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Subsidies and farming: A microempirical analysis of financial allocation to promote agricultural production

Congxian He[1,2]*, *Lulu Yu*[1,3], *Huwei Wen*[4]

[1]*Soviet Area Revitalization Institute, Jiangxi Normal University, Nanchang, P.R. China*
[2]*Research Base for Revitalization and Development of Old Revolutionary Base Areas of Jiangxi Province, Jiangxi Normal University, Nanchang, P.R. China*
[3]*School of Marxism, Jiangxi Normal University, Nanchang, P.R. China*
[4]*School of Economics and Management, Nanchang University, Nanchang, P.R. China*

**Corresponding author: 005693@jxnu.edu.cn*

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Abstract: Agriculture's stable development is vital to the national economy, and its vulnerability justifies fiscal support. On the basis of data from the China Family Panel Studies from 2012 to 2022, this study examines how fiscal allocation affects agricultural production, particularly rural households' grain-growing enthusiasm and their productive income. Results show that public expenditure significantly boosts agricultural production, supported by ordered probit and ordinary least squares fixed effect models and confirmed in robustness tests. Mechanistic tests indicate that agricultural public expenditure promotes agricultural production by improving agricultural technical levels, enhancing production services, and expanding the agricultural scale. Heterogeneity analysis shows that agricultural public expenditure has a stronger effect on grain-growing enthusiasm among low-educated rural households and on productive income in major grain production areas. It also has a stronger effect on productive income for rural households with emerging and prime-aged farmers, in nonmajor grain production areas, and those with high educational attainment. The research offers empirical insights for exploring ways to achieve the 'dual goals' of food security and poverty alleviation.

Keywords: agricultural production; fiscal allocation; food security; rural household

Agricultural sustainability is vital for food security and poverty reduction. The Food and Agriculture Organisation highlights its key role in both areas. As mentioned by FAO (2023), small-scale producers earn significantly less than large-scale ones, and global hunger continues to rise.

Agricultural public expenditure is a crucial policy tool that boosts agricultural production, encourages rural households' enthusiasm for growing crops, and increases productive income, thereby supporting food security and rural poverty reduction.

Scholars have extensively studied the scale and effectiveness of agricultural public expenditure, enriching its theoretical foundations. In terms of scale, Barro (1990) posited that optimal allocation occurs when the marginal productivity of government spending equals one, thereby maximising agricultural output, reducing the urban–rural income gap (Tang and Sun 2022), and delivering positive incentives (Deng et al. 2023). Regarding effectiveness, empirical evidence shows a strong, growing link between agricultural public expenditure and economic growth across development stages (He et al. 2024).

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When directed toward rural infrastructure and industrialisation, such expenditures improve living and production conditions, generate employment, and expand rural income sources (Fu et al. 2024).

Agricultural production depends on modernisation, institutions, and finance. Technology boosts output and incomes: artificial intelligence improves irrigation (Shaikh et al. 2022) and pest detection (Misra et al. 2020), thereby increasing yields and sustainability (Ahmad et al. 2024). Land reform, contract farming, and cooperatives also raise rural incomes. China's 'three rights separation' expands investment, credit, and off-farm jobs, which boost income (Wen et al. 2025). In Pakistan, contract farming improves land quality, productivity, and jobs (Schaub et al. 2023). Cooperatives increase output and sustainability (Zhong et al. 2023). Targeted insurance reduces disaster risks and supports rural incomes (Fang et al. 2021). Digital finance delivers funds to farmers, thereby raising investment, production, and income (Fu et al. 2024).

Fiscal allocation boosts agricultural production through policy incentives and guidance. Schultz stressed that prudent fiscal policies can effectively raise rural incomes (Loužek 2022). Agricultural subsidies offer limited incentives (Chen et al. 2024b), whereas broader public expenditure drives rural industry integration, value chain extension, added value, short-term output, and lower transaction costs (Wang et al. 2024). Governments should expand secondary and tertiary sectors in agriculture to further increase incomes (Wang and Li 2024). Transfer payments support this by funding ecological governance, improving environmental productivity, and raising yields and rural households' incomes (Piñeiro et al. 2020).

The key contributions of this study are as follows:

i) This study focuses on agricultural production, highlighting rural households' motivation for grain farming and their productive income. Prior research has linked fiscal distribution to overall rural income (Tang et al. 2024; Wang et al. 2024). Conversely, this work examines its influence on agricultural productive income. By connecting fiscal design to farming motivation and output returns, it offers a unified approach to improving food security and reducing poverty.

ii) This study advances research on the longitudinal compensatory effect of fiscal support in agriculture and broadens agricultural economics theory. Prior work (Gu et al. 2024) has identified farm scale, technology, and credit as mediators. By contrast, this study shows how public expenditure enhances rural households' motivation for grain farming and productive income through investment enhancement (Vasavaada and Champs 1986), thereby clarifying fiscal support's role in agricultural production.

iii) This study analyses how different rural households respond to agricultural public expenditures, complementing prior research (Wang et al. 2022; Gu et al. 2024), and provides evidence for more precise household assessments and targeted policy design.

This study uses China Family Panel Studies (CFPS) data from 2012 to 2022 to construct an ordered probit (Oprobit) and a two-way fixed-effects ordinary least squares (OLS) model, empirically analysing the effect of fiscal allocation on agricultural production. On the basis of endogenous growth theory (Kopf 2007), agricultural investment theory (Vasavaada and Champs 1986), and economies of scale theory (Stigler 1958), the study tests underlying mechanisms. It also examines how agricultural public expenditure affects production across regions and among rural households differing in age and education level. Figure 1 shows the

Background. Food security is central to national strategies (Henderson and Ziadah 2023). Despite China's economic growth, urban–rural income gaps and low rural incomes remain major challenges. As shown in Figure 2, from 2014 to 2023, GDP grew at an average of 5.92% annually. Urban incomes rose from USD 4 700 to USD 7 565, whereas rural incomes increased from USD 1 707 USD to USD 3 078, widening the gap. Agricultural development was hindered by long payback periods, low technology use, and frequent natural disasters, thereby reducing incentives for farm labour and grain production.

Theoretical analysis framework. Figure 3 shows that from 2014 to 2023, China's primary sector workforce declined from 223.72 million to 168.82 million, and its share of the rural population fell from 36.73% to 35.39%. Facing widening urban–rural income gaps, structural labour loss in agriculture, and systemic food security risks (Wen and Zeng 2024), public agricultural expenditure remains a key policy tool for boosting production and advancing agricultural and rural modernisation.

As shown in Figure 4, China's agricultural expenditure rose steadily from 2014 to 2023, increasing by USD 333.64 billion at an average annual growth rate of 4.07%. Grain and service subsidies have maintained household planting incentives, keeping grain output above 65 million tonnes for nine years. R&D investment exceeded USD 70.956 billion, raising technology's share in agricultural growth from 55% to 62% and boosting sector competitiveness. Infrastructure subsidies of USD 198.671 billion have created 0.71 billion hectares of high-standard farmland, whereas spending

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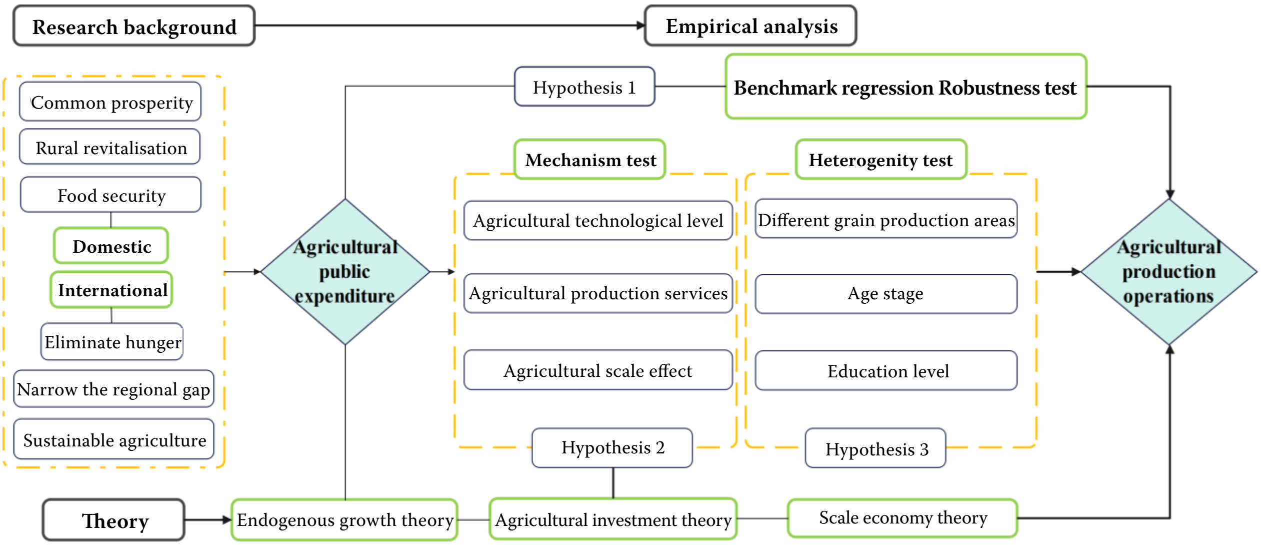

Figure 1. The theoretical framework for financial allocation to promote agricultural production

Source: Authors' own elaboration

on cold chain logistics and digital networks has expanded rural income opportunities.

Theoretical framework. Optimal resource allocation directs agricultural expenditure to areas where social benefits exceed private ones (Moriguchi and Shioura 2004). Input and irrigation subsidies lower costs, raise productivity, and expand output potential (Evans et al. 2022). Coupled and decoupled payments encourage shifts to high-demand crops, thereby boosting farm income. Crop insurance and countercyclical transfers stabilise income, reduce risk, and attract private investment (Gu et al. 2024). Lower land user costs increase permanent income expectations and convert public expenditure into lasting rural gains (Liang and Meng 2024). Thus, H_1 is proposed.

H_1: Agricultural public expenditure significantly promotes agricultural production.

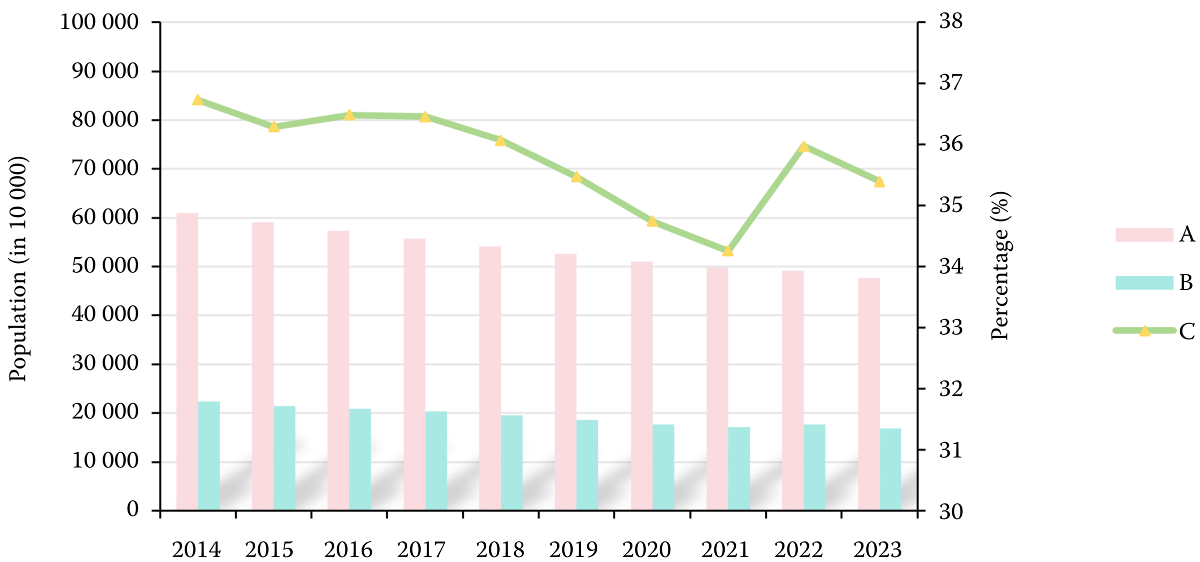

Figure 2. Growth rate of per capita disposable income and GDP of rural and urban residents in China from 2014 to 2023

A – growth rate; B – *per capita* disposable income of rural residents; C – *per capita* disposable income of urban residents
Source: Authors' own elaboration by author according to the China Statistical Yearbook

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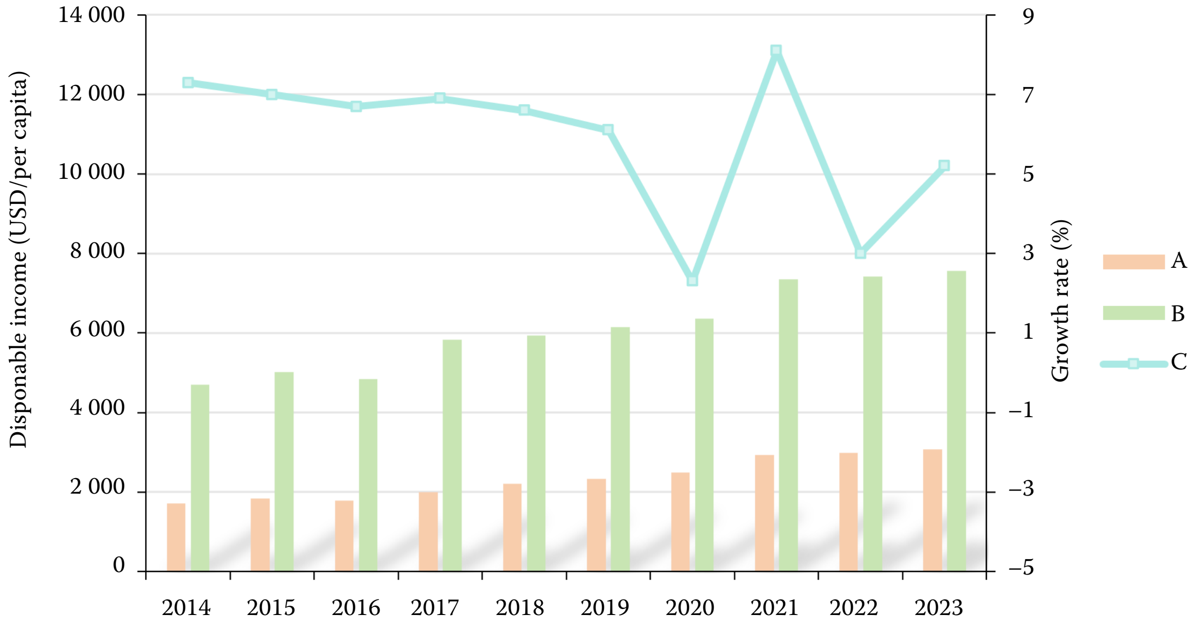

Figure 3. Trend chart of population engaged in agricultural production operations in China

A – rural population; B – employment in the primary industry; C – employment in the primary industry/rural population
Source: Authors' own elaboration according to the China Statistical Yearbook

Endogenous growth theory holds that technology and human capital drive sustained growth (Kopf 2007). Public grants, credit, and tax incentives attract private investment and boost innovation. Mechanisation raises productivity, saves labour, and shortens farming windows (Ceballos et al. 2020). Reduced postharvest losses and quality variation increase yields and prices (Fang et al. 2024). Subsidised equipment replaces labour and

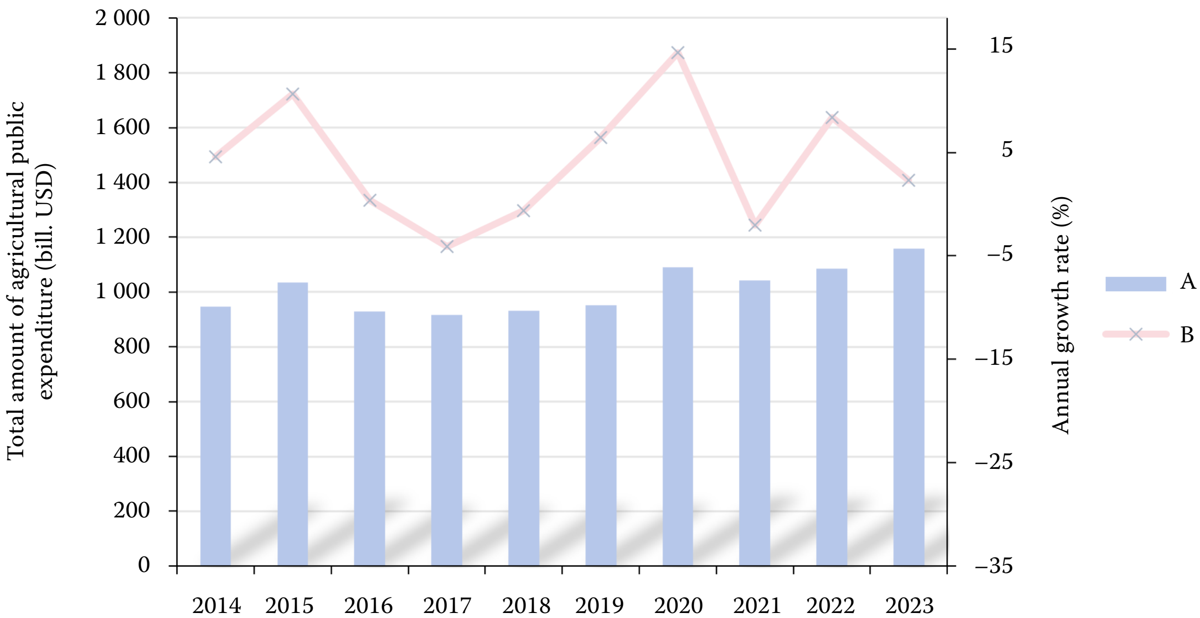

Figure 4. Trend chart of China's agricultural public expenditure from 2014 to 2023

A – agricultural public expenditure; B – annual growth rate
Source: Authors' own elaboration according to the China Statistical Yearbook

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expands grain supply (Meng et al. 2024). Over time, growth shifts from labour to embedded technology, enabling sustainable intensification and agri-food transformation (Daum 2023).

Agricultural public expenditure, guided by investment theory, redirects fiscal resources to high-multiplier points in the value chain, thereby lowering transaction costs and attracting private investment (Vasavada and Chambers 1986). Targeted fertiliser vouchers and calibrated subsidies reduce nutrient costs, drive efficiency gains, and cut environmental harm. Public programmes promote straw use and balanced fertilisers to stabilise yields per hectare and reduce weather risks (Phares and Akaba 2022). Evidence shows optimised input policies increase yields and quality, raising farm gate prices and producer surplus (MacLaren et al. 2022; Zhang et al. 2024).

Agricultural public expenditure drives structural change through economies of scale. Stigler (1958) showed that costs fall and surplus rises when output exceeds minimum efficient scale. Funding lowers land lease costs, supports farm consolidation, and co-finances levelling and irrigation (Liu et al. 2023). Larger farms cut average costs and adopt capital-intensive tools like precision seeders, drones, and decision systems. They gain from experience, attract skilled managers, and spread risk, thereby stabilising returns (Li and Shen 2021). Scale efficiency boosts profits and sustains income growth. Thus, $H_{2a–2c}$ are proposed.

H_{2a}: Agricultural public expenditure can promote the innovation and development of agricultural production operations by improving agricultural technological levels.

H_{2b}: Agricultural public expenditure can promote agricultural production by enhancing productive services.

H_{2c}: Agricultural public expenditure can promote agricultural production by strengthening scale effects.

Spatial differences shape agricultural spending. On fertile plains, subsidies and infrastructure support scale and mechanisation (Xu et al. 2024). In dry, saline areas, falling land value causes abandonment, so funds shift to grants and extension services for recovery (Feizizadeh et al. 2023). Geographically weighted regression shows varying returns (Brunsdon et al. 1996). Urban farming adds little to GDP and relies on external supplies (Zhong et al. 2020); thus, urban expenditure prioritises food security, supply chains, and modern circulation (Chen et al. 2024a).

Human capital theory holds that farmer age affects health, learning, and planning, shaping how well fiscal support works (Caire 1967). More local jobs reduce farm investment, as working-age farmers shift resources, which weakens program effects (Acevedo et al. 2020). Younger farmers benefit faster from subsidies due to longer repayment periods and better absorption than older farmers (Jeanneaux et al. 2025). As farmers age, they respond less to financial incentives due to declining skills (Liu et al. 2023).

Agricultural public expenditure works better where farmers are more educated. Education reduces information gaps, thereby lowering risks in credit and technology markets (Perloff and Rausser 1983). Educated farmers use subsidies more effectively for modern farming, raising output and prices (Liu et al. 2021). Less skilled farmers face higher costs and stay in low-profit traditional farming (Arndt et al. 2020). Capital outflows reduce jobs, speed up rural migration, and slow agricultural growth (Bi and Yang 2023). Therefore, H_3 is proposed.

H_3: The effect of agricultural public expenditure on agricultural production operations varies among different characteristic groups of rural households.

MATERIAL AND METHODS

Empirical model

Baseline regression model. This paper uses Oprobit and OLS regression. On the basis of the hypotheses above, provincial agricultural fiscal support is the independent variable, whereas the number of rural households engaged in agricultural production and their productive income are the dependent variables. A two-way fixed effects model is used to empirically test H_1.

$$FAR_{it} = \alpha + \beta AgPE_{it} + \sum_{k=1}^{n}\theta_{\kappa} Controls_{kit} + \mu_p + \omega_t + \varepsilon_i \quad (1)$$

where: FAR_{it} – the number of household members engaged in agricultural production for rural household i in year t, ranging from [0, 10] as an ordered discrete variable; $AgPE_{it}$ – provincial agricultural support intensity in year t; $Controls_{kit}$ – a set of control variables with coefficients θ_k indicating their effects on FAR_{it}; ε_{it} – the random error term; μ_p – the province fixed effect, controlling for unobserved provincial factors; ω_t – the year fixed effect, accounting for unobserved time-specific factors; α – the constant; i – rural households; t – years; p – provinces; β – the coefficient of the core explanatory variable AgPE.

$$\ln Inc_{it} = \alpha_0 + \beta_0 AgPE_{it} + \sum_{k=1}^{n}\theta_{\kappa} Controls_{kit} + \mu_p + \omega_t + \varepsilon_{it} \quad (2)$$

where: $\ln Inc_{it}$ – the farm income of rural household i in year t; $Controls_{kit}$ – control variables; α_0 – the constant; β_0 and θ_k – the estimated coefficients for agricultural public expenditure and control variables, respectively.

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Using a two-way fixed effects model (province and time), the coefficient β_0 captures the effect of agricultural public expenditure on rural households' productive income.

Mechanism test model. On the basis of the prior theoretical analysis, this study uses Baron and Kenny's (1996) hierarchical regression approach to examine how agricultural technology level, production services, and scale effects mediate the effect of agricultural public expenditure on rural households' productive income.

$$\ln Mediate_{it} = \alpha_1 + \beta_1 AgPE_{it} + \sum_{k=1}^{n} \theta_\kappa Controls_{kit} + \\ + \mu_p + \omega_t + \varepsilon_{it} \quad (3)$$

where: $Mediate_{it}$ – the mediator variable for agricultural technology level, production services, and scale effects; β_1 – the coefficient for agricultural public expenditure; θ_k – the coefficient for the control variables.

Data sources

This study uses CFPS data, a national panel survey by Peking University's Institute of Social Science Survey. The sample includes 11 856 rural household observations from 22 provinces, covering the period of 2012–2022. CFPS provides household-level data on farming participation, income, gender, marital status, health, education, and size. Agricultural public expenditure, fixed asset investment, *per capita* cultivated land area, machinery power, area of grain crop sowing, fertiliser input, and cultivated land area come from the China Statistical Yearbook and China Rural Statistical Yearbook (mainly for the years 2012, 2014, 2016, 2018, 2020, and 2022).

Variable description

Dependent variables. This study selects the number of residents engaged in agricultural production in every household (*Far*) and the productive income of rural

Table 1. Descriptive statistics of the variables

Variable	Description	Obs.	Mean	SD	Max	Min
Far	the number of residents engaged in agricultural production in every rural household	11 856	1.755	1.172	10.000	0.000
Inc	total value of agricultural and sideline products (USD/year)	5 244	9.200	1.211	13.816	0.000
AgPE	the intensity of provincial-level fiscal support for agriculture	11 856	0.297	0.152	0.716	0.122
Gen	0 = female; 3 = male	11 856	1.594	0.491	3.000	0.000
Mar	0 = widowed, divorced, unmarried; 3 = married, cohabiting	11 856	1.902	0.297	3.000	0.000
Hea	0 = unhealthy, average; 3 = relatively healthy, very healthy, extremely healthy	11 856	1.688	0.463	3.000	0.000
Edu	0 = illiterate/semiliterate, primary school; 3 = junior high school, high school/technical school/trade school/vocational school, college, bachelor's degree, master's degree	11 856	1.481	0.500	3.000	0.000
Fac	the total household population of the persons	11 856	4.319	1.802	13.000	1.000
Inv	the amount of fixed assets invested by rural households (USD billion)	11 856	4.225	0.773	5.754	2.092
Lan	the area of cultivated land per capita (ha per person)	11 856	2.714	1.617	16.013	0.577
Tec	total power of agricultural machinery/sown area of grain crops	11 856	0.956	0.325	2.121	0.356
Fer	per capita fertiliser input volume (t/10 000 people)	11 856	0.043	0.015	0.094	0.010
Are	agricultural land area (thousands of ha)	11 856	8.613	0.338	9.752	6.825

Source: Authors' own elaboration

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households (ln*Inc*) as the dependent variables. The total value of agricultural and sideline products in the CFPS database is used to represent the productive income of rural households, and it is logarithmically transformed.

Independent variables. This study uses agricultural public expenditure (*AgPE*) as the independent variable, measured by provincial fiscal support intensity (agricultural, forestry, and water resources spending divided by the value added in agriculture, forestry, and fisheries). National fiscal expenditure on agriculture is used in robustness tests.

Control variables. Numerous factors influence agricultural production. Based on prior literature, this research selects three types of control variables, namely, individual, family, and provincial characteristics, and uses seven proxy indicators to improve regression accuracy and validity. Individual characteristics are captured by the farmer's gender (*Gen*), marital status (*Mar*), health condition (*Hea*), and highest educational attainment (*Edu*); family characteristics are represented by household size (*Fac*); and provincial characteristics are measured by fixed asset investment (*Inv*) and per capita arable land area (*Lan*).

Mediating variables. On the basis of the prior theoretical and literature review, this paper uses agricultural technology level (*Tec*), production services (*Fer*), and scale effects (*Are*) as mediating variables. Descriptive statistics for the main variables are in Table 1.

RESULTS

Basic regression

The two-way fixed effects model results in Table 2 show the baseline effects of agricultural public expenditure on agricultural production, including rural households' enthusiasm for growing grain and their productive income. Column (1) includes only the independent variable, whereas Column (2) adds all

Table 2. Baseline regression results

Variables	(1)		(2)	
	Far	ln*Inc*	*Far*	ln*Inc*
AgPE	0.327*** (0.094)	0.664* (0.341)	0.571*** (0.140)	0.576* (0.340)
Fac	–	–	0.164*** (0.006)	0.051*** (0.013)
lnInv	–	–	0.144*** (0.019)	0.053 (0.048)
Lan	–	–	0.025*** (0.007)	0.079** (0.037)
Gen	–	–	0.015 (0.010)	0.032 (0.033)
Mar	–	–	0.087*** (0.008)	0.054 (0.067)
Hea	–	–	0.034*** (0.007)	0.073** (0.034)
Edu	–	–	0.008 (0.007)	0.081** (0.039)
Constant		9.445*** (0.161)		8.458*** (0.302)
Province FE		yes		yes
Year FE		yes		yes
n	11 856	4 396	11 856	4 396
R^2	0.001 0	0.010 6	0.035 2	0.014 4

*, ** and ***significance levels of 10%, 5% and 1%, respectively; values within parentheses are clustered robust standard errors; variables as explained in Table 1; *FE* – fixed effects

Source: Authors' own elaboration

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control variables. Agricultural public expenditure is significantly positively associated with the number of rural households engaged in agricultural production and their productive income. Thus, H_1 is supported.

Endogeneity tests

In 2015, the Ministry of Finance and the Ministry of Agriculture of China issued the 'Guiding Opinions on Adjusting and Improving the Three Agricultural Subsidy Policies', proposing to implement agricultural support and protection subsidies nationwide. This study uses DID to assess the effect of fiscal subsidies on agricultural production activities. Columns (1 and 2) in Table 3 show that fiscal subsidies significantly boost agricultural production, confirming the robustness of the baseline findings.

This study uses the average fiscal support intensity for agriculture in other provinces as an instrumental variable and applies two-stage least squares to address endogeneity. Columns (3–6) in Table 3 report the instrumental variable regression results. First-stage results [Columns (3 and 5)] show that the instrument significantly predicts local fiscal support at the 1% level. The *F*-statistic exceeds 10, confirming strong instruments with no issue of weak instrumental variables. Second-stage results [Columns (4 and 6)] confirm the main finding: fiscal support significantly increases agricultural production, including income and grain producers. Thus, the paper's conclusion remains robust.

Robustness check

The independent variable is replaced. The independent variable 'agricultural public expenditure' is redefined using national fiscal expenditure on agriculture, forestry, and water conservancy instead of provincial support intensity. This revised measure is denoted as ln$AgPE_1$. Column (1) in Table 4 shows the regression with only the new independent variable, whereas Column (2) includes all control variables. The results show that agricultural fiscal allocation remains positively and significantly associated with agricultural production, confirming the robustness of the results.

The model is replaced with a high-dimensional fixed effects model. This study also uses a high-dimensional fixed effects model to examine the effect of agricultural public expenditure on agricultural production. Column (3) in Table 4 reports the results with only the independent variables, whereas Column (4) includes all control variables. The effect of agricultural public expenditure on agricultural production remains significantly positive, confirming its role in promoting sustainable agricultural development and supporting the robustness of the findings.

The sample size is adjusted. This study uses random sampling to examine the effect of fiscal allocation on agricultural production. Stratified by year, 60% of each year's data are randomly selected to ensure sample randomness and proportionality within strata.

Table 3. Endogeneity test result

Variables	DID		IV			
			Far		ln*Inc*	
	(1) *Far*	(2) ln*Inc*	(3) first stage	(4) second stage	(5) first stage	(6) second stage
did	0.922*** (0.057)	0.120** (0.058)	–	–	–	–
mean	–	–	−5.7846*** (0.0400)	–	−4.8428*** (0.0369)	–
AgPE	–	–	–	0.7163*** (0.2218)	–	0.6678* (0.3858)
F	–	–	–	9 564.88	9 038.86	–
Controls	yes	yes	yes	yes	yes	yes
Province FE	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes
n	11 856	4 396	11 856	11 856	4 379	4 379
R^2	0.081 9	0.013 5	–	0.190 5	–	0.015 7

*, ** and ***significance levels of 10%, 5% and 1%, respectively; values within parentheses are clustered robust standard errors; variables as explained in Table 1; DID – Differences-in-Differences; *FE* – fixed effects

Source: Authors' own elaboration

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Table 4. Regression results after replacing the independent variables and the empirical model

Variables	(1)		(2)		(3)		(4)	
	Far	ln*Inc*	*Far*	ln*Inc*	*Far*	ln*Inc*	*Far*	ln*Inc*
ln$AgPE_1$	1.565*** (0.108)	0.343*** (0.083)	1.559*** (0.101)	0.217** (0.105)	–	–	–	–
AgPE	–	–	–	–	0.376*** (0.062)	0.802** (0.352)	0.601*** (0.076)	0.742** (0.354)
Controls	yes	yes	yes	yes	yes	yes	yes	yes
Constant		6.524*** (0.777)		6.708*** (0.923)	1.644*** (0.021)	9.446*** (0.148)	–0.266*** (0.093)	7.752*** (0.334)
Province FE	yes	yes	yes	yes		yes		yes
Year FE	yes	yes	yes	yes		yes		yes
n	11 856	4 396	11 856	4 396	11 856	4 396	11 856	4 396
R^2	0.045 4	0.009 3	0.045 5	0.013 5	0.003 1	0.077 6	0.118 5	0.103 1

** and ***significance levels of 5% and 1%, respectively; values within parentheses are clustered robust standard errors; variables as explained in Table 1
Source: Authors' own elaboration

As shown in Table 5, Column (1) reports the results with only the independent variable, whereas Column (2) includes all control variables. Agricultural public expenditure remains significantly positively associated with agricultural production, confirming the robustness of the estimates.

Mechanism tests

To examine how public expenditure enhances agricultural production through improved technology, stronger production services, and expanded scale effects, this study conducts mechanism tests using a two-step approach based on Equation (2), with the results in Table 6. Columns (1–3) show that agricultural public expenditure significantly promotes all three mechanisms, supporting H_{2a}–H_{2c}.

Heterogeneity tests

Regional heterogeneity. According to China's 2017 policy 'Guiding Opinions on Establishing Grain Production Function Areas and Important Agricultural Product Production Protection Areas', grain production areas are classified as major or nonmajor based on indicators such as grain output, per capita availability, and commercial grain stocks. Analysing fiscal policy effects across these regions helps clarify regional

Table 5. Results after random sampling and regression analysis

Variables	(1)		(2)	
	Far	ln*Inc*	*Far*	ln*Inc*
AgPE	0.332*** (0.074)	0.614*** (0.086)	0.613*** (0.097)	0.582*** (0.123)
Controls	yes	yes	yes	yes
Constant	–	4.237*** (0.748)	–	3.511*** (1.134)
Province FE	–	yes	–	yes
Year FE	–	yes	–	yes
n	7 116	3 135	7 116	3 135
R^2	0.001 0	0.020 6	0.035 3	0.024 8

***significance level of 1%; values within parentheses are clustered robust standard errors; variables as explained in Table 1
Source: Authors' own elaboration

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Table 6. Mechanism test results

Variables	(1) Agricultural technology level	(2) Agricultural production service	(3) Agricultural scale effect
	Tec	*Fer*	*lnAre*
AgPE	0.223** (0.098)	0.020*** (0.004)	0.146*** (0.013)
Controls	yes	yes	yes
Constant	0.210*** (0.078)	0.031*** (0.004)	8.527*** (0.018)
Province FE	yes	yes	yes
Year FE	yes	yes	yes
n	5 244	5 244	5 244
R^2	0.024 9	0.008 3	0.678 4

** and ***significance levels of 5% and 1%, respectively; values within parentheses are clustered robust standard errors; variables as explained in Table 1

Source: Authors' own elaboration

responsibilities for national food security. The sample is split accordingly, and each subsample is regressed. The results are reported in Table 7.

The effect of public expenditure on agricultural production varies across grain functional areas. In major grain production areas, it positively affects rural households' enthusiasm for grain cultivation but significantly reduces agricultural production income. In nonmajor areas, it has no significant effect on cultivation enthusiasm but significantly increases production income.

Age heterogeneity. This study classifies rural residents into three age groups based on World Health Organisation criteria: emerging farmers under 44, prime-age farmers aged 44–60, and senior residents over 60. The separate regression results in Table 8 show that agricultural public expenditure affects agricultural production differently across groups. Agricultural public expenditure has a stronger motivating effect on emerging and prime-age farmers than on seniors. Regarding grain cultivation enthusiasm, the effect is greater for prime-age farmers; regarding productive income, it is greater for emerging farmers.

Educational heterogeneity. The sample is divided into farmers with primary education or below and those with junior high education or above. The regression results are reported in Table 9. The effect of public expenditure on agricultural production varies by education level. For grain cultivation enthusiasm, the incentive effect is stronger among farmers with primary education or below. For productive income, the effect is greater for those with junior high education or above. Thus, H_3 is supported.

Table 7. Results of the regional heterogeneity tests

Variables	Major grain production areas		Nonmajor grain production areas	
	Far	ln*Inc*	*Far*	ln*Inc*
AgPE	2.161*** (0.309)	−0.133** (0.052)	0.072 (0.103)	0.206*** (0.057)
Controls	yes	yes	yes	yes
Constant		10.035*** (0.336)		7.784*** (0.356)
n	6 340	2 441	5 516	1 955
R^2	0.033 6	0.001 3	0.042 1	0.003 0

** and ***significance levels of 5% and 1%, respectively; values within parentheses are clustered robust standard errors; variables as explained in Table 1

Source: Authors' own elaboration

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Table 8. Results of the age heterogeneity tests

Variables	Emerging farmers		Prime-Age farmers		Senior farmers	
	Far	ln*Inc*	*Far*	ln*Inc*	*Far*	ln*Inc*
AgPE	0.571** (0.263)	0.299*** (0.100)	0.747*** (0.201)	0.115** (0.045)	0.262 (0.232)	–0.448*** (0.143)
Controls	yes	yes	yes	yes	yes	yes
Constant		7.353*** (0.637)		8.415*** (0.287)		11.882*** (0.936)
n	3 563	785	6 366	3 129	1 927	482
R^2	0.031 4	0.021 5	0.035 7	0.001 2	0.044 1	0.048 6

** and ***significance levels of 5% and 1%, respectively; values within parentheses are clustered robust standard errors; variables as explained in Table 1
Source: Authors' own elaboration

Table 9. Results of education heterogeneity tests

Variables	(1) Primary school education or below		(2) Junior high school education or above	
	Far	ln*Inc*	*Far*	ln*Inc*
AgPE	0.726*** (0.206)	–0.010 (0.054)	0.450** (0.182)	0.106* (0.057)
Controls	yes	yes	yes	yes
Constant		9.211*** (0.344)		8.487*** (0.360)
n	6 526	2 286	5 330	2 110
R^2	0.040 7	0.000 0	0.030 1	0.000 3

*, ** and ***significance levels of 10%, 5% and 1%, respectively; values within parentheses are clustered robust standard errors; variables as explained in Table 1
Source: Authors' own elaboration

DISCUSSION

This study provides a comprehensive analysis of China's agricultural fiscal policies. The results show that higher agricultural public expenditure boosts rural households' enthusiasm for grain cultivation and increases productive income, consistent with findings from multiple studies (Wang et al. 2024; Wang and Li 2024; Gu et al. 2024).

Multiple factors shape rural households' grain cultivation enthusiasm and income, including individual, family, and provincial characteristics. Larger households boost production through greater labour, land, and resource access. Higher rural investment strengthens infrastructure and resilience, increasing cultivation motivation (Qiao et al. 2022), whereas more per capita arable land raises output and efficiency (Duan et al. 2021). Gender matters less in modern farming due to mechanisation (Nichols 2024). Married households are more motivated but may not earn more due to labour division (Hornby and Hull 2023). Good health improves labour performance and decisions (Ma et al. 2023), and education enhances technology use and adaptability, thereby boosting income (Arndt et al. 2020).

Agricultural public expenditure promotes production by improving agricultural technical levels, which enhances production services and expands the agricultural scale.

i) Agricultural public expenditure boosts production through technology. Mechanisation and electrification expand scale, raise productivity and efficiency, lower costs, and increase household enthusiasm and income. The state has expanded machinery subsidies and improved credit access (Qian et al. 2022). New technologies reduce task time, boost yield and quality (Khan et al. 2022), and save inputs (Xu et al. 2022). Thus, technological progress mediates fiscal effects and drives agricultural growth.

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ii) Agricultural public expenditure boosts production by improving services. Subsidies for inputs like fertiliser encourage greater use, enhancing soil nutrients and crop yields (Hu et al. 2024). Fiscal support also promotes agricultural technology and efficient fertiliser use. The government has set application standards and adopted practices such as soil testing and formula fertilisation, thereby increasing efficiency and supporting sustainable farming with ecofriendly fertilisers (He et al. 2022; Kumar et al. 2023).

iii) Agricultural public expenditure boosts production through scale effects. Subsidies for grain and machinery reduce costs and expand cropping area. Fiscal investment improves irrigation and builds high-standard farmland, converting uncultivable land into arable land (Xiao et al. 2023). This expansion supports mechanisation, lowers unit costs, and increases grain output efficiency (Ma and Chen 2022). Farmers can adjust planting structures based on market demand, thereby shaping production and income patterns.

Major grain-producing areas benefit from policies like the national minimum purchase price and fertility subsidies. These support measures guarantee farmers' income, increasing their motivation compared to those in nonmajor areas who lack such incentives (Wang et al. 2022). In major grain-producing areas, farmland is mainly used for low-profit, low-value grain crops. By contrast, nonmajor grain-producing areas grow economic crops and add value through extended production chains (Osumanu and Ayamdoo 2022), resulting in higher farmer incomes than in major grain-producing regions.

Operator age reflects embodied capital, which shapes fiscal transfer efficiency (Caire 1967). Younger farmers, with longer planning horizons and lower risk aversion, adopt technology faster; older farmers, facing declining human capital and traditional preferences, benefit less from subsidies. Prime-aged farmers respond more strongly to incentives and new technologies (Szymkowiak et al. 2021), boosting income via mechanisation and advanced practices (Carbone et al. 2024). For elderly farmers, subsidies have limited effect due to conservative choices, low policy awareness, and reduced labour capacity (Ren et al. 2023).

Education reduces adverse selection and moral hazard by acting as a low-cost signal (Perloff and Rausser 1983). Low-educated farmers, lacking information and negotiation skills, accept fixed prices after losing information rent but are more likely to grow grain due to stable income (Cai et al. 2023). Better-educated farmers use information advantages to earn higher returns through contract farming and direct sales, leading to faster income growth (Arndt et al. 2020). However, higher search, negotiation, and opportunity costs reduce their willingness to focus solely on grain production.

This study has several limitations, including sample size, data quality, and time range. Future research with more detailed data including county-level could examine broader influence and extend the scope of current findings.

CONCLUSION

This study examines the effect of fiscal allocation on agricultural production using 2012–2022 panel data. Applying Oprobit and OLS two-way fixed effects models, the results show that agricultural public expenditure significantly boosts production, with robustness confirmed across tests. The effect operates through technological empowerment, service enhancement, and scale expansion. Heterogeneity analysis reveals stronger effects on grain-growing enthusiasm among low-educated rural households and on productive income in major grain production areas, as well as on productive income of rural households with emerging and prime-aged farmers, in nonmajor grain production areas and high educational attainment. The findings extend existing research frameworks and provide theoretical support for promoting agricultural prosperity.

Therefore, more precise countermeasures should be adopted to enhance the positive policy effect of fiscal support on agricultural production.

First, the government should prioritise agricultural public expenditure to support rural development by increasing investment, allocating funds precisely, and meeting farmers' actual needs through targeted measures. It should also innovate financing methods, such as purchasing services and attracting social capital.

Second, agricultural expenditures should target regional and farmer-specific needs. In major grain production areas, investment in processing, storage, and logistics is necessary to boost farm value. In nonmajor grain production areas, direct grain subsidies should be combined with high-standard farmland support to encourage production. Assistance should be tailored by farmer type: emerging farmers need smart tools and data; prime-age farmers need skill training and greenhouse programs; senior farmers benefit from expert advice; educated farmers can use technology and e-commerce to improve efficiency; and less educated farmers require training to adopt new methods.

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Third, policymakers should strengthen agriculture through targeted spending. They should subsidise advanced machinery to improve efficiency. They must also build a multitiered technology network using field classrooms and remote guidance to deliver innovations. Furthermore, the government should use soil data to tailor fertiliser support and promote eco-friendly options, thereby enhancing soil health and yields. Finally, they ought to promote land transfer and large-scale farming through cooperatives and family farms to boost intensification and resilience.

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