Application of Fuzzy Matter Element Analysis to the Evaluation of Circulation Efficiency of Agricultural Products

Zhixing Hu

Abstract: This article builds an evaluation indicator system based on the process of agricultural circulation and the balance of many-sided benefits. A new classification of indicator types was made from the perspective of benefit balance, and gross profit margin and inventory-sales ratio were classified as interval indicators, which enriched the indicator types. The matter-element analysis method is used to measure the circulation efficiency of agricultural product wholesale markets. The study found that in terms of geographical location, in the vertical direction of Aihui-Tengchong Line, the closer to the southeast, the higher the circulation efficiency; Since 2016, the overall circulation efficiency has almost stagnated, mainly because the wholesale industry has strengthened its ability to control upstream and downstream relationships, and the entry barriers of agricultural products have been continuously increased.

Keywords: circulation efficiency, matter-element analysis, agricultural cycle efficiency.
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The agricultural product wholesale market is an important bridge connecting many scattered small-scale producers and consumers, and is the hub of capital flow, information flow and logistics. At the same time, it undertakes the public welfare functions of ensuring market supply, stabilizing market prices, and promoting food safety. At present, about 70% of China's agricultural products flow to consumers through the agricultural product wholesale market. Improving the efficiency of the agricultural product wholesale market plays an important role in the development of agriculture.

The core content of the research on agricultural product circulation efficiency lies in the scientific measurement and evaluation of circulation efficiency, and the basis of scientific measurement of circulation efficiency lies in understanding the scientific connotation of circulation efficiency, decomposing the evaluation objectives in detail, and constructing an evaluation indicator system. Due to the wide connotation of circulation and efficiency, the academic definition of circulation efficiency and the construction of the indicator system are still inconclusive. Generally speaking, there are two representative methods for measuring and evaluating circulation efficiency.

The first method is to measure and evaluate circulation efficiency based on reducing transaction costs. Shepherd, Gong M. and Qi C.J. believe that circulation efficiency is the ratio of the total price of circulation products to the total cost of circulation. [1] [2] Li H.H. and He S. believes that the profit margin created by commodity circulation per unit time is circulation efficiency. [3] Xu W.F. further decomposes circulation efficiency into technical efficiency and pricing efficiency ; Improving technical efficiency is to obtain more output in the same time, and improving pricing efficiency is to obtain maximum value output with the least resource input.[4] Sun J. established an evaluation indicators system from the three aspects of circulation speed, circulation efficiency, and circulation scale, and used factor analysis to measure the circulation efficiency of China's agricultural products from 1998 to 2009.[5] Zhang Y.Q. and his coworker constructed 11 basic indicators (involving negative indicators) from four aspects of circulation speed, circulation scale, circulation cost, and circulation efficiency, and used factor analysis to study the phased characteristics of the evolution of China's agricultural product circulation efficiency.[6] Wang X.Y., Huang M. ers used data envelopment analysis to evaluate the e-commerce level of agricultural products from the four aspects of logistics industry scale, information efficiency, human resources and cultural level.[7]The measurement and evaluation of circulation efficiency oriented to reduce transaction costs is widely used in empirical research because of the clear definition of circulation efficiency and clear evaluation goals.

The main choice of measurement method is DEA method or factor analysis method.

Zhixing HuSchool of Economics and Statistics, Guangzhou University, Guangzhou 510006, China

The second method is to measure and evaluate the circulation efficiency based on the balance of many-sided benefits. Yan B. and his coworker think that the circulation efficiency of the fresh agricultural product is greatly influenced by the purchasing power of end consumers. [8]This method can be regarded as a further deepening of the first method. Anronny believes that circulation efficiency refers to the reasonable allocation of resources to maximize consumer satisfaction, and the three factors of market control, externality and information availability will affect this satisfaction, and then affect the efficiency of circulation. [9]

Kou R., Tao H., etc., put forward a more comprehensive indicator system from the circulation indicators that the society, circulators, producers and consumers pay attention to.[10][11] The indicator system put forward by Zhang Lei is more representative. It comprehensively evaluates the level of circulation efficiency through seven indicators: market integration degree, market concentration degree, technical efficiency, consumer satisfaction, circulation price difference, transaction cost and circulation time, and details the connotation of these indicators.[12] The benefit balance -oriented measurement and evaluation of circulation efficiency pays attention to the different requirements of various market participants for circulation efficiency, and enriches the research perspective. Due to the difficulty in obtaining the data required by most indicators, they have been discussed in theory for a long time and seldom applied in empirical research.

In summary, the academic circles have produced fruitful results in the selection and evaluation of indicators of agricultural product circulation efficiency, but there are still three deficiencies. First, in the study of circulation efficiency, there is not enough attention to the different requirements of various market participants for circulation efficiency. Second, in the construction of the indicator system, the structural relationship between indicators lacks clear logic. Third, in terms of quantitative research methods, DEA or SFA methods are not suitable for using proportional indicators such as gross profit margin and asset turnover rate, and even less suitable for using interval indicators, which have certain limitations on the choice of indicators ;Factor analysis or principal component analysis (PCA) methods are suitable for the processing and analysis of panel data, but there is an implicit assumption that requires each sample to have the same direction in the time dimension for each same indicator, otherwise it will inaccurate or wrong conclusions appear.[13] However, the sales data of agricultural products wholesale markets in different provinces do not meet this assumption.

This article will try to improve in the following three aspects: First, the indicator selection is combined with the carry forward process "investment → inventory → main business income → main business gross profit → main business net profit", and select indicator in each link. Second, taking into account the different requirements of various market participants for circulation efficiency, the types of specific indicators were investigated and reclassified. For example, gross profit margin and inventory-sales ratio should be classified as interval indicators, and should not be classified as positive or negative indicators. Too high or too low of these indicators often reflects excessive or insufficient competition, which is not conducive to the healthy development of the circulation industry. Third, the measurement method draws on the panel data dimensionality reduction processing method, and the matter-element analysis method is used to measure the Euclidean closeness to achieve a comparative analysis of the circulation efficiency of agricultural product wholesale markets in different years and different provinces.

Models, Variables, and Data Description

In the evaluation, the provinces are regarded as different things. These things, their evaluation indicators and corresponding values constitute the composite matter-element. Through the coefficient of variation method to determine the weight coefficient, and finally calculate the Euclidean closeness to measure the circulation efficiency of agricultural products wholesale market.

Selection of Indicators and Data Sources

If the company's profitability is examined by the circulation of inventories or commodities, it is not difficult to find that in the case of gross profit, the faster the turnover, the stronger the profitability. From the perspective of the business process of enterprises or industries, within a period of time, the investment measured in currency will be directly or indirectly converted into costs and period expenses to promote the achievement of main business income (deducting main business taxes and surcharges) and finally form main business results, namely main business profits. The main carry forward process of operating business is in the form of "investment → inventory → main business income → main business gross profit → main business net profit". This article decomposes the circulation efficiency and selects indicators based on the main carry forward process. The main indicators selected include:

Sales. Sales directly reflect the scale of circulation. In a certain period of time, the higher the sales, and the faster the circulation speed. Therefore, this article classifies sales into a positive indicator (or called an effect indicator).

Stock-to-sales ratio. For the link of " inventory

→ main business income ", we select the stock-to-sales ratio as an indicator to detect whether the inventory is reasonable. If the stock-to-sales ratio is too large, it may mean that the supply of goods is sufficient, but it is conducive to the stability of agricultural product prices. If the stock-to-sales ratio is too low, it may mean that the supply of goods is in short supply, which is not conducive to the stability of agricultural product prices. In the actual business process of enterprises, they will not blindly reduce inventory to push up inventory-sales ratios, inventory turnover rates, and other financial indicators that reflect inventory turnover. They often choose to maintain a certain amount of safety stock. Therefore, this article believes that the inventory-sales ratio is not suitable to be treated as a positive indicator, but more suitable to be treated as an interval indicator.

Gross profit margin. From the link of "main business income → main business gross profit", we select gross profit rate as a representative indicator. For the industry, the high gross profit margin indicates that the industry may have competitive barriers and insufficient competition, which is not good for consumers. The low gross profit margin may indicate that the industry may be over-competitive and unfavorable to producers. Whether the gross profit margin is too high or too low is not conducive to the healthy development of the industry. Combining the historical data of the gross profit margin of Chinese agricultural product wholesale enterprises above designated size from 2005 to 2018, we find that the minimum gross profit margin is 19.24% and the maximum is 24.98%, which basically fluctuates within a narrow range around the mean value of 23.28%. The relatively stable gross profit margin also reflects that commodity circulation in the agricultural wholesale market is basically in a state of orderly competition. Therefore, this article classifies the gross profit rate indicator as an interval indicator.

Period expenses to gross profit ratio. From the link of "main business gross profit → main business net profit", we select the period expenses to gross profit ratio as an indicator to reflect the strength of the enterprise or industry's cost control ability. The higher the value of this indicator, the stronger the ability to manage upstream and downstream resources. The period expenses to gross profit ratio should be classified as a negative indicator (or called a cost indicator).

Gross profit margin and inventory-sales ratio are classified as interval indicators. Since there is no reference standard for the optimal interval of gross profit margin and inventory-sales ratio, by drawing on the method of constructing the confidence interval in statistics, we use the range of one standard deviation from the sample average as the optimal interval.

Due to the limitation of data availability, the sample selected in this article is panel data of agricultural products wholesale industry above designated size in 31 provinces from 2005 to 2018. In the selection of data corresponding to the indicators, the characteristic data of the food, beverage industry and tobacco product wholesale industry above designated size are selected. The data comes from the " China Trade and External Economic Statistical Yearbook " (2006-2019). [14]Based on the 2005 national CPI, the sales in the panel data was revised. The national CPI data comes from the "China Statistical Yearbook" (2006-2019). [15]The evaluation indicators and corresponding calculation methods are shown in Table 1.

Table 1Description of indicators

Indicators	Calculation Method	Type
sales	main business income/current CPI index(based on 2005 CPI)	positive indicator
stock-to-sales ratio	main business income/year-end inventory amount	interval indicator
gross profit margin	(main business income-main business cost)/main business income	interval indicator
period expenses to gross profit ratio	period expense/(main business income-main business cost)	negative indicator

Model selection

In the matter-element analysis, it is assumed that there is a thing M, which has a characteristic C and a corresponding magnitude x, then the basic element describing the thing is an ordered triplet $R = (M,C,x)$ or $R = (M,C,C(M))$. The binary group (C,x) formed by C and x is called the feature element of a thing M. If a thing M has n features $C_1,C_2,¼,C_n$ and the corresponding n values $x_1,x_2,¼,x_n$, it is said that

$R = (M, C, x)$ is an n-dimensional matter element. When describing m things $M_1, M_2, \cdots, M_m$, each thing has n characteristics and constitutes the n-dimensional composite element R_{mn} of m things.

$$R_{mn} = \begin{matrix} & M_1 & M_2 & \cdots & M_m \\ C_1 & x_{11} & x_{21} & \cdots & x_{m1} \\ C_2 & x_{12} & x_{22} & \cdots & x_{m2} \\ \vdots & \vdots & \vdots & & \vdots \\ C_n & x_{1n} & x_{2n} & \cdots & x_{mn} \end{matrix}, \quad (1)$$

where M_i is the $i\text{-}th$ thing$(i = 1, 2, \cdots, m)$; C_j is the $j\text{-}th$ feature; x_{ij} is the value corresponding to the $j\text{-}th$ feature of the $i\text{-}th$ thing.

Regarding things in different years as different things, they are included in the original n-dimensional matter element R_{mn} to construct the composite matter element $R_{mn}(t)$.

$$R_{mn}(y) = \begin{matrix} & M_1(1) & M_2(1) & \cdots & M_m(1) & M_1(2) & M_2(2) & \cdots & M_m(2) & \cdots & M_1(t) & M_2(t) & \cdots & M_m(t) \\ C_1 & x_{11}(1) & x_{21}(1) & \cdots & x_{m1}(1) & x_{11}(2) & x_{21}(2) & \cdots & x_{m1}(2) & \cdots & x_{11}(t) & x_{21}(t) & \cdots & x_{m1}(t) \\ C_2 & x_{12}(1) & x_{22}(1) & \cdots & x_{m2}(1) & x_{12}(2) & x_{22}(2) & \cdots & x_{m2}(2) & \cdots & x_{12}(t) & x_{22}(t) & \cdots & x_{m2}(t) \\ \vdots & \vdots & \vdots & & \vdots & \vdots & \vdots & & \vdots & & \vdots & & & \\ C_n & x_{1n}(1) & x_{2n}(1) & \cdots & x_{mn}(1) & x_{1n}(2) & x_{2n}(2) & \cdots & x_{mn}(2) & \cdots & x_{1n}(t) & x_{2n}(t) & \cdots & x_{mn}(t) \end{matrix}, \quad (2)$$

where $M_i(y)$ is the $i\text{-}th$ thing in the $y\text{-}th$ year$(i = 1, 2, \cdots, m, y = 1, 2, \cdots, t)$; C_j is the $j\text{-}th$ feature $(j = 1, 2, \cdots, n)$; $x_{ij}(t)$ is the value corresponding to the $j\text{-}th$ feature of the $i\text{-}th$ thing in the $y\text{-}th$ year.[16]

Calculate Optimal Subordinate Degree

According to the type of indicator, we process the optimal subordinate degree of decision data.

The processing method for positive indicators is:

$$u_{ij}(t) = (x_{ij}(t) - \min x_{ij}(t)) / (\max x_{ij} - \min x_{ij}) \quad (3)$$

The processing method for negative indicators is:

$$u_{ij}(t) = (\max x_{ij}(t) - x_{ij}(t)) / (\max x_{ij} - \min x_{ij}) \quad (4)$$

If the optimal interval of the indicator is [a,b], the processing method is:

$$u_{ij}(t) = \begin{cases} 1 - (a - x_{ij}(t)) / \max\{a - \min x_{ij}(t), \max x_{ij}(t) - b\}, & x_{ij}(t) < a \\ 1, & a \le x_{ij}(t) \le b \\ 1 - (x_{ij}(t) - b) / \max\{a - \min x_{ij}(t), \max x_{ij}(t) - b\}, & x_{ij}(t) > b \end{cases} \quad (5)$$

where $\min x_{ij}(t)$ and $\max x_{ij}(t)$ are the maximum and minimum values of the $j\text{-}th$ characteristic of all things in all years.

According to the optimal subordinate degree , the composite matter element $\dot{R}_{mn}(t)$ is established,

$$R_{mn}(t) = \begin{matrix} \\ C_1 \\ C_2 \\ \vdots \\ C_n \end{matrix} \begin{bmatrix} M_1(1) & M_2(1) & \cdots & M_m(1) & M_1(2) & M_2(2) & \cdots & M_m(2) & \cdots & M_1(t) & M_2(t) & \cdots & M_m(t) \\ u_{11}(1) & u_{21}(1) & \cdots & u_{m1}(1) & u_{11}(2) & u_{21}(2) & \cdots & u_{m1}(2) & \cdots & u_{11}(t) & u_{21}(t) & \cdots & u_{m1}(t) \\ u_{12}(1) & u_{22}(1) & \cdots & u_{m2}(1) & u_{12}(2) & u_{22}(2) & \cdots & u_{m2}(2) & \cdots & u_{12}(t) & u_{22}(t) & \cdots & u_{m2}(t) \\ \vdots & \vdots & & \vdots & \vdots & \vdots & & \vdots & & \vdots & & & \\ u_{1n}(1) & u_{2n}(1) & \cdots & u_{mn}(1) & u_{1n}(2) & u_{2n}(2) & \cdots & u_{mn}(2) & \cdots & u_{1n}(t) & u_{2n}(t) & \cdots & u_{mn}(t) \end{bmatrix} \quad (6)$$

Structure Standard Matter Element and Difference Square Composite Matter Element

Through the results of (6), the fuzzy matter element R_{0n} of the standard scheme M_0 can be constructed, where the $j\text{-}th$ term is equal to the maximum value in the $j\text{-}th$ row of (6)

$$R_{0n} = \begin{matrix} \\ C_1 \\ C_2 \\ \vdots \\ C_n \end{matrix} \begin{bmatrix} M_0 \\ u_{01} \\ u_{02} \\ \vdots \\ u_{0n} \end{bmatrix} \quad (7)$$

From (6) and (7), the square of the difference of each corresponding term, construct the difference square composite matter element R_{D}

$$R_{\mathrm{D}} = \begin{matrix} \\ C_1 \\ C_2 \\ \vdots \\ C_n \end{matrix} \begin{bmatrix} M_1(1) & M_2(1) & \cdots & M_m(1) & M_1(2) & M_2(2) & \cdots & M_m(2) & \cdots & M_1(t) & M_2(t) & \cdots & M_m(t) \\ \mathrm{D}_{11}(1) & \mathrm{D}_{21}(1) & \cdots & \mathrm{D}_{m1}(1) & \mathrm{D}_{11}(2) & \mathrm{D}_{21}(2) & \cdots & \mathrm{D}_{m1}(2) & \cdots & \mathrm{D}_{11}(t) & \mathrm{D}_{21}(t) & \cdots & \mathrm{D}_{m1}(t) \\ \mathrm{D}_{12}(1) & \mathrm{D}_{22}(1) & \cdots & \mathrm{D}_{m2}(1) & \mathrm{D}_{12}(2) & \mathrm{D}_{22}(2) & \cdots & \mathrm{D}_{m2}(2) & \cdots & \mathrm{D}_{12}(t) & \mathrm{D}_{22}(t) & \cdots & \mathrm{D}_{m2}(t) \\ \vdots & \vdots & & \vdots & \vdots & \vdots & & \vdots & & \vdots & & & \\ \mathrm{D}_{1n}(1) & \mathrm{D}_{2n}(1) & \cdots & \mathrm{D}_{mn}(1) & \mathrm{D}_{1n}(2) & \mathrm{D}_{2n}(2) & \cdots & \mathrm{D}_{mn}(2) & \cdots & \mathrm{D}_{1n}(t) & \mathrm{D}_{2n}(t) & \cdots & \mathrm{D}_{mn}(t) \end{bmatrix} \quad (8)$$

CALCULATE THE WEIGHT

According to the different methods of weight generation, it can be divided into subjective weighting evaluation method and objective weighting evaluation method[17] . Entropy method, neural network analysis method, principal component analysis method, factor analysis method and coefficient of variation method are widely used as objective weighting evaluation methods. Among them, the neural network analysis method has higher requirements on the sample size, so it is not suitable to be used as the method to calculate the weight. When the panel data is reduced to the cross-sectional data, the principal component analysis method and factor analysis method may be an option[18]. However, based on the previous exploratory analysis of related indicators such as gross profit margin, inventory-sales ratio, it is found that these indicators do not meet the application conditions of factor analysis or principal component analysis. According to the application of entropy weight method to test data of different sample sizes, it is found that as the sample size increases, the weight difference tends to decrease, and the effect is not good. Finally, we choose the coefficient of variation method for analysis. The calculation method is as follows:

The coefficient of variation of the $j\text{-}th$ indicator is $d_j = S_j / \bar{u}_j$, where $S_j = \sqrt{\frac{1}{m}\sum_{i=1}^{m}(u_{ij}(y) - \bar{u}_j)^2}$, $\bar{u}_j = \sum_{i=1}^{m} u_{ij}(y)$, $i = 1,2,\cdots, m$; $y = 1,2,\cdots, t$; $j = 1,2,\cdots, n$.

Normalize d_j and calculate the corresponding weight $w_j = d_j / \sum_{i=1}^{n} d_j, j = 1,2,\cdots, n$. w_j reflects the amount of information of each indicator, the larger the value, the greater the effect of the indicator on comprehensive decision-making.

CALCULATE EUCLIDEAN CLOSENESS

Considering that the purpose of the study is to make a comprehensive evaluation, the M (•, +) algorithm is used to calculate the Euclidean closeness: $rH_i(y) = 1 - \sqrt{\sum_{j=1}^{n} w_j D_{ji}(y)}$.

The Euclidean closeness indicates the closeness between the *i-th* thing ($i = 1,2,¼, m$) in the *y-th* year and the standard thing. Since the establishment of the composite matter element $R_{mn}(t)$ absorbs the information of the two dimensions of time and things, the difference between groups is maintained, so that the last calculated Euclidean closeness is comparable. Thus, things in different years can be sorted according to the degree of Euclidean closeness.

Empirical Results and Analysis

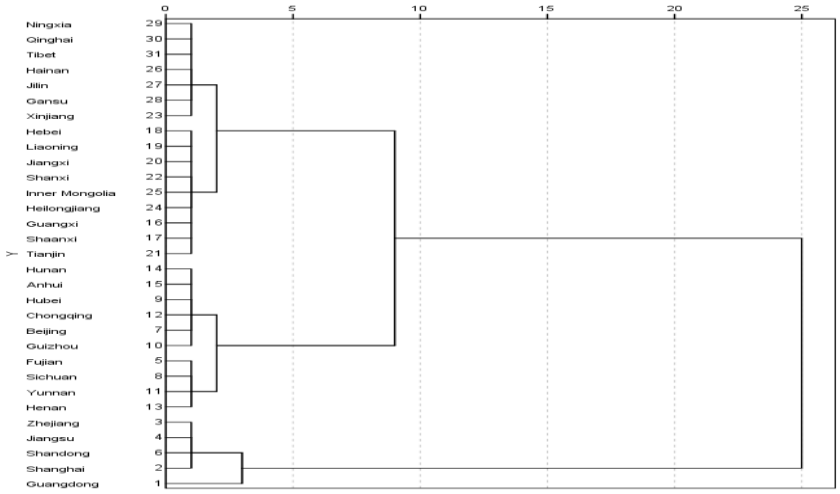
Through data analysis, it is found that the weights of sales revenue, inventory-sales ratio, gross profit ratio, and period expenses to gross profit ratio are 0.6760, 0.0923, 0.0391, and 0.1926, respectively. The optimal range of gross profit rate is [21.60%, 24.97%], and the optimal range of inventory-sales ratio is [8.38%, 10.93%]. Calculating the agricultural product circulation efficiency values of 31 provinces from 2005 to 2018 based on European closeness, the specific results are shown in Table 2.

Table 2Circulation efficiency values of agricultural wholesale markets based on panel data

Province	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Guangdong	0. 374	0. 398	0. 401	0. 423	0. 425	0. 480	0. 541	0. 540	0. 678	0. 700	0. 753	0. 756	0. 755	0. 742
Shanghai	0. 211	0. 233	0. 276	0. 297	0. 261	0. 291	0. 293	0. 307	0. 470	0. 453	0. 475	0. 531	0. 572	0. 586
Zhejiang	0. 306	0. 338	0. 368	0. 394	0. 392	0. 413	0. 453	0. 476	0. 489	0. 520	0. 510	0. 508	0. 525	0. 565
Jiangsu	0. 285	0. 288	0. 288	0. 343	0. 335	0. 352	0. 389	0. 408	0. 495	0. 484	0. 508	0. 511	0. 523	0. 550
Fujian	0. 226	0. 253	0. 253	0. 256	0. 290	0. 305	0. 339	0. 357	0. 373	0. 407	0. 428	0. 444	0. 457	0. 488
Shandong	0. 228	0. 222	0. 270	0. 353	0. 350	0. 403	0. 416	0. 489	0. 575	0. 610	0. 602	0. 614	0. 480	0. 464
Beijing	0. 181	0. 177	0. 188	0. 211	0. 235	0. 283	0. 300	0. 305	0. 311	0. 308	0. 325	0. 313	0. 393	0. 419
Sichuan	0. 215	0. 223	0. 239	0. 247	0. 262	0. 281	0. 318	0. 338	0. 372	0. 387	0. 412	0. 415	0. 388	0. 408
Hubei	0. 204	0. 175	0. 204	0. 242	0. 236	0. 265	0. 291	0. 316	0. 347	0. 376	0. 384	0. 377	0. 385	0. 403
Guizhou	0. 138	0. 165	0. 177	0. 203	0. 215	0. 225	0. 228	0. 241	0. 250	0. 284	0. 331	0. 327	0. 391	0. 399
Yunnan	0. 296	0. 292	0. 304	0. 281	0. 302	0. 315	0. 349	0. 379	0. 389	0. 421	0. 373	0. 390	0. 384	0. 392
Chongqing	0. 159	0. 159	0. 177	0. 219	0. 231	0. 252	0. 275	0. 295	0. 323	0. 340	0. 379	0. 383	0. 365	0. 356
Henan	0. 197	0. 208	0. 222	0. 241	0. 242	0. 261	0. 282	0. 307	0. 337	0. 408	0. 471	0. 532	0. 401	0. 349
Hunan	0. 207	0. 214	0. 220	0. 228	0. 255	0. 251	0. 272	0. 289	0. 321	0. 330	0. 339	0. 350	0. 350	0. 349
Anhui	0. 219	0. 203	0. 222	0. 236	0. 247	0. 257	0. 278	0. 290	0. 295	0. 315	0. 323	0. 315	0. 324	0. 345
Guangxi	0. 174	0. 181	0. 192	0. 187	0. 202	0. 206	0. 218	0. 226	0. 230	0. 237	0. 292	0. 291	0. 327	0. 319
Shaanxi	0. 175	0. 179	0. 187	0. 186	0. 193	0. 210	0. 216	0. 223	0. 245	0. 245	0. 268	0. 275	0. 283	0. 282
Hebei	0. 203	0. 201	0. 211	0. 230	0. 236	0. 229	0. 235	0. 250	0. 257	0. 269	0. 273	0. 267	0. 267	0. 267
Liaoning	0. 198	0. 211	0. 234	0. 220	0. 223	0. 227	0. 250	0. 262	0. 276	0. 290	0. 289	0. 265	0. 264	0. 259
Jiangxi	0. 193	0. 204	0. 205	0. 204	0. 213	0. 216	0. 222	0. 233	0. 240	0. 248	0. 255	0. 253	0. 255	0. 258
Tianjin	0. 170	0. 186	0. 147	0. 192	0. 196	0. 233	0. 258	0. 265	0. 284	0. 312	0. 333	0. 314	0. 271	0. 257
Shanxi	0. 200	0. 199	0. 208	0. 209	0. 213	0. 224	0. 233	0. 233	0. 237	0. 242	0. 246	0. 235	0. 238	0. 243
Xinjiang	0. 103	0. 078	0. 129	0. 096	0. 120	0. 149	0. 155	0. 214	0. 220	0. 229	0. 235	0. 239	0. 244	0. 237
Heilongjiang	0. 168	0. 172	0. 187	0. 189	0. 196	0. 209	0. 227	0. 252	0. 275	0. 276	0. 269	0. 268	0. 226	0. 221
Inner Mongolia	0. 193	0. 187	0. 202	0. 195	0. 199	0. 210	0. 219	0. 224	0. 227	0. 238	0. 234	0. 227	0. 213	0. 218
Hainan	0. 168	0. 185	0. 170	0. 180	0. 196	0. 195	0. 200	0. 203	0. 206	0. 211	0. 214	0. 214	0. 215	0. 217
Jilin	0. 156	0. 176	0. 186	0. 191	0. 191	0. 205	0. 195	0. 201	0. 203	0. 202	0. 207	0. 200	0. 210	0. 211
Gansu	0. 191	0. 158	0. 163	0. 178	0. 181	0. 190	0. 194	0. 202	0. 208	0. 233	0. 242	0. 247	0. 216	0. 204
Ningxia	0. 165	0. 169	0. 175	0. 173	0. 175	0. 177	0. 177	0. 180	0. 182	0. 186	0. 192	0. 189	0. 191	0. 192
Qinghai	0. 180	0. 180	0. 181	0. 160	0. 178	0. 181	0. 185	0. 186	0. 187	0. 194	0. 194	0. 193	0. 187	0. 190
Tibet	0. 168	0. 162	0. 152	0. 160	0. 173	0. 157	0. 164	0. 172	0. 164	0. 169	0. 175	0. 151	0. 176	0. 176

For the panel data in Table 2, Ward clustering analysis method is used to cluster provinces with squared Euclidean distance. The results are shown in Figure 1.It is not difficult to see from the Ward cluster analysis map of the provinces that the 31 provinces are divided into 4 categories: The first category includes Guangdong, Jiangsu, Zhejiang, Shandong and Shanghai; The second category includes Beijing, Fujian, Anhui, Henan, Hubei, Hunan, Chongqing, Sichuan, Guizhou, and Yunnan; The third category includes Tianjin, Hebei, Liaoning, Shanxi, Inner Mongolia, Heilongjiang, Jiangxi, Guangxi, Shaanxi; The fourth category includes Hainan, Jilin, Tibet, Qinghai, Ningxia, Gansu, Xinjiang.

Figure 1Ward cluster analysis diagram of provinces



Based on the data in Table 1 and the clustering results in Figure 1, we have drawn the circulation efficiency curves of agricultural products wholesale markets in different categories of provinces, which helps to observe the differences in different types of provinces, as shown in Figure 2-5.

Figure 2 Provinces in the first category

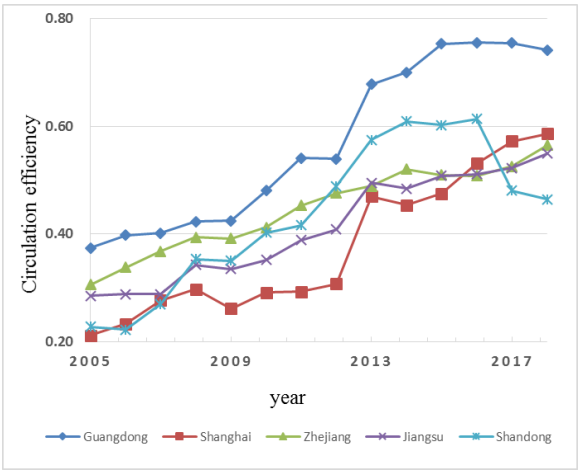


Figure 3Provinces in the second category

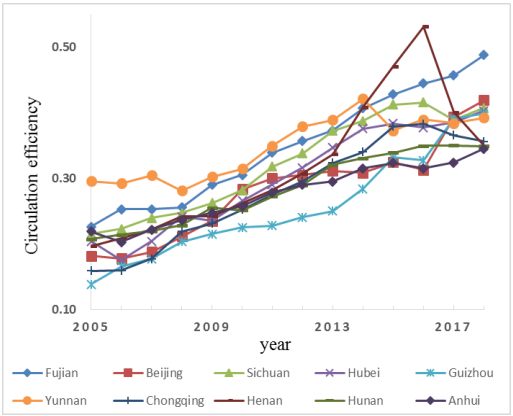


Figure 4Provinces in the third category

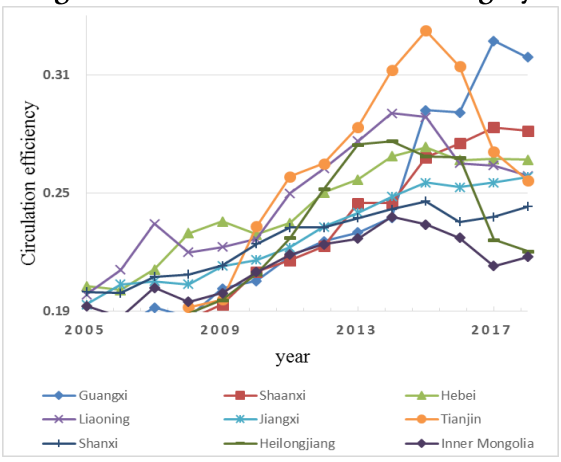
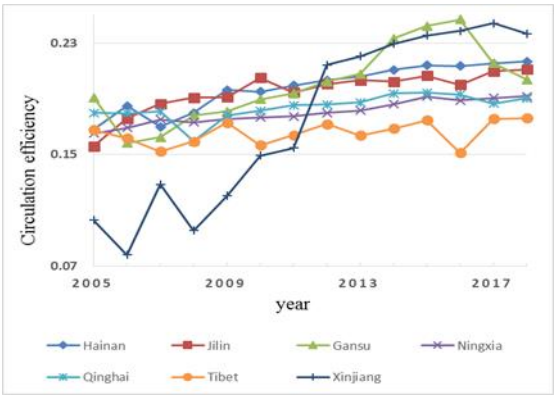


Figure 5Provinces in the fourth category



The first category of the provinces is are mainly composed of East China provinces and Guangdong province (a strong economic province in South China). The characteristics of these provinces are obvious advantages of circular efficiency. The second category of provinces is mainly composed of central China and southwest provinces. The characteristics of these provinces is the significant increase in circulation efficiency. The third category of provinces is mainly composed of North China and Northeast provinces, which is characterized by less advantages and slower improvement in circulation efficiency. The fourth category of the provinces is represented by provinces in the northwest region, and the circulation efficiency has been maintained at a low level for a long time, and the improvement of circulation efficiency is not good. In terms of geographical location, in the vertical direction of Aihui-Tengchong Line, the closer to the northwest, the lower the circulation efficiency; the closer to the southeast, the higher the circulation efficiency.

From different periods of time, from 2005 to 2016, the overall circulation efficiency has been improved. Since 2016, the overall circulation efficiency has almost touched the ceiling.From the perspective of efficiency value calculation, it is easy to find that this is mainly subject to two aspects: the period cost cannot be effectively reduced and the sales growth is slowing down.

By examining the breakdown of period expenses, the management expense ratio of the agricultural product wholesale industry dropped from 4.29% (2015) to around 2.90% (2017, 2018), reflecting the continuous improvement of management level, which is conducive to the improvement of circulation efficiency. At the same time, the sales expense ratio has continued to rise, from 3.28% (2005) to more than 5% (2017, 2018), which fully offsets the efficiency improvement brought by the management level. It shows that the competition of product distribution is intensified, and the oversupply has not been fundamentally alleviated.

From 2005 to 2018, the asset-liability ratio of the agricultural product wholesale industry has continued to increase, reaching 56.72% in 2018. Financial expenses reached a maximum value in 2016 and began to decline. In 2018, financial expenses were already negative. According to our visits to relevant wholesale companies, the main reason is that the wholesale industry has realized the occupation of upstream and downstream resources through "advance payments" and "accounts payable".It reflects that wholesale companies are strengthening their ability to control upstream and downstream relationships. In the case of oversupply, the surplus agricultural products will not appear in the inventory, but will not enter the circulation or even be directly abandoned. This is consistent with our experience of visiting sugar orange production areas in Guangxi Province and crisp pear production areas in Anhui Province.

CONCLUSION AND INSPIRATION

In this paper, the composite matter element of panel data is constructed by the method of dimensionality reduction, and the matter element analysis method is used to measure the circulation efficiency values of agricultural wholesale markets of each province.

Combining the Ward cluster analysis method, the characteristics of the category of provinces are discussed. Empirical findings and cause analysis found:

(1) In terms of geographical location, in the vertical direction of Aihui-Tengchong Line, the closer to the northwest, the lower the circulation efficiency of agricultural products wholesale markets; the closer to the southeast, the higher the circulation efficiency of agricultural products wholesale markets. The circulation efficiency in East China (involving Jiangsu, Zhejiang, Shandong, Shanghai) and Guangdong Province has obvious

advantages. The circulation efficiency in northwest provinces (involving Qinghai, Ningxia, Gansu and Xinjiang) has remained at a low level for a long time.

(2) Since 2016, the overall circulation efficiency has almost stagnated, mainly because the wholesale industry has strengthened its ability to control upstream and downstream relationships, and the entry barriers of agricultural products have been continuously increased. In addition, oversupply also leads to the increase of marketing cost, which restricts the further improvement of agricultural products circulation efficiency.

Based on the measurement and results of the circulation efficiency of the agricultural product wholesale market, this paper proposes the following policy recommendations : (1) Strengthen the information construction of agricultural products, establish the network marketing platform of agricultural products, and make the circulation information of agricultural products more transparent. (2) Adjust the supply structure of agricultural products and realize the transformation from quantity growth to quality growth. (3) Increase the number of public welfare agricultural products wholesale markets and effectively reduce transaction costs.

DECLARATIONOFCONFLICTINGINTERESTS

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