

Study on the Impact of Agricultural Digitization on the Output of Agricultural Products in China

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Abstract

With the popularization of the Internet and the promotion of Rural Revitalization Strategy, agricultural digitization has attracted the attention of many scholars. The study of agricultural digitization has important theoretical and practical significance for the development of agriculture. This paper selects the time series data from 2012 to 2020 and takes the agricultural output value as the explanatory variable. The number of agricultural broadband access users, Internet penetration and optical cable line length are selected as the statistical indicators of agricultural digitization. The entropy method is used to weight the three statistical indicators, and finally a weighted index is obtained as the main explanatory variable. At the same time, the total power of agricultural machinery, effective irrigation area and net amount of chemical fertilizer application were selected as explanatory variables. This paper analyzes the impact of agricultural digitization on the output of agricultural products in China by using row linear regression method. Finally, it summarizes the impact of agricultural digitization on agricultural gross output value, and puts forward corresponding policy suggestions.

Keywords

Agricultural Digitization; Entropy Method; Agricultural Output.

1. Introduction

With the development of the Internet, digital economy has gradually entered the public's vision, in which industrial digitization is one of the cores of digital economy. In 2020, China will further promote rural revitalization after fully eradicating poverty. The No. 1 central document in 2022 focuses on rural revitalization, and proposes to stabilize the basic agricultural situation and ensure stable agricultural production and increase production. Digital economy enables agriculture to bring new development opportunities for traditional agricultural production. With the promotion of smart agriculture and the integrated application of information technology and agricultural machinery and agronomy, digitization has been applied to crop real-time monitoring platform, irrigation, fertilization, pest control, heat preservation, harvesting and other processes, which can not only reduce the cost of human and material resources, but also greatly increase the output of agricultural products. Therefore, the study of the impact of agricultural digitization on the total agricultural output value has important theoretical and practical significance.

As a new economic model, digital economy plays a very important role in all aspects. In China's current industry, agricultural digitization is at a low level, only 7.3%. This data also shows that agricultural digitization started late, but it has great development prospects. In terms of

agricultural output, agriculture, as China's basic industry, has maintained an output of more than 130 million tons for seven consecutive years, with sufficient grain inventory. The China Agricultural Outlook conference in 2022 stressed the need to continue to strengthen the construction of monitoring and early warning system for the whole industrial chain of agricultural products and accelerate the application of agricultural and rural big data.

Theoretically, due to the large scope of China's rural areas, the process of agricultural digitization has not been further promoted, and less research data can be obtained, so there are fewer articles on agricultural digitization. This paper can enrich this research and provide new ideas for the promotion of agricultural digitization.

2. Literature Review

(1) Research on the role of agricultural digitization in promoting agricultural development. Agricultural digitization has a significant positive impact on the development of China's agriculture and has a great impact on China's agricultural production and development. Shi Yiwei (2021) studied the impact of digital economy on China's agricultural high-quality development, and found that digital economy has a positive impact on China's agricultural high-quality development through digital infrastructure, digital industrialization and industrial digitization, and there is a significant spatial spillover effect [1]. Chai Wuyue and Zhong Juan (2020) found that China's agricultural development has obvious regional differences by studying the influencing factors of China's regional total agricultural output value [2]. Mu Juan and Ma Liping (2021) found that China's agricultural development showed a positive aggregation phenomenon through the measurement of China's agricultural and rural digital economy development index and regional differences. Agricultural digitization also plays an important role in the development of Rural Revitalization in China, which can effectively improve China's total agricultural output value [3]. Jiang Weiguo et al. (2021) through the research on rural digital economy and rural governance, found that the integrated digital governance using digital technologies such as big data and artificial intelligence can improve the scientific level of rural governance decision-making and further improve the scientific development of rural agriculture [4]. Cheng Xianqi (2021) studied the agricultural digital transformation under the Rural Revitalization Strategy and found that the agricultural digital transformation is an all-round and multi-level industrial transformation, and its wide application is also an important way to realize rural revitalization [5]. Wang Xiaobing (2021) found that China's agricultural digital transformation is extremely rich in agricultural data resources, farmers' demand for digital technology is extremely urgent, and the development potential of rural digital economy is extremely huge [6]. Sulimin V (2020) found that introducing a new generation of digital technology and financial technology into the agricultural field will be an important part of the development strategy of the agricultural sector by studying the innovation and development mode of agricultural digital technology [7].

(2) Research on the current situation and shortcomings of agricultural digitization. First, the concept of agricultural digitization needs to be innovated. Gao Zengxia (2022) found that in the current agricultural economic development, the promotion of agricultural modernization is relatively slow, and relevant departments have not improved the corresponding management system around agricultural digitization [8]. Second, the transformation of agricultural digitization is more difficult. Wang Tingyong et al. (2021) found that there is a large gap between China's agricultural digitization level and developed countries by studying the problem of rural digital construction. As China's agriculture is dominated by small farmers, it is difficult to meet the basic conditions of agricultural digitization, resulting in its weak willingness to upgrade agricultural digitization, difficulties in upgrading agricultural digitization, capital, liquidity and other problems [9]. Zhou Jing (2021) studied the problems

and Countermeasures of China's traditional agricultural digital transformation under the background of digital economy. The research conclusion shows that at present, China's agricultural network infrastructure is weak, and its data acquisition is also very difficult, which is also one of the major obstacles to agricultural digitization [10]. Third, there is a lack of effective integration between digital agricultural technology and traditional agriculture. Qiao Lisha (2021) studied the digital transformation of agriculture in Tianjin. The results show that at present, China's intelligent agriculture is not applicable, and its technology application is difficult to take root, which is related to farmers with low digital literacy dominated by small-scale peasant economy [11]. Fourth, from the perspective of research, the current research on agricultural digitization in China is mostly theoretical analysis, lack of empirical analysis. Fan Shengyue (2021) et al. Studied the research of digital level on agricultural green development and found that the theoretical analysis in the research literature of agricultural digitization in China is far more than the empirical analysis. At present, many empirical analyses are still needed for further research [12].

(3) Prospect of the impact of agricultural digitization on China's agricultural output. Li Qixiu (2021), in his research on agricultural digitization in the 5G era, believes that agricultural digitization will develop well in the gradual application of 5G technology, and agricultural digitization will have a huge transformation space [13]. Wang Yunjia (2019) concluded from the analysis of China's current agricultural situation that in the face of China's current agricultural situation, it is necessary to use new technologies to keep pace with the times, adhere to new ideas and enter the ranks of agricultural powers as soon as possible [14].

(4) Commentary. From the data collected in this topic, many Chinese scholars have conducted multi-directional research on agricultural digitization. In the research results of these topics, almost all scholars affirmed that China's agricultural digitization will be the general direction of future development, and its future development prospect is very broad. Some scholars have raised their doubts about the possibility and difficulty of building agricultural digitization, while others have questioned that the current theoretical research on agricultural digitization is more than empirical analysis. Generally speaking, agricultural digitization will be the focus and difficulty of China's agricultural development for a long time in the future. Its current development is still in its infancy, and there is still a long way to go before the goal of agricultural digitization is completed. In the process of searching the literature, we found that although scholars have carried out many aspects of research on agricultural digitization, they always take the yield benefits that agricultural digitization can bring to China's agriculture in one stroke, lack of detailed demonstration process and less research on relevant aspects, which also provides some space and possibilities for the writing of this paper. This paper selects the time series data from 2012 to 2020 to empirically study the impact of agricultural digitization on China's agricultural output, and puts forward countermeasures and suggestions.

3. Variable Selection and Processing

3.1. Variable Selection

(1) Explained variable (Y). This paper selects the output value of national agricultural products as the explanatory variable.

(2) Explanatory variables. Since China's agricultural digitization is mainly reflected in information and communication technology, this paper selects the number of agricultural broadband access users (X_1), Internet penetration rate (X_2) and optical cable line length (X_3) as the main explanatory variables.

3.2. Variable Processing

Because the three have obvious common growth trend and internal economic relationship, if they are introduced into the model as three explanatory variables at the same time, there will

be serious multicollinearity. Therefore, firstly, the entropy method is used to weight the three to get a comprehensive index. Entropy method is a mathematical method used to judge the dispersion degree of an index. The greater the degree of dispersion is, the greater the impact of the index on the comprehensive evaluation. Entropy can be used to judge the dispersion degree of an index. The variables of entropy method are shown in Table 1. In Table 1, the values of i are 1, 2 and 3, which respectively represent the number of agricultural broadband access users, Internet penetration and optical cable line length. The values of j are 1, 2, 3, 4, 5, 6, 7, 8 and 9, corresponding to 2012 to 2020 respectively.

Table 1. List of entropy method variables

Variable symbol	Variable meaning
X_{ij}	Initial data of the i-th indicator in the j-th year
T_{ij}	Standardized data of the i-th indicator in the j-th year
P_{ij}	Weight of standardized data in the index
e_i	Information entropy of each index
d_i	Difference coefficient of each index
w_i	Weight of each indicator in the three indicators

(1) Standardize the data. Since the measurement units of the three indicators are not unified, it is necessary to standardize the data. In order to avoid the meaningless logarithm when calculating the entropy value, we can add a real number of smaller orders to each 0 value. In this paper, we add 0.0001. Calculate the maximum and minimum values of each index respectively to obtain $Max(X_{ij})$ and $Min(X_{ij})$. Because the three explanatory variables have positive effects on the explained variables, these explanatory variables are standardized. The standardized formula is:

$$T_{ij} = \frac{X_{ij} - Min(X_{ij})}{Max(X_{ij}) - Min(X_{ij})} + 0.0001 \tag{1}$$

(2) Calculate the proportion of the index in the j year under each index. The calculation formula is as follows:

$$P_{ij} = \frac{T_{ij}}{\sum_{j=1}^9 T_{ij}} \tag{2}$$

(3) Calculate the information entropy of each index in the j-th year. The calculation formula is as follows:

$$e_i = -\frac{1}{\ln 9} \sum_{j=1}^9 P_{ij} \ln(P_{ij}) \tag{3}$$

(4) Calculate the difference coefficient of index j. The calculation formula is as follows:

$$d_i = 1 - e_i \tag{4}$$

(5) Calculate the weight of the three indicators. The calculation formula is as follows:

$$w_i = \frac{d_i}{\sum_{i=1}^3 d_i} \tag{5}$$

(6) Calculate the comprehensive score of each sample and finally add it to get a comprehensive index.

$$X_1 = \sum_{i=1}^3 \sum_{j=1}^9 w_i X_{ij} \quad (6)$$

4. Empirical Analysis

This paper makes an empirical analysis by establishing the multiple linear regression model of each explanatory variable and the explained variable. Through the empirical analysis, this paper studies whether the influence of each explanatory variable on the explanatory variable is significant.

4.1. Model Setting

Select the statistical indicators corresponding to the variables of the National Bureau of statistics from 2012 to 2020, and take the agricultural output value as the explained variable (Y_1), the comprehensive index (X_1), the total power of agricultural machinery (X_2), the effective irrigation area (X_3), the net amount of chemical fertilizer application (X_4), the water and soil loss control area (1000 hectares) (X_5) and the affected area (1000 hectares) (X_6) as the explanatory variables. The following measurement models are preliminarily established:

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \varepsilon \quad (7)$$

The symbols, economic significance and prediction symbols of regression analysis of each variable is shown in the table below.

Table 2. Variables and their economic implications

Variable	Economic implication	Prediction symbol
Y	Agricultural output value	
X_1	Comprehensive index of agricultural digitization	+
X_2	Total power of agricultural machinery	+
X_3	Effective irrigation area	+
X_4	Net amount of chemical fertilizer application	+
X_5	Soil erosion control area (1000 HA)	+
X_6	Affected area	-

Regression analysis is carried out with EViews 10 software to obtain the results of parameter estimation, as shown in Table 3.

Table 3. Results of regression analysis

Variable	Coefficient	t statistic	P
C	-93.2796	-2.7847	0.1084
LNX1	-0.5125	-1.1862	0.3573
LNX2	0.6214	1.9968	0.1839
LNX3	10.4889	1.8980	0.1981
LNX4	-0.9984	-0.6879	0.5626
LNX5	-0.3149	-0.3041	0.7898
LNX6	0.1172	0.7081	0.5523

The following measurement model is obtained according to table 3:

$$\ln Y = -93.280 - 0.513 \ln X_1 + 0.621 \ln X_2 + 10.489 \ln X_3 - 0.998 \ln X_4 - 0.315 \ln X_5 + 0.117 \ln X_6 \quad (8)$$

$$\overline{R^2} = 0.971, F = 45.702, DW = 3,141$$

4.2. Model Test

(1) Economic significance test. According to the least square estimation results, the symbols of $\ln X_1$, $\ln X_4$, $\ln X_5$ and $\ln X_6$ are opposite to the prediction, and the coefficient of $\ln X_3$ is too large, which does not accord with the practical economic significance, and the economic significance test fails.

(2) Statistical test. Revised decision factor $\overline{R^2} = 0.971$, close to 1, indicating that the model has a high degree of fitting to the explained variables. The value of F statistic is 45.702, and the corresponding P value is 0.021, which is less than 0.05. Therefore, the combination of explanatory variables has a high degree of explanation for explanatory variables. The t statistic value of each variable is small, and the corresponding P value is greater than 0.05, indicating that each explanatory variable is not significant to the explained variable.

(3) Econometric test. Because the overall fitting degree of the above model is high, but the economic significance test fails and the explanatory variables are not significant, the model needs to be tested by econometrics.

① Autocorrelation test. This paper will use autocorrelation diagram to test. According to the autocorrelation chart, the statistical values from 2012 to 2020 are within the specified range, indicating that there is no autocorrelation in the model.

② Heteroscedasticity test. This paper will use white test to construct auxiliary regression model. Because the model contains a large number of explanatory variables and the observed data of the model are less, the cross term between explanatory variables is not included in this test. Judge according to the decisive coefficient nR^2 obtained by regression. According to the white test results, the p value corresponding to the F test of the auxiliary regression model is 0.741, greater than 0.05, and the P value corresponding to nR^2 is 0.453, greater than 0.05. Therefore, the original hypothesis is accepted and it is considered that there is no Heteroscedasticity in the model.

③ Multicollinearity test. This paper uses the variance expansion factor Vif to test. When the VIF value of an explanatory variable in the model is greater than 10, it is considered that the model has multicollinearity. According to the results of variance expansion factor test, the VIF values of $\ln X_1$, $\ln X_3$, $\ln X_4$, $\ln X_5$ and $\ln X_6$ are greater than 10, so the model has serious multicollinearity.

④ Correction of multicollinearity. In this paper, the stepwise regression method is used to modify the multicollinearity. By fixing $\ln y$, c and $\ln X_1$, the P value of stepwise regression is 0.05, and the following regression results are obtained.

$$\ln Y = 6.377 + 0.284 \ln X_1 \quad (9)$$

$$\overline{R^2} = 0.868, F = 53.428, DW = 1.046$$

According to the results of stepwise regression, the revised decisive coefficient of the new model $\overline{R^2} = 0.868$, close to 1, so the fitting degree of the model is high. F statistic value = 53.428, and the corresponding p value is equal to 0.0002, less than 0.05, so the explanatory variables of the model have a significant impact on the explanatory variables. The regression coefficient of the explanatory variable $\ln X_1$ is 0.284, which shows that for every 1% increase in the comprehensive index representing agricultural digitization, the agricultural output value will increase by 0.28%, which is in line with the economic significance. And the t-statistic value of $\ln X_1$ is 7.309, and the corresponding P-value is 0.0002, which is less than 0.05, so the t-test passes. It can be seen that China's agricultural digitization can indeed increase the output value of agricultural products.

5. Conclusions and Suggestions

From the above analysis, it can be seen that the number of agricultural broadband access, Internet penetration and optical cable line length studied in this paper can indeed increase the output value of agricultural products. Based on the above analysis results, we believe that the application of digital technology has become a fruitful and extremely important link in China's agricultural development, which can effectively improve the output value of agricultural products. This also means that in the future agricultural development, agricultural digitization will be the direction of national key development and breakthrough, and will play a very important role in China's development into an agricultural power. Based on the current situation of China's agriculture and the pain points and difficulties in the process of digitization, we put forward the following suggestions from the perspective of agricultural digitization.

(1) We will continue to develop the rural information and communication industry and accelerate the construction of rural informatization. The state should continue to promote the construction of information and communication industry in rural areas, especially the development of networks in rural areas, accelerate the process of agricultural digitization, and strive to shorten the digital divide between urban and rural areas. On the way of information construction, we should focus on strengthening infrastructure services, laying optical cable tracks, accessing broadband services, laying a good foundation for information and communication, ensuring that the rural foundation comes first, and laying a good foundation for the future development of agricultural digitization. In the construction of rural communication industry, we can realize the lofty goal of enriching and strengthening agriculture by digital.

(2) Based on the current situation of China's rural areas, actively build digital transformation. China's agricultural economy is still dominated by small-scale peasant economy, and there are still great limitations on the supply side of agricultural factors. The Chinese government should optimize the supply side structure based on China's agricultural conditions. In the face of the high cost of agricultural digitization and its weak short-term benefits, the government should base on the long-term goal, increase the capital investment of agricultural digitization, appropriately increase the corresponding subsidy measures, and issue corresponding preferential policies to actively promote the cooperative construction between digital enterprises and farmers. In terms of technology, set up an expert team, carry out agricultural digitization pilot work in rural areas, and take innovation driven as the internal productivity to implement digitization. Advocate the implementation of digital achievements in agricultural colleges and universities, improve the conversion rate of digital achievements, improve the digital level, provide effective support for the development of smart agriculture, and provide strong support for the implementation of China's agricultural digital transformation.

(3) Facing the 5G era, promote the deep integration of 5G technology application and digital agriculture. At present, on the tide of 5G era, how to use 5G technology to promote the development of agriculture with relatively weak digitization is also one of the topics to be paid close attention to. At the sales end, rural e-commerce live broadcasting, network operation and other fields have great potential and vitality. Its low threshold and vertical sales are very suitable for the development of agricultural digital agriculture. Relevant e-commerce and government platforms can work together to create a professional rural e-commerce platform, establish fast transportation channels, improve the transportation efficiency of goods, effectively control the quality and price, ensure the quality of consumers and enable farmers to obtain better benefits. On the production side, the agricultural production department can vigorously promote the application of 5G big data, establish data files for each poultry by using Internet of things and artificial intelligence technology in the breeding industry, record various data indicators, and effectively investigate the abnormal behavior of livestock, such as disease,

to achieve the goal of scientific breeding. Based on the advantages of digitization in both sales and production, digital enterprises and relevant departments of agricultural production should encourage to explore relevant integrated development modes of agriculture and digital technology, and carry out reasonable pilot development to create a good breakthrough for agricultural digitization.

(4) Improve the digital popularization system and improve farmers' digital literacy. In the construction of agricultural digitization, in addition to the popularization of digital facilities, how farmers make good use of digital information equipment to create better benefits is also a very important link. The 49th statistical report on the development of China's Internet shows that the Internet penetration rate in rural China is only 57.6%, of which teenagers account for 94.7%. Compared with the middle-aged people who are the main force of agricultural production, their Internet penetration rate is less than 50%. Such Internet penetration rate is far from the goal of agricultural digitization. First, the Chinese government should pay attention to relevant education, take the initiative to provide digital education and training services for farmers, help farmers establish a digital concept and improve their awareness of agricultural digitization. Second, encourage returning college students to participate in the work of digital popularization, to provide new vitality for digital construction. Third, establish a complete digital agricultural system, better improve farmers' digital literacy under a complete system, cultivate high-quality agricultural talents, and provide intellectual support for agricultural digitization.

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