

Applying Rough Set Theory to Evaluate Network Marketing Performance of China's Agricultural Products

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Abstract—Agricultural products network marketing means fully introducing e-commerce systems into the sale process of agricultural products, using information technologies to publish and collect the demand and price information, and relying on agricultural production bases and logistics distribution systems to enhance brand images, improve customer services, develop online marketing channels and ultimately expand marketing activities. It is very important to evaluate the performance of agricultural products network marketing. The paper proposed a performance evaluation model of agricultural products network marketing based on rough set theory. The model used genetic algorithm to reduce the initial decision table and, through calculating the importance of the decision attributes in the reduced decision table, identified the weight coefficients of various influencing indexes, effectively overcoming the subjectivity of weight coefficient determination in the current evaluation models. In the same time, the paper evaluated the network marketing performance of six agricultural enterprises and the results were in line with the actual results, which verified the validity of the proposed evaluation model. Lastly, the paper, according to the reduced results of the initial index system, proposed specific measures and suggestions to improve the network marketing performance of agricultural products.

Index Terms—agricultural products; network marketing; performance evaluation; rough set theory; measures and suggestions

I. INTRODUCTION

With the development of science and technology and the adjustment of industrial layout, China's markets for agricultural products are rapidly expanding. Especially after the accession to WTO, with a large influx of foreign agricultural products, the domestic supply of agricultural products becomes relative surplus and there are more intense competitions in agricultural products marketing. Network marketing is based on the Internet, computer communications and digital switching telecommunications for the media to implement the company's creative philosophy and objectives in new ways, methods and ideas and to complete entire marketing activities including product pricing, promotion,

distribution etc. With the rapid development of the Internet, the network economy, as an important form of knowledge-based economies, is very much concerned about by all sectors of society, and network marketing is an important component of network economy, which is known as the mainstream of the 21st century.

At present, some foreign countries had early starts for researching on network marketing. Economists Philip Kotler and Gary Armstrong believe that network marketing is electronically linking customers and dealers to carry out marketing through network and computer systems [1]. Thomas Melon, an U.S economist Professor, first proposed the concept of network marketing and divided network marketing into a kind of narrow network marketing and a kind of broad network marketing. The former refers to that in the process of electronic trading, sellers find out potential customers and understand their needs and buyers find out potential sellers and understand the conditions of their products and so on. The latter refers to that all the commercial activities in various aspects including not only buying and selling but also designing, manufacture and management are supported by information technology. American scholars Andrew and Whiston defined that network marketing is a kind of modern business method which can improve the quality of products and services and fasten service delivery speed to meet the needs of governmental organizations, manufacturers and consumers for lower costs. Ward Mason, a professor in Stanford University, in his book "*Principles of Internet Marketing*", systematically overviewed the profound changes brought to marketing by the Internet, revealed the basic principles of network marketing, described the framework of network marketing and proposed specific implementation strategies of network marketing [2]. Don Peppers and Martha Rogers, in their book "*The One to One Future*", discussed the combination of future marketing and technologies as well as the prospect of one-on-one technology, and, in particular, referred to the characteristics of marketing taking an individual as the target and group services [3]. Cliff Allen, in his "*Internet World Guide to One-to-One Web Marketing*", provided

valuable lessons, tips, and guidelines on how to make the best technology selections for company's budget and goals, and plan a successful one-to-one Web marketing initiative; built relationships with customers using personalization, push, interactivity, telephone and A/V conferencing, e-mail, virtual community, and other cutting-edge Web technologies; and integrated one-to-one Web marketing strategies with other processes and systems, such as customer service and support and databases [4]. Lee Fox and Janus Research results show that the customer response to online content and conduct of the physical world can be very similar. Like in the physical world, users in many of the same characteristics and tendencies of human nature in dealing with virtual information.

Though the late emergence of network marketing in China, only more than a decade, but more and more scholars start studying network marketing. Feng Yingjian has written more than 300 articles related to network marketing in three years, and published the book "*Basis and Practice of Network Marketing*", which comprehensively described the functions of network marketing, revealed the essence of network marketing, systematically and clearly set out the basic framework and methodology system of network marketing, proposed various practices of network marketing with higher values [5]. Qu Yunbo and Qi Limin, in the "*Network Marketing*" book, discussed the theoretical framework of network marketing and proposed concrete network marketing strategies such as website strategy, online advertising strategy, network public relations strategy, network channel strategy, customer service strategies and so on [6]. Liu Manfeng, LI Zhicheng and Wang Yan et al researched on the performance evaluation of enterprises' network marketing. The former set up a network marketing evaluation index system including four aspects: marketing costs, marketing expenses, marketing outputs and marketing influence; the latter focused on the evaluation of network marketing with Web sites including indicators of Web site design, website promotion, site traffic and network marketing efficiency [7, 8].

Agricultural products network marketing means fully introducing e-commerce systems into the sale process of agricultural products, using information technologies to publish and collect the demand and price information, and relying on agricultural production bases and logistics distribution systems to enhance brand images, improve customer services, develop online marketing channels and ultimately expand marketing activities [9]. Network marketing is a new marketing approach which may open up a broader market for agricultural products trade, strengthen the links between farmers and the outside world, promote the sales of agricultural products, improve the relationships between farmers and customers, and help farmers analyze market needs to decide the production direction [10]. China's local governments have established their local agricultural information networks, have opened the agricultural on-line exhibitions, and have displayed their new and special

agricultural products with various languages. And many have established their web platforms for agricultural products network marketing, which have achieved very good results. However, at present there are few studies on the performance evaluation of agricultural products network marketing, lacking a sound evaluation index system and no mature evaluation methods. Therefore, it is of great practical significance to study the performance evaluation of agricultural products network marketing. The paper will firstly establish an evaluation index system of agricultural products network marketing performance, and then propose a performance evaluation model based on rough set theory. The model uses the importance of decision attributes to determine the weight coefficients of various influencing indexes and calculates comprehensive evaluation values according to the scores of various indexes, realizing the performance evaluation of agricultural products network marketing. Through evaluating six agricultural enterprises, the results are in line with the actual results, which verified the validity of the performance evaluation model.

II. THE IMPORTANCE OF IMPLEMENTING NETWORKING MARKETING OF AGRICULTURAL PRODUCTS IN CHINA

A. *Accessing to More Market Information and Increasing Trading Opportunities*

Internet can send information to every corner of the world. The implementation of network marketing of agricultural products can use advanced and convenient network technologies to establish agricultural market information systems, which can enable agricultural producers and consumers informed of the varieties, quantity, supply and demand, price changes and other information of agricultural products both at home and abroad, breaking the limitations of time and space to achieve the diversification of traders and providing agricultural producers and consumers with broader business opportunities.

B. *Reducing Circulation Costs and Lowering Transaction Costs*

The implementation of network marketing of agricultural products can make agricultural producers and consumers directly exchange each other, which reduces the circulation links of agricultural products and shortens the circulation time. Many surveys show that Web-based dissemination of information and selling products do not need to pay the booth fee, product display fees, and does not require large investments in fixed assets, making a significant reduction in transaction costs.

C. *Guiding Scientific Production and Avoiding Blind Follow*

Through network marketing of agricultural products, producers can quickly understand the market information, and in accordance with market demand and price changes, scientifically organize their production, providing what the market needs to avoid losses brought about by blind production.

D. Building Brands and Establishing Product Image

Comparing with the traditional methods of agricultural marketing, online media owns the advantages such as high speed of designing, wide coverage ability, excellent dynamic effects and low-cost publicity, especially in network messaging environment, fast communication and display of merchandise using the Internet are in favor of the establishment of brand reputation.

III. THE EVALUATION INDEX SYSTEM OF AGRICULTURAL PRODUCTS NETWORK MARKETING PERFORMANCE

A. The Principles of Establishing Evaluation Index System of Agricultural Products Network Marketing Performance

In order to make the index system not only reflect network marketing performance of agricultural products comprehensively, scientifically, systematically, but also be of good maneuverability in the implementation, we must follow some principles when designing the evaluation index system.

(1) Scientific Principle. Any index in the evaluation index system of agricultural products network marketing performance should have definite connotation and scientific interpretation. It should take account of index selection, confirm of index weight and the comparability of data selection and scientific calculation methods, and reflect the operation of network marketing performance of agricultural products.

(2) Objectivity Principle. The setting of every index should reflect a situation of the network marketing performance of agricultural products objectively and factually. It also reflects the connotation of network marketing performance of agricultural products and to better reflect the level and existing problems of network marketing performance of agricultural products.

(3) Overall Principle. Index system should measure the functions and final effects of network marketing performance of agricultural products. It should have both subjective "soft index" and objective "hard index", to strive for a comprehensive scientific evaluation of the level and performance of network marketing performance of agricultural products.

(4) Goal Congruence Principle. Goal congruence principle refers to obtaining consistence among network marketing performance of agricultural products targets, evaluation index and evaluation purposes in the evaluation system. Network marketing performance of agricultural products aims at measuring levels and performance of it, reflecting problems existed in the process of network marketing performance, in order to serve for agricultural enterprises to realize strategic target. On the other hand, evaluation index embodies the request of evaluation purpose. Therefore, evaluation indexes should be also consistent with the target of network marketing performance of agricultural products.

(5) Maneuverability Principle. The design of performance evaluation index of network marketing of

agricultural products should follow definitude, specification, measurability and other principles. The required data being selected should be relatively easy to obtain and measurable, and calculation methods should also be relatively easy to master, in order to improve maneuverability of index system in practice. The agricultural enterprises should try to select comprehensive and critical index and some complementary index. The design of index should consider not only support, difficult degree and reliability of data, but also simplification of calculation methods and so on. If evaluation index is too complicated, it would cause difficulties for evaluation, and even not allowed to manipulate; on the other case, it cannot reflect the basic situation of evaluation objects.

(6) Practicality Principle. Index system should start from simple one and combine needs with possibility, theory with practice, making index simple and practical.

B. The Evaluation Index System of Agricultural Products Network Marketing Performance

Network marketing of agricultural products, according to the availability of online marketing website, can be divided into two categories: non-site network marketing and website network marketing. Based on the positioning of network promotion, network marketing of agricultural products can use corresponding non-site network marketing strategy, especially when the strength of marketing enterprises are not enough powerful. Considering that the establishment and maintenance of websites require huge investment, enterprises whose own strengths are not very strong and with relatively small operation scale should not invest in the construction of their own websites but release supply and demand information in professional agricultural websites (such as agro-processing websites, agricultural market information websites as well as some official agriculture websites) to release information with small costs. This marketing strategy has been proved a practical practice for agricultural enterprises whose strength is not strong. Although Non-site network marketing of agricultural products is more practical and cheaper for agricultural enterprises with inadequate strength, it is not conducive to branding their products and their long-term development. So when enterprises own a certain scale and strength, they should set up their own Websites. The paper mainly studies on performance evaluation of the website network marketing. Performance indicators which may reflect the network marketing performance of agricultural products mainly include the following aspects:

1) Financial effect indicators

(1) Growth rate of sales profit. It is a composite indicator, which not only reflects the growth in production, but also reflects the improvement of quality and the reduction of consumption. Growth rate of sales profit refers to the rate of sales profit to sales cost in a certain period.

(2) Return on net assets. It means the ratio of net profit of a certain period to average net assets, which reflects the profitability of enterprise owned capital, highlights the relationship between investment and reward, and is one of

the core indicators to evaluate the effectiveness of business operations.

2) Marketing influence indicators

(1) Website social popularity. The higher the visibility of websites, the better the effectiveness of website promotion is. To some extent it reflects the site's status and its influence on enterprises.

(2) Consumer loyalty degree. It is represented by the times the same user visits a site in a certain period. This indicator reflects the site's attractiveness to users. The higher customer loyalty, the more successful the website operates.

(3) Customer satisfaction degree. It reflects the satisfaction degree of customers with enterprise products, services, management philosophy and corporate image, which can be obtained through the investigation.

3) Website effect indicators

Website effect indicators mainly include categories: website design, website performance, website promotion, website traffic, which reflects the support function effects of websites to enterprise's network marketing.

(1) Website design

① Function comprehensiveness: The roundness and practicality are the main standards off websites' function comprehensiveness. The indicator is a qualitative indicator with a wide range, which mainly refers to the comprehensiveness of providing information, the convenience of online transactions and payments, as well as the statistical function of customer information. ② Style uniqueness: It mainly refers to whether the design of one website is different from other related websites, including different page designs, different website contents, and the unique service way. ③ Information update frequency: Both website pages and website contents need constantly updated in order to improve the quality of website information resources and the confidence of the site.

(2) Website performance

① Safety reliability: It includes the site's own security, the security of online transactions (consumers' transaction

information and private information) and online payment security, and so on. ② Network linking validity: The Linking validity of all pages of a website. ③Homepage download speed: It refers too the time required to open the homepage, which is an important factor impacting customer satisfaction. Long time waiting may bring customers a sense of disgust.

(3) Website promotion

① Web page hits: The times of all the visitors browsing the pages in a certain period. A visitor may visit the same page several times in the period. ② Registered users growth rate: The number of registered users in a certain sense shows the customers resources owned by the website. ③Website external linking numbers: The more the number of external linking numbers of a website, the easier it is to raise awareness.

(4) Website traffic

① Independent visitor numbers: The number of visitors of a website in a certain period of time. Each fixed visitor represents a unique user. ②Average retention time per visitor: The time all users stay on the site divided by the average user number. The stay length of visitors reflects the attraction of the site.

According to the principles of purposefulness, scientific, practicality and comprehensiveness, the paper establishes an evaluation index system of agricultural products network marketing performance [11], as shown in Table. I

IV. THE PERFORMANCE EVALUATION MODEL OF AGRICULTURAL PRODUCTS NETWORK MARKETING BASED ON ROUGH SET THEORY

A. Rough Set Theory

Rough set concept was introduced by Professor Z.Pawlak in early 1980s. Rough set theory is a mathematical tool for extracting knowledge from uncertain and incomplete information. The theory assumes that we first have necessary information or knowledge of all the objects in the universe with which the objects

TABLE I.
THE EVALUATION INDEX SYSTEM OF AGRICULTURAL PRODUCTS NETWORK MARKETING PERFORMANCE

Evaluation objective	Evaluation criteria	Indexes	Symbol representation
The performance evaluation of agricultural products network marketing	Financial effects	Growth rate of sales profit	F ₁
		Return on net assets	F ₂
	Marketing influence	Website social popularity	F ₃
		Consumer loyalty degree	F ₄
		Customer satisfaction degree	F ₅
	Website effects	Function comprehensiveness	F ₆
		Style uniqueness	F ₇
		Information update frequency	F ₈
		Safety reliability	F ₉
		Network linking validity	F ₁₀
		Homepage download speed	F ₁₁
		Web page hits	F ₁₂
		Registered users growth rate	F ₁₃
		Website external linking numbers	F ₁₄
		Independent visitor numbers	F ₁₅
		Average retention time per visitor	F ₁₆

can be divided into different groups. If we have exactly the same information of two objects, then we say that they are indiscernible (similar), that is, we cannot distinguish them with known knowledge. Rough set theory can be used to mine dependence relationship among data, evaluate the importance of attributes, discover the patterns of data, learn common decision-making rules, reduce all redundant objects and attributes and seek the minimum subset of attributes [12].

B. Related Concepts

- Upper approximation, lower approximation and positive region. Let: U is a given universe and R is an equivalence relation family in the universe; $K = (U, R)$ represents a knowledge base. Let: $X \subseteq U$, when X can be represented by the union of the subsets of R , X is definable; otherwise, X is indefinable. The definable sets of R are called precise sets and the indefinable sets are called rough sets. They are described by upper and lower approximation [13]: The lower approximation of X on R : $\underline{R}X = U \{Y \in U / R | Y \subseteq X\}$; The upper approximation of X on R :

$$\overline{R}X = U \{Y \in U / R | Y \cap X \neq \Phi\}; \text{ The positive region of } X \text{ on } R: pos_R(X) = \underline{R}X.$$

- Dependency degree. In the knowledge base $K = (U, R)$, let $C, D \subseteq R$, the dependency degree of D on C is:

$$\gamma_C(D) = |pos_C(D)| / |U| \quad (1)$$

where $|U|$ is the cardinal number of U .

- Information representation systems. An information representation system can be represented:

$$S = (U, A, V, f)$$

where U is the objects set; $C \cup D = A$ is the attributes set; uncorrelated subsets C and D are respectively called condition attributes set and decision attribute set; V is the set of attribute values and $f: U \times A \rightarrow V$ is a information function which defines the value of each attribute in the universe U .

- Attribute reduction and attribute importance. Attribute reduction is one of the core contents of rough set theory. Attribute reduction is to delete unrelated or unimportant attributes under the condition of keeping the same classification ability of knowledge base. In decision table, different attributes may have different importance. In order to gain the importance of attributes, we first delete some attribute from the decision table and then see whether the classification ability is changed. If without the attribute, the classification ability is changed great, which shows that the importance of the attribute is high, otherwise, the importance is low. The importance of attribute subsets $C' \subseteq C$ about D is:

$$\sigma_{CD}(C') = \gamma_C(D) - \gamma_{C-C'}(D) \quad (2)$$

Especially, when $C' = \{a\}$, the importance of attribute $a \in C$ about D :

$$\sigma_{CD}(a) = \gamma_C(D) - \gamma_{C-\{a\}}(D) \quad (3)$$

C. The Basic Steps of the Performance Evaluation Model of Agricultural Products Network Marketing Based on Rough Set Theory

According to the above analysis, we now propose the basic steps of the performance evaluation model of agricultural products network marketing based on rough set theory:

Step 1: Establishing the evaluation index system of agricultural products network marketing performance. In the second part, we have established the index system;

Step 2: Acquiring and discretizing index data. Rough set theory generally deals with discrete data. In the paper, the quantitative data are obtained according to the actual data and qualitative data are scored by related experts. After acquiring the index data, we use rough set theory to discretize them firstly;

Step 3: Constructing the decision table of the agricultural products network marketing performance evaluation. According to the first two steps, we can obtain the attribute value and establish the decision table;

Step 4: Reducing the decision table and obtaining core attribute set;

Step 5: In accordance with the reduced decision table, deriving the positive region of attribute set C on D : $pos_C(D)$, and using the formula (1) to calculate the dependency degree of each attribute $\gamma_C(D)$;

Step 6: Using the formula (3) to calculate the importance of each attribute in the reduced decision table $\sigma_{CD}(a)$, and sort the various attributes.

Step 7: Normalizing the importance of various attributes:

$$\omega_i = \frac{\sigma_{C'D}(F_i)}{\sum \sigma_{C'D}(F_i)} \quad (4)$$

Step 8: Calculating the total score of evaluation objects, using the following formula:

$$V = \sum_{i=1}^t \omega_i y_i \quad (5)$$

V. APPLICATION EXAMPLES

The paper applies the evaluation index system of agricultural products network marketing performance proposed in the second part, including sixteen indexes: Growth rate of sales profit, Return on net assets, Inventory turnover, Website social popularity, Consumer loyalty degree, Customer satisfaction degree, Function comprehensiveness, Style uniqueness, Information update frequency, Safety reliability, Network linking validity, Homepage download speed, Web page hits, Registered users growth rate, Website external linking numbers, Independent visitor numbers, Average retention time per visitor.

TABLE II.
THE DECISION TABLE OF AGRICULTURAL PRODUCTS NETWORK
MARKETING PERFORMANCE EVALUATION

Samples U	Condition attributes C								Decision attribute D
	F ₁	F ₂	F ₃	F ₄	F ₅	F ₆	F ₇	F ₈	
X ₁	2	1	4	1	3	4	2	1	2
X ₂	1	4	3	1	1	4	3	1	3
X ₃	4	2	1	3	1	2	2	3	4
X ₄	1	1	2	4	3	1	2	2	2
X ₅	4	4	2	2	2	3	1	1	2
X ₆	2	3	3	3	1	4	1	1	3
X ₇	2	3	1	1	4	4	4	4	3
X ₈	1	4	2	3	1	1	3	3	3
X ₉	2	2	4	1	3	4	1	2	4
X ₁₀	1	2	3	1	2	2	2	2	1
X ₁₁	4	1	2	1	1	2	2	2	2
X ₁₂	1	3	4	2	1	2	3	1	2
X ₁₃	1	2	3	1	1	2	1	4	1
X ₁₄	2	2	1	1	3	3	2	4	3
X ₁₅	2	1	2	3	1	4	4	4	3
X ₁₆	4	4	4	1	2	2	4	1	4
X ₁₇	2	4	1	2	4	3	3	3	2
X ₁₈	1	4	4	2	3	1	1	4	3
X ₁₉	2	3	1	4	2	2	1	1	3
X ₂₀	1	2	4	3	4	1	3	1	4

Samples U	Condition attributes C								Decision attribute D
	F ₉	F ₁₀	F ₁₁	F ₁₂	F ₁₃	F ₁₄	F ₁₅	F ₁₆	
X ₁	1	4	4	4	1	1	2	1	2
X ₂	1	2	3	1	2	3	4	1	3
X ₃	2	3	4	1	2	3	1	1	4
X ₄	2	3	1	4	4	2	3	1	2
X ₅	2	3	2	2	2	4	4	2	2
X ₆	2	3	4	2	3	1	1	1	3
X ₇	2	3	1	2	3	2	3	2	3
X ₈	2	4	1	3	1	2	4	1	3
X ₉	2	3	4	1	2	3	1	1	4
X ₁₀	2	4	4	1	1	1	1	2	1
X ₁₁	2	1	3	4	2	1	2	3	2
X ₁₂	2	3	2	1	2	3	3	1	2
X ₁₃	1	2	4	3	1	2	3	1	1
X ₁₄	2	4	3	1	2	2	2	2	3
X ₁₅	2	1	3	3	2	3	4	1	3
X ₁₆	4	2	2	2	2	1	1	4	4
X ₁₇	2	3	1	2	3	4	4	1	2
X ₁₈	2	1	1	2	3	2	3	3	3
X ₁₉	1	4	2	1	1	2	3	2	3
X ₂₀	1	2	4	2	4	1	3	1	4

A. Constructing the Decision Table of the Agricultural Products Network Marketing Performance Evaluation

The paper carried on survey on twenty agricultural enterprises and obtained related index data. The qualitative very important, important, general and not

important, respectively represented by 4, 3, 2 and 1. And the quantitative data are obtained according to the actual data and are discretized in ROSETTA. Thus, we can construct the decision table of the agricultural products network marketing performance evaluation, as Table.II shown. data are scored by related experts and divided into four levels:

B. Reducing the Decision Table

In ROSETTA, we apply the reduction algorithm of Genetic Algorithm to get a reduction of the above decision table is {F₂, F₅, F₁₂, F₁₆}, as Table.III shown.

C. Calculating the Dependency Degree and Importance of the Attributes in the Reduced Decision Table.

From the reduce decision table, we can get [14]:

$$U / \{F_2\} = \{\{X_1, X_4, X_{11}, X_{15}\}, \{X_3, X_9, X_{10}, X_{13}, X_{14}, X_{20}\}, \{X_6, X_7, X_{12}, X_{19}\}, \{X_2, X_5, X_8, X_{16}, X_{17}, X_{18}\}\}$$

$$U / \{F_5\} = \{\{X_2, X_3, X_6, X_8, X_{11}, X_{12}, X_{13}, X_{15}\}, \{X_5, X_{10}, X_{16}, X_{19}\}, \{X_1, X_4, X_9, X_{14}, X_{18}\}, \{X_7, X_{17}, X_{20}\}\}$$

$$U / \{F_{12}\} = \{\{X_1, X_2, X_8, X_9, X_{11}, X_{13}, X_{18}\}, \{X_4, X_5, X_6, X_{15}, X_{16}, X_{17}, X_{19}\}, \{X_7, X_{12}, X_{14}\}, \{X_3, X_{10}, X_{20}\}\}$$

$$U / \{F_{16}\} = \{\{X_1, X_2, X_3, X_5, X_7, X_8, X_{11}, X_{12}, X_{14}, X_{16}, X_{19}, X_{20}\}, \{X_4, X_6, X_9, X_{13}, X_{18}\}, \{X_{10}, X_{17}\}, \{X_{15}\}\}$$

$$U / \{F_2, F_5\} = \{\{X_1, X_4\}, \{X_{11}, X_{15}\}, \{X_3, X_{13}\}, \{X_{10}\}, \{X_9, X_{14}\}, \{X_{20}\}, \{X_6, X_{12}\}, \{X_{19}\}, \{X_7\}, \{X_2, X_8\}, \{X_5, X_{16}\}, \{X_{18}\}, \{X_{17}\}\}$$

TABLE III.
THE REDUCED DECISION TABLE OF AGRICULTURAL PRODUCTS NETWORK
MARKETING PERFORMANCE EVALUATION

Samples U	Condition attributes C'				Decision attribute D
	F ₂	F ₅	F ₁₂	F ₁₆	
X ₁	1	3	1	1	2
X ₂	4	1	1	1	3
X ₃	2	1	4	1	4
X ₄	1	3	2	2	2
X ₅	4	2	2	1	2
X ₆	3	1	2	2	3
X ₇	3	4	3	1	3
X ₈	4	1	1	1	3
X ₉	2	3	1	2	4
X ₁₀	2	2	4	3	1
X ₁₁	1	1	1	1	2
X ₁₂	3	1	3	1	2
X ₁₃	2	1	1	2	1
X ₁₄	2	3	3	1	3
X ₁₅	1	1	2	4	3
X ₁₆	4	2	2	1	4
X ₁₇	4	4	2	3	2
X ₁₈	4	3	1	2	3
X ₁₉	3	2	2	1	3
X ₂₀	2	4	4	1	4

$U/\{F_2, F_{12}\} = \{\{X_1, X_{11}\}, \{X_4, X_{15}\}, \{X_9, X_{13}\}, \{X_{14}\},$
 $\{X_3, X_{10}, X_{20}\}, \{X_6, X_{19}\}, \{X_7, X_{12}\}, \{X_2, X_8, X_{18}\},$
 $\{X_5, X_{16}, X_{17}\}\}$
 $U/\{F_2, F_{16}\} = \{\{X_1, X_{11}\}, \{X_4\}, \{X_{15}\}, \{X_3, X_{14}, X_{20}\},$
 $\{X_9, X_{13}\}, \{X_{10}\}, \{X_7, X_{12}, X_{19}\}, \{X_6\}, \{X_2, X_5, X_8,$
 $X_{16}\}, \{X_{18}\}, \{X_{17}\}\}$
 $U/\{F_5, F_{12}\} = \{\{X_2, X_8, X_{11}, X_{13}\}, \{X_6, X_{15}\}, \{X_{12}\},$
 $\{X_3\}, \{X_5, X_{16}, X_{19}\}, \{X_{10}\}, \{X_1, X_9, X_{18}\}, \{X_4\},$
 $\{X_{14}\}, \{X_{17}\}, \{X_7\}, \{X_{20}\}\}$
 $U/\{F_5, F_{16}\} = \{\{X_2, X_3, X_8, X_{11}, X_{12}\}, \{X_6, X_{13}\},$
 $\{X_{15}\}, \{X_5, X_{16}, X_{19}\}, \{X_{10}\}, \{X_1, X_{14}\}, \{X_4, X_9,$
 $X_{18}\}, \{X_7, X_{20}\}, \{X_{17}\}\}$
 $U/\{F_{12}, F_{16}\} = \{\{X_1, X_2, X_8, X_{11}\}, \{X_9, X_{13}, X_{18}\},$
 $\{X_5, X_{16}, X_{19}\}, \{X_4, X_6\}, \{X_{17}\}, \{X_{15}\}, \{X_7, X_{12},$
 $X_{14}\}, \{X_3, X_{20}\}, \{X_{10}\}\}$
 $U/\{F_2, F_5, F_{12}\} = \{\{X_1\}, \{X_4\}, \{X_{11}\}, \{X_{15}\}, \{X_{13}\},$
 $\{X_3\}, \{X_{10}\}, \{X_9\}, \{X_{14}\}, \{X_{20}\}, \{X_6\}, \{X_{12}\}, \{X_{19}\},$
 $\{X_7\}, \{X_2, X_8\}, \{X_5, X_{16}\}, \{X_{18}\}, \{X_{17}\}\}$
 $U/\{F_2, F_5, F_{16}\} = \{\{X_1\}, \{X_4\}, \{X_{11}\}, \{X_{15}\}, \{X_3\}, \{X_{13}\},$
 $\{X_{10}\}, \{X_9\}, \{X_{14}\}, \{X_{20}\}, \{X_6\}, \{X_{12}\}, \{X_{19}\}, \{X_7\}, \{X_2,$
 $X_8\}, \{X_5, X_{16}\}, \{X_{18}\}, \{X_{17}\}\}$
 $U/\{F_2, F_{12}, F_{16}\} = \{\{X_1, X_{11}\}, \{X_4\}, \{X_{15}\}, \{X_9, X_{13}\},$
 $\{X_{14}\}, \{X_3, X_{20}\}, \{X_{10}\}, \{X_6\}, \{X_{19}\}, \{X_7, X_{12}\}, \{X_2,$
 $X_8\}, \{X_{18}\}, \{X_5, X_{16}\}, \{X_{17}\}\}$
 $U/\{F_5, F_{12}, F_{16}\} = \{\{X_2, X_8, X_{11}\}, \{X_{13}\}, \{X_6\}, \{X_{15}\},$
 $\{X_{12}\}, \{X_3\}, \{X_5, X_{16}, X_{19}\}, \{X_{10}\}, \{X_1\}, \{X_9, X_{18}\},$
 $\{X_4\}, \{X_{14}\}, \{X_{17}\}, \{X_7\}, \{X_{20}\}\}$
 $U/C' = U/\{F_2, F_5, F_{12}, F_{16}\} = \{\{X_2, X_8\}, \{X_{11}\}, \{X_{13}\},$
 $\{X_6\}, \{X_{15}\}, \{X_{12}\}, \{X_{13}\}, \{X_{19}\}, \{X_5\}, \{X_{16}\}, \{X_{10}\},$
 $\{X_1\}, \{X_9\}, \{X_{18}\}, \{X_4\}, \{X_{14}\}, \{X_{17}\}, \{X_7\}, \{X_{20}\}\}$
 $U/D = \{\{X_{10}, X_{13}\}, \{X_1, X_4, X_5, X_{11}, X_{12}, X_{17}\},$
 $\{X_2, X_6, X_7, X_8, X_{14}, X_{15}, X_{18}, X_{19}\}, \{X_3, X_9, X_{16}, X_{20}\}\}$

And,

$$\begin{aligned}
 pos_{C'}(D) &= \bigcup_{X \in U/D} C'X = \{X_2, X_8\} \cup \{X_{11}\} \cup \{X_{13}\} \cup \{X_6\} \\
 &\cup \{X_{15}\} \cup \{X_{12}\} \cup \{X_{13}\} \cup \{X_{19}\} \cup \{X_{15}\} \cup \{X_{16}\} \cup \\
 &\{X_{10}\} \cup \{X_1\} \cup \{X_9\} \cup \{X_{18}\} \cup \{X_4\} \cup \{X_{14}\} \cup \{X_{17}\} \\
 &\cup \{X_7\} \cup \{X_{20}\} = \{X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, \\
 &X_{10}, X_{11}, X_{12}, X_{13}, X_{14}, X_{15}, X_{16}, X_{17}, X_{18}, X_{19}, X_{20}\} \\
 pos_{C'-F_2}(D) &= \{X_{13}\} \cup \{X_6\} \cup \{X_{15}\} \cup \{X_{12}\} \cup \{X_3\} \\
 &\cup \{X_{10}\} \cup \{X_1\} \cup \{X_4\} \cup \{X_{14}\} \cup \{X_{17}\} \cup \{X_7\} \cup \\
 &\{X_{20}\} = \{X_1, X_3, X_4, X_6, X_7, X_{10}, X_{12}, X_{13}, X_{14}, X_{15}, \\
 &X_{17}, X_{20}\} \\
 pos_{C'-F_5}(D) &= \{X_1, X_{11}\} \cup \{X_4\} \cup \{X_{15}\} \cup \{X_{14}\} \cup \\
 &\{X_3, X_{20}\} \cup \{X_{10}\} \cup \{X_6\} \cup \{X_{19}\} \cup \{X_2, X_8\} \cup \\
 &\{X_{18}\} \cup \{X_{17}\} = \{X_1, X_2, X_3, X_4, X_6, X_8, X_{10}, X_{11}, \\
 &X_{14}, X_{15}, X_{17}, X_{18}, X_{19}, X_{20}\}
 \end{aligned}$$

$$\begin{aligned}
 pos_{C'-F_{12}}(D) &= \{X_1\} \cup \{X_4\} \cup \{X_{11}\} \cup \{X_{15}\} \cup \{X_3\} \cup \\
 &\{X_{13}\} \cup \{X_{10}\} \cup \{X_9\} \cup \{X_{14}\} \cup \{X_{20}\} \cup \{X_6\} \cup \{X_{12}\} \cup \\
 &\{X_{19}\} \cup \{X_7\} \cup \{X_2, X_8\} \cup \{X_{18}\} \cup \{X_{17}\} = \{X_1, X_2, X_3, \\
 &X_4, X_6, X_7, X_8, X_9, X_{10}, X_{11}, X_{12}, X_{13}, X_{14}, X_{15}, X_{17}, X_{18}, \\
 &X_{19}, X_{20}\}
 \end{aligned}$$

$$\begin{aligned}
 pos_{C'-F_{16}}(D) &= \{X_1\} \cup \{X_4\} \cup \{X_{11}\} \cup \{X_{15}\} \cup \{X_{13}\} \\
 &\cup \{X_3\} \cup \{X_{10}\} \cup \{X_9\} \cup \{X_{14}\} \cup \{X_{20}\} \cup \{X_6\} \cup \{X_{12}\} \\
 &\cup \{X_{19}\} \cup \{X_7\} \cup \{X_2, X_8\} \cup \{X_{18}\} \cup \{X_{17}\} = \{X_1, X_2, \\
 &X_3, X_4, X_6, X_7, X_8, X_9, X_{10}, X_{11}, X_{12}, X_{13}, X_{14}, X_{15}, \\
 &X_{17}, X_{18}, X_{19}, X_{20}\}
 \end{aligned}$$

So, using (1) and (3), we get the importance of each attribute:

$$\begin{aligned}
 \gamma_{C'}(D) &= |pos_{C'}(D)|/|U| = 20/20 = 1 \\
 \sigma_{C'D}(F_2) &= \gamma_{C'}(D) - \gamma_{C'-F_2}(D) = 1 - 12/20 = 0.4 \\
 \sigma_{C'D}(F_5) &= \gamma_{C'}(D) - \gamma_{C'-F_5}(D) = 1 - 14/20 = 0.3 \\
 \sigma_{C'D}(F_{12}) &= \gamma_{C'}(D) - \gamma_{C'-F_{12}}(D) = 1 - 18/20 = 0.1 \\
 \sigma_{C'D}(F_{16}) &= \gamma_{C'}(D) - \gamma_{C'-F_{16}}(D) = 1 - 18/20 = 0.1
 \end{aligned}$$

Using (5), we can get the normalized weights of reduced indexes:

$$\begin{aligned}
 \omega_2 &= \frac{\sigma_{C'D}(F_2)}{\sum \sigma_{C'D}(F_i)} = \frac{0.4}{0.4 + 0.3 + 0.1 + 0.1} = 0.445 \\
 \omega_5 &= \frac{\sigma_{C'D}(F_5)}{\sum \sigma_{C'D}(F_i)} = \frac{0.3}{0.4 + 0.3 + 0.1 + 0.1} = 0.333 \\
 \omega_{12} &= \frac{\sigma_{C'D}(F_{12})}{\sum \sigma_{C'D}(F_i)} = \frac{0.1}{0.4 + 0.3 + 0.1 + 0.1} = 0.111 \\
 \omega_{16} &= \frac{\sigma_{C'D}(F_{16})}{\sum \sigma_{C'D}(F_i)} = \frac{0.1}{0.4 + 0.3 + 0.1 + 0.1} = 0.111
 \end{aligned}$$

Seen from the above values, in the proposed evaluation index system of agricultural products network marketing performance, the importance order of various indexes is: Return on net assets, Consumer loyalty degree, Web page hits, Average retention time per visitor, and other indexes are either contained by the above four indexes or are redundant indexes.

D. The Examples of Agricultural Products Network Marketing Performance Evaluation.

The paper evaluates of the network marketing performance six agricultural enterprises, as Table.VI shown. Seen from the above table, we can get the comprehensive evaluation scores of various enterprises, the higher the score is, the better the performance is, otherwise, the worse. We can see that the comprehensive evaluation scores of enterprises are respectively 78.255, 78.81, 76.59, 66.045, 61.605 and 41.07, so we can get the order: E₂, E₁, E₃, E₄, E₅ and E₆.

VI. COUNTERMEASURES AND SUGGESTIONS OF IMPROVING THE PERFORMANCE OF CHINA'S AGRICULTURAL PRODUCTS MARKETING NETWORK

According to the reduced results of the performance evaluation index system of network marketing in Part V,

TABLE IV.
THE EXAMPLES OF AGRICULTURAL PRODUCTS NETWORK MARKETING
PERFORMANCE EVALUATION

Enterprises E	Single index scores y_i				Comprehensive evaluation scores $V = \sum_{i=1}^t \omega_i y_i$
	F ₂	F ₅	F ₁₂	F ₁₆	
E ₁	75	80	90	75	78.255
E ₂	85	75	65	80	78.81
E ₃	85	75	40	85	76.59
E ₄	70	65	45	75	66.045
E ₅	55	65	85	55	61.605
E ₆	20	55	80	45	41.07

return on net assets, consumer loyalty degree, web page hits and average retention time per visitor are the key factors to affect the network marketing performance of agricultural products. Therefore, agricultural enterprises should improve their performance of network marketing of agricultural products from the following specific aspects:

A. Taking Full Advantage of Internet Resources to Reduce Transaction Costs and Transaction Costs

Agricultural enterprises should make full use of Internet resources to establish personalized e-commerce sites, display their products and services online, receive orders, and then send agricultural products to the final consumers through logistics and distribution system. This kind of trading model can reduce many distribution links such as agents, wholesalers and retailers, which can not only reduce transaction costs but make the ultimate benefit for final consumers by lowering product prices. In addition, advertising online can also lower costs. Studies have shown that if using the Internet as an advertising medium to promotions online, the expenses are only ten percent of traditional advertising budget with an increase of 10 times sales. In network marketing, agricultural enterprises can grasp the supply and demand information of all the goods through the network in order to adjust inventory levels in accordance with orders, which can achieve zero inventory, greatly reducing the transaction costs of storage.

B. Serving Customers Better and Meeting Customers' More Needs

In the network marketing model, agricultural enterprises should produce personalized products according to customer requirements to meet customers' more needs, and set proper prices which can be accepted by customers willingly. Network marketing should provide a full range of goods information display and retrieval mechanisms for multi-functional products in order to meet consumers' demand once. Agricultural enterprises should also provide after-sale tracking service through the establishment of electronic files to discover new customer needs and do their best to meet customers' realistic and potential demand. From the view of meeting customer demands, agricultural products should be classified in accordance with the most important attributes so that consumers will be able to purchase agricultural

products according to their own needs. As a result of agricultural production affected by natural conditions, it is difficult for producers to control the yield and quality, so it is particularly important to grade agricultural products in the sales. After being graded, agricultural products can meet consumer demands at different levels and different requirements.

C. Overall Planning Agricultural Marketing Systems to Increase Web Page Hits

(1) The construction of website must first register a concise domain name which is in accordance with enterprise's name to avoid taking a long time to remember the domain name. In addition, the domain name should also take into account the international characters of the Internet such as the domain name of Gannan Fruit www.gnorange.com and Dunhuang Seed www.dhseed.com.

(2) Selecting the appropriate server in accordance with enterprise's actual scale and development plans. Under normal circumstances, large-scale agricultural enterprises, considering these enterprises' own large database as well as security problems, should choose to set up their own server. And medium-sized businesses can share the server with other enterprises or rent virtual hosts from network operating company, which can save large sums of money to maintain servers and network administrators. But when renting a virtual host, enterprises must choose reliable network operators to avoid the trouble of the slow speed.

(3) Web design strategy. First, we must refer to experts' advice of network marketing design experts. Second, the design should weigh against the visual impact and the speed. Netizens' endurance is limited. If in order to show off the company's strength, put panoramic photos on the home page or insert a pile of product pictures in a single page, most viewers will choose to leave because of too slow speed. Needed to take pictures, files' size should also be controlled.

(4) Web page strategy. According to the survey of China Internet Network Information Center by the end of 2006, 87.6% of internet users know new websites by search engine, 65.8% from other sites' links, so search engine is the key of improving the discovery rate. In light of the search features of search engines, in order to facilitate the search, on the one hand, all the articles in the website should be given index titles. On the other hand, websites should contain the keywords clearly. In the production of web pages, the title of the article to the most important keyword and cultural refinement, to not only appear in the title of the article, in the core of the article should be appropriate to increase the frequency of use of key words. Furthermore, if the release is a dynamic web page, search engines have been difficult to do the technical processing.

VII. CONCLUSIONS

Agricultural products network marketing can provide all-sided market information for farmers and agricultural enterprises to help them analyze the market and make right decision. The paper proposed a performance evaluation model of agricultural products network

marketing based on rough set theory and evaluated the network marketing performance of six agricultural enterprises and the results were in line with the actual results, which verified the validity of the proposed evaluation model. Lastly, the paper proposed countermeasures and suggestions of improving the performance of China's agricultural products marketing network according to the reduced results.

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