Research on performance evaluation mechanism of fresh agricultural products distribution system

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Abstract—Performance evaluation of fresh agricultural products public distribution system includes evaluation index and evaluation method. The distribution system is a strategic organization, the Balanced ScoreCard method should be used for index design, and the evaluation indexes include distribution enterprises, distribution centers and alliances. For the evaluation method, the fuzzy comprehensive evaluation method combining qualitative and quantitative methods is selected. Scientific evaluation mechanism provides the basis for the development strategy of distribution system.

1 INTRODUCTION

Fresh agricultural products distribution system is an operational system that provides agricultural products to urban customers and meets the needs of life through distribution enterprises. The operators of this system are composed of alliance enterprises and distribution centers which carry out distribution services, so it is difficult to operate, and needs to build a scientific evaluation mechanism to evaluate the system performance, so as to improve the operation level of the system.

2 THOUGHTS ON PERFORMANCE EVALUATION

The evaluation mechanism of distribution system mainly includes evaluation index and method. The subject and object of the mechanism is the alliance management organization, and the evaluation purpose is to reveal the performance level of the system operation, find the operation problems, and provide the basis for formulating the development strategy of distribution system.

2.1 Thougthts on Index Design

The performance index design theory of distribution alliance includes strategic alliance evaluation, life cycle evaluation and dynamic alliance evaluation. The strategic alliance evaluation uses the Balanced Scorecard idea to design the index; Life cycle evaluation divides alliance life cycle into design, implementation, output and termination stages, and establishes corresponding index system according to the characteristics of different stages [1]; the evaluation of dynamic alliance divides the operation process into several stages. The Balanced Scorecard is used in the index design of public distribution system of fresh agricultural products to deepen the alliance attribute of enterprise evaluation.

The Balanced Scorecard (BSC) is a strategic performance evaluation system proposed by Robert Kaplan, an American scholar. The BSC includes finance, customer, internal process, learning and growth, the financial indicators include sales, customer retention rate, customer satisfaction, etc., Internal process indicators include product quality, productivity and key business process improvement, Learning and growth indicators include employee ability, organizational information system, etc. The BSC method realizes the effective management of the alliance by solving the evaluation problems of the core enterprises of the alliance. In this study, the BSC are used to establish the first-class evaluation indicators of distribution enterprises including finance, customers, internal processes, learning and growth.

2.2 Seletion of Evaluation Methods

The performance evaluation of public distribution system of agricultural products include distribution enterprises, distribution centers and alliances, and the fuzzy comprehensive evaluation method is selected. Firstly the evaluation index factor set and comment set are established, and the weight of evaluation index is determined by Analytic Hierarchy Process (AHP),then the fuzzy evaluation of each single index factor is carried out, and the composite operation of fuzzy comprehensive evaluation matrix is carried out, Finally the result of fuzzy evaluation is obtained.

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3 DESIGN OF EVALUATION INDEX SYSTEM

3.1 Design Principle of Index

The index design follows the principles of scientificity, consistency with evaluation objectives, comparability, optimization and quantification. The principle of scientificity refers to the use of scientific methods and means to design indicators; the principle of consistency with the evaluation objectives means that the indicators can not only evaluate the merits and demerits of the evaluation objects, but also guide and encourage the alliance enterprises to develop towards the alliance goals; the principle of comparability means that the indicators can be compared in different periods or different objects; the optimization principle means that the index design should be carried out by the method of system theory. The principle of quantification means that the index is easy to measure.

3.2 Selection of Index

Comprehensive evaluation of distribution system starts from two points and one side to reflect the overall operation performance level of the system. Among them, two points refer to the core distribution enterprises and distribution centers, while the other refers to the alliance. In index design, based on BSC method, performance evaluation index system is proposed as shown in Table 1.

TABLE I. PERFORMANCE EVALUATION INDEX SYSTEM OF FRESH AGRICULTURAL PRODUCTS PUBLIC DISTRIBUTION SYSTEM

Primary index		Secondary index	
Index（Ai）	*Weight (Wi)*	*Index（Aij）*	*Weight (Wij)*
Finance （A1）	W1	Asset liability ratio（A12）	W11
		Return on total assets（A13）	W12
Customer （A2）	W2	Customer acquisition rate（A21）	W21
		Customer retention（A22）	W22
Internal process （A3）	W3	Turnover rate of total assets（A31）	W31
		Turnover rate of accounts receivable （A32）	W32
		Timeliness of delivery（A33）	W33
		Customer complaint handling rate（A34）	W34
Learning and growth （A4）	W4	Staff training rate（A41）	W41
		labour productivity（A42）	W42
		Growth rate of operating revenue（A43）	W43
		Growth rate of total assets（A44）	W44
Public Distribution Service （A5）	W5	Infrastructure service capacity（A51）	W51
		Drug residue inspection rate（A52）	W52
		Vehicle allocation rate（A53）	W53
		Circulation processing capacity（A54）	W54
		Information management level（A55）	W55
		Loss rate of agricultural products（A56）	W56
		Customer satisfaction（A57）	W57
Alliance satisfaction （A6）	W6	Enterprise qualification（A61）	W61
		Enterprise matching degree（A62）	W62
		Resource complementarity（A63）	W63
		Alliance Learning（A64）	W64
		Proportion of cooperative business income （A65）	W65

In the table 1, Top 5 first level indicators are used to evaluate core enterprises and distribution centers, and the last one is used to evaluate distribution alliance.

3.3 Enterprise evaluation

Enterprise evaluation includes five first-class indicators: finance, customers, internal process, learning and growth, and public distribution service [2]. The first four items are used to evaluate the core enterprises in the system. Item 5 is used to evaluate the distribution center. The secondary index design of enterprise evaluation focuses on the basis and accessibility of enterprise financial data [3].

- Financial indicators. including asset liability ratio and return on total assets. The asset liability ratio is calculated by the proportion of total liabilities to total assets, which is the key to the healthy survival and development of enterprises. The rate of return on total assets refers to the ratio between the enterprise's profit before interest and tax and the average total assets, which indicates the level of income obtained by all assets of the enterprise.

- Customer indicators. Including customer acquisition rate and retention rate. Customer acquisition rate refers to the market share of the business; Customer retention rate refers to the maintenance level of old customers, and the indicator value approaches 100%, which indicates that the customer loyalty is high and the service is satisfied.

- Internal process indicators. Including total assets turnover rate, accounts receivable turnover rate, delivery timeliness and customer complaint handling rate. The turnover rate of total assets refers to the ratio of business income to average total assets in a certain period of time, which reflects the utilization efficiency of all assets of an enterprise. The turnover rate of accounts receivable reflects the speed of realizing accounts receivable and the management efficiency of enterprises, the higher the turnover rate is, the stronger the recovery ability of accounts receivable is. Delivery timeliness refers to the ratio of the number of delivery delays to the total number of delivery times in a certain period of time, which reflects the level of distribution service. Customer complaint handling rate refers to the proportion of the number of customer complaints handled in the total number of customer complaints, reflecting the service level of enterprises to customers.

- Learning and growth indicators. including employee training rate, labor productivity, growth rate of operating income and growth rate of total assets. The employee training rate is expressed by the proportion of the number of trainees to the total number of employees, reflecting the degree of enterprise learning. Labor productivity is expressed by the average number of products per person, which reflects the productivity of employees. The growth rate of operating revenue refers to the ratio of the increase in operating revenue of the current year to the total operating revenue of the previous year, which indicates the increase or decrease of the operating income of the enterprise. The growth rate of total assets is a measure of the growth of the assets scale of an enterprise in the current period, and reflects the influence of the growth level of the enterprise scale on the development potential of the enterprise.

- Public distribution service indicators. Public distribution service refer to the service provided by distribution center to both parties of transaction and distribution enterprises, and the evaluation includes infrastructure service capacity, drug residue inspection rate, vehicle allocation rate, circulation and processing capacity, information management level, agricultural products loss rate, customer satisfaction. Infrastructure services should be measured from transaction area, car park area, water and electrical facilities; The inspection rate of pesticide residues refers to the proportion of the amount of drug residues in the total amount of agricultural products entering the market; Vehicle allocation rate refers to the proportion of the number of vehicles owned by the distribution center to the total number of vehicles distributed in the market every day; Circulation processing capacity is measured by the proportion of distribution processing volume in the total market after entering the market; The level of information

management is measured by the integrity and utilization rate of front and back office management functions of market information management system and e-commerce platform; The loss rate of agricultural products refers to the proportion of the average monthly loss of agricultural products to the total amount of monthly transactions; Customer satisfaction refers to the satisfaction degree of agricultural products trading parties and distribution enterprises to the service of distribution center.

3.4 Evaluation of alliance satisfacion

Alliance satisfaction refers to the satisfaction degree of distribution enterprises to the realization degree of alliance strategic objectives, including two aspects. One is the satisfaction degree of the enterprise to the alliance operation process; the other is the contribution of strategic alliance to the realization of enterprise strategic objectives and the realization degree of objectives. According to the distribution alliance satisfaction principle, we can design the enterprise qualification, enterprise matching degree, resource complementarity, alliance learning, and the proportion of cooperation business income in the lower level. According to the satisfaction principle of distribution alliance, we can design the lower level indicators of enterprise qualification, enterprise matching degree, resource complementarity, alliance learning, and the proportion of cooperation business income to the lower level indicators. The first four indicators are used to evaluate the enterprise satisfaction with the operation process of the alliance, and the last index evaluates the enterprise's satisfaction with the operation results of the alliance.

Enterprise qualification refers to the degree of alliance quality of participating enterprises, including cooperation experience, reputation, etc. Enterprises with good qualifications have the better ability to promote the realization of alliance goals. Enterprise matching degree refers to the matching degree in the aspects of enterprise culture, competition and cooperation balance, the more similar the corporate culture, the easier the knowledge transfer among alliance partners; the reasonable equilibrium of competition and cooperation can avoid vicious competition, and high degree of strategic matching can reduce opportunism. This index reflects the "3C" principle of alliance object selection, that is compatibility, capability and commitment. The higher the matching degree of enterprises is, the less problems appear in the process of cooperation. Resource complementarity refers to the extent to which enterprises make use of each other's resources. A high degree of resource complementarity is conducive to improving the utilization efficiency of enterprise resources. Alliance learning refers to the mutual learning of knowledge or skills between enterprises. Only when the participating enterprises obtain the desired knowledge or skills, the alliance can be recognized as effective. The lower level indicator of cooperative business income refers to the proportion of business income realized through alliance or enterprise cooperation to total enterprise income. The

higher the index value is, the better the cooperation effect will be.

4 FUZZY EVALUTIONF

Fuzzy evaluation includes establishing index factor set and comment set, determining index weight and fuzzy analysis.

4.1 Set up evaluation index factor set and comment set

The evaluation index factor set is divided into two levels, corresponding to the first level index factor set (AI, I = 1,2,3,4,5,6) and the second level index factor set (AIJ) in Table 5-1 respectively. The evaluation index factor set is divided into two levels, corresponding to the first level index factor set (AI, I = 1,2,3,4,5,6) and the second level index factor set (AIJ) in Table 5-1, where j is the serial number of the second level index under the I first level index. The first level index factor set includes six indicators: Finance (A1), customer (A2), internal process (A3), learning and growth (A4), public distribution service (A5) and alliance satisfaction (A6).

The second level index factor set (Aij) has six sub factor sets, including A1j (j=1,2,3),which is the operating revenue growth rate (A11),asset liability ratio (A12) and return on total assets (A13),A2j (j = 1,2) which is the customer acquisition rate (A21) and customer retention rate (A22),A3j (j = 1,2,3,4) which is the total assets turnover rate(A31),accounts receivable turnover rate (A32),delivery timeliness (A33) and customer complaint handling rate (A34).A4j (j= 1,2,3,4) which is the employee training rate(A41),labor productivity (A42), operating income growth rate (A43) and total asset growth rate (A44), A5j (j = 1,2,3,4,5,6,7) which is the infrastructure service capacity(A51),drug residue inspection rate(A52),vehicle allocation rate (A53), circulation and processing capacity (A54), information management level (A55), loss rate of agricultural products (A56),customer satisfaction (A57), A6j (j= 1,2,3,4,5) which is the enterprise qualification(A61),enterprise matching degree(A62),resource complementarity(A63), alliance learning (A64) and the proportion of cooperative business income (A65). There are five grades in the comment set, and V_k={v_1,v_2,v_3,v_4,v_5} ={excellent, good, general, qualified, unqualified}.

4.2 Determine index weight

Using analytic hierarchy process (AHP) to determine the index weight.

4.2.1 Determine the weight of the first level index Wi

Invite experts to rate the importance of index Ai. Using 1-9 scale method to make pairwise comparison and assignment, the first level index judgment matrix A can be established. According to the formula $CI = (\lambda_{max} - n)/(n - 1)$, the consistency index

CI of matrix A is calculated, where λ_{max} is the largest eigenvalue of matrix A and n is the order of matrix A; Calculating eig (A) in matlab, and λ_{max} and its corresponding eigenvector ξ are obtained, CI can be obtained by bringing the obtained λ_{max} into CI formula. According to table 2, the average random consistency index RI can be obtained.

TABLE II. Average Random Consistency Index Ri

n	1	2	3	4	5	6	7	8	9
RI	0.00	0.00	0.58	0.9	1.12	1.24	1.32	1.41	1.45

Calculate the random consistency ratio CR=CI/RI, if CR<0.1, then the judgment matrix A has satisfactory consistency. After normalizing the eigenvector ξ, the weight set Wi(i=1,2,3,4,5,6) of the first level index can be obtained.

4.2.2 Determine the weight of the second level index Wij

In the same way, six secondary indexes can be established to compare the judgment matrix. By using the function eig (), we can get the largest eigenvalue and corresponding eigenvector of each judgment matrix of the secondary index, and conduct consistency test. If the test is passed, the consistency index of total ranking is calculated, hierarchical total sorting $CI = \sum_{j=1}^{5} w_j CI_j$, $RI = \sum_{j=1}^{5} W_j RI_j$, CR=CI/RI. If CR<0.1, The overall consistency test is passed, which proves that the weight distribution of secondary indicators is reasonable. Finally, the eigenvectors corresponding to the largest eigenvalue of each judgment matrix A_i are normalized to obtain the weight set W_{ij} of each secondary index.

4.3 Fuzzy evaluation analysis

4.3.1 Determine the intial value of secondary index

Eight experts are invited to determine the evaluation grade of each secondary index by voting according to the evaluation set, and the expert voting vector V_{ik} is used to express the evaluation result of the experts on the index grade. The expert voting vector V_{ik} consists of 5 digits, from left to right, respectively representing the number of expert votes rated as excellent, good, general, qualified and unqualified, V_{ik} is the result of experts' grade evaluation on index j, The total number of this vector is 8 (votes).

According to the data source or quantifiable, the secondary indicators are divided into qualitative and quantitative indicators. The evaluation grade of quantitative index can be expressed by the total number of experts. For qualitative indicators, the grade evaluation needs to be determined by experts' voting, and the number of experts' votes may be distributed in each grade,

indicating the possible grade evaluation results of qualitative indicators. The expert voting vector set V_{ik} of all indexes is the initial value of fuzzy evaluation.

4.3.2 Determine the fuzzy evaluation value

Let the subordinate degree of the secondary index A_{il} to the evaluation set V_k is r_{ik}, $r_{ik} = V_{ik}/8$, V_{ik} is the number of eight experts who believe that A_{il} belongs to V_k, the subordinate degree of A_{il} to each evaluation grade is calculated respectively, and the fuzzy evaluation matrix $r_i(i = 1,2,3,4,5,6)$ of each secondary index is obtained. According to the weight set of secondary index $W_{il}(i = 1,2,3,4,5,6)$ and r_i, the fuzzy evaluation matrix R of the first level index can be obtained by using the formula $R_i = W_{il} \cdot r_i (i = 1,2,3,4,5,6)$;according to the weight set W and matrix R of the first level index, the evaluation result vector V of agricultural product distribution system can be obtained by using the formula $V = W \cdot R$. Set five evaluation grades {excellent, good, general, qualified, unqualified} and take 95 points, 85 points, 75 points, 65 points and 50 points respectively, then we can calculate the hundred point system score of fuzzy evaluation of agricultural products distribution system.

5 CONCLUSION

This paper evaluates the performance of public distribution system of agricultural products by constructing a scientific evaluation mechanism. The operation of the system is realized through distribution alliance, distribution enterprises and distribution centers, and the performance indicators should be fully covered.

Alliance index is designed according to alliance evaluation theory and practice requirements, reflecting the characteristics and attributes of alliance; the index of distribution enterprises and distribution centers is designed according to the requirements of distribution theory and practice, reflecting the characteristics of distribution operation.

The indicators used in the performance evaluation of distribution system are qualitative indicators, and the fuzzy comprehensive evaluation method combining qualitative and quantitative methods is adopted. First of all, we should establish the evaluation index factor set and comment set, and determine the weight of the evaluation index by AHP. Then the single index factors are fuzzy evaluated, and the fuzzy comprehensive evaluation matrix is calculated to get the fuzzy evaluation results.

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