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A Study of the Impact of New Quality Productive Forces on Agricultural Modernization: Empirical Evidence from China

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Abstract: New quality productive forces are the fundamental driving force for the progress of human civilization. To deeply explore the relationship between new quality productive forces and agricultural modernization, data from 30 provinces in China from 2011 to 2022 were selected to construct the index system of new quality productive forces and agricultural modernization, carry out scientific measurement, and conduct empirical analysis using the fixed effect model. The results show that new quality productivity can significantly promote agricultural modernization. The new quality productive force has a significant effect on the modernization of agriculture in the eastern, middle, and western regions of China, but the effect is more prominent in the middle and western areas. New productive forces are significantly and positively associated with agricultural modernization in both main grain-producing and non-main grain-producing areas, but the effect is greater in main grain-producing areas. The upgrading of the agricultural industrial structure plays a mediating effect between new productive forces and agricultural modernization. There is a single-threshold effect of the new productive forces empowering agricultural modernization. Accordingly, to better utilize new productive forces to empower agricultural modernization, we should fully activate the talent engine and cultivate modern "new farmers"; strive to build efficient agriculture by taking scientific and technological innovation as the driving force; and promote the sustainable development of agriculture by taking agricultural green production as the orientation.

Keywords: new quality productive forces; agricultural modernization; upgrading of agricultural industrial structure; scientific and technological innovation; threshold effect

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1. Introduction

Agricultural modernization is the foundation of national modernization [1] and an important guarantee of food security [2]. China is traditionally a large agricultural country with a lack of arable land and water resources, with a per capita arable land area of only 906.67 square meters, less than 40 percent of the world average, and a per capita water resource of only 2100 cubic meters, which is only 28 percent of the world per capita level. Therefore, issues of agriculture, farmers, and rural areas have drawn much attention in China, and the Chinese government has always attached great importance to the development of agriculture and food security [3] and has proposed the goal of agricultural modernization. Productive forces determine relations of production, and all economic and social phenomena are ultimately determined by the development of productive forces [4], so agricultural modernization requires the support of high levels of productive forces. In 2023, China proposed for the first time the new quality productive forces, which originate from the industrial upgrading driven by the technological revolution and are the advanced productive force with a strong driving force and leading the new era. Therefore, the development of new quality productive forces is timely and promising for agricultural modernization.

Compared with traditional productive forces, new productive forces are driven by scientific and technological innovation, free from the crude economic growth pattern of the past, and characterized by high technology, high efficiency, and high quality, making them high-level productive forces [5]. The development of agricultural modernization urgently needs the support of new productive forces, driven by both innovation and reform, eliminating the past inefficient development mode that mainly relied on resource inputs such as water resources, arable land, pesticides, chemical fertilizers, and labor, and adopting high-efficiency, intelligent, and green and sustainable production methods. Digital technology will be used to promote the transformation of traditional agriculture, form a new digital agricultural ecosystem, and effectively improve the total factor productivity of agriculture [6].

Agricultural modernization has become an irreversible global trend and is of immeasurable importance in ensuring national food security and sustainable development. However, the realization of the grand blueprint of agricultural modernization cannot be achieved overnight; it requires time and unremitting efforts. Against this background, the vigorous rise of new productive forces has injected new vitality and hope into the development of agricultural modernization. With its unique advantages and innovative capabilities, the new productive forces have opened up new paths and possibilities for the realization of agricultural modernization. An in-depth investigation of the intrinsic connection between the new productive forces and agricultural modernization is undoubtedly of far-reaching significance for accelerating the process of agricultural modernization and promoting the vigorous development of the agricultural economy. This research can not only provide powerful theoretical support for us to understand the development law of agricultural modernization in a more comprehensive and in-depth way but also provide valuable practical guidance and strategic suggestions for realizing the ambitious goal of agricultural modernization. Therefore, exploring the relationship between new productive forces and agricultural modernization is not only a need for theoretical research but also an urgent call for practical development.

New quality productive forces were proposed by China, essentially referring to high levels of productivity, and existing research has focused on the following three areas. The first is the definition of new quality productive forces. Pu et al. believe that new quality productive forces are a kind of ability to utilize nature and change nature produced under the emerging industry, which is a high-quality productive force [7]. Hu believes that new quality productive forces are the productive forces that can promote the high-quality development of society, which specifically includes new human resources, new production methods, new science and technology, and new industrial forms [8]. New quality productivity is the productive force that can promote economic development with science and technology innovation as endogenous power [9,10]. Secondly, it is about the measurement of new quality productive force. Some scholars have constructed an indicator system to measure the new quality productive forces in China's provinces based on the three main elements of productive forces—laborers, labor resources, and labor objects. Although the first-level indicators are all centered on the three elements of productive force, the specific selection of second-level indicators varies among scholars [11–14]. Based on the understanding of new quality productivity, some scholars take innovation productivity, factor productivity, and digital productivity as the first-level indicators [15]. Some scholars have constructed a comprehensive indicator system for new quality productivity by selecting indicators representing new quality productivity from the micro, meso, and macro levels [16]. Thirdly, it is about the role of new quality productivity. New quality productive forces can shorten the necessary labor time [17], promote the high-quality development of the economy [18], accelerate the integration and upgrading of industries [19,20], contribute to the high-quality development of agriculture [14,21], and promote the Chinese path to modernization [22].

The Chinese government has always attached great importance to the issue of agriculture and has taken a series of measures to promote agricultural and rural development,

proposing during the 14th Five-Year Plan to comprehensively promote the revitalization of the countryside and accelerate the modernization of agriculture and rural areas [3]. Agricultural modernization is not a new concept, and some developed agricultural countries have already accumulated a lot of experience in realizing agricultural modernization, such as the United States, France, Brazil, etc. In recent years, some developing countries have also proposed to realize agricultural modernization in their own countries. Studies on agricultural modernization mainly focus on the following three aspects. First, on the measurement of agricultural modernization. Zhang et al. constructed an indicator system to measure the level of agricultural modernization using three levels: agricultural production capacity, agricultural mechanization level, and grain sown area [23]. Shi et al. constructed an indicator system to measure the efficiency of China's agricultural modernization from three levels: production, operation, and service [1]. Luo et al. constructed an indicator system to measure the level of agricultural modernization in the central provinces of China from the six levels of agricultural input levels, level of agricultural output, agricultural economic efficiency, level of agricultural science and technology, sustainable development of agriculture, and living standards of farmers [24]. Chang and Shi constructed the indicator system from four levels: agricultural input level, agricultural synthetical output level, rural social development level, and agricultural ecological level to measure the agricultural modernization level in China [25]. The second is about the influencing factors of agricultural modernization. Digital Economy [26,27], the accessibility of rural finance [28], the strength of financial support for agriculture [29], the integration of rural industries [30], the level of green development in agriculture [31], and the degree of agricultural mechanization [32], population aging [33–35], the system of rural land [35–37], the level of agricultural technology [38], and other factors all have an impact on the realization of agricultural modernization. Third, it is about the impact of agricultural modernization. Agricultural modernization can improve the quality of agricultural production [39], increase the efficiency of agricultural production [40], improve the income of farmers [41], promote the low-carbon development of agriculture [42,43], and contribute to guaranteeing food security [44]. It also has an impact on the traditional land system [45] and ultimately promotes rural development [46].

After a systematic review of the existing literature, there is a wealth of research on the two areas of new productive forces and agricultural modernization. However, academics have yet to explore in depth the intrinsic links and interaction mechanisms between the new quality productive forces and the modernization of agriculture. The realization of the goal of agricultural modernization depends on the strong support of many aspects. As a representative of advanced productive forces, the new quality productive forces bring new opportunities for the development of agricultural modernization. It is not only a key force to promote the transformation and upgrading of agricultural production methods but also an important engine to lead agricultural modernization to a higher level. Given this, this paper is committed to filling this research gap and deeply analyzing the relationship between new quality productive forces and agricultural modernization. This study not only has important theoretical value, which can provide a new perspective for us to study the development path of agricultural modernization; at the same time, it also has significant practical significance, which can provide useful inspiration and practical suggestions for developing countries in the process of exploring the path of agricultural modernization.

2. Theoretical Analysis and Research Hypotheses

2.1. Analysis of the Meaning of New Quality Productive Forces

New quality productivity is a new concept; it is a type of productive force, using "new quality" as an adjective and thus distinguishing it from traditional productive forces, but still essentially a productive force. In Marx's view, productive force is the ability of human beings to transform nature and utilize it. Therefore, productive force is a kind of ability, not only the ability to manufacture products to meet people's daily needs, but also a profound reflection of the comprehensive ability of human beings to adapt to the natural environment,

effectively utilize natural resources, and transform them to meet their own development needs. Productive force is not static and will continue to progress with the development of science and technology. In this paper, we believe that the new quality productive force is to leap new quality laborers, new quality labor resources, and new quality labor objects and their optimal combination as the basic connotation, to take scientific and technological innovation as the first driving force, to take the strategic emerging industries and future industries as the main carrier, to achieve the high level of dynamic balance between the new supply and the new demand as the goal of action, and ultimately to lead the creation of a new era of powerful productive forces.

2.2. New Quality Productive Forces and Agricultural Modernization

China is a large agricultural country but not an agricultural powerhouse. Since the founding of New China, the Chinese government has attached great importance to agricultural issues and, at this stage, proposes to accelerate the modernization of China's agriculture and rural areas [3]. As China enters a new stage of development, the connotation of agricultural modernization is being further deepened. Agricultural modernization should include at least three levels, one is the leapfrog improvement of agricultural total factor productivity; the second is the upgrading and optimization of agricultural industrial structure; and the third is the realization of sustainable agricultural development. The new quality productive forces and agricultural modernization have a lot in common in terms of connotation, which can contribute to the development of agricultural modernization.

2.2.1. New Quality Workers and Agricultural Modernization

Development depends on people, who are the most active and crucial element of productive forces. The development of new productive forces is helping to transform traditional agricultural workers into high-quality farmers. New quality workers are the key to agricultural modernization. Traditional Chinese farmers have short years of education, a low average literacy level, and generally rely on experience to engage in agricultural production [47]. With the development of urbanization, most young people have gone to the cities to work, and the number of workers engaged in agricultural production has aged seriously, resulting in low agricultural productivity and poor agricultural economic returns [47].

The development of new quality productive forces is expected to alleviate the low quality of labor in current agriculture. On the one hand, technical support will be increased from the stock of farmers, and professional and technical personnel will go to the countryside and combine with the experience of traditional agricultural laborers to improve the scientific literacy of existing farmers. On the other hand, with the further standardization of land transfer, it is conducive to the realization of large-scale operations, changing the original accumulation of weak and low-profit status quo. Attract high-quality talents with professional knowledge and technology to build the countryside, improve the level of human capital of the agricultural labor force, and provide talent support for agricultural modernization [48].

2.2.2. New Quality Labor Resources and Agricultural Modernization

The means of labor is the sum of all material materials used by the laborer to change or influence the object of labor during the labor process. With the development of new quality productive forces, agricultural labor resources have advanced from conventional agricultural inputs to new inputs. In the process of agricultural production, land is an unavoidable input. In the 1.8 billion acres of arable land red line, at the same time, speed up the construction of "high-standard farmland" so that every inch of arable land has become a fertile ground for harvest. Important labor inputs in the agricultural production process include seeds, fertilizers, and pesticides. New quality labor resources refer to the cultivation of high-yield and pest-resistant high-quality varieties through relevant biogenetic technology [49]; the research and development of new types of concentrated

and slow-release fertilizers that can improve the soil ecological environment [50]; and the design of new types of pesticides based on the database of natural products and chemical small molecules, which will provide high-tech support for agricultural production [51]. Through the full application of biogenetic technology, the use of pesticides and fertilizers can be greatly improved, while protecting soil fertility and promoting the sustainable development of arable land. With the development of science and technology, advanced agricultural machinery and equipment, agricultural production tools, and agricultural management systems have also gradually entered the application stage. The development of new quality productive forces prompted people to make full use of digitalization and informatization technology to liberate farmers from the land, greatly improve the efficiency of agricultural production, reduce the cost of agricultural production, and improve the lives of farmers [52].

The new quality labor resources in agriculture are "smart agriculture", which is the application of Internet of Things (IoT) technology to traditional agriculture, which is the advanced stage of agricultural production, combining artificial intelligence, cloud computing, big data, blockchain, and other digital technologies with traditional agricultural production to enhance agricultural productivity [53].

2.2.3. New Quality Labor Objects and Agricultural Modernization

The objects of labor in agriculture are all the things to which labor is added in the process of agricultural production. Labor objects and labor materials will be transformed into each other under certain conditions. For example, seeds can be used as labor material and, at the same time, can also be the object of labor. With the development of science and technology, the object of agricultural labor is also undergoing profound changes, not only in the original object of labor changes but also in the scope of the object of labor is constantly expanding. Traditional agricultural labor objects are land, seeds, crops, water resources, etc. With the development of the new quality productive forces, these kinds of labor objects have also produced qualitative changes.

The scope of agricultural new quality labor objects not only includes the traditional labor objects discussed earlier but also includes intelligent agricultural equipment, drones, agricultural special sensors, agricultural robots, etc. People can remotely control the completion of agricultural production through computers and grasp the relevant growth information of agricultural products in real-time [54]. Relying on digital technology, agricultural production is more intelligent and precise, improving the efficiency and quality of agricultural production [55].

In summary, new quality productive forces provide new quality laborers, new quality labor resources, and new quality labor objects for agricultural modernization, and the combination of these production factors also leaps from traditional farming to new industries and new modes of new industries and new modes of new industries, which promotes the modernization of China's agriculture and helps the construction of a strong agricultural country. Based on the above analysis, this paper puts forward H1.

H1. *New quality productive forces can significantly improve agricultural modernization.*

2.3. New Quality Productive Forces, Agro-Industrial Structure, and Agricultural Modernization

2.3.1. The Driving Effect of New Quality Productive Forces on the Structural Upgrading of the Agricultural Industry

New quality productive forces are based on the basic concepts of workers, labor resources, labor objects, and their optimal combination, which can significantly increase the total factor productivity of agriculture. On the one hand, the new quality labor force enriches agricultural labor resources and objects and no longer relies on a single-factor input but an optimal combination of multiple factors. On the other hand, through technological innovation, the form of input of production factors is transformed from rough to refined

and efficient, which improves the economic efficiency of agriculture and promotes the rationalization of the structure of the agricultural industry [56].

New quality productive forces significantly extend the agricultural industry chain and promote industrial integration. In the information age, consumer demand can be transmitted to the production side as soon as possible, greatly improving the efficiency of information transmission, and the integration of agriculture with manufacturing and service industries is further strengthened [57]. Farmers can be producers, processors of agricultural products, and sellers of rural e-commerce, which promotes the development of the whole agricultural industry chain, increases the added value of agricultural products, and promotes the advanced structure of the agricultural industry.

2.3.2. Promotional Effects of Upgrading the Structure of the Agricultural Industry on Agricultural Modernization

Upgrading the structure of the agricultural industry can significantly increase farmers' disposable income [58]. The use of intelligent equipment frees the rural labor force while promoting the integration of rural industries and providing more employment opportunities for farmers [59]. The upgrading of the agricultural industrial structure extends the agricultural industry chain. On the one hand, farmers can deep process agricultural products and increase the added value of agricultural products. On the other hand, farmers can sell their agricultural products through live e-commerce, increasing farmers' income [26]. Deeply excavating rural tourism resources, combining agriculture with sightseeing and leisure, running farmhouses, selling local specialties, building sightseeing experience bases, etc., to enhance the advanced structure of the agricultural industry and increase the proportion of service industry income in the disposable income of farmers.

The new quality productive forces have promoted industrial integration and upgraded the structure of the agricultural industry. It not only improves farmers' living standards but also increases their capacity for agricultural production and investment, providing strong support for agricultural modernization.

In summary, H2 is proposed based on the relationship between new quality productive forces, upgrading of agricultural industrial structure, and agricultural modernization.

H2. *Agricultural industrial structure upgrading plays a mediating role in the new quality productive forces empowering agricultural modernization.*

Based on the above theoretical analysis, the development of new quality productive forces is closely related to agricultural modernization, and exploring the relationship between the two can more accurately grasp the deep-rooted problems of agricultural modernization and further promote the development of agricultural modernization empowered by new quality productive forces. To further clearly demonstrate the theoretical and logical relationship between the new quality productive forces and agricultural modernization, this paper draws a mechanism map of the relationship between the two, as shown in Figure 1.

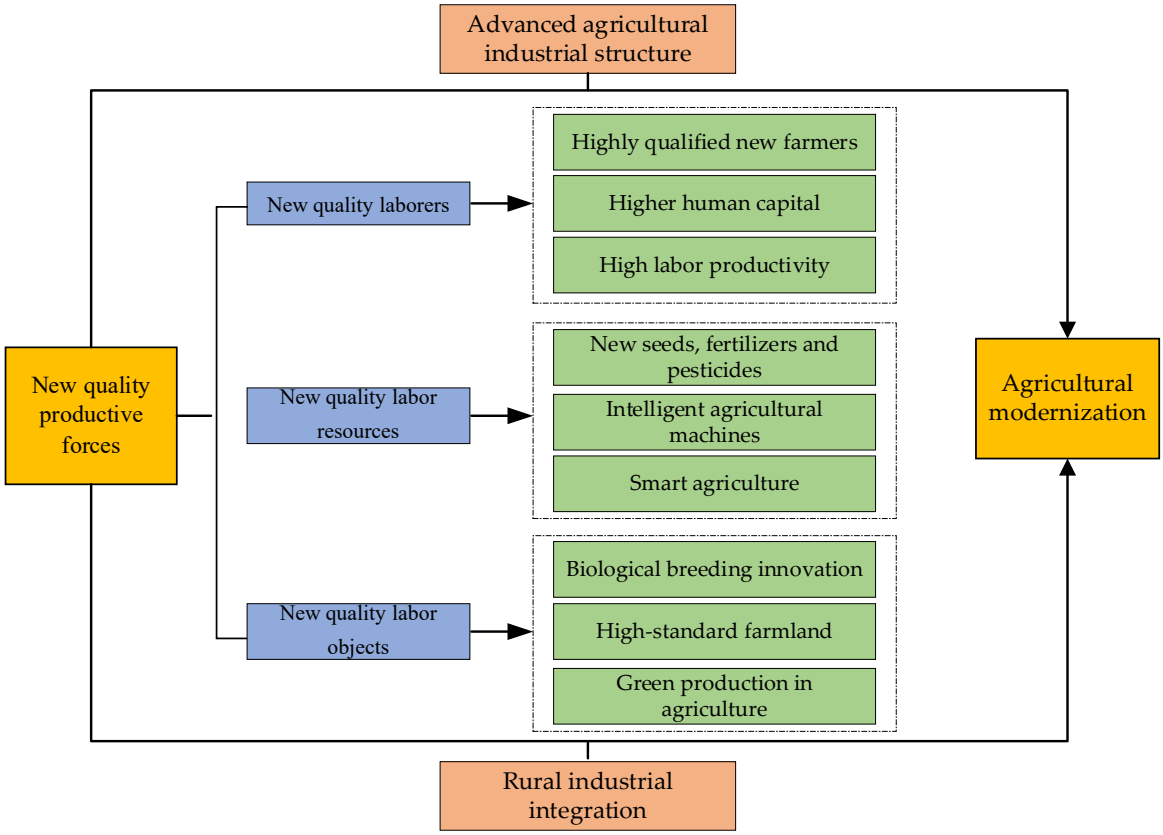

Figure 1. Analysis of the mechanism of new quality productive forces and agricultural modernization.

3. Research Design

3.1. Description of Variables

3.1.1. Core Explanatory Variables

The core explanatory variable of this paper is new quality productive forces, and concerning existing studies [11,13,14], the indicator system is constructed from three levels: new quality laborers, new quality labor objects, and new quality labor resources. See Table 1 for specific indicator explanations.

Table 1. New quality productive forces indicator system.

Level 1 Indicators	Secondary Indicators	Tertiary Indicators	Indicators Nature	Weights
New quality workers	Worker skills	Educational attainment per capita	+	0.0030
		Undergraduate enrollment	+	0.0200
	Labor productivity	GDP per capita	+	0.0245
		Wages per capita (average wage of employed persons in urban units)	+	0.0259
	New human capital inputs and outputs	Science finance expenditure (CNY ten hundred million)	+	0.0632
		Fiscal Expenditure on Education (CNY ten hundred million)	+	0.0267
		Number of R&D personnel (Full-time equivalent of R&D personnel)	+	0.0604

Table 1. *Cont.*

Level 1 Indicators	Secondary Indicators	Tertiary Indicators	Indicators Nature	Weights
New quality labor resources	Digital industrialization	Total telecommunication business (CNY ten hundred million)	+	0.0729
		Revenue from software operations (CNY ten hundred million)	+	0.1106
		Employment in urban units of the information transmission, software, and information technology services industry (ten thousand people)	+	0.0666
	Industrial Digitization	E-commerce purchases and sales (CNY ten hundred million)	+	0.0872
		Internet penetration (%)	+	0.0135
		Digital Economy Index	+	0.0177
	Level of science, technology, and innovation	Patents per capita	+	0.0651
		R&D investment (CNY ten thousand)	+	0.0718
		Number of robots/total population	+	0.0955
New quality labor objects	Green	Forest cover (%)	+	0.0230
		Strength of environmental protection (environmental protection expenditure/General fiscal expenditure)	+	0.0971
		Investment in pollution treatment (CNY ten thousand)	+	0.0442
	Pollutant emissions	Waste production/GDP	−	0.0011
		Wastewater discharge/GDP	−	0.0073
		Sulfur dioxide in exhaust gas/GDP	−	0.0026

Note: "+" in Table 1 means that the larger the indicator, the higher the level of new quality productive forces will be, known as a positive indicator; "−" in the table means that the smaller the indicator, the higher the level of new quality productive forces will be, known as a negative indicator.

3.1.2. Explained Variables

The explanatory variable in this paper is agricultural modernization. Based on the understanding of agricultural modernization, the index system is constructed from the three levels of agricultural production efficiency, agricultural scale operation, and agricultural green development, and the detailed index system is shown in Table 2.

In this paper, the entropy method is used to provide a comprehensive measure of new quality productive forces and agricultural modernization. The specific methods are as follows. First, we standardize the indicators, in which the positive and negative indicators are specified as follows.

$$X'_{ij} = \frac{X_{ij} - \min\{X_j\}}{\max\{X_j\} - \min\{X_j\}} \quad (1)$$

$$X'_{ij} = \frac{\max\{X_j\} - X_{ij}}{\max\{X_j\} - \min\{X_j\}} \quad (2)$$

Where X_{ij} is the original data, i is the region, j is the indicator, X'_{ij} is the result of standardization, $\min\{X_j\}$ is the minimum value of the indicator j, and $\max\{X_j\}$ is the maximum value of the indicator j.

Next, we calculate the weight of the i sample in the indicator j, $P_{ij} = \frac{X'_{ij}}{\sum_{i=1}^{n} X'_{ij}}$ where n is the number of samples.

Next, calculate the information entropy of the indicator j, $e_j = -k\sum_{i=1}^{n}(P_{ij} \times \ln P_{ij})$, where $k = \frac{1}{\ln n}$.

Then, calculate the information entropy redundancy, $d_j = 1 - e_j$. Calculate the weight of each indicator, $W_j = \frac{d_j}{\sum_{j=1}^{m} d_j}$, where m is the number of indicators j.

Finally, calculate the score, $S_i = \sum_{j=1}^{m} W_j \times X'_{ij}$.

Table 2. Indicator system for agricultural modernization.

Level 1 Indicators	Secondary Indicators	Description of Indicators	Indicators Nature	Weights
Agricultural productivity	Growth rate of gross agricultural output	Value added in agriculture in the current year/Gross value of agricultural output in the previous year	+	0.0382
	Land productivity	Grain production/Area sown with grain	+	0.0707
	Labor productivity	Value added of agriculture, forestry, and fisheries/Employment in urban units of agriculture, forestry, and fisheries	+	0.4906
Scale operation of agriculture	The growth rate of land transfers	Area of family-contracted arable land transferred/Area of family-contracted arable land transferred in the previous year	+	0.0196
	Intensity of agricultural mechanization	Gross power of agricultural machinery	+	0.2872
Greening of agriculture	Water use per unit area in agriculture	Total water use in agriculture/Area sown with crops	−	0.0221
	Fertilizer application intensity	Fertilizer application/Crop sown area	−	0.0487
	Pesticide application intensity	Pesticide application/area sown to crops	−	0.0229

Note: "+" in Table 2 means that the larger the indicator, the higher the level of agricultural modernization will be, which is called a positive indicator; "−" in the table means that the smaller the indicator, the higher the level of agricultural modernization will be, which is called a negative indicator.

3.1.3. Control Variables

In addition to the core explanatory variable of new quality productive forces, there are many other factors affecting agricultural modernization. Given that urbanization, agricultural disaster situation, rural residents' living conditions, agricultural-related factor inputs, and financial support all have an impact on agricultural modernization, this paper selects urbanization (Czh), crop disaster rate (Cpd), Engel's coefficient (Ec), the use rate of agricultural plastic film (Pau), and the share of agricultural financial expenditure (Fea) as control variables, as shown in Table 3.

Table 3. Summary of indicators.

Variable	Variable Name and Code	Description of Variables
Dependent variable	Agricultural modernization (AM)	Measured by the indicator system
Explanatory variable	New quality productive forces (NAP)	Measured by the indicator system
Mediating Variables	Rural Industrial Integration (DV)	Calculated from the indicator system
	Advanced structure of the agricultural industry (Uai)	Agriculture, forestry, animal husbandry, and fishery services/Total agricultural output

Table 3. *Cont.*

Variable	Variable Name and Code	Description of Variables
Control variables	Urbanization (Czh)	Urban population/Area resident population
	Crop damage rate (Cpd)	Area affected/Area sown with crops
	Engel coefficient (Ec)	Expenditure on food/Total consumption expenditure in rural households
	Agricultural plastic film utilization rate (Pau)	Agricultural plastic film/Total sown area of crops
	Share of fiscal expenditure on agriculture (Fea)	Agricultural and forestry fiscal expenditures/Local general fiscal expenditures

3.1.4. Mediating Variables

To explore the path of agricultural modernization empowered by new quality productive forces, agricultural industrial structure upgrading is selected as a mediating variable. In this paper, two indicators, rural industrial integration and the advanced agricultural industrial structure, are selected to measure agricultural industrial structure upgrading, and the rural industrial integration index is measured by the index system. Regarding the advanced industrial structure, referring to Zhao et al. who used the ratio of the output value of the tertiary industry to the output value of the secondary industry to measure and apply it to the field of agriculture [60], this paper adopts the ratio of the output value of agriculture, forestry, animal husbandry, and fishery services to the total output value of agriculture to measure the advanced agricultural industry.

3.2. Data Source

The indicator system of new quality productive forces and agricultural modernization contains 30 indicators. To ensure the continuity and availability of the research data in this paper, 30 provinces in China were selected as the research sample from 2011 to 2022, and due to the large amount of missing data of Tibet in China, they are not taken into account for the time being, and at the same time, Hong Kong, Macao, and Taiwan are excluded from the study. The data for the indicator system of new quality productive forces mainly come from the China Statistical Yearbook, the data for the indicator system of agricultural modernization mainly come from the China Rural Statistical Yearbook, and the data for the remaining indicators come from the publicly available information of the National Bureau of Statistics of China. For some of the missing data, linear interpolation is used to fill in the blanks. The research data of this paper are China's provincial-level panel data with 360 observations. The empirical analysis of this paper is performed with the help of Stata 16.0 software.

3.3. Model Setting

Based on the theoretical analysis and research hypotheses, this paper uses panel data to analyze the impact of new quality productive forces on agricultural modernization with the following model.

$$AM_{it} = \alpha_0 + \alpha_1 NAP_{it} + \alpha_2 Controls_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (3)$$

In Equation (3), AM is the explanatory variable, which is the level of agricultural modernization in each province of China, NAP is the core explanatory variable, which is the level of new quality productive forces in each province of China, and $Controls$ is a series of control variables. i is the region, t is time, μ_i is the region-fixed effect, δ_t is the time-fixed effect, and ε_{it} is the random disturbance term.

To further explore the mechanism of agricultural modernization empowered by new quality productive forces, drawing on the research of Wen, this paper constructs a mediating effect model [61].

$$M_{it} = \alpha_0 + \alpha_1 NAP_{it} + \alpha_2 Controls + \mu_i + \delta_t + \varepsilon_{it} \quad (4)$$

$$AM_{it} = \alpha_0 + \alpha_1 NAP_{it} + \alpha_2 Controls + \alpha_3 M_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (5)$$

In Equations (4) and (5), M_{it} is a series of mediating variables, and the meaning of the rest of the variables is the same as in Equation (3).

3.4. Descriptive Statistical Analysis

The descriptive statistical analysis of the research variables in this paper is shown in Table 4. The mean value of agricultural modernization water is 0.2625, indicating that China's overall agricultural development needs to be improved. The difference between the maximum value and the minimum value is large, indicating that the level of agricultural development is not balanced between regions in China. The mean value of the new quality productive forces is 0.1355; the same maximum and minimum values have a large difference, and the development between regions is not balanced. The variance of all variables is smaller than the mean value, indicating high data stability.

Table 4. Results of descriptive statistics.

Variables	N	Mean	SD	Min	Max
AM	360	0.2625	0.1231	0.0942	0.8561
NAP	360	0.1355	0.1082	0.0138	0.6883
Czh	360	0.6011	0.1205	0.3504	0.8958
Cpd	360	0.1409	0.1160	0.0000	0.6959
Ec	360	33.4694	5.2211	23.8000	49.1000
Pau	360	0.0020	0.0015	0.0004	0.0087
Fea	360	0.1135	0.0334	0.0404	0.2038

4. Empirical Results and Analysis

4.1. Baseline Regression Results

According to the regression model set in the previous section, the regression analysis of new quality productive forces and agricultural modernization was carried out, and random effects and two-way fixed effects were used for the benchmark regression, respectively, and the Hausman test was carried out, which concluded that the two-way fixed effects were more in line with the actual situation, as shown in Table 5. Through the empirical test, the new quality productive force can significantly enhance agricultural modernization; regardless of whether the control variables are added, the positive promotion effect of the new quality productive forces on agricultural modernization is significant at the 1% level. With the development of new quality productive forces, the productivity of agricultural workers is improved. Through the introduction of advanced labor tools, agricultural production is promoted to intelligent development, and agricultural production costs are reduced. High-quality crop varieties are cultivated, new types of pesticides and fertilizers are used, and arable land is protected while yields are enhanced to promote sustainable development. The multifaceted value of agriculture is explored in depth to promote the upgrading of the agricultural industry, and the overall efficiency of the agricultural and rural areas is enhanced so that the fruits of reform and development can be shared by farmers.

Table 5. Benchmark regression results: new qualitative productive forces empowering agricultural modernization.

Variable	Random Effects		Bidirectional Fixed Effect	
	AM	*AM*	*AM*	*AM*
NAP	0.3507 ***	0.5472 ***	0.1765 ***	0.3200 ***
	(4.75)	(6.30)	(3.17)	(6.27)
Czh		−0.5986 ***		0.9396 ***
		(−8.70)		(7.19)
Cpd		−0.2510 ***		−0.0033
		(−5.91)		(−0.20)
Ec		−0.0076 ***		0.0011
		(−6.91)		(0.92)
Pau		−15.5591 ***		−13.5089 ***
		(−4.49)		(−3.03)
Fea		−0.5508 ***		−0.2065
		(−3.24)		(−1.29)
Control variable	NO	YES	NO	YES
Province FE	NO	NO	YES	YES
Year FE	NO	NO	YES	YES
Constant	0.2150 ***	0.9324 ***	0.0236	−0.7021 ***
	(26.00)	(10.89)	(1.03)	(−5.05)
Observation	360	360	360	360
R^2	0.0951	0.4273	0.9147	0.9280

Notes: *** denotes 1% significance level, t-statistics in parentheses.

Regarding the control variables, the level of urbanization significantly and positively enhances agricultural modernization at the 1% level. The promotion of urbanization can accelerate the upgrading of the agricultural industry and attract more capital, talent, and technical elements to help rural construction. Population transfer to cities in the process of urbanization accelerates the transfer of rural land, promotes the large-scale operation of agriculture, improves quality and efficiency, and promotes agricultural modernization. The degree of agricultural plastic film use is negatively correlated with agricultural modernization at the 1% level. There have been mixed reviews about the use of plastic films, and although agricultural plastic films play an important role in protecting plants from water loss and blocking cold air, wind, rain, and pests, they also have many disadvantages [62]. Firstly, the purchase of agricultural plastic films raises the cost of agricultural production, and they have a limited service life and have to be replaced frequently. Secondly, it will produce serious environmental pollution because plastic film is not easy to degrade, releasing toxic and harmful substances, and the residual film is discarded in the field, affecting the rural habitat [63]. Finally, the long-term use of plastic film is detrimental to the soil ecosystem, leading to a decline in the quality of arable land and ultimately affecting the quality of agricultural products [64].

4.2. Mediation Effects

To further explore the relationship between new quality productive forces and agricultural modernization and to test the mediating effect of agricultural industrial structure upgrading, regression analyses of new quality productive forces with rural industrial integration and agricultural industrial structure advancement are carried out separately, and the results are shown in Table 6. Regardless of whether control variables are added,

the coefficients of the core explanatory variables of new quality productive forces on rural industrial integration and agricultural industrial structure advancement are all significantly positive and passed the significance level test. Meanwhile, the coefficients of the core explanatory variables on rural industrial integration and agricultural industrial structure upgrading are all significantly positive and pass the significance level test, so that agricultural industrial structure upgrading is an important transmission mechanism of new quality productive forces to enhance agricultural modernization, and the research H2 has been verified. New quality productive forces bring new scientific and technological achievements, production tools, and production methods to agriculture, promote the scale, greening, and informatization of agricultural production, and promote the optimization and upgrading of the structure of the agricultural industry, thus providing new impetus and support for agricultural modernization.

Table 6. Results of the mechanism of action tests.

Variables	DV	AM	Uai	AM
NAP	0.1411 **	0.2926 ***	0.0548 ***	0.2776 ***
	(2.42)	(5.75)	(4.28)	(5.66)
DV		0.1939 **		
		(2.12)		
Uai				0.7739 ***
				(3.68)
Control variable	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Constant	−0.1859	−0.6661 ***	−0.0026	−0.7001 ***
	(−1.64)	(−4.76)	(−0.07)	(−5.14)
Observation	360	360	360	360
R^2	0.8881	0.9294	0.8634	0.9302

Notes: ***, ** denote 1% and 5% significance levels, respectively; t-statistics in parentheses.

4.3. Heterogeneity Analysis

Agricultural development is characterized by obvious heterogeneity due to the different agricultural resource endowments in each region and the variability of various factors such as socio-economic conditions, historical and cultural backgrounds, and policy support. Then whether there is heterogeneity in the impact of new quality productive forces on agricultural modernization is a question worth discussing. Therefore, this paper firstly divides the sample into three parts according to geographic location, East, Central, and West, and carries out regression analysis, respectively, and the detailed results are shown in Table 7. The regression results of the three economic zones show that the new quality productive forces can significantly promote agricultural modernization in all of them, and the impact coefficients of the eastern region and the central region are significant at the 1% level, and the impact coefficients of the western region are significant at the 10% level. According to the empirical results, it can be found that the promotion effect of new quality productive forces on agricultural modernization is more prominent in the central and western regions. The possible reason is that there is a gap between the economic development level of the central and western areas and the eastern areas, and the new quality productive forces bring new technologies, new production materials, and new production methods to improve the weak agricultural production infrastructure, thus exerting a catching-up effect, so the regression coefficient is larger than that of the eastern region. Therefore, the

development of new quality productive forces is expected to narrow the development gap between the east and the west of China's agriculture.

Table 7. Heterogeneity analysis.

Variable	East	Central	West	Major Grain-Producing Areas	Non-Grain Producing Areas
	AM	*AM*	*AM*	*AM*	*AM*
NAP	0.2348 ***	0.9560 ***	0.9764 *	0.6346 ***	0.2404 ***
	(3.89)	(3.27)	(1.88)	(4.41)	(3.54)
Control variable	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Constant	−0.6833 **	−0.3275	−0.3215 *	−0.1575	−0.5225 ***
	(−2.31)	(−0.91)	(−1.68)	(−0.73)	(−2.99)
Observation	132	96	132	156	204
R^2	0.9471	0.9473	0.8437	0.9399	0.8499

Notes: ***, **, * denote 1%, 5%, and 10% significance levels, respectively; t-statistics are in parentheses.

Since agriculture is the basis of food security, the sample was divided into grain-producing and non-grain-producing regions and analyzed empirically. According to the regression results, the new quality productive forces have a significant contribution to agricultural modernization in both main grain-producing and non-main grain-producing areas, and the contribution is more prominent in the main grain-producing areas, probably because the main grain-producing areas bear a great social responsibility for guaranteeing food security, and are better able to integrate science and technology innovations with traditional agriculture, thus contributing to agricultural modernization.

4.4. Robustness Tests

Although the empirical results in the previous section have confirmed that the new quality productive forces help agricultural modernization, to ensure the robustness of the research results, a series of robustness tests was performed, including shrinking the sample data and replacing the core explanatory variables and the explanatory variables, and the specific test results are shown in Table 8. First, to prevent the impact of sample outliers on the regression results, the shrinking treatment is carried out at 1%; second, agricultural modernization is mainly reflected in the increase of agricultural output value and the improvement of farmers' lives, so the total agricultural output value (Agdp) and the disposable income of rural residents (Dir) are selected as the proxy variables for agricultural modernization; third, the new quality productive forces mainly lie in scientific and technological innovation, so the number of patents per capita (PPC) and the input of R&D expenditure are replaced with the core explanatory variables. Through the three robustness tests, the conclusion that new productive forces promote agricultural modernization is still valid, indicating that the study's conclusions are more robust.

Table 8. Robustness test.

Variable	Shrinkage Treatment	Substitution of the Dependent Variable		Replacement of Explanatory Variable	
	AM	ln *Agdp*	ln *Dir*	*AM*	*AM*
NAP	0.3040 ***	4.5019 ***	0.0634 **		
	(5.68)	(8.02)	(2.44)		
PPC				13.3962 ***	
				(3.20)	
ln *R&D*					0.0337 ***
					(2.88)
Control variable	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Constant	−0.6398 ***	11.4723 ***	8.8225 ***	−0.6672 ***	−0.6518 ***
	(−4.97)	(18.63)	(100.37)	(−4.59)	(−3.92)
Observation	360	360	360	360	360
R^2	0.9344	0.5519	0.9985	0.9235	0.9226

Notes: ***, ** denote 1% and 5% significance levels, respectively; t-statistics in parentheses.

4.5. Endogeneity Test

Generally speaking, regions with modernized agriculture have a low economic level, more capital investment in science and technology innovation, and better development of new quality productive forces, so there may be a mutual causal relationship between new quality productive forces and agricultural modernization. The instrumental variable method is chosen to solve the endogeneity problem, drawing on Huang et al.'s use of the number of landline telephones and the number of post offices in 1984 as instrumental variables for new quality productive forces [65]. On the one hand, the development of China's new quality productive forces cannot be separated from the progress of information technology such as the Internet, and the rapid development of new communication technology cannot be separated from the accumulation of infrastructure such as telephones and post offices in the early period, which is in line with the principle of correlation. On the other hand, the modernization of agriculture in different parts of China has little correlation with the traditional telecommunication facilities such as telephones and post offices in 1984, which is in line with the principle of exogenousness. In this paper, for a provincial-level balanced panel, we draw on Nunn and Qian to introduce a variable that accompanies time-varying construction of panel data [66] and thus form interaction terms between the number of fixed-line telephones per 100 people and the number of post offices per million people in 1984 and the number of Internet broadband access ports in the region in the previous year as instrumental variables for the region's new qualitative productive forces, specifically. The detailed results of the two-stage least squares (2SLS) for the instrumental variables are shown in Table 9. According to the second-stage regression results, the promotional effect of new qualitative productive forces on agricultural modernization still holds significantly after considering the existence of endogeneity. According to the results of the Kleibergen–Paap rk LM statistic, the original hypothesis is rejected and there is no under-identification of instrumental variables; the Kleibergen–Paap Wald rk F statistic is greater than the critical value at the 10% level of the weak identification test, which indicates that there are no weak instrumental variables, so that the instrumental variables selected in this paper have rationality and scientific validity.

Table 9. Results of endogeneity analysis.

Variable	2SLS	
	(1)	**(2)**
	NAP	AM
NAP		0.1560 **
		(2.01)
$IV1$	0.1484 ***	
	(4.74)	
$IV2$	−0.0004 ***	
	(−4.01)	
Control variable	YES	YES
Province FE	YES	YES
Year FE	YES	YES
Kleibergen–Paap rk LM statistic	16.69	
	0.0002	
Kleibergen–Paap Wald rk F statistic	44.43	
	{19.93}	
Observation	360	360
R^2	0.5629	0.5627

Notes: ***, ** denote 1% and 5% significance levels, respectively; t-statistics in parentheses.

4.6. Further Analysis

The preceding analysis is based on the linear relationship between the role of new quality productive forces on agricultural modernization. However, from a realistic point of view, the development of new quality productive forces requires inputs and support from many parties, and the process of quantitative change must experience a pain period, so it is necessary to explore the non-linear relationship between new quality productive forces and agricultural modernization. Therefore, this paper adopts the panel threshold effect model to test whether there is a nonlinear relationship. First of all, through the bootstrap method of new quality productive forces level as a threshold variable for repeated sampling 500 times to test the threshold effect, the specific results are shown in Table 10. According to the results, there is a single threshold of new quality productive forces; there is no double threshold or triple threshold; the threshold value is 0.1607.

Table 10. Results of the threshold effect test for new quality productivity.

Number of Thresholds	F-Value	*p*-Value	10% Threshold Level	5% Threshold Level	1% Threshold Level
Single threshold	26.5800	0.0300	20.3069	24.1991	30.9043
Dual threshold	10.0300	0.3720	17.0009	19.9187	27.0302
Triple threshold	3.9500	0.8500	14.7814	17.8867	30.8637

Based on the results of the threshold effect test, a single-threshold effect model of new quality productive forces on agricultural modernization is established.

$$AM_{it} = \varphi_0 + \varphi_1 NAP_{it} I(NAP \leq \xi) + \varphi_2 NAP_{it} I(NAP > \xi) + \varphi_3 Controls_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (6)$$

AM is agricultural modernization, where φ_1 and φ_2 are the parameters to be estimated. $I(\cdot)$ is a schematic function that takes the value of 1 when the condition in parentheses is satisfied, and 0 otherwise. *Controls* is a set of control variables, the same as in the previous Equation (3). μ_i is a set of area fixed effects, δ_t is a set of time fixed effects, and ε_{it} is a random perturbation term.

Using Stata16.0 software, the results of parameter estimation under the condition of new quality productive forces as a threshold were obtained and are shown in Table 11. When the new quality productive forces are less than 0.1607, its coefficient of influence on the modernization of agriculture is negative but does not pass the significance test. When the new quality productivity develops further and crosses 0.1607, its impact coefficient on high agricultural modernization turns positive and passes the 1% significance test. Thus, it can be concluded that the driving effect of the new quality productive forces on agricultural modernization is not monotonically increasing but a non-linear relationship, and there is an inflection point, that is, the development of the new quality productive forces to a certain stage before it can significantly empower the modernization of agriculture. The possible reason is that the new quality productive forces to innovation as a source of development, the early need to invest a lot of money, manpower, material resources, and so on, and the return on investment are uncertain, only when the development of scientific and technological innovation to a certain extent shows the promotion of new quality productive forces to promote the role of agricultural modernization.

Table 11. Threshold model parameter estimates.

Variable	NAP ≤ 0.1607	NAP > 0.1607	Czh	Cpd	Ec	Pau	Fea	Constant
Ratio	−0.0693	0.1861 ***	0.7696 ***	−0.0055	0.0021 **	−16.8585 ***	−0.2872	−0.2115 **
T-value	−0.7	2.84	6.39	−0.30	2.25	−4.03	−1.42	−2.22

Notes: ***, ** denote 1% and 5% significance levels, respectively; t-statistics in parentheses.

5. Conclusions and Policy Recommendations

5.1. Conclusions

Starting from the analysis of the connotation of new quality productive forces, the paper theoretically analyzes the impact of new quality laborers, new quality labor resources, and new quality labor objects on agricultural modernization, constructs the index system of new quality productive forces and agricultural modernization, measures them separately, and empirically examines the relationship between the two by selecting the provincial panel data from 2011–2022, and draws the following conclusions. First, using the double fixed effects model, the empirical results show that new quality productive forces have a significant positive effect on agricultural modernization, and after a series of robustness tests and endogeneity tests using instrumental variables, the conclusion still holds. Secondly, the heterogeneity analysis of the three economic zones, the main grain-producing areas, and the non-grain-producing areas shows that the new quality productive forces have a significant effect on agricultural modernization in the eastern, central, and western regions, but the effect on the central and western areas is more obvious; the new quality productive forces have a positive effect on agricultural modernization in both the main grain-producing areas and the non-grain-producing areas, but the positive effect on the main grain-producing areas is more prominent. Third, through the threshold effect model, it is found that there is a single-threshold effect of new quality productive forces on agricultural modernization; only when the new quality productive forces have developed to a certain stage can they significantly and positively affect agricultural modernization. Fourth, taking the upgrading of the agricultural industrial structure as a mediating variable, the test finds that the development of new quality productive forces is conducive to the improvement of the agricultural industrial structure, thus promoting agricultural modernization.

This paper provides an in-depth analysis of the theoretical logic and path of how new quality productive forces can empower agricultural modernization, enriches the research content of the intersection of new quality productive forces and agricultural modernization, and effectively fills the gaps in the current literature on this topic. The conclusion of the study points out that the development of new quality productive forces should be actively promoted as a gas pedal to promote the transformation and upgrading of agricultural production methods and then build a highly efficient and modern agricultural industrial system. Accordingly, the research results of this paper provide solid theoretical support and guidance for the relevant departments in the formulation of policies to promote the process of agricultural modernization.

5.2. Policy Recommendations

Based on the findings of the study, the following countermeasures are proposed to empower agricultural modernization with new productive forces.

First, activate the talent engine and cultivate modern "new farmers" through the establishment of special agricultural talent training programs and the use of live online classrooms combined with offline training to improve the professional skills and comprehensive quality of agricultural workers. Introduce and cultivate agricultural scientific and technological talents, further improve the talent introduction program, increase incentives for professionals, and form a high-level agricultural scientific and technological talent team. Enhance workers' awareness of innovation; innovation is the first power to lead development. Encourage workers to actively participate in the practice of agricultural innovation and enhance awareness of innovation and innovation ability.

Secondly, take scientific and technological innovation as the driving force and strive to create efficient agriculture. Grasp science and technology to strengthen agriculture, focus on overcoming difficulties in biological breeding, intelligent agricultural machinery and equipment, digital agriculture, new pesticides, and fertilizers, adhere to the plan to promote the revitalization of the seed industry, increase investment in agricultural research, strengthen cooperation between schools and enterprises, and accelerate the landing of agricultural scientific and technological achievements, to make scientific and technological innovation become a powerful driving force to promote agricultural modernization. Grasp machinery to strengthen agriculture, develop appropriate and efficient agricultural machinery according to China's different terrains and other natural conditions, and improve the mechanization level of agricultural production. Strengthen the construction of agricultural informatization, promote the development of agricultural informatization and intelligence, optimize the allocation of agricultural resources, improve the efficiency of agricultural resource utilization, and enhance agricultural competitiveness.

Thirdly, take agricultural green production as the guide to promote the sustainable development of agriculture. New quality productive forces are green productive forces that make full use of agricultural science and technology, enhance the use of high-quality seeds, promote the use of new fertilizers and pesticides, and protect arable land resources. Improve agricultural water conservancy facilities, precise irrigation, and save water resources. Properly handle agricultural waste, promote straw fertilizer and energy, centralize the treatment of agricultural waste plastic film, and actively research and develop environmentally friendly plastic film. Combined with the actual situation of the region, actively develop green organic agriculture, the production of high-quality agricultural products, and at the same time the development of leisure and tourism agriculture to promote farmers to increase income, agriculture quality, and efficiency.

This paper has some limitations in the study. For example, the development of new quality productive forces shows significant variability among major cities, and the same is true for agricultural modernization. However, the discussion in this paper is mainly based on the provincial level in China, and future research can be further refined by taking prefecture-level cities in China as the research samples to obtain more precise research conclusions. In terms of research methodology, this paper quantitatively measures new

quality productivity and agricultural modernization by constructing an indicator system. Future research can explore the use of field research, in-depth interviews, and other ways to collect first-hand information. On this basis, the indicator measurement method should be further innovated to continuously enrich and improve the research methodology in the fields of new quality productivity and agricultural modernization and to open up new paths for in-depth research in related fields.

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