

# Research on Comprehensive Evaluation of Food Governance Sustainable Development Based on Entropy Weight Method

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**Abstract.** Based on the connotation and characteristics of food modernization governance, this paper constructs a comprehensive evaluation system for sustainable development of food governance from the three dimensions. These three dimensions include industrial development, safety risk and social co-governance. Based on the availability of data, entropy weight method is used to carry out empirical evaluation on the index data of the past three years. Variability in the index data provide suggestions for the sustainable development path of food governance in the next step.

## 1 INTRODUCTION

The management of public health problems cannot be separated from assessment. Food safety is a common problem facing the whole world. Ensuring food safety is an important part of governments' social and public affairs governance functions.[1] However, due to the long-term, complex and repetitive nature of food safety problems, how to prevent and control food safety risks more effectively remains the most challenging major public social issue faced by all countries in the world. At present, the issue of food safety has transitioned from "food and clothing" to "hygiene", "health" and "quality".[2] Food safety is related to public health and social security. It is an important issue in government governance practice. The definition of governance by the Global Governance Commission is that governance refers to the sum of many ways that individuals and institutions manage common affairs in the public or private sphere. Governance is not a set of rules or activities, but a set of processes. Governance involves both public and private sectors. Governance is not a formal system, but an ongoing interaction. As the "vane" and "thermometer" to reflect the food safety situation, the comprehensive evaluation system of food safety continues to maintain the research heat.[3] Food safety regulatory assessment is used to test regulation effect and provide information for decision making process.[4] This paper constructs a comprehensive evaluation system for sustainable development of food governance from the three dimensions based on the connotation and characteristics of food modernization governance.

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The three dimensions include industrial development, safety risk and social co-governance. According to the public availability of the data, 10 three-level indexes were selected for data statistics and analysis in the past three years. The entropy weight method was used to determine the weights of indexes at each level, and finally the comprehensive evaluation results were calculated. Variability in the index data provide suggestions for the sustainable development path of food governance in the next step.

## 2 INDEX EVALUATION SYSTEM

This study systematically analyzes the research and practice status of food safety evaluation at home and abroad. On the basis of drawing on the mature food safety evaluation system and evaluation method at home and abroad, referring to the construction idea of CPI, PMI and other macroeconomic indexes, this study establishes an index system framework including industry, society and government mode based on stakeholder theory.

In order to avoid the disconnection between the government's recognition of the performance of food safety supervision and the public's perception of food safety, the principle of combining subjective feeling and objective evaluation is adopted during the establishment of indexes. The establishment of indexes comprehensively considers the objective situation of food safety, the objective indexes of the actual situation of industrial development, and the satisfaction indexes reflecting the subjective feelings of the public. Through the analytic hierarchy process, a 4-level hierarchical evaluation system is constructed, which consists of objective level, criterion level, sub-criterion level and index level. This method constructs the index system framework from the whole elements of food safety evaluation, and comprehensively considers food safety laws and regulations as well as food safety practice.

In this paper, the entropy weight method is selected to weight the index. According to the original information and historical data of the index, the entropy weight method studies the relationship between the index and the evaluation results through mathematical or statistical methods, and then obtains the weight through comprehensive evaluation. The advantage of entropy weight method is that the weight coefficient is more objective and avoids the deviation caused by human subjective factors. The data of 10 evaluation indexes in this study came from open channel search.

The construction of evaluation index system includes the following four principles: The first principle is systematic. A qualified evaluation index system should regard the evaluation object as an organic whole and reflect the real situation of the results completely. System should exist a certain inner link between each indexes and include the same logic relation between each hierarchy. The second principle is purpose. When constructing the evaluation index system, the key indexes should be selected according to the characteristics of the evaluation object and the specific evaluation purpose to reflect the evaluation purpose truly and clearly. On the basis of reflecting the purpose of evaluation, the evaluation index should also provide the improvement direction for realizing the purpose of evaluation.[5] The third principle is operability. In the selection of indexes, it is necessary to ensure that the data sources and access ways of each index are stable and reliable enough, so that the evaluation subject can carry out standard calculation by processing on the collected effective index data. It's helpful to ensure the appropriate number of indexes, refine the levels and improve the efficiency of evaluation activities. The fourth principle is comparability. The indexes in this paper are quantitative indexes, which can ensure that the evaluation results can be compared, so that the evaluation subject can successfully obtain the results of the value evaluation. Only by establishing an index system based on the unified statistical caliber and the same comparable benchmark point can the evaluation contents be quantified and compared.[6]

The evaluation index system is a 4-level evaluation system with hierarchical structure, which is composed of target level, criterion level, sub-criterion level and index level. In this

model, the elements of the upper level dominate the elements of the next level as criteria and the elements of the next level are the decomposition of the previous level as components.[7]

The target layer is the evaluation goal to be realized by the whole index system, which represents the current situation of sustainable development of food governance.

The criterion layer is the first-level index of the system, which refers to the framework layer of the system and indicates the categories included in the index system. The criterion layer includes industrial development, security risk and social co-governance.

The sub-criterion level is the refinement and decomposition of the criterion level index, which belongs to the secondary index. The secondary indexes include industrial scale, standard, product qualification rate and public satisfaction.

The index layer is the measurement index of the index system, which belongs to three-level index. The three-level indexes include proportion of food industry enterprises above designated size, proportion of revenue of food industry enterprises above designated size, quantity of the quality and safety standard of edible agricultural products, food safety local standard quantity, qualified rate of food safety evaluation sampling inspection, qualification rate of routine monitoring of agricultural product quality and safety, qualified rate of food related product quality, satisfaction with food safety status, proportion of consumer complaints and proportion of consumers reporting. The paper collected data of these 10 indexes from public sources in the past three years for empirical analysis. The evaluation index system is shown in Table 1.

Table 1. Comprehensive Evaluation System for Sustainable Development of Food Governance

First-level Index	Secondary Index	Three-level Index
Industrial Development (48.23%)	Industrial Scale (21.09%)	Proportion of Food Industry Enterprises Above Designated Size (10.36%)
		Proportion of Revenue of Food Industry Enterprises above Designated Size (10.73%)
	Standard (27.14%)	Quantity of the Quality and Safety Standard of Edible Agricultural Products (12.16%)
		Food Safety Local Standard Quantity14.98%
Security Risk (29.4%)	Product Qualification Rate (29.4%)	Qualified Rate of Food Safety Evaluation Sampling Inspection (10.25%)
		Qualification Rate of Routine Monitoring of Agricultural Product Quality and Safety (9.71%)
		Qualified Rate of Food Related Product Quality (9.44%)
Social Co-governance (22.37%)	Public Satisfaction (22.37%)	Satisfaction with Food Safety Status (8.27%)
		Proportion of Consumer Complaints (6.57%)

		Proportion of Consumers Reporting (7.53%)
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### 3 CALCUTION PROCESSES of ENTROPY WEIGHT METHOD

The basic idea of entropy weight method is to determine the objective weight according to the size of the index variability. In general, if the information entropy of an index is smaller, it indicates that the degree of variation of the index is greater. This index includes the more information and plays the greater role in the comprehensive evaluation. More weight is given to this index. The specific steps are as follows:

#### 3.1 Index Standardization

In this paper, the deviation standardization method is used to standardize the three-level index data. If the index is a positive index, the normalization of the deviation is calculated using the following formula.

$$y_{ij} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})} \tag{1}$$

If the index is a negative index, the deviation normalization is calculated using the following formula.

$$y_{ij} = \frac{\max(x_{ij}) - x_{ij}}{\max(x_{ij}) - \min(x_{ij})} \tag{2}$$

In the formula,  $x_{ij}$  represents the original value of the evaluation object  $i$  on the index  $j$ .  $y_{ij}$  represents the index value processed by the deviation normalization method.  $\max(x_{ij})$  represents the maximum value of  $x_{ij}$ .  $\min(x_{ij})$  represents the minimum value of  $x_{ij}$ .

#### 3.2 Index Entropy Calculation

The entropy of index  $j$  is calculated by the following formula. In the formula,  $n$  represents the number of samples to be evaluated.

$$E_j = -\frac{1}{\ln n} \sum_{i=1}^n p_{ij} \ln p_{ij} \tag{3}$$

$$p_{ij} = y_{ij} / \sum_{i=1}^n y_{ij} \tag{4}$$

3.3 Index Entropy Weight Calculation

The entropy weight of index  $j$  is calculated by the following formula. In the formula,  $m$  represents the number of indexes.  $w_j'$  is the objective weight calculated by the entropy weight method.

$$w_j' = \frac{1 - E_j}{m - \sum_{j=1}^n E_j} \tag{5}$$

According to the above steps, the weights of indexes at each level can be calculated. The weight calculation results of the three-level indexes are shown in the following table.

Table 2. Objective Weights of the Three-level Indexes

Three-Level Index	Objective Weight
Proportion of Food Industry Enterprises Above Designated Size	10.36%
Proportion of Revenue of Food Industry Enterprises above Designated Size	10.73%
Quantity of the Quality and Safety Standard of Edible Agricultural Products	12.16%
Food Safety Local Standard Quantity	14.98%
Qualified Rate of Food Safety Evaluation Sampling Inspection	10.25%
Qualification Rate of Routine Monitoring of Agricultural Product Quality and Safety	9.71%
Qualified Rate of Food Related Product Quality	9.44%
Satisfaction with Food Safety Status	8.27%
Proportion of Consumer Complaints	6.57%
Proportion of Consumers Reporting	7.53%

The weight calculation results of the secondary indexes are shown in the following table.

Table 3. Objective Weights of the Secondary Indexes

Secondary Index	Objective Weight
Industrial Scale	21.09%
Standard	27.14%
Product Qualification Rate	29.4%
Public Satisfaction	22.37%

The weight calculation results of the first-level indexes are shown in the following table.

Table 4. Objective Weights of the First-Level Indexes

First-Level Index	Objective Weight
Industrial Development	48.23%
Security Risk	29.4%
Social Co-governance	22.37%

3.4 Comprehensive Evaluation Result

Index evaluation result is calculated by the following formula.

$$D_{ij} = y_{ij}w'_j$$

(6)

Evaluation results in the three-level indexes are shown in the following table.

Table 5. Evaluation results of the Three-level Indexes in the Last Three Years

Three-Level Index	Evaluation Results in 2020	Evaluation Results in 2021	Evaluation Results in 2022
Proportion of Food Industry Enterprises Above Designated Size	0.0051	0.0055	0.0058
Proportion of Revenue of Food Industry Enterprises above Designated Size	0.0081	0.0068	0.0070
Quantity of the Quality and Safety Standard of Edible Agricultural Products	0.0123	0.0144	0.0154
Food Safety Local Standard Quantity	0.0042	0.0084	0.0101
Qualified Rate of Food Safety Evaluation Sampling Inspection	0.0710	0.0752	0.0781
Qualification Rate of Routine Monitoring of Agricultural Product Quality and Safety	0.0455	0.0615	0.0588
Qualified Rate of Food Related Product Quality	0.0398	0.0514	0.0306
Satisfaction with Food Safety Status	0.0533	0.0560	0.0597
Proportion of Consumer Complaints	0.0657	0.0604	0.0408
Proportion of Consumers Reporting	0.0748	0.0678	0.0625

Evaluation results in the secondary indexes are shown in the following table.

Table 6. Evaluation results of the Secondary Indexes in the Last Three Years

Secondary Index	Evaluation Results in 2020	Evaluation Results in 2021	Evaluation Results in 2022
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Industrial Scale	0.0626	0.0583	0.0607
Standard	0.0608	0.0840	0.0940
Product Qualification Rate	0.5316	0.2656	0.5697
Public Satisfaction	0.8663	0.8234	0.7287

Evaluation results in the secondary indexes are shown in figure 1.

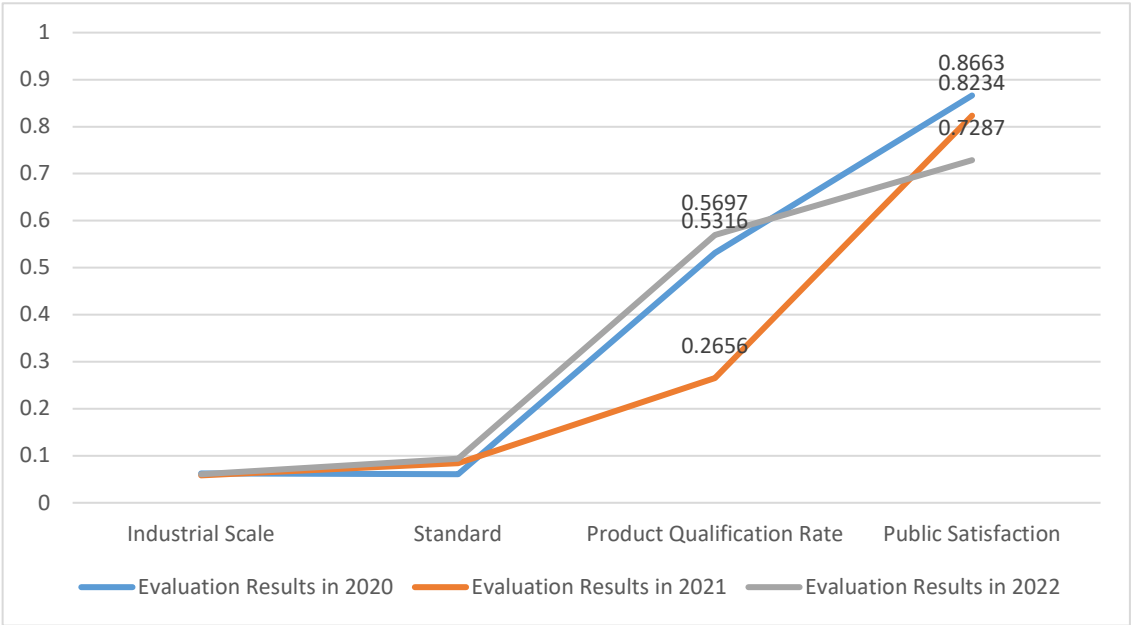


Figure 1. Evaluation Results of The Secondary Indexes in the Last Three Years

Evaluation results of the first-level indexes are shown in the following table.

Table 7. Evaluation results of the first-level Indexes in the Last Three Years

First-Level Index	Evaluation Results in 2020	Evaluation Results in 2021	Evaluation Results in 2022
Industrial Development	0.2558	0.2951	0.3207
Security Risk	0.5316	0.5697	0.5697
Social Co-governance	0.8663	0.8234	0.7287

Evaluation results of the first-level indexes are shown in figure 2.

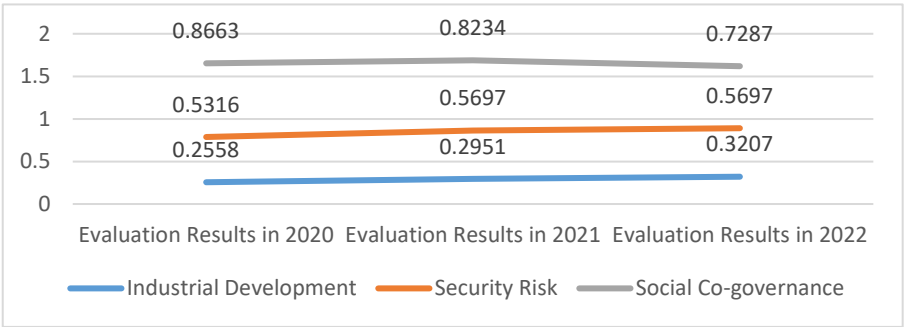


Figure 2. Evaluation Results of the First-Level Indexes in the Last Three Years

4 CONCLUSION

Based on the perspective of sustainable development, this paper sets up an evaluation index system of sustainable development of food governance based on three dimensions. The three dimensions include industrial development, safety risk and social co-governance. According to the public availability of the data, 10 three-level indexes were selected for data statistics and analysis in the past three years. The entropy weight method was used to determine the weights of indexes at each level, and finally the comprehensive evaluation results were calculated. Through the achievements of food management in the past three years, the rationality of constructing the index system is confirmed. Through the weight analysis, industrial development, safety risk and social co-governance are all very important in the sustainable development of food governance. Meanwhile they are indispensable. The improvement of industrial development indicators shows that the scale of the food industry has been expanding in the past three years. The quality and safety management level of edible agricultural products and the standardized management level of enterprises have been improved continuously. The awareness of enterprises to perform the main responsibility of food safety, their risk control ability and quality management level have been greatly improved. The decrease of social co-governance index is due to the continuous increase in the number of consumer complaints and reports, which shows that the degree of public participation in food safety governance is deepening to a certain extent. From the comprehensive evaluation results, the two indexes of industrial scale and standard deserve attention in the next work. First, the national food safety standards need to be further developed and improved. Second, the level of modern food safety supervision and governance needs to be further improved to help the development of food enterprises. Third, we should give full play to the role of social supervision forces and achieve positive interactions between producers, consumers and supervisors. In practical application, due to index data collection, index dynamic adjustment and other factors, it is necessary to form an index system according to the actual situation for comprehensive evaluation. Through the measurement of the index system, the weak points of food safety supervision can be understood, and the modernization level of food safety governance can be improved.

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