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Study on Promoting the Green and Low-carbon Transformation Development of Animal Husbandry in Anhui Province under the "Double Carbon" Goal

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Abstract

In the context of global warming, energy conservation and emission reduction are the needs of The Times, and green and low-carbon development is the future trend. As one of the main sources of carbon emissions, animal husbandry is conducive to green and low-carbon development to reduce carbon emissions and alleviate climate problems. China has been a big agricultural country since ancient times, and Anhui Province is a big province of animal husbandry in China. Therefore, aiming at the problem of carbon emission in animal husbandry of Anhui province, this paper firstly calculates the carbon emission efficiency of animal husbandry of Anhui Province in recent years using the non-radial output model. The results show that there is still room for improvement in animal husbandry of Anhui Province. Then, the Tobit model was used to deeply analyze the influencing factors of carbon emissions in animal husbandry. The research showed that the education level, endowment structure and economic level of local animal husbandry employees had a positive impact on carbon emission efficiency. The industrial structure and energy consumption have a negative impact on the carbon emission efficiency of animal husbandry. Finally, this paper puts forward some suggestions, such as the government should increase the support of relevant policies, enterprises should accelerate the construction of scientific and technological innovation system in animal husbandry, and individual retail investors should actively improve their professional skills.

Keywords

Animal Husbandry; Low-carbon Development; Non-radial Output Model;Tobit Model.

1. Introduction

With the increase of carbon emissions, global warming is becoming more and more serious. As we all know, it has seriously affected the human environment and natural ecology, resulting in a substantial reduction in agricultural output, water resources imbalance, and serious destruction of the ecosystem. There are many reasons for climate warming, among which the carbon dioxide emitted by livestock farming is also one of the important causes of global warming. China has been an agricultural country since ancient times, and animal husbandry is an important part of agriculture. China's livestock sector accounts for about 15% of global carbon emissions, which have a significant impact on global warming. In the context of energy conservation and emission reduction, countries have gradually realized the importance of low-carbon life and consumption, and started to implement relevant policies and actions. Under the two-carbon target, the constraints of resources and environment are increasingly severe. In

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order to meet the requirements of The Times and adapt to the development of The Times, animal husbandry is gradually transforming to green and low-carbon development.

As a major province of animal husbandry in China, Anhui Province has accelerated the modernization and green and low-carbon development of animal husbandry in Anhui Province under the background of the national promotion of green and low-carbon development of animal husbandry, and has made certain achievements. However, at present, on the road of green and low-carbon development of Anhui Province's animal husbandry, there are still some problems, such as lack of relevant talents and scale, resulting in low production efficiency of Anhui Province's animal husbandry and great room for improvement in carbon emission reduction. Therefore, taking Anhui province, a large agricultural province in China, as an example, using relevant index data during 2012-2019 and utilizing SBM-Undesirable model to estimate the carbon emission efficiency of animal husbandry in Anhui province, and on this basis, using Tobit model to in-depth analyze the influencing factors of carbon emission efficiency. To provide empirical evidence for the formulation of policies related to the green and low-carbon transformation development of animal husbandry in Anhui Province, China, and promote the green and low-carbon development of animal husbandry in Anhui Province.

2. Literature Review

With the increasingly severe environmental problems, energy conservation and emission reduction is the needs of The Times, green and low-carbon development is the future trend. As a major source of carbon emissions, animal husbandry has been studied by more and more scholars.

In terms of the development status of animal husbandry, Ding Xiaodong et al. (2021) believe that there are still problems in China's animal husbandry, such as low degree of production organization and poor ability of scientific and technological innovation. Wang et al. (2021) believe that most of the existing breeding institutions in our country belong to extensive and have not formed large-scale breeding institutions, and the industry efficiency is low, the quality of livestock products can still not be guaranteed, and the development of animal husbandry may cause a great deal of pollution to the environment under the current circumstances. He et al. (2021) believe that the comprehensive production capacity of animal husbandry in China is constantly improving, and remarkable results have been achieved in green development. In terms of suggestions on the development of animal husbandry, THORNTON et al. (2010) believed that the improvement of animal feed and its varieties could reduce carbon emissions. GERBER et al. (2011) believed that improving the processing efficiency of animal husbandry products could effectively reduce carbon emissions. Shi et al. (2019), from the perspective of regional development and agricultural innovation and development, proposed that green development should lead ecological revitalization, strengthen the comprehensive treatment of prominent environmental problems in rural areas, increase the supply of agricultural ecological products and services, and realize the unity of people's prosperity and ecological beauty. Shao (2018), from the realistic level and the practical idea of solving the problem, believes that the development of animal husbandry needs to pay attention to pollution remediation, and the first principle of pollution remediation is prevention, and prevention at the source is the focus of work. Li (2021) believes that it is necessary to guarantee the factors related to the green development of animal husbandry, proposes the establishment of a comprehensive guarantee system, and details relevant suggestions. Fan (2020) puts emphasis on the standardization system and believes that the standardization system for the green development of animal husbandry should be further improved. Based on this, he puts forward suggestions such as guiding the standard construction of livestock farms, strengthening the assessment and evaluation of livestock farms, and establishing demonstration bases for the green development

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of animal husbandry. COLE et al. (2000) believes that supervision cost and enforcement intensity are key factors for effective implementation of carbon emission reduction policies.

Based on the above analysis, we can see that many scholars have carried out relevant research on the development of animal husbandry. However, most scholars study the development status and existing problems of animal husbandry qualitatively, while relatively few analyze the factors affecting its green and low-carbon transformation development quantitatively. Therefore, taking Anhui province, a major animal husbandry province in China, as an example, this paper quantitatively analyzed the factors influencing carbon emissions in the livestock industry through the SBM-Undesirable model and Tobit model, and then proposed an optimization path for the green and low-carbon transformation development of the livestock industry in order to promote its green and sustainable development.

3. Research Methods

3.1. SBM-Undesirable Model

Data Envelopment analysis (DEA) is a method to measure the relative effectiveness of multiple decision-making units, and it is often used to measure the production efficiency of some decision-making departments. However, the traditional data envelopment method has strict assumption of radiality and neglect of non-expected output factors, which leads to the deviation of calculation results. Therefore, this paper proposed to use the non-radial undesirable output (SBM-Undesirable) model to solve the shortcomings existing in the traditional data envelope analysis, and introduced undesirable output into the efficiency evaluation, taking carbon emissions of livestock industry as an indicator of undesirable output. Suppose it exists in n vectors with input X, expected output and unexpected output, and its expression is as follows:

$$\begin{aligned} X &= [x_1, x_2, \dots, x_n] \in R^{m\times n} \\ Y^g &= [y_1^g, y_2^g, \dots, y_n^g] \in R^{s_1\times n} \\ Y^b &= [y_1^b, y_2^b, \dots, y_n^b] \in R^{s_2\times n} \end{aligned} \tag{1}$$

Where, X, Y^g and Y^b>0, R is the set of real vectors, m, s1 and s2 are the number of factors of input, expected output and unexpected output respectively. The SBM model of undesired output can be expressed as:

$$\begin{aligned} \rho^* = min & \frac{1-\frac{1}{m}\sum_j^m \frac{S_i^-}{x_{10}}}{1+\frac{1}{s_1+s_2}\left(\sum_{r=1}^{s_1}\frac{S_r^g}{y_r^{g0}}+\sum_{r=1}^{s_2}\frac{S_r^b}{y_r^{g0}}\right)} \\ s.t. \quad & x_0 = X\lambda + s^- \\ & y_0^g = Y^g\lambda - s^g \\ & y_0^b = Y^b\lambda + s^b \end{aligned} \tag{2}$$

Where: $\rho^*$is the carbon emission efficiency value, and s^-, s^g and s^b are the relaxation amount of input, expected output and non-expected output respectively. When ρ^*= 1, the decision unit is valid, that is, there is Pareto optimal. When 0≤ρ^*< 1 is invalid, efficiency can be improved by optimizing input-output.

3.2. Tobit Model

The Tobit model is applicable to the roughly continuous distribution of the dependent variable over positive values, but contains some observations that value 0 with positive probability. It is

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also known as truncated regression model or censored regression model, which belongs to a regression of restricted dependent variable. Restricted dependent variable means that the observed value of the dependent variable is continuous, but due to some limitations, the obtained results cannot fully reflect the real condition of the dependent variable. Its model is expressed as:

$$Y=\begin{cases}\alpha+\beta x+\varepsilon, Y>0\\ 0, Y\le 0\end{cases} \tag{3}$$

Where, Y is the restricted dependent variable, α is the intercept term, β is the estimated coefficient, x is the independent variable, and ε is the random disturbance term.

4. Index Selection and Data Sources

4.1. Input-output Index Selection

The carbon emission efficiency of animal husbandry plays an important role in the evaluation of the coordinated development of economic growth, resource input and carbon emission of animal husbandry. Referring to previous studies, this paper selected livestock capital and labor as input indicators, the output value of livestock production as expected output indicators, and carbon emissions as non-expected output indicators. The indicators and data sources are shown in Table 错误!未找到引用源。.

Table 1. Measurement indicators of carbon emission efficiency of animal husbandry.

Category	Index	Measure index
Input factor	Capital input	Animal husbandry capital stock
	Labor input	Number of employees in animal husbandry
Output factor	Expected output	Output value of animal husbandry
	Undesirable output	Carbon emissions from animal husbandry

According to relevant data, pigs, poultry, cattle and sheep were selected as the main carbon sources of animal husbandry in Anhui Province, and the carbon emissions of animal husbandry mainly came from methane and nitrous oxide produced by livestock. The specific calculation formula of carbon emissions from animal husbandry is as follows:

$$C=\sum_{i=1}^{4} C_i^t=\sum_{i=1}^{4}[6.82\times\lambda_i^t\times(u_i+v_i)+81.27\times\lambda_i^t\times w_i] \tag{4}$$

Where, C is the total carbon emission of animal husbandry, λ_i^t is the average breeding quantity of the i type of livestock and poultry in year t, and u_i, v_i, w_i is the emission coefficient of methane and nitrous oxide of livestock and poultry. The details calculated are shown in Table 错误!未找到引用源。.

Table 2. Methane and nitrous oxide emission coefficients for livestock and poultry.

Carbon source	u_i	v_i	w_i
The pig	1.0	3.50	0.53
poultry	—	0.02	0.02
The cow	47.8	1.00	1.39
The sheep	5.0	0.17	0.33

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4.2. Data Sources and Processing

The data in this paper are from Anhui Statistical Yearbook and Anhui Provincial Bureau of Statistics from 2012 to 2019. The output value of animal husbandry was converted to the ratio based on the production price index and the fixed investment in animal husbandry was converted to the ratio based on the fixed investment price index in 2012, and some missing data were made up by proportional conversion.

5. Calculation of Carbon Emission Efficiency of Animal Husbandry

Matlab software was used to calculate the carbon emission efficiency value of animal husbandry in Anhui Province from 2012 to 2019, and the results were shown in Table 错误!未找到引用源。.

Table 3. Carbon emission efficiency of animal husbandry in Anhui Province from 2012 to 2019.

Year	2012	2013	2014	2015	2016	2017	2018	2019
Carbon emission efficiency value	1.0000	0.8951	1.0000	0.7743	1.0000	1.0000	0.9137	1.0000

It can be seen from Table 错误!未找到引用源。 that the carbon emission efficiency of animal husbandry in 2012, 2014, 2016, 2017 and 2019 was 1, which reached Pareto optimization. However, the carbon emission efficiency value in 2013, 2015 and 2018 was less than 1, which was in an invalid state, and there was room for optimization and improvement. However, at the same time, we observed that the values of these years were all above 0.75, indicating a higher overall carbon emission efficiency value. This is closely related to Anhui Province's continuous improvement of economic development in recent years and its emphasis on the green development of animal husbandry.

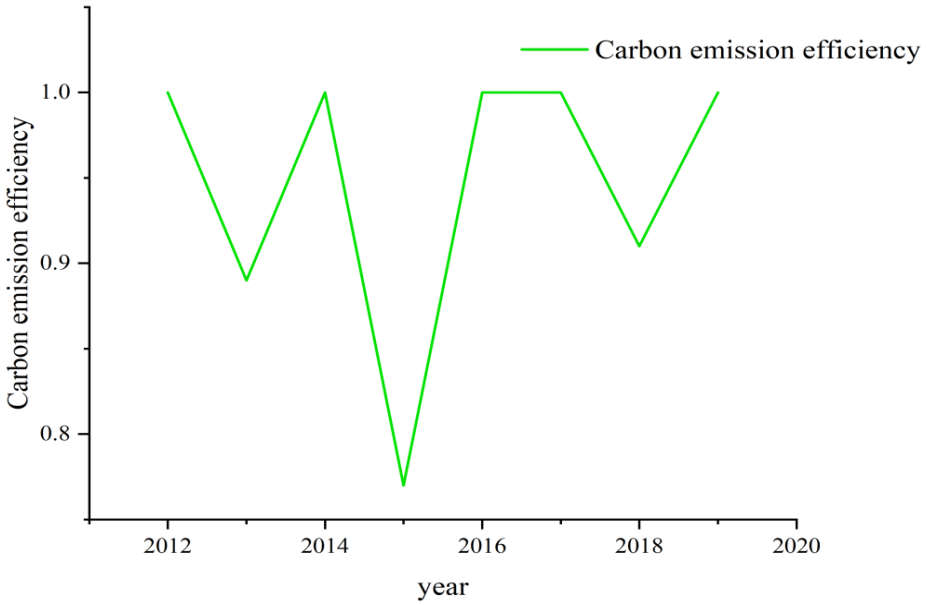

Figure 1. Variation trend of animal husbandry carbon emission efficiency in Anhui Province from 2012 to 2019.

In order to more intuitively show the carbon emission efficiency of Anhui animal husbandry from 2012 to 2019, the temporal trend distribution of carbon emission efficiency was drawn, as shown in Figure 错误!未找到引用源。. It can be seen that the carbon emission efficiency of

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animal husbandry in Anhui province fluctuates to a certain extent, but the carbon emission efficiency reached the optimal level in the five years during the observation period, which is because Anhui government has been improving livestock breeding technology and standards, paying attention to the development of livestock and poultry vaccines, and exploring the resource utilization of livestock and poultry manure pollution. Through the promotion of mechanization, scale, specialization and standardization, the transformation of agricultural production mode has been realized, the effective production-investment ratio has been increasing, and the efficiency of carbon emission has been significantly improved. At the same time, the damage of pollutants to the ecological environment is controlled from the source by strengthening the treatment of livestock and poultry manure, sharing the centralized manure treatment system, and intelligent monitoring of pollution in the process of breeding. However, in some years, the carbon emission efficiency of animal husbandry is not optimal, which means that there is still room for optimization and improvement.

6. Research on Influencing Factors of Carbon Emission Efficiency in Animal Husbandry

6.1. Model Setting

Since the carbon emission efficiency values of animal husbandry are not less than 0, this paper adopts the Tobit model which can avoid the negative fitting effect of traditional regression. In order to explore the factors affecting the carbon emission efficiency of animal husbandry in Anhui province, this paper selected the carbon emission efficiency of animal husbandry as the dependent variable, and on the basis of reading a large number of literatures, selected the endowment structure, energy consumption, education level, number of animal husbandry employees, industrial structure, and economic level of animal husbandry as the independent variables to construct the Tobit model. The specific indicators are shown in Table 错误!未找到引用源。, and the calculation formula is as follows:

$$CE^t = \alpha^t + \beta_1 EL^t + \beta_2 EI^t + \beta_3 EP^t + \beta_4 IS^t + \beta_5 ES^t + \beta_6 AE^t \quad (5)$$

Where, CE is carbon emission efficiency of animal husbandry, A is intercept, B is estimate coefficient, EL is economic level of animal husbandry, EI is education level, EP is number of people employed in animal husbandry, IS is industrial structure, ES is endowment structure, AE is energy consumption, and t is period.

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Table 4. List of indicators.

Symbol	Measure index	Index composition
CE	Carbon emission efficiency of animal husbandry	—
EL	Economic level of animal husbandry	Total output value of animal husbandry/number of employees in animal husbandry
EI	Educational level	Number of students at General high School and above/total population of the district at the end of the year
EP	Number of employees in animal husbandry	—
IS	Industrial structure	Total output value of animal husbandry/total output value of agriculture, forestry, animal husbandry and fishery
ES	Endowment structure	Livestock capital stock/number of employees in animal husbandry
AE	Energy structure	Take the logarithm of rural electricity consumption

6.2. Results and analysis

In this paper, STATA was used to perform Tobit regression on the model, and the model likelihood ratio test was used to analyze the effectiveness of the overall model. The results are shown in Table 错误!未找到引用源。:

Table 5. Likelihood ratio test of Tobit regression model.

Model	-2x log likelihood value	Chi-square value	df	p	AIC value
Intercept only	-29.301				
Final model	-42.112	56.289	7	0.001	-21.588

Since P value <0.05, the model constructed is effective, that is, the explanatory variables put into it are meaningful, which also indicates that the model construction is meaningful.

Table 6. Results of Tobit regression model

Item	Regression coefficient	Standard error	Z value	P value	95% CI
intercept	0.739	0.119	3.744	0.001	0.302~1.131
Educational level	0.653	0.000	2.328	0.003	0.000~0.000
Number of employees in animal husbandry	0.012	0.005	0.769	0.454	0.014~0.006
Industrial structure	-0.075	1.438	0.031	0.000	-2.892~2.744
Economic level of animal husbandry	0.021	0.018	0.584	0.000	0.070~0.042
Endowment structure	0.023	0.011	0.208	0.000	0.091~1.766
Energy consumption	-0.037	0.426	0.087	0.001	-1.155~2.092

Note:1) Dependent variable: carbon emission efficiency of animal husbandry.

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2)McFadden R square: 0.885.

According to the analysis results (Table 6), the value of McFadden R square was 0.885, indicating a better regression fitting effect. The P value of the number of livestock practitioners was >0.05, indicating that the number of livestock practitioners would not have an impact on the carbon emission efficiency of animal husbandry, but the remaining independent variables would have a significant positive impact on the carbon emission efficiency of animal husbandry. Therefore, the regression model we constructed is as follows:

$$CE^t = 0.739^t + 0.653EI^t + 0.012EP^t - 0.075IS^t + 0.021EL^t + 0.023ES^t - 0.037AE^t \quad (6)$$

According to the regression equation, among the positive effects of education level, endowment structure and economic level of animal husbandry, the promoting effect of education level is higher than the other two. Education is used to popularize the harm of carbon emission to people, and at the same time to improve the professional knowledge and comprehensive ability of animal husbandry practitioners. On the one hand, it is conducive to the development of animal husbandry, and on the other hand, it can reduce the carbon emission in the process through scientific means, so as to improve the efficiency of carbon emission. Industrial structure and energy consumption have a significant negative impact on the carbon emission efficiency of animal husbandry, and the negative impact of industrial structure is greater than that of energy consumption. The industrial structure may be due to the fact that there are a lot of self-employed people in Anhui Province, the farming is scattered, the pollution is widespread, and the employees are generally not highly educated. The negative impact of energy consumption may be due to the fact that the livestock industry is still dominated by coal for power generation, and the burning and transportation of coal produce large amounts of carbon dioxide. The economic level of animal husbandry promotes the carbon emission efficiency of animal husbandry probably because the improvement of economic level indicates that the modern farming mode in Anhui Province has been effective, and the input of production factors such as machinery and equipment in animal husbandry bureau has brought the expected benefits. Although the number of livestock practitioners has a positive impact on carbon emission efficiency, it is not significant, and the reason is well understood. If the professional knowledge and literacy of livestock practitioners cannot be improved, just increasing the number of practitioners will not bring much improvement to carbon emission.

7. Conclusions and Suggestions

7.1. Conclusions

In this paper, through SBM-Undesirable model, the efficiency of carbon emissions from the livestock industry in Anhui province in recent years was estimated, and the results showed that there was still room for improvement. The Tobit model was used to analyze the factors affecting the carbon emission efficiency of animal husbandry in Anhui Province from 2012 to 2019. It was found that the factors were closely related to the local economic development level, the education level of employees, the industrial structure, the endowment structure, and the energy consumption. Among them, the education level, the endowment structure, and the economic level of animal husbandry had a positive impact on the carbon emission efficiency. The industrial structure and energy consumption have a negative impact on the carbon emission efficiency of animal husbandry.

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7.2. Suggestions

1) The high-quality development of animal husbandry needs more precise, forward-looking and stable policies. The government should increase the support of funds to alleviate the problem of lack of funds. At the same time, the government should constantly guide the development direction of animal husbandry with the idea of circular ecological type, organically combine government regulation and market, pay attention to the protection of ecological environment while developing economy, and promote the green and low-carbon development of animal husbandry in Anhui province.

2) Enterprises need to accelerate the construction of forage and feed system and scientific and technological innovation system in animal husbandry, improve the output and benefit conversion rate of feed and equipment, so as to reduce the unexpected output in factor input, accelerate the optimization of the internal structure of the industry and resource allocation, and promote the modernization of animal husbandry. In terms of livestock and poultry excrement, enterprises can adopt the combination of planting and breeding and the construction of biogas digester to realize the scientific and reasonable reuse of livestock and poultry excrement, so as to reduce the carbon emissions of animal husbandry excrement and improve the efficiency of animal husbandry carbon emissions. In terms of energy use, enterprises should actively develop new energy technologies, strengthen the construction of environmental protection energy equipment, so as to reduce the unexpected output generated in the process of animal husbandry, improve environmental benefits, and promote the green and low-carbon development of animal husbandry.

3) Individual retail investors of animal husbandry should actively participate in some training, lectures or independent learning of relevant knowledge organized by the government to improve their professional skills. At the same time, reasonably maximize the use of government financial support to improve production equipment, in order to improve production efficiency, emission reduction from the source, reduce environmental pollution in the process of animal husbandry.

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