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# A Three-Stage DEA-Based Efficiency Evaluation of Broiler Breeding in China

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# 3단계 DEA를 이용한 중국 육계 생산효율성 분석에 관한 연구

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**Abstract** Broiler chickens are one of the essential meats for residents in China. To analyze and improve the efficiency of broiler chicken breeding and to promote the industry's healthy and stable development is of great significance, improving international competitiveness in China. The three-stage data envelopment analysis (DEA) model estimated the production efficiency of broiler breeding in 13 provinces of China in 2020. The results showed that China's broiler production efficiency was generally at a low level, that the average value of technical efficiency for Stage 1 was 0.595, and that there are differences between efficiencies of the regions. After removing facts about the environment and random interference, the average value of technical efficiency for Stage 3 was 0.630, and the efficiency in most areas had increased. The impact of per capita GDP and market openness on broiler production efficiency was not noticeable, but agricultural support affected broiler production efficiency. Therefore, this study puts forward countermeasures, such as strengthening investment in science and technology and actively cultivating and introducing high-quality breeds, promoting the development of appropriate-scale broiler chicken breeding according to local conditions, and we suggest increasing government support to improve the scale of breeding.

**요 약** 육계는 중국 주민들에게 가장 중요한 육류 식품 중의 하나이다. 따라서 생산효율에 착안하여 육계 양식의 효율을 향상하는 것을 연구하는 것이 중국 육계 산업이 건전하고 안정하게 발전되도록 추진할 수 있을 뿐만이 아니라 중국 육계 산업의 국제경쟁력을 높이는 데에도 중요한 의미가 있는 것이다. 본 연구는 3단계 DEA 모형을 활용해서 2020년 중국 13개 성의 육계 생산효율을 측량 계산하였다. 그 결과 중국의 육계 생산효율은 전반적으로 낮은 수준이었고, 1단계 생산효율의 평균값은 0.595였으며, 지역별로 효율성에 차이가 있는 것으로 나타났다. 환경요인의 사실을 제거한 후 3단계의 생산효율 평균값은 0.630으로 대부분 성에서 효율성이 증가하였다. 1인당 GDP와 시장 개방성이 육계 생산효율에 미치는 영향은 크지 않았지만, 농업정책 지원은 육계 생산효율에 영향을 미쳤다. 연구 결과에 따라 본 연구는 과학기술 투자 확대, 고품질 육계 품종의 적극적인 육성 및 도입, 지역 여건에 따른 육계의 규모화 발전 촉진, 정부 정책 지원 및 육계 사육 규모 확대를 위한 방안을 제시하고자 한다.

**Keywords :** Broiler Production, Environment Variables, Three-stage DEA, SFA Model, Production Efficiency

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## 1. Introduction

The broiler industry is an essential part of China's animal husbandry, which started in the 1980s and rose rapidly in the 1990s. At present, the scale of China's broiler industry is growing, and the output of broilers has increased from 1.171 million tons in 1980 to 18.656 million tons in 2020[1]. The broiler industry has become a pillar in China's agriculture and rural economy, playing an essential role in solving rural labor employment and increasing farmers' income. China has become the world's second-largest broiler producer after the United States. Chicken has also become the second-largest livestock and poultry production and consumer product in China after pork. Under the current tight supply of meat products in China, the broiler industry has made significant contributions to improving the dietary structure of Chinese urban and rural residents and providing animal protein[2]. After 40 years of constant and rapid development, the broiler industry in China has become the most industrialized, marketization, and large-scale industry in animal husbandry[3]. With the improvement of the income level of urban and rural residents in China and the continuous advancement of urbanization, the demand for meat products from Urban and rural residents in China will continue to grow. However, due to the constraints of feed, land, labor, and other resources, it is difficult for each breeding enterprise to achieve the optimal combination of factors in actual production. In addition, the increasingly severe shortage of feed grain resources has brought tremendous pressure to the supply of meat products in China. Under all the development resistance, how to promote the efficient development of China's broiler industry has become the focus of academic attention.

At present, several works of literature have studied the efficiency of broiler production. Among them, Chen et al. (2014)[4] studied the cost efficiency of broiler production in different regions of China. She measured the cost efficiency of broiler breeding in different provinces and regions and compared and analyzed the changing trend and differences in the cost efficiency of broiler breeding in different provinces and regions. Zhang Jing (2011)[5] used the SFA analysis method to study the efficiency of broiler breeding at different scales in China. A. Todsadee et al. (2012)[6] estimated the efficiency score of broiler farms in northern Thailand using by SFA model, and the results showed that feed, bird stocks, operating costs, and other costs were important factors to broiler output in the Chiang Mai Province. Kim (2019)[7] analyzed the management efficiency of broiler integration companies and sought plans for improving the inefficiency management of broiler integration companies. He used the DEA model to evaluate the efficiency of broiler integration companies and analyzed the causes for four-year productivity changes and changes in efficiency. There are also some regional broiler production efficiency studies. Zhang et al. (2015)[8] analyzed the production efficiency of the Shandong broiler industry. In contrast, Wang et al. (2019)[9] analyzed the cost-benefit and production efficiency in Shanxi Province. Through literature review, it was found that although all the studies on broiler efficiency had their own merits, some studies did not consider the influence of environmental factors and random items in different regions. Therefore, this study employed a three-stage DEA model, which was proposed by Fried[10], to incorporate environmental effects and statistical noise into efficiency evaluation. A sample set of 13 provinces in 2020 were analyzed to calculate the efficiency of broiler breeding in China throughout the study period.

## 2. Method and data

## 2.1 Three-stage DEA model

The three-stage DEA model is a method proposed by Fried et al. (2002), which can better evaluate the efficiency of Decision Making Unit (DMU).

### 2.1.1 Stage 1: Traditional DEA model

In the first stage, we apply DEA to input and output data to obtain an initial evaluation of producer performance. This evaluation does not account for the impacts of either the operating environment or statistical noise on producer performance.

The traditional DEA model is proposed by Charnes, Cooper, and Rhodes (CCR model)[11]. Banker, Charnes, and Cooper (BCC model)[12] extended the CCR model and proposed the BCC model under the assumption of Variable Returns to Scale (VRS) in 1984. Technical efficiency (TE) relates to the productivity of inputs. The technical efficiency of a firm is a comparative measure of how well it actually processes inputs to achieve its outputs, as compared to its maximum potential for doing so, as represented by its production possibility frontier (TE=1). A firm is said to be technically inefficient (0〈TE〈1) if it operates below the frontier.

The BCC model splits the technical efficiency resulting from the CCR model into two parts: pure technical efficiency (PTE), which overlooks the influence of scale size by only comparing a DMU to a unit of similar scale and measures how a DMU utilizes its sources under exogenous environment. And scale efficiency (SE), which measures how the scale size affects efficiency. If after applying both the constant return to scale (CRS), and variable returns to scale (VRS) model on the same data, there is an alteration in the two technical efficiencies, this designates that DMU has a scale efficiency and can be calculated by: SE=TE/PTE. SE is not greater than 1, for a BCC-efficient DMU, i.e., in the most productive scale size, its scale efficiency is 1.

Suppose a system has $n$ DMUs, $m$ input and $s$ output vectors, the input and output vectors of the $j-th$ DMU are respectively.

$$
\begin{aligned}
&X_j = (x_{1j}, x_{2j}, \cdots, x_{mj})^T > 0 \\
&Y_j = (y_{1j}, y_{2j}, \cdots, x_{sj})^T > 0 \\
&j = 1, 2, \cdots\ n
\end{aligned}
\tag{1}
$$

Under the Variable Returns to Scale (VRS) model, the BCC model introduces the slack variable values $s^-$ and $s^+$.

$$
\begin{aligned}
&\min\{\theta\} \\
&\sum_{j=1}^{n} X_j \lambda_j + s^- = \theta X_{j0} \\
&\sum_{j=1}^{n} Y_j \lambda_j - s^+ = Y_{j0} \\
&\sum_{j=1}^{n} \lambda_j = 1 \\
&\lambda \geq 0, s^- \geq 0, s^+ \geq 0
\end{aligned}
\tag{2}
$$

Where $\theta$ demonstrates the technical efficiency value of each DMU, and $\lambda_j$ implies a $j$ dimensional weight vector of the DMU$j$. If $\theta^* = 1$, $s^{-*} = s^{+*}$, the DEA of DMU is considered to be effective, if $\theta^* = 1$, $s^{-*}$, $s^{+*}$ are not all 0, then the DEA of DMU is considered to be weakly effective, if $\theta^* < 1$, then the DEA of DMU is not effective.

### 2.1.2 Stage 2: Similitude analysis for the stochastic frontier analysis (SFA) model

After the traditional DEA model analysis, the input slacks of all DMUs are influenced by the external environment parameters, managerial inefficiency, and statistical noises. Following Fried[10], we built up a stochastic frontier analysis regression formulation.

$$S_{ik} = f^i(Z_k;\beta^i) + v_{ik} + \mu_{ik} \quad i = 1,2,\cdots,m; k = 1,2,\cdots,n \tag{3}$$

Where, $S_{ik}$ represents the slack variable of input item $i$ of the $k^{th}$ DMU, $Z_k$ represents observable environmental variables in the amount of P, $\beta^i$ implies the coefficients of the environmental variables, $f^i(Z_k;\beta^i)$ represents the effect of environment variable on input slack variable $S_{ik}$, $v_{ik} + \mu_{ik}$ represents composed error, $v_{ik}$ represents managerial inefficiency term as $v_{ik} \sim N(0,\sigma_{vi}^2)$, $\mu_{ik}$ illustrates the statistical noises as $\mu_{ik} \sim N^+(\mu_i,\sigma_{ui}^2)$, and $v_{ik}$, $\mu_{ik}$ are distributed independently. Let $\gamma = \sigma_{ui}^2/(\sigma_{ui}^2 + \sigma_{vi}^2)$, the closer the value of $\gamma$ is to 1, the more managerial factors dominate the error part of the model, the closer the value of $\gamma$ is to 0, the more statistical noise dominates the error part of the model.

According to the results of SFA model, the input vectors of the DMUs are adjusted to increase the input for the DMUs with better external environment.

$$\hat{x}_{ik} = x_{ik} + [\max_k\{Z_k\hat{\beta}^i\} - Z_k\hat{\beta}^i] + [\max_k\{\hat{v}_{ik}\} - \hat{v}_{ik}] \quad i = 1,2,\cdots,m; k = 1,2,\cdots,n \tag{4}$$

where $x_{ik}$ is the input before adjustment, $\hat{x}_{ik}$ implies the input after adjustment, $\hat{\beta}^i$ are the coefficients of the environment variables, $\hat{v}_{ik}$ illustrates the statistical noise. In Eq. (4), $[\max_k(Z_k\hat{\beta}^i) - Z_k\hat{\beta}^i]$ represents to adjust all DMUs to the same external environment. $[\max_k(\hat{v}_{ik}) - \hat{v}_{ik}]$ represents to adjust all statistical noise of DMUs to the same situation.

### 2.1.3 Stage 3: The adjusted DEA model

This phase improved measures of managerial efficiency, the adjustment data $\hat{x}_{ik}$ obtained in the second stage was replaced by the original actual value $x_{ik}$, then repeated the first stage analysis by applying DEA to the adjusted data.

## 2.2 Indicator selection and data source

### 2.2.1 Input and output indicators

Selecting appropriate indicators is crucial for achieving a comprehensive and objective evaluation of the efficiency of broiler production. In this study, according to the production characteristics of broilers, the controllable variables of broiler breeding efficiency mainly included production value, labor, feed and epidemic prevention costs, and so on[2-4]. This study set the production value of broiler breeding as an output variable. According to National Farm Product Cost-benefit Survey, we obtained the input and output information of broiler production, so we directly selected the following four indicators as input variables: feed consumption, labor cost, fuel cost, and epidemic prevention cost. According to the agricultural conditions and many literature references, the input and output variables are selected to measure by a three-stage model, as shown in

Table 1. Input and output indicators and environment variables

| Category | Indicator | Mean | SD |
|---|---|---|---|
| Output Indicator | Production value | 3290.965 | 2060.800 |
| Input Indicator | Feed consumption | 426.237 | 130.850 |
| | Labor cost | 230.360 | 155.147 |
| | Fuel cost | 40.922 | 16.809 |
| | Epidemic prevention cost | 101.756 | 47.841 |
| Environment Variables | per capita GDP | 67038.539 | 20394.414 |
| | market openness | 0.236 | 0.174 |
| | agricultural support | 0.113 | 0.032 |

Table 1 According to the conclusions of literature research and the availability of data[4,5], the input and output indicators are selected.

### 2.2.2 Environment variables

Environmental variables refer to the factors that can affect broiler production efficiency but are not within the subjective control of animal husbandry. Due to environmental factors, the efficiency of those individuals in a better environment may be higher, while the efficiency of those individuals in a worse environment may not be ideal. Therefore, environmental variables are introduced in the second stage of the analysis, and the influence of environmental variables on efficiency is eliminated. Referring to the existing literature and considering the actual situation and data availability, the following indicators are mainly selected, the per capita GDP, market openness, agricultural support, and other aspects that affect the production value of broiler breeding. These external factors will have a certain impact on agricultural production efficiency, specifically analyzed as follows.

1) Per capita GDP: It is generally believed that regions with a stronger economy have more basic conditions favorable to improving broiler production efficiency[13]. At the same time, Liu et al. (2019)[14] pointed out by studying the production efficiency of animal husbandry in China that the overall development level of the regional economy will have an impact on all aspects of the animal husbandry industry in the region, and the economic development level is reflected by the per capita GDP index of each region. Therefore, this study employed the per capita GDP to characterize regional economic development.

2) Market openness: The increase in the Market openness means an increase in the opportunity cost of labor, and the supply of factor resources is tight. Agricultural production must develop in the direction of intensification, which improves agrarian production efficiency[15]. The market opening degree of the regional economy reflects, to a certain extent, the environmental impact of the trade status of the local economy on the production links of the local broiler industry[16]. The market openness is represented by the proportion of import and export value in the GDP.

3) Agricultural support: Regarding the related financial support policies for agriculture, this study considers that the agricultural subsidies can increase farmers' enthusiasm for farming[17], and the support of subsidy policy is of great significance to broiler production. The local government's support for agricultural development will have a direct impact on the investment willingness and income level of local broiler farmers[18]. Since the agricultural support cannot be obtained directly from the statistical yearbook, we need to process the following data. It is calculated by the proportion of agricultural subsidies in the total budget outlays[19].

### 2.2.3 Date source

Considering the integrity and availability of data, the data used in this paper is from the year 2021. Those data were collected from China Statistical Yearbook 2021 and National Farm Product Cost-benefit Survey 2021.

## 3. Empirical study of the efficiency of China's Broiler Breeding

### 3.1 The results of the DEA model: Stage 1

In stage 1, DEAP 2.1 was used to measure broiler production efficiency. Table 2 shows the mean values of efficiency of broiler production and the returns to scale in 2020. The value for technical efficiency (TE), pure technical efficiency (PTE), and scale efficiency (SE) for stage 1 was 0.595, 0.944, and 0.630, respectively.

Scale efficiency and pure technical efficiency were the factors that limited the broiler production efficiency in China. In addition, Zhejiang, Fujian, and Hubei were at the frontier of efficiency. Six provinces and municipalities, such as Heilongjiang, Anhui, Shandong, Henan, Guangdong, and Guangxi, were high in PTE, indicating weak DEA efficiency. PTE and SE of the remaining provinces and municipalities could be further improved.

Table 2. Broiler production efficiency in 2007-2019: Stage 1

| Region | TE | PTE | SE | RTS |
|---|---|---|---|---|
| Liaoning | 0.575 | 0.776 | 0.741 | irs |
| Jilin | 0.298 | 0.882 | 0.338 | irs |
| Heilongjiang | 0.358 | 1.000 | 0.358 | irs |
| Zhejiang | 1.000 | 1.000 | 1.000 | - |
| Anhui | 0.747 | 1.000 | 0.747 | irs |
| Fujian | 1.000 | 1.000 | 1.000 | - |
| Shandong | 0.406 | 1.000 | 0.406 | irs |
| Henan | 0.340 | 1.000 | 0.340 | irs |
| Hubei | 1.000 | 1.000 | 1.000 | - |
| Hunan | 0.337 | 0.883 | 0.382 | irs |
| Guangdong | 0.462 | 1.000 | 0.462 | irs |
| Guangxi | 0.684 | 1.000 | 0.684 | irs |
| Yunan | 0.533 | 0.732 | 0.729 | irs |
| Mean | 0.595 | 0.944 | 0.630 | |

Note: "TE", "PTE", "SE", and "RTS" represent technical efficiency, pure technical efficiency, scale efficiency, and return to scale, respectively. In addition, "irs", "drs", and "-" signify that the return to scale increased, decreased, or remained unchanged, respectively.

## 3.2 The results of the stochastic frontier analysis model : Stage 2

According to Table 3, the Likelihood Ratio (LR) test for one-sided of the SFA model passed the significance test at the 1% level. It rejected the null hypothesis that there was no managerial inefficiency, indicating that it was reasonable to apply the SFA model. The slack variables of the input variables in stage 1 are regarded as the dependent variable. The three environmental variables (Per capita GDP, Market openness, and agricultural support) are regarded as the independent variables. The software application, Frontier 4.1, was utilized to perform the stochastic frontier analysis (SFA). Both $\sigma^2$ and $\gamma$ value passed the significance test ($\gamma$=0.999), indicating that compared with random error, managerial inefficiency in the mixed error term has a dominant influence on the slack variable. In addition, the estimated coefficients of the three environmental variables also passed the significance test, indicating that environmental factors have a significant impact on the slack values of the feed consumption, labor cost, fuel cost, and epidemic prevention cost. Therefore, applying the SFA model to separate the environmental variables and statistical noises is reasonable.

1) Per capita GDP:

The slack coefficient of per capita GDP and

Table 3. The results of the SFA model: Stage 2

| Variable | Feed consumption | Labor cost | Fuel cost | Epidemic prevention cost |
|---|---|---|---|---|
| Constant | 9.255E+03*** | -1.882E+02*** | 2.002E+01*** | -8.164E+01*** |
| Per capita GDP | -6.786E-04** | 1.083E-03*** | -1.183E-04*** | 3.855E-04 |
| Market openness | -8.533 | 7.334*** | -3.529*** | 1.379E+01*** |
| Agricultural support | -4.885E+02*** | -8.086E+02*** | -1.182E+02*** | -3.792E+02*** |
| $\sigma^2$ | 602.367*** | 2391.859*** | 17.536*** | 540.704*** |
| $\gamma$ | 0.999*** | 0.999*** | 0.999*** | 0.999*** |
| Log Likelihood | -50.299 | -60.557 | -28.293 | -49.039 |
| LR text for one-sided | 7.439 | 7.496 | 4.093 | 8.555 |

Note: *: p<0.1, **: p<0.05, ***: p<0.01

feed consumption is negative, and the per capita GDP growth will reduce the input slack of feed consumption, consistent with the expectation. With the improvement of the economic level, feed waste will be improved. The coefficient between per capita GDP and labor cost input slack is positive, indicating that the improvement of economic level will increase the redundancy of labor input. It may be due to the influence of intensive production methods in economic development regions. For capital-intensive production methods, in the case of large-scale production, the increase in labor input will lead to a waste of labor. Similar to the case of feed consumption, the improvement of the economic level will promote the improvement of fuel input waste. The input slack in per capita GDP and epidemic prevention costs has not passed the test.

2) Market openness:

The total imports and exports to GDP (market openness) ratio and the feed consumption input slack variable do not pass the test. The slack variable coefficient of its and fuel cost is positive, indicating that broiler production and the waste of power fuel will be reduced. It may be due to the improvement of openness to the outside world, and breeding enterprises will be exposed to more advanced breeding technology and technology results, leading to increased production efficiency. The input slack variables of labor cost and epidemic prevention cost are all positive, and this shows that market openness has not played its due role in the broiler production efficiency.

3) Agricultural support: It can be seen from the above Table 3 that the regression coefficients of the agricultural support to the slack variable are all negative, indicating that the improvement of agricultural support can indeed realize the effective allocation of resources.

After the above analysis, it can be concluded that the three environmental variables of per capita GDP, market openness, and agricultural support all affect the production efficiency of Chinese broiler production to varying degrees. As a result, some areas with suitable environmental conditions will perform higher than their actual efficiency levels. The actual productivity of some regions will be underestimated. Therefore, it is necessary to adjust the original input data, and the model selection in this paper is appropriate.

### 3.3 The results of the DEA model: Stage 3

The SFA model in stage 2 eliminated the influence of environmental factors and statistical noises on efficiency. The adjusted input value was then introduced into the model to replace the original input value at stage 1. the efficiency of broiler production (Table 4).

In stage 3, DEAP 2.1 was used to measure broiler production efficiency without considering the impact of external environment variables. The values of efficiency of broiler breeding and the returns to scale in 2020 as shown in Table 4. The mean value for technical efficiency (TE), pure technical efficiency (PTE), and scale efficiency (SE) for stage 3, without considering the impact of external environment variables, was 0.630, 0.964, and 0.630, respectively. After removing the influence of the external environment parameters, managerial inefficiency, and statistical noises, Zhejiang, Fujian, and Hubei were at the frontier of efficiency on the provincial level. The finding confirms that the broiler production efficiency of Zhejiang, Fujian, and Hubei remained consistently high, as they remained at the efficient frontier. The efficiency of Liaoning, Jilin, Anhui, Shandong, Hunan, Guangdong, Guangxi, and Yunan significantly changed after the model adjustments, indicating that environmental factors have a considerable impact on these provinces/municipalities. In addition, the TE of Heilongjiang, Henan decreased after the model adjustment.

Table 4. Broiler production efficiency in 2007-2019: Stage 3

| Region | TE | PTE | SE | RTS |
|---|---|---|---|---|
| Liaoning | 0.734 | 0.888 | 0.827 | irs |
| Jilin | 0.331 | 1.000 | 0.331 | irs |
| Heilongjiang | 0.344 | 1.000 | 0.344 | irs |
| Zhejiang | 1.000 | 1.000 | 1.000 | - |
| Anhui | 0.820 | 1.000 | 0.820 | irs |
| Fujian | 1.000 | 1.000 | 1.000 | - |
| Shandong | 0.437 | 1.000 | 0.437 | irs |
| Henan | 0.330 | 1.000 | 0.330 | irs |
| Hubei | 1.000 | 1.000 | 1.000 | - |
| Hunan | 0.345 | 0.896 | 0.385 | irs |
| Guangdong | 0.527 | 1.000 | 0.527 | irs |
| Guangxi | 0.760 | 1.000 | 0.684 | irs |
| Yunan | 0.560 | 0.753 | 0.729 | irs |
| Mean | 0.630 | 0.964 | 0.630 | |

Note: "TE", "PTE", "SE", and "RTS" represent technical efficiency, pure technical efficiency, scale efficiency, and return to scale, respectively. In addition, "irs", "drs", and "-" signify that the return to scale increased, decreased, or remained unchanged, respectively.

## 4. Conclusions and suggestions

This study employed a three-stage DEA model to analyze the efficiency of China's broiler breeding in 2020. The conclusions are as follows. (1) Before and after stage 2 of adjustment, the broiler production efficiency of provinces and municipalities has changed, indicating that environmental variables and random errors have significantly impacted grain production efficiency. (2) Through the second stage of SFA regression analysis, it is found that environmental variables have significant effects on broiler production efficiency. The increase in per capita GDP can reduce the input redundancy of feed cost and fuel cost and improve production efficiency, but it will cause input redundancy of labor input and epidemic prevention cost, resulting in waste of input and lower production efficiency. The improvement of agricultural support can realize the effective allocation of resources to improve production efficiency. The further improvement of market openness will introduce new technologies and promote the saving of fuel input. Still, because of the development status of China's broiler industry, its impact on improving China's broiler production efficiency is limited. On the contrary, it will increase the redundancy of labor input and epidemic prevention costs, thereby reducing production efficiency. (3) After removing environmental variables and random errors, the national average technical efficiency increased from 0.595 to 0.630. The average pure technical efficiency increased from 0.944 to 0.964, and the average scale efficiency remains constant.

Based on the findings of the study, the following suggestions are proposed: (1) Strengthen scientific research investment in broiler breeding and cultivation and introduce improved varieties actively. Cultivate and raise high-quality breeds, pay attention to the training of animal husbandry professionals, ensure the prevention and control of disease, and the standardized use of various anti-epidemic drugs in broiler breeding and production. While guaranteeing the stock of broilers, we should produce healthy and safe products to improve the market competitiveness. (2) Develop appropriate-scale broiler breeding. According to the analysis results, the efficiency of broiler breeding in China is relatively low, and the level between different regions is quite different. Because of the development status of the broiler breeding industry in various provinces, it is necessary to take advantage of regional advantages to develop large-scale breeding according to local conditions. Encourage experienced local farmers to gradually transition to large-scale farming to improve their operating income and risk response capabilities. At the same time, in response to large-scale breeding farmers, we should continuously improve the production technology, improve the breeding environment, improve scientific management, and give full play to the advantages of large-scale breeding. (3) Strengthen the precision of agricultural support, because the environmental variables and random errors significantly impact broiler production efficiency. Random errors are uncontrollable factors, so controlling environmental variables is one of the inevitable choices to improve broiler production efficiency. Support policies should be directed towards enterprises that are short of funds and carrying out technological innovations, increasing breeding training, improving the performance evaluation of breeding support funds, and improving support efficiency.

This study uses the data of China's Statistical Yearbook for analysis, which cannot fully reflect the investigation and analysis of farmers in the breeding process. In addition, there is a lack of data at the micro-level, the countermeasures and conclusions drawn are relatively macro, and there is a lack of more targeted suggestions. Therefore, in the following research, it is necessary to start from the farmers and reasonably analyze the input and output of broiler breeding in China. Meantime, when analyzing the input factors of broiler breeding, we should fully consider the impact of price fluctuations.

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