

Research on effectiveness evaluation method and application of quality management system of manufacturing enterprise based on interval-valued hesitation fuzzy set

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Abstract. Based on acquaintance of effectiveness of quality management system of manufacturing enterprise, the evaluation index system is structured by confirmation of production conditions and other seven respects which include effectiveness of validation, effectiveness of document management, effectiveness of production management, effectiveness of quality assurance and quality control, effectiveness of commissioned production and inspection, effectiveness of Issue and recall of products and effectiveness of self-checking; the assessment model of effectiveness of quality management system of manufacturing enterprise based on interval-valued hesitation fuzzy set is structured and the feasibility of theoretical research was validated by concrete cases.

Keywords: effectiveness of quality management system, evaluation methods, interval-valued hesitation fuzzy set.

1. Introduction

Under the background of economic integration trend to strengthen, Chinese companies are facing greater pressure of market competition, which is about not only domestic enterprises but also foreign enterprise. Companies can get a better development by widening the market, which include the advance of market share of enterprises and the widen of international market. There is a different and necessary way to enhance companies by improving their own management, which include the construction and dynamic management of quality management system, the improvement of enterprise own development ability and the construction of unique enterprise core competitiveness.

Enterprise management system is aimed at induction and summary of a series of managements, is systematic content, is the organic unity of the enterprise management activities, the rules and regulations and the management way. One of the most necessary content of the survival and development of the enterprise is quality management system for manufacturing enterprise. Thus, the manufacturing enterprise must strengthen quality management system to ensure the efficiency of management of manufacturing enterprise [1].

It is not enough that manufacturing enterprises only have quality management system. Because of the development of the manufacturing enterprises itself and the development of macro environment, industry environment and regional environment, manufacturing enterprises should adjust the quality management system of enterprises to ensure the effectiveness of the quality management system and meet the need of enterprises development. Manufacturing enterprises deciding whether they need to conduct its own quality management system by adjusting the effectiveness of quality management system [2]. Due to effectiveness of manufacturing enterprise quality management system is embodied in many aspects, effectiveness evaluation model that can handle the multi-index problem and comprehensive evaluation index system of manufacturing enterprise quality management system effectiveness is built by analyzing the characteristics of management of manufacturing enterprises and affecting factors of effectiveness of manufacturing enterprise quality management system.

Based on the above analysis, this research is aimed at effectiveness evaluation of manufacturing enterprise quality management system, and it plays an important role in promoting business management theories and solving manufacturing enterprise managed problems.

2. Definition on effectiveness of quality management system of manufacturing enterprise

2.1. Definition on effectiveness of quality management system of manufacturing enterprise

Quality management system and effectiveness evaluation should be defined before effectiveness of quality management system of manufacturing enterprises is defined.

Quality management system can be defined by following words: the organization adopt series of management methods, such as organization, technology, economy, contract and so on, to achieve the goal of quality management, which include relevant government regulations, industry standards, and specific requirements.

Effectiveness evaluation can be defined by following words: the estimator can assess the value of activities and judge the outcome of activities by setting the target and measures.

Based on the definition of quality management system and effectiveness evaluation, evaluation on the effectiveness of the quality management system of manufacturing enterprises can be defined by following:

Evaluation on the effectiveness of the quality management system of manufacturing enterprises is an activity, which is used to analysis the positive influence in the process of normal operations by making evaluation standard, determining the size of the influence and getting the special judgment.

2.2. Overall thinking on construction of quality management effect evaluation index system of manufacturing enterprises

According to the above analysis, the evaluation on the effectiveness of the quality management system of manufacturing enterprises is an activity, which is used to analysis the positive influence in the process of normal operations by making evaluation standard, determining the size of the influence and getting the special judgment. And evaluation on the effectiveness of the quality management system of manufacturing enterprises mainly involves two aspects: one is the construction of evaluation index system on the effectiveness of the quality management system of manufacturing enterprises, the other is the construction of evaluation model on the effectiveness of the quality management system of manufacturing enterprises. Meanwhile the specific operation of effectiveness of the quality management system and feedback and summary of effectiveness evaluation results are involved in the evaluation on the effectiveness of the quality management system of manufacturing enterprises [3].

Thus the evaluation on the effectiveness of the quality management system of manufacturing enterprises should follow the following procedure: firstly, evaluation index system on the effectiveness of the quality management system of manufacturing enterprises should be built by analyzing the characters and affecting factors of quality management of manufacturing enterprise, combining with the relevant provisions of the existing, following the principles of establishing the index system and according to the first-class-second-class sequence; secondly, evaluation model of effectiveness on quality management system of manufacturing enterprise should be built. because many aspects are involve in the effectiveness of the quality management system of manufacturing enterprises, mathematical model of multiple index values should be built in the process of evaluation on the effectiveness of the quality management system of manufacturing enterprises; thirdly, evaluation on the effectiveness of the quality management system of manufacturing enterprises can be operating by building the mathematical model and evaluation index system of effectiveness of the quality management system of manufacturing enterprises; finally, analyzing the evaluation results of effectiveness on quality management system of

manufacturing enterprise and reflecting the situation on the quality management system of manufacturing enterprises to improve the quality management system of manufacturing enterprise.

3. Establishment of index system and method of weight determination on effectiveness evaluation of manufacturing enterprise quality management system

3.1. Establishment of index system

To ensure the reliability and practicability of the index system construction, the systematic principle, the typical principle, the principle of operation and quantification, and comprehensive principle should be followed and thinking of first-class index system - second-class index system should be followed in the process of developing the effectiveness evaluation index system of manufacturing enterprise quality management system.

3.1.1. Establishment of first-class index system

Carrying out the manufacturing enterprise quality management system effectiveness evaluation is used to timely assess the effectiveness of the size of the quality management system and provide support for manufacturing enterprises timely detection of problems and deficiencies existing in its own quality management system. So, effectiveness evaluation index system on manufacturing enterprise quality management system should be built by following the relevant principle and consulting the content of the quality management system of the manufacturing enterprise and the requirement of the enterprise quality management system in the country.

First-class index system for evaluating the effectiveness of manufacturing enterprise quality management system should be composed of 7 first level indicators, which include effectiveness of validation, effectiveness of document management, effectiveness of production management, effectiveness of quality assurance and quality control, effectiveness of commissioned production and inspection, effectiveness of Issue and recall of products and effectiveness of self-checking.

3.1.2. Establishment of second-class index system and formation of index system

After the first-class index system on effectiveness evaluation of quality management system of manufacturing enterprise is established, the problem is establishment of second-class index system which can reflect the characteristics of the first-class index system to form an evaluation index system on effectiveness of manufacturing enterprise quality management system.

Evaluation index system of effectiveness of manufacturing enterprise quality management system is summarized in Table 1.

Something can be seen from the Table 1 that the evaluation index system is structured by seven first-class indexes which include effectiveness of validation, effectiveness of document management, effectiveness of production management, effectiveness of quality assurance and quality control, effectiveness of commissioned production and inspection, effectiveness of Issue and recall of products and effectiveness of self-checking, and each first-class index can be reflected through a number of second-class indexes. Finally, the index system, which has seven first-class indexes and twenty-seven second-class indexes, is built, and it can reflect the effectiveness of the quality management system of the manufacturing enterprise overall.

3.2. Determination of weight of index system

This paper makes an attempt to determine the weight of indexes through GAHP. The basic idea of this method is to determine the weight of indexes using AHP by experts respectively based on which the arithmetic mean value of evaluation results from experts are taken as the final result. This method makes up for the traditional AHP can only be determined by a single index weight problem [4].

Table 1. Evaluation index system of effectiveness of manufacturing enterprise quality management system

The target layer	First-class index	Second-class index
The effectiveness of the quality management system of manufacturing enterprises	Effectiveness of validation X_1	Verification and validation of institutions and personnel X_{11}
		Validation and verification of plant and facility X_{12}
		Verification and validation of equipment X_{13}
		Verification and validation of materials and products X_{15}
	Effectiveness of document management X_2	Quality standard X_{21}
		Processing procedure X_{22}
		Production records X_{23}
		Packaging record X_{24}
		Procedures, processes, and records of operation X_{25}
	Effectiveness of production management X_3	Prevention of pollution and cross contamination X_{31}
		Production operation management X_{32}
		Packaging operation management X_{33}
	Effectiveness of quality assurance and quality control X_4	Quality control and laboratory management X_{41}
		Material and product release X_{42}
		Continuous stability study X_{43}
		Change control X_{44}
		Processing bias X_{45}
		Corrective and preventive action X_{46}
		Supplier evaluation and approval X_{47}
		Product quality review X_{48}
		Complaints and adverse reaction reports X_{49}
	Effectiveness of commissioned production and inspection X_5	Commissioned production X_{51}
		Commissioned inspection X_{52}
	Effectiveness of Issue and recall of products X_6	Issue of products X_{61}
		Recall of products X_{62}
	Effectiveness of self-checking X_7	Self-checking plan X_{71}
		Self-checking report X_{72}

Although the GAHP method is able to achieve the goal of multi person decision weight, considering that when judging the relative importance weights of two indexes, decision makers may not judge through the numbers of “one to nine”, thus, judging from an interval-value may better reflect the intent of decision makers. It is necessary to clear each weight of every expert, because different experts have different experience, different status and different weight.

The core content of GAHP method is the determination of relative importance weights between two indexes, so the determination of relative importance weights between two indexes should be focused on the discussion.

Assuming that a total number of K experts participates in the effectiveness of the quality management system of manufacturing enterprises, then in the weight determination process of index system, the relative importance interval-value between x_g and x_h in the same level gotten by K expert ($k = 1, 2, \dots, K$) is $[d_{1e}^{(k)}, d_{2e}^{(k)}]$ ($d_{2e}^{(k)} \geq d_{1e}^{(k)}$) and the weights of each experts are c_k ($k = 1, 2, \dots, K$) respectively. Thus, the comparison value of relative importance of x_g and x_h is:

$$f_{g,h} = \frac{1}{2} \cdot \frac{\sum_{k=1}^K \{ [d_{2e}^{(k)}]^2 - [d_{1e}^{(k)}]^2 \} \cdot c_k}{\sum_{k=1}^K [d_{2e}^{(k)} - d_{1e}^{(k)}] \cdot c_k} \quad (1)$$

After determining the comparison value of relative importance of two indexes in the same level, according to the steps and requirements of AHP methods, the weight of evaluation index

system of the effectiveness of the quality management system of manufacturing enterprises can be determined.

The weight of X_i in the evaluation index system on the effectiveness of the quality management system of manufacturing enterprises is X_i ($i = 1, 2, \dots, 7$), first-class index weight vector $A = (w_1, w_2, \dots, w_7)$ and meet the condition of $w_i \geq 0$, and $\sum_{i=1}^7 w_i = 1$; the set formed by the weight of second-class indexes to the target layers is X_{is} ($i = 1, 2, \dots, 7$; $s = 1, 2, \dots, n_i$), second-class index weight vector $W_{ij} = (w_{i1}, w_{i2}, \dots, w_{in})$ and meet the condition of $w_{is} \geq 0$ and $\sum_{s=1}^{n_i} w_{is} = 1$.

4. Evaluation index system construction on the effectiveness of the quality management system of manufacturing enterprises based on interval-valued hesitation fuzzy set

As shown in Table 1, evaluation index system of the effectiveness of the quality management system of manufacturing enterprises involves five first-class indexes and twenty-seven second-class indexes among which the value of each index is determined by the understanding of experts to give the interval-valued hesitation fuzzy set [5-7]. Assuming that there is a total of K experts participate in the evaluation on the effectiveness of the quality management system of manufacturing enterprises, then, K expert ($k = 1, 2, \dots, K$) gives an interval-valued hesitation fuzzy set \tilde{X}_{ij} to a second-class index x_{ij} , with $\tilde{X}_{kij} = \{ \langle x, h_k(x) \rangle \}$, and $\sup h_k(x) \leq 1$.

Based on these, the interval-valued hesitation fuzzy set of second-class index x_{ij} given by these K experts is:

- Define the score function of \tilde{X}_{ij} as $s(\tilde{X}_{ij})$, then:

$$s(\tilde{X}_{ij}) = \sum_{k=1}^K \frac{1}{2K} (h_{kij}^-(x) + h_{kij}^+(x)). \tag{2}$$

Make the score function of \tilde{X}_{ij} , $s(\tilde{X}_{ij})$ as the index value of second-class index. The set formed by all these index values of second-class indexes is D_{ij} ($i = 1, 2, \dots, m$; $j = 1, 2, \dots, n$).

Based on these, the evaluation on the effectiveness of the quality management system of manufacturing enterprises can be carried out for a specific region. Take B as the effectiveness of the quality management system of manufacturing enterprises, then:

$$B = D_{ij} \otimes W_{ij}. \tag{3}$$

5. Conclusion

The research is aimed at effectiveness evaluation of manufacturing enterprise quality management system to improve the quality management system of manufacturing enterprise. Based on acquaintance of effectiveness of quality management system of manufacturing enterprise, the evaluation index system is structured by confirmation of production conditions and other seven respects which include effectiveness of validation, effectiveness of document management, effectiveness of production management, effectiveness of quality assurance and quality control, effectiveness of commissioned production and inspection, effectiveness of Issue and recall of products and effectiveness of self-checking; the assessment model of effectiveness of quality management system of manufacturing enterprise based on interval-valued hesitation fuzzy set is structured and the feasibility of theoretical research was validated by concrete cases.

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