Research on Product Quality Influencing Factors Based on ISM and Discrete Hopfield Neural Network

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Abstract: For the manufacturing enterprises, the 13 factors affecting the product quality factors are selected, the product quality influencing factors system is established, and the internal relationship and hierarchical structure between the factors are constructed by the interpretation construction model method. Then the products are constructed through the discrete hopfield neural network. The quality evaluation model was simulated by the Matlab neural network toolbox for product quality evaluation. The results show that the leadership's awareness and management ability, product design and specification, the degree of training and technical level of employees, and process feedback are key to improving product quality and provide reference value for enterprises.

1. Introduction

There are many factors affecting quality, and the relationship between factors is more complicated. The United States Malcolm Baldrige National Quality Award (MBNQA) (1993) takes the business results of the company as the research object and proposes seven factors that affect the quality: Flynn, Alexander, etc. also summarize the quality impact from different angles. Factors; In 2006, the General Administration of Quality Supervision, Inspection and Quarantine and the National Bureau of Statistics jointly released the 2005 Quality Competitiveness Index. This is the first time that China has used systematic data to evaluate China's macro quality level and quality development capabilities. Many domestic scholars have also devoted themselves to the study of macro quality, and the evaluation method of enterprise quality competitiveness has expanded to the macro level.

Research methods on product quality factors generally use regression analysis, factor analysis, etc. These methods cannot effectively analyze the internal relationships and hierarchical relationships among various factors, and can not find the root cause. ISM can better study the relationship between many factors. Internal relationships and levels to find the key factors. For the multi-index comprehensive evaluation problem, the analytic hierarchy process, TOPSIS, the comprehensive index method, and the fuzzy comprehensive evaluation method are usually adopted. The reliability of analytic hierarchy process is poor, the sensitivity of tonia is low, and the evaluation results of fuzzy comprehensive evaluation method are not comprehensive. Discrete Hopfield neural network method has associative memory function, intuitive image, and is widely used in various rating classification problems. In this paper, based on the shortcomings of the research methods of traditional enterprise product quality influencing factors, the combination of ISM and discrete Hopfield neural network is used to analyze the factors affecting product quality, which provides a reference for enterprises to improve product quality.

2. Analysis of factors affecting product quality

2.1 Internal factor analysis

(S1) Leaders awareness of quality and management capabilities, especially those at the decision-making level, play an important role in improving the quality of production products.

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(S2) The level of training and technical level of the employees, even the highly automated production workshops require human involvement.

(S3) The degree of perfection of the quality organization in the enterprise. A sound quality organization is conducive to the implementation and implementation of corporate policy guidelines.

(S4) Production process and core technology seriously affect product quality.

(S5) Resources of the company. Including raw materials, production equipment, quality inspection technology, etc.

(S6) The implementation of the quality system in the enterprise. The higher the execution, the higher the quality level of the final product.

(S7) The design and specification of the product is the beginning of product production, and the quality standard of the design is the highest level of final product production.

(S8) Process preparation is very important throughout the production process, especially the required technical preparation, which directly affects the stability of production quality.

(S9) The higher the quality of the process control, the better the quality of the final product produced.

(S10) Process feedback, timely correct errors in the production process and quickly correct, so that the product is maintained at a good level.

2.2 Analysis of external factors

(S11) Policy environment Policy environmental factors include management policies, economic policies, and quality industrial policies.

(S12) The rule of law environment The environmental factors of the rule of law include laws and regulations on quality and supervision of enterprises by administrative law enforcement.

(S13) Social environment Social environmental factors mainly include market operation mechanism, material resource status and social quality awareness.

3. ISM establishment of product quality influencing factors

3.1 Explain the structural model overview

The Interpret Structural Model Method is a method proposed by Professor J.N. Warfield in 1973 to analyze complex problems. It quantifies the qualitative research, studies the logical relationship between various factors, transforms the ambiguous thought into an intuitive model with good structure, and determines the hierarchical relationship between the factors and their internal relations.

3.2 Establish adjacency matrix

The interrelationship between these thirteen influencing factors is determined by interviewing experts. Where m is the number of features, and each row and column of the matrix correspond to the features in the graph. According to the rule, if the element Si affects Sj, the element aij in the matrix is 1; if the element Si has no effect on Sj, the matrix element aij is 0. which is:

$$a_{ij}\begin{cases}1\cdots\cdots \text{When } S_i \text{ has an effect on } S_j; \\ 0\cdots\cdots \text{When } S_i \text{ has no effect on } S_j\end{cases} \quad (1)$$

3.3 Reachable matrix calculation

$$A=\begin{bmatrix}1&1&0&0&0&0&0&0&0&0&0&0&0\\0&1&1&1&0&1&1&0&0&0&0&0&0\\0&0&1&0&1&0&0&1&1&1&0&0&0\\0&0&0&1&0&0&0&1&1&1&0&0&0\\0&0&0&0&1&0&0&0&0&0&0&0&0\\0&0&0&0&0&1&0&0&0&1&0&0&0\\0&0&0&0&1&0&1&0&0&0&0&0&0\\0&0&0&0&0&0&0&1&0&0&0&0&0\\0&0&0&0&0&0&0&0&1&0&0&0&0\\0&0&0&0&0&0&0&0&0&1&0&0&0\\0&0&0&0&0&0&0&0&0&0&1&0&1\\0&0&0&0&0&0&0&0&0&0&0&1&1\\1&0&0&0&0&0&0&0&0&0&1&1&1\end{bmatrix} \quad (2)$$

The reachable matrix reflects the direct and indirect transfer relationship between any two elements in the system. According to the Budar matrix operation rule (0+0=0, 0+1=1, 1+0=1, 1+1=1, 0×0=0, 0×1=0, 1×0=0,1 ×1=1), find the sum A+I of A and the unit matrix I, and obtain the reachable matrix M according to the equation (2) as shown in the equation (3)

$$M=(A+I)^{k+1}=(A+I)^{k}\neq(A+I)^{k-1}\neq\cdots\neq(A+I)^{2}\neq(A+I) \quad (3)$$

3.4 Determine the level of each factor

After the hierarchical matrix is obtained, the hierarchical division is performed. The steps of hierarchical division are generally as follows: 1 First find the highest-level element L1 in the whole system, delete it 2 and find the highest-level element L1 in the system, delete it and repeat the second step until the lowest level element Li is found.

According to the conditions and the above steps, the level of product quality influencing factors is divided, as shown in Table 1.

Table 1 Hierarchical division of factors affecting product quality

Level	Element
L1	5,8,9,10
L2	3,4,6,7
L3	2
L4	1
L5	11,12,13

3.5 Establish an explanatory structure model

According to the relationship between the various elements obtained by the above analysis and the grades thereof, the ISM of the product quality influencing factors shown in Figure 1 is obtained.

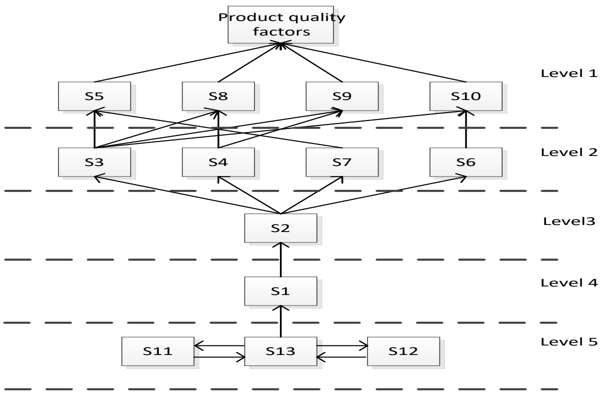

Figure 1 Product quality influencing factors explain structural model

4. Introduction to the principle of discrete hopfield neural network

Hopfield neural network was proposed by American scholar J Hopfield in 1982. Among them, the discrete Hopfield neural network has better associative memory ability and fault tolerance and error correction performance, and the research object is well classified.

4.1 Network structure

DHNN is a single-layer, two-value feedback network. Therefore, the discrete values 1 and -1 output indicate that the neurons are in the active and suppressed states, respectively, and the formula is as follows:

$$u_j = \sum \omega_{ij} y_i + x_j \quad (4)$$

$$\begin{cases} y_j = 1, u_j \geq \theta_j \\ y_j = -1, u_j < \theta_j \end{cases} \quad (5)$$

In the formula, x_j is an external input and has a formula

Each neuron in a DHNN network has the same function, and its network state is the set of output neurons. If there is n neurons in an output layer of the neural network, the state at time t is an n-dimensional vector, that is:

$$Y(\mathrm{t}) = [y_1(t), y_2(t), \cdots y_n(t)]^T \quad (6)$$

Since yi(t)(i=1,2,...,n) can take a value of 1 or -1, the n-dimensional vector Y(t) has 2n states, that is, the network has 2n states. Considering the general node state of DHNN, the jth neuron is represented by yj(t), and the state of node j at time t, the state of the node at time (t+1) can be obtained:

$$y_j(t+1) = f[u_j(t)] = \begin{cases} 1, u_j(t) \geq 0 \\ -1, u_j(t) < 0 \end{cases} \quad (7)$$

$$u_j(t) = \sum_{i=1}^{n} \omega_{ij} y_i(t) + x_j - \theta_j \quad (8)$$

When the discrete Hopfield neural network is operated, its state evolves toward the direction in which the energy function decreases. Since the energy function is bounded, the system will eventually tend to be in a steady state, which is the output of the network.

4.2 Established a product quality evaluation model

According to the above design ideas, the product quality evaluation is studied. Firstly, the evaluation index system is established and the relevant data is collected. Then the data is modeled by the applicable algorithm, and finally the data is evaluated.

4.2.1 Ideal grade evaluation index design

This paper randomly selects 50 manufacturing enterprises to score through the expert group, and scores the influencing factors of the quality products of the enterprise. The average value of each index corresponding to each level of the sample is used as the ideal evaluation index. Let each factor influence the five levels from 1, 2, 3, 4, and 5. See Table 2 for details.

Table 2 Ideal Evaluation Indicators

grade	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
1	92	90	86	83	87	90	91	88	86	91	85	84	89
2	83	82	77	75	79	83	84	78	78	83	76	77	80
3	75	70	68	66	70	71	73	68	67	74	67	68	69
4	67	63	60	60	62	62	65	61	60	65	59	61	62
5	58	55	54	51	55	55	56	53	54	57	50	52	51

4.2.2 Ideal grade indicator code

Since the state of discrete Hopfield neural network neurons is only 1 and -1, it is necessary to encode the evaluation index when it is mapped to the state of the neuron. Coding rule: When the greater than or equal to the index value is =, the corresponding neuron state is set to "+1", and the opposite is set to "-1". The ideal five-level evaluation index coding is shown in Figure 2. Where ● indicates that the neuron state is "+1" and ○ indicates that the neuron state is "-1".

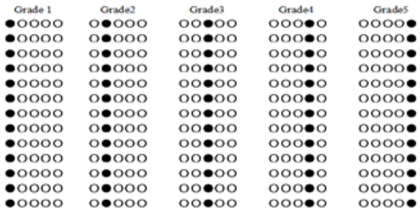

Figure 2 Encoded ideal rating indicator

4.2.3 Coding of the classification index to be classified

Select five manufacturing companies m1, m2...m5 in the large sample, and score the product quality influencing factors of the five manufacturing companies according to 13 factors such as S1, S2, ..., S13, etc., as shown in Table 3. Five companies' product quality evaluation values. According to the above evaluation value encoding results are shown in Figure 3.

Table 3 Evaluation values to be classified

number	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
m1	98	96	83	73	93	95	97	94	84	96	81	85	95
m2	81	65	64	64	78	77	70	63	62	78	66	67	82
m3	88	78	87	74	82	85	88	77	85	88	83	76	93
m4	80	85	76	72	77	78	88	80	75	77	70	58	77
m5	83	91	88	82	90	91	79	89	85	94	89	83	96

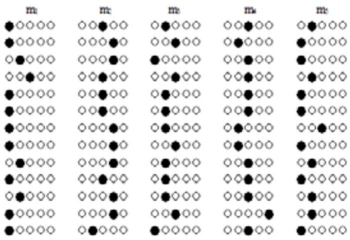

Figure 3 The factors affecting the quality of the product to be evaluated

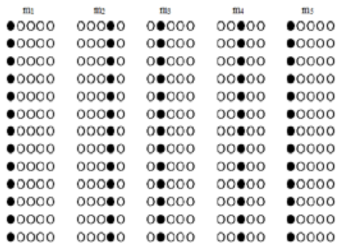

Figure 4 Network classification results

4.2.4 Simulation result analysis

Using the neural network toolbox function in MATLAB to create a discrete Hopfield neural network, input the code of the five manufacturing industries to be classified, and continue to iterate until the result is not changed, as shown in Figure 4. It can be seen from the simulation results that m1 and m5 belong to the first level, which is better than the second level of m3, the third level of m4, and the fourth level of m2, but it is impossible to compare m1 and m5 from the classification result. Therefore, it is necessary to carry out a new round of classification for the m1 and m5 elevation ideal rating indicators, and the corresponding new rounds of m1 and m5 are shown in Figure 5. The new ideal level indicators are shown in Table 4.

Table 4 Enhanced Evaluation Indicators

Grade	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
I	97	95	91	88	92	95	96	93	91	96	90	89	94
II	89	87	82	80	84	88	89	83	83	88	81	82	85
III	80	75	73	71	75	76	78	73	72	79	72	73	74
IV	72	68	65	65	67	67	70	66	65	70	64	66	67
V	63	60	59	56	50	60	61	58	59	62	55	57	56

From Figure 6, it can be concluded that the result 1 belongs to the first level, and m5 belongs to the second level, that is, 1 is superior to m5. The final order is m1>m5>m3>m4>m2, so the product quality of the enterprise m1 is the best among the five companies.

The simulation results show that the quality of the m1 products in the five manufacturing companies is the best. The four most significant factors affecting the quality of m1 products are the awareness and management ability of S1 leaders on quality, the design and specification of S7 products, the degree of training and technical level of S2 employees, and the feedback of S10 process.

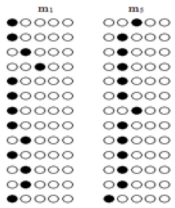

Figure 5 New round of coding for m1 and m5

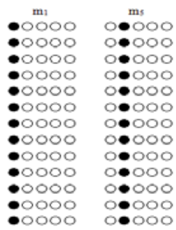

Figure 6 Simulation results for m1 and m5

5. Conclusion

Based on the above conclusions, this paper puts forward some suggestions for the production of manufacturing enterprises: 1) Improve the quality awareness and attention of leaders, and cultivate the executive ability of leaders at all levels. 2) Ensure that the mechanical equipment and process documents of the production meet the specified requirements. 3) Pay attention to the technical level of the employees. The quality of the employees directly determines the quality of the products. 4) Ensure that all departments involved in the production process participate in the production process. Prepare work, control situation and feedback.

Based on the research of the existing literature, this paper interprets the structural model to sort out the hierarchical relationship and internal relations between the factors affecting the quality of manufacturing enterprises, and provides a theoretical basis for judging the impact of various factors on product quality, and effectively avoids subjective The impact of consciousness on the outcome. The discrete hopfield neural network does not require large samples, and the training ability is simple. The constructed DHNN model can screen out the optimal results by improving the ideal indicators. The example analysis proves that the model is feasible, the design time is short, and the time is short, which can help the production and quality improvement of the manufacturing enterprise products.

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