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Evaluation on Coordinated Development of Rice Mechanization and Regional Economy in China

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Abstract

The degree of coordinated development of rice mechanization and regional economy (CDME) is related to the sustainable development of regional economy, but there is little research on the coordination between the two. This paper constructs an evaluation index system for the coordinated development of rice mechanization and regional economy based on the relevant research. Then this paper obtains the weight of each index combining the entropy method and the analytic hierarchy process. Finally, this paper conducts an empirical analysis on the coordinated development of rice mechanization and regional economy based on the coordination degree model in the country from 2008 to 2018.

Keywords

Evaluation Index System; Entropy Method; Analytic Hierarchy Process; CDME.

1. Introduction

Rice is the second largest food crop in China and is widely grown. With the development of modern agriculture, the mechanized production of rice has become more and more popular. In 2018, the comprehensive mechanization level of rice farming and harvesting exceeded 81.91%, and the level of mechanical farming, mechanical planting, and mechanical harvesting were 98.00%, 50.86%, and 91.52%, respectively. Overall, the key production link of rice has entered a new stage dominated by mechanization, and the proportion of rice mechanical operation cost in agricultural production cost is increasing year by year [1], and the development of agricultural mechanization is more closely related to regional economic development. Agricultural mechanization must be coordinated with economic development in order to become a booster for the development of modern agriculture [2]. Therefore, it has important theoretical and practical significance to carry out the evaluation research on the coordinated development of rice mechanization and regional economy.

So far, scholars' research on rice mechanization mainly focuses on the following aspects: 1) Evaluation of rice mechanization level and regional differences [3-4]. 2) Analysis of factors affecting the development of rice mechanization [5-6]. 3) Research on rice mechanization technology [7-8]. 4) Research on the coordinated development of rice mechanization and other systems, including research on the coordinated development of new agriculture, agricultural modernization and agricultural labor [9]. Most of the existing studies focus on the development of the rice mechanization system itself, and fail to consider it in conjunction with other systems. A small number of studies involving the development of other systems, mostly stay in qualitative discussions, lack of quantitative analysis. Few scholars pay attention to the research on the coordinated development of rice mechanization and regional economy (CDME). However, as mentioned above, it is of great significance to conduct evaluation research on the coordinated development of rice mechanization and regional economy.

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In view of this, this paper attempts to carry out evaluation research on the CDME. First, it constructs an evaluation index system for the CDME, and combines the entropy method and the analytic hierarchy process to determine the index weights. Finally, a comprehensive evaluation model of coordinated development is constructed to measure the degree of the CDME from an empirical point of view. The research results are of great value to correctly understand the CDME in china, and to adjust and formulate relevant policies to help the coordinated and sustainable development of the two.

2. Research Methods and Data Sources

2.1 Indicator Weight Determination Method

The methods for determining the weight of indicators are divided into subjective weighting method and objective weighting method. Subjective weighting method means that people subjectively determine the weight of each factor of the object of analysis according to its importance and experience. Such methods are more mature, but less objective, such as AHP method, expert scoring method, etc. The objective weighting method refers to sorting, calculating and analyzing the actual data, so as to obtain the weight. Compared with the subjective weighting method, this method is relatively late and is not perfect, such as entropy weighting method, standard deviation method, etc. Therefore, this paper combines the AHP in the subjective weighting method with the AHP in the objective weighting method to jointly determine the index weight.

2.1.1 Analytic Hierarchy Process(AHP)

An AHP structure model for evaluating rice mechanization and regional economic development is established, a pairwise comparison judgment matrix is constructed, and normalized to solve the eigenvector of the largest eigenvalue of each matrix. Then the paper calculates the relative weight of each index by the square root method and carries out the consistency test [11].

2.1.2 Entropy Method

With m evaluation indicators and n evaluation objects, the original data matrix R =(rij)m×n. The entropy for the ith index is defined as:

$$H_i = -k\sum_{j=1}^{n} f_{ij} \ln f_{ij} \tag{1}$$

$$\left(i = 1,2,3,\ldots,m; j = 1,2,3,\ldots,n\right)$$

in the formula, $k = \ln n$, f_{ij} is the proportion of the jth evaluation object under the ith index to the index, n is the number of evaluation objects; H_i is the entropy of the ith index, and the entropy weight of the ith index is defined as:

$$\omega_{2i} = \frac{1 - H_i}{n - \sum_{i=1}^{m} H_i} \tag{2}$$

in the formula, ω_{2i} is the entropy weight of the ith index $0 \le \omega_{2i} \le 1$; H_i is the entropy of the ith index; m is the number of evaluation indicators.

2.1.3 Minimum Relative Information Entropy to Determine Combination Weights

Combining the subjective weight ω_{1i} and the objective weight ω_{2i} can get the combined weight ω_i, $i = 1 - m$ .According to the principle of minimum relative information entropy [12], the combined weight calculation formula can be obtained by optimizing the Lagrange multiplier method:

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$$\omega_i = \frac{\left(\omega_{1i}\omega_{2i}\right)^{0.5}}{\sum_{i=1}^{m}\left(\omega_{1i}\omega_{2i}\right)^{0.5}}\left(i=1,2,3,\ldots,m\right) \tag{3}$$

Through the above steps, the weight of each index in the evaluation system of the CDME under different methods can be determined.

2.2 Coordination Evaluation Model

The integrated development evaluation values of the rice mechanization system and the regional economic system were fitted by mutual linear regression, and the regression value of each comprehensive level measurement value was obtained. The coordination degree between the two systems can be obtained by using the following formula.

$$U(x/y) = \exp[-(F_x - F'_x)/S_x^2] \tag{4}$$

In the formula, x and y represent two systems, $U(x/y)$ represents the coordination group of system x, F_x and F' represent the actual value and the regression value of the comprehensive level measure value, S_x^2 is the variance of system x.

$$C_s(x/y) = \left\{\min\left[U(x/y), U(y/x)\right]\right\} / \left\{\max\left[U(x/y), U(y/x)\right]\right\} \tag{5}$$

In the formula, $C_s(x/y)$ represents the static coordination value, $U(x/y)$ and $U(y/x)$ represent the respective coordination values of the X and Y systems, respectively. It can be seen from the above formula that the smaller the difference between $U(x/y)$ and $U(y/x)$, the better the coordination. The value range of the static coordination degree is [0,1].The larger the value, the better the coordination [13].The specific classification is: when the static coordination degree is 0-0.2, it stands for severe disorder; when the static coordination degree is 0.2-0.4, it stands for moderate disorder; when the static coordination degree is 0.4-0.6, it stands for barely disordered; when the static coordination degree is 0.6-0.8, it stands for moderate coordination; when the static coordination degree is 0.8-1.0, it stands for high-quality coordination.

2.3 Data Sources

The data used in this article come from the "National Agricultural Product Cost and Benefit Data Compilation" (2009-2019), "China Statistical Yearbook" (2009-2019), "National Agricultural Mechanization Statistical Yearbook" (2008-2018), "China Agricultural Statistical Yearbook" (2009-2019) and “China Agricultural Machinery Industry Yearbook” (2009-2019).

3. Results and Analysis

3.1 Evaluation Indicators and Weights

Numerous scholars at home and abroad have analyzed the evaluation research of rice mechanization development and have achieved many valuable research results. On the basis of theoretical analysis, literature review and expert consultation, this paper divides the evaluation indicators of rice mechanization development into three categories: mechanical popularization level, mechanical operation ability, and economic effect. The regional economic development is evaluated from three aspects: economic level, residents' living standard and economic structure (Table 1).

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Table 1. Evaluation index system of Coordinated Development of Rice Mechanization and Regional Economy

system layer	first-level indicator	Weights	Secondary indicators	Weights
The development of rice mechanization	Mechanical popularity level	0.41	Comprehensive mechanization level of rice farming and harvesting	0.18
			Tractor matching ratio	0.10
			Number of workers per unit area	0.13
	Mechanical operation ability	0.29	Fuel consumption per unit operating area	0.15
			Irrigation water consumption per unit operating area	0.14
	economic effect	0.30	cost utilization	0.10
			land productivity	0.08
			Labor productivity	0.12
regional economic development	economic level	0.34	GDP per capita	0.11
			local revenue per capita	0.23
	living standard of residents	0.38	per capita consumption expenditure	0.13
			per capita disposable income	0.25
	economic structure	0.28	Contribution rate of the secondary industry	0.12
			Contribution rate of the tertiary industry	0.16

3.2 Time Series Characteristics of Comprehensive Development Level

According to the selected evaluation indicators and the corresponding indicator weights, the comprehensive level data of rice mechanization development and the comprehensive level data of regional economic development from 2008 to 2018 were calculated (Figure 1). On this basis, according to the coordination degree model, the coordination degree of rice mechanization and regional economic development in each year was obtained (Figure 2).

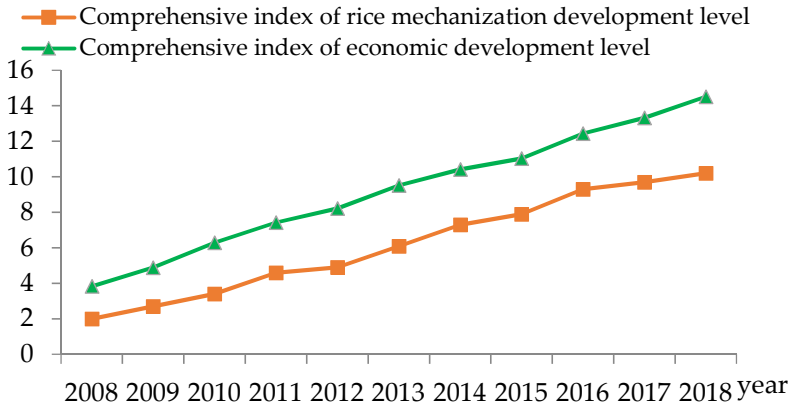

Figure 1. Comprehensive index of rice mechanization and regional economic development level

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From the perspective of changing trends, the comprehensive level of rice mechanization development generally maintained an increasing trend from 2008 to 2018. But the growth rate fluctuated. According to the changing trend, it can be roughly divided into two stages: the growth rate was relatively fast and the growth rate was relatively stable From 2008 to 2013;the growth rate decreased from 2014 to 2018.

It can be seen from Figure 1 that the level of my country's economic development shows an increasing trend year by year, and the growth rate is relatively stable and obvious. The comprehensive level of economic development increased from 3.83 in 2008 to 14.51 in 2018, indicating that china's economy has maintained rapid development in the past decade. This is mainly because China steadily promotes various reforms, promotes the gradual optimization of its economic structure, and gradually increases the proportion of the secondary and tertiary industries[14]. Moreover, the government has built a stable socialist market economic structure through the implementation of macro-control.

3.3 Coordinated Development Time Series Characteristics

As can be seen from Figure 2, rice agricultural mechanization and economic development were generally well coordinated from 2008 to 2018. The average value is 0.824, all of which are above the moderate coordination state, of which 6 years are in the high-quality coordination state. However, the fluctuation of coordination is more obvious. In 2012, 2015, 2017 and 2018, the coordination degree was below 0.8. In 2008 and 2009, the coordination degree reached above 0.9. The coordination degree shows a downward trend. The coordination degree in 2008 was 0.95, and the coordination degree in 2018 was 0.67, a decrease of 0.28.

The reason is that the comprehensive development level of rice mechanization and regional economy is on the rise, but the growth rate of economic development is much faster than that of rice mechanization from 2008 to 2018. During this period, the economic growth rate was relatively stable and maintained a high growth rate, but the development rate of rice mechanization has slowed down since 2014. Under the condition that rice mechanization and regional economic development speed are not consistent, the system coordination fluctuates significantly. It can be seen that in order to promote the improvement of the development coordination of the two systems, the development of rice mechanization should be further promoted to narrow the gap between rice mechanization and the development speed of the regional economy.

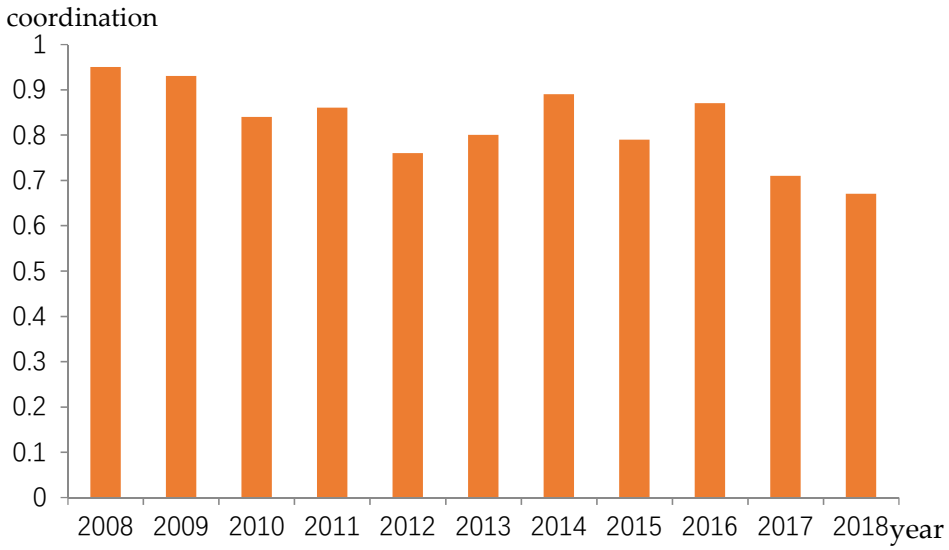

Figure 2. The degree of coordination between rice mechanization and regional economic in China

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4. Conclusion

(1) From the perspective of changing trends, the comprehensive level of rice mechanization development generally maintained an increasing trend from 2008 to 2018. But the growth rate fluctuated. According to the changing trend, it can be roughly divided into two stages: the growth rate was relatively fast and the growth rate was relatively stable From 2008 to 2013;the growth rate decreased from 2014 to 2018.

(2) China's economic development level shows a trend of increasing year by year, with a relatively stable and obvious growth rate. The comprehensive level of economic development increased from 3.83 in 2008 to 14.51 in 2018, indicating that china's economy has maintained rapid development in the past decade. This is mainly because China steadily promotes various reforms, promotes the gradual optimization of its economic structure, and gradually increases the proportion of the secondary and tertiary industries. Moreover, the government has built a stable socialist market economic structure through the implementation of macro-control.

(3) Rice agricultural mechanization and economic development were generally well coordinated from 2008 to 2018. The average value is 0.824, all of which are above the moderate coordination state, of which 6 years are in the high-quality coordination state. However, the fluctuation of coordination is more obvious. In 2012, 2015, 2017 and 2018, the coordination degree was below 0.8. In 2008 and 2009, the coordination degree reached above 0.9. The coordination degree shows a downward trend. The coordination degree in 2008 was 0.95, and the coordination degree in 2018 was 0.67, a decrease of 0.28.

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