A Study on the Impact of Agricultural New-quality Productivity on Food Security in China: Based on Mediating Effects

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Abstract. Agricultural new-quality productive capacity is a key driver for enhancing food security and achieving agricultural modernization. Based on panel data from 30 provinces and unicipalities in mainland China from 2013 to 2022, this study constructed a dual fixed-effects and mediation effects model and employed empirical analysis methods to validate the impact of agricultural new-quality productive capacity on food security and its underlying mechanisms. Research results show that developing new high-quality production capacity in agriculture greatly improves food security, but with heterogeneity. In grain-producing regions and eastern regions, the enabling effect of agricultural new-quality productive capacity on food security is more pronounced. The mediating effect suggests that the development level of rural industrial chains and supply chains, as well as digital agriculture, play a mediating role in the process by which agricultural new-quality productive capacity promotes food security.

Keywords: Agriculture New Quality Production, Food Security, Mediating Effects Model.

1. Introduction

Regarding food security, academics mainly carry out research from the connotation [1], influencing factors [2-3], and evaluation systems [4-5]. With regard to new qualitative productivity in agriculture, existing research has mainly focused on the connotation, logic and avenues of qualitative research, and some quantitative research focuses on the construction of the evaluation index system of the new quality productivity [6], the measurement of the development level and the regional differences from the macro perspective [7], and the interpretation of the dynamic changes [8]and other aspects. Research on new agricultural productivity and food security focuses mainly on the theoretical study of their logical implications and practical challenges [9], ways of achieving them, and proposing countermeasures [10].

In summary, although academic circles have conducted research on food security and new-quality agricultural productivity, marginal contributions can still be made in the following areas: Firstly, with regard to the content of the research, most existing literature sources devoted to the quality of new agricultural products remain at a theoretical level, do not contain sufficient empirical analysis, and the research results are not supported by the necessary data; second, as for the subject of the study, available studies have mainly focused on the correlation between new qualitative productivity in agriculture, digital technology, and digital finance, neglecting the correlation with food security and the mechanism of its specific role. Technology and digital finance, lack the consideration of food security and its specific mechanism. On this basis, this article selects panel data from 30 Chinese provinces for the period 2013–2022, constructs a double constant effect and indirect effect model, and integrates the new quality of agricultural production and food security into the same research framework, by selecting the supply chain level of rural industries and digital agriculture as intermediate variables, the internal mechanism of the impact of new agricultural productivity on food security was revealed, and provide references for the formulation of agricultural new quality productivity and food security strategies at the policy level.

2. Research design on new agricultural quality productivity for food security

2.1. Research hypothesis on the impact of new agricultural quality productivity on food security

Assumption 1: Agricultural new quality productivity promotes food security.

Assumption 2: Agricultural new quality productivity promotes food security by improving the level of rural supply chain and industrial chain construction.

Assumption 3: Agricultural new quality productivity promotes food security by improving the level of agricultural digitization.

2.2. Model Building

2.2.1. Benchmarking model

The following benchmark regression models are constructed to conduct an in-depth analysis of the direct effects of new quality productivity in agriculture on food security.

$$fsc_{it} = \alpha_0 + \alpha_1 anqp_{it} + \alpha_2 cv_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (1)$$

In Eq. (1), i and$t$ denote province and year respectively,$adnqp_{it}$ denotes the level of agricultural new quality productivity of province,i means id which is the province,t indicates time which is year of the period, fsc_{it} is the food security indicator of agriculture in provincei in yeart ,cv_{it} denotes the control variable, μ_i represents the province fixed effect,γ_t represents the year fixed effect, andε_{it} is the randomized perturbation term. This paper focuses on the positive and negative ofα_1 , if α_1>0, it means that the new quality productivity in agriculture has a positive effect on food security; As opposed to, if α_1<0, it means that the new quality productivity in agriculture exerts a suppressive effect on food security.

2.2.2. Mediating effects model

With the aim of undertaking a comprehensive analysis of how modern quality productivity affects food safety mechanisms, this study is based on the research results of Jiangting (2022) [11], the following mediator effect model is constructed on the grounds of equation (1) for testing.

$$maicscc_{it} = \beta_0 + \beta_1 adnqp_{it} + \beta_2 cv_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (2)$$

$$fsc_{it} = \gamma_0 + \gamma_1 anqp_{it} + \gamma_2 maicscc_{it} + \gamma_2 cv_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (3)$$

$$dec_{it} = \delta_0 + \delta_1 anqp_{it} + \delta_2 cv_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (4)$$

$$fsc_{it} = \mu_0 + \mu_1 anqp_{it} + \mu_2 dec_{it} + \mu_2 cv_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (5)$$

Where, the mediating parameters are the level of rural industrial chain supply chain construction ($maicsc$) and the level of agricultural informatization (dec_{it}), respectively, and the meanings of other variables are consistent with equation (1). Eq. (2)$maicsc_{it}$ represents the level of rural industrial chain supply chain construction of provincei in yeart , and Eq. (4)dec_{it} is the level of agricultural digital informatization of provincei in yeart.

2.3. Description of variables

2.3.1. Explanatory variables

Agricultural new-quality productivity (ANQP). Given the analysis of the connotation of new quality productivity in agriculture and with reference to the selection of indicators and treatment of related studies, an integrated assessment methodology for evaluating innovative quality productivity in agriculture is proposed in this dissertation by selecting indicators from three dimensions: agricultural modernized labor force, objectives of new-quality agricultural labor force cultivation, modern agricultural production materials.

The system consists of 7 first-level indexes and 10 second-level indexes, and the entropy method is used to assign weights to the indexes to measure and evaluate the development level of agricultural new quality productivity in each province, as shown in Table 1.

Table 1. Indicator System for Explanatory Variables

Dimension	Level 1 Indicators	Level 2 Indicator
Agricultural laborers	Quality of workers	Average level of education
		Proportion of adult technical training
	labor force reserve	Rural labor mobility
	labor productivity	Output per capita in primary sector
Objects of agricultural labor	New Agricultural Quality Industry	Situation of agriculture, forestry and fishery services
		Agricultural industry structural adjustment index
	New quality environment for agriculture	Sustainable agricultural development
Agricultural labor information	material means of production	Traditional infrastructure
		digital infrastructure
	Intangible means of production	Agricultural science, technology and innovation
		Level of digitization of agriculture

2.3.2. Explained Variables

Food security (FS). The development of the index system for assessing food security is a systematic project aimed at comprehensively reflecting the food security situation of a specific country or region. In this paper, we define as the established literature from the food production security and food supply security, consumption security, sustainable development security and trade security five dimensions as indicators, and select 7 first-level indicators, 13 second-level indicators, using entropy weight method to measure, as presented in following Table 2.

Table 2. Indicator system for explanatory variables

dimension	Level 1 indicators	Level 2 indicator
Food production security	Supply capacity	Food production per unit of cultivated area
		total grain output
	Production Stability	Volatility coefficient of food production
		Proportion of area affected
Food access security	Acquisition of competence	Per capita food consumption
		Engel's coefficient
Food consumption security	consumer protection (law)	Per capita disposable income of rural residents
Food sustainability	ecological environment	Fertilizer application rate
		Pesticide application rate
		Plastic film use
	Resource utilization	Water carbon emissions from agriculture, forestry and fisheries
		Agricultural water use efficiency
Food trade security		Dependence on food imports and exports

2.3.3. Mediating variables

With respect to established documents and taking into account the reality, the level of rural industrial chain supply chain construction (maicsc) is measured by the volume of railroad freight

transport (10,000 tons), rural delivery routes (kilometers), total agricultural output, cultivated area and total value of agricultural products; indicators of agricultural digitalization (de) include the penetration of mobile phones and computers in rural areas, the penetration level of rural Internet, the sales volume of e-commerce, and the proportion of digital technology talents, and measured by the entropy method. sales, e-commerce purchases, and the proportion of digital technology talents are measured, and the entropy value method is applied to measure it.

2.3.4. Control variables

The urbanization rate (urb), external openness (open), human capital level (cap), and GDP per capita were selected as control variables in order to comprehensively assess the factors influencing economic growth and other socio-economic phenomena.

2.3.5. Data sources

Based on data availability, this study selected panel data from 30 provinces, autonomous regions, and municipalities (hereinafter referred to as "provinces") in China between 2013 and 2022, excluding Hong Kong, Macao, Taiwan, and the Tibet Autonomous Region, as the research sample. China Statistical Yearbook, China Environmental Statistical Yearbook, China Science and Technology Statistical Yearbook, China Social Statistical Yearbook, China Energy Statistical Yearbook, China Business Management Statistical Yearbook, China Rural Cooperative Economy Statistical Yearbook, China Rural Policy and Reform Statistical Yearbook, Peking University's Center for Digital Finance Research, as well as the statistical yearbooks of each province, and the statistical yearbooks of each province, with some missing values filled in by the linear interpolation method. method to fill in.

3. Empirical analysis

3.1. Benchmark regression analysis results

The results of the baseline regression of ANQP on FS without and with the introduction of the control variables are presented in table 3 below. Observation of the data in Table 3 shows that the coefficients of the food security indicators with and without the introduction of the control variables are significant at the 1% level, the coefficient values increase, the effects of the variables are more significant and the overall explanatory power of the model may have been enhanced. Hypothesis 1 is verified, confirming the strategic concept of new quality productivity to ensure national economic security.

Table 3. Benchmark regression results

	FS	FS
ANQP	0.604 *** (0.052)	0.605 *** (0.053)
Urb		-0.109 (0.133)
Open		0.015 (0.037)
Cap		1.075 (1.750)
GDP		0.002 (0.004)
CONS	0.052 *** (0.012)	0.078 (0.138)
Province fixed	YES	YES
Year fixed	YES	YES
observed value	300.000	300.000
R2	0.9637	0.9639

Note: ① ***, ** and * indicate significance levels of 1%, 5% and 10% respectively. ② Standard errors are indicated in parentheses.

3.2. Robustness and endogeneity tests

3.2.1. Robustness test

To ensure result reliability, this paper employs three distinct methodologies for robustness verification: First, since food security, after being processed using the entropy weight method, takes values between 0 and 1, it meets the condition of a restricted dependent variable. Therefore, the Tobit model is used to re-estimate the results. The results are shown in Column (1) of Table 4. After controlling for the control variables, the Tobit model regression results persist in showing significant positive values, consistent with the baseline regression outcomes, which demonstrates the robustness of the baseline estimation results. Second, given that the four municipalities of Beijing, Shanghai, Tianjin, and Chongqing have significantly higher levels of economic development and resource allocation than other provinces and regions, they may interfere with the research results. To reduce the occurrence of random phenomena, it was decided to exclude these four municipalities from the dataset and conduct regression analysis again based on the remaining data. The results are shown in Column (2) of Table 4. After tailing all the data and conducting robustness analysis, as shown in Table 4 (3), it was found that the new quality productivity of agriculture remains significantly at the 1% level for food security, which suggests that the conclusions of this paper are reasonably robust.

Table 4. Robustness test results

Variant	Explained variable: fs		
Food Security	Tobin (1)	Excluding municipalities (2)	Shrinking primary explanatory and explanatory variables (3)
ANQP	0.605*** (0.049)	0.666** (0.059)	0.645*** (0.056)
Control Variable	YES	YES	YES
Province Fixed	YES	YES	YES
Year Fixed	YES	YES	YES

Note: ① ***, ** and * indicate significance levels of 1%, 5% and 10% respectively. ② Standard errors are indicated in parentheses.

3.2.2. Endogeneity test

Using the two-stage least squares method, the lagged one-period new quality productivity (L.anqp) was selected as the instrumental variable to carry out the endogeneity test, and the results are shown in Table 5. Observing the data results, it can be seen that the regression coefficient of L.anqp is still significant at the 1% level after the introduction of the instrumental variable, which aligns with the baseline regression results, and it shows that the previous conclusions are reliable.

Table 5. Endogeneity test results

	ANQP	FS
L.ANQP	0.609***	
	(0.056)	
ANQP		0.286***
		(0.088)
CONS.	-0.039	0.103
	(0.155)	(0.170)
Province fixed	YES	YES
Year fixed	YES	YES
observed value	270.000	270.000
R^2	0.951	0.962

Note: ① ***, ** and * indicate significance levels of 1%, 5% and 10% respectively. ② Standard errors are indicated in parentheses.

3.3. Heterogeneity Analysis

3.3.1. Regional Heterogeneity Analysis

According to the classification method of the National Bureau of Statistics and authoritative scholars, the sample data of all provinces in China are divided into three parts: eastern region, central region, and western region. As illustrated in Table 6, the results of the heterogeneity analysis reveal variations across subgroups, which confirm that the development level of new-quality productivity across the country exhibits a spatial distribution of higher levels in eastern area and lower levels in the west. In the eastern region, the new-quality productive capacity of agriculture has a significant impact on food security. However, in the central and western regions, although new agricultural production capacity has also promoted food security, the return coefficient is relatively small, indicating that its impact is weak. This is primarily due to the eastern region's strong economic strength and advanced technological level, which enable robust food security capabilities. The new-quality productive capacity in agriculture, such as smart agriculture and biotechnology, is developing rapidly, with high levels of informatization and digitization, and leading supply chain modernization. The central region, as a major grain-producing area, makes a significant contribution to food security, with agricultural new-quality productive capacity gradually improving and informatization, digitization, and supply chain modernization developing rapidly. However, it still lags behind the eastern region. The western region, constrained by natural conditions and economic development levels, has relatively weak food security, with room for improvement in agricultural new-quality productive capacity and informatization and digitization levels, and a relatively lagging supply chain modernization process.

3.3.2. Heterogeneity Analysis of Major Grain-producing Regions

From the results in Table 6, we can conclude that the impact of new-type agricultural productivity in grain-producing regions on food security was significantly strong at the 1% level, with a coefficient of 0.882. In non-grain-producing regions, although the impact was significant at the 1% level, the coefficient was only 0.224. This difference primarily stems from the fact that grain-producing regions typically possess well-developed agricultural infrastructure and receive substantial policy support from the government. Farmers in these regions have extensive experience in grain production, and favorable natural resources such as suitable climate conditions and fertile soil provide a solid foundation for grain production. In contrast, agriculture in non-grain-producing regions may not be the core industry of the local economy, leading to relatively lower levels of investment and attention to agriculture. Limited resource allocation, insufficient investment in agricultural infrastructure development, and scientific and technological research for agricultural development have become constraints on the growth of agricultural new-quality productivity.

Table 6. Heterogeneity test results

FS	Eastern	Central	Western	Grain-Producing Regions	Non-Grain-Producing Regions
	(1)	(2)	(3)	(1)	(2)
ANQP	0.982*** (0.087)	0.200** (0.096)	0.180*** (0.054)	0.882*** (0.082)	0.224*** (0.053)
control variable	YES	YES	YES	YES	YES
CONS	0.235*** (0.082)	0.349*** (0.043)	0.284*** (0.045)	0.438*** (0.083)	0.057* (0.030)
Province fixed	YES	YES	YES	YES	YES
Year fixed	YES	YES	YES	YES	YES
observed value	130.000	60.000	110.000	130.000	170.000
R^2	0.491	0.521	0.628	0.448	0.618

Note: ① ***, ** and * indicate significance levels of 1%, 5% and 10% respectively. ② Standard errors are indicated in parentheses.

3.4. Mediated effects test

In order to further analyze how agricultural new quality productivity affects food security, this paper adopts the mediator effect model, aiming to verify the mediating effect of supply chain industry chain modernization and digital agriculture in this influence mechanism. As is shown in Table 7, where the regression coefficient of agricultural new quality productivity on the level of modernization and construction of industrial chain supply chain is 0.08, the regression coefficient proves to be significantly positive, with the outcomes in Column 2 additionally suggesting that the level of modernization and construction of industrial chain supply chain significantly and positively affects food security. It proves that hypothesis 2 is valid. The results of column (3) in Table 7 show that the regression coefficient of agricultural new quality productivity on digital agriculture development is 0.106 and the coefficient is significantly positive, while the results of column (4) show that digital agriculture development significantly and positively affects food security. It indicates that under the mediating mechanism of digital agriculture, agricultural new quality productivity through the development of digital agriculture, which in turn promotes agricultural new quality productivity, and hypothesis 3 is verified. This is because agricultural new quality productivity strengthens the stability and responsiveness of the food supply chain by improving productivity and quality of products. In addition, the new quality productivity enhances the modernization level of the food supply chain through the application of high-quality workers, high-efficiency labor objects, and high-tech labor materials. Therefore, the construction of supply chains in the rural industrial chain and the digitalization of agriculture are not just from the natural evolution of new-quality productivity, but also a key way to ensure the sustainability of food security.

Table 7. Intermediary effect results

	(1) Macisc	(2) FS	(3) De	(4) FS
ANQP	0.080*** (0.024)	0.581*** (0.054)	0.106*** (0.040)	0.585*** (0.054)
Macisc		0.294** (0.137)		
De				0.183** (0.083)
CONS	-0.110* (0.062)	0.110 (0.138)	0.335*** (0.103)	0.016 (0.140)
Year fixed effects	YES	YES	YES	YES
Province fixed effects	YES	YES	YES	YES
observed value	300.000	300.000	300.000	300.000

Note: ① ***, ** and * indicate significance levels of 1%, 5% and 10% respectively. ② Standard errors are indicated in parentheses.

4. Conclusion

This study uses panel data from 30 provinces from 2013 to 2022 to construct a food security indicator system from the angle of food production and supply, and empirical analysis is used to construct an individual and time bidirectional fixed-effects model and conducts a study on the impact exerted by new-type productive forces in agriculture on food security. The findings validate that: (1) agricultural new quality productivity has a significant positive impact on food security, and passes a variety of robustness endogeneity tests, which to a certain extent illustrates the positive impact that the development of agricultural new quality productivity can have on food security. (2) The heterogeneity test results indicate that in eastern and central China and in major grain-producing areas, the new agricultural productivity has a more significant promoting effect on food security. (3) The results of the mediating effect indicate that the construction of rural industrial chain supply chains and the development of agricultural digitalization conducive to the enabling effect of agricultural new quality productivity on food security. The modernized agricultural industry chain supply chain

provides strong support for food security by boosting the distribution efficiency of farm produce, reducing post-harvest losses, and enhancing the resilience and risk-resistance of the supply chain. At the same time, agricultural digital Informa ionization further enhances food security by improving the precision and intelligence of agricultural production and increasing the adaptability of agriculture to climate change and changes in market demand.

In the future, it will be possible to conduct in-depth research on the behavioral logic and decision-making mechanisms of micro-level agricultural production and operation entities in adopting new productive forces. Additionally, detailed studies can be conducted around regional differences, taking into account the varying effectiveness of policy implementation across different regions.

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