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Research on Calculation and Driving Factors of Production Efficiency of Smart Agriculture under the Background of Rural Revitalization

-- Take Anhui Province as an Example

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Abstract

Smart agriculture has promoted the rapid development of China's traditional agriculture. Our team conducted Social Research on the rice shrimp co cultivation demonstration base in Quanjiao County, Anhui Province during the holiday. After that, we collect the indicators related to agricultural production efficiency of Intelligent Agriculture in Anhui Province, then analyze the main factors affecting agricultural production efficiency, and construct the evaluation model of intelligent agricultural production efficiency, the real value of agricultural production efficiency is calculated, and the ways to improve agricultural production efficiency are further put forward. Finally, find ways to improve the production efficiency of smart agriculture, so as to promote the optimization and promotion of smart agriculture application.

Keywords

Smart Agriculture; Production Efficiency; Evaluation Model.

1. Research Background And Significance

1.1. Research Background

Smart agriculture is a new agricultural development mode with the deep integration of modern information technology such as Internet of things and big data with agriculture. It is an important step in implementing the Rural Revitalization Strategy, a booster for the transformation and upgrading of China's traditional agriculture, and an important way to improve agricultural production efficiency and realize the large-scale and industrialized production of new agriculture. At present, China's intelligent agricultural technology has been applied in many fields, such as agricultural sensors, plant protection UAVs, agricultural robots, intelligent water-saving irrigation and so on.

1.2. Research Significance

While smart agriculture promotes the high-quality development of agricultural production, how to accurately measure the actual development level of smart agriculture is a topic of great concern to the government, enterprises and farmers. Smart agriculture production efficiency is an important indicator to measure the development level of smart agriculture. At the same time, it can also reflect the development level of science, technology and economy. Smart agriculture can also protect the environment, save resources and promote green and sustainable economic development. Therefore, paying attention to the improvement of production efficiency of smart

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agriculture is of great significance to improve the development mode of smart agriculture and realize green and sustainable economic growth.

2. Construction of Measurement Model of Production Efficiency of Intelligent Agriculture

2.1. Research Methods

2.1.1. Establishment of Evaluation Index System

According to the actual situation of the development of smart agriculture in Anhui Province, following the principles of systematicness, preciseness, representativeness and practicality, and considering the authenticity and availability of data, this paper constructs the evaluation index system of smart agricultural production efficiency from three levels. The first layer is the target layer, which takes the production efficiency of intelligent agriculture as the evaluation target; The second layer is the criterion layer, including four aspects of the improvement of agricultural production efficiency by smart agriculture, namely infrastructure, production conditions, talent technology and output benefits; The third layer is the 18 indicators corresponding to the four criteria layers, as shown in Table 1.

Table 1. Evaluation index system of production efficiency of smart agriculture

Target layer	Criterion layer	Index layer	Index code	Index Interpretation
Intelligent agricultural production efficiency	Smart agricultural infrastructure	Proportion of fixed asset investment in research and scientific research in technical service industry(%)	C11	Fixed assets investment in technical services and scientific research / total investment in fixed assets
		Proportion of fixed asset investment in information transmission, software and information technology services(%)	C12	Fixed assets investment in information transmission, software and information technology services / total fixed assets investment
		Proportion of fixed asset investment in transportation, warehousing and postal industry(%)	C13	Total fixed assets / fixed investment in transportation, warehousing and postal industry
	Intelligent agricultural production conditions	Proportion of tractor tillage area(%)	C21	Machine cultivated area / crop sown area
		Proportion of machine sowing area(%)	C22	Machine sown area / crop sown area
		Proportion of machine harvesting area(%)	C23	Machine harvest area / crop sowing area
		Average rural power consumption per person (kW / person)	C24	Rural electricity consumption / rural population
		Total power of agricultural machinery per unit cultivated land area (w / HA)	C25	Total power of agricultural machinery / cultivated land area
		Fertilizer application per unit sowing area (kg / HA)	C26	Fertilizer application amount / crop sowing area
		Effective irrigation rate of cultivated land (%)	C27	Cultivated land effective irrigation area / cultivated land area

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	Intelligent agricultural talents and technology	Proportion of local financial expenditure on Education (%)	C31	Local financial expenditure on education / total financial expenditure
		Proportion of service personnel engaged in information transmission, information technology and software (%)	C32	Service personnel / total employees engaged in information transmission, information technology and software
		Proportion of agricultural science and technology expenditure (%)	C33	Agricultural science and technology expenditure / total financial support for agriculture
	Output benefit of smart agriculture	Grain yield per unit cultivated area (kg / HA)	C41	Total grain output / cultivated land area
		Agricultural productivity (yuan / person)	C42	Total agricultural output value / total agricultural population
		Land productivity (yuan / HA)	C43	Total agricultural output value / cultivated land area
		Proportion of output value of agriculture, forestry, animal husbandry and fishery (%)	C44	Output value of agriculture, forestry, animal husbandry and fishery / regional GDP
		Proportion of output value of agricultural service industry (%)	C45	Total output value of Agricultural Services / agriculture, forestry, animal husbandry and fishery

2.1.2. Index Weighting Method

In order to prevent the weight determined by the subjective method from being untrue and inaccurate, the entropy method is used to calculate the index weight. Entropy method is a method to calculate the information entropy of the index and then calculate the index weight according to the principle of information theory. There are four main steps:

(1) After the decision matrix $X=(x_{ij})_{m\times n}$ is standardized, $Y=(y_{ij})_{m\times n}$ is obtained and normalized:

$$P_{ij}=y_{ij}/\sum^{m}_{i=1}y_{ij}(1\le i\le m,\ 1\le j\le n)$$

(2) Use the following formula to calculate the entropy of the j-th index(e_j):

$$e_j=-k\cdot\sum^{m}_{i=1}P_{ij}\ln P_{ij}(1\le i\le n)$$

among, $k>0$, $e_j\ge 0$, Take $k=1/\ln m$

(3) Use the following formula to calculate the difference coefficient of the j-th index(g_i):

$$g_j=1-e_j(1\le j\le n)$$

(4) The weight (WJ) of the j-th index is obtained by normalizing g_j

$$W_j=g_j/\sum^{n}_{j=1}g_j$$

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2.1.3. Design of Comprehensive Evaluation Model

The production efficiency of smart agriculture is measured by calculating the sum of the product of weight coefficient and standardized value. The comprehensive evaluation model of production efficiency of smart agriculture is constructed as follows:

$$AT_i=\sum^{n}_{i=1}W_iB_i$$

$$B_i=\sum^{m}_{j=1}W_{ij}C_{ij}$$

Among them, AT_i is the weighted total score of intelligent agricultural production efficiency, n is the number of indicators in the second layer, W_i is the weight of indicators in the second layer, B_i is the index in the second layer, m is the number of indicators in the third layer, W_{ij} is the weight of indicators in the third layer, and C_{ij} is the standardized value of the j-th index.

2.2. Data Acquisition and Processing

2.2.1. Data Acquisition

According to the statistical yearbook of 2015-2020 compiled by Anhui Provincial Bureau of statistics, we selected the data from 2014 to 2019 as the original values of various indicators, some of which are missing and replaced by the estimated values obtained by linear regression method, as shown in Table 2.

Table 2. Original data of production efficiency indicators of smart agriculture in Anhui Province from 2014 to 2019

	2014	2015	2016	2017	2018	2019
C11	1.03	1.09	1.29	0.96	1.00	0.81
C12	0.71	1.08	1.12	0.94	0.72	0.61
C13	5.17	6.13	6.88	6.98	6.38	6.86
C21	48.25	47.91	49.55	85.81	85.39	86.20
C22	52.40	55.91	58.64	62.18	65.56	67.99
C23	69.75	71.96	74.02	78.25	82.65	83.70
C24	275.72	290.23	301.45	318.79	336.06	351.74
C25	1.08	1.12	1.17	1.08	1.11	1.13
C26	381.63	378.40	367.69	359.99	355.43	339.35
C27	73.71	74.88	75.56	76.77	77.10	77.93
C31	15.93	16.35	16.49	16.36	16.94	16.53
C32	1.41	1.49	1.55	1.59	1.58	1.59
C33	0.62	0.92	0.61	0.60	0.66	0.68
C41	5812.78	6020.65	5818.83	5924.90	6808.16	6896.30
C42	7893.80	8129.82	8683.35	8797.51	8685.89	9599.42
C43	71875.94	74716.12	79279.01	80581.84	79397.61	87813.61
C44	17.96	17.62	16.78	15.04	12.96	13.11
C45	4.25	4.37	5.19	5.60	5.66	5.72

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2.2.2. Standardized Treatment

The data is standardized by the root square method, and the formula is as follows:

$$y_{ij}=a_{ij}/\sqrt{\sum^{n}_{i=1}a^{2}_{ij}}(1\leq i\leq n)$$

The data after standardization is shown in Table 3.

Table 3. Standardized data of production efficiency indicators of smart agriculture in Anhui Province from 2014 to 2019

	2014	2015	2016	2017	2018	2019
C11	0.4057	0.4266	0.5065	0.3778	0.3917	0.3175
C12	0.3271	0.4987	0.5168	0.4339	0.3307	0.2822
C13	0.3281	0.3893	0.4368	0.4429	0.4052	0.4355
C21	0.2825	0.2805	0.2902	0.5025	0.5000	0.5048
C22	0.3525	0.3761	0.3945	0.4183	0.4410	0.4574
C23	0.3703	0.3820	0.3930	0.4154	0.4388	0.4443
C24	0.3591	0.3780	0.3926	0.4152	0.4377	0.4582
C25	0.3964	0.4098	0.4279	0.3937	0.4068	0.4140
C26	0.4280	0.4244	0.4124	0.4037	0.3986	0.3806
C27	0.3959	0.4022	0.4058	0.4124	0.4141	0.4186
C31	0.3957	0.4061	0.4096	0.4063	0.4207	0.4106
C32	0.3759	0.3959	0.4118	0.4218	0.4187	0.4234
C33	0.3673	0.5423	0.3604	0.3567	0.3892	0.4029
C41	0.3809	0.3945	0.3813	0.3882	0.4461	0.4519
C42	0.3726	0.3838	0.4099	0.4153	0.4100	0.4531
C43	0.3710	0.3856	0.4091	0.4159	0.4097	0.4532
C44	0.4667	0.4579	0.4361	0.3908	0.3368	0.3408
C45	0.3360	0.3454	0.4097	0.4426	0.4473	0.4517

2.3. Index Weighting

The entropy method is used to assign the index proportion. After data calculation, the final determination of the weight of the intelligent agricultural production efficiency evaluation index system is shown in Table 4.

2.4. Secondary Index Weighted Index

Using the index proportion obtained by entropy method, the weighted index of index elements of each index layer from 2014 to 2019 is calculated, as shown in Table 5.

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Table 4. Weight determination diagram of intelligent agricultural production efficiency evaluation index system

Comprehensive index layer (y)	Criterion layer (b)	weight	Indicator layer (c)	weight
Smart agricultural production efficiency (Y)	Smart agricultural infrastructure (B1)	0.1605	Proportion of fixed asset investment in scientific research and technical services(C11)	0.0547
			Proportion of fixed assets invested in information transmission, software and information technology services(C12)	0.0497
			Proportion of fixed asset investment in transportation, warehousing and postal industry(C13)	0.0562
	Production conditions of smart agriculture (B2)	0.3885	Proportion of tractor tillage area(C21)	0.0454
			Proportion of machine sowing area(C22)	0.0565
			Proportion of machine harvesting area(C23)	0.0570
			Average per capita electricity consumption in rural areas(C24)	0.0567
			Total power of agricultural machinery per unit cultivated land area(C25)	0.0576
			Amount of chemical fertilizer applied per unit sowing area(C26)	0.0575
			Effective irrigation rate of cultivated land(C27)	0.0577
	Intelligent agricultural technology talents (B3)	0.1692	Proportion of local financial expenditure on Education(C31)	0.0577
			Proportion of personnel engaged in information transmission, information technology and software services(C32)	0.0575
			Proportion of agricultural science and technology expenditure(C33)	0.0540
	Output benefit of smart agriculture (B4)	0.2818	Grain yield per unit cultivated area(C41)	0.0569
			Agricultural productivity(C42)	0.0571
			Land productivity(C43)	0.0571
			Proportion of output value of agriculture, forestry, animal husbandry and fishery(C44)	0.0551
			Proportion of output value of agricultural service industry(C45)	0.0555

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Table 5. Weighted index of production efficiency index layer of smart agriculture in Anhui Province from 2014 to 2019

	2014	2015	2016	2017	2018	2019
C11	0.0222	0.0233	0.0277	0.0207	0.0214	0.0174
C12	0.0162	0.0248	0.0257	0.0215	0.0164	0.0140
C13	0.0184	0.0219	0.0245	0.0249	0.0228	0.0245
C21	0.0128	0.0127	0.0132	0.0228	0.0227	0.0229
C22	0.0199	0.0212	0.0223	0.0236	0.0249	0.0258
C23	0.0211	0.0218	0.0224	0.0237	0.0250	0.0253
C24	0.0203	0.0214	0.0222	0.0235	0.0248	0.0260
C25	0.0228	0.0236	0.0247	0.0227	0.0235	0.0239
C26	0.0246	0.0244	0.0237	0.0232	0.0229	0.0219
C27	0.0228	0.0232	0.0234	0.0238	0.0239	0.0242
C31	0.0228	0.0234	0.0236	0.0234	0.0243	0.0237
C32	0.0216	0.0228	0.0237	0.0242	0.0241	0.0243
C33	0.0198	0.0293	0.0195	0.0193	0.0210	0.0218
C41	0.0217	0.0225	0.0217	0.0221	0.0254	0.0257
C42	0.0213	0.0219	0.0234	0.0237	0.0234	0.0259
C43	0.0212	0.0220	0.0234	0.0238	0.0234	0.0259
C44	0.0257	0.0252	0.0240	0.0215	0.0185	0.0188
C45	0.0187	0.0192	0.0227	0.0246	0.0248	0.0251

2.5. Intelligent Agricultural Production Efficiency Index

According to the weight and measurement analysis model of each main index calculated by the previous summation method, then calculate the comprehensive index of each index, and further calculate the production efficiency index of Intelligent Agriculture in Anhui Province from 2014 to 2019, as shown in Table 6.

Table 6. Production efficiency index of smart agriculture in Anhui Province from 2014 to 2019

		Criterion layer			
Year	Total index	Smart agricultural infrastructure	Intelligent agricultural production conditions	Intelligent agricultural talents and technology	Output benefit of smart agriculture
2014	0.1067	0.0091	0.0561	0.0109	0.0306
2015	0.1129	0.0112	0.0577	0.0128	0.0312
2016	0.1153	0.0125	0.0590	0.0113	0.0325
2017	0.1182	0.0108	0.0635	0.0113	0.0326
2018	0.1192	0.0097	0.0652	0.0117	0.0326
2019	0.1210	0.0090	0.0660	0.0118	0.0342

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3. Evaluation of Measurement Results of Intelligent Agricultural Production Efficiency

According to Table 6 and Figure 1, the production efficiency of Intelligent Agriculture in Anhui Province has shown a stable upward trend in recent years, and the comprehensive index has increased from 0.1067 to 0.1210, but it is still in an immature stage. The future development needs the attention and promotion of the state.

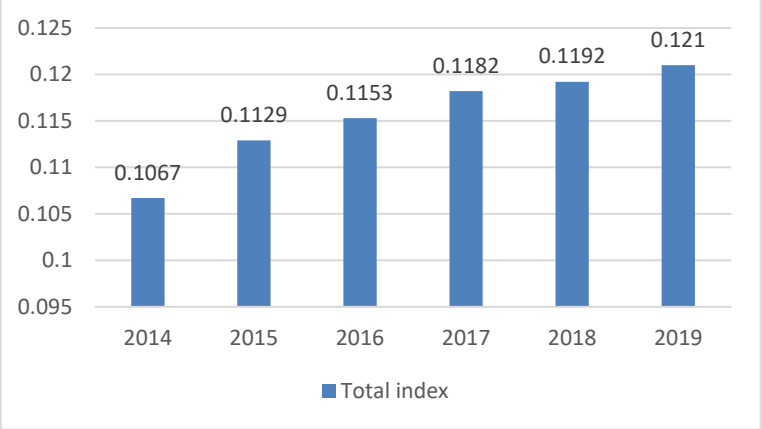

Figure 1. Trend chart of comprehensive index of intelligent agricultural production efficiency in Anhui Province from 2014 to 2019

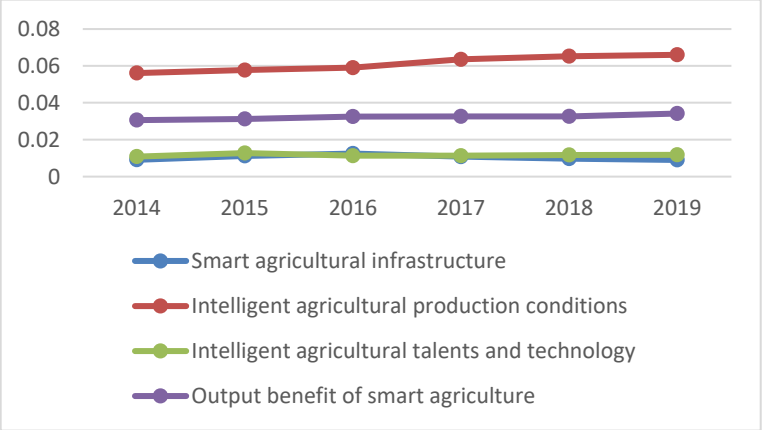

Figure 2. Trend chart of production efficiency criterion level index of smart agriculture in Anhui Province from 2014 to 2019

As can be seen from Figure 2, the production condition index showed an upward trend from 2014 to 2019, and its growth was more obvious than other indexes. Therefore, the production condition index is the main factor affecting the production efficiency of smart agriculture. At the same time, the talent technology index is at a low level and makes little contribution to the production efficiency of intelligent agriculture, indicating that the technical level of intelligent agricultural talents in Anhui province needs to be improved.

4. Suggestions on Improving Production Efficiency of Smart Agriculture

4.1. Realize the Maximum Utilization of Intelligent Agricultural Resources

To improve the production efficiency of smart agriculture, we must give full play to the role of smart agriculture in improving production conditions and maximize the development and

utilization of smart agricultural resources. First, use agricultural intelligent equipment to improve the level of agricultural mechanization. Secondly, we will vigorously develop intelligent agricultural equipment and agricultural robots, strive to promote the automation of agricultural operations, and realize effective fertilization and irrigation of farmland. Finally, we will vigorously develop Internet + agriculture and realize big data and scientific agricultural decision-making.

4.2. Improve the Technical Level of Intelligent Agricultural Talents

First, pay attention to the knowledge and cultural level of agricultural producers, which includes not only the theoretical knowledge of agricultural science, but also the learning of agricultural machinery and equipment and the ability to accept and apply agricultural information. Second, the government should increase subsidies to agricultural producers, make more and more people willing to engage in agricultural production, make agriculture a new industry, and change people's inherent ideas about traditional agriculture. Third, scientific research institutes should pay attention to the creation and invention of agricultural technology and agricultural machinery and equipment, combine science and technology with agricultural production, and make agricultural planting no longer a hard and tiring work.

5. Summary

Through the investigation of rice and shrimp demonstration base in Quanjiao County, Chuzhou City, Anhui Province, we have a general understanding of the development of Intelligent Agriculture in Anhui Province. Finally, through the analysis of the relevant influencing factors of agricultural production efficiency in Anhui Province, we establish the calculation and evaluation model of intelligent agricultural production efficiency in Anhui Province, and finally put forward some suggestions. The measurement of intelligent agricultural production efficiency has guiding significance for further improving the agricultural production level and Realizing Rural Revitalization in Anhui Province.

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