International Journal of Business and Management
www.ccsenet.org/journal.html
Vol. 3, No. 12
December 2008

Research on the Quality Competence in Manufacturing Industry

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Abstract

In this article, we established the evaluation index system of manufacturing quality competence, implemented the comprehensive evaluation of quality competence by AHP (Analytic Hierarchy Process), empirically studied the evaluation objects including more than one thousand manufacturing enterprises, and validated the rationality of the evaluation index system and the evaluation method.

Keywords: Quality competence, Quality competence index, AHP, Manufacturing

1. Introduction of the problem

The so-called quality competence is the ability that the organization acquires sustainable competitive predominance and realizes sustainable development in virtue of excellent quality, and it can be measured by the quality competence index. In this article, we established the evaluation index system of manufacturing quality competence, and evaluated and analyzed the quality competence of the evaluation objects including more than one thousand manufacturing enterprises.

2. Index system of quality competence

The index system of manufacturing quality competence can be divided into four layers including object layer, criterion layer, judgment layer and index layer. The object layer is the first class index, i.e. "the manufacturing quality competence index", the criterion layer is the second class index which includes two indexes such as "explicit competence" and "potential competence", and the judgment layer is the third class index which includes "practicality quality", "performance", "technical innovation", "human resource" and "quality management ability", and the index layer includes 11 indexes, and the concrete structure is seen in Table 1.

3. Evaluation analysis method of quality competence

The evaluation of quality competence belongs to the problem of multiple index comprehensive evaluation. The multiple index comprehensive evaluation methods usually include subjective weight average method, AHP, main components analysis method and factor analysis method. The evaluation of quality competence can be evaluated by above methods, and in this article, we adopt AHP to analyze and evaluate the quality competence.

(1) Establishing judgment matrix

Judgment matrix is the core of AHP, and it is acquired by the comparison between two factors, and its factor a_{ij} can be confirmed by Table 2.

The judgment matrix obtained by this way is

$$A = \begin{pmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{pmatrix}.$$

(2) Confirmation of weight

There are many single ranking methods to confirm the weight W from the judgment matrix A, but the eigenvector method put forward by T. L. Saaty is the optimal method. The method first solves the character equation $AW=\lambda_{max}W$, where, λ_{max} is the maximum latent root of matrix A, W is the character vector corresponding to λ_{max}. We can obtain the weight by the normalization to W. All works can be implemented by Matlab.

(3) Consistent test

The consistent test is implemented through the computation of consistent index and test coefficients.

Consistent index $CI = \frac{\lambda_{\max} - n}{n-1}$

Test coefficient $CR = \frac{CI}{RI}$

Where, RI is the average consistent index which can be checked through Table 3. Generally, when $CR<0.1$, we can think the judgment matrix possesses satisfactory consistence, or else, we need readjust the judgment matrix.

4. Comprehensively evaluating the quality competence by AHP

According to AHP, we first establish judgment matrixes of various layers (Table 4-Table 11). To avoid the limitations such as individual ability level, we can use many methods which utilize collective wisdom such as experts grading method and Delphi method to compare and judge. To various indexes evaluating quality competence, we can compose the expert group including some experts in the domain of quality management, persons who engage relative works of quality management in enterprises, competitors in same industry and consumers to evaluate.

Next, compute the weights of various indexes in the index layer to the object layer by the weight coefficients obtained by the above method, and then rank the object layer.

Cumulate and multiply the weight coefficients of various layers, we can obtain the weights (seen in Table 12) of various indexes corresponding to the object layer.

So, we can get the score Z of the total object through the weight coefficients of above various indexes.

$$Z=0.4445x_1+0.1481x_2+0.0741x_3+0.0313x_4+0.0173x_5+0.0095x_6+0.0320x_7+0.0320x_8+0.1267x_9+0.0422x_{10}+0.0422x_{11}$$

Where, x_i is the actual observation value of corresponding i'th index in various samples, and to eliminate the influence induced by the differences among various quality index dimensions, we can first implement normalization processing to the sample observation data, and here, we think x_i is normalized.

Finally, we translate Z_i into percent, and so we can obtain the micro-quality competence index QI_{A1}, and rank original data by the size of QI_{A1}, which can be realized in the software of SPSS.

5. Conclusion

In this article, we established the index system of manufacturing quality competence, utilized AHP and factor analysis method to comprehensively evaluate the quality competences of more than one thousands manufacturing enterprises, and ranked these enterprises according to various layers and various classes based on the results of evaluation. Because of too much data, we didn't list the ranking result in the article.

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Table 1. Index system of manufacturing quality competence

Object layer (A)	Criterion layer (B)	Judgment layer (C)	Index layer (D)
Index of manufacturing quality competence (QI_{A1})	Explicit competence (B1)	Practicality quality (C1.1)	Product eligibility of first-time check out (D1.1.1)
		Performance (C1.2)	Increase rate of sales income (D1.2.1)
			Production value rate of brand product (D1.2.3)
	Potential competence (B2)	Technical innovation (C2.1)	Proportion of scientific activity outlay payout in sales income (D2.1.1)
			Proportion of accumulated technical change outlay payout in accomplished amount of accumulated investment (D2.1.2)
			Quantity of invention and patent (D2.1.3)
		Human resource (C2.2)	Proportion of engineering technical personnel in total amount of employee (D2.2.1)
			Proportion of the amount of quality engineer in total amount of employee (D2.2.2)
		Ability of quality management (C2.3)	Pass quality system certification (D2.3.1)
			Pass environmental system certification (D2.3.2)
			Pass occupational security healthy system certification (D2.3.3)

Table 2. Confirmation of various factors in judgment matrix

a_{ij}	Comparison between two objects
1	Same important
3	Little important
5	Obviously important
7	Much important
9	Extremely important
2, 4, 6, 8	Situation between above two instances
Reciprocal above numbers	Inversely comparing two objects

Table 3. Table of *RI* coefficients

Orders	3	4	5	6	7	8	9
RI	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Table 4. A-B judgment matrix

A	B_1	B_2	W
B_1	1	2	0.6667
B_2	1/2	1	0.3333

Table 5. B-C_{1i} judgment matrix

B	C_{11}	C_{12}	W
C_{11}	1	2	0.6667
C_{12}	1/2	1	0.3333

Where, the second-order matrix needs not consistent test.

Table 6. B-C_{2i} judgment matrix

B	C_{21}	C_{22}	C_{23}	W
C_{21}	1	1	1/4	0.1744
C_{22}	1	1	1/3	0.1919
C_{23}	4	3	1	0.6337

Where, λ_{max} =3.0091, CI=0.00455, RI=0.5800, CR=0.0078<0.1000.

Table 7. C-D_{11i} judgment matrix

C	D_{111}	W
D_{111}	1	1

Table 8. C-D_{12i} judgment matrix

C	D_{121}	D_{122}	W
D_{121}	1	2	0.6667
D_{122}	1/2	1	0.3333

Table 9. C-D_{21i} judgment matrix

C	D_{211}	D_{212}	D_{213}	W
D_{211}	1	2	3	0.5390
D_{212}	1/2	1	2	0.2972
D_{213}	1/3	1/2	1	0.1638

Where, λ_{max} =3.0093, CI=0.00465, RI=0.5800, CR=0.0080<0.1000.

Table 10. C-D_{22i} judgment matrix

C	D_{221}	D_{222}	W
D_{221}	1	1	0.5000
D_{222}	1	1	0.5000

Table 11. C-D_{23i} judgment matrix

C	D_{231}	D_{232}	D_{233}	W
D_{231}	1	3	3	0.6000
D_{232}	1/3	1	2	0.2000
D_{233}	1/3	1	1	0.2000

Where, λ_{max} =3.0000, CI=0, RI=0.5800, CR=0<0.1000.

Table 12. Weighted coefficients of various indexes

First-time check out x_1	Sales increase x_2	Production value of brand x_3	Outlay of science and technology x_4	Outlay of technical change x_5	Invention and patent x_6
0.4445	0.1481	0.0741	0.0313	0.0173	0.0095
Technical personnel x_7	Quality personnel x_8	Quality system x_9	Environment system x_{10}	Security system x_{11}	
0.0320	0.0320	0.1267	0.0422	0.0422	