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Study on Evaluation Model of International Trade in Agricultural Products Based on Unascertained Measure

Yongzhi Chang, Suocheng Dong*

Institute of Geographic Sciences and Natural Resources Research, the Chinese Academy of Sciences, Beijing 100101, China
dongsc@igsnrr.ac.cn

Considering the trade deficit, China's agricultural trade situation is not optimistic. Traditional evaluation of agricultural products trade is analyzed using the gravity model from the viewpoint of qualitative analysis. This paper attempts to build the unascertained measure model to evaluate the trade of agricultural products qualitatively and quantitatively. Through the analysis of domestic and foreign trade in agricultural products, it constructs 4 first grade indices and 12 second grade indices from the angle of policy, economy, agricultural products and market, and then confirms the weights of the first indices and the weights of the second indices in the means of information entropy and the AHP theory separately. The system of agricultural products trade is calculated using the unascertained measure model, and the evaluation result of China-India trade in agricultural products in 2012 is encouraging. The evaluation result of China-India trade in agricultural products matches the reality, which verifies the feasibility of unascertained measurement model.

1. Introduction

China has become the world's third largest agricultural trading nation, the fourth largest exporter and the third largest importer of agricultural products (Liu and Huang, 2013). According to the statistics data in 2014, China's import volume of agricultural products, exports and deficit are $ 122.54 billion, $ 71.96 billion and $ 50.58 billion, respectively. The high deficit not only reflected the competitiveness of China's agricultural products in the world, but also warned us that it is important to consider the reasonableness of trade during agricultural trade, and thus the evaluation of agricultural products trade is necessary.
The traditional way to evaluate agricultural products trade is based on the qualitative analysis, which evaluates factors in the aspect of the way and the cause of trade (Sheng and Liao, 2014). (Tao, 2013) studied the causes of the bilateral agricultural products trade deficit in China and concluded that the unfavorable balance of trade is due to the lack of the relevant information of the trading countries. Although this evaluation method is able to describe the factors in the angle of qualitative analysis, the influencing extent of these factors cannot be explained, which shows the drawbacks of this method. The major applications are the gravity models that can be used to evaluate agricultural trade. (Zhao and Lin, 2008) used the gravity model to study the affecting factors in the China-ASEAN agricultural trade and pointed out that the main influencing factors of agricultural trade between China and ASEAN are GNP, population, the distance and some related system policies, etc. However, this method also has some limitations considering that it only evaluates the fixed factors and ignores the unascertained information. (McCallum, 1995) used gravity model to confirm the existence of the border is the factors that affects the cost of bilateral trade. And then, (Anderson and Wincoop, 2003) pointed out that the results from McCallum J gravity model deviated due to the lack of analysis. So the imperfection of gravity model is obvious. Based on the analysis above, this paper takes the unascertained measurement to evaluate the importance and the rationality of the factors that affect agricultural products trade. The model used in this paper is a method that combines both qualitative and quantitative analysis, and it takes the uncertain information into consideration. And this paper presents the calculated results.

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2. The unascertained measure

The uncertain information was called fuzzy or random information for a long time, and the nature of fuzzy and random information was considered to be the same. Actually, in terms of their nature, there is tremendous difference between them. Random information refers to the information that the number of the types are confirmed but their types remain unconfirmed. Fuzzy information refers to the information that the number of the types is unconfirmed, and unknown condition and situation may occur.

In 1990, Mr. Wang G. Y., who is a doctor of Chinese Academy of Engineering proposed the third concept of the unascertained information that is distincts from random and fuzzy information in the study of architectural engineering theory. The concepts of unascertained information and the previous gray information are the same, and both of them are used to describe the "incomplete information". However, the unascertained and the gray differ from each other, sincein that gray information expresses more certain information than the uncertain information. Based on Wang G. Y.'s idea of unascertained information coupled with the work from (Liu et. al, 1999), (Wu, 1999) and other scholars, the unascertained information now has already become a systematic theory and method.

Setting F as the property space of a certain universe U, $\{F_1F_2\ldots\ldots F_n\}$ are some of the divisions of F, and there are many factors x to affect universe U that are referred to as attributes or indices. Supposing there are m attributes $\{I_1I_2\ldots\ldots I_m\}$ affect factors x, then $I=\{I_1I_2\ldots\ldots I_m\}$ can be called attribute space in universe U. If x_i for any given $\in U$, set observed value I_i of factors x about some kind of attribute j as x_{ij} that can be precisely measured. But when information is incomplete or unknown, it is difficult or even impossible to show the properties F of factor x_i with observed value x_{ij}. In fact, the expression of varying degrees in nature reflects the difference in quantization of some attributes, and then the degree of quantization can be present in the form of data that can be estimated or indirectly measured. But the measurement standards and conditions, including normalization, additivity and non-negativity, must to be met. Only in this way, can we obtain a measurement to describe the degree of nature, which is referred to as an unascertained measure.

3. The establishment of unascertained measure model

3.1 The single-index measure

3.1.1 The single-index measure matrix

Set $\mu_{ijrq}=\mu(x_{ijr}\in c_q)$ express the degree that x_{ijr} belongs to c_q, which is the q^{th} th evaluation class (rating). μ must meet the following conditions:

$$0\leqslant\mu(x_{ijrq}\in c_q)\leqslant 1; i=1,2,\cdots,n; j=1,2,\cdots,m; r=1,2,\cdots,k; q=1,2,\cdots,p \tag{1}$$

$$\mu\left(x_{ijr}\in C\right)=1 \text{ , } i=1,2,\cdots,n \text{ ; } j=1,2,\cdots,m \text{ ; } r=1,2,\cdots,k \tag{2}$$

$$\mu\left(x_{ijr}\in\bigcup_{l=1}^{q}c_l\right)=\sum_{l=1}^{q}\mu(x_{ijr}\in c_l) \quad q=1,2,\cdots,p \tag{3}$$

Define formula (2) as the normalization, formula (3) as the additivity. That which meets the three formulas above is unascertained measurement. The matrix $(u_{ijrq})_{kxp}$ is a single index measure matrix (Liu et al, 2000).

3.1.2 The distinction weight of single-index index

Using the concept of information entropy to define the peak of index I_{ijr}.

$$V_{ijr}=1+\frac{1}{\ln p}\sum_{q=1}^{p}\mu_{ijrq}\ln\mu_{ijrq} \tag{4}$$

$p$in formula(4) represents the number of the evaluate ratings, μ_{ijrq} is the measure of a single index, and the value of V_{ijr} expresses the degree that I_{ijr} different to each evaluation class. The distinction weight is as follows (Li et. al, 2005):

$$\omega_{ijr}=\frac{V_{ijr}}{\sum_{r=1}^{k}V_{ijr}} \quad i=1,2,\cdots,n \text{ ; } j=1,2,\cdots,m \text{ ; } r=1,2,\cdots,k \tag{5}$$

3.2 The first grade index measure

Set $\mu_{iq}=\mu(x_r \in c_q)$ to express the degree that sample x_i belongs to c_r, which is the r^{th} evaluation class (rating).

$$\mu_{iq} = \sum_{j=1}^{m} \omega_{ij}\mu_{ijq} \quad , \quad i = 1,2,\cdots,n \; ; \; q = 1,2,\cdots,p \tag{6}$$

The matrix $(\mu_{iq})_{nxp}$ is the measure matrix of the comprehensive index (Wu et. al, 2011).

3.3 The determination of first grade index weight by AHP

AHP is one of the best-known and most widely used multi-criteria analysis approaches (Saaty, 1990). Lacking quantitative ratings, AHP can help policy makers evaluate the importance of strategies for a specific issue (Javid et. al, 2014). Pairwise comparison is accomplished by adopting a matrix, consisting of Saaty's basic scale of 1–9. This scale is adopted in matrices to determine the weights of relative criteria and to compare the alternatives linked to every criterion. Table 1 summarizes the basic ratio scale. All final weighted coefficients are shown in matrices. Alternatives and criteria can be ranked based on the overall aggregated weights in the matrices. The alternative with the highest overall weight would be the most preferable (Javid et. al, 2014).

Table 1: Saaty's scale for AHP pairwise comparisons (Wang et. al, 2009)

Weight	Description
1	equal importance
3	moderately more important
5	strongly more important
7	very strongly more important
9	dominant importance
2, 4, 6, 8	reciprocals

Based on this primary index's judgment matrix, the weights of every first grade index can be calculated by the geometric calculation method of mean.

$$\bar{\omega}_i = \sqrt[n]{\prod_{j=1}^{n} a_{ij}} \quad (i = 1,2,\cdots,n) \tag{7}$$

Then making the normalized processing, using the following formula:

$$\omega_i = \frac{\bar{\omega}_i}{\sum_{i=1}^{n} \bar{\omega}_i} \tag{8}$$

The weight vector of first index is obtained: $\omega=\{\omega_1, \omega_2 \ldots\ldots \omega_n\}^T$. The largest characteristic roots λ_{max} can be calculated by the following formula:

$$\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n}\frac{(AW)_i}{W_i} \tag{9}$$

But due to the extreme complexity of objective things, the influencing factors of subjective understanding occasionally cannot entirely meet the requirement of consistency. So, checking the matrix for consistency is necessary, and the process is as follows:

The consistency ratio requirements: $C.R = \frac{C.I}{R.I}$ <0.1. $C.I = \frac{\lambda_{\max} - n}{n-1}$, $\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n}\frac{(AW)_i}{W_i}$.

Table 2: The mean random consistency index

Order	2	3	4	5	6	7	8	9	10	11	12	13	14
R.I.	0	0.52	0.86	1.10	1.26	1.34	1.40	1.43	1.49	1.51	1.54	1.56	1.58

3.4 Identification

Because the evaluation space C is an ordered partition class, the recognition criterion of maximum membership degree is inapplicable. Therefore, credible degree criteria is introduced. Set:

$$k_0 = \min_k \left\{ k : \sum_{l=1}^{k} \mu_{il} \geq \lambda, k = 1,2,\cdots,p \right\} \quad (10)$$

Usually, λ=0.6 or 0.7, so the evaluation objects can be classified into c_{k0}.

4. Case study

The trade between China and India in 2012 will be taken as an example to evaluate the reliability of trade in agricultural products. In 2012 India exports to China in a total amount of $ 53.94 billion, while it imports from China in a total amount of $ 14.85 billion. Through investigating a large number of documents, from the viewpoints of politics, economy and product, experts list the terms affecting the agricultural products trade, and the 12 secondary 4 level indicators are shown in Table 3.
Based on cascade theory of rationality of the agricultural trade is divided into 5 grades, as shown in the Table 4.

Table 3: The results of evaluation index system of agricultural trade and expert evaluation

Index	First grade index	Second grade index	Score
Factors affecting the trade of agricultural products P	policy P_1	country of origin policies on import and export P_{11}	93
		import and export of consumer policy P_{12}	92
		import and export duties P_{13}	85
	agricultural products P_2	the quality of agricultural products P_{21}	83
		prices of agricultural products P_{22}	85
		agricultural production P_{23}	71
		agricultural species P_{24}	78
	economy P_3	gross national product P_{31}	88
		currency exchange ratio P_{32}	77
	market P_4	changes in market demand P_{41}	81
		market management system P_{42}	76
		marketing management arrangements P_{43}	69

Table 4: The classification criteria

Level	Poor (R1)	Medium (R2)	Good(R3)	Better(R4)	Excellent (R5)
Score	60~70	70~80	80~90	90~95	≥95

The membership function is established as follows according to the level of sustainable development:

$$\mu(x \in c_1) = \begin{cases} 1 & x \leqslant 60 \\ \dfrac{70 \quad x}{70 \quad 60} & 60 < x \leqslant 70 \\ 0 & x > 70 \end{cases} \qquad \mu(x \in c_2) = \begin{cases} \dfrac{80 \quad x}{80 \quad 70} & 70 < x \leqslant 80 \\ \dfrac{x \quad 60}{70 \quad 60} & 60 < x \leqslant 70 \\ 0 & others \end{cases} \qquad \mu(x \in c_3) = \begin{cases} \dfrac{90 - x}{90 - 80} & 80 < x \leq 90 \\ \dfrac{x - 70}{80 - 70} & 70 < x \leq 80 \\ 0 & others \end{cases}$$

$$\mu(x \in c_4) = \begin{cases} \dfrac{95 - x}{95 - 90} & 90 < x \leq 95 \\ \dfrac{x - 80}{90 - 80} & 80 < x \leq 90 \\ 0 & others \end{cases} \qquad \mu(x \in c_5) = \begin{cases} 1 & x > 95 \\ \dfrac{x - 90}{95 - 90} & 90 < x \leq 95 \\ 0 & x \leq 90 \end{cases}$$

After the evaluation by experts, the score of each factor is shown in Table 3, According to the scores in Table 3 and the membership formula, can get secondary indicators measure vector, from this second-level indicators measure matrix is as follows.

$$I_1:\overline{\mu}_1=\begin{pmatrix}0&0&0&0.4&0.6\\0&0&0&0.6&0.4\\0&0&0.5&0.5&0\end{pmatrix}\qquad I_2:\overline{\mu}_2=\begin{pmatrix}0&0&0.7&0.3&0\\0&0&0.5&0.5&0\\0&0.9&0.1&0&0\\0&0.2&0.8&0&0\end{pmatrix}$$

$$I_3:\overline{\mu}_3=\begin{pmatrix}0&0&0.2&0.8&0\\0&0.3&0.7&0&0\end{pmatrix}\qquad I_4:\overline{\mu}_4=\begin{pmatrix}0&0&0.9&0.1&0\\0&0.4&0.6&0&0\\0.1&0.9&0&0&0\end{pmatrix}$$

4.1 The weight calculation of second grade index

Classification of second grade index calculated as weighted by information entropy. The following guidelines policy (P1) for example:

By the formula (4):V11=0.3874 , V12=0.3874 , V13=0.3691. By the formula (5): ω11=0.3387 , ω12=0.3387 , ω13=0.3226. So level indicators can be obtained under the P1 category weights:

$\overline{\omega_1}=(0.3387\quad 0.3387\quad 0.3226)$, $\overline{\omega_2}=(0.2271\ \ 0.2029\ \ 0.3107\ \ 0.2593)$, $\overline{\omega_3}=(0.7009\quad 0.2991)$, $\overline{\omega_4}=(0.3921\quad 0.2158\quad 0.3921)$

4.2 The measure calculation of first grade index

By the formula (6) first grade index available policy (P1) measurement vector is:

$$\mu_1=\overline{\omega_1}\times\overline{\mu_1}=\begin{matrix}0.3387\\0.3387\\0.3226\end{matrix}^{T}\times\begin{matrix}0&0&0&0.4&0.6\\0&0&0&0.6&0.4\\0&0&0.5&0.5&0\end{matrix}=(0\ \ 0\ \ 0.1613\ \ 0.5000\ \ 0.3387)$$

Similarly, we know that, P2, P3, P4 measure vector corresponding to μ_2=(0 0.3315 0.4989 0.1696 0), μ_3= (0 0.0897 0.3496 0.5607 0) , μ_4= (0.0392 0.4392 0.4824 0.0392 0) . Level indicators measure matrix can be obtained as follows:

$$\overline{\mu}=\begin{bmatrix}\mu_1\\\mu_2\\\mu_3\\\mu_4\end{bmatrix}=\begin{bmatrix}0&0&0.1613&0.5000&0.3387\\0&0.3315&0.4989&0.1696&0\\0&0.0897&0.3496&0.5607&0\\0.0392&0.4392&0.4824&0.0392&0\end{bmatrix}$$

4.3 Determining the classification weight of first grade index

Using analytic hierarchy process on the level of weight is calculated as follows:

Based on the "1-9 of Saaty scale" for level indicator construction of judgement matrix is shown in Tab. 5.

Table 5: The first grade index of judgement matrices

P	P_1	P_2	P_3	P_4
P_1	1	3	2	5
P_2	1/3	1	1/2	2
P_3	1/2	1/8	1	1/4
P_4	1/5	1/2	1/3	1

By equation (7), (8) weight you will receive each level disaggregation of indicators shown in Tab. 6.

Table 6: The first grade index's categorization weight

	P_1	P_2	P_3	P_4
w_i	2.3404	0.7598	1.3161	0.4273
w_{i0}	0.4832	0.1569	0.2717	0.0882

According to the formula (9), we can calculate its maximum eigenvalue, the process is as follows.

AW_1/W_1=((0.4832 0.1569 0.2717 0.0882)X(1325)^T)/(0.4832)=4.0114. The same reason: AW_2/W_2=4.0167, AW_3/W_3=4.0180, AW_4/W_4=4.0120, get the largest eigenvalue λ_{max}=4.0145.

Due to the factor of 4, R.I. value of 0.86, by the formula *CR*=(*C.I/R.I*)<0.1, and meet compliance requirements.

4.4 Confidence level recognition

Using the formula (10) and synthetic vectors for calculating confidence identification, this value is 0.7 available: When λ=0.7, that $k_0 = \min \sum_{l=1}^{k} \mu_{il} \geq 0.7$, *k*=4. So the rationality of agricultural trade to R_4, that is for the better.

5. Conclusions

1) Traditional evaluation methods of agricultural products trade is given priority to the gravity model, the principle of which is the single variable method. So it’s hard to reflect the influences of multiple factors and to consider the factors comprehensively. Also, the unascertained factors and conditions are lack of consideration.
2) Based on the unascertained measurement model, we try to evaluate the rationality for Chinese agricultural trade. The results show that it is feasible to evaluate the rationality of our agricultural products trade by the unascertained measurement model and the result is "good", which is consistent with the reality. And it provides a new way for the evaluation method of agricultural products trade.
3) The analysis results according to the weight of each index show that the factors affecting the market and the agricultural products require more attention for China. So in the next step, China need to open the market continually to make enterprises of different ownerships compete together, stimulate their initiative to increase China’s competitiveness in international market. At the same time, quality of agricultural products is needed to strictly controlled, which not only can strengthen the competitiveness of China’s agricultural products trade, but also reflects the strength of China.

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