Research on Information Equipment Grading Management of Cold Chain Logistics Enterprise Based on Extenics

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Abstract: It was proposed to a new method of information equipment classification management in cold-chain logistics enterprises based on extension theory, it was established to a extensible matter-element model of the importance of information equipment in cold-chain logistics enterprises ,it was studied to the extension decision method based on correlation function, and it was studied to take the application of a cold chain logistics enterprise-sorting line for example, it finally was provided to a new scientific method for information equipment classification management and decision making of cold chain logistics enterprise in this paper.

Keywords: Cold-chain logistics enterprises; Information equipment; Classification management; Extenics; Discrimination model.

The management of cold chain logistics enterprise information equipment is the scientific management to the whole process of purchasing , installing , using , maintaining , repairing , transforming , updating and discarding of cold chain logistics enterprise information equipment by a series of technical , economic and organizational measures based on the production and management objectives of cold chain logistics enterprises .The management of information equipment in cold-chain logistics enterprises mainly involves three aspects: technology, economy and organization. The three aspects are inseparable and a organic whole. With the continuous improvement of the information and automation degree of the cold chain logistics enterprises in the production , circulation and warehousing , the cold chain logistics enterprises are required to strengthen the management of information equipment in order to ensure the accuracy , performance and reliability of the information equipment . In order to improve the efficiency of information equipment management in cold chain logistics enterprises, it should be formed into a whole to the people, money and objects involved in the information equipment management of cold chain logistics enterprises for realizing the best combination and pursuing benefit maximization[1] .Therefore, it can not only meet the cold chain logistics enterprises production and operation needs, reduce the cost of management and maintenance, but also improve the efficiency of information equipment maintenance by information equipment classification management [2].

1. A brief introduction to the method of evaluating the importance of Information equipment

It is difficult to evaluate the importance of information equipment in cold chain logistics enterprises by classical mathematical methods[3-4]. The existing methods for evaluating the importance of information equipment mainly include fuzzy clustering method and fuzzy comprehensive evaluation method, but these kinds of methods have many disadvantages such as many subjective parameters, complex calculation and so on. So a method for evaluating the importance of information equipment based on extension theory was established in this paper[5].

(1) Determine classical field and segmental domains

When N_j is the standard thing, that is, the information equipment to be evaluated, the range of the value of the information device characteristic c_i is $v_{ji} =< a_{ji}, b_{ji} >$ 时 ($i = 1, 2, \cdots, n$; $j = 1, 2, \cdots, m$; n denotes the number of characteristics of a thing and m denotes the number of classes of a thing), The matter-element of the classical domain of the information device to be evaluated may be expressed as:

$$R_j = (N_j, c, v) = \begin{bmatrix} N_j & c_1 & < a_{j1}, b_{j1} > \\ & c_2 & < a_{j2}, b_{j2} > \\ & \vdots & \vdots \\ & c_i & < a_{ji}, b_{ji} > \\ & \vdots & \vdots \\ & c_n & < a_{jn}, b_{jn} > \end{bmatrix} \quad (1)$$

The matter- element R_P consisting of all the importance of the information device N_j to be evaluated and the importance of all the information devices that can be converted is referred to as segment field matter-element.

And $v_{pi} =< a_{pi}, b_{pi} >$ is the range of expanded values for the corresponding standard of the segment field matter-element on the characteristic c_i. The segment field matter-element may be expressed as:

$$R_p = (N_p, c, v) = \begin{bmatrix} N_j & c_1 & < a_{p1}, b_{p1} > \\ & c_2 & < a_{p2}, b_{p2} > \\ & \vdots & \vdots \\ & c_i & < a_{pi}, b_{pi} > \\ & \vdots & \vdots \\ & c_n & < a_{pn}, b_{pn} > \end{bmatrix} \quad (2)$$

In the formula, N_p is the whole of the importance of the information equipment. Obviously, here is $< a_{ji}, b_{ji} > \subset < a_{pi}, b_{pi} > (i = 1, 2, \cdots, n)$.

(2) Determine the matter-element to be evaluated

For the information equipment *N* of a cold chain logistics enterprise, the data or analysis results of the information equipment are expressed with the matter element R as:

$$R = \begin{bmatrix} N & c_1 & v_1 \\ & c_2 & v_2 \\ & \vdots & \vdots \\ & c_i & v_i \\ & \vdots & \vdots \\ & c_n & v_n \end{bmatrix} \quad (3)$$

R is called the matter-element to be evaluated of the importance of information device, and the N is the information device. v_i expresses the value of N about c_i, that is, the specific value of c_i, which is the characteristic index of information equipment to be evaluated in cold chain logistics enterprises[6].

(3) Calculation of weight coefficient

The weight coefficient can be determined by the "top-down system analysis method", the elementary association function method or the analytic hierarchy process (AHP) ,it was applied to top down system analysis method to determine the weights of each feature in this paper.

The so - called " top - down system analysis method " is to take the median value of the interval determined by each class of classical domain sets , and the threshold value matrix *RT* can be obtained :

$$RT = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & r_{ij} & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix} \quad (4)$$

In the formula, r_{ij} is the median value of the interval $< a_{ji}, b_{ji} > (i = 1, 2, \cdots, n; j = 1, 2, \cdots, m)$, n denotes the number of characteristics of a thing ; m denotes the number of classes of a thing. It is then dimensionless, that is, each row element is divided by the maximum value in the row element, and then each column is normalized, Set up $\alpha_{ij} = \frac{r_{ij}}{\sum_{i=1}^{n} r_{ij}}$,then weight coefficient matrix can be obtained:

$$\alpha_{ij}=\begin{bmatrix}\alpha_{11} & \alpha_{12} & \cdots & \alpha_{1m}\\ \alpha_{21} & \alpha_{22} & \cdots & \alpha_{2m}\\ \vdots & \vdots & \alpha_{ij} & \vdots\\ \alpha_{n1} & \alpha_{n2} & \cdots & \alpha_{nm}\end{bmatrix} \quad (5)$$

And meet $\sum_{i=1}^{n}\alpha_{ij}=1$

(4) Calculation of correlation function and correlation degree

The correlation function indicates that the value of the matter- element is a point on the real axis, and the matter- element meets degree of the requirements. It possible to solve the problem of incompatibility because of the correlation function of the extension set can be expressed in algebraic expression .

According to the extension theory, the correlation function of the operation state of the unrated information equipment is determined. The correlation function of the i index value belongs to the j standard grade is as follows:

$$K_j(x_i)=\begin{cases}\dfrac{\rho(x_i,x_{ji})}{\rho(x_i,x_{pi})-\rho(x_i,x_{ji})} & x_i\in x_{ji};\\ -\dfrac{\rho(x_i,x_{ji})}{|x_{ji}|} & x_i\notin x_{ji}\end{cases} \quad (6)$$

Among them :

$$\left.\begin{aligned}\rho(x_i,x_{ji})&=\left|x_i-\frac{a_{ji}+b_{ji}}{2}\right|-\frac{1}{2}(b_{ji}-a_{ji})\\ \rho(x_i,x_{pi})&=\left|x_i-\frac{a_{pi}+b_{pi}}{2}\right|-\frac{1}{2}(b_{pi}-a_{pi})\end{aligned}\right\} \quad (7)$$

(5) Evaluation of comprehensive correlation degree and relative importance degree of things

For multi-index evaluation, for the sake of comparison, it is necessary to design the comprehensive evaluation value, and the comprehensive correlation degree $k_j(N_x)$ of things N to be evaluated in relation to grade j is as follows:

$$k_j(N_x)=\sum_{i=1}^{n}\alpha_{ij}k_j(x_i) \quad (8)$$

In the formula $k_j(N_x)$ is the comprehensive correlation degree of the things to be evaluated on each grade j and $k_j(x_i)$ is the thing to be evaluated about the correlation degree of each grade. α_{ij} is weight coefficient for each evaluation index. If

$$k_{j0}=\max[k_j(N_x)] \quad (j=1,2,\cdots,m) \quad (9)$$

then the evaluation object N_x belongs to the rank k_{j0}. The rank of the object may also be determined by calculating the rank variable characteristic value j^*, which is as follows:

$$\overline{k}_j=\frac{k_j-\min\limits_j k_j}{\max\limits_j k_j-\min\limits_j k_j} \quad (10) \qquad j^*=\frac{\sum_{j=1}^{m} j\times\overline{k}_j}{\sum_{j=1}^{m}\overline{k}_j} \quad (11)$$

then the evaluation object N belongs to the rank j^* [7].

2. Classification and Evaluation of Information Equipment in Cold Chain Logistics Enterprises

(1) Selection of evaluation index

The evaluation index system of information equipment importance degree of cold chain logistics enterprise is constructed according to the system theory method ,it reflects a system structure that is

composed of the relevant index of information equipment importance degree of cold chain logistics enterprise. According to the cold chain logistics production information equipment, combined with the experience accumulated in the production of cold chain logistics enterprises,
it was selected to five indexes including the data reading accuracy requirements, the original value of assets, the average annual stop time, the average annual maintenance cost and the reciprocal of average fault interval time to measure the importance of information equipment in cold chain logistics enterprises, according to the cold chain logistics production information equipment, combined with the experience accumulated in the production of cold chain logistics enterprises in this paper.

c_1: the data reading accuracy requirements, digits; c_2: the original value of assets, ten thousand yuan; c_3: the average annual stop time ,minutes/year; c_4: the average annual maintenance cost , ten thousand yuan/year; c_5: the reciprocal of average fault interval time,1/hours.

Take a cold chain logistics enterprise with seven information equipment as an example, the actual data is collected for nearly six years, and the data is detailed in table 1.

Table 1. Information equipment statistics of a cold chain logistics enterprises

Equipment Number	Data reading accuracy requirements C_1	Original value of assets C_2	Average annual stop time C_3	Average annual maintenance cost C_4	Reciprocal of average fault interval time C_5
	Digits	Ten thousand yuan	Minutes/year	Ten thousand yuan/year	1/hour
013-033	0.005	6.901203	1690	1.84	0.0047
013-036	0.0055	7.181069	2600	1.32	0.0038
017-034	0.0032	1.61245	1980	1.58	0.0034
053-052	0.0017	20.227572	340	3.06	0.0024
032-025	0.0015	12.073535	480	3.49	0.0015
032-026	0.0018	14.924658	520	2.95	0.0017
037-046	0.002	3.9499929	870	2.86	0.0019

(2) Grading standards for information equipment importance

In the important level of evaluation for the information equipment of cold chain logistics enterprise, selected all kinds of factors, which contain the descriptive index and comparative index of fault and maintenance of cold chain logistics enterprise information equipment, are summarized as the qualitative and quantitative types according to the specific content of the index, The importance level assessment adopts " secondary " , " general " , " keynote " and " key " four levels . According to the data statistical results and maintenance practical experience , the importance level of the cold chain logistics enterprise information equipment is divided into four categories , as shown in Table 2 .

Table 2.The information equipment classification standard of cold chain logistics production line

Index	levels			
	secondary	general	keynote	key
Data reading accuracy requirements C_1（Digits）	0.0019~0.0001	0.002~0.0039	0.004~0.005	0.005~0.1
Original value of assets C_2（Million)	0~3	3.1~10.32	10.32~16.56	16.57~30
Average annual stop time C_3（minute)	0 ~1500	1500~2000	2000~2500	2500~5000
Average annual maintenance cost C_4（Million)	0~1.5	1.6~2.0	2.1~3.0	3.1~10
Reciprocal of average fault interval time C_5	0.0001~0.0017	0.0018~0.0034	0.0035~0.0049	0.005~0.1

Table 2 shows that the classical domain R_j of the importance of information equipment for each cold-chain logistics enterprise is as follows:

$$R_1=\begin{bmatrix} N_1 & c_1 & <0.0056,0.1> \\ & c_2 & <0,3> \\ & c_3 & <2500,5000> \\ & c_4 & <0,1.5> \\ & c_5 & <0.0001,0.0017> \end{bmatrix} \quad R_2=\begin{bmatrix} N_2 & c_1 & <0.004,0.0055> \\ & c_2 & <3.1,10.32> \\ & c_3 & <2000,2500> \\ & c_4 & <1.6,2.0> \\ & c_5 & <0.0018,0.0034> \end{bmatrix}$$

$$R_3=\begin{bmatrix} N_3 & c_1 & <0.0039,0.002> \\ & c_2 & <10.32,16.56> \\ & c_3 & <1500,2000> \\ & c_4 & <2.1,3.0> \\ & c_5 & <0.0035,0.0049> \end{bmatrix} \quad R_4=\begin{bmatrix} N_4 & c_1 & <0.0001,0.0019> \\ & c_2 & <16.57,30> \\ & c_3 & <0,1500> \\ & c_4 & <3.1,10> \\ & c_5 & <0.005,0.1> \end{bmatrix}$$

Segment field is determined according to the value range of the information equipment importance of the evaluated cold chain logistics enterprises. The Segment field R_p of the importance degree of the information equipment of the cold chain logistics enterprises is as follows:

$$R_p=\begin{bmatrix} N_p & c_1 & <0.0001,0.1> \\ & c_2 & <0,30> \\ & c_3 & <0,5000> \\ & c_4 & <0,10> \\ & c_5 & <0.0001,0.1> \end{bmatrix}$$

(3) Grade evaluation of the important degree of information equipment for cold chain logistics enterprises

The table 1 shows that the four indicators including the data reading accuracy, the original value of assets, the average annual stop time, the average annual maintenance cost and the reciprocal of average fault interval time in the equipment number is 013 - 033 are small in all of the information, the average annual maintenance fee is at a medium level. calculating the comprehensive association degree and the rank variable characteristic value of this equipment with number 013-033 j^*.Among them, $i=1,2,\cdots,5;\ j=1,2,\cdots,4$. The cold-chain logistics enterprise information equipment 013-033 is expressed as the form of matter-element R to be evaluated as follow:

$$R_{013-033}=\begin{bmatrix} 013—033 & c_1 & 0.005 \\ & c_2 & 6.901203 \\ & c_3 & 1690 \\ & c_4 & 1.84 \\ & c_5 & 0.0047 \end{bmatrix}$$

It was adapted to top down system analysis method to calculate extension weight coefficient , the threshold value matrix RT is obtained from equation (4) according to the data of table 2:

$$RT=\begin{bmatrix} 0.0528 & 0.00475 & 0.00295 & 0.001 \\ 1.5 & 6.71 & 13.44 & 23.285 \\ 0.375 & 0.225 & 0.175 & 0.075 \\ 0.75 & 1.8 & 2.55 & 6.55 \\ 0.0009 & 0.0026 & 0.0042 & 0.525 \end{bmatrix}$$

Matrix RT is then dimensionless, that is, each row element is divided by the maximum value in the row element, and then each column is normalized, then weight coefficient matrix can be obtained as follows:

$$a_{ij}=\begin{bmatrix} 0.458582 & 0.071518 & 0.037321 & 0.005884 \\ 0.029541 & 0.229088 & 0.385556 & 0.310661 \\ 0.458582 & 0.476988 & 0.311725 & 0.062132 \\ 0.052509 & 0.218468 & 0.260054 & 0.310661 \\ 0.000786 & 0.003937 & 0.005344 & 0.310661 \end{bmatrix}$$

The correlation degree of each grade of the information equipment with number 013 - 033 of the cold chain logistics enterprise is calculated out by the formula (6), (7) ,the result is as follows:

$$k_j(x_i)=\begin{bmatrix} -0.3853 & -0.1819 & 0.1125 & -0.1091 \\ -0.3611 & -0.4735 & 0.9817 & -0.5831 \\ -0.1011 & 0.1267 & -0.155 & -0.324 \\ -0.16 & 0.0952 & -0.1238 & -0.2923 \\ -0.417 & -0.2366 & 0.05 & -0.0667 \end{bmatrix}$$

The comprehensive correlation of each grade is calculated by the formula (8): $k_{013-033}=[-0.2425 \quad -0.0412 \quad 0.3025 \quad -0.3135]$， the characteristic value of the grade variable J can be obtained by the formula (10) and (11): $j^*_{013-033}=1.635$， it indicates that level of importance of this information equipment is general.

Similarly, it was calculated to the comprehensive correlation of level of importance and rank variable characteristic value J is calculated is the importance level of degree and rank variable characteristic value j^* of other cold chain logistics enterprise information equipment by the formula (10) and (11),the result is as shown in table 3:

Table 3 Evaluation results of information equipment level for cold chain logistics enterprises

Textile equipment No .	Comprehensive correlative degree j^*	Levels
013-033	1.635	General
013-036	1.951	General
017-034	1.216	Secondary
053-052	3.569	Key
032-025	2.783	Keynote
032-026	2.611	Keynote
037-046	1.524	General

Through the above analysis, it may be accurately classified to the seven information equipment belong to the cold chain logistics enterprise according to importance of the equipment. Among them, the equipment with number 053-052 is the key equipment of information, the information management of equipment in addition to the daily inspection and maintenance, mainly focus on the following four points: to strengthen the monitoring, information technology improvement, renewal of equipment and spare parts to ensure adequate. the equipments with number 053-052032-025 and 032-026 are the key equipment of its information management, in addition to the inspection and maintenance of basic daily work, should focus on the following aspects: regular monitoring, maintenance plan, spare parts plan. The equipment with number 017-034 belongs to the secondary information equipment, the equipments with number 013-033013-036 and 037-046 belong to the general information equipment, the management in daily inspection, spare parts inventory can be maintained at a low level, until the realization of zero inventory.

3. conclusion

Through the above analysis, the following conclusions can be drawn: first, it is feasible to solve the cold chain logistics enterprise information equipment classification management by establishing decision model based on the extenics theory ; Second, This method is not only simple, accurate ,but also requires high precision of the grade division of each index, and needs to be judged by the actual management experience; Third, Extension analysis method is a method that can combine qualitative analysis and quantitative calculation of things to be evaluated ,and has great superiority in evaluating the importance of information equipment comparing with the existing evaluation methods.

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