PERFORMANCE EVALUATION MODEL OF REVERSE LOGISTICS MANAGEMENT IN MANUFACTURING ENTERPRISES

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***ABSTRACT**: The implementation of reverse logistics strategy can effectively help modern manufacturing enterprises to establish a good corporate image, reduce production costs and significantly improve the core competitiveness of enterprises. At present, there is not a set of evaluation method and system of reverse logistics management which can be really effective and highly accurate, so it is impossible to scientifically evaluate and analyze the performance level of reverse logistics management. Thus, this paper introduces the analytic hierarchy process (AHP) to deeply analyze and study the influencing factors and index system of reverse logistics performance in modern manufacturing enterprises. The performance evaluation model of reverse logistics is constructed based on this with fuzzy comprehensive evaluation method. Through empirical research and analysis, this paper expounds in detail the use of the basic principles and framework of reverse logistics management to establish a modern manufacturing enterprise-oriented reverse logistics management hierarchy model. By using the fuzzy comprehensive evaluation model, the performance level of reverse logistics of enterprises is evaluated scientifically.*

***KEYWORDS**: logistics management, reverse logistics, analytic hierarchy process, performance evaluation.*

1 INTRODUCTION

As a kind of logistics activity which is completely opposite to the traditional supply chain logistics direction, reverse logistics is the reverse logistics behavior from the consuming section to the starting section, aiming at restoring the value of original production materials, intermediate inventory and final products, or reasonably disposing expired products beyond service life (Cheng and Liu, 2007; Tang and Jing, 2008). The effective management of reverse logistics can reasonably restore the value of reverse logistics resources of enterprises, not only can help enterprises to significantly improve the achievements and benefits of environmental protection, but also can effectively reduce the production and operating costs of enterprises, meeting the requirements of sustainable development of enterprises. With the implementation and popularization of sustainable development strategy and green economic concept, the environmental protection consciousness and energy-saving economic development mode of the society have been enhanced effectively. No matter in academic circles or business circles, the reverse logistics management has drawn higher and higher attention. In the aspects of reducing the production cost, improve the core competitiveness and establishing the good social image of enterprises, the reverse logistics management has the unique advantage, so many famous enterprises at home and abroad, including GM, IBM, Haier and Huawei, have opened up the layout and implementation of reverse logistics management strategy in succession.

In the reverse logistics management, an enterprise must be able to carry out the scientific and reasonable analysis and evaluation of the enterprise's reverse logistics management cost and the performance, so as to determine the enterprise's own reverse logistics management performance and provide accurate decision-making basis for further improving the reverse logistics management level and enterprise competitiveness. In recent years, there is not much research on the performance evaluation of reverse logistics management in academic circles. The research mainly focuses on the channel mode optimization and dynamic evaluation of enterprises' reverse logistics, the agility analysis of reverse logistics management, the performance analysis and comprehensive evaluation of reverse logistics outsourcing and others (Agrawal et al., 2015; Rogers and Tibben-Lembke, 2011; Moussaoui et al., 2016), while the performance evaluation of reverse logistics management in growing manufacturing enterprises is not much involved. Therefore, this paper studies the comprehensive evaluation and analysis method of reverse logistics management performance of enterprises, especially for manufacturing enterprises, and establishes a concise, scientific, reasonable and accurate comprehensive evaluation model for reverse logistics management of enterprises, which has important realistic needs and academic value (Bouzon and Govindan, 2015; Sobotka and Czaja, 2015; Lai et al., 2013).

Based on this, this paper introduces the analytic hierarchy process (AHP) to deeply analyze and study the influencing factors and index system of reverse logistics performance in modern manufacturing enterprises. The performance evaluation model of reverse logistics is constructed based on this with fuzzy comprehensive evaluation method. Through empirical research and analysis, this paper expounds in detail the use of the basic principles and framework of reverse logistics management to establish a modern manufacturing enterprise-oriented reverse logistics management hierarchy model. By using the fuzzy comprehensive evaluation model, the performance level of reverse logistics of enterprises is evaluated scientifically.

2 REQUIREMENTS FOR THE PAPER

As a basic method of enterprise management performance, Key Performance Indicator (KPI) is a goal-oriented quantitative management index that can measure enterprise process performance, can help the enterprise to disassemble its own strategic objectives into operational individual work objectives. According to the overall business concept and the overall business objectives of the enterprise, each module related to the business process of the enterprise is decomposed into relevant indexes, and then the enterprise index score in the actual business process is reviewed and analyzed. According to the difference between the decomposed index score and the actual index score, the reasons are analyzed and summarized, so as to find out the solutions and methods that can make the score of actual indexes reach the ideal result, and finally help the enterprise to improve the operating condition and improve the operating level for more efficiently achieving business objectives, which is the key concept of KPI ((Agrawal et al., 2015; Rezgui and Maaouia, 2016).

In the actual operation, it is necessary to define the management strategy and target of the enterprise at first, determine the key management direction of the enterprise accordingly, and then carry out multi-level decomposition and KPI index quantification from the enterprise level, the department level and the individual level. The implementation of KPI evaluation and assessment by enterprises, especially production and manufacturing enterprises, can analyze the benefit level of various business processes scientifically and accurately as far as possible, so as to help enterprises improve the management level and implement the strategic concept.

Fuzzy comprehensive analysis is an effective dynamic decision-making method for evaluating and decision-making targets that are affected by many factors. Fuzzy comprehensive evaluation uses the membership function and the membership value to carry out the comprehensive analysis of the target result or the value, instead of the affirmation and the negation of the result simply with "0" and "1" value, such comprehensive analysis and the evaluation result is more scientific, objective and reasonable. In terms of the practical target decision-making and evaluation problem, the fuzzy comprehensive analysis method should first analyze and define the target factor set and the evaluation set, and then reasonably determine the weight of each level factor set according to the actual data and the factor analysis result; secondly, the membership function of each level factor set and evaluation set is constructed, and the membership value is calculated; finally, the fuzzy comprehensive evaluation matrix corresponding to the factor set and the evaluation set is established, and the evaluation matrix and the factor set weight eigenvector are synthetically analyzed, and the fuzzy comprehensive evaluation result is finally determined according to the principle of maximum membership degree (Nikolaou et al., 2013; Abdulrahman et al., 2014).

Production and manufacturing enterprises must face the comprehensive influence and restriction of multiple factors in their reverse logistics management. It is difficult for us to evaluate the influence or effect of some factors on management benefits. It is also difficult to identify whether some factors will have a significant impact on the efficiency of reverse logistics management, or it is difficult to determine whether there are any factors that can influence and restrict the efficiency of reverse logistics management. By using the fuzzy comprehensive analysis method to carry out the performance evaluation of reverse logistics management, we can avoid the problems and difficulties which must be solved with the above traditional evaluation methods and systems, so as to scientifically and reasonably carry out the comprehensive analysis of the cost and benefit of reverse logistics management of manufacturing enterprises, and provide scientific decision-making basis for promoting enterprises to improve and improve their own ability of reverse logistics management. Therefore, when using the fuzzy comprehensive analysis method to construct the reverse logistics management model of manufacturing enterprises, we can reasonably construct a targeted KPI index evaluation system by using reverse thinking analysis for reverse logistic management business, based on the business objectives and strategic intention of reverse logistics management of enterprises. Then, the KPI index is calculated and evaluated by using the fuzzy comprehensive analysis method, and thus the reverse logistics performance level and management ability of enterprises are scientifically measured and evaluated, so as to help enterprises realize efficient reverse logistics performance management strategy with scientific decision-making.

3 PERFORMANCE EVALUATION MODEL OF REVERSE LOGISTICS MANAGEMENT FOR MANUFACTURING ENTERPRISES

As an important link in the management and business of production and manufacturing enterprises, reverse logistics management must be consistent with the overall objectives and strategic intentions of the enterprises. Therefore, when carrying on the performance evaluation of the reverse logistics management business of the production and manufacturing enterprises, it is necessary to evaluate and reflect the contribution of the business completion and business objectives of reverse logistics management of enterprises to the implementation of enterprise strategic concept in a scientific, reasonable, complete and accurate as much as possible. This paper uses the 3W1H method and framework based on WHY, WHAT, WHO, and HOW to deeply analyze the management strategy, management objectives and management process of reverse logistics business of manufacturing enterprises. Through comprehensive analysis of the overall strategy and overall objectives of the enterprise, the management idea and strategy of reverse logistics business of the enterprise are clarified, and the index system that can reasonably reflect the completion degree of the enterprise's strategic objectives is defined accurately (Brito and Dekker, 2003). Therefore, we construct the performance index model for reverse logistics management business of manufacturing enterprises as shown in Figure 1.

The model includes two important processes and stages: the analysis and extraction of performance evaluation KPI indicators on reverse logistics management business for manufacturing enterprises, and the collation of KPI indicators data according to the actual business analysis. The KPI performance evaluation index extracted in the first stage must ensure the scientificity, objectivity, completeness and accuracy of the data on the basis of convenient and real-time acquisition. In addition, the KPI index must have sufficient extensibility and hierarchy in the breadth and depth, and can be consistent with the business objectives and basic contents of enterprise reverse logistics management. In order to ensure the scientificity and accuracy of the comprehensive evaluation and analysis results, it is necessary to make sure that the business data is true and reliable and can be collected and sorted in time in the second stage of analyzing and processing the data.

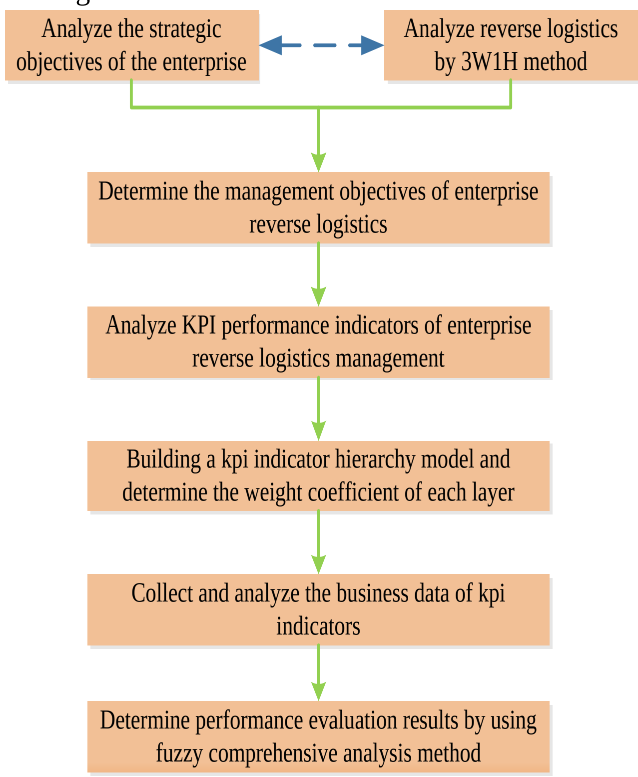

Figure 1. Schematic diagram of reverse logistics KPI performance hierarchy model

After constructing the complete performance index model of reverse logistics management, this paper uses the fuzzy comprehensive analysis method to establish the performance evaluation model of reverse logistics management for manufacturing enterprises quantitatively, which can scientifically and objectively reflect the management performance of reverse logistics business of enterprises. It is assumed that the KPI performance index is determined by the analysis of the performance index model as $A_{KPI}=(T;\ R_i;\ D_j)$ i=1,2,…,m; j=1,2,…n, where O represents the business objectives of reverse logistics management for manufacturing enterprises, *Ri* represents the sub-objectives of the general objectives of the reverse logistics management business of the enterprise, and *Di* is KPI index item, which reflects the degree of achievement of each sub-objective.

In the performance index model of enterprise reverse logistics management business, the weight coefficient of each KPI index can be analyzed and determined by using analytic hierarchy process. Assume $W_1 = (w_1, w_2, \ldots, w_m)$ is the index weight vector of the first layer in the hierarchical model, the weight vector of the *i*-th layer index in the index model is $W_1 = (w_{i-1}, w_{i-1,2}, \ldots, w_{i-1,n})$. In the process of comprehensive evaluation and analysis of indicators, because some KPI indicators cannot be precisely quantified in the actual process, fuzzy analysis method is adopted to quantify the degree of completion of each indicator with fuzzy evaluation set. The fuzzy evaluation set is $V=\{V_i\}$, where $\{V_1$=Excellent, V_2=Good, V_3=Medium, V_4=Qualified, V_5=Fail$\}$. After the fuzzy evaluation set is determined, the fuzzy comprehensive evaluation matrix of each sub-objective of a layer in the hierarchical model can be calculated by using the expert scoring method, i.e., $H_i^k = (h_{ij})^T k = 1,2,\ldots,m; j = 1,2,\ldots,n$, where each row vector in the fuzzy evaluation matrix H_i respectively corresponds to the membership value of the sub-objective in the evaluation set. Therefore, the fuzzy comprehensive evaluation results of enterprise reverse logistics management performance can be obtained as follows:

$$B = \max\{W_m * H^m\} = \max\{b_i\}\ i = 1,2,\ldots,n \tag{1}$$

Where

$$W_m = \{w_{m-1,1}, w_{m-1,2}, \ldots, w_{m-1,n}\} \tag{2}$$

Then

$$b_i = \sum_{j=1}^{m} w_{i,j} \cdot h_{j,k} \tag{3}$$

4 EMPIRICAL ANALYSIS OF THE APPLICATION OF EVALUATION MODEL

In order to test and verify the performance index model and performance evaluation model of reverse logistics management in enterprises and analyze the model performance, this paper take a manufacturing enterprise X as the experimental object, and comprehensively evaluates and analyzes The management performance of enterprise reverse logistics by the model constructed here with the evaluation and analysis process as follows:

Table 1. Reverse logistics KPI performance hierarchy model of A

	3W1H Method	Weight coefficient	Decomposition of the target	Weight coefficient	Value
Management performance of enterprise reverse logistics	W_1(Why)	0.449	Increase corporate profits	W_{11}	0.197
			Legal requirements	W_{12}	0.251
			Social responsibility	W_{13}	0.203
			Increase the utilization of raw materials	W_{14}	0.099
			Reduce return rates on products	W_{15}	0.104
			Improve product quality	W_{16}	0.152
	W_2(What)	0.198	Increase the recovery rate of parts and components	W_{21}	0.202
			Reduce packaging cost	W_{22}	0.803
	W_3(Who)	0.151	The recycling enterprise's acquisition intention	W_{31}	0.204
			Emphasis on reverse logistics	W_{32}	0.31
			The scale of investment in reverse logistics	W_{33}	0.498
	W_4(How)	0.202	Unblocked product recycling channels	W_{41}	0.196
			Cost control of product recovery	W_{42}	0.301
			Cost control ability of product reprocessing	W_{43}	0.152
			High utilization of recycled products	W_{44}	0.349

(1) The reverse logistics business management of the enterprise is analyzed by using 3W1H analysis method according to the overall objective and strategic intention of the enterprise. According to the analysis results, the whole management objective is divided and a hierarchical performance evaluation index system of KPI reverse logistics is constructed.

(2) Using AHP to analyze the objective of this layer in each layer of the performance index model, and according to the influence degree of the index and factors on the performance evaluation, sort the importance of the index and thus determine the weight coefficient of the index. Thus, the enterprise reverse logistics management performance index hierarchy model as shown in Table 1 can be constructed.

(3) The performance index model constructed in Table 1 is of two layers. For each key index in the second layer, the expert scoring method is used for comprehensive analysis and evaluation, and the membership matrix of each key index is calculated according to the given fuzzy evaluation set, with results as shown in table 2.

(4) The result of Step 2 and Step 3 is the input set of the enterprise reverse logistics management performance evaluation model. According to the model and Formula (1), the fuzzy evaluation result of the enterprise reverse logistics management performance can be obtained as follows, B= {0.468,0.366,0.167,0,0}, i.e., the reverse logistics management performance of the enterprise can be evaluated as Excellent.

Table 2 KPI indicator evaluation results

Decomposition of the target	The evaluation results				
	Excellent	Good	Medium	Qualified	Fail
Increase corporate profits	0.521	0.447	0.032	0	0
Legal requirements	0.596	0.401	0.003	0	0
Social responsibility	0.452	0.397	0.151	0	0
Increase the utilization of raw materials	0.646	0.198	0.156	0	0
Reduce return rates on products	0.55	0.152	0.298	0	0
Improve product quality	0.41	0.347	0.243	0	0
Increase the recovery rate of parts and components	0.603	0.299	0.098	0	0
Reduce packaging cost	0.311	0.498	0.191	0	0
The recycling enterprise's acquisition intention	0.398	0.305	0.297	0	0
Emphasis on reverse logistics	0.7	0.3	0	0	0
The scale of investment in reverse logistics	0.814	0.098	0.088	0	0
Unblocked product recycling channels	0.795	0.196	0.009	0	0
Cost control of product recovery	0.2	0.8	0	0	0
Cost control ability of product reprocessing	0.099	0.198	0.703	0	0
High utilization of recycled products	0.214	0.315	0.471	0	0

5 CONCLUSIONS AND PROSPECTS

By using the fuzzy comprehensive evaluation method based on KPI evaluation index, the management level and performance of reverse logistics business for manufacturing enterprises can be evaluated scientifically, reasonably and accurately, and the evaluation result of the model is extensible and comprehensive and can objectively reflect the insufficiency and shackles of reverse logistics business of enterprises, thus providing scientific decision-making basis for enterprises to raise and improve its management level and ability of reverse logistics business pertinently. Based on this, the paper introduces the analytic hierarchy process to deeply analyze and study the influencing factors and index system of the performance of reverse logistics in modern manufacturing enterprises. The performance evaluation model of reverse logistics is constructed based on this with fuzzy comprehensive evaluation method. This model makes up for the blank that at present there is no real effective and accurate evaluation method and system of reverse logistics management in manufacturing enterprises. It also overcomes the difficulties and challenges to evaluate and analyze the performance level of reverse logistics management of enterprises scientifically.

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