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An Empirical Study of the Factors Influencing Grain Yield: The Case of Sichuan Province, China

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Abstract: In this study, in order to analyze the multiple factors affecting grain production in Sichuan Province, grain production data and its related variables from 1982 to 2022 were selected as the object of the study and empirical research was conducted. The unit root test and cointegration test were applied to ensure the smoothness of the data, heteroskedasticity and autocorrelation tests were performed, and the model was adjusted to finally select a feasible generalized least squares model. The results show that all the examined influencing factors have a significant impact on grain yield in Sichuan Province, especially the sown area of grain crops, which has the most significant effect. Based on these findings, this study proposes the following recommendations: ensure sufficient sown area and high-quality arable land resources, accelerate the process of agricultural mechanization and intelligence, and use chemical fertilizers rationally, in order to enhance the grain production capacity of Sichuan Province and guarantee food security.

Keywords: Multiple linear regression; Grain yield; Influencing factors; Feasible generalized least squares

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1 . Introduction

Food has always been fundamental to supporting human survival and social development, as well as key to national stability and security. In the implementation of the rural revitalization strategy, ensuring the supply of important agricultural products, especially food, is the most urgent task. An in-depth investigation of the factors influencing crop yield is not only very necessary, but also of great significance in guiding agricultural production practice, optimizing resource allocation, and sustainable development.

As an important grain production base in Southwest China, the steady growth of grain production in Sichuan Province plays an important role in national food security. The growth of grain production in Sichuan Province is not only due to its rich agricultural resources and favorable climate conditions, but also closely related to the improvement of infrastructure and scientific and technological progress [1]. The aim of this study is to investigate the influencing factors of grain yield in Sichuan Province, with a view to providing a basis for food security and sustainable development of agriculture in Sichuan Province, and further providing a reference for increasing grain production in the whole country.

2. Literature review

In studies exploring the impact of agricultural infrastructure construction on grain yield enhancement, there have been numerous scholars and experts who have explored the various influencing factors of grain yield increase in different regions, including infrastructure, land, and irrigation, from both theoretical and practical perspectives.

Liu constructed a comprehensive grain production capacity evaluation system, and through the entropy method, found that grain sown area, labor input, fertilizer use, and the level of digital economic development are the main positive factors of regional grain production [2]. Liao *et al.* assessed the impact of land use change on food production potential and concluded that food production in Guangdong Province is highly correlated with the coordination of population and economic development [3]. Shen *et al.* examined the drivers of eco-efficiency in food production and found that the level of economic development, agricultural production structure, urban-rural income gap, and labor-per-sown-area ratio all had a significant positive effect on eco-efficiency in food production [4]. Cao *et al.* used the stochastic frontier production function to measure the output elasticity of factors and the technical efficiency of food production, and found that the location of arable land was positively correlated with food production and the technical efficiency of food production [5]. Li constructed a threshold model by measuring the total factor productivity of grain greening, the change in the efficiency of grain greening technology (GECG), and the change in the progress of grain greening technology, and found that greening technology would have a sustainable impact on grain yield [6]. Li, through spatial autocorrelation analysis, found that the positive influence of the agricultural labor force on grain yield gradually decreases, showing a decreasing trend from Southwest to Northeast. The promotion effect of agricultural mechanization on grain output increases year by year, with the spatial distribution characteristics of high in the northeast and low in the Southwest [7].

Overall, scholars generally agree that agricultural infrastructure and land management are important factors in boosting food production, and land factors such as sown area and agricultural labor migration are also considered to be critical in influencing food production [8].

3. Variables and data

This paper examines grain output and its influencing factors in Sichuan Province from 1982 to 2022, with data from the China Statistical Yearbook and other sources. The study considers six key variables: grain output (GrainYield), sown area (SArea), total power of agricultural machinery (AMP), fertilizer application (FAmt), and rural electricity consumption (REU). The sown area reflects the impact of changes in arable land on yield; the total power of agricultural machinery and rural electricity consumption reflect the level of agricultural modernization and mechanization; and the amount of fertilizer applied is indicative of the efficiency of water management and fertilizer use, respectively. These variables work together to influence grain production in Sichuan Province.

4. Empirical analysis

4.1. Unit root test

The smoothness of a time series means that the statistical pattern of the time series does not change over time. In order to avoid the pseudo-regression problem, it is necessary to test the smoothness of the time series data of the observations, and this paper uses the unit root test to test the smoothness of each variable.

From the results of the unit root test of each variable, it can be seen that the data selected in this paper are all non-stationary time series. In order to further determine its single integer order, each variable is differentiated once, and the differentiated time series are tested again, respectively.

Table 1. First order difference unit root test results

Variables	*t*-statistic	*p*-value
GrainYield	-7.417	0.000
SArea	-4.282	0.008
AMP	-4.609	0.004
FAmt	-4.530	0.004
REU	-5.982	0.000

From the above table, it can be seen that all the variables are smooth time series after one difference, i.e., all the variables selected in this paper are first-order single integer time series.

4.2. Cointegration test

Cointegration describes the possibility that a linear combination of non-stationary variables may form a stationary series, thus revealing the equilibrium relationship between the variables and avoiding pseudo-regression. In this paper, the EG two-step method to conduct the cointegration test and OLS estimation of the benchmark regression is used to obtain the residual series:

$$e_t = GrainYield - (\hat{\beta}_1 + \hat{\beta}_2 SArea + \hat{\beta}_3 AMP + \hat{\beta}_4 FAmt + \hat{\beta}_5 REU)$$

Next, determine whether the residual series e_t is smooth. If e_t is smooth, the variables are cointegrated. On the contrary, it is not cointegrated. According to the results, it can be seen that the t-statistic is -5.684 and the p-value is 0.000, which indicates that there is no unit root in the residual series, i.e., the variables selected in this paper affecting the grain production in Sichuan Province and the grain production show a more stable cointegration relationship in the long run, and there will be no pseudo-regression.

4.3. Linear regression

4.3.1. Model setting

In this paper, a multiple linear regression model is developed as follows:

$$GrainYield = \beta_1 + \beta_2 SArea + \beta_3 AMP + \beta_4 FAmt + \beta_5 REU + u_t$$

Where t denotes the time, GrainYield denotes the grain output in Sichuan Province, SArea denotes the sown area of grain crops, AMP denotes the total power of agricultural machinery, FAmt denotes the amount of fertilizer applied, REU denotes the amount of electricity consumed in rural areas, and u_t denotes the random perturbation term.

4.3.2. Regression results

Using Eviews software, OLS was used to estimate the model parameters and the regression results were obtained as shown below:

Table 2. Regression results

Variables	Coefficient	Standard error	*t*-statistic	*p*-value
constant	-2917.210	2056.808	-1.418	0.165
SArea	0.992	0.200	4.962	0.000
AMP	0.193	0.134	1.441	0.158
FAmt	1.295	1.226	1.057	0.297
REU	2.388	2.698	0.885	0.382

The regression results show that R_2 is 0.506 and $\overline{R}^2$ is 0.435, and the regression equation is significant as a whole, and the variables combined have a significant effect on grain production in Sichuan Province. To ensure that the estimation results of the econometric model are valid and reliable, the heteroskedasticity test and autocorrelation test are then performed.

4.3.3. Heteroscedasticity and autocorrelation test

In time series data, the heteroskedasticity that can be considered to exist is the ARCH process, and the presence or absence of heteroskedasticity in the time series is determined by testing whether this process holds. Calculate the residuals e_t resulting from the estimation of the original model parameters and use the squared residual series e_t^2, e_{t-1}^2,……, e_{t-p}^2 as an estimate of σ_t^2, σ_{t-1}^2,……, σ_{t-p}^2, respectively, where p is the order of the ARCH process. Make the following regression of the ARCH process:

$$\widehat{e_t^2} = \widehat{\alpha_0} + \widehat{\alpha_1} e_{t-1}^2 + \cdots + \widehat{\alpha_p} e_{t-p}^2$$

In the large sample case, the statistic $(n-p)R^2$ asymptotically obeys the chi-square distribution when $\alpha_1 = \alpha_2 = \cdots = \alpha_p = 0$. Eventually, in the case of *p*=1, the test for heteroskedasticity is: statistic $(n-p)R^2 = 9.405 > \chi_{0.05}^2(1) = 3.84146$, so the model is considered to have heteroskedasticity.

The presence of autocorrelation was further verified by the Breusch-Godfrey test. The presence of autocorrelation in the error term is considered to be absent by performing an auxiliary regression analysis of the OLS estimated residuals of the model on the explanatory variables and several period lagged residuals, if these lagged residuals adequately explain the variation in the current residuals.

The results show a chi-square distribution statistic of 11.521 and a *p*-value of 0.003, thus the model estimates are biased and autocorrelation is present.

4.4. Applications of feasible generalized least squares

From the above test, it can be seen that the data have both heteroskedasticity and autocorrelation, at this point, using the feasible most generalized least squares method to solve the model heteroskedasticity and autocorrelation problems at the same time was considered. Here the Newey-West consistent standard error method was used.

Newey-West is known as the HAC standard error, and it provides a more accurate estimation method for the model. This standard error estimation method improves the accuracy and reliability of the standard error by using a weighted average. It gives a consistent estimate of $\widehat{\mathrm{Cov}}(\hat{\beta}_{OLS})$:

$$\widehat{Cov}(\hat{\beta}_{OLS}) = \sigma^2(X'X)^{-1}X'\hat{\Omega}X(X'X)^{-1}$$

This helps us to obtain robust estimation results. The regression results obtained by applying this method are as follows:

$$GrainYield = -4056.77 + 0.98Area + 0.14AMP + 1.24FAmt + 1.28REU + u_t$$

From the regression results, the modified decidable coefficient $\bar{R}^2$ is 0.441. At the given significance level $a = 0.05$, $F = 8.905 > F_{0.05}(4, 36)$, indicating that the regression equation as a whole is significant, and that the variables of sown area of grain crops, total power of agricultural machinery, and other variables jointly have a significant effect on grain production in Sichuan Province.

5. Conclusions and recommendations

Focusing on grain production in Sichuan Province during the period from 1982 to 2022, this study empirically explored the key factors influencing grain production in the province. The results reveal that sown area, agricultural machinery power, fertilizer use and rural electricity consumption are the four main drivers of grain production in Sichuan Province, and these factors have a significant impact on grain production in the province.

Based on the above findings, the following recommendations are made:

First, sown area is a key factor influencing grain production in Sichuan Province. In order to guarantee food security, it is necessary to promote the construction of high-standard farmland, improve the farmland management system, and enhance the quality of arable land under the rural revitalization strategy. Meanwhile, agricultural mechanization and fertilizer application are also crucial to increasing grain output. The government should support the development of agricultural mechanization, rationalize the application of chemical fertilizers, and strengthen soil quality monitoring to prevent problems such as declining soil strength and soil acidification, in order to increase grain production and safeguard farmland ecology. It is also necessary to scientifically plan and manage the construction of farmland in conjunction with territorial spatial planning and water resource utilization, establish a hierarchical, regional, and typological farmland management system, strengthen the construction of high-quality farmland, and improve the relevant elements in accordance with local rural development.

Disclosure statement

The author declares no conflict of interest.

References

[1] Qian L, Yingying D, Jiahui T, et al., 2023, Research on the Factors Influencing the Security of Grain Supply Capacity in Sichuan Province Based on PLS Structural Equation Modelling. Journal of Agricultural Science, 16(1): 22–22.

[2] Liu Z, Hong S, Wang J, 2025, A Multidimensional Exploration of the Factors Influencing Comprehensive Grain Production Capacity from a Spatial Perspective. Sustainability, 17(7): 3264–3264.

[3] Liao Y, Lu X, Liu J, et al., 2024, Integrated Assessment of the Impact of Cropland Use Transition on Food Production

Towards the Sustainable Development of Social–Ecological Systems. Agronomy, 14(12): 2851–2851.

[4] Shen L, Sun R, Liu W, 2024, Examining the Drivers of Grain Production Efficiency for Achieving Energy Transition in China. Environmental Impact Assessment Review, 105: 107431.

[5] Cao X, Han J, Li X, 2023, Analysis of the Impact of Land Use Change on Grain Production in Jiangsu Province, China. Land, 13(1): 20.

[6] Jingdong L, Qingning L, 2023, Threshold Effects of Green Technology Application on Sustainable Grain Production: Evidence from China. Frontiers in Plant Science, 14: 1107970.

[7] Shaoting L, Daojun Z, Yuan X, et al., 2021, Analysis on the Spatio-Temporal Evolution and Influencing Factors of China's Grain Production. Environmental Science and Pollution Research International, 29(16): 23834–23846.

[8] Ennaji O, Hamma A, Vergütz L, et al., 2025, The Assessment of Soil Variables Relative Importance for Cereal Yield Prediction under Rainfed Cropping System in Morocco. Smart Agricultural Technology, 11: 100950.

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