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China's Agricultural Total Factor Productivity and Its Influencing Factors

An Empirical Analysis Based on Provincial Panel Data from 2005 to 2016

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***Abstract*—In this paper, DEA-Malmquist index method is used to analyze agricultural total factor productivity and its main influencing factors in 31 provinces in China from 2005 to 2016. Through empirical analysis, it was found that the average annual growth rate of agricultural total factor productivity during this period was two point one percent, compared with the primary industry GDP annual growth rate, the contribution rate of TFP is thirty point four five percent. The development of the three major regions in the east, middle, and west still presents an unbalanced characteristic, and the total factor productivity of agriculture has declined in turn. At the same time, with the development of economy, the most important factor affecting the total factor productivity of agriculture is the proportion of wage income, while the proportion of grain sown area has the constraint effect.**

Keywords—total factor productivity; regional agriculture; DEA-malmquist index; influencing factors

I. Introduction

The 2017 Global Food Crisis Report released by the UN Food and Agriculture Organization pointed out that the food crisis caused by conflicts and climate change is still going on. As early as 2012, the Rio Summit agreed that there is a convergence between the two goals of eliminating hunger and achieving sustainable agricultural development. But after five years, the food crisis still plagues humans, especially current conflicts and climate disasters often interact with other factors have led to more complex crises, so the issue of agriculture has always been the focus of the international community.

After nearly 40 years of development, China's agriculture has achieved remarkable development. The total agricultural output value increased from 101.85 billion yuan in 1978 to 6,367.07 billion yuan in 2016, an increase of more than 62 times. However, with the Chinese economy entering a new normal state in 2013, China's agriculture has also exposed many problems, including the improvement of the quality of agricultural products with the improvement of people's living standards, the lack of supply of high-quality agricultural products, the oversupply of low-quality products, and the growing safety of agricultural products. Significantly, at the same time, as the environment deteriorates and the quality of cultivated land declines, the production cost of China's agricultural products continues to increase, while the prices of foreign agricultural products are often lower than domestic ones. Imported agricultural products have an impact on domestic agriculture. All these problems have led to the slow growth of farmers' income. Therefore, although agriculture has achieved considerable development, problems and contradictions still exist.

Agricultural development is the foundation of China's economic development. As early as 1997, Johnson & Richard clearly pointed out that for developing countries like China, the improvement of agricultural productivity is the core of national wealth growth. One way to improve agricultural productivity is to increase agricultural total factor productivity (TFP). Although there have been many studies on the total factor productivity of China's agriculture in academia, it is a problem worthy of long-term attention and research. First of all, compared with developed countries, China's agricultural productivity is still relatively low, and farmers' income is also relatively low. To overcome the middle-income trap, the key is to increase farmers' income, so agricultural productivity must be improved. Secondly, through the comparative analysis of total factor productivity with developed countries, we can find out our deficiencies, and then draw on global experience to develop targeted improvement measures. Thirdly, as China's aging is getting worse, especially rural aging is more serious than urban aging, the quantity and quality of the labor force that can be input into agricultural production has been affected, which also poses new challenges to the development of China's agriculture. Finally, after the global financial crisis in 2008, the global economy recovered slowly, and the Chinese economy entered the "new normal" of growth since 2013, which also had a direct and indirect impact on China's agricultural production, and also affected China's agricultural productivity. Therefore, the current analysis of China's agricultural total factor productivity is still valuable. Based on the data of 31 provinces in China from 2005 to 2016, this paper analyzed China's agricultural total factor productivity and its influencing factors based on DEA-Malmquist index method.

II. LITERATURE REVIEW

After years of development, the research on the growth of China's agricultural TFP is relatively comprehensive, both for the study of China's agriculture as a whole, as well as for research based on various provinces. At the provincial level, Gao Fan (2015) used the land, labor, total mechanical power and fertilizer application as input factors. Based on the DEA-Malmquist index method, the provincial panel data of 31 provinces in China from 1992 to 2012 were analyzed. Agricultural TFP and its influencing factors suggest that technological progress is the main factor in the change of agricultural TFP, and the agricultural TFP in the eastern, central and western regions declines in turn. Han Haibin and Zhao Lifen (2013) used land, labor, machinery, fertilizer, and irrigation as input factors. Based on the panel data of 28 provinces from 1993 to 2010, the agricultural TFP was analyzed by Malmquist-Luenberger index method, and the agricultural TFP growth in East and West China was considered. Decrease in turn. Guo Ping et al. (2013) used labor, land, machinery, organic fertilizer, working animals, fertilizer, and irrigation as input factors. Based on the panel data of 29 provinces from 1988 to 2007, the Fare-Primont index method was used to analyze agricultural TFP and considered agriculture. The difference in the TFP region presents a V-shaped wave dynamic potential. Kuang Yuanfeng (2012) used land, machinery, labor, and fertilizer as input factors. Based on the panel data of 31 provinces from 1988 to 2009, the agricultural TFP was analyzed by the stochastic frontier method (SFA), and the agricultural TFP in the eastern, central and western regions was successively decreasing. Convergence is diverse. Wang Bing et al. (2011) used the land, labor, machinery, fertilizer, irrigation, and working animals as input factors. Based on the panel data of 31 provinces from 1995 to 2008, the agricultural TFP was analyzed by the SBM directional distance function, and it was considered that the eastern and western parts were Agricultural TFP is declining in turn, and education has a positive effect on TFP. Fang Fuqian and Zhang Yanli (2010) used land, labor, fertilizer, and rural electricity consumption as input factors. Based on the panel data of 29 provinces from 1991 to 2008, the agricultural TFP was analyzed by Malmquist index method, and the agricultural TFP in the west was higher than that in the east. Quan Zhenzhen (2009) used land, labor, machinery, and fertilizer as input factors. Based on the panel data of 30 provinces from 1978 to 2007, the agricultural TFP was analyzed by Malmquist index method, and the agricultural TFP in the eastern, central and western regions was successively declining. Progress drives the TFP changes. Li Jing and Meng Lingjie (2006) used labor, machinery, irrigation, fertilizer, land, and large livestock as input factors. Based on the panel data of 30 provinces from 1978 to 2004, the agricultural TFP was analyzed by HMB index method, and inter-regional agriculture was considered. TFP is unbalanced and the east is growing faster than the Midwest.

The above related researches are based on provincial research, but they have great differences in research methods, time spans, input factors and conclusions.

First of all, there are big differences in research methods. Different authors used HMB index method, stochastic frontier method (SFA), Malmquist index method (including DEA-Malmquist index method and Malmquist-Luenberger index method) and Fare-Primont index method according to the needs of the research, with their own characteristics. In the TFP measurement method, there is no best or best method, especially with the development of econometrics, various measurement methods are also constantly improving.

Second, there is a big difference between the time period of the study and the province. Although the statistics are all after 1978, the span is very different, and the provinces range from 28 to 31. Considering the global financial crisis in 2008, and China’s per capita income has entered the upper middle income level since 2010, China’s economy has entered a new normal in 2013. All these factors will affect the agricultural TFP, so it is necessary to Interval to analyze the development of China's agricultural TFP.

Third, there are big differences in the choice of variables. On the one hand, due to the different availability and continuity of data, different time periods have been chosen. On the other hand, with the development of the economy, some indicators are no longer important. For example, the variable of “serving animals” is no longer in the recent research. Involved, basically, indicators such as land, labor, machinery, and fertilizer are indicators that are commonly used to measure agricultural inputs.

Finally, due to the different time spans and the different input variable indicators selected, the resulting results are different. In the regional TFP comparison, everyone thinks that regional development is unbalanced. The difference is that some think that the east is higher than the west, and some think that the west is higher than the east. In terms of convergence, there is a belief that there is convergence, and there is also a belief that there is divergence. There is no unified opinion, but it is still very valuable to conduct regional research and convergence studies on current agricultural TFP based on the input variable indicators that everyone agrees.

In summary, based on the DEA-Malmquist index method, the research on agricultural TFP in 31 provinces in China from 2005 to 2016 still has practical value. It can reveal the current development trend of China's agricultural TFP. At the same time, the analysis of TFP growth factors has It will help to understand the driving force of TFP growth from a deeper level, and then adopt targeted policy measures. Compared with the existing literature, this paper uses the latest sample data and incorporates the reasonable variables considered in the previous literature into the model analysis.

III. METHOD AND DATA

Since the Malmquist index does not require a preset frontier production function, it not only includes the characteristics of single factor productivity, but also decomposes the TFP growth rate into various factors such as technological progress and technical efficiency. In this paper, the DEA-Malmquist index method is proposed by Fare et al. (1994). Under the condition of Variable Return to Scale

(VRS), the technical efficiency change (TEC) under CRS (Constant Return to Scale) is decomposed into pure-technical efficiency change (PEC) and scale efficiency change (SEC). The relevant TFP growth rate can be expressed as:

$$M_{i,t+1}(x_i^t, y_i^t, x_i^{t+1}, y_i^{t+1}) = TEC_i^{t+1} \times TP_i^{t+1} = SEC_i^{t+1} \times PEC_i^{t+1} \times TP_i^{t+1} \quad (1)$$

While:

$$TP_i^{t+1} = \left[\frac{D_i^t(x_i^{t+1}, y_i^{t+1}|c)}{D_i^{t+1}(x_i^{t+1}, y_i^{t+1}|c)} \bullet \frac{D_i^t(x_i^t, y_i^t|c)}{D_i^{t+1}(x_i^t, y_i^t|c)}\right]^{1/2} \quad (2)$$

$$TEC_i^{t+1} = \frac{D_i^{t+1}(x_i^{t+1}, y_i^{t+1}|c)}{D_i^t(x_i^t, y_i^t|c)} \quad (3)$$

$$TEC_i^{t+1} = \frac{D_i^{t+1}(x_i^{t+1}, y_i^{t+1}|c)}{D_i^t(x_i^t, y_i^t|c)} = \frac{D_i^{t+1}(x_i^{t+1}, y_i^{t+1}|c)/D_i^{t+1}(x_i^{t+1}, y_i^{t+1}|v)}{D_i^t(x_i^t, y_i^t|c)/D_i^t(x_i^t, y_i^t|v)} \bullet \frac{D_i^{t+1}(x_i^{t+1}, y_i^{t+1}|c)}{D_i^t(x_i^t, y_i^t|c)} = \underbrace{\frac{SE_i^{t+1}(x_i^{t+1}, y_i^{t+1})}{SE_i^t(x_i^t, y_i^t)}}_{SEC_i^{t+1}} \bullet \underbrace{\frac{D_i^{t+1}(x_i^{t+1}, y_i^{t+1}|v)}{D_i^t(x_i^t, y_i^t|v)}}_{PEC_i^{t+1}} \quad (4)$$

$$M_{i,t+1}(x_i^t, y_i^t, x_i^{t+1}, y_i^{t+1}) = \underbrace{\frac{D_i^{t+1}(x_i^{t+1}, y_i^{t+1}|c)}{D_i^t(x_i^t, y_i^t|c)}}_{TEC_i^{t+1}} \bullet \underbrace{\left[\frac{D_i^t(x_i^{t+1}, y_i^{t+1}|c)}{D_i^{t+1}(x_i^{t+1}, y_i^{t+1}|c)} \bullet \frac{D_i^t(x_i^t, y_i^t|c)}{D_i^{t+1}(x_i^t, y_i^t|c)}\right]^{1/2}}_{TP_i^{t+1}} \quad (5)$$

The above equation, $M_{i,t+1}(x_i^t, y_i^t, x_i^{t+1}, y_i^{t+1})$ represents the TFP growth rate, (x_i^t, y_i^t) and (x_i^{t+1}, y_i^{t+1}) respectively represent the input and output sets of the t-th and t+1-th phases, TEC_i^{t+1} is the technical efficiency index, reflecting the degree of the boundary from the production front; TP_i^{t+1} is the technological progress index, indicating the degree of movement of the production frontier boundary. $D_i^t(x_i^t, y_i^t)$ and $D_i^t(x_i^{t+1}, y_i^{t+1})$ represent the technical efficiency level of the t-th period, $D_i^{t+1}(x_i^t, y_i^t)$ and $D_i^{t+1}(x_i^{t+1}, y_i^{t+1})$ represent the technical efficiency level of the t+1-th phase.

The review period of this paper is from 2005 to 2016. The survey targets are 31 provinces and the provinces are based on the eastern, central and western regions. On the one hand, there have been many relevant analyses in the previous years, and there are few data on the current analysis. On the other hand, the period includes the global financial crisis and the Chinese economy has entered a new normal. Understand the development trend of agricultural TFP under the new situation.

The DEA-Malmquist index method for measuring agricultural TFP requires agricultural inputs and agricultural output indicators. The indicators used in this paper are as follows: (1) Agricultural inputs. Like Gao Fan (2015), this paper will also set agricultural inputs from four aspects: labor, land, machinery and fertilizer. The data of each indicator are selected as follows: the labor input is expressed by the number of employed persons in the primary industry, the planting area for land use is expressed, the total power of agricultural machinery is indicated by mechanical input, and the amount of chemical fertilizer applied by chemical fertilizer is expressed. Relevant statistical data comes from the "China Statistical Yearbook" and the "Statistical Yearbook" of the provinces, "China Agricultural Statistics" and "China Population and Employment Statistics Yearbook". (2) Agricultural output. The agricultural output of this paper is expressed by the Primary Industry Value Added Index (2005=100), which eliminates the impact of price changes and thus more accurately reflects real output. Relevant statistics are from the "China Agricultural Statistics".

IV. MEASUREMENT OF AGRICULTURAL TOTAL FACTOR PRODUCTIVITY

With the data of agricultural investment and output in 31 provinces from 2005 to 2016, the Malmquist index can be calculated using DEAP2.1 software, and the growth rate of agricultural TFP in China is obtained. The relevant calculation results are shown in “Table I”.

Through the analysis of the results, we can find the following characteristics of agricultural TFP: First, the overall agricultural TFP in China shows a trend of continuous growth. From 2006 to 2016, China's agricultural TFP average index was 1. 021, that is, the average annual growth rate was 2.1%, and the cumulative growth rate (2005 = 1. 000) was 1.256, which is an increase of 0.256 times compared with 2005. Second, the agricultural technology efficiency index and the technological progress index in agricultural TFP growth are 1.003 and 1.018, respectively. Although they are all positive, the agricultural technology efficiency remains basically unchanged. The agricultural technology efficiency index is 1.003, and the technical efficiency index is mainly improved. It is due to the increase in scale efficiency. The agricultural technology progress index is 1.018, which is a significant improvement over agricultural technology efficiency. Third, since 2005, China's agricultural TFP improvement has benefited from the improvement of technological progress, but the related improvement is not stable, showing obvious volatility characteristics, especially in 2006 and 2008. Fourth, compared with the data analyzed by Gao Fan (2015) based on 1992-2012, the contribution rate of TFP to GDP growth has decreased. The contribution of agricultural TFP to GDP growth of primary industry reached 79.21% during 1992-2012. However, during the period of 2005-2016, the contribution of agricultural TFP to GDP growth of the primary industry was 30.453%. One of the reasons is that TFP itself is an analysis of factors that cannot be identified for economic growth. With the deepening of research and the improvement of statistical techniques, it can refine the identification of economic growth factors, which in this case will lead to a decrease in the value of TFP.

TABLE I. AGRICULTURAL TFP GROWTH RATE FROM 2006 TO 2016

Year	Technical efficiency change (TEC)	Technical change (TP)	Pure-technical efficiency change (PEC)	Scale efficiency change (SEC)	TFP growth rate	primary industry GDP growth rate	TFP growth rate / primary industry growth rate	TFP cumulative growth rate
2006	1.030	0.984	0.990	1.041	1.014	1.075	18.545	1.014
2007	0.989	1.041	0.991	0.999	1.030	1.155	19.412	1.044
2008	1.013	0.995	1.010	1.003	1.008	1.181	4.410	1.053
2009	1.000	1.004	0.999	1.000	1.004	1.044	9.096	1.057
2010	1.002	1.017	1.001	1.001	1.019	1.151	12.622	1.077
2011	0.999	1.017	0.996	1.003	1.016	1.171	9.378	1.094
2012	1.000	1.027	1.002	0.998	1.027	1.104	26.009	1.124
2013	0.990	1.031	0.993	0.997	1.021	1.088	23.996	1.147
2014	1.000	1.004	0.996	1.004	1.004	1.024	16.519	1.152
2015	0.999	1.002	1.004	0.995	1.001	1.043	2.316	1.153
2016	1.011	1.077	1.005	1.006	1.089	1.046	192.678	1.256
Average	1.003	1.018	0.999	1.004	1.021	1.098	30.453	

There are significant differences in the level of agricultural modernization and resource endowments in different provinces in China. The development of each province is uneven, showing the characteristics of gradient development, reflecting that agricultural TFP also exhibits gradient characteristics, so this paper gives 31 provinces agricultural TFP, as shown in “Table II”. We can find the following features at the provincial level:

First, the agricultural TFP growth rate and technological progress index of 31 provinces are both greater than 1, and the agricultural TFP growth rate and technological progress index based on the province's three regions of East, West and West are also greater than 1; except for Liaoning, Jilin and Inner Mongolia, other provinces. The technical efficiency index is greater than 1, and both technological advancement and technical efficiency have promoted the promotion of agricultural TFP in various provinces. Second, there are significant differences in agricultural TFPs in different provinces, resulting in differences in TFPs in the three regions of East, Central and West. The agricultural TFP in the central and western regions has gradually decreased. The annual average TFP growth rates of the three regions are 2.2%, 2.1% and 2.0%, respectively. Third, the contribution rate of agricultural TFP to the growth of the primary industry is also different. The contribution of agricultural TFP to the growth of the primary industry in the three regions of East, Central and West is 63.693%, 46.754% and 40.140% respectively.

TABLE II. AGRICULTURAL TFP IN 31 PROVINCES OF CHINA FROM 2006 TO 2016

Province/Region	Technical efficiency change (TEC)	Technical change (TP)	Pure-technical efficiency change (PEC)	Scale efficiency change (SEC)	TFP growth rate	Primary industry GDP growth rate	TFP growth rate / primary industry growth rate
Beijing	1.008	1.012	1.000	1.008	1.020	1.015	136.986
Tianjin	1.002	1.019	0.998	1.004	1.021	1.030	69.048
Hebei	1.002	1.031	1.000	1.003	1.033	1.038	86.019
Liaoning	0.996	1.020	0.997	0.999	1.016	1.040	40.047
Shanghai	1.017	1.010	1.000	1.017	1.027	1.100	26.973
Jiangsu	1.003	1.014	0.999	1.004	1.017	1.036	46.622
Zhejiang	1.006	1.017	1.000	1.006	1.023	1.024	95.216
Fujian	1.003	1.017	0.998	1.005	1.020	1.040	50.073
Shandong	1.004	1.027	1.000	1.004	1.031	1.042	73.591
Province/Region	**Technical efficiency**	**Technical change (TP)**	**Pure-technical**	**Scale efficiency**	**TFP growth**	**Primary industry GDP**	**TFP growth rate / primary industry**

	change (TEC)		efficiency change (PEC)	change (SEC)	rate	growth rate	growth rate
Guangdong	1.001	1.018	0.997	1.004	1.019	1.037	51.359
Hainan	1.003	1.013	1.000	1.003	1.016	1.065	24.688
Eastern mean	1.004	1.018	0.999	1.005	1.022	1.043	63.693
Shanxi	1.014	1.040	1.000	1.014	1.055	1.039	140.304
Jilin	0.999	1.012	0.999	1.000	1.011	1.045	24.643
Heilongjiang	1.000	1.014	0.999	1.001	1.014	1.060	23.342
Anhui	1.005	1.013	0.998	1.007	1.018	1.046	39.322
Jiangxi	1.002	1.009	0.999	1.003	1.011	1.046	24.152
Henan	1.001	1.019	0.999	1.002	1.020	1.046	43.632
Hubei	1.005	1.015	1.000	1.005	1.020	1.048	41.812
Hunan	1.001	1.014	0.998	1.003	1.015	1.041	36.824
Central mean	1.003	1.017	0.999	1.004	1.021	1.046	46.754
Inner Mongolia	0.994	1.022	0.994	1.000	1.016	1.047	34.336
Guangxi	1.000	1.015	0.998	1.002	1.015	1.048	31.301
Chongqing	1.005	1.013	1.000	1.005	1.018	1.047	38.661
Sichuan	1.002	1.014	0.998	1.004	1.016	1.038	42.512
Guizhou	1.004	1.024	1.000	1.004	1.028	1.053	52.952
Yunnan	1.003	1.011	1.000	1.003	1.014	1.060	23.175
Tibet	1.001	1.015	0.998	1.004	1.016	1.039	41.459
Shanxi	1.001	1.021	0.999	1.002	1.022	1.056	39.352
Gansu	1.003	1.028	1.000	1.003	1.031	1.056	55.236
Qinghai	1.004	1.013	1.000	1.004	1.017	1.049	34.824
Ningxia	1.005	1.031	0.999	1.005	1.036	1.059	61.289
Xinjiang	1.001	1.015	0.999	1.002	1.016	1.060	26.577
Western mean	1.002	1.018	0.999	1.003	1.020	1.051	40.140

In order to further compare the differences between the provinces, we converted the Malmquist index into the cumulative growth rate of each province based on 2004, and respectively calculated the cumulative growth rates of TFP and TP. The relevant calculation results are shown in Figure 1. From the figure, we can clearly see that there is a regional difference in the cumulative growth rate of agricultural TFP from 2005 to 2016. The highest is Shanxi (1.055) and the lowest is Jiangxi (1.011). There is a significant correlation between the cumulative growth rate of agricultural TP and the cumulative growth rate of TFP, and it also shows regional differences. The highest is Shanxi (1.040), and the lowest is Yunnan and Hunan (1.009).

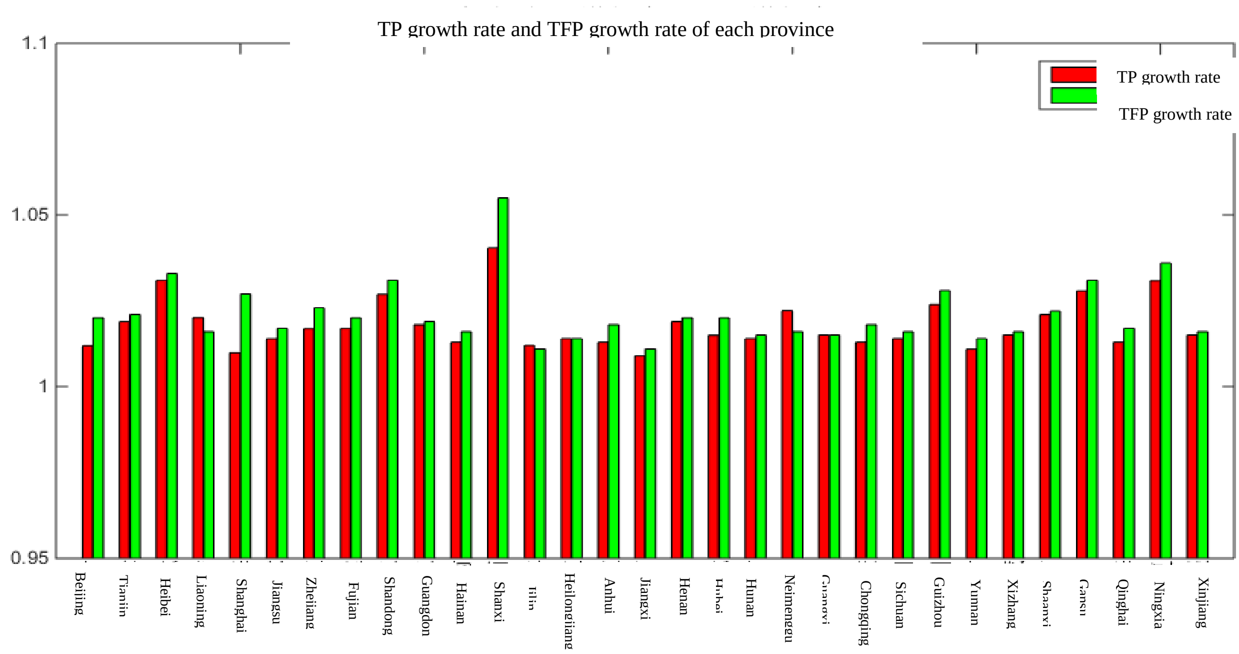

Fig. 1. Cumulative growth rate of agricultural TFP and TP cumulative growth rate in each province from 2006 to 2016.

V. Analysis of the Factors Affecting the Change of Agricultural Total Factor Productivity

Based on the above analysis, we found that the average annual growth rate of agricultural TFP in different provinces was different from 2006 to 2016, and there was no convergence in agricultural TFP in various regions. So what factors lead to different agricultural TFP growth rates in different regions, and this needs to be analyzed from the reasons. In general, the factors affecting the total factor productivity of agriculture can be divided into two categories, one is the agricultural production factor itself, and the other is factors other than production factors such as institutions. This paper uses the model used by Gao Fan (2015) to analyze the influencing factors of agricultural TFP changes. The relevant formula is as follows:

$$\ln TFP_{i,t} = \alpha + \beta_1 \ln IA_{i,t} + \beta_2 \ln HC_{i,t} + \beta_3 \ln WI_{i,t} + \beta_4 \ln AO_{i,t} + \beta_5 \ln CA_{i,t} + \beta_6 \ln AE_{i,t} + \mu_{i,t} \quad (6)$$

All variables in the formula are in logarithmic form, where IA represents the land quality, the value is the proportion of the irrigated area, that is, the proportion of the irrigated area to the planted area; HC represents the labor quality, and the value is the average years of education of the rural labor. WI indicates the quality of income, which is the proportion of wage income to the per capita net income of farmers; AO indicates the quality of agricultural structure, and the value is the proportion of total agricultural output value to the total output value of agriculture, forestry, animal husbandry and fishery; CA indicates the quality of crop structure, and the value is The area planted with grain accounts for the proportion of crop planted area; AE indicates the quality of policy, and the value of agricultural fiscal expenditure accounts for the proportion of local fiscal expenditure. Relevant data are compiled according to the "China Rural Statistical Yearbook" and the "Statistic Yearbook" of each province.

In the panel data analysis of 31 provinces from 2006 to 2016, this paper adopts the same method as Gao Fan (2015), firstly performing unit root test on related variables. Unit root tests include Levin, lin & Chut; ADF-Fisher Chi-square; PP-Fisher Chi-square. The results obtained using eviws9.0 show that the level test of the seven sequences cannot reject the null hypothesis with unit roots, but the first-order difference can reject the null hypothesis of unit roots at a significant level. As shown in "Table III", except that the PP-Fisher Chi-square first-order difference P value is 0.0001, and the first-order difference P value of all cases is 0.000, the null hypothesis can be rejected. This indicates that the seven sequences of TFP, IA, HC, WI, AO, CA, and AE are all first-order and monolithic.

TABLE III. Unit Root Check of Interpreted and Explanatory Variables in the Model

Testing method	TFP	IA	HC	WI	AO	CA	AE
Levin, lin&Chut	-0.155331 (0.0000)	-0.936941 (0.0000)	-15.44335 (0.0000)	- 1.085341(0.0 000)	-1.740578 (0.0000)	-0.589669 (0.0000)	-0.290562 (0.0000)
ADF-Fisher Chi-square	-11.47882 (0.0000)	-14.91489 (0.0000)	-15.44613 (0.0000)	-14.81049 (0.0000)	-7.335068 (0.0000)	-7.111276 (0.0000)	-8.523500 (0.0000)

Testing method	TFP	IA	HC	WI	AO	CA	AE
PP-Fisher Chi-square	-204.7313 (0.0001)	-50.65422 (0.0001)	-27.92469 (0.0001)	-65.81167 (0.0001)	-121.3339 (0.0001)	-112.7744 (0.0001)	-87.05151 (0.0001)

[a] Note: The data in parentheses is the P value of the corresponding statistic for the first-order differential test.

The agricultural TFP and its explanatory variables pass the unit root test and the cointegration test, so the regression model can be performed using the set model. In order to determine the form of the regression model, this paper uses the Hausman statistic to test, and "Table IV" gives the regression results of the national and three major regions from 2006 to 2016. Table 4 shows that, for the whole country, the P values of the explanatory variables are all less than 0.05, and the determination coefficient R2 of the equation and the adjusted determination coefficient R2 are 0.286021 and 0.148941, respectively. The irrigated area ratio (IA), wage income share (WI), agricultural output value (AO), and agricultural fiscal expenditure ratio (AE) are 0.012760, 0.065361, 0.059791, and 0.007297, respectively. It has a positive effect on agricultural TFP growth. The ratios of grain planting area (CA) and human capital content (HC) are -0.009385 and -0.004090, respectively; indicating that the above two factors have inhibited or restrained the growth of agricultural TFP.

TABLE IV. REGRESSION RESULTS OF THE MODEL (FIXED EFFECT MODEL)

Variable	National		Eastern		Central		Western	
	coefficient	*P value*	*coefficient*	*P value*	*coefficient*	*P value*	*coefficient*	*P value*
Constant term	0.327651	0.0000	0.247027	0.0000	0.45307	0.0000	0.291909	0.0000
IA	0.012760	0.0489	0.042897	0.0355	0.056337	0.2596	8.87E-05	0.9915
HC	-0.004090	0.0002	-0.003649	0.0284	-0.003565	0.1989	-0.00355	0.0077
WI	0.065361	0.0000	0.021638	0.2906	0.131004	0.0000	0.044079	0.0001
AO	0.059791	0.0001	0.062621	0.0602	0.053823	0.309	0.033527	0.039
CA	-0.009385	0.4523	-0.103707	0.0000	0.133382	0.0031	-0.007731	0.6386
AE	0.007297	0.2090	-0.000138	0.9876	-0.007605	0.667	0.019708	0.0109
R^2	0.286021		0.362985		0.431633		0.258225	
after adjustment R^2	0.148941		0.162273		0.146262		0.138507	
Number of samples	341		121		88		132	

The regression results show that from 2006 to 2016, the most significant contribution to the promotion of agricultural TFP in each province is the proportion of wage income, followed by the proportion of total agricultural output value, the proportion of irrigated area, and the proportion of agricultural fiscal expenditure. The proportion of grain sown area and human capital content has a binding effect. As far as the three major regions are concerned, the most important factor affecting the eastern agricultural TFP is the proportion of total agricultural output value, with a coefficient of 0.062621; the most important factor affecting the central agricultural TFP is the proportion of grain sown area, with a coefficient of 0.133382 respectively; The most important factor affecting the western agricultural TFP is the proportion of wage income, with a coefficient of 0.044079. It can be seen that the proportion of total agricultural output value, the proportion of wage income, and the proportion of grain planted area have affected the agricultural TFP of each province, and led to the difference of agricultural TFP among provinces and three regions.

VI. CONCLUSION

Based on the DEA Malmquist index method, we found that the average annual growth rate of China's agricultural TFP from 2006 to 2016 was 2.1%, and the cumulative growth rate was 25.6%. The contribution of agricultural TFP growth rate to the GDP growth rate of the primary industry was 30.45. Technical efficiency and technological progress have jointly promoted the growth of TFP, but the main factor is the advancement of agricultural technology; there are significant differences between the 31 provinces and the three regional agricultural TFP based on the provinces, and the agricultural TFP in the eastern, central and western regions have declined in turn; Irrigation area, wage income, and agricultural fiscal expenditure have a positive effect on agricultural TFP growth, while grain planting area and human capital have played a binding role in agricultural TFP growth.

Improving agricultural productivity is the only way for China's agriculture to achieve sustainable development, and one of the ways to improve agricultural productivity is continuous investment in agriculture, including investment in physical capital and human capital. Agricultural investment is critical to promoting agricultural growth and enhancing environmental sustainability for sustainable development. The State of Food and Agriculture 2012 pointed out that farmers are the largest agricultural investors in developing countries. In terms of agricultural capital stocks, farmers' agricultural investment is equivalent to three times the total investment of other sources, so it is necessary to create good Investment Environment. A good investment climate should include: sound governance, stable macroeconomics, transparent and stable trade policies, effective market mechanisms and respect for property rights, all of which involve the formulation and implementation of agricultural policies. Of course, a good agricultural investment environment also includes the provision of public goods. Evidence from 50 years in many countries shows that public investment in agricultural R&D, education and rural infrastructure will bring better returns than other expenditures such as agricultural subsidies. At the same time, investments in public goods in rural areas can be complementary: investing in education and rural infrastructure will promote agricultural investment and is often seen as some of the most important factors driving agricultural growth and overall rural economic development. The government must invest in the necessary institution building and human capital development, build an enabling environment for agricultural investment, and at the same time guide various policies to inject high-quality physical capital and human capital into agricultural production.

Our empirical analysis results are coupled with the above policy analysis. Promoting the land transfer system to improve agricultural intensive management will help increase the irrigated area, help increase the use of agricultural machinery, and increase agricultural productivity. Investing in farmers to expand farmers' wage income sources is conducive to raising farmers' investment in agriculture. The improvement of agricultural fiscal expenditures is conducive to improving the provision of rural public goods to lay a solid foundation for further improvement of agricultural productivity.

One of the reasons why human capital plays a binding role in the growth of agricultural TFP is that the higher the level of education, the easier it is for people to leave the agricultural industry. Agriculture cannot attract high-quality talents. Therefore, “public entrepreneurship, innovation” and returning home business With the encouragement of the policy, the follow-up of human capital will play a positive role in promoting the promotion of agricultural TFP. The grain planting area plays a binding role in the promotion of agricultural TFP, indicating that agriculture must diversify, improve the structure of agriculture, and increase the planting area of other industries such as forestry, animal husbandry and fishery, on the one hand, improve the type and quality of product supply, and on the other hand, The promotion of agricultural TFP and the sustainable development of agriculture. Therefore, the current policies adopted by Chinese agriculture will play a positive role in the improvement of agricultural productivity in the foreseeable future.

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