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Research Article

An Empirical Study of Agricultural Product Logistics Cost Control Evaluation via Fuzzy Analytic Hierarchy Process

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Abstract: It is one of the core agricultural logistics cost control to establish a reasonable and effective evaluation system of agricultural logistics cost control. In this study, based on the cost basis of the value chain, an agricultural logistics cost control evaluation system is established from three levels, including the logistics costs of agricultural pre-value chain, logistics costs of agricultural mid-value chain, logistics costs of agricultural late-value chain. AHP theory and expert investigation are used to determine weights and weights of the three levels of integrated sub-level indicators, which are as evaluation criteria to achieve quantified indicators. Finally, the index system established and fuzzy comprehensive evaluation are used to evaluate the logistics costs of a real agricultural logistics enterprise, demonstrating that the evaluation method is effective.

Keywords: Agricultural product, analytic hierarchy process, fuzzy comprehensive evaluation, logistics cost

INTRODUCTION

As the first industry in China, the agriculture has always been the foundation of the national economy which cannot be shaken. Agriculture not only created a huge demand for the market and provided the production factors but also provided an important product for the market. Production and consumption of agricultural products distribution exchange constitute the organic agriculture reproduction chain. With the development of economic integration, as one of the important part, the agricultural product logistics played a pivotal role. Traditional logistics cost control evaluation only took the enterprise as a standpoint, ignored the impact of the relationship between the enterprise and the cost of the logistics provider customers, which apparently has been difficult to obtain a competitive advantage to meet the business needs for development goals (Zhang, 2007). In view of this, an effective analytical tool is needed to meet the business requirements of the target to gain competitive advantage. And the modern theory of value chain analysis is this efficient method, which could analyze the impact from all aspects of the logistics costs of agricultural start. Therefore, based on the value chain theory, the agricultural logistics cost control should be evaluated the value creation and value of the investment from the perspective of a comprehensive evaluation of the level of agricultural logistics cost control. It reduces logistics costs of agricultural products and maximize the value of agricultural products are of great significance (Zhang, 2001). From the perspective of the value chain, the study will build logistics cost control evaluation index system of agricultural products and perform the comprehensive evaluation via the fuzzy comprehensive evaluation and analytic hierarchy process.

CONSTRUCTION OF EVALUATION INDEX SYSTEM

Cost control evaluation index systems of agricultural logistics is both contact and interact with each other by a group and it is an organic whole consisting of index factor according to a certain hierarchy. Evaluation system is a link to contact an expert assessment and evaluation object and also is a bridge linked the evaluation methods and evaluation object (Liang, 2009). Only to perform comprehensively the evaluation system and the indicators, we can produce a reasonable assessment of logistics costs as much as possible, to promote agricultural products logistics cost control reforms. Ding *et al*. (2012) used the fuzzy comprehensive evaluation method to produce a comprehensive evaluation of the logistics cost control from three aspects, including the outside, the internal value chain, the external value chain downstream; Zhao (2011) studied the agricultural products logistics system from logistics activity, logistics management mode, system structure and circulation mode based on the system theory of logistics and ABC Theory. Ou (2013) introduced the development mode and cost accounting of agricultural produce logistics and discussed the requirement in optimizing the cost structure of the

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Table 1: Evaluation system of agricultural value chain logistics cost control

First-level indicators	No.	Weight (w_i)	Second-level indicators	Indicators meaning	No.
The logistics costs of agricultural pre-value chain	U_1	w_1	Logistics costs of before production	It mainly refers to the kind of farming involves logistics costs and logistics costs related information	u_{11}
			Logistics costs in the production process	It mainly refers to nurture the growth of crops in the field of logistics cost management activities and farming class logistics management and other activities that occur	u_{12}
			Logistics costs of after production	It refers to the formation of the harvest logistics costs eventually produce	u_{13}
The logistics costs of agricultural mid-value chain	U_2	w_2	Procurement logistics costs	It mainly refers to the logistics costs of agricultural products produced in the procurement process	u_{21}
			Production logistics costs	It mainly refers to the logistics costs of agricultural products produced in the processing and production process	u_{22}
			Auxiliary production logistics costs	It mainly refers to the logistics costs of agricultural products produced in the auxiliary production process	u_{23}
The logistics costs of agricultural late-value chain	U_3	w_3	Sales logistics costs	It mainly refers to the logistics cost of the acquisition, packaging, storage, distribution and other long-haul and short-range transportation logistics activities	u_{31}
			Return logistics, waste stream costs	It mainly refers to the logistics cost of transport, handling and processing activity takes a lot of waste in agricultural production, marketing and consumption	u_{32}
			Customer service logistics costs	It mainly refers to the cost of providing logistics services for customers produced, including customer service information logistics costs and customer service implementation of logistics costs	u_{33}

Table 2: The average standard value random consistency index

n	2	3	4	5	6	7	8
RI	0.00	0.58	0.90	1.12	1.24	1.32	1.41

agricultural produce logistics. Taking these studies, many scholars have done a lot of valuable research on the evaluation experiments using different teaching methods from different angles. Consolidated results of their research, referring to its index system, this study attempts to construct an evaluation system consisting of the three first-level indicators, nine second-level indicators, which is shown as in the Table 1.

Comprehensive evaluation model based on AHP and the fuzzy comprehensive evaluation: Analytic Hierarchy Process is a weight decision analysis method, which was raised by the American Operations Research Professor Satty (1980) at the University of Pittsburgh in 1980s and the element will always be associated with the decision-making down into goals, guidelines, programs and other levels and the qualitative and quantitative analysis could be performed based on this method. This study combine it with the fuzzy comprehensive evaluation theory to quantize the evaluation factors and ultimately to quantify the value of the way to represent the results of the evaluation. The main steps of the application are shown as the following (Xiong *et al*., 2013; Jiang *et al*., 2009; Cao, 2008):

- According interrelated indexes and affiliation, the study generates the multi-level analysis of the structure to meet the requirements.
- To analyze the relationship between various factors analysis system and compare the importance of each element on the same level in the hierarchy on a certain criteria, the study constructs the comparison judgment matrix U.
- To calculated separately for each judgment matrix and its largest eigenvalue eigenvector λ_{max} and obtain a single-level sorting.
- To perform the consistency test to each judgment matrix:

$$CI = \frac{\lambda_{\max} - n}{n-1} \quad (1)$$

$$CR = \frac{CI}{RI} \quad (2)$$

where,

CI : The consistency of judgment matrix deviation indicator

CR: The random consistency ratio

RI : The random consistency index

If $CR<0.1$, then the result of the sort of level of consistency meets the requirements, otherwise you will need to re-amend the judgment matrix; and RI is related with the order of the matrix and under normal circumstances, the greater the number of matrix order, then the larger there is also the possibility of consistency random deviations, the corresponding relationship is shown in Table 2.

- To build a collection of reviews rating:

$$V = \{v_1, v_2, ..., v_m\}$$

- To establish judgment under the matrix:

$$R = \begin{pmatrix} R_1 \\ R_2 \\ \vdots \\ R_m \end{pmatrix} = \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{pmatrix} \quad (3)$$

where,
R_i : The evaluation outcome of the factor No. *i*
r_{ij} : The membership of the factor No. *i* which responds to the evaluation grade No. *j*
n : The number of rating scale in the reviews set
m : The number of factors to be evaluated

- To perform the first fuzzy compensative evaluation:

$$S_i = w_i \bullet R_i = \{w_{i1}, w_{i2}, ..., w_{ij}\} \bullet \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{pmatrix} \quad (4)$$

where,
w_i : The inner weight of the first-level indicators
R_i : The judgment under the matrix responding to the first-level indicators

- To perform the second fuzzy compensative evaluation:

$$A = W \bullet S \quad (5)$$

where,
W: The weight among the first-level indicators
S : The membership of reviews set V responding to the factor U
A : The total evaluation vector

- **To determine the evaluation grade:** For comparison, the results of the evaluation will be converted to the integrated value, where value of the evaluation level is V and evaluation results are F, then the results calculated are obtained from the Eq. (6):

$$F = A \bullet V^T \quad (6)$$

where,
V^T : The transpose matrix of a matrix evaluation level value V

CASE STUDY

- **Simulation experiments on AHP:** According to the above methods and principles, combined with the actual situation of certain agricultural products logistics enterprises, the analytic hierarchy structure model of simulation experiments is built and judgment matrix is established and calculated, weights of corresponding each index are shown in the last column of Table 3 to 6:
  - Calculation of the judgment matrix U
  - Calculation of the judgment matrix U_1
  - Calculation of the judgment matrix U_2
  - Calculation of the judgment matrix U_3
- **To build a collection of reviews rating:** According to the purpose of logistics cost control evaluation on agricultural, a set of five reviews is established below:

  $V = (v_1, v_2, v_3, v_4, v_5)$ = (very good, good, middle, weak, very weak)

- **To establish judgment under the matrix:** In accordance with the second-level indicators, evaluation of certain agricultural enterprise logistics cost control is performed the score. And based on the evaluation rating given rater, the membership is established; finally a judge under the matrix is constructed below:

$$R_1 = \begin{pmatrix} 0.36 & 0.24 & 0.22 & 0.13 & 0.05 \\ 0.42 & 0.31 & 0.16 & 0.07 & 0.04 \\ 0.28 & 0.30 & 0.26 & 0.10 & 0.06 \end{pmatrix}$$

$$R_2 = \begin{pmatrix} 0.48 & 0.20 & 0.18 & 0.12 & 0.02 \\ 0.41 & 0.33 & 0.15 & 0.08 & 0.03 \\ 0.28 & 0.32 & 0.25 & 0.10 & 0.05 \end{pmatrix}$$

$$R_3 = \begin{pmatrix} 0.32 & 0.30 & 0.21 & 0.15 & 0.02 \\ 0.40 & 0.28 & 0.20 & 0.09 & 0.03 \\ 0.28 & 0.30 & 0.24 & 0.11 & 0.07 \end{pmatrix}$$

Table 3: The judgment matrix U and inner weight w_0

Level	u_1	u_2	u_3	w_0
u_1	1	3	2	0.5396
u_2	1/3	1	1/2	0.1634
u_3	1/2	2	1	0.2970

λ_{max} = 3.0092; CI = 0.0046; CR = 0.0079<0.10

Table 4: The judgment matrix U_1 and inner weight w_1

Criterion U_1	u_{11}	u_{12}	u_{13}	w_1
u_{11}	1	1/5	1/3	0.1095
u_{12}	5	1	2	0.5816
u_{13}	3	1/2	1	0.3090

λ_{max} = 3.0037; CI = 0.0018; CR = 0.0032<0.10

Table 5: The judgment matrix U_2 and inner weight w_2

Criterion U_2	u_{21}	u_{22}	u_{23}	w_2
u_{21}	1	3	5	0.6370
u_{22}	1/3	1	3	0.2583
u_{23}	1/5	1/3	1	0.1047

λ_{max} = 3.0385; CI = 0.0193; CR = 0.0332<0.10

Table 6: The judgment matrix U_3 and inner weight w_3

Criterion U_3	u_{31}	u_{32}	u_{33}	w_3
u_{31}	1	5	2	0.5695
u_{32}	1/5	1	1/4	0.0974
u_{33}	1/2	4	1	0.3331

λ_{max} = 3.0246; CI = 0.0123; CR = 0.0212<0.10

Table 7: The classification evaluation

Reviews	90~100	80~90	70~80	60~70	0~60
Rating	Very good	Good	Middle	Weak	Very weak

- To perform the first fuzzy compensative evaluation:

$$S_1 = w_1 * R_1 = (0.3702,\ 0.2993,\ 0.1975,\ 0.0858,\ 0.0473)$$

$$S_2 = w_2 * R_2 = (0.4410,\ 0.2461,\ 0.1796, 0.1076,\ 0.0257)$$

$$S_3 = w_3 * R_3 = (0.3145,\ 0.2981,\ 0.2190,\ 0.1308,\ 0.0376)$$

- To perform the second fuzzy compensative evaluation:

$$S = \begin{pmatrix} 0.3702 & 0.2993 & 0.1975 & 0.0858 & 0.0473 \\ 0.4410 & 0.2461 & 0.1796 & 0.1076 & 0.0257 \\ 0.3145 & 0.2981 & 0.2190 & 0.1308 & 0.0376 \end{pmatrix}$$

and,

$$W = w_0 = (0.2797, 0.0936, 0.6267)$$

According to the Eq. (5):

$$A = w_0 * S$$
$$= (0.3652, 0.2903, 0.2010, 0.1027,\ 0.0409)$$

- To determine the evaluation grade and outcome analysis.
According to the Table 7, the median for each grade level are as a judge on behalf of each score, the outcome is as follows:

$$V = (95,\ 85,\ 75,\ 65,\ 30)$$

Therefore, Scores of evaluation results corresponding to each second-indicator were as follows:

$$F_1 = S_1 * V^T = 82.4185$$

$$F_2 = S_2 * V^T = 84.0477$$

$$F_3 = S_3 * V^T = 81.2683$$

Similarly, evaluation score of the results of the primary:

$F = A*V^T$ = (0.3652, 0.2903, 0.2010, 0.1027, 0.0409) * $(95, 85, 75, 65, 30)^T$ = 82.3438

The above scores are compared with in Table 7, the grade of three first-level indicators is all in the good grade, finally the total evaluation score is in the good grade, which is consistent with the practice.

CONCLUSION

In this study, an evaluation system of agricultural logistics cost is established from three aspects. A model of AHP and fuzzy comprehensive evaluation is used to analyze the agricultural logistics cost. And the result of an empirical analysis proved to be valid.

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