Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
May-June 2022 Page No. 2159-2176
Article History: Received: 24 February 2022, Revised: 05 April 2022, Accepted: 08 May 2022, Publication: 30 June 2022

Can Improving Agricultural Benefits Promote Total Factor Productivity?

Wenxia Wang[1, 2], Hengyun Ma[1,*]
[1]School of Economics and Management, Henan Agricultural University, Zhengzhou, Henan, China
[2]School of Economics, Henan University of Economics and Law, Zhengzhou, Henan, China
*Corresponding Author.

Abstract:

We assessed the influence of agricultural benefits on agricultural total factor productivity (TFP) by using macro panel data of 13 major grain-growing provinces of China from 2006 to 2016. Multiple estimation methods were used, including OLS, 2SLS, FE models, and instrumental variables. We test the impact, heterogeneity and action mechanism. We found agricultural benefits exert a positive impact on agricultural TFP, and that the effects of profit, income, and price on agricultural TFP increase successively. The higher the economic strength or grain production capacity is, the greater the promotion effect of price on agricultural TFP will be. Price can promote agricultural TFP through the mediating factor of investments into agricultural fixed assets. Improving agricultural benefits can help to promote TFP, thus achieving the dual goal of increasing both agricultural production and income.

Keywords: *Agriculture, Benefit, TFP.*

I. INTRODUCTION

In recent years, China's agricultural production (especially grain production) has entered the prominent dilemma of stagnant income despite rising output. This dilemma weakens the motivation of rural households to engage in agriculture, and inhibits the realization of agricultural modernization. From an economics perspective, increasing output implies the production of more products with fewer investments, i.e., increasing agricultural total factor productivity (TFP). However, increased output does not necessarily imply a higher income, as income is also impacted by many external factors associated with the industry, market, and policies. The impacts of these external factors are specifically embodied in the benefits that can be obtained through agricultural operations. For any country, increasing output and increasing income are both highly important. Governments value the effective supply of agricultural products, so they emphasize increased output. In contrast, producers pursue profit, and therefore, they emphasize increased income. This contrast makes it difficult to effectively coordinate both goals in practice. By taking the Chinese grain production as example, it becomes clear that on the one hand, grain output continuously increases with technological progress. On the other hand, profits are restricted by both the "cost floor" and the "price ceiling", resulting in ever narrower profit margins. In this context, the government is striving to maintain and improve the benefits of grain growing by abolishing agricultural taxes and introducing

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
May-June 2022 Page No. 2159-2176
Article History: Received: 24 February 2022, Revised: 05 April 2022, Accepted: 08 May 2022, Publication: 30 June 2022

agricultural support policies [1]. However, it remains unknown whether improved agricultural benefits indeed affect production in such a way that increases agricultural TFP. This critical question is addressed in this paper.

In this paper, agricultural TFP is defined as the portion of output that can still increase when the quantities of input factors (e.g., labor, land, and capital) remain constant [2]. This refers to technological progress in its broad sense. Increasing agricultural TFP constitutes an important path toward achieving a high-quality agricultural development. From 2002 to 2016, China's agricultural TFP grew at a mean annual growth rate of 2.2%. On the whole, agricultural technology has achieved unceasing progress, but specific aspects are still impacted by many deficiencies. For instance, while the mechanization rate of crop ploughing, sowing, and harvesting has reached 80%, numerous producers are still operating on small scales. This however, raises the costs of socialized services, poses great difficulties to whole-process mechanization, and restricts the increase of productivity. Moreover, further problems such as low grain quality and specification standards, poor innovation in fine variety development, and inadequate competitive advantages and competitiveness on the international market also restrict productivity [3]. Faced with these problems, great efforts should be made to further increase the agricultural TFP of China, thus realizing technological innovation and quality standardization. A path of high-quality and efficient agricultural development needs to be identified. The pursuit of benefits by agricultural producers is the primary driver of the progress of agricultural technology [4-5]. Currently, the general condition of low agricultural benefits is bound to impact the effective increase of agricultural TFP.

The agricultural benefits this paper investigates cover three aspects: price, income, and profit. To be specific, they not only include the benefits directly obtained from agricultural operations (e.g., agricultural product price and agricultural income), but also the benefit comparison between agriculture and other industries in operations, such as agricultural trade condition (i.e., the market price of agricultural products/input price of agricultural means of production, which measures the "scissors difference in price" between agriculture and industry) [6], agricultural income condition (i.e., the operational income from agricultural production/salary income, which reflects the income gap between engagement in agriculture and engagement in industrial production for rural households), and agricultural profit condition (i.e., agricultural income/agricultural cost, which evaluates the profitability of agriculture). As a result of both the industrialization and urbanization of China, the price elasticity of the demand for agricultural products has weakened. In China, the labor productivity of agriculture is far lower than that of industrial and service sectors, and the benefits from agricultural operations have also gradually declined. Constrained by the land system, urban-rural segmentation, and resource endowment, 90% of rural households can only engage in small-scale planting (based on data from the Third National Agricultural Census conducted in 2016). Restricted by the need to pursue a non-farming job, most farmers choose to grow grain crops such as wheat, corn, and rice, which generate low agricultural income. With the massive increase of inputs in mechanization, fine varieties, chemical technology, and other agricultural production services, all of which yield corresponding increases of costs, the agricultural profit retained by rural households is further reduced. Many rural households try to expand their production scale and obtain returns to scale by renting land. However, constrained by high land rent costs (reaching as much as 12,870 yuan/hectare on average

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
May-June 2022 Page No. 2159-2176
Article History: Received: 24 February 2022, Revised: 05 April 2022, Accepted: 08 May 2022, Publication: 30 June 2022

according to a survey by the Economic Daily in 2018) and rigid production cost, these rural households are incapable to cope with both the market and natural risks; increasing their agricultural profit is often an unattainable goal. The high costs of agricultural production and the low prices of agricultural products inevitably weaken the motivation of rural households to either engage in agricultural production or increase their agricultural TFP.

To achieve a high-quality agricultural development, the Chinese government has established the goals of improving agricultural technology and raising the income of rural households. According to this background, it is of vital practical significance to perfect external market conditions and institutional environments and improve agricultural benefits. These measures can spur technological innovation with benefits and realize a benign cycle of "increase in both output and income" [7]. With regard to the impact of agricultural benefits on TFP, existing studies mainly support one of the following two viewpoints: The first viewpoint is that improving agricultural benefits helps to significantly promote agricultural productivity. The second viewpoint, while acknowledging the promoting effect of the first viewpoint, claims that this effect is not significant. Zeller et al [8]. maintained that high-income agricultural producers have the motivation to select high-quality varieties and adopt advanced technologies; thus, they become capable to increase their productivity. Schreinemacher et al. [9] suggested that high-income countries usually take the initiative to reduce the use of pesticides, thus guaranteeing environmental optimization and increasing their agricultural TFP. Uzun et al. [10] pointed out that the state has invested heavily in supporting agriculture, but, depending on regional and individual differences, not all rural households can benefit from such support. Kelly et al. [11] argued that agricultural subsidies are often not used entirely for agricultural production by rural households; therefore, the promoting effect of agricultural subsidies on agricultural TFP is not obvious.

In summary, existing studies have not yet reached a consensus regarding the impact of agricultural benefits on TFP, and they also vary with regard to variable selection and research methods. For instance, the options of proxy variables are limited, no comprehensive consideration has been given to all impacting factors, there is no solid theoretical basis that supports the selection of the study period, and mechanism analyses and discussions about endogeneity problems are also missing. Since 2006, the Chinese government has completely abolished agricultural taxes, energetically implemented agricultural support policies, and attached great importance to the improvement of agricultural benefits. Consequently, this paper suggests that selecting 2006-2016 as the study period makes it easier to observe the results induced by changes in agricultural benefits. The Chinese government has always highly valued the issue of grain security. In this paper, 13 major grain-growing provinces of China (Hebei, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Jiangsu, Anhui, Jiangxi, Shandong, Henan, Hubei, Hunan, and Sichuan), which collectively account for 75% of China's total grain output, are selected as study objects, as they basically reflect China's grain production problems. By empirically testing the impacts of agricultural benefits on agricultural TFP in these 13 major grain-growing provinces, this paper analyzes the drivers of the growth of agricultural technology. This paper proposes that the pursuit and realization of benefits by agricultural producers constitute a major driver of progress in agricultural technology. The findings of this paper offer ideas and suggestions for the government toward resolving the dilemma of "stagnant income despite rising

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
May-June 2022 Page No. 2159-2176
Article History: Received: 24 February 2022, Revised: 05 April 2022, Accepted: 08 May 2022, Publication: 30 June 2022

output". Furthermore, the macroeconomic goals of the government and the microeconomic interests of rural households can be better coordinated, and reasonable agricultural support policies can be better formulated.

II. THEORETICAL ANALYSIS

The progress of agricultural technology not only provides a lasting driving force for agricultural growth, but also a critical guarantee for the development of the national economy. In fact, technological progress in its broad sense exactly matches the growth of TFP[12]. Agricultural TFP can be increased by a series of measures, such as elevating the level of human capital, strengthening policy support, promoting urbanization, improving infrastructure, and improving market environment. In particular, an agricultural production-friendly environment with reasonable price, income, and profit conditions provides a basic driver and fundamental guarantee for rural households to continue with production and improve their technological level.

However, it remains unknown whether improved agricultural benefits can promote TFP. At the microscopic level, a higher agricultural product price and a lower input factor price will motivate producers to increase TFP through technological progress and management upgrades. However, at the macroscopic level, because of the weakened price elasticity of the demand for agricultural products and the lagging adjustment of supply, the results of market equilibrium always tend to deviate from the desirable state. The "cobweb"[13] fluctuations of the agricultural product price frequently pose the risks of "low prices for grain hurting the peasants" and "high prices for rice hurting the peasants", thus making it impossible to realize the relative agricultural benefit and inhibit the increase of TFP. This means that TFP can only be increased through implementing public policies, reducing market uncertainties and transaction costs, and guaranteeing the relative benefit of agriculture.

According to microeconomics, the agricultural product market is approximately a perfectly competitive market. Such a market contains numerous homogeneous products and homogeneous producers. Each producer can only passively accept market prices (including agricultural product price and input factor price) and then adjust their own modes of production and outputs accordingly. In long-term production, the rise of the agricultural product price or the decline of the input factor price at the market will motivate producers to increase their technological level by introducing high-yield varieties and adopting high-efficiency equipment, all of which are measures that increase output. Thus, from a microscopic perspective, the improvement of agricultural benefits will guide producers to constantly improve their production technology, thus realizing a benign cycle of "increase of both output and income".

In contrast, according to macroeconomics, prices that formed through spontaneous equilibrium on the agricultural product market always show a tendency to deviate from the desirable state. When the supply of agricultural products increases, the agricultural product price begins to decline at an amplitude higher than the amplitude with which output increases. Eventually, this leads to the decline of overall benefits, and inhibits the increase of agricultural output at the next stage. Under this condition, the government

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
May-June 2022 Page No. 2159-2176
Article History: Received: 24 February 2022, Revised: 05 April 2022, Accepted: 08 May 2022, Publication: 30 June 2022

usually tries to stabilize the input factor price by implementing agricultural support policies or providing production subsidies. By continuously focusing on the guiding role of the price, the government reduces the loss of interest for producers, and creates a friendly external market environment in which agricultural output can be increased on a long-term basis through technological progress. This will help China to overcome the vicious cycle of "stagnant income despite rising output".

International experience shows that a number of countries try to guarantee their agricultural production capacity by adjusting public policies on agricultural resources and market conditions. In developed countries, because of the reductions of agricultural scale and profit as a result of industrialization and urbanization, governments attach greater importance to defining agricultural products as public goods, and implementing agricultural support policies to maintain the attractiveness of agriculture. Seen from the practice of China, the government has abolished agricultural taxes, introduced major preferential policies for agricultural products, and provided grain-growing subsidies to maintain agricultural benefits and encourage competent producers to continue to engage and even specialize in agriculture. These measures guarantee the effective supply of agricultural products, and create conditions for increasing agricultural TFP.

III. MODEL SPECIFICATION AND VARIABLE SELECTION

To empirically test the impact of agricultural benefits on TFP, this paper builds an econometric model. The macro panel data of 13 major grain-growing provinces of China from 2006 to 2016 are used, and regression analysis is performed on this data.

3.1 Data Source

The data used in this paper are mainly derived from the China Statistical Yearbook, the China Agriculture Yearbook, the China Rural Statistical Yearbook, the China Population & Employment Statistics Yearbook, the Compilation of Cost-Benefit Data for Agricultural Products in China, provincial-level Statistical Yearbooks, and the official website of the National Bureau of Statistics. Table I provides the descriptive statistics of all main variables.

TABLE I. Descriptive statistics on individual variables

VARIABLES	MEAN	STD. DEV.	MINIMUM	MAXIMUM
TFP	1.2698	0.2393	0.7407	1.7512
Price	156.0650	29.9079	99.3000	222.3549
Income	3634.0020	1366.3080	1550.8310	7746.3820
C_Price	1.1946	0.1605	0.9485	1.7804
C_Income	1.7004	1.0524	0.5717	5.3420
C_Profit	1.2828	0.1748	0.8075	1.7152
Education	7.7071	0.3480	6.5184	8.3020

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
May-June 2022 Page No. 2159-2176
Article History: Received: 24 February 2022, Revised: 05 April 2022, Accepted: 08 May 2022, Publication: 30 June 2022

Finance	0.1079	0.0224	0.0528	0.1897
Urban	0.5051	0.0811	0.3247	0.6772
Industry	6.4327	0.1541	6.1418	6.8969
Environment	0.2153	0.1414	0.0156	0.6886
Road	0.9096	0.4453	0.1125	1.7318

3.2 Model Specification

This paper builds an econometric model to investigate the impact of agricultural benefits on TFP. The regression model is set up as follows:

$$\begin{aligned} Ln(TFP_{it}) = {} & \alpha + \beta Ln(Benefit_{it}) + \gamma_1 Ln(Education_{it}) + \gamma_2 Ln(Finance_{it}) \\ & + \gamma_3 Ln(Urban_{it}) + \gamma_4 Ln(Industry_{it}) + \gamma_5 Ln(Environment_{it}) \\ & + \gamma_6 Ln(Road_{it}) + \lambda_t + \mu_i + \varepsilon_{it} \end{aligned} \quad (1)$$

where the explained variable is agricultural TFP, the core explanatory variable is agricultural benefits (Benefit), and the control variables are rural human capital (Education), financial support for agriculture (Finance), urbanization level (Urban), industry upgrading (Industry), disaster rate (Environment), and road facility (Road). α represents a constant term, λ_t represents time fixed effects, μ_i represents individual fixed effects, β, γ represents the coefficient to be estimated, and ε_{it} represents the disturbance term that varies with individual and time, where i denotes the individual and t denotes time. To eliminate heteroscedasticity, all variables have been subjected to logarithmic processing before regression.

3.3 Variable Selection

(1) Explained variable: TFP is measured using the widely used Malmquist-DEA index method [14-17]. The output index is the gross output value of agriculture (unit: 100 million yuan) (calculated with a constant price). The factor input indices include the number of persons employed in agriculture (unit: 10,000), the total power of agricultural machinery (unit: 10,000 kWh), sown area of crops (unit: 1,000 ha), converted pure amount of agricultural consumption of fertilizers (unit: 10,000 t), and agricultural consumption of diesel (unit: 10,000 t). The TFP measured using this method is a chained index of variation and adopts the last period as base period. By line of reasoning, multiplying the chained indexes of variation of previous years yields the cumulative agricultural TFP of the same base period. The result, which is also the growth rate of agricultural TFP, is used as the explained variable.

(2) Core explanatory variable: agricultural benefits (Benefit). This variable reflects the merits of the external market environment of agricultural production, including: the agricultural product price (Price), the agricultural income (Income), 3.the agricultural trade condition (C_Price), the agricultural income condition (C_Income), and the agricultural profit condition (C_Profit). Among these, the agricultural

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
May-June 2022 Page No. 2159-2176
Article History: Received: 24 February 2022, Revised: 05 April 2022, Accepted: 08 May 2022, Publication: 30 June 2022

product price is represented by the producer price index for farm products (uniformly adopting 2006 as base period). Agricultural income is represented by the operational income of rural households from agricultural production (calculated with constant price). The agricultural trade condition is represented by the producer price index for farm products / price index of agricultural means of production. The agricultural income condition is represented by the rural households' operational income from agricultural production / salary income. The agricultural profit condition is represented by the mean output value per hectare / cost of the three major crops (i.e., wheat, rice, and corn). Agricultural benefits are taken as core explanatory variable.

(3) Control variables: In reference to existing literature, this paper selects six factors that may impact agricultural TFP as control variables [18-20]. These include: rural human capital (Education), which is represented by the "mean educational level of rural population". The weighted mean educational level of rural population is calculated by province, based on the length of education and the number of population. Financial support for agriculture (Finance) is represented by the "proportion of fiscal expenditure on agriculture, forestry, and water conservancy in total fiscal expenditure". The urbanization level (Urban) is represented by the "urbanization rate (i.e., the proportion of urban population in permanent population in a region)". Industry upgrading (Industry) is represented by the "index of Moore structure change of the three major sectors", which can be calculated from the formula $M_t = \frac{\sum_{i=1}^{3} W_{it} W_{i,t+1}}{\sqrt{\sum_{i=1}^{3} W_{it}^2} \sqrt{\sum_{i=1}^{3} W_{i,t+1}^2}}$, where W represents the proportion of the i sector in GDP. The index of Moore structural change is generally used to measure the level of advancement of the industrial structure. The disaster rate (Environment) is represented by the "proportion of disaster-affected area of crops of total sown area of crops". Road facility (Road) is represented by the "proportion of regional highway mileage of total regional land area".

To visually depict the relationship between agricultural benefits and TFP, the trend charts of agricultural TFP and agricultural benefits varying with time have been plotted (Fig. 1, where variables are shown in their initial forms), and presented as scatter diagrams and fitting curves (Fig. 2, where variables are shown in their logarithmic forms). According to Fig. 1, agricultural TFP presents a trend of improving year by year, showing stable growth in the early stage but a lack of impetus in the later stage. Both agricultural product price and agricultural income have improved with each passing year. The agricultural trade condition tends to be stable. The agricultural income condition worsens year after year, and presents a trend of polarization. The agricultural profit condition also deteriorates quickly, resulting in losses. Fig. 2 shows that agricultural product price, agricultural income, and agricultural trade condition have obvious positive correlations with agricultural TFP, while the agricultural income condition and agricultural profit condition have obvious negative correlations with agricultural TFP. This means that while agricultural TFP is in urgent need of improvement, the promoting effect of agricultural benefits on TFP varies with the specific circumstances. The absolute benefit of agriculture improves constantly, but its relative benefit is worsening. As a result, the motivation of producers to engage in agriculture will inevitably decrease, and the progress and long-term development of agricultural technology will be restrained by a lack of economic base and interest drivers. For the purposes of a more accurately analysis and comparison of the impacts of different types of agricultural benefits on TFP, rigorous econometric tools will be adopted in the

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
May-June 2022 Page No. 2159-2176
Article History: Received: 24 February 2022, Revised: 05 April 2022, Accepted: 08 May 2022, Publication: 30 June 2022

following part.

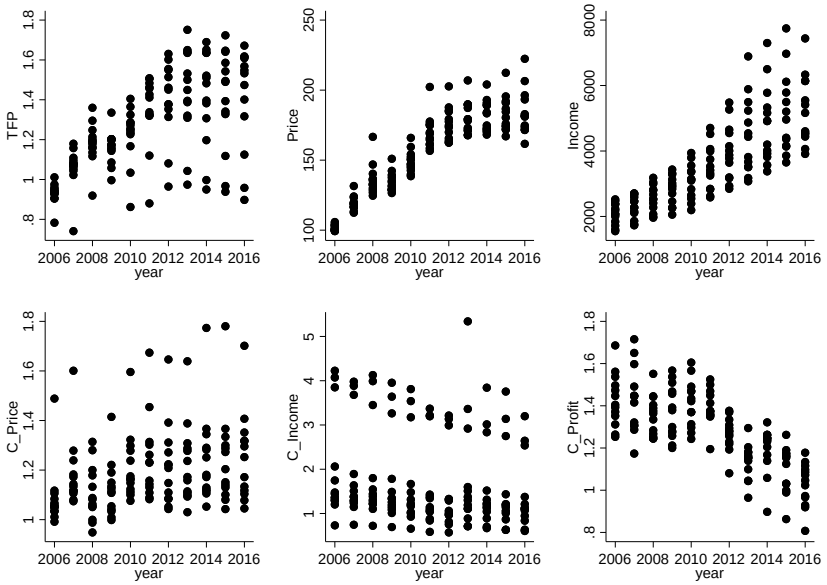

Fig 1: Trend on agricultural TFP and benefit

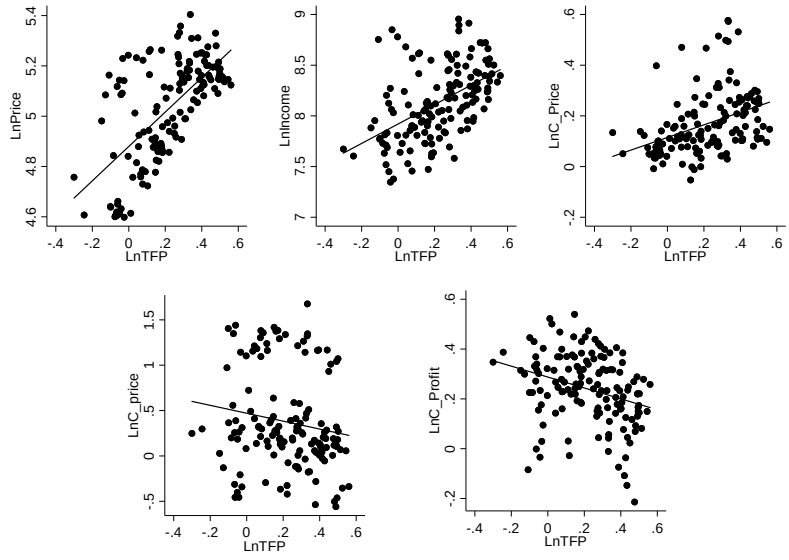

Fig 2: Scatter diagram and fitting curve on agricultural TFP and benefit

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
May-June 2022 Page No. 2159-2176
Article History: Received: 24 February 2022, Revised: 05 April 2022, Accepted: 08 May 2022, Publication: 30 June 2022

IV. EMPIRICAL TEST AND RESULT ANALYSIS

4.1 Baseline Regression Analysis

This section investigates the impacts of five types of agricultural benefits on agricultural TFP. Fixed effects (FE) models are used for regression, and the individual effects of provinces are controlled under each model. Model (1) in Table II provides the regression results of the six control variables only, regardless of the impact of agricultural benefits on TFP. Models (2)-(6) provide the regression results of all impacting factors, considering the impacts of agricultural benefits and the six control variables on TFP.

Judging from the regression results of the core explanatory variable, agricultural benefits impact agricultural TFP. In particular, agricultural product price and agricultural trade condition exert significant positive impacts on TFP, and the agricultural trade condition exerts a more significant impact. It thus becomes clear that, when the agricultural product price is high or higher than the price of industrial products that are invested into agricultural production, agricultural operations will produce benefits, thus driving the further improvement of agricultural TFP. Agricultural income also positively impacts TFP, but to a smaller extent. The impact coefficients of the agricultural income condition and agricultural profit condition are smaller, and both are statistically non-significant. Thus, although rural households are benefitting from an increase in agricultural income, the promoting effect of such income increase on TFP is small. With the increase of non-agricultural working opportunities and the rapid increase of non-agricultural income, the advantages of engaging in agriculture are declining for rural households; therefore, the promoting effect on TFP is non-significant. Above all, when rural households can no longer cover their costs with the benefits obtained from grain growing or even suffer losses as a result of grain growing, they will lose the motivation to improve TFP.

Judging from the regression results of the control variables, rural human capital and urbanization level exert extremely significant positive impacts on agricultural TFP. This suggests that a higher educational level of the rural population will more greatly promote the development, popularization, and application of agricultural technology. When more rural labor forces move to cities, the allocation of agricultural production factors will be optimized, and mechanization, informatization, and digitalization technology will be utilized. However, the optimization of industrial structure adversely impacts agricultural TFP. In other words, the upgrading of the industrial structure increases the output value of the service sector and decreases the output value of the agricultural sector. In the absence of effective industrial policies, the disadvantaged industrial status will certainly inhibit the increase of agricultural TFP. In addition, financial support for agriculture and infrastructure level both positively impact agricultural TFP, while natural disasters adversely impact agricultural TFP. Their impacts are either statistically non-significant or too small, but basically conform to reality.

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
May-June 2022 Page No. 2159-2176
Article History: Received: 24 February 2022, Revised: 05 April 2022, Accepted: 08 May 2022, Publication: 30 June 2022

TABLE II. Effect of benefits on TFP by using Fixed Effect Model

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Price		0.3700***				
		(0.0992)				
Income			0.1214			
			(0.1013)			
C_Price				0.5066***		
				(0.1304)		
C_Income					0.0443	
					(0.0995)	
C_Profit						0.0110
						(0.1477)
Education	1.7221***	1.2930***	1.5296***	1.3730***	1.6875***	1.7076**
	(0.4764)	(0.4107)	(0.4584)	(0.4262)	(0.4306)	(0.5841)
Finance	0.0759	-0.0430	0.0319	0.0624	0.0867	0.0766
	(0.0931)	(0.0774)	(0.0809)	(0.0895)	(0.0905)	(0.0887)
Urban	1.1133**	0.7907*	1.0326**	1.1164***	1.1582***	1.1200**
	(0.3664)	(0.3849)	(0.3941)	(0.3004)	(0.3646)	(0.4386)
Industry	-2.6452*	-1.9210	-3.1281**	-2.8932**	-2.6540*	-2.6106**
	(1.2581)	(1.2167)	(1.0861)	(0.9993)	(1.2374)	(1.0542)
Environment	-0.0233	-0.0050	-0.0130	-0.0241	-0.0227	-0.0233
	(0.0201)	(0.0180)	(0.0155)	(0.0222)	(0.0200)	(0.0206)
Road	0.0136	-0.1423	-0.0653	-0.0437	0.0166	0.0166
	(0.1357)	(0.1044)	(0.1269)	(0.0974)	(0.1406)	(0.1374)
Constant	2.5374	-0.2981	2.6833	3.5805	2.6655	2.5071
	(3.2921)	(3.1640)	(3.0015)	(2.7186)	(3.1248)	(3.0889)
Observations	143	143	143	143	143	143
R-squared	0.807	0.836	0.816	0.830	0.808	0.807

4.2 Heterogeneity Effect Analysis

This section examines the differences in the impacts of agricultural benefits on agricultural TFP under different economic strength and grain production capacity conditions.

The 13 investigated major grain-growing provinces are classified into two types based on per capita GDP, i.e., provinces with weak economic strength and those with strong economic strength. Table III provides the regression results of the two types of provinces obtained using FE models. Provinces with weak economic strength include Hebei, Heilongjiang, Anhui, Jiangxi, Henan, and Sichuan, while provinces with strong economic strength include Inner Mongolia, Liaoning, Jilin, Jiangsu, Shandong, Hubei, and Hunan. According to the results, agricultural product price, agricultural income, and

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
May-June 2022 Page No. 2159-2176
Article History: Received: 24 February 2022, Revised: 05 April 2022, Accepted: 08 May 2022, Publication: 30 June 2022

agricultural trade condition exert strong promoting effects on agricultural TFP in provinces with strong economic strength. In contrast, in provinces with weak economic strength, agricultural income condition and agricultural profit condition exert great promoting effects on agricultural TFP. Clearly, regional economic strength affects the impacts of agricultural benefits on agricultural TFP. When the improvement of regional economic strength is combined with the implementation of agricultural support policies, agricultural product price and agricultural income can be guaranteed and improved. This exerts increasingly prominent positive promoting effects on agricultural TFP. In contrast, when the income and profit conditions of agriculture worsen relative to other industries, the positive promoting effects of agricultural product price and agricultural income on agricultural TFP will fade.

TABLE III. Effect of benefits on TFP by using Fixed Effect Model: heterogeneity test of economic strength

VARIABLES	(1)	(2)	(3)	(4)	(5)
Panel A: weak economic strength					
Price	0.0857 (0.1161)				
Income		-0.0571 (0.0675)			
C_Price			0.2574 (0.2323)		
C_Income				0.1811* (0.0821)	
C_Profit					0.1940** (0.0740)
Constant	4.1770 (2.1787)	5.0361* (2.3863)	4.7663** (1.8209)	6.1372*** (1.5181)	4.8446* (2.0288)
Controls	Yes	Yes	Yes	Yes	Yes
Observations	66	66	66	66	66
R-squared	0.893	0.893	0.895	0.907	0.897
Panel B: strong economic strength					
Price	0.4191*** (0.0971)				
Income		0.1771*** (0.0370)			
C_Price			0.5646*** (0.1016)		
C_Income				-0.0365 (0.0821)	
C_Profit					-0.1212 (0.1684)
Constant	3.1163 (4.1667)	7.0929 (4.6789)	9.1726** (3.3039)	7.2993 (4.8102)	8.1036 (4.9409)

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
May-June 2022 Page No. 2159-2176
Article History: Received: 24 February 2022, Revised: 05 April 2022, Accepted: 08 May 2022, Publication: 30 June 2022

Controls	Yes	Yes	Yes	Yes	Yes
Observations	77	77	77	77	77
R-squared	0.882	0.867	0.877	0.847	0.850

Table IV classifies the 13 major grain-growing provinces into two types based on their grain production capacity level (i.e., provinces with low grain production capacity and those with high grain production capacity), and provides the regression results of the two types of provinces obtained using FE models. Provinces with low grain production capacity include Inner Mongolia, Liaoning, Anhui, Jiangxi, and Hubei, while those with high grain production capacity include Hebei, Jilin, Heilongjiang, Jiangsu, Shandong, Henan, Hunan, and Sichuan. According to the results, agricultural product price, agricultural income, agricultural trade condition, and agricultural income condition exert strong promoting effects on agricultural TFP in provinces with high grain production capacity. In contrast, in provinces with low grain production capacity, the agricultural profit condition exerts a strong promoting effect on agricultural TFP. Clearly, grain production capacity (i.e., the status of the province as a major grain-growing province) affects the impacts of agricultural benefits on agricultural TFP. This means that a province with a higher grain production capacity shoulders a heavier responsibility to ensure grain security. A province that receives more national policy support is capable of creating a better external environment for agricultural production, and can maintain and raise the agricultural product price to a larger extent, thus promoting an increase of agricultural TFP. However, because of the heavy requirements grain-growing tasks impose and the low agricultural profit these yield, the benefits may not be able to cover the costs caused by grain growing. In this case, the agricultural profit condition will not exert any promoting effect on agricultural TFP.

TABLE IV. Effect of benefits on TFP by using Fixed Effect Model: heterogeneity test of production capacity

VARIABLES	(1)	(2)	(3)	(4)	(5)
Panel A: weak production capacity					
Price	0.3291* (0.1582)				
Income		0.0802 (0.1215)			
C_Price			0.4064 (0.2583)		
C_Income				-0.3484** (0.1195)	
C_Profit					0.2959** (0.1059)
Constant	3.8790 (5.6052)	7.1889 (4.9229)	8.1861* (3.8308)	8.1849* (3.8782)	7.5055* (3.6207)
Controls	Yes	Yes	Yes	Yes	Yes
Observations	66	66	66	66	66

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
May-June 2022 Page No. 2159-2176
Article History: Received: 24 February 2022, Revised: 05 April 2022, Accepted: 08 May 2022, Publication: 30 June 2022

R-squared	0.904	0.889	0.898	0.907	0.899
Panel B: strong production capacity					
Price	0.3455* (0.1429)				
Income		0.1329 (0.1060)			
C_Price			0.4781** (0.1732)		
C_Income				0.1549 (0.0848)	
C_Profit					-0.1566 (0.1658)
Constant	-5.4220 (3.3547)	-3.0924 (3.1634)	-2.2391 (3.4792)	-3.0430 (4.2456)	-3.4077 (3.7589)
Controls	Yes	Yes	Yes	Yes	Yes
Observations	77	77	77	77	77
R-squared	0.798	0.784	0.794	0.783	0.775

4.3 Robustness Test

This section tests the robustness of the impacts of agricultural benefits on agricultural TFP using the instrumental variable method and the explained variable transformation method.

High agricultural TFP level and advanced technology themselves contribute to an increase of agricultural benefits. Because of the possible presence of reverse causality in models, estimates may be biased. In general, the fiscal solvency of local governments exerts an impact on agricultural benefits. Consequently, the governments of provinces with a high fiscal self-sufficiency rate usually try to improve the relative benefit of agriculture through tax returns and transfer payments. Table V provides the regression results obtained using the instrumental variable-two-stage least squares (IV-2SLS) method by considering endogeneity problems and utilizing the fiscal self-sufficiency rate (i.e., fiscal income / fiscal expenditure) as the instrumental variable of agricultural benefits. Durbin-Wu-Hausman's test results strongly rejected the original hypothesis that "all explanatory variables are exogenous", and they argued that the relative benefit of agriculture is endogenous. Considering the presence of individual effects, regional dummy variables are upgraded as instrumental variables for the estimation. According to the results, agricultural product price, agricultural trade condition, and agricultural income (especially the agricultural product price) exert significant positive impacts on agricultural TFP. Neither the agricultural income condition nor the agricultural profit condition exert any positive impact on agricultural TFP, and their impacts are both small. Compared with the FE method, under the IV-2SLS method, price still exerts a significant impact on agricultural TFP. The impact of income becomes more significant. The impacts of agricultural income condition and agricultural profit condition are both non-significant. The research results are relatively robust and reliable.

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
May-June 2022 Page No. 2159-2176
Article History: Received: 24 February 2022, Revised: 05 April 2022, Accepted: 08 May 2022, Publication: 30 June 2022

TABLE V. Effect of benefits on TFP by using Instrumental Variable Model

VARIABLES	(1)	(2)	(3)	(4)	(5)
Price	0.6480*** (0.1003)				
Income		0.2821*** (0.0771)			
C_Price			0.4674*** (0.1273)		
C_Income				-0.0050 (0.0421)	
C_Profit					-0.0207 (0.1401)
Constant	-1.5275 (2.2808)	-0.9650 (2.5247)	2.8085 (2.3877)	1.7331 (2.5420)	1.6701 (2.3695)
Controls	Yes	Yes	Yes	Yes	Yes
DWH Test	7.7659***	7.1397***	8.6277***	3.7062*	3.9486**
Observations	143	143	143	143	143
R-squared	0.501	0.412	0.455	0.385	0.385

The explained variable in the models can be replaced by other indices. When TFP is measured with the Malmquist-DEA index method, it can be decomposed into technological efficiency and technological progress, which examine the efficiency aspect and the technology aspect, respectively. Table VI provides the regression results obtained using FE models by partially adopting the technological progress in agricultural TFP as explained variable. According to the results, agricultural benefits impact the progress of agricultural technology. Agricultural product price, agricultural income, and agricultural trade condition (especially the agricultural product price) exert significant promoting effects on the progress of agricultural technology. Neither the agricultural income condition nor the agricultural profit condition exert any significant positive effects on the progress of agricultural technology, and their impacts are both small. When TFP is replaced by technological progress, the impacts of agricultural benefits uniformly become more significant. The impacts of agricultural benefits on agricultural technology may be more direct. After changing the explained variable, the regression results are still consistent, which confirms the robustness and reliability of the research results.

TABLE VI. Effect of benefits on TFP by using Fixed Effect Model: replace dependent variables

VARIABLES	(1)	(2)	(3)	(4)	(5)
Price	0.6685*** (0.1030)				
Income		0.2933*** (0.0682)			
C_Price			0.3735***		

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
May-June 2022 Page No. 2159-2176
Article History: Received: 24 February 2022, Revised: 05 April 2022, Accepted: 08 May 2022, Publication: 30 June 2022

			(0.0915)		
C_Income				0.0160	
				(0.1225)	
C_Profit					-0.0763
					(0.0806)
Constant	-7.8714***	-2.3964	-1.9797	-2.7024	-2.5378
	(2.2722)	(2.5819)	(2.7217)	(2.8482)	(3.1403)
Controls	Yes	Yes	Yes	Yes	Yes
Observations	143	143	143	143	143
R-squared	0.916	0.883	0.852	0.843	0.843

4.4 Testing the Impact Mechanism

This section mainly explores whether agricultural fixed asset investments exert a mediating effect on the impacts of agricultural benefits on TFP. Improved agricultural benefits can encourage producers to increase agricultural fixed asset investments by purchasing machinery, ameliorating land, and perfecting facilities. The improvement of the material conditions for agricultural production in this manner further contributes to the improvement of agricultural technology and productivity. Table VII presents the results estimated by the ordinary least squares (OLS) method and the two-stage least squares (2SLS) method by defining agricultural fixed assets investments (Agriinvest) as mediating variable. Here, the fiscal self-sufficiency rate is still taken as the instrumental variable of agricultural benefits. Comparisons show that, among agricultural benefits, only agricultural trade condition (C_Price) best conforms to the requirements of the mediating variable and exerts a mediating effect. The other four agricultural benefit indexes are omitted from the regression results of Table VII. According to the regression results, the agricultural trade condition indeed acts on agricultural TFP via the mediating variable of agricultural fixed asset investments. When the differences in price between agriculture and other industries are small, the external market environment of agricultural production will improve. This will further encourage producers to increase investments and improve material conditions, thus ultimately promoting the long-term development and technological progress of agriculture. When these two methods are used for estimation, the regression results of the main variables are all extremely significant. Thus, strengthening agricultural fixed assets investments constitutes an important mechanism for improving agricultural benefits and increasing agricultural TFP.

TABLE VII. Effect of benefits on TFP by using Fixed Effect Model: agricultural investment as mediator

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	TFP	Agriinvest	TFP	TFP	Agriinvest	TFP
	OLS	OLS	OLS	2SLS	2SLS	2SLS
C_Price	0.5166***	1.0562*	0.4684***	0.4674***	2.5065**	0.4803***
	(0.1361)	(0.6277)	(0.1589)	(0.1273)	(1.1266)	(0.1212)
Agriinvest			0.0453*			0.0351**

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
May-June 2022 Page No. 2159-2176
Article History: Received: 24 February 2022, Revised: 05 April 2022, Accepted: 08 May 2022, Publication: 30 June 2022

			(0.0256)			(0.0152)
Constant	4.1251	-11.3920	4.5342*	2.8085	-14.4505	3.5761
	(2.5373)	(12.3240)	(2.3436)	(2.3877)	(11.1987)	(2.3195)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	143	143	143	143	143	143
R-squared				0.455	0.465	0.471
DWH Test				8.6277***	4.6825**	11.9053***

V. CONCLUSION AND POLICY IMPLICATIONS

In case of a highly volatile international situation and constant trade disputes, it is of vital significance to stabilize and improve the benefits gained from agricultural operations; furthermore, agricultural technology need to be improved, thus guaranteeing agricultural self-confidence and safeguarding grain security. In this paper, the macro panel data of 13 major grain-growing provinces of China from 2006 to 2016 are used to test the impacts of agricultural benefits on agricultural TFP and the related heterogeneity and action mechanism. Multiple estimation methods were used, including OLS, 2SLS, FE models, and instrumental variables. According to the findings of this paper, (1) improved agricultural benefits exert positive impacts on agricultural TFP. The impacts of agricultural benefits vary, depending on the measurement criteria. The promoting effects of agricultural benefits on agricultural TFP are successively enhanced when measured by profit, income, and price. (2) With the enhancement of regional economic strength, the promoting effects of income and profit on agricultural TFP are weakened, while the promoting effect of price is enhanced. In major grain-growing provinces, the promoting effect of profit on agricultural TFP fades; however, benefiting from national policy support, the promoting effect of price is more significant. (3) By introducing the mediating variable of agricultural fixed asset investments, improving agricultural benefits (which is represented by agricultural trade condition) first encourages producers to increase agricultural investments, and then promotes the increase of agricultural TFP.

The specific policy implications this paper yields suggest that, to overcome the current problem of "stagnant income despite rising output" agriculture faces in China, the Chinese government must prioritize the increase of income, stabilize and improve agricultural benefits through institutional reform and public policies, and maintain the attractiveness of agriculture. These measures will contribute toward increasing the agricultural TFP and realizing the increase of output. To do so, the following advances must be achieved: (1) The reform of rural land system should be further promoted to equip farmers with more property rights and interests and more operational rights. Moreover, the reasonable urban-rural flow of factors, and all-round urbanization and rural revitalization should be promoted. By encouraging the combination of agriculture with the Internet, ecology, and tourism and by developing a more modern agriculture, the intelligence, industrialization, and socialization levels of agriculture will all be elevated. (2) Continuous efforts should be exerted to implement agricultural public policies, provide public welfare services (e.g., irrigation, water conservancy, meteorology, epidemic prevention, and technological promotion). Furthermore, quality monitoring, quality management, price guarantees, and order-based purchase over major agricultural products should be implemented. In addition, it is also necessary to

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
May-June 2022 Page No. 2159-2176
Article History: Received: 24 February 2022, Revised: 05 April 2022, Accepted: 08 May 2022, Publication: 30 June 2022

support and assist agricultural associations in completing price discovery and information guidance, and fully emphasize the role of the agricultural product market as a circulative intermediary in information, negotiation, and coordination. (3) Price subsidies should be provided for major agricultural products to encourage the differentiation of demand levels through extending agricultural value chains and improving product quality. Moreover, the tolerance of the rise of agricultural product price needs to be strengthened. Macroeconomic control should be moderate and progressive, and the legalization of the agricultural product price should be implemented. This will send definite signals to agricultural producers and avoid policy and institutional risks.

ACKNOWLEDGEMENTS

This research was supported by National Social Science Fund Major Project of China (Grant: 18ZDA072).

REFERENCES

[1] Huang J, Wang X, Rozelle S (2013) The subsidization of farming households in China's agriculture. Food Policy 41: 124-132
[2] Solow RM (1960) Technical change and the aggregate production function. Review of Economics and Statistics 39: 312-320
[3] Gong B (2018) Interstate competition in agriculture: cheer or fear? evidence from the United States and China. Food Policy 81: 37-48
[4] Griliches Z (1957) Specification bias in estimates of production functions. Journal of Farm Economics 39:8-20
[5] Hayami Y, Ruttan V (1985) Agricultural Development: An International Perspective. Baltimore: The Johns Hopkins University Press. ISBN0-801-82376-5
[6] Lin JY (1992) Rural reforms and agricultural growth in China. The American Economic Review 82:34-51
[7] Fan S (1991) Effects of technological change and institutional reform on production growth in Chinese agriculture. American Journal of Agricultural Economics 73: 266-275
[8]. Zeller M, Diagne A, Mataya (1998) Market access by smallholder farmers in Malawi: implications for technology adoption, agricultural productivity and crop income. Agricultural Economics 19: 219-229
[9] Schreinemachers P, Tipraqsa P (2012) Agricultural pesticides and land use intensification in high, middle and low income countries. Food Policy 37: 616-626
[10] Uzun V, Lerman Z (2017) Outcomes of Agrarian Reform in Russia. Switzerland: Springer International Pub. Co. ISBN978-3-319-33238-3
[11] Kelly A, Coatney KT, Li X, et al. (2020) Subsidy incidence in the presence of bertrand suppliers of complementary inputs: a U.S. agricultural example. Journal of Industry, Competition and Trade 20:479-501
[12] Gong B (2020) Agricultural productivity convergence in China. China Economic Review 60:101423
[13] Kaldor N, Mirrlees JA (1962) A new model of economic growth. Review of Economic Studies 29:174-192
[14] Caves DW, Christensen L, Diewert WE (1982) The economic theory of index numbers and the measurement of input, output, and productivity. Econometrica 50: 1393-1414
[15] Coelli TJ, Rao DP (2005) Total Factor Productivity growth in agriculture: a Malmquist index analysis of 93 countries, 1980~2000. Agricultural Economics 32: 115-134
[16] Malmquist S (1953) Index numbers and indifference surfaces. Trabajos de Estadística 4:209-242
[17] Fare R, Grosskopf S, Lovell CAK (2008) Production frontiers. Economic Journal 105

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
May-June 2022 Page No. 2159-2176
Article History: Received: 24 February 2022, Revised: 05 April 2022, Accepted: 08 May 2022, Publication: 30 June 2022

[18] Shen ZY, Baležentis T, Ferrier GD (2019) Agricultural productivity evolution in China: a generalized decomposition of the Luenberger-Hicks-Moorsteen productivity indicator. China Economic Review 57:101315
[19] Li C, Tanna S (2019) The impact of foreign direct investment on productivity: new evidence for developing countries. Economic Modelling 80:453-466
[20] Morakinyo O, Adetutu, Ajayi V (2020) The impact of domestic and foreign R&D on agricultural productivity in Sub-Saharan Africa. World Development 125:104690.