Analysis of Key Influencing Factors and Policy Recommendations for Agricultural Modernization in Guangdong

Yihang Zhu *

School of Integrated Circuits, Guangdong University of Technology, Guangzhou, China, 510006

* Corresponding Author Email: 3121006155@mail2.gdut.edu.cn

Abstract. In the context of China's push towards agricultural modernization, Guangdong Province faces distinct challenges and opportunities due to globalization and technological advancements. This study identifies five key factors impacting agricultural output in Guangdong: the number of agricultural workers, the area of crops sown, fertilizer usage, agricultural machinery power, and the count of agricultural science and technology personnel. Among these, the personnel dedicated to agricultural science and technology emerge as the most significant, showing a 13% greater impact than the next leading factor, the crop planting area. Conversely, the number of agricultural workers has the least effect. Analysis using the grey correlation method corroborates these findings. However, projections suggest that Guangdong may not meet its 2035 agricultural goals with current policies and development pace. Thus, enhancing the recruitment and training of agricultural science and technology talents is crucial for advancing Guangdong's agricultural modernization and overall agricultural growth.

Keywords: Agricultural Modernization in Guangdong, Multiple Linear Regression Model, Grey Prediction Model, Grey Relativity.

1. Introduction

With the wave of globalization, along with the leap-forward development of technology, agriculture, which was once regarded as a traditional industry, is now standing at the tuyere of transformation. Agricultural modernization is not only the only way to improve production efficiency and ensure national food security, but also related to the optimization of economic structure, the stability of rural society, and the far-reaching impact of sustainable development. Especially in such a populous country as China, the significance of agricultural modernization has been magnified and has become one of the core contents of comprehensively promoting economic development and improving national living standards. As one of the most populous countries in the world, China's rural economy has always played a pivotal role [1]. By 2021, the total output value of the rural economy and related industries will reach CNY 1844.19 billion, an increase of 10.5 % over the previous year, accounting for 16.05 % of GDP. In the same year, the import and export volume of China's agricultural products was USD 304.17 billion, an increase of 23.2 %. Among them, exports were USD 84.35 billion, an increase of 10.9 %, imports of USD 219.82 billion, an increase of 28.6 %, and the trade deficit was US $ 135.47 billion, an increase of 42.9 % [2]. It can be seen from this that as the country's first industry, it is an important industrial sector in the national economy. Taking land resources as the production object, and supporting the construction and development of the national economy has a great binding force on the scale of China's economic construction [3] [4].

In this study, we used a multiple linear regression model [5]. Firstly, the factors affecting the development of agricultural modernization in Guangdong Province are analyzed, so that under the support of data, the influence of various factors on promoting the development of agricultural modernization in Guangdong Province can be seen, so that the government and all parties can speed up the development of agricultural modernization in Guangdong Province. Secondly, the grey prediction model method and its application are introduced to analyze the development trend of various output values of agriculture, forestry, animal husbandry, and fishery in Guangdong Province.

Through the analysis of the predicted values, we can see the development problems and put forward targeted suggestions.

2. Key Factors in Guangdong Agricultural Output

2.1. Research object and variable determination

From a traditional point of view, the development of agriculture and its output value will be affected by the number of agricultural workers, that is, the number of the labor force, but also inseparable from the planting area of crops and the amount of chemical fertilizer application [6]. Under the background of modernization development, mechanization is more and more commonly used in agricultural production and life, and agricultural mechanization has become an important factor affecting agricultural output value. Moreover, science and technology are the primary productive forces and scientific and technological talents also play an increasingly important role in the development of agriculture.

This research delves into the factors influencing agricultural modernization in Guangdong Province, China, by examining the total agricultural output value, which includes agriculture, forestry, animal husbandry, and fisheries. Drawing on existing literature and information sourced from network searches, the study identifies five pivotal factors: the number of agricultural workers, the sown area of crops, the usage of chemical fertilizers, the total power of agricultural machinery, and the quantity of agricultural science and technology personnel. Utilizing data from the Guangdong Statistical Yearbook and the Guangdong Rural Statistical Yearbook spanning 2010 to 2021, the analysis employs both multiple linear regression and grey correlation methods to assess the impact of these variables. The consistency in data sources ensures a reliable evaluation of how these factors contribute to the agricultural sector's modernization in Guangdong, highlighting the province's shift towards a more technologically advanced and scientifically driven agricultural development model.

2.2. Data preprocessing

In this paper, the Guangdong Statistical Yearbook and Guangdong Rural Statistical Yearbook in the Guangdong Statistical Information Network are used as data sources, and data preprocessing is carried out. The data selection years are from 2010 to 2021. However, because the data is not released in some years, the data is missing. This paper will use Matlab to fill in the missing data. The data for Guangdong agricultural chemical fertilizer application amount in 2012 was 241.24 thousand tons, The data for Guangdong agricultural science and technology personnel in 2010 was 3,182 people, in 2011 was 3,246 people, in 2012 was 3,310 people, and in 2013 was 3,374 people.

2.3. Distribution structure of data

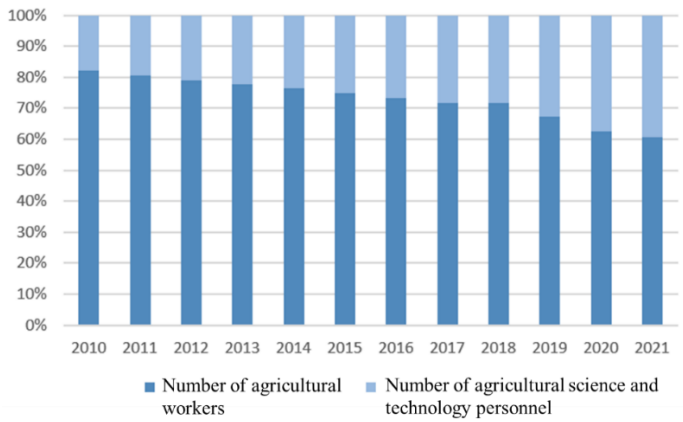

Fig 1. Percentage of agricultural employees and agricultural science and technology accumulation.

Figure 1 shows that the number of agricultural practitioners is decreasing year by year, but the number of agricultural science and technology personnel is increasing year by year, and the

proportion is increasing. To a certain extent, it shows that science and technology are the primary productive forces, and scientific and technological talents are also playing an increasingly important role in the development of agriculture.

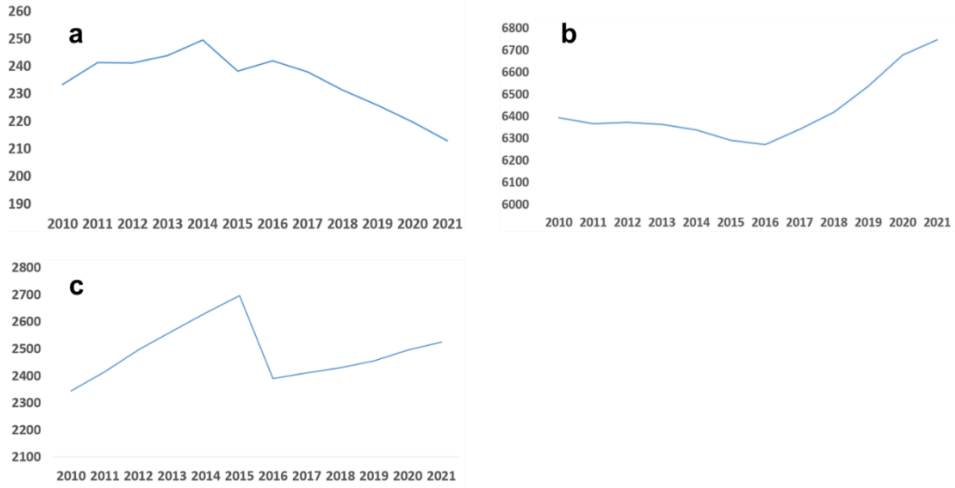

Fig 2. Visualization of the remaining indicators.

Figure 2 Visualization of the remaining indicators. a: chemical fertilizer application rate. b: crop planting area. c: total power of agricultural machinery.

The most representative node is in 2016.After 2016, the amount of chemical fertilizer application decreased year by year, and the sown area of crops increased year by year. It fully shows that the excessive use of chemical fertilizers will also cause eutrophication of soil and water sources, causing environmental pollution and reducing the available sown area. There is a negative correlation between the two.

2.4. Multiple linear regression model

This paper analyzes the factors affecting the total agricultural output value of Guangdong Province by establishing a model, and which factors have the most significant impact. Therefore, before the analysis, it is necessary to select some factors that have a certain impact on it, such as the number of agricultural practitioners, the total power of agricultural machinery, etc., and calculate the regression coefficients of some explanatory variables selected by the multiple linear regression model.

A multiple linear regression model is established by the selected explanatory variables of each influencing factor and the explanatory variables of total exports:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 \quad (1)$$

Among them, Y is the total output value of agriculture, X_1 is the number of agricultural employees, X_2 is the sown area of crops, X_3 is the amount of chemical fertilizer, X_4 is the total power of agricultural machinery, X_5 is the number of agricultural science and technology personnel, β_0 is the regression constant, $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ is the regression coefficient.

Multiple linear regression was performed by SPSS software. The results are shown in the following Table 1:

Table 1. SPSS multiple linear regression results.

Indicator	B	Standard error	Significance	VIF
C	682.774	4229.138	0.876	—
X1	-3.957	0.193	<0.001	3.832
X2	1.395	0.539	0.036	9.833
X3	-3.866	6.602	0.577	8.921
X4	-0.640	0.274	0.052	1.356
X5	0.745	0.148	0.002	9.773

The regression model obtained from the data in Table 1 is:

$$E_T = 682.774 - 3.957X_1 + 1.395X_2 - 3.866X_3 - 0.604X_4 + 0.745X_5 \quad (2)$$

Taking the sown area of crops (X_2) as an example to explain the model, the coefficient before X_2 is 1.395, that is, when other variables remain unchanged, for every unit increase in X_2 value, the total agricultural output value (Y) of Guangdong will increase by an average of 1.395 units. In the significance test of this variable, the corresponding significance is 0.036, less than 0.05, so it is considered that the variable is significant. However, in the significance test of chemical fertilizer application (X_3), the corresponding value is 0.577, which is greater than 0.05. It is considered that the variable is not significant in the model. Similarly, it is considered that the number of agricultural employees (X_1) and the total power of agricultural machinery (X_4) are not significant in the model.

Therefore, through this model, it is found that the sown area of crops (X_2) and the number of agricultural science and technology personnel (X_5) have a significant impact on the total agricultural output value of Guangdong, while the number of agricultural employees (X_1), the amount of chemical fertilizer applied (X_3) and the total power of agricultural machinery (X_4) have no significant impact on the total agricultural output value of Guangdong.

Establish a standardized equation:

$$Y = -0.603X_1 + 0.152X_2 - 0.030X_3 - 0.041X_4 + 0.293X_5 \quad (3)$$

From the results, taking the number of agricultural science and technology personnel as an example (X_5), the standardized coefficient of this variable is 0.293, which is the largest among all standardized coefficients. Therefore, the impact of the number of agricultural science and technology personnel (X_5) on Guangdong's total agricultural output value (Y) is the largest among these five explanatory variables.

R^2 test of the model are as shown in Table 2:

Table 2. R2 test results of multiple linear regression model.

R	R^2	Adjusted R^2
0.999	0.998	0.997

It can be seen from the regression results that R^2 is 0.998, and the adjusted R^2 is 0.997, indicating that these five independent variables can explain 99.7 % of the dependent variables, so the fitting optimization of the model is very good.

2.5. Grey correlation model

Substitute into the correlation formula [7]:

$$\begin{cases} \xi_i(k) = \dfrac{\min\limits_i \max\limits_k |X_0(k) - X_i(k)| + \rho \max\limits_i \max\limits_k |X_0(k) - X_i(k)|}{|X_0(k) - X_i(k)| + \rho \max\limits_i \max\limits_k |X_0(k) - X_i(k)|} \\ r_{0i} = \dfrac{1}{5} \sum_{k=1}^{5} \xi_i(k) \end{cases} \quad (4)$$

The correlation coefficient diagram of the grey correlation model is shown in Figure 3:

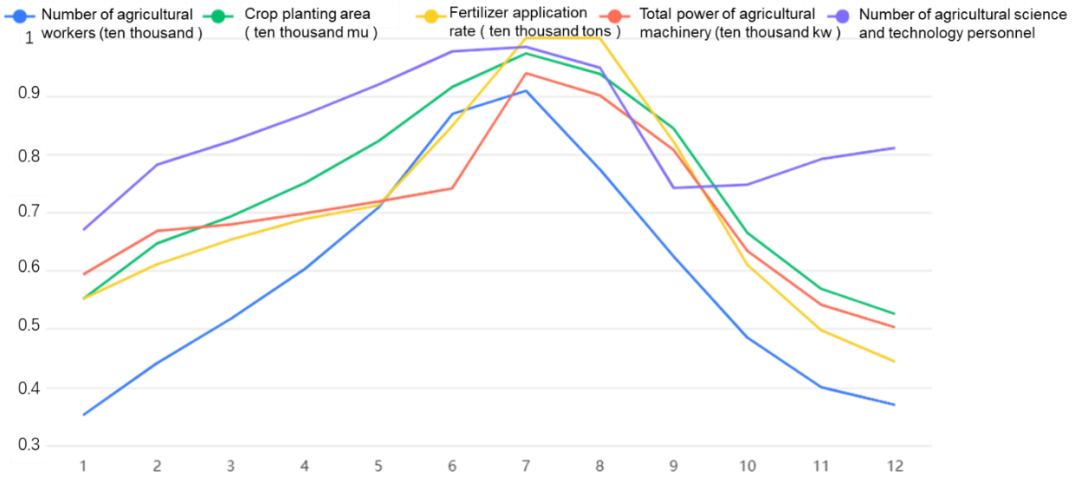

Fig 3. Grey relational model correlation coefficient diagram.

The results of the grey correlation coefficient are as shown in Table 3:

Table 3. Correlation degree results of the grey correlation model.

Appraisal Items	Degree of Association	Rank
Number of agricultural science and technology personnel	0.839	1
Crop planting area	0.742	2
Fertilizer application rate	0.703	3
Total power of agricultural machinery	0.702	4
Number of agricultural workers	0.588	5

The correlation coefficient represents the number of agricultural practitioners in the subsequence, the area sown by crops, the amount of fertilizer applied, the total power of agricultural machinery, the number of agricultural science and technology personnel, and the correlation degree value on the corresponding dimension of the parent sequence. The larger the number, the stronger the correlation [8].

Combined with the results of the correlation coefficient, the correlation value is finally obtained. Among them, the largest correlation with the total output value of agriculture, forestry, animal husbandry, and fishery is the number of agricultural science and technology personnel, and the smallest correlation with the total output value of agriculture, forestry, animal husbandry, and fishery is the number of agricultural employees.

3. Grey Forecast Reveals Difficulties in Agricultural Progress

3.1. The establishment of the grey correlation prediction model

In the 14th Five-Year Plan for the development of the forestry industry in Guangdong Province, it is clear that by 2025, the total output value of the forestry industry in Guangdong Province will reach 1 trillion yuan. In the '14th Five-Year Plan' for the development of modern animal husbandry in Guangdong Province, it is clear that by 2025, the total output value of animal husbandry should be greater than or equal to 180 billion yuan. In the 'Opinions on Accelerating the High-quality Development of Modern Fisheries' of Guangdong Province, it is proposed that by 2025, the total economic output value of fishery in Guangdong Province will reach more than 450 billion yuan [9].

Based on the obtained data, we will predict the sub-industries of agriculture, forestry, animal husbandry, and fishery in Guangdong Province, and predict whether Guangdong Province can complete the indicators by 2025 [10].

3.2. Grey correlation model prediction results

The grey model of agricultural output value time series, forestry output value time series, animal husbandry output value time series, and fishery output value time series are constructed respectively. The specific results are as shown in Table 4:

Table 4. Grey prediction model relative error results table.

Index Entry	Agricultural output value relative error (%)	Forestry output value relative error (%)	Animal husbandry output value relative error (%)	Fishery output value relative error (%)
2010	0	0	0	0
2011	1.195	0.963	11.491	0.058
2012	1.319	2.363	7.047	1.127
2013	1.715	0.15	1.071	0.292
2014	0.176	2.875	5.365	2.772
2015	2.176	0.864	5.301	1.322
2016	0.801	0.46	0.499	1.844
2017	2.224	0.487	13.629	1.202
2018	3.033	1.431	19.94	0.363
2019	2.836	1.118	5.168	2.048
2020	1.943	6.677	13.765	1.557
2021	0.796	4.775	6.834	1.148

From Table 4, the average relative error of agricultural output value is 1.518 %, the average relative error of forestry output value is 1.847 %, the average relative error of animal husbandry output value is 7.509 %, and the average relative error of fishery output value is 1.144 %, which means that the model fitting effect is good.

Based on the model obtained above, the data from 4 years after predicting the output value of agriculture, forestry, animal husbandry, and fishery in Guangdong are as shown in Figure 4 [11]:

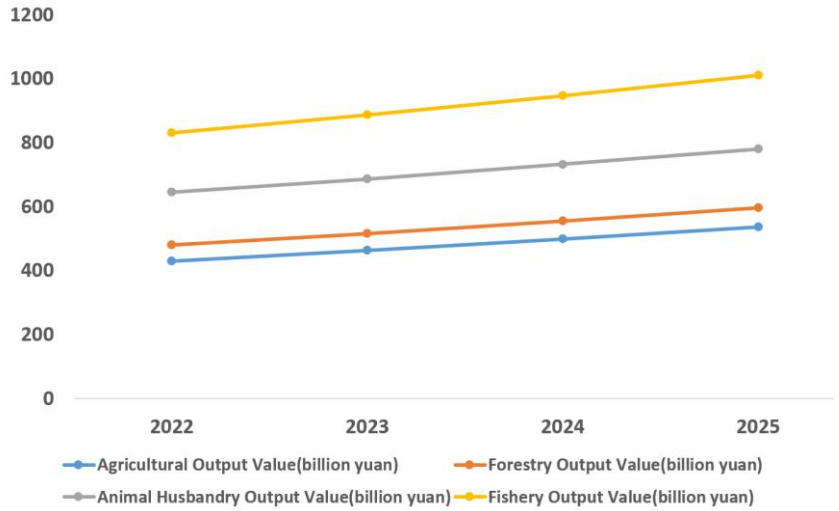

Fig 4. Trend chart of output value prediction of agriculture, forestry, animal husbandry, and fishery from 2022 to 2025.

Table 5. Prediction of output value of agriculture, forestry, animal husbandry, and fishery from 2022 to 2025.

Industry Output	2022	2023	2024	2025
Agricultural Output Value (billion yuan)	429.1388	462.4114	498.2637	536.8957
Forestry Output Value (billion yuan)	50.2557	53.4312	56.7077	60.0883
Animal Husbandry Output Value (billion yuan)	164.9825	170.9558	177.0331	183.2164
Fishery Output Value (billion yuan)	185.7518	199.7581	214.8204	231.0185

From Table 5, it can be seen that in 2025, the predicted value of agricultural output value is 536.8957 billion yuan, the predicted value of forestry output value is 600.883 billion yuan, the predicted value of animal husbandry output value is 183.2164 billion yuan, and the predicted value of fishery output value is 231.0185 billion yuan. Compared with the indicators of Guangdong's '14th Five-Year Plan', the predicted values have not been reached. Therefore, at the current development speed, Guangdong has a long way to go to complete the task of '14th Five-Year' agricultural indicators. The following will study the influencing factors of agricultural modernization development and make recommendations based on the results.

4. Conclusions

4.1. Analysis of the key factors affecting

Agricultural practitioners (X_1): The per capita arable land area of agricultural practitioners in China is relatively small, and it is difficult to promote mechanized production on a large scale during the farming process, resulting in a long-term low per capita total output value. China's national conditions show a decrease in the marginal productivity of labor caused by the surplus of the rural labor force [12].

The sown area of crops (X_2) has an important impact on the gross agricultural production. According to the results of multiple regression, the standardized coefficient is 0.152, which has a positive correlation with the total agricultural output value. In addition, the amount of chemical fertilizer (X_3) is also an important factor, the reason may be that the excessive use of chemical fertilizer will also make the soil and water eutrophication, causing environmental pollution, and its use has an obvious marginal decreasing tendency, resulting in marginal results are not significant [6]. However, the use of chemical fertilizers can effectively improve soil fertility, effectively increase crop nutrition, and have a positive impact on increasing food production and increasing total agricultural output value.

Agricultural mechanization (X_4): mechanized mass production is a sign of the progress of modern agriculture, reflecting the degree of development of agricultural infrastructure. However, its impact on the total output value of agriculture is not great, so the country's attention to the development of agriculture should not be too much on the development of large mechanization.

The number of agricultural science and technology personnel (X_5): agricultural science and technology personnel to promote the transformation of agricultural scientific and technological achievements, to carry out agricultural production services 'conventional army', but also the closest to the farmers, the most popular a talent team of farmers. Whether this team is strong or not is directly related to agricultural efficiency, farmers' income increase, and the implementation of a rural revitalization strategy. Under the background of today's era, we should not only do a good job in the construction of agricultural science and technology talent teams but also play a good role in agricultural science and technology personnel to ensure the overall harvest of agriculture [12].

4.2. Policy proposal

The country should increase employment support for farmers, further promote the construction of new countryside, transfer the rural surplus labor force through urbanization, and eliminate obstacles for farmers to enter cities, to ensure the transfer of the rural surplus labor force and further improve the employment system of farmers.

It is necessary to keep the area of agricultural production and strictly control the occupation of cultivated land by non-agricultural construction. The reward and punishment system of cultivated land protection should be implemented to strengthen the control and supervision of cultivated land occupied by non-agricultural construction. At the same time, we should not blindly expand the agricultural planting area to avoid the occurrence of soil erosion.

The way out of agriculture lies in modernization, and to build modernization, fundamentally speaking, is to liberate the agricultural labor force from the heavy and inefficient manual labor,

through modern machinery and equipment to improve agricultural productivity and economic benefits, to improve the income of agricultural workers.

It is necessary to establish an incentive mechanism for grassroots agricultural science and technology personnel so that agricultural technology promotion can truly become a decent profession. At the same time, we should encourage communication between agricultural science and technology personnel, encourage more excellent middle and senior agricultural science and technology personnel to display their talents in the agricultural field, enhance the pertinence, and send technology and ideas according to the actual situation of each village, to truly make scientific and technological personnel go door to door, and direct good seeds and good methods to the field [12].

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