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Analysis of Agricultural Investment Efficiency in Anhui Province based on Entropy Method-DEA

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Abstract

Chinese agriculture is in the stage of transforming and upgrading from traditional agriculture to modern agriculture. Investment is one of the indispensable factors for promoting and realizing agricultural upgrading. All parts of China are increasing investment in agricultural production, and the driving force for agricultural growth continues to increase, but there are still factors that restrict the efficiency of agricultural investment. Therefore, this paper takes Anhui Province as an example, firstly analyzes the agricultural investment environment and current situation in Anhui, secondly constructs an agricultural investment efficiency evaluation index system, and then uses the DEA method optimized by entropy method to determine the technical efficiency, pure technical efficiency and scale efficiency of agricultural investment in Anhui Province. The evaluation found that the overall level of agricultural investment efficiency in Anhui Province is medium, showing a good development trend. There are large differences in agricultural investment in various regions, and the efficiency of agricultural investment needs to be improved. Finally, it is recommended to increase financial support for agriculture, increase investment in agricultural innovation, give full play to location advantages, and optimize the agricultural layout.

Keywords

Agricultural Investment; Investment Efficiency; DEA; Entropy Method.

1. Introduction

Investment is an indispensable element to promote and achieve sustained and stable economic development [1]. As the foundation of the national economy, agriculture is also an organic part of the national economy. Agriculture plays an irreplaceable role in the process of economic development. The development of agriculture is inseparable from the drive of investment, and agricultural modernization cannot be realized without investment [2]. After more than 40 years of reforms, China's overall economy has maintained stable and rapid growth, but the development of agriculture and other industries has increasingly highlighted the gap. Among them, the low efficiency of agricultural investment is the main problem. High-efficiency agricultural investment plays an important role in giving full play to the benefits of agricultural investment and in ensuring the construction of modern agriculture in China. If the efficiency of agricultural investment cannot be effectively improved, the blind expansion of the scale of agricultural investment cannot truly solve the problem of agricultural modernization. However, in some provinces, the agricultural investment mechanism is not perfect, the rights and responsibilities of the investment subject are not clear, the investment decision is unreasonable, the enthusiasm of social capital investment is low, and the efficiency of agricultural investment is not high, which restrictthe healthy development of the agricultural economy [3]. Anhui is a largely agricultural province and an important commodity grain base in China[4].Correctly understanding and analyzing the status of agricultural investment in Anhui, scientifically

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evaluating agricultural investment efficiency, formulating policies and measures to improve agricultural investment efficiency are of great practical significance to promoting the healthy development of the agricultural economy.

At present, the research on agricultural investment mainly focuses on two aspects.On the one hand, the econometric model is used to analyze the performance of the agricultural investment. For example: Huang Hongqiu (2013) used weighted average and principal component analysis to evaluate the efficiency of agricultural industrialization in Guangdong province [5]; Duan Xiaoqing et al. (2016) used spatial panel model to make an empirical analysis on the relationship between financial investment and agricultural economic growth in China's comprehensive agricultural development projects [6]; Chi Liang (2017) conducted quantitative analysis on the dynamic relationship between various capital investment and per capita net income of farmers in the industrialization project of comprehensive agricultural development [7]; Zhao Yongzhi (2018) analyzed the impact of comprehensive agricultural development investment by using panel data model [8]; Huang Li (2020) use three-stage DEA method to measure the production efficiency of farmers with different agricultural investment scales [9]; Xu Baoli (2021) build a dynamic panel data model to analyze the problems related to innovation investment of agricultural enterprises [10].On the other hand, it is aimed at the comprehensive development path of agricultural investment.For example, Chen Zhengming (2016) takes Chongqing as an example, combining the local realistic foundation and potential, put forward the development mode of comprehensive agricultural development to support advantageous characteristic industries[11]; He Pingjun (2019) explore and popularize PPP mode, broaden the channels of social capital investment, and speed up the process of agricultural modernization [12]; Liu Zhi (2020) research pointed out that the green transformation of agricultural development mode needs to improve the efficiency of agricultural production and investment, and guide agriculture to transform to the direction of low carbonization, recycling and environmental protection[13]; Gao Yunsheng (2021) deeply study the driving and restraining factors of China's private agricultural enterprises, improve the overall anti-risk ability and supply chain competitiveness of private enterprises, in order to provide reference experience for China's private agricultural enterprises to "go out" [14].From the research conclusion of the existing literature, it can be seen that agricultural investment is beneficial to the development of agricultural economy and the increase of farmers' income in general, but the existing literature still lacks in-depth analysis of the agricultural capital investment and use performance.Therefore, taking Anhui province as an example, this paper first analyzes the agricultural investment situation in Anhui province, and then uses the BCC Model of Data Envelopment Analysis (DEA) to analyze the technical efficiency of agricultural investment, pure technical efficiency and scale efficiency. Finally, the restrictive factors of agricultural investment efficiency were analyzed and corresponding countermeasures and suggestions were put forward.

2. Current Status of Agricultural Investment

2.1. Agricultural Financial Investment

In the past ten years, the total expenditure of agricultural investment in Anhui province has been rising continuously, but the proportion of agricultural investment has shown a downward trend in general.Agricultural investment expenditure rose from 270.672 billion yuan in 2011 to 747.1 billion yuan in 2020, showing an increasing trend year by year.However, the proportion of agricultural investment in fiscal expenditure shows a declining trend year by year.From 2011 to 2014, Anhui's agricultural investment accounted for about 11.43% of the fiscal expenditure; Except that the proportion rose slightly from 11.61% to 12.23% in 2016-2015, the proportion of agricultural investment in fiscal expenditure declined at an average

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rate of 0.4 percentage points per year.In 2019, the proportion of agricultural investment in fiscal expenditure was only 10.07%. In 2020, the proportion of agricultural investment in fiscal expenditure increased to 10.78%, an increase of 0.7 percentagepoints. It can be seen that the total amount of Anhui's investment in agriculture is continuously increasing, but it is not as fast as the investment in the secondary and tertiary industries, thus leading to the overall decline trend of the proportion of agricultural investment year by year.

2.2. Agricultural Mechanization Investment

Anhui has increased its investment in agricultural mechanization by filling up shortcomings, thus improving the level of agricultural mechanization in Anhui. The total amount of subsidies for purchasing agricultural machinery in Anhui province in 2020 was 1.689 billion yuan, an increase of 0.4337 billion yuan compared with 1.2513 billion yuan in 2019, and the number of agricultural machinery subsidies in the whole province in 2020 reached 155,800, an increase of 30,740 compared with that in 2019.Compared with 2019, 42 new machinery categories were added in 2020, and the categories of subsidy categories continued to be expanded, which was the year with the widest scope of agricultural machinery subsidies.As many as 110,400 peasant households benefited from agricultural machinery purchase subsidies in 2020, an increase of 22,278 peasant households benefited from subsidies over 2019. In 2020, it boosted the social capital investment of 4.169 billion yuan, with a year-on-year growth of 28.59%. Under the situation that the national agricultural machinery market continued to be depressed, the growth rate of agricultural machinery in Anhui was higher than that in the whole country, which stabilized the implementation of the policy of agricultural machinery purchase subsidies, increases investment in agricultural mechanization, so that the level of agricultural mechanization is steadily improved.

2.3. Agricultural Investment in Different Cities

From 2010 to 2019, the average proportion of agricultural investment in each prefecture-level city in Anhui province also has great differences.The average agricultural investment proportion of Lu 'an is the largest, reaching 17.20%; The second is Chuzhou and Suzhou, reaching 15.65% and 14.37% respectively; The prefecture-level cities with low average agricultural investment proportion are Tongling, Wuhu, Hefei, Maanshan, 6.00%, 6.64%, 6.72% , and 7.82% respectively.It can be seen that the prefecture-level cities with a large proportion of agricultural investment in Anhui are mainly concentrated in the central and northern regions with developed agriculture, while the prefecture-level cities with a small proportion of investment are concentrated in the southern mountainous areas.The central and northern parts of Anhui province are mainly plains with more land resources. Farmers mainly make a living by planting grain, therefore, the proportion of agricultural investment in the central and northern prefecture-level cities is relatively large. The southern region is dominated by hills and mountains, and the cultivated land area is scattered and limited, which is not suitable for the development of large-scale planting, however, the southern region is close to the southern coastal region. Through undertaking the transfer industry of coastal cities and so on to develop the secondary and tertiary industries, the secondary and tertiary industries have better development, as a result, it reduces the investment in the primary industry.

3. DEA Analysis of Agricultural Investment Efficiency

3.1. Selection of Evaluation Methods

Data Envelopment Analysis (DEA) is used to evaluate the relative effectiveness of decision-making units (DMUs).The CCR model assumes that the scale reward remains unchanged, and the increasing input of the decision-making unit can achieve the goal of expanding output in equal proportion. However, in reality, most of the production activities cannot meet the

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assumption condition that the scale reward remains unchanged.Therefore, a BCC model based on the variable scale compensation hypothesis is constructed [15]. Considering the remuneration of agricultural investment of different scales, this paper chooses the BCC model to evaluate the efficiency of agricultural investment in Anhui. The hypothesis of this model is as follows: there are s decision units in total, and each decision unit has m kinds of inputs and n kinds of outputs: the input and output vectors of the j th decision unit are:

$$X_j = (x_{1j}, x_{2j}, \dots, x_{mj})^T, j = 1,2,3, \dots s \quad (1)$$

$$Y_j = (y_{1j}, y_{2j}, \dots, y_{nj})^T, j = 1,2,3, \dots s \quad (2)$$

Where: $x_{ij}$is the input of the j-th decision-making unit on the i-th input, and $x_{ij}>0$,y_{rj} is the output of the j-th decision unit on the r-th output, and $y_{rj}> 0$.The BCC model is as follows:

$$\min \theta$$

$$s.t. \begin{cases} \sum_{j=1}^{n} \lambda_j X_j + S^- = \theta X_{j0} \\ \sum_{j=1}^{n} \lambda_j Y_j - S^+ = Y_{j0} \\ \sum_{j=1}^{n} \lambda_j = 1, \forall \lambda_j \geq 0 \end{cases} \quad (3)$$

Where: θ is a decision Unit DMU_0 relative valid values; S^-represents a vector composed of slack variables and corresponding to the input, $S^- \geq 0$;S^+represents a vector consisting of slack variables and corresponding to the output, $S^+ \geq 0$;λ_j is the linear combination coefficient of the decision unit. According to the value of θ、 S^- and S^+, put the decision Unit DMU_0, divided into three categories: when $\theta = 1$, $S^- = 0$ and $S^+ = 0$, DMU_0 is DEA effective; When $\theta = 1$ and at least one of $S^- > 0$ or $S^+ > 0$,DMU_0 is weak DEA valid ; when $\theta < 1$,DMU_0 is non-DEA valid.

3.2. Index System Construction

Based on the criteria of selecting input-output indexes and combining with the research purpose of this paper, this paper summarizes the agricultural evolution process of developed countries abroad, combines the characteristics of China's agricultural development, and considers the data accessibility and consistency, select the following indexes as input and output Index.

This paper divides the input index into three aspects: capital input, technology input and labor input.Among them, the capital investment is expressed by the expenditure of Agriculture, Forestry and Water Affairs; The technology investment is evaluated by two indexes: the effective irrigation area of agriculture and the total power of agricultural machinery; labor input is expressed by the proportion of agricultural, forestry, animal husbandry and fishery employees in the total number of employees.Outputs are divided into expected outputs and undesirable outputs.Expected output mainly refers to the output value of the agricultural economy, which is expressed by the total output value of agriculture, forestry, animal husbandry and fishery.The undesirable output index mainly adopts three indexes, namely, the amount of chemical fertilizer lost, the amount of pesticide invalid usage and the residue of rural agricultural film, to comprehensively reflect the agricultural non-point source pollution situation, and the specific index system is shown in Table 1.

3.3. Data Sources and Pre-processing

The specific data of each index in the evaluation index system of Anhui Agricultural Investment efficiency in 2020 comes from the Statistical Yearbook of Anhui province and the website of Anhui Bureau of Statistics, and some of the data are processed from the original data.

To make the calculation result of the DEA model more accurate, the entropy method is adopted to fit the three indexes of fertilizer loss, pesticide invalid usage amount and rural agricultural film residue into an agricultural non-point source pollution index, to reduce the number of

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Indexes and achieve the purpose of improving the accuracy of measurement.The procedure is as follows[16]:

Table 1. Evaluation Index System of Agricultural Investment Efficiency

level-I Indexes	Level-II Indexes	level-III Indexes	Unit
Input Indexes	Capital input	Agriculture, forestry and water expenditure	Ten thousand yuan
	Technical input	Agricultural effective irrigation area	Thousand hectares
		Total power of agricultural machinery	Ten thousand kWh
	Labor input	Proportion of employees in agriculture, forestry, animal husbandry and fishery	%
Output Indexes	Expected output	Total output value of agriculture, forestry, Animal Husbandry and Fishery	Ten thousand yuan
	Undesired output	Agricultural non-point source pollution	/

$$b_{ij} = \frac{s_{ij}}{\sum_{i=1}^{m} s_{ij}} (i = 1,2,3 \dots m; j = 1,2,3 \dots n) \quad (4)$$

First, use formula (4) to calculate the proportion of the j index of the i-th sample in this indexb_{ij}. Secondly, use formula (5) to analyze the j-thindex entropy value of item h_j:

$$h_j = -\frac{1}{\ln(n)} \sum_{i=1}^{m} b_{ij} * \ln(b_{ij}) (i = 1,2,3 \dots m) \quad (5)$$

Then use the formula (6) to calculate the weight of each index w_j:

$$w_j = \frac{1-h_j}{\sum_{j=1}^{n}(1-h_j)} (j = 1,2,3, \dots n) \quad (6)$$

Finally, the final comprehensive score value Z of each sample is calculated by using formula (7):

$$Z_i = \sum_{j=1}^{n} w_j * s_{ij} (i = 1,2,3 \dots m; j = 1,2,3 \dots n) \quad (7)$$

Because the output index of the DEA model requires to choose of positive output instead of expected output index as negative output, if the undesirable output index is directly brought into the model, the method will fail. Therefore, this paper uses the linear data conversion method to transform the undesirable output index into a positive index, which not only effectively maintains the convexity and linear relationship of the model, but also improves the accuracy of the model [17].

$$f(Z_i) = \max(Z_i) + C - Z_i \quad (8)$$

Where, Z_i is the pollutant emissions of the i-th city; $\max(Z_i)$ is the maximum discharge of pollutants in all cities; In order to ensure that the converted data of all output indexes are greater than 0, C is selected as 0.1 times of the maximum discharge of pollutants.

3.4. Result Analysis of Agricultural Investment Efficiency

Using DEAP2.1 software, the relevant data of input and output indexes of 16 cities in Anhui province in 2020 were brought into the DEA-BCC model, and the technical efficiency, pure technical efficiency and scale efficiency of agricultural investment in each city were obtained, and the cross-sectional analysis of the agricultural investment efficiency of each city in 2020 was carried out.Among them, the technical efficiency mainly reflects the total efficiency of agricultural investment of 16 cities in Anhui in 2020, while the pure technical efficiency reflects

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the investment efficiency influenced by factors such as management and technology under the condition of variable scale reward, scale efficiency reflects Anhui Agricultural Investment efficiency affected by investment scale.

Taking Huaihe River and Yangtze River as the dividing line, this paper divides Anhui into three major regions: southern Anhui, central Anhui and northern Anhui.Among them. the Southern Anhui region includes Huangshan, Wuhu, Ma'anshan, Tongling, Xuancheng and Chizhou; the central Anhui region includes Hefei, Liu'an, Chuzhou and Anqing; the Northern Anhui region includes Suzhou, Huaibei, Bengbu, Fuyang, Huainan, Bozhou. The evaluation results of agricultural investment efficiency in 16 cities of Anhui in 2020 are shown in Table 2 below.

Table 2. Evaluation Results of Agricultural Investment Efficiency in 16 Cities of Anhui Province

Region	City	Technical Efficiency	Pure Technical Efficiency	Scale Efficiency	Return to Scale
Southern Anhui	Huangshan City	1	1	1	Constant
	Wuhu City	1	1	1	Constant
	Maanshan City	0.919	1	0.919	Increase
	Tongling City	0.833	1	0.833	Increase
	Xuancheng City	0.971	0.995	0.977	Increase
	Chizhou City	0.888	0.992	0.894	Increase
	Mean	0.935	0.998	0.937	/
Central Anhui	Hefei City	1	1	1	Constant
	Lu'an City	0.626	0.646	0.97	Decrease
	Chuzhou City	0.862	0.891	0.967	Decrease
	Anqing City	1	1	1	Constant
	Mean	0.872	0.884	0.984	/
Northern Anhui	Suzhou City	1	1	1	Constant
	Huaibei City	0.712	1	0.712	Increase
	Bozhou City	1	1	1	Increase
	Fuyang City	0.992	1	0.992	Decrease
	Bengbu City	1	1	1	Constant
	Huainan City	1	1	1	Constant
	Mean	0.951	1	0.951	/
Provincial Mean		0.914	0.962	0.951	/

The average technical efficiency of 16 cities in Anhui is 0.914, the average pure technical efficiency is 0.962, and the average scale efficiency is 0.951.Among them, the agricultural investment efficiency of the seven prefecture-level cities of Huangshan, Wuhu, Hefei, Anqing, Suzhou, Bengbu and Huainan is in the stage of constant scale reward, which indicates that the agricultural investment efficiency of the seven cities is in the optimal state, for cities in the best stage of agricultural investment, the corresponding proportion of agricultural investment should be maintained to maintain the optimal efficiency of agricultural investment. For the cities in the stage of increasing returns of agricultural investment scale, agricultural investment should be increased and the scale of investment should be expanded to improve the efficiency of agricultural investment. The agricultural investment efficiency of 6 prefecture-level cities including Ma'anshan, Tongling, Xuancheng, Chizhou, Huaibei and Bozhou are all in the stage of increasing returns to scale, which indicates that these cities can improve the agricultural investment efficiency by Appropriately increasing the agricultural investment scale, agriculture has a large development space; The agricultural investment efficiency of the three prefecture-

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level cities of Liu'an, Chuzhou and Fuyang is in the decline of scale, which indicates that the agricultural investment scale of the three prefecture-level cities is too large, and the agricultural investment scale should be reduced, to improve the efficiency of agricultural investment.

From the perspective of Scale efficiency, the agricultural scale efficiency value of 8 prefecture-level cities of Huangshan, Wuhu, Hefei, Anqing, Suzhou, Bozhou, Bengbu and Huainan is 1, which has reached the best agricultural scale; Ma'anshan, the agricultural scale efficiency of eight prefecture-level cities including Tongling, Xuancheng, Chizhou, Liu'an, Chuzhou, Huaibei and Fuyang is less than 1, basically floating around 0.9, it shows that these 8 prefecture-level cities can adjust agricultural investment from the aspects of optimizing the allocation of agricultural industrial structure and adjusting the scale, to promote the continuous improvement of agricultural investment efficiency.

From the perspective of technical efficiency and pure technical efficiency, the technical efficiency values of seven prefecture-level cities, Huangshan, Wuhu, Hefei, Anqing, Suzhou, Bengbu and Huainan, are 1, accounting for 43.75% of the total number of evaluated cities, it shows that the overall investment efficiency of Anhui province is relatively high; Huangshan, Wuhu, Ma'anshan, Tongling, Hefei, Anqing, Suzhou, Huaibei, Bozhou, Fuyang, Bengbu, the agricultural pure technical efficiency value of 12 prefecture-level cities such as Huainan is 1, and the pure technical efficiency has reached the optimal, accounting for 75% of the total number of evaluated cities; Xuancheng, Chizhou, Liu'an, the agricultural pure technology efficiency of the four prefecture-level cities in Chuzhou is less than 1, which indicates that these four prefecture-level cities can consider adjusting the direction of agricultural investment and expanding investment in agricultural technology. Through improving the level of agricultural technology, realize agricultural modernization. It is worth noting that the technical efficiency of agricultural investment in three cities of Ma'anshan, Tongling and Huaibei is less than 1, but the pure technical efficiency of agricultural investment in these three prefecture-level cities is 1, it shows that these three prefecture-level cities are only effective in technology, not in scale.

From the regional comparison, there is a big gap in agricultural investment efficiency among southern Anhui, central Anhui and northern Anhui. From the perspective of agricultural investment technology efficiency, the level of investment efficiency in northern Anhui is the highest, followed by southern Anhui and the lowest in central Anhui; From the perspective of pure technology efficiency, the level of efficiency in northern Anhui is the highest, followed by southern Anhui and the worst in central Anhui; in terms of scale efficiency, Central Anhui is the highest, Northern Anhui is the second, and Southern Anhui is the worst.Northern Anhui is dominated by plains with more land resources. Farmers mainly make a living by planting grain, while industry and service industry are relatively weak, therefore, the technical efficiency and pure technical efficiency of agricultural investment in northern Anhui are relatively high; While the economy in central Anhui is developed and the investment in agriculture is relatively large, therefore, the agricultural investment technology efficiency, pure technology efficiency and scale efficiency in central Anhui are not ideal; The Southern Anhui region is dominated by hills and mountains, and the cultivated land area is scattered and limited, it is not suitable for the development of large-scale planting, which makes the scale efficiency of agricultural investment in Southern Anhui low.

4. Countermeasures and Suggestions on Agricultural Investment Efficiency

4.1. Strengthen Financial Support and Consolidate the Basic Position of Agriculture

From 2011 to 2019, the output value of the primary industry in Anhui increased steadily, and the scale of agricultural investment continued to expand. However, compared with the

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increasing speed of the investment of the secondary and tertiary industries, the agricultural investment was still insufficient, therefore, the proportion of agricultural investment generally shows a downward trend year by year. At the same time, the main body of agricultural investment, such as government financial investment, financial institution investment, private capital investment and peasant household investment, has relatively large fluctuations, and foreign investment is relatively small. The government should constantly strengthen government functions, increase financial support for agriculture at all levels and promote rural development. Local governments should constantly improve the integration of agriculture-related funds, increase the total number of agricultural investment projects, increase the total investment plan of agricultural projects, pay close attention to the commencement of agricultural infrastructure projects, and steadily expand government investment.

4.2. Increase Investment in Agricultural Innovation and Promote the Development of Agricultural Modernization

The economic development level of different regions in Anhui is different, and the investment level of agricultural infrastructure and the income level of farmers vary greatly among regions. In economically developed areas, agricultural investment accounts for a large proportion of the total investment, agricultural technology is advanced, and the level of agricultural investment efficiency is relatively high. In economically underdeveloped areas, agricultural investment accounts for a small proportion of the total investment, the level of agricultural investment efficiency is relatively low. The free flow of resources within and between regions is conducive to the optimal allocation of resources and the improvement of utilization efficiency. Although the overall efficiency of agricultural investment in Anhui is at the middle and upper level with a good development trend, some cities are still in the stage of increasing returns of agricultural investment scale, and there is still room for improvement in the efficiency of agricultural investment, the investment scale has not reached the optimum. The whole province should speed up the improvement of agricultural mechanization level, increase investment in agricultural science and technology, improve the quality of agricultural workers, increase investment in agricultural technology innovation, and promote the development of agricultural modernization.

4.3. Give Full Play to Regional Advantages and Optimize Agricultural Layout

Anhui has the innate and potential advantages of upgrading a largely agricultural province into a strong agricultural province, and has the innate genes and strong impetus for the reform of "agriculture, rural areas and farmers.Under the precious opportunity of the Yangtze River Delta regional integration development strategy, Anhui should learn from others and promote their own strengths, undertake more and more important responsibilities and roles, and actively promote the integration and development of the three major industries, especially to play the linkage role of the production, processing and supply base of agricultural products in Yangtze River Delta, promote the integration of agricultural products in Yangtze River Delta, promote the in-depth penetration of information technology, and deeply integrate modern agriculture with new industry and modern service industry, build the whole industry supply chain, promote the integration of agricultural products logistics and finance, so as to speed up the implementation of the rural revitalization strategy, drive the rural prosperity and increase farmers' income; at the same time, logistics financial products should follow the experience accumulated in the integration development of Yangtze River Delta and constantly bring forth the new through the old, so as to promote the development and expansion of Anhui agricultural enterprises and agricultural products logistics enterprises[18].

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