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Analysis on Production Efficiency of Laying Hens in China—Based on the Survey Data of Five Provinces

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Abstract

Problem Description: China is one of the major countries in the world of laying hens. However, compared with the United States and the European Union, the production efficiency of laying hens in China still lags far behind. *Objectives*: To guide the farmers to improve the effiency of laying hens breeding, we use the survey data to analysis the effiency and give advice. *Methodology*: This paper uses field survey data from five provinces to measure the technical efficiency of laying hens through DEA model. *Key Findings*: The results show that the average technical efficiency of survey households is 95.411%. Through the analysis, we found that layer chicken production technology in Hebei province is the highest, Liaoning province layer chicken production efficiency is the lowest. *Implications*: In the overall layout of laying hens breeding, the laying hens industry development should vigorously promote the rationalization of regional layout, give full play to regional advantages, and promote the development of laying hens industry.

Keywords: laying hens breeding, factor input, breeding efficiency

1. Introduction

Judging from the number of laying hens, since 1978, the industrial structure of laying hens in China has been constantly optimized, with gradually formed industrial advantages and enhanced industrial competitiveness. According to FAO statistics, the number of laying hens in China increased from 1.931 billion to 3.12 billion from 2000 to 2018, with an increase of 61.58%. The number of laying hens in the world increased from 4.973 billion to 7.891 billion, with an increase of 58.67%. According to calculations by FAO data, in 2018, the global number of laying hens is about 7.891 billion, and the number of laying hens in China is about 3.12 billion, accounting for 39.53% of the world's total (Table 1). The production of egg in China can meet the demand of the domestic egg market due to the support of progenitor generation, parent generation and commodity generation of laying hens.

Table 1. Number of laying hens in China and the world (Units: 10^3)

Year	Laying hens in China	Laying hens in the world	The proportion
2000	1930728	4973197	38.82%
2001	1960030	5104308	38.40%
2002	2032233	5268888	38.57%
2003	2035608	5362179	37.96%
2004	2135187	5557018	38.42%
2005	2234630	5722925	39.05%
2006	2305184	5919076	38.94%
2007	2386209	6077851	39.26%
2008	2487063	6254151	39.77%
2009	2536580	6348748	39.95%
2010	2563295	6520825	39.31%
2011	2581398	6616415	39.02%
2012	2656831	6821009	38.95%
2013	2686888	6946665	38.68%
2014	2737784	7113998	38.48%
2015	2978377	7525802	39.58%
2016	3014565	7671156	39.30%
2017	3153819	7838380	40.24%
2018*	3119705	7891167	39.53%

Note. 2018 data is estimated.

Source: FAO.

In terms of the production of egg, egg is the most important bird egg variety in China, and the production of egg accounts for more than 80% of the production of bird egg. Therefore, we can analyze the production of egg through the change of the production of bird egg. China's egg production continued to grow from 2000 to 2018, according to the FAO data. In 2000, China's egg production was 18.91 million tons. According to calculations, China's egg production in 2018 was 30.39 million tons, an increase of 60.7 percent over 2000. China's egg production accounted for between 36% and 41% of the world's egg production, of which the largest proportion was 40.49% in 2016. From the perspective of the overall trend, the proportion shows a slight upward trend (as shown in table 2).

Table 2. Production of egg in China and the world (Units: t)

Year	Egg production in China	Egg production in the world	The proportion
2000	18911899	51139609	36.98%
2001	19153719	52184057	36.70%
2002	19658920	53493695	36.75%
2003	20183020	54312163	37.16%
2004	20500750	55562956	36.90%
2005	21040577	56686312	37.12%
2006	20935240	57945805	36.13%
2007	21833160	59585101	36.64%
2008	23292120	61735079	37.73%
2009	23633516	62937724	37.55%
2010	23820080	64240171	37.08%
2011	24231630	65497298	37.00%
2012	24659155	67096642	36.75%
2013	24786994	68690640	36.08%
2014	24942678	70114454	35.57%
2015	30809783	76678893	40.18%
2016	31972681	78968196	40.49%
2017	31338856	80088559	39.13%
2018*	30390957	78978746	38.48%

Note. 2018 data is estimated.

Source: FAO.

From the perspective of geographical distribution, the northern region is the main production area of China's egg production, and the four regions of Shandong, Hebei, Henan and Liaoning account for about half of the country's egg production. Jiangsu, Hubei, Sichuan, Anhui bird egg production is bigger in southern area. From 2010 to 2018, the output of bird egg in the northern region has always occupied a large share, with Shandong, Hebei and Henan showing a declining trend. There is an upward trend in Liaoning. However, the 4 southern provinces showed little change. Since 2006, they also showed a downward trend, but the decline was smaller than that in the north (as shown in Table 3). With the development of breeding technology and equipment, the trend of laying hens southward is obvious. Because of the environmental protection policy control and the land use restraint and so on the condition, the laying chicken culture also presents the westward trend.

Table 3. Major egg-producing provinces in China (Unit: 10,000 tons)

Year	Hebei	Shandong	Henan	Liaoning	Jiangsu	Hubei	Sichuan	Anhui
2010	339.08	384.28	388.59	275.73	190.57	132.59	144.39	119.02
2011	339.84	401.19	390.5	277.4	194.86	137.03	144.85	119.65
2012	342.56	401.99	404.17	279.9	197.2	139.36	146.44	122.65
2013	346.06	396.21	410.23	276.82	197.87	145.05	145.2	124.53
2014	362.71	388.02	404	279.3	194.58	155.06	145.35	122.53
2015	373.59	423.9	410	276.5	196.23	165.29	146.65	134.66
2016	388.54	440.59	422.5	287.6	198.5	167.77	148.12	139.55
2017	383.72	444.78	401.18	270.43	183.39	168.17	144.5	154.7
2018 *	395.18	445.36	412.94	280.38	196.07	150.4	145.65	129.59

Note. 2018 data is estimated.

Source: National Bureau of Statistics.

2. Data Source and Descriptive Statistical Analysis

2.1 Data Sources

According to the project requirements of the national modern agricultural industrial technology system project, the data required in this paper are all from the field research from September 2018 to April 2019. The questionnaire mainly includes family basic information, basic information of layer breeding, factor investment, income from layer breeding and social services of layer breeding. The research method is mainly in the form of a face-to-face interview, in which the investigator communicates directly with the farmers to reflect the farmers' actual situation to the greatest extent. Hebei, Hubei, Jiangsu, Liaoning and Sichuan were selected in the survey area. Among them, 93 households in Hebei, 100 in Hubei, 122 in Jiangsu and 99 in Liaoning were selected. The five selected provinces involved east, central and west, which were highly representative.

Table 4. Regional distribution of large-scale breeding of laying hens

Province	City	Country	Frequency	The percentage	Frequency	The percentage
Hebei	Shijiazhuang	Jinzhou	22	4.2	93	17.6
		Zhao country	6	1.1		
	Handan	Guantao	65	12.3		
Hubei	Wuhan	Huangpi	11	2.1	100	18.9
	Xiantao	Xiantao	25	4.7		
	Xiaogan	Hanland	16	3		
	Huanggang	XiShui	8	1.5		
		YingShan	17	3.2		
	Ezhou	Liangzi lake	23	4.3		
Jiangsu	Nantong	Haian	41	7.8	122	23.1
		Rudong	41	7.8		
		Rugao	40	7.6		
Liaoning	Chaoyang	Beipiao	6	1.1	99	18.7
		Kazuo	13	2.5		
		Kangping	14	2.6		
		Longcheng	37	7		
	Huludao	lianshan	14	2.6		
		Nanpiao	15	2.8		
Sichuan	Chengdu	Jintang	25	4.7	115	21.7
	Deyang	Jingyang	3	0.6		
		Luojiang	2	0.4		
		Mianzhu	25	4.7		
		Zhongjiang	3	0.6		
	Mianyang	Anxian	31	5.9		
		Fucheng	26	4.9		
Total			529	100	529	100

Source: Field research.

2.2 Survey Household Factor Input

From Table 5 statistical analysis we can see, every one hundred only labor costs in addition to the scale of farming in 800 yuan of above, we here in the artificial cost refers to the farmers the opportunity cost of laying hens breeding, land costs for land rent and land use of the opportunity cost of one hundred per material and service refers to the daily investment, fixed assets depreciation and cope with the environmental policy. Since there was only one farmer from 300 to 1999, we mainly analyzed the factor input rules of farmers from 2000 to above. As can be seen from the above table, the larger the scale of breeding, the lower the labor cost per hundred. This is because farmers with larger scale of breeding adopt more mechanized breeding, which replaces artificial breeding and reduces labor input. The cost per hundred pieces of land is about 60 yuan, among which, the land area above 50000 is more than 2000-9999 and 10000-49999 pieces because more functional land is needed. Material and service charges may be related to depreciation and increased expenditure in response to environmental policies.

Table 5. Basic information of household farming scale

The size of the laying hens	Number	The percentage	Labor cost per hundred	Land cost per hundred	Material and service charge per hundred
300-1999	1	0.2	405.5555556	66.66666667	16731.11111
2000-9999	229	43.3	860.0738935	59.78803767	18268.02403
10000-49999	261	49.3	858.2992723	59.74258312	18272.97075
50000 or more	38	7.2	822.9373787	63.26942988	18796.44475

Source: Field research.

3. Production Efficiency Analysis of Farmers

3.1 Theoretical Model

We assume that the basic form of the production function is:

$$y_i = f(x_i, \beta) \cdot \xi_i \tag{1}$$

where, β is the parameter to be estimated, ξ_i is the production level to make the product reach the frontier of efficiency, and $0 < \xi_i \leq 1$. Considering that the production function is also subject to random shocks, the basic form of the production function is:

$$y_i = f(x_i, \beta) \cdot \xi_i e^{v_i} \tag{2}$$

where, e^{vi} is random shock, $e^{vi} > 0$. The frontier of production function $f(x_i, \beta) \cdot e^{v_i}$ is random, so this kind of model is called the "stochastic frontier model". The stochastic frontier model was proposed by Aigner, Lovell, and Schmidt (1977) and has been widely used in the empirical field.

$$\ln y_i = \beta_0 + \sum_{k=1}^{K} \beta_k \ln x_{ki} + \ln \xi_i + v_i \tag{3}$$

Based on the Cobb-Douglas production function and assuming the production function $f(x_i, \beta) = e^{\beta_0} x_{1i}^{\beta_1} \ldots x_{ki}^{\beta_k}$, the deformation of the production function can be obtained as follows:

$$\ln y_i = \beta_0 + \sum_{k=1}^{K} \beta_k \ln x_{ki} + v_i - u_i \tag{4}$$

As a result of $0 < \xi_i \leq 1$, $\ln \xi_i \leq 0$, let $u_i = -\ln \xi_i \geq 0$.

where, $u_i \geq 0$ is the item of "inefficiency", reflecting the distance between the manufacturer *i* and the efficiency frontier.We use the semi-normal distribution to estimate the inefficiencies. The technical efficiency can be calculated by calculating the ratio of the observed output to the corresponding random frontier output, that is:

$$TE = \frac{y_i}{\exp(x_i + v_i)} = \frac{\exp(x_i\beta + v_i - u_i)}{\exp(x_i\beta + v_i)} = \exp(-u_i) \tag{5}$$

3.2 Empirical Analysis

We select the number of laying hens as the output, capital, labor and land area as the input, and build the following model based on the Cobb-Douglas function:

$$\ln Y = \beta_0 + \beta_1 \ln(labor) + \beta_2 \ln(cap) + \beta_3 \ln(land) + v_i - u_i \tag{6}$$

where, *Y* represents survey 2018 households laying hens breeding stock, *labor* represents laying hens breeding labour recruitment days (including family labor force and number of employees), *cap* means money of laying hens breeding(including laying hens breeding daily devotion, depreciation of fixed assets and to cope with the environmental policy and increase cost), *land* means area of farm.

3.3 Results

We used frontier 4.1 to estimate the farmers' technical efficiency. The estimated results show that the average technical efficiency of survey households is 95.411%, that of survey households in Hebei province is 96.34%, that of survey households in Hubei province is 95.75%, that of survey households in Jiangsu province is 95.14%, that of Liaoning province is 94.98%, and that of Sichuan province is 95.01%.Through the above analysis, we found that the laying chicken production technology in Hebei province is the highest, and the reasons are as follows:

Laying hens in Hebei province have a long history. The development of laying hens in Hebei province started early with a large number of laying hens. For many years, laying hens' inventory and egg output ranked top three in China. Farmers have high breeding technology and pay attention to breeding management. Water quality monitoring, drug sensitivity test, antibody detection and disinfection effect evaluation are widely used. The detection frequency and density are very high. The disease and death of laying hens were less in the process of breeding. We will take appropriate measures to prevent and control epidemics.

The farming efficiency of Jiangsu, Sichuan and Hubei provinces is lower than that of Hebei province, but the development trend is good. At present, the development of laying hens industry in China shows a trend of equalization. Compared with the north, the southern layer breeding industry started late, but the breeding scale is higher, the equipment is advanced, the management level and the enterprise's operating conditions are relatively good.

4. Conclusions and Suggestions

4.1 Conclusion

The average technical efficiency of survey households was 95.411%. Through the above analysis, we found that Hebei province layer breeding production technology is the highest; the efficiency of layer breeding is the lowest in Liaoning province, which is related to the input of local land factors. Northern area has endowment advantage and comprehensive comparative advantage in breeding laying hens compared with other areas in China, so in short term laying hens breeding layout in China will be mainly in the north, especially in north China. South area in China should vigorously develop and utilize and upgrade the existing resources, promote the regional moderate scale cultivation of laying hens.

4.2 Suggest

4.2.1 Mechanized and Standardized Production

Farmers need to improve the level of chicken coop construction, improve technology, feed and so on, improve the ability to deal with the risk of large-scale farming. In 2017, the price of egg appeared a “roller coaster” situation, and the farmers failed to cope with the situation and their income was showing an obvious decline, forcing some farmers with anti-risk ability to withdraw from the laying hens breeding market. At the same time, the government formulated various environmental policies, farmers environmental pressure is increasing. However, the environmental protection requirements vary from place to place. Jiangsu, Zhejiang, Fujian, Hubei, Shandong and other places have higher environmental protection requirements and stronger implementation for the breeding industry.

4.2.2 Make Full Use of Agricultural Credit

One of the important characteristics of modern agricultural development is the use of advanced production equipment and technology, and the use of advanced equipment and technology cannot be separated from the support of funds. In addition, compared with planting, the breeding industry invests needs more money in fixed assets and equipment, which requires more agricultural credit funds. Agricultural credit funds can enable farmers to obtain the investment needed for breeding relatively quickly. Meanwhile, advanced technologies and equipment can be adopted to reduce the cost of breeding, improve the efficiency of breeding and obtain excess profits.

4.2.3 Use Modern Information Technology to Master Market Information

Layer farmer can make full use of network sale, fixed customer group, undertake egg sale directly. At the same time, through the combination of retail and online sales, improve the overall profitability of the chicken farm. And attract the ability to egg business into shares, joint in-depth marketing efforts. At the same time, e-commerce can reduce the information asymmetry between supply and demand in the process of product production, develop order agriculture, and directly connect the production and demand of agricultural products.

4.2.4 Improve Breeding Technology

First, advances in aquaculture technology can address the impact of environmental policies. Because of the traditional aquaculture equipment, sewage treatment and sanitary conditions are relatively poor. The application of professional equipment and the progress of breeding technology can greatly improve the sanitary conditions and sewage treatment capacity. The improvement of aquaculture technology will become a necessary condition for the development of large-scale aquaculture in the future.

Secondly, breeding technology is directly related to breeding efficiency. Feed cost occupies bigger share in cost of layer chicken breed. Reducing cost is an important way to improve the income of laying hens. Through technological progress, the cost of laying hens can be reduced and the income of laying hens can be increased. The content of other nutrients can be regulated in proportion to feeding standards through technological advances. Scientific breeding should be widely used which means a technology assure the nutrition according to the quantity laying hens need. Finally, green feed can be made through technological progress to ensure feed safety.

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