Technical Evaluation of Grain Industry Based on Coefficient of Variation Weighting Method

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Abstract: Technological development is the driving force of progress. To comprehensively improve the technological development capacity of the grain industry and the conversion rate of agricultural scientific and technological achievements, it is necessary to build and improve a suitable technical system for the development of the grain industry. This paper uses the coefficient of variation weighting method to study the technological level of the grain industry, scientifically determining the weights of factors affecting competitiveness, and removing the influence of subjective factors on indicator weight assignment. Using the research methods in this paper to study the technology of the grain industry can help identify the shortcomings in the development of the grain industry and provide effective suggestions for promoting the healthy development of the grain industry.

Keywords: grain industry,grain industry technology, coefficient of variation weighting method, design production capacity

1. Introduction

Grain industry is the foundation of the national economy and grain supply has always been a major issue related to the national economy and people's livelihood. The establishment of scientific technical evaluation system of grain industry is the basis to ensure the development of local grain industry. Establishing a scientific evaluation system for grain industry technology is the foundation for ensuring the development of local grain industry. In this paper, the grain industry is studied as an open system based on the coefficient of variation method, and an index system is established to evaluate the technical level of the grain industry in a region, and an evaluation method of the competitiveness level of the grain industry is proposed[1-4].

2. Coefficient of variation method

Coefficient of variation method is a common weight allocation method, which is especially suitable for the case of large data variation. It is based on the calculation of variance, considering the difference in the degree of variation of each factor, so as to determine the weight of each factor, mainly used to evaluate the relative importance of different factors or variables[5-7]. This method has been widely applied in evaluation and decision analysis, such as in marketing, sales management, risk management, medical research, and other fields, especially in engineering and economics.

Specifically, the steps of the coefficient of variation method are as follows:

(1) Collect evaluation indicator data: Firstly, relevant data needs to be collected.

(2) Calculate the average and standard deviation of each evaluation indicator

(3) Calculate the coefficient of variation of indicators: For each data indicator, calculate its coefficient of variation. The coefficient of variation refers to the proportion of the difference between the indicator value and the average value to the average value. The formula is: coefficient of variation equal standard deviation/mean.

(4) Determine the weight of each evaluation indicator based on the coefficient of variation: For each data indicator, calculate the weight based on its coefficient of variation. The weight represents the degree to which an indicator has an impact on the overall results, and usually the larger the indicator, the higher the weight.

(5) Evaluate the importance of factors: Based on the calculated weights, evaluate the importance of different factors or variables[8-10].

The advantage of the coefficient of variation method is that it can consider the degree of data variation. For cases with large data variation, it can accurately reflect the degree of influence of each factor on the overall population, and can easily and quickly calculate the weight values of different factors or variables, helping decision-makers better understand the essence of the problem and make wiser decisions.

However, the coefficient of variation method also has some drawbacks. First, the weight distribution results are sensitive to the distribution of data, and when the data distribution is not uniform, the weight distribution results may be biased. Second, the method ignores the correlation between indicators, which may lead to inaccurate weight distribution results when there is correlation between indicators.

3. Experimental design

Collected multiple indicators of the grain industry in a central region from 2018 to 2022. Establish a technical evaluation index system for the grain industry.

3.1 Principles for establishing an indicator system

The design of the indicator system must be based on scientific foundations in order to objectively and truthfully reflect the comprehensive competitiveness of a region's grain industry technology development. The complexity and simplicity of the indicator system should be appropriate, neither too much nor too much, making the indicators mutually important, nor too little or too simplistic, resulting in the omission of indicator information. Therefore, when establishing a comprehensive competitiveness evaluation index system for the development of regional grain industry, we should adhere to the basic principles of goal orientation, comprehensiveness, quantification, measurability, timeliness, operability, consistency, traceability, and dynamism in the design and establishment of these nine index systems. These nine principles can help us establish a scientific and effective index system, providing guidance for the performance evaluation and management of organizations or individuals[11-12].

Based on the above principles, the technical indicators of the grain industry in this experiment are divided into: research and development investment, number of patents obtained, processing capacity of finished grain and oil, processing capacity of grain, oil and food, feed processing capacity, deep processing capacity of grain, area of high-quality raw grain base, number of associated farmers of high-quality raw grain base, and quantity of purchased grain orders.

3.2 Comprehensive evaluation of grain industry technology

Firstly, standardize the data. Data standardization eliminates the magnitude differences between data from different sources and formats, converting the data to a unified scale; Reduce data errors and biases, avoid the influence of outliers, and improve the credibility and reliability of the data, making it easier to compare and analyze within the same framework to improve data quality and accuracy. Improve data consistency and comparability. Through standardized processing, data can be simplified and standardized, reducing the need for duplicate collection and integration, and saving resources and costs. Improve the efficiency and reliability of data analysis. Data standardization reduces redundant workload in data processing, analysis, and application, reduces weight differences between features, balances the contributions of each feature, accelerates algorithm convergence, and improves model stability and accuracy. Therefore, Z-score method is adopted to standardize the data of various indicators and calculate according to the following formula:

$$z_{ij} = \frac{x_{ij} - \bar{x}_i}{\sigma_i} \tag{1}$$

In the formula (1), Z_{ij} represents the standardized variable value; xij is the actual variable value; $\bar{x}_i$ is the arithmetic mean of the i-th indicator; σ_i is the standard deviation of the i-th indicator. The standardized data is shown in Table 1:

Table 1. Standardized data of various indicators in the comprehensive evaluation of grain industry technology

Year	2022	2021	2020	2019	2018
Research and development investment	-0.0962161	-0.0510434	0.1314035	-0.0554186	0.0712746
Number of patents obtained	0.4712124	-0.0942414	-0.1256561	-0.1256561	-0.1256561
Processing capacity of finished grain and oil	0.0497497	0.0408378	0.0135155	-0.0497018	-0.0544012
Processing capacity of grain, oil and food	0.1156775	0.0799494	0.0111016	-0.1028493	-0.1038792
Feed processing capacity	0.1961326	-0.0037615	0.0193943	-0.1057335	-0.1060318
Deep processing capacity of grain	0.1346494	-0.0425766	0.1138688	-0.1025410	-0.1034006
Area of high-quality raw grain base	0.0323983	0.0569805	0.0678167	-0.0821521	-0.0750434
Number of associated farmers of high-quality raw grain base	0.0686899	0.0500262	0.0658550	-0.0931120	-0.0914599
Quantity of purchased grain orders	0.1033631	-0.0568696	0.0958835	-0.0704450	-0.0719320

Secondly, the coefficient of variation method is used to calculate the weight. The coefficient of variation is the ratio of standard deviation and average value of the index, which is:

$$\mathrm{CV_i} = \frac{\sigma_i}{\bar{x}_i} \tag{2}$$

C_{vi} represents the coefficient of variation of the i-th indicator; σ_i is the standard deviation of the i-th indicator; $\bar{x}_i$ is the arithmetic mean of the i-th indicator. When determining weights, the index with a larger coefficient of variation has a larger weight, while the index with a smaller weight has a smaller weight.

The specific calculation method of weight is as follows:

$$W_i = CV_i/\Sigma(Cv_i) \tag{3}$$

In the formula (3), W_i represents the weight of the i-th indicator, and C_{vi} represents the coefficient of variation of the i-th indicator, $\Sigma(CV_i)$ represents the sum of the coefficients of variation for all indicators.

Finally, the standardized data of each index is multiplied by the weight and calculated as a sum to obtain the regional grain industry technical comprehensive score from 2018 to 2022. The formula for calculating the comprehensive score M.

$$M=W1*Z1+W2*Z2+W3*Z3+W4*Z4+W5*Z5+W6*Z6+W7*Z7+W8*Z8+W9*Z9 \tag{4}$$

In the formula (4), W1~W9 are the weight values of 9 indicators respectively; Z1 to Z9 are research and development investment, number of patents obtained, processing capacity of finished grain and oil, processing capacity of grain, oil and food, feed processing capacity, deep processing capacity of grain, area of high-quality raw grain base, number of associated farmers of high-quality raw grain base, and quantity of purchased grain orders, and the standardized values of these nine indicators are shown in Table 2 for the comprehensive evaluation results.

Table 2. Comprehensive evaluation of grain industry technology by year

Year	2022	2021	2020	2019	2018
Comprehensive score	1.0756569	-0.0206986	0.3931827	-0.7876094	-0.6605298
Sort	1	3	2	5	4

4. Result analysis

The results of this article show that the weight value and coefficient of variation of the number of patents obtained are both the maximum values, indicating that the number of patents obtained has the greatest impact on the technological development of the grain industry. This study analyzed the impact of technical indicators on the technological development of the grain industry, and evaluated the technological development of the grain industry in different years using the coefficient weight distribution method. The results showed that the region had the best technological development of the grain industry in 2022, followed by 2020. This article starts with the analysis and research of the technological development of the grain industry, and based on a systematic study of the economic development issues of the grain industry, a detailed analysis of various technical indicators of the regional grain industry is conducted. It provides reference services for further constructing an agricultural technology system suitable for the current stage of agricultural development in the region, promoting agricultural technology innovation and progress, improving the scientific and technological contribution rate of grain production, and thereby improving the comprehensive production capacity of grain.

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