluation.

References

- [1] Chen, Guanrong. Introduction to D&A system: Models and structures [M]. Higher Education Press, 2012.
- [2] Lawley, D. N. "A generalization of Fisher's consistency tests ." *Biometrika* 30.1/2 (1938):180-187.
- [3] Rencher AC, Christensen WF. *Methods of Goal Programming Analysis*[J]. *Technometrics*, 2002, 38(443):76-77.
- [4] McKnight, Patrick E., and Julius Najab. "Exponential function model " *The Corsini encyclopedia of psychology* (2010): 1- 1.
- [5] Bai J, Perron P. *Computation and analysis of goal programming models*[J]. *Journal of Applied Econometrics*, 2003.