Analysis of Broiler Production Cost-Revenue and Efficiency in Jilin Province, China

Shuang-Yu Hu, Li Yang, Jong-In Lee[*]
Department of Agricultural & Resource Economics, Kangwon National University

중국 길림성 육계 생산의 비용수익 및 효율성에 관한 분석

호쌍우, 양리, 이종인[*]
강원대학교 농업자원경제학과

Abstract Because it is the main area for producing broiler chickens, a cost-revenue and production efficiency analysis of Jilin Province is significant. Based on data in the National Agricultural Product Cost-Revenue Data Compilation, cost-revenue and production efficiency of broiler production in Jilin Province for 2007 to 2020 was analyzed using panel data and the data envelopment analysis (DEA) model. The results showed that broiler production costs in Jilin Province rose overall, but were still lower than the national mean. Concentrated feed costs accounted for the largest proportion of the cost structure, followed by newborn animal costs (for chicks). The technical efficiency, pure technical efficiency, and scale efficiency of broiler chicken production in Jilin Province from 2007 to 2020 were 0.991, 0.994, and 0.997, respectively. Broiler chicken production was still in a state of high input and low output, and had a non-economic scale phenomenon, so its technical efficiency should be improved. The research results determined the purpose of improving the development of the broiler industry, combined with the specific conditions of broiler production in Jilin Province. This study puts forward corresponding suggestions in terms of attaching importance to the development and application of broiler production technology, large-scale breeding, and the development of intensive management.

요 약 중국 길림성은 육계 주요 생산지역으로서 거기에 대한 비용수익 및 생산효율을 분석하면 의미가 있다. "중국 전국 농산물 비용수익 데이터 총집"에 실려 있는 데이터를 토대로 패널 데이터와 DEA 모델을 이용해 중국 길림성의 2007~2020년 육계 생산의 비용수익 및 생산 효율성을 분석했다. 그 결과에 따르면 길림성 육계 생산 비용은 전반적으로 올랐지만, 중국 평균 수준보다는 낮은 것으로 나타났다. 비용 구조 중 농축사료 비용은 차지하는 비중이 가장 크다. 다음은 병아리의 가격이다. 2007~2020년 중국 길림성 육계 생산의 기술효율, 순수 기술효율, 규모효율은 각각 0.991, 0.994, 0.997이다. 육계 생산은 여전히 고 투입 저 산출 상태이다. 육계 생산은 규모의 불경제 현상이 있으므로 기술적 효율을 높여야 한다. 연구 결과를 바탕으로 중국 길림성에서의 육계 생산의 구체적인 조건과 결합하여 육계 생산기술의 개발과 응용 등을 중시하는 측면에서 제안함으로써 규모화 생산, 집약적인 경영을 실현하게 하고자 한다.

Keywords : Broiler Industry, Cost-Revenue, Production Efficiency, Scale Breeding, Jilin Province

1. Introduction

With the deepening of the supply-side structural reform of animal husbandry, the broiler industry in Jilin Province is facing a new round of development opportunities and challenges. How to effectively realize the high-quality and high-efficiency development of the broiler industry is a vital issue that needs to be considered in the future. According to the "Jilin Provincial Statistical Yearbook," from 2007 to 2020, the per capita poultry consumption of urban residents in Jilin Province increased from 3.57kg to 7.13kg, with an average annual increase of 5.47%, and the per capita consumption growth trend was noticeable. At the same time, the output per 100 large-scale broilers in Jilin Province increased from 271.60kg to 297.72kg, with an average annual increase of 0.71%, which was lower than the national average growth rate of 0.81%. In recent years, affected by the frequent outbreaks of avian influenza and other poultry food safety incidents, the domestic competitiveness of broiler production in Jilin Province has declined significantly, and it faces enormous challenges. It is of great significance to further reduce the production cost and improve the production efficiency to improve the competitiveness of the broiler industry in Jilin Province.

In recent years, the research on the broiler industry at home and abroad has mainly focused on the characteristics, status quo, and trends of the development of the broiler industry[1-5], as well as the design of the quality traceability system for broiler products[6], and there is little analysis of broiler production. The existing literature's economic research of broiler production mainly focuses on two perspectives: The first is the cost-revenue analysis of broiler breeding. The costs of broiler production in China are rising, and the annual growth rate is fast. The feed costs account for a large proportion of the year, and the cost of different breeding scales varies significantly[7,8]. At the same time, affected by the dual factors of market risk and natural risk, the income level of broiler farming in China is unstable. The second is the analysis of production efficiency. Some scholars believe that large-scale breeding can improve the production efficiency of broilers. However, Begum et al. (2019) took broiler production in Bangladesh as an example, arguing that large-scale operation is not conducive to improving production efficiency[9]. The overall efficiency of broiler production in China is not high, and there is a certain degree of cost inefficiency in all regions[10]. Some studies take large-scale broiler breeding as an example. Because of technology and scale factors, the efficiency of large-scale broiler breeding regions in China is significantly different[11]. The development should follow the principle of adjusting measures to local conditions. This study found that although existing studies have their own merits, there are still deficiencies in the research on cost-revenue and production efficiency of broiler breeding. Few studies have combined the analysis of cost-revenue and production efficiency, ignoring the relationship between cost-revenue and production efficiency. To sum up, most studies on the cost-revenue and production efficiency of broiler breeding in the existing literature focus on the macro level in China. Few previous studies analyze the cost-revenue and production efficiency in specific provinces. As China's one of the largest broiler production provinces, Jilin Province is significant for the stable development of China's broiler industry to analyze its cost-revenue and production efficiency. Therefore, this study draws on the existing research results to explore the cost-revenue and production efficiency of broiler production in Jilin Province, aiming to promote the development of the broiler industry in Jilin Province.

2. Costs analysis of broiler production in Jilin Province

2.1 Production costs of broiler

The database of this study is the cost-revenue data of broiler in Jilin Province in the "National Agricultural Product Cost-Revenue Data Compilation." According to the "National Agricultural Product Cost-Revenue Data Compilation," the total broiler production costs include production and land costs. The production costs include material and service costs and labor costs.

According to the "National Agricultural Product

Cost-Revenue Data Compilation division," Jilin Province belongs to medium-scale breeding, so it is compared and analyzed with the national medium-scale broiler breeding[12]. It can be seen from Table 1 that the production costs of broiler production in Jilin Province were higher than the national costs from 2007 to 2015, and the rest of the years were lower than the national costs.

It can be seen from Fig. 1 that the total costs of broiler production in Jilin Province increased significantly from 2007 to 2020, from 1,854.11 yuan per 100 broilers to 2,659.19 yuan per broilers, with an average annual growth rate of

Table 1. Production costs per 100 broilers in Jilin Province

(Unit: yuan)

Year	Jilin	Difference with last year	National	Difference with Jilin Province
2007	1,854.11	-	1,769.87	84.24
2008	2,015.21	161.1	1,934.86	80.35
2009	2,165.29	150.08	1,953.12	212.17
2010	2,213.72	48.43	2,121.11	92.61
2011	2,456.37	242.65	2,303.13	153.24
2012	2,681.67	225.3	2,492.37	189.3
2013	2,782.72	101.05	2,559.25	223.47
2014	2,782.72	0	2,559.25	223.47
2015	2,534.23	-248.49	2,472.36	61.87
2016	2,430.73	-103.5	2,442.53	-11.8
2017	2,260.05	-170.68	2,444.18	-184.13
2018	2,501.91	241.86	2,598.10	-96.19
2019	2,477.00	-24.91	3,052.16	-575.16
2020	2,659.19	182.19	2,972.37	-313.18

Source: National Agricultural Product Cost-Revenue Data Compilation, 2008~2021
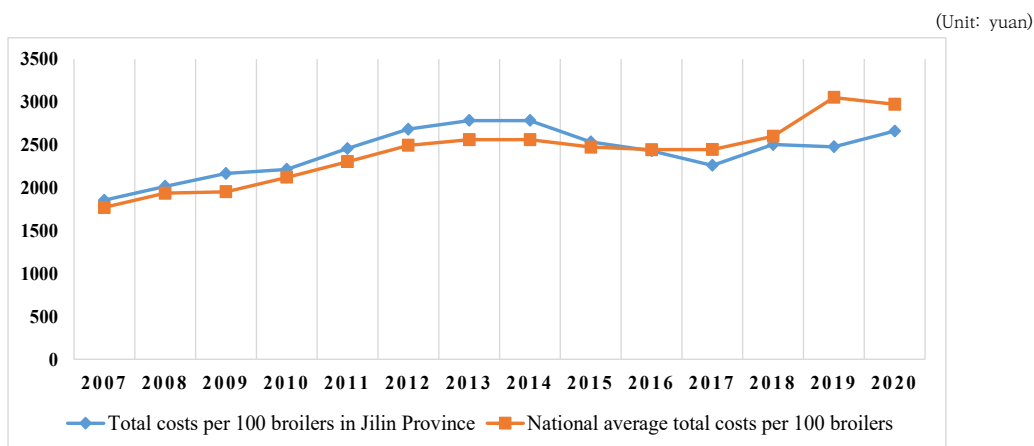
(Unit: yuan)

Fig. 1. Production costs curve per 100 broilers in Jilin Province and nationwide

2.81%, lower than the national level of 4.07%. The growth rate was the most obvious between 2010 and 2011, as high as 10.96%. From 2007 to 2013, after seven years of steady and low growth, the total costs of broiler production in Jilin Province showed a negative growth trend, with an average annual growth rate of -6.7% from 2014 to 2017. On the other hand, the production costs of broiler production in Jilin Province were consistently higher than the national average from 2007 to 2015 and were gradually lower than the national average in the following five years and were about 89.46% of the national average in 2020.

2.2 Composition of broiler production costs

In the composition of various costs and expenses of broiler production in Jilin Province, the proportion of the newborn animal costs, the concentrated feed costs, the medical expenses and epidemic costs, and labor costs were relatively high. Therefore, the costs of these four aspects were mainly analyzed.

Among the costs that constitute the total production costs per 100 broilers in Jilin Province, the concentrated feed costs are higher than 50% all year round, followed by labor costs,

and the sum of the two costs is greater than 75%. After deducting the factors of rising price levels, this reflects that the growth of output in broiler breeding in Jilin Province mainly comes from the input of concentrated feed. The government should lead the further improvement of broiler breeding infrastructure, cultivate new professional farmers, and increase the feed conversion rate by improving the broiler breeding level of farmers. Labor costs are the second-largest cost element after concentrate feed costs and have increased in recent years. Its proportion and growth trend reflect the increase in labor costs in the broiler industry and its promotion of the total costs of broiler production. The rise in labor will further squeeze the cost advantage of broiler breeding in Jilin Province. The medical expenses and epidemic costs generally showed a fluctuating trend, reflecting the fluctuation of broiler breeding technology and disease prevention and control capabilities in Jilin Province during the study period. The instability of the cost in this aspect enhances the risk of broiler breeding, which is not conducive to improving the competitiveness of broiler breeding in Jilin Province.

Table 2. Composition of production cost per 100 broilers in Jilin Province

(Unit: yuan)

Year	Newborn animal costs	Concentrate feed costs	Medical expenses and epidemic costs	Labor costs
2007	311.00 (17.85%)	1,239.32 (71.14%)	44.26 (2.54%)	147.39 (8.46%)
2008	264.70 (14.05%)	1,402.55 (74.44%)	45.97 (2.44%)	170.89 (9.07%)
2009	235.90 (11.65%)	1,538.98 (76.03%)	60.74 (3.00%)	188.43 (9.31%)
2010	252.69 (12.18%)	1,555.92 (74.98%)	42.48 (2.05%)	223.89 (10.79%)
2011	334.47 (14.43%)	1,614.29 (69.67%)	57.61 (2.49%)	310.73 (13.41%)
2012	249.78 (9.88%)	1,809.61 (71.55%)	71.15 (2.81%)	398.70 (15.76%)
2013	282.00 (10.71%)	1,793.82 (68.12%)	61.67 (2.34%)	495.72 (18.83%)
2014	282.00 (10.71%)	1,793.82 (68.12%)	61.67 (2.34%)	495.72 (18.83%)
2015	290.70 (12.16%)	1,465.73 (61.30%)	54.52 (2.28%)	580.17 (24.26%)
2016	352.97 (15.42%)	1,324.25 (57.85%)	66.03 (2.88%)	545.78 (23.84%)
2017	302.77 (14.37%)	1,188.67 (56.42%)	68.40 (3.25%)	547.12 (25.97%)
2018	258.30 (10.96%)	1,452.96 (61.66%)	63.83 (2.71%)	581.40 (24.37%)
2019	315.50 (13.59%)	1,306.56 (56.26%)	60.13 (2.59%)	640.14 (27.56%)
2020	321.23 (12.83%)	1,417.55 (56.62%)	58.11 (2.32%)	706.77 (28.23%)

Source: National Agricultural Product Cost-Revenue Data Compilation, 2008~2021

3. Revenues analysis of broiler production in Jilin Province

The revenue analysis of broiler production in Jilin province is mainly carried out from three indexes: net output value, net revenue, and net revenue margin.

The net output value reflects the input-output relationship of broiler production. It can be seen from Table 3 that from 2007 to 2020, the net output value of broiler production in Jilin Province generally showed a fluctuating trend. The highest value appeared in 2011, and the net output value reached 731.33 yuan. At the same time, compared with the national net output value, from 2007 to 2015, the input-output relationship of broiler production in Jilin Province was higher than the national average. From 2016 to 2020, the input-output relationship of broiler production in Jilin Province was lower than the national average.

The net revenue reflects the net rate of return on invested resources. From 2007 to 2020, the net revenue of broiler production in Jilin Province generally showed a downward trend. It has dropped to negative numbers since 2015. This is mainly due to the impact of avian influenza, the large-scale death of broilers, and the difficulty in sales of live broilers, resulting in a sudden drop in the net revenue of broiler production. At the same time, it can be seen from Table 3 that since 2012, the net revenue of broiler production in Jilin Province has been lower than the national average, indicating that there is still room for profit in broiler production in Jilin Province. Therefore, producers should further rationally optimize resource investment.

The net revenue margin reflects the profit per unit of broiler input cost. In general, the higher the cost-revenue ratio, the higher the operating efficiency. From 2007 to 2014, the broiler production cost rate of return in Jilin Province was positive, indicating that broiler production was profitable. Still, the cost rate of return fluctuated wildly, and the profitability level was unstable. From 2015 to 2020, the cost-revenue ratio of broiler production was negative, and broiler production suffered losses, indicating that broiler production had certain operational risks. At the same time, in most years, the cost-revenue ratio of broiler production in Jilin Province is lower than the national average.

Through the analysis of the net output value, net revenue, and net revenue margin of broiler

Table 3. Comparison of revenue per 100 broilers in Jilin Province and nationwide

(Unit: yuan, %)

Year	Net output value		Net revenue		Net revenue margin	
	Jilin	Nationwide	Jilin	Nationwide	Jilin	Nationwide
2007	495.15	381.09	340.32	287.14	18.35	16.22
2008	397.76	328.80	219.26	224.91	10.88	11.62
2009	420.74	282.62	220.68	162.71	10.19	8.33
2010	524.16	365.14	288.49	231.96	13.03	10.94
2011	731.33	441.69	408.57	288.88	16.63	12.54
2012	472.33	379.05	62.55	180.61	2.33	7.25
2013	515.89	369.28	8.83	123.65	0.32	4.83
2014	515.89	369.28	8.83	123.65	0.32	4.83
2015	547.49	516.95	-44.74	244.42	-1.77	9.89
2016	476.02	569.88	-81.77	295.23	-3.36	12.09
2017	458.39	565.09	-101.46	268.76	-4.49	11.00
2018	370.76	766.19	-223.51	457.54	-8.93	17.61
2019	567.71	1096.46	-82.21	728.36	-3.32	23.86
2020	401.43	874.00	-314.25	528.88	-11.82	17.79

Source: National Agricultural Product Cost-Revenue Data Compilation, 2008~2021

production in Jilin Province, it is found that the revenue of broiler production is generally fluctuating, and the level of profitability is unstable. In addition, the revenue level of broiler production in Jilin Province is lower than the national average level, and broiler production is still in a mode of high input and low output.

4. Efficiency analysis of broiler production in Jilin Province

In this study, the production costs and revenues of broiler breeding in Jilin Province are analyzed, respectively. Based on the analysis results, we further use the data envelopment analysis method to reveal the trend characteristics of the input-output changes of broiler breeding in Jilin Province to explore the change in efficiency and revenue fluctuation, which can enhance the persuasion of the study. According to the efficiency theory of Western economics, production efficiency refers to the comparison of input and output with the ideal state under the current technical level. The efficiency of broiler production refers to the number of qualified broilers produced by inputting a certain number of chicks, feed, veterinary drugs, and labor under the current level of broiler breeding[13]. Production efficiency generally includes two parts: technical efficiency and scale efficiency. At present, domestic and foreign scholars mainly use the DEA model to study production efficiency. Data Envelopment Analysis (DEA) is the most commonly used method to study input-output productivity. DEA is a mathematical liner programming method to construct a non-parametric piecewise surface (or frontier) over the data, which could be able to calculate efficiencies relative to this surface Coelli[14]. DEA is an efficient evaluation method developed by Farrell based on relative efficiency in

1957[15]. Charnes et al.[16], Fare and Lovell[17], and Banker et al[18]. establish some models for further study. Each of the selected years was considered one DMU in this research. Introduced by Banker, Chames, and Cooper (1984), this model measures Technical Efficiency as the convexity constraint and ensures that the composite unit is of similar scale size as the unit being measured. The variable returns to scale (BCC) model shows that the addition of a convexity constraint to the constant returns to scale (CCR) model results in a DEA model that allows increasing, constant, and decreasing returns to scale. The envelopment form of BCC is:

$$\min \theta_o$$
$$s.t \sum_{j}^{n} \lambda_j x_{ij} - \theta_o x_{io} \leq 0, i = 1,2,\cdots m$$
$$\sum_{j}^{n} \lambda_j y_{rj} - y_{ro} \geq 0, r = 1,2,\cdots,s \qquad (1)$$
$$\sum_{j}^{n} \lambda_j = 1$$
$$\lambda_j \geq 0$$

There are n DMUs each employs m similar inputs and produces s similar outputs. Note that BCC model differs from CCR in that it has the additional convexity constraint, $\sum_{j}^{n} \lambda_j = 1$. A DMU0 is BCC-efficient if it has an optimal solution of $\theta = 1$, $\lambda = 1$ and $\lambda \neq 0$.

After years of development, DEA has been widely used in many industries such as agriculture, manufacturing, and construction and has become a specialized efficiency analyzing tool. In this study, the method is used to analyze the production efficiency of broilers in Jilin Province from both static and dynamic perspectives. Technical efficiency includes scale efficiency and pure technical efficiency. Scale efficiency refers to the degree of scale economy exerted. Pure technical efficiency relates to

management and production technology at a certain point relative to other technologies. Technical efficiency, scale efficiency, and pure technical efficiency are between 0 and 1, and the larger the value, the higher the efficiency.

This study uses the broiler industry's cost and revenue data in Jilin Province in the National Agricultural Product Cost-Revenue Data Compilation from 2008~2021. It adopts DEA model to analyze the production efficiency of broiler breeding in Jilin Province. After data processing, the output value (y) of broiler production in Jilin Province is finally selected as output variables, the newborn animal costs (x_1),

the concentrate feed costs (x_2), labor costs (x_3), depreciation of fixed assets (x_4), medical expenses and epidemic costs (x_5), and other expenses (x_6) (including management fees and sales fees, etc.) are input indicators, as shown in Table 4.

Using DEAP 2.1 software to process the data, the technical efficiency of Jilin Province from 2007 to 2020 when the scale returns are constant, the technical efficiency and scale efficiency when the scale returns are variable, and the specific results are shown in Table 5.

Overall, the technical efficiency of broiler

Table 4. Summary descriptive statistics of variables

(Unit: kg, yuan)

| Year | Output | Input | | | | | |
	y	x_1	x_2	x_3	x_4	x_5	x_6
2007	271.60	311.00	1,239.32	147.39	26.79	44.26	8.61
2008	270.90	264.70	1,402.55	170.89	26.33	45.97	12.37
2009	304.09	235.90	1,538.98	188.43	29.01	60.74	7.04
2010	293.00	252.69	1,555.92	223.89	28.17	42.48	7.18
2011	289.96	334.47	1,614.29	310.73	25.37	57.61	8.15
2012	293.20	249.78	1,809.61	398.70	23.31	71.15	7.57
2013	292.17	282.00	1,793.82	495.72	22.25	61.67	11.67
2014	292.17	282.00	1,793.82	495.72	22.25	61.67	11.67
2015	290.93	290.70	1,465.73	580.17	19.45	54.52	11.00
2016	295.37	352.97	1,324.25	545.78	20.45	66.03	9.50
2017	288.93	302.77	1,188.67	547.12	19.84	68.40	10.74
2018	296.43	258.30	1,452.96	581.40	19.77	63.83	11.43
2019	296.89	315.50	1,306.56	640.14	26.67	60.13	13.22
2020	297.72	321.23	1,417.55	706.77	28.64	58.11	12.85

Source: National Agricultural Product Cost-Revenue Data Compilation, 2008~2021

Table 5. Production efficiency of broiler breeding in Jilin Province from 2007 to 2020

Year	Technical efficiency	Pure technical efficiency	Scale efficiency	Return to scale
2007	1.000	1.000	1.000	–
2008	0.997	1.000	0.997	irs
2009	1.000	1.000	1.000	–
2010	1.000	1.000	1.000	–
2011	0.987	0.993	0.994	irs
2012	1.000	1.000	1.000	–
2013	0.968	0.969	0.999	irs
2014	0.968	0.969	0.999	irs
2015	1.000	1.000	1.000	–
2016	1.000	1.000	1.000	–
2017	1.000	1.000	1.000	–
2018	1.000	1.000	1.000	–
2019	0.998	1.000	0.998	drs
2020	0.960	0.985	0.975	drs
Mean	0.991	0.994	0.997	

breeding in Jilin Province from 2007 to 2020 was 0.991, and the technical efficiency of 6 years still needs to be improved. The technical efficiency in 2007, 2009, 2010, 2012, 2015, 2016, 2017, and 2018 reached 1.000, reaching a technically effective state. The technical efficiency in 2008, 2011, 2013, 2014, 2019, and 2020 were 0.997, 0.987, 0.968, 0.968, 0.998, and 0.960, respectively, which were close to the effective state of technical efficiency, indicating that there was input redundancy in these six years.

As shown in Table 5, the scale efficiency of broiler production in Jilin Province was unchanged from 2007 to 2018, and the return to scale began to decline from 2019 to 2020. It indicates that the proportion of the output of broiler production is smaller than the proportion of input factor increase, and there is a phenomenon of non-economic scale in broiler production, so the rise in income factor cannot be relied on improve the output efficiency. The excessive input factors are mainly due to the increase in production factors cost in broiler production. The price of chickens and feed generally increased. Increased medical and epidemic prevention expenses due to multiple avian flu outbreaks. The increase in labor wages increased labor costs. The main reason for the non-economic of broiler production in Jilin province is that most of the broiler production in Jilin province belongs to medium and small scale, which is limited by technical level, has the phenomenon of low survival rate of chicks and low feed conversion rate, which leads to more input and less output of broiler production.

5. Conclusions and suggestions

Based on the National Agricultural Product Cost-Revenue Data Compilation data, this study analyzed the cost-revenue and production efficiency of broiler production in Jilin Province from 2007 to 2020 and draws the following conclusions. The total cost of broiler production in Jilin Province is lower than the national average from 2016 to 2020. And the revenue level of broiler production in Jilin Province is lower than the national average level, and broiler production is still in a mode of high input and low output. The technical efficiency of broiler breeding in Jilin Province from 2007 to 2020 was 0.991, and the technical efficiency of 6 years still needs to be improved. The reason for the non-economic of broiler breeding is that most of the broiler production in Jilin province belongs to medium and small scale and has the phenomenon of low survival rate of chicks and low feed conversion rate. Due to the limited data obtained, the current efficiency analysis is only limited to the change in broiler production efficiency in different periods in Jilin Province. It cannot reflect the difference in efficiency caused by the shift in production scale, so it is necessary to compare farming units of different production scales, which is the focus of subsequent research.

According to the research conclusions, to promote the development of broiler production in Jilin Province, the following suggestions are put forward. (1) Strengthen scientific and technological investment and improve the technical system of broiler production. Jilin Province has abundant labor resources and natural resource conditions suitable for breeding livestock and poultry. However, due to the cost burden, the development of broiler breeding in Jilin Province is affected. It is necessary to increase the investment in science and technology-driven by leading local enterprises to achieve low costs and high revenues. Cultivate and introduce excellent broiler breeds, pay attention to the training of professional and technical personnel, and ensure the prevention and control of epidemic diseases in broiler production. Based on ensuring the output of

broilers, the safety of livestock and poultry products is realized. (2) Develop large-scale breeding, reduce the number of free-range and small-scale broiler breeding, and pay attention to the reasonable recycling and utilization of broiler manure. Large-scale breeding has unparalleled advantages in production cost control, technology application, and improvement management. It is an inevitable way to develop the broiler industry in Jilin Province. Vigorously developing large-scale aquaculture can first reduce production costs, including the cost saved by advancing breeding and feeding technologies. Therefore, the government should provide financial, technical, and policy support to promote the rapid development of large-scale farms. Farmers and broiler breeding enterprises should reasonably plan the breeding scale and use various development models such as enterprise + farmers to reduce breeding costs and maximize the scale. (3) Increase government support to promote broiler production efficiency. It is necessary to strengthen policy support for broiler production, mainly including: increasing capital investment in projects that improve broiler production efficiency, improving the welfare of broiler farmers, moderately raising barriers to entry for large-scale broiler farming, and creating a development environment conducive to the improvement of broiler production. (4) The broiler industry should improve its management level. Through vigorous publicity and training, enhance the efficiency awareness and revenue concept of the farm, make it understand that management level and revenue are closely related, and fully understand the importance of management. Meantime, the enterprises carry out relevant professional training such as production efficiency measurement and cost-revenue accounting and implement refined management of broiler breeding.

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Shuang-Yu Hu [Regular member]

• Jun. 2017 : Yanbian Univ., Agriculture and Forestry Economic Management, BM
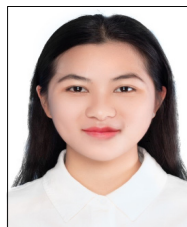• Jun. 2019 : Yanbian Univ., Rural Regional Development, MSC(Agr)
• Sept. 2019 ~ current : Kangwon Univ., Dept. of Agricultural and Resource Economics, PhD Program

⟨Research Interests⟩
Agriculture Circulation, Consumer Behavior

Li Yang [Associate member]

• Jun. 2020 : Qiannan Normal University for Nationalities, Economics,,BS
• Sept. 2021 ~ current : Kangwon Univ., Dept. of Agricultural and Resource Economics,JiLin Univ., Agriculture and Forestry Economic Management, Graduate student

⟨Research Interests⟩
Livestock Economy

Jong-In Lee [Regular member]

• Feb. 1987 : Kangwon Univ., Animal Science, BSC(Agr)
• Feb. 1993 : Kangwon Univ., Livestock Management, MM
• Aug. 1997 : Missouri Univ., Agricultural Economics, MSAE
• Dec. 2000 : Oklahoma Univ., Agricultural Economics, PhD
• Feb. 2006 ~ current : Kangwon Univ., Dept. of Agricultural and Resource Economics, Professor

⟨Research Interests⟩
Livestock Management, Livestock Economy, Food Consumption