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An econometric perspective on the factors affecting China's gross agricultural product

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ABSTRACT
Through an in-depth analysis of China's agricultural economic development data from 1993 to 2023, this paper aims to reveal the key factors affecting the gross agricultural product with the help of econometric models. This paper elaborates on the multi-dimensional consideration of new quality productivity, including key variables such as per capita disposable income of rural residents, agricultural fertilizer application rate, effective irrigation area, and grain yield per unit cultivated area. Eviews software was used to construct an econometric model to explain the gross agricultural product, and the relationship between each variable and the gross agricultural production value was revealed. The results show that the per capita disposable income of rural residents, the amount of agricultural chemical fertilizer applied and the effective irrigation area have a significant positive impact on the gross value of agricultural production. The results of this study have important reference value for policymakers to optimize the allocation of agricultural resources, promote the green development of agriculture, and improve the well-being of rural residents, in order to provide more in-depth theoretical support for the sustainable development of agricultural economy.

KEYWORDS
Chinese Agricultural Gross Output Value; Econometrics; New Quality Productivity

1 Background to the study

The remarkable growth of China's gross agricultural product (GAP) over the past four decades has not only contributed to global food security, but also played an important role in domestic economic stability. However, the driving mechanism behind this growth and the factors influencing it remain a continuing focus of attention for academics and policymakers alike. With the transformation of China's economic structure and the advancement of agricultural modernisation, the connotation and extension of agricultural production are undergoing profound changes, traditional factors of production and new qualitative productive forces, such as science and technology, the environment and policy, combine to shape the dynamic trends in agricultural GDP.

The aim of this paper is to construct an econometric model using Eviews software to reveal the key factors affecting China's gross agricultural product through rigorous econometric analyses. The growth of agricultural GDP does not depend solely on inputs of factors of production, but rather on how to optimise the allocation of resources, improve production efficiency [1] and adapt to changing environmental and policy contexts. The findings of this paper will help policy makers to make more informed decisions on optimising agricultural inputs, enhancing agricultural productivity, promoting green agriculture and improving the well-being of rural people.

This study aims to provide theoretical support and practical guidance for the sustained growth of China's agricultural economy and the advancement of agricultural modernisation through the empirical analysis of econometrics, in the hope that through the efforts of this paper, more seeds of wisdom can be sown in a fertile soil of Chinese agriculture.

2 Econometric modelling and testing

2.1 Data sources and sample selection

The data for the study in this paper were selected as a sample of China's nationwide data from 1993-2023 through the China Statistical Yearbook, and the literature was referred to for the selection of data indicators that may affect the gross agricultural product，Seven data indicators, namely, agricultural energy consumption, rural population, disposable income per capita of rural residents, total sown area, agricultural fertiliser application, effective irrigated area, and grain production per unit of arable land area, were selected after screening, and finally the data were analysed and processed by using Excel and EViews7 statistical software.

2.2 Determination and description of variables

According to the previous model building experience [2], this paper takes the gross agricultural product as the explanatory variable; chooses the disposable income per capita of rural residents as the explanatory variable, and the agricultural energy consumption, rural population, total sown area, agricultural fertiliser application, effective irrigated area, and grain production per unit of arable land area as the control variables. Table 1 has been produced for the reader's clarity and understanding.

2.3 Model building and testing

2.3.1 Establishment of the model

Based on the previous assumptions, this paper uses Eviews7 statistical software to establish a linear regression model for time series data by taking the gross agricultural product as an explanatory variable and selecting the following variables as explanatory variables to gain insights into the extent of the impact of different factors on China's gross agricultural product. Estimated by OLS method and calculated using Eviews, the results are shown in Table 2.

2.3.2 Tests and corrections of the model

(1) Multicollinearity test and correction

The adjusted fit reaches 0.980827, close to 1,F=64.94731, p-value=0.015250, the overall equation is very significant at the 0.05 level of significance, but all the variables of the parameter did not pass the t-test, so it is initially judged that the equation has a more serious multicollinearity. STEPLS method was used for the multicollinearity test as well as correction.Eviews final calculations were as follows, see Table 3.

The empirical regression equation eliminating severe multicollinearity can be derived from the above table:

$$\hat{y} = 36306.96 + 4.971108x_3 + 28.596208x_5 - 1.275054x_6$$

$$t \quad (2.016) \quad (12.254) \quad (5.797) \quad (-2.715)$$

$$R^2 = 0.997082 \quad F\text{ - Statistic} = 3075.516 \quad \text{Prob(F)} = 0.000$$

Table 1 Definition of variables

Variable Classifica - tion	Variable Name	Variable Symbo	Variable Definition
explana - tory vari- able	Gross agricultural product	Y	Total volume of all agricultural products expressed in monetary terms during the year
explana - tory vari- able	Rural energy con- sumption	X1	Energy consumed by rural socio-economic activities and rural inhab- itants.
	Rural energy con- sumption	X2	Population of any occupation living in rural areas.
	Per capita disposable income of rural resi- dents	X3	Income received by rural households after primary distribution and redistribution.
	Total sown area	X4	The area of crops actually sown or transplanted at the end of a year.
	Fertiliser application in agriculture	X5	The amount of fertiliser actually used in agricultural production dur- ing the year, including nitrogen, phosphate, potash and compound fertiliser.
	Effective irrigated area	X6	The area of farmland that has a certain water source and irrigation fa- cilities that can be irrigated normally within a year.
	Food production per unit of arable land	X7	Yield per unit area is also known as harvest rate.。

Table 2 Eviews output - model estimation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
X1	0.001871	0.043984	0.042533	0.9699
X2	-0.131036	1.769494	-0.074053	0.9477
X3	0.093379	0.05937	1.57282	0.2564
X4	-0.017032	0.053813	-0.316507	0.7816
X5	215.9617	141.2131	1.529332	0.2658
X6	6.55E-05	0.000208	0.313984	0.7833
X7	-0.002096	0.000917	-2.284867	0.1497
C	-982.2726	3320.776	-0.295796	0.7953
R-squared	0.996165	Adjusted R-squared		0.980827
F-statistic	64.94731	Durbin-Watson stat		2.199177
Prob(F-statistic)	0.01525			

Table 3 Eviews output results - multiple covariance test

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
C	36306.96	18012.81	2.015619	0.0539
X3	4.971108	0.405659	12.25439	0
X5	8.596208	1.482813	5.797228	0
X6	-1.275054	0.469565	-2.715396	0.0114

(2) Test for heteroscedasticity

Based on the new equation that eliminates multicollinearity, the test for heteroskedasticity is continued. Assuming the existence of homoskedasticity in the model, White test was used and the output is shown in Table 4.

Table 4 Eviews Output Results - Heteroscedasticity Test White's Test

Obs*R-squared	16.67948	Prob. Chi-Square(9)	0.054

Taking α = 0.05, LM = 16.67948 corresponds to a p-value of 0.0540 > α = 0.05, so the assumption of homoskedasticity is valid and the model is considered to be free of heteroskedasticity.

(3) Serial correlation test and correction

The test of serial correlation was continued for the equations and the residual plots were produced to perform an initial test of serial correlation for the equations, resulting in Figure 1.

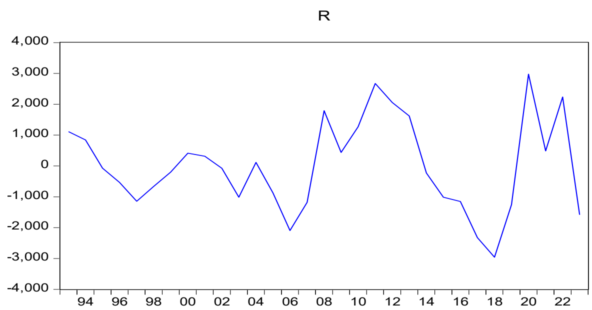

Figure 1 Plot of residuals versus time

According to the residual plot, it can be seen that the estimated value of the random error term presents a sawtooth shape and changes sign with the time major and minor, and it can be preliminarily judged that the equations have serial correlation and are negatively correlated.

On the basis of the previous step, the LM test was used to further test the serial correlation of the equations, and the results of Eviews calculations are shown in Table 5.

Table 5 Eviews output results - Serial correlation test LM test

F-statistic	6.857824	Prob. F(1,26)	0.0145
Obs*R-squared	6.470074	Prob. Chi-Square(1)	0.011
Included observations: 31			

According to the above graph, LM = 6.470074, taking α = 0.05, the p-value is 0.0110 < α = 0.05, so the model is considered to have first order serial correlation.

The original model had serial correlation, so a correction for serial correlation was carried out. The Cochrane-0rcutt iterative method was used to estimate ρ and then the generalised difference method was applied to correct the model. Table 6 was derived.

From the above table, DW=1.794064, <DW=1.794064< , falls in the uncorrelated region.

Table 6 Eviews output - Sequential correlation correction Cochrane-0rcutt iterative approach

Convergence achieved after 8 iterations				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	12196.21	27112.37	0.449839	0.6567
X3	4.433657	0.613	7.232725	0
X5	7.037842	2.326092	3.025608	0.0057
X6	-0.674231	0.706558	-0.954247	0.3491
AR(1)	0.517928	0.200274	2.586096	0.0159
Durbin-Watson stat	1.794064			

Therefore, the model that eliminates serial correlation is:

$$\hat{y} = 12196.21 + 4.433657x_3 + 7.037842x_5 - 0.674231x_6 + [AR(1) = 0.51]$$
$$t \quad (0.4498) \quad (7.2327) \quad (3.0256) \quad (-0.9542) \quad (2.5861)$$
$$R^2 = 0.997642 \quad F\text{ - Statistic} = 2644.564 \quad Prob(F) = 0.000$$

After tests for multicollinearity, heteroskedasticity and serial correlation and corrections, the final model estimate is obtained as:

$$\hat{y} = 12196.21 + 4.433657x_3 + 7.037842x_5 - 0.674231x_6 + [AR(1) = 0.51]$$
$$t \quad (0.4498) \quad (7.2327) \quad (3.0256) \quad (-0.9542) \quad (2.5861)$$
$$R^2 = 0.997642 \quad F\text{ - Statistic} = 2644.564 \quad Prob(F) = 0.000$$

3 Empirical analyses

3.1 Descriptive statistical analysis

Table 7 Eviews Outputs - Descriptive Statistics Outputs

	Gross agricultural product	Per capita disposable income of rural residents	Fertiliser application in agriculture	Effective irrigated area
Mean	40244.65	7555.655	4896.509	59380.78
Maximum	94463.00	21690.87	6022.600	71573.00
Minimum	6963.340	921.6000	3151.900	48727.90
Std. Dev.	27372.64	6345.333	840.4368	7322.796
Sum	1247584.	234225.3	151791.8	1840804.
Observations	31	31	31	31

According to Table 7, 31 observations of Gross Agricultural Product, Per Capita Disposable Income of Rural Residents, Agricultural Fertiliser Application, and Effective Irrigated Area of China for the period 1993-2023 are available:

The mean value of the gross agricultural product is 40244.65, the maximum value is 94,463.00, the minimum value is 6,963.340, and the standard deviation is 27,372.64, which indicates that the national gross agricultural product changes very much in different years, but since the reform and opening up of China in 1978, China has continued to emancipate the productive forces, and the level of agricultural production and the production capacity of agriculture in the early days are weak, which indicates that China's agriculture has been in the last 30 years of rapid development, so the variance is larger.

The average value of disposable income per capita for rural residents is 7555.655, the maximum value is 21690.87, the minimum value is 921.6000, and the standard deviation is 6345.333, which indicates that disposable income per capita for rural residents has grown considerably in different years, and that the standard of living of rural residents has been upgraded.

The mean value of agricultural fertiliser application is 4896.509, the maximum value is 6022.600, the minimum value is 3151.900, and the standard deviation is 840.4368, which indicates that there exists a large growth in the application of fertiliser in China, agricultural cultivation pays more and more attention to the application of fertilisers and the application is getting bigger and bigger, and also because of the popularisation of the state's knowledge of agriculture to the rural residents, China has not been a large-scale The phenomenon of chemical fertiliser abuse has not occurred on a large scale in China.

The mean value of effective irrigated area is 59,380.78, the maximum value is 71,573.00, the minimum value is 48,727.90, and the standard deviation is 7,322.796, which indicates that, with the deepening change of reform and opening up, China's effective irrigated area has achieved a highspeed and high-quality growth, which lays a solid foundation for the defence of food.

3.2 Regression analysis of time series data models

This chapter provides an in-depth discussion on how to use econometric methods to conduct a systematic empirical study on the influencing factors of agricultural gross product. By constructing a scientific econometric model, this paper will examine the relationship between key variables such as agricultural energy consumption, rural population, per capita disposable income of rural residents, total sown area, agricultural fertiliser application, effective irrigated area, and grain production per unit of arable land area, etc., and the agricultural GDP. This process includes the steps of variable selection, model setting, data processing, and model testing.

Data processing is a key step in model building, and this paper first preprocesses the collected raw data, including data cleaning, missing value processing and outlier detection. Then, this paper performs appropriate variable transformations, such as logarithmic transformation, to ensure comparability between variables and deal with potential nonlinear relationships. In addition, correlation analyses are performed to identify potential multicollinearity issues that may need to be addressed through variable screening or model adjustment.

In the model testing stage, this paper will use Eviews software for parameter estimation, including least squares, generalised least squares or ridge regression to find the optimal parameters of the model. In this paper, the explanatory power of the model will be assessed, including calculating the coefficient of determination, adjusting the coefficient of determination and F-statistic to measure the degree of the model's fit to the data. In addition, this paper will perform residual analysis to view the distribution and serial correlation of the residuals to ensure the robustness and validity of the model.

4 Trends in China's gross agricultural product

The future trend of Gross Agricultural Product (GAP) is influenced by a confluence of factors, including technological advances, environmental policies, adjustments in agricultural structure, and global market movements [4]. Based on historical data and existing development trends, this paper allows for the use of econometric modelling to forecast trends in future gross agricultural product, with a view to providing policymakers with a basis for long-term planning.

Progress in agricultural science and technology will continue to be a key driver of agricultural GDP growth. With the rapid development of smart agriculture, biotechnology and precision agriculture, agricultural productivity is expected to increase further, and growth in food production per unit of arable land will become more significant. However, the benefits of technological progress are not linear and may be constrained by factors such as the rate of technology diffusion, farmer acceptance, and financial investment, so projections need to be made with a careful assessment of the pace and breadth of future technological progress.

Environmental policies will have a profound impact on agricultural production methods. With the emphasis on sustainable development and green agriculture, more agricultural policies that encourage low-carbon and environmentally friendly farming are likely to be introduced in the future. This may lead to a reduction in the use of chemical fertilisers and pesticides, which, although it may have an impact on yields in the short term, is conducive to improving soil quality and water resources in the long term, thus having a positive impact on the sustainable growth of the gross agricultural product.

Restructuring of agriculture will be another important engine of growth of the gross agricultural product. With policy guidance and market drive, the production of high value-added agricultural products, such as organic farming and speciality agricultural products, is likely to receive more attention. This will help boost agricultural output and achieve growth in gross agricultural product even when the area under cultivation remains unchanged.

Changes in the global market landscape will also affect China's gross agricultural product. As international trade deepens, China's agricultural exports are likely to continue to grow, especially in the market for high-quality agricultural products. However, uncertainties in the international trade environment, such as trade barriers, exchange rate fluctuations and volatility in international agricultural commodity prices, can have an uncertain impact on agricultural GDP, and projections should take into account the volatility of these external factors.

Constructing an econometric forecasting model incorporating these factors allows this paper to apply historical data for parameter estimation and use the model to simulate forecasts of future gross agricultural product. At the same time, sensitivity analyses make it possible to assess possible changes in agricultural GDP under different scenarios and provide more targeted recommendations for agricultural policymaking. For example, policymakers can formulate strategies for scientific and technological inputs, environmental policies, agricultural restructuring and international trade strategies to cope with possible changes in the future and to ensure stable growth of the gross agricultural product and sustainable development of the agricultural economy.

Forecasting the future trend of China's agricultural GDP requires a combination of factors such as technological advances, environmental policies, agricultural restructuring and global market dynamics. Through the empirical analyses of the econometric model, this paper can provide a strong basis for the formulation of agricultural policies to meet the future challenges and to promote China's agricultural economy to move forward steadily.

5 Analysis of factors affecting China's gross agricultural product

The decrease in the rural population does not mean a decrease in the gross agricultural product. On the contrary, with the rural labour force moving to the cities, the reduction of surplus rural labour actually promotes the improvement of agricultural productivity [5]. The off-farm transfer of the rural labour force has led to a greater concentration of the labour force remaining in the countryside on agricultural production, which has increased output per unit of labour by raising the level of agricultural intensification, thus providing a positive boost to agricultural GDP. According to our econometric model, the transfer of rural labour and the increase in disposable income per capita of rural residents together constitute an important mechanism affecting the gross agricultural product. The increase in per capita disposable income of rural residents not only reflects the results of rural economic development, but also has a significant contribution to the gross agricultural product. As incomes increase, farmers can afford to invest in agricultural technology and equipment, which improves the efficiency of agricultural production; at the same time, higher incomes also mean that farmers are more committed to agricultural production, and they tend to invest in agricultural production for higher returns. In addition, higher incomes are likely to increase farmers' willingness to pursue agricultural education and training, thereby upgrading their agricultural skills, further contributing to an increase in the gross agricultural product.

Agricultural energy consumption plays a crucial role in the agricultural production process, affecting not only productivity but also having a profound impact on the environment. Between 1993 and 2023, China's agricultural energy consumption experienced a shift from traditional biomass to modern fossil fuels, reflecting to some extent the modernisation of agricultural production methods. Through econometric modelling, this paper finds that there is a significant positive correlation between agricultural energy consumption and agricultural GDP, which indicates that rational energy use can effectively promote the growth of agricultural GDP. The increase in agricultural energy consumption reflects the increase in the degree of agricultural mechanisation and electrification, such as the increase in the total power of agricultural machinery, which significantly improves the efficiency of sowing and harvesting crops in the short term, thus directly promoting the growth of agricultural GDP. The increase in agricultural energy consumption reflects the increased mechanisation and electrification of agriculture, such as the increase in the total power of agricultural machinery, which in the short term significantly improves the efficiency of sowing and harvesting crops, thus directly contributing to the growth of agricultural GDP. However, overdependence on fossil energy sources may bring about environmental problems, such as increased greenhouse gas emissions, which may have long-term negative impacts on the environment for agricultural production, thereby constraining the sustained growth of the gross agricultural product (GAP). The use of agricultural biomass, such as biomass power generation and biogas, not only reduces dependence on fossil energy sources, but also enhances the efficiency of agricultural resource utilisation to a certain extent. For example, the energy use of crop waste saves energy and reduces the pressure of waste on the environment, and this "green" pattern of energy consumption contributes to agricultural gross domestic product (GDP) in a long-term, sustainable way. However, the impact of agricultural energy consumption on agricultural GDP is not linear and can be affected by the interaction of technological advances, energy price volatility, and the policy environment. For example, with technological advances, improvements in the efficiency of energy use can lead to larger increases in agricultural GDP while maintaining or slightly increasing agricultural energy consumption. And when energy prices rise, farmers may reduce production costs by using energy more efficiently or by switching to more economical sources of energy, which may also have a complex impact on agricultural GDP

6 Conclusion

Energy consumption in agriculture is a double-edged sword, as it can either drive growth in GDP by increasing productivity or it can affect the sustainability of GDP by creating environmental pressures through inappropriate patterns of energy consumption. Therefore, policymakers should balance the short-term benefits of agricultural production with long-term sustainability when formulating energy policies. Encourage farmers to adopt efficient and environmentally friendly energy use in order to balance the relationship between agricultural energy consumption and gross agricultural product.

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