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Empirical study on factors influencing farmers' income in Zhaoqing City

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Abstract

A significant portion of farmers' income comes from the primary industry. Based on time series data from 1985 to 2020, this study empirically examines the relationship between farmers' real income in Zhaoqing City and the actual output value of agriculture, forestry, animal husbandry, fishery, and service industry using methods such as unit root test, cointegration analysis, elimination of multicollinearity, and elimination of serial correlation. The results show that:

- Animal husbandry and fishery have no significant impact on farmers' real income in Zhaoqing City;
- Agriculture, forestry, and the agricultural, forestry, animal husbandry, and fishery service industry have a significant impact on farmers' real income in Zhaoqing City. Specifically, for every 100 million yuan increase in the output value of agriculture, farmers' per capita disposable income increases by an average of 0.0717%; for every 100 million yuan increase in the output value of forestry, farmers' per capita disposable income increases by an average of 0.1056%; for every 100 million yuan increase in the output value of the agricultural, forestry, animal husbandry, and fishery service industry, farmers' per capita disposable income increases by an average of 0.0858%;
- The impact has a significant positive effect with a lag of 3 years. Based on the research findings, some policy recommendations are provided.

Keywords: Zhaoqing City; Farmer income; Time series data; Cointegration analysis

1. Introduction

In recent years, China's rural economy has made significant progress, and the income level of farmers has also increased. However, compared to urban residents, there is still a large income gap for farmers. This not only restricts the improvement of rural residents' living standards but also affects the sustainable development of the rural economy. Therefore, it is of great significance to conduct in-depth research on the factors influencing farmers' income and explore effective ways to increase farmers' income in order to promote rural economic development and achieve rural modernization.

As an important agricultural base in Guangdong Province, Zhaoqing City's level of farmers' income has always been a concern. However, there is still relatively little research on the factors influencing farmers' income in Zhaoqing City, especially a lack of empirical research. Therefore, this study aims to explore the factors influencing farmers' income in Zhaoqing City through empirical analysis, providing scientific basis for the formulation of targeted rural development policies.

The significance of this study lies in providing experience and reference for rural development in Zhaoqing City and similar areas, as well as providing scientific decision-making basis for government departments and decision-makers.

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At the same time, this study also contributes to enriching the theory of rural economics and providing new perspectives and methods for rural economic research.

2. Literature Review

2.1. Research on Foreign Literature

Ronald Aylmer Fisher (1925) introduced the concepts of significance testing and p-values, proposing a probabilistic approach to assess the significance of differences between observed data and hypotheses [1]. John William Tukey (1949) first proposed methods to eliminate serial correlation [2]. Dickey and Fuller (1979) developed the Dickey-Fuller test, which examines whether a time series has a unit root, providing important insights into unit root problems in time series analysis and economics [3]. Engle and Granger (1987) introduced the concept of cointegration and its impact on time series analysis, providing a framework for modeling and analyzing non-stationary data using error correction models (ECMs) [4]. Stein Holden, Bekele Shiferaw, and John Pender (2004) emphasized the importance of non-farm economic development and sustainable land management in promoting rural development and reducing poverty in disadvantaged areas [5].

2.2. Domestic Literature Research

Zhou Han (2021) found that improving agricultural production technology, strengthening rural infrastructure construction, and improving rural financial services contribute to the increase of per capita income of Chinese farmers [6]. Cao Yonghui (2016) conducted empirical analysis and found that farmers' income is influenced by multiple factors such as agricultural technology, infrastructure, and education level, providing important references for rural development [7]. Li Qingling (2016) studied the factors affecting farmers' income and effective countermeasures, including improving farmers' agricultural technology, strengthening market information dissemination and agricultural product marketing to increase farmers' income level [8]. Chen Yiyu and Fu Yuanyuan (2014) reviewed the influencing factors and countermeasures of farmers' income, including land use, agricultural technology, market environment, policy support, etc., and proposed measures such as strengthening land management, promoting agricultural technology, improving market environment, and providing policy support to increase farmers' income level [9]. Yu Xinping et al. (2010) found that the development of rural finance in China has a positive impact on the growth of farmers' income, and proposed strategies and measures such as improving the rural financial system, strengthening financial services, and innovating financial products, which are of great significance for promoting rural economic development and increasing farmers' income [10].

Wang Dong (2008) studied the current situation of farmers' income and proposed suggestions such as strengthening agricultural industrialization, promoting economic structural adjustment, enhancing financial services, and providing farmer training to improve farmers' income and promote rural economic development [11]. Zhu Mingyuan (2009) researched the constraints and countermeasures for increasing farmers' income, including improving land resource utilization efficiency, agricultural technology level, and agricultural product market system to promote rural economic development [12]. Zhao Lejun (2008) conducted surveys and analysis and concluded that the main reasons for slow growth in farmers' income are low agricultural technology level, large fluctuations in agricultural product prices, and insufficient market competitiveness of farmers. Measures such as strengthening technical training, establishing stable price mechanisms, and improving market competitiveness were proposed [13]. Wu Qilun (2008) found that farmers' income is influenced by various factors, including agricultural production technology, market demand, and agricultural policies. A series of strategies were proposed, including improving agricultural production technology, strengthening market regulation mechanisms, and optimizing agricultural policies to increase farmers' income and promote rural economic development [14]. Ma Yiqun and Kong Tingting (2019) found that agricultural technological progress has a positive impact on farmers' income, but the effect of labor force transfer on narrowing the income gap of farmers is limited. Therefore, it is necessary to pay attention to the comprehensive impact of both factors [15].

2.3. Literature Review and Critique

The foreign literature listed here mainly proposes new concepts, introduces new research methods, and provides a new research framework. Of course, there are also studies on practical problems. Most of the domestic literature focuses on the actual problems of China's "three rural issues". There are various factors that affect farmers' per capita income, such as agricultural production technology level, rural infrastructure construction, rural financial services, rural education level, market information transmission, agricultural product marketing, agricultural product price fluctuations, farmers' market competitiveness, market demand, agricultural policies, agricultural industrialization, land resource utilization efficiency, agricultural product market system, and labor force transfer. These literature enrich the database and also have a certain reference value for the formulation of policies related to the "three rural issues". However, there are very few literature studies on the factors influencing farmers' income in Zhaoqing City using empirical methods. Therefore, studying it has practical significance.

3. The current situation of farmers' income and the total output value of agriculture, forestry, animal husbandry, fishery, and agricultural, forestry, animal husbandry, and fishery services in Zhaoqing City

3.1. The income of farmers in Zhaoqing City continues to grow

As a traditional agricultural city in Guangdong Province, Zhaoqing has always aimed to achieve agricultural growth benefits, increase farmers' income, and promote sustainable agricultural development. It has been driving continuous development reforms in agriculture and maintaining a good development trend. Since the reform and opening up in 1978, Zhaoqing has gradually introduced an economic system reform led by the household contract responsibility system. The household contract responsibility system empowers farmers with the right to independent operation, greatly stimulating their initiative and enthusiasm. Some farmers actively utilize their professional expertise and develop new production methods, becoming key households and professional households in various industries. They pursue good economic benefits and play an important role in various stages of production, promoting diversified operations.

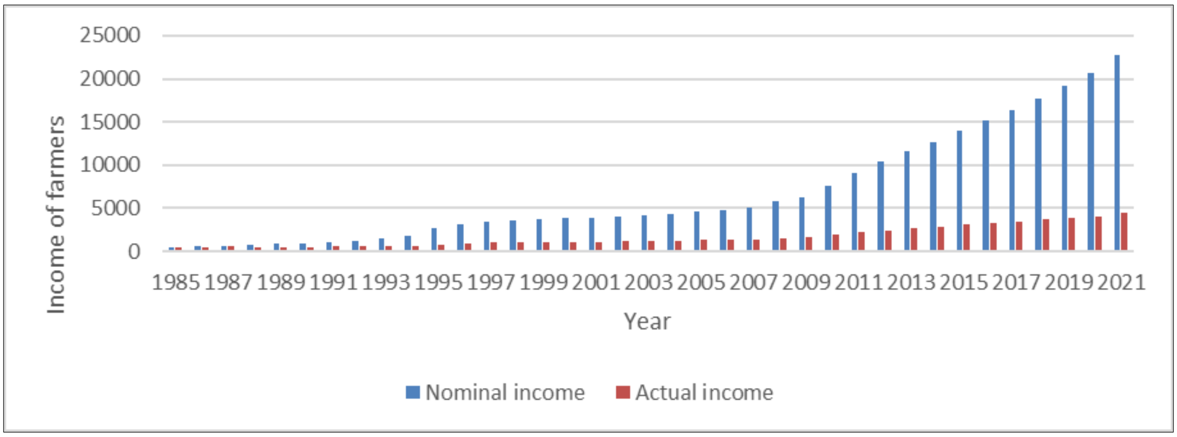

Figure 1 Histogram of nominal and real income of farmers in Zhaoqing City from 1885 to 2021(Unit: yuan)

In the process of agricultural modernization and the construction of new rural areas, the income of farmers in Zhaoqing City has continued to increase. According to the heights of the bars in Figure 1, the whole process can be roughly divided into three stages: the first stage from 1985 to 1995, the second stage from 1996 to 2008, and the third stage from 2009 to 2020.

In the first stage from 1985 to 1995, farmers' income grew rapidly, especially during this stage, farmers' income saw a significant improvement. The per capita nominal income of farmers in Zhaoqing City maintained a stable growth trend, increasing from 474 yuan in 1985 to 2682 yuan in 1995, a growth of 4.658 times, with an average annual growth rate of 46.58%. During the same period, the per capita real income increased from 474 yuan in 1985 to 801 yuan in 1995, a growth of 0.6899 times, with an average annual growth rate of 6.899%. The growth of farmers' income in this stage benefited from the beginning of reform and opening up, the significant increase in agricultural output, the improvement of agricultural product prices, and the rapid development of various enterprises.

In the second stage, from 1996 to 2008, the per capita disposable income of farmers in Zhaoqing City showed a growth trend, but the growth rate was not significant. The per capita nominal income of farmers increased from 3062 yuan in 1996 to 5872 yuan in 2008, a growth of 0.9177 times, with an average annual growth rate of 7.65%. During the same period, the per capita real income increased from 880 yuan in 1996 to 1500 yuan in 2008, a growth of 0.7045 times, with an average annual growth rate of 5.87%. The nominal and real growth rates in this stage were lower than before, indicating that the growth of farmers' income was hindered to some extent. This may be due to restrictions on agricultural production, which directly or indirectly affected farmers' per capita income. Therefore, it is necessary to take corresponding measures to accelerate the recovery of agricultural production in order to alleviate the problem of decreasing nominal income of farmers.

In the third stage, from 2009 to 2021, the nominal income of farmers in Zhaoqing City experienced significant growth, increasing from 6291 yuan in 2009 to 22689 yuan, a growth of 2.6066 times, with an average annual growth rate of 11.85%. During the same period, the per capita real income increased from 1643 yuan in 2009 to 4445 yuan in 2021, a growth of 1.7054 times, with an average annual growth rate of 7.75%. During this period, farmers' income showed a steady upward trend, and the growth rate also began to stabilize and improve. This is due to the city adopting a development strategy at the level of modernization, significantly improving the comprehensive technical content of agricultural products, and the economy gradually stabilizing and rising. Therefore, farmers' income has also shown a steady upward trend.

3.2. The nominal and actual total agricultural output in Zhaoqing City has experienced fluctuating growth

The nominal total agricultural output value of Zhaoqing City increased from 72,969 million yuan in 1985 to 3,214,166 million yuan in 2021, an increase of 43.05 times. Adjusted by the agricultural production price index of Zhaoqing City (1978=100) for the same period, the actual total agricultural output value of Zhaoqing City increased from 54,453.5 million yuan in 1985 to 205,937.1 million yuan in 2021, an increase of 2.78 times. From the information in Figure 2, it can be concluded that during the same period, the line representing the actual total agricultural output value is more stable compared to the line representing the nominal total agricultural output value, while the line representing the nominal total agricultural output value shows more dramatic changes.

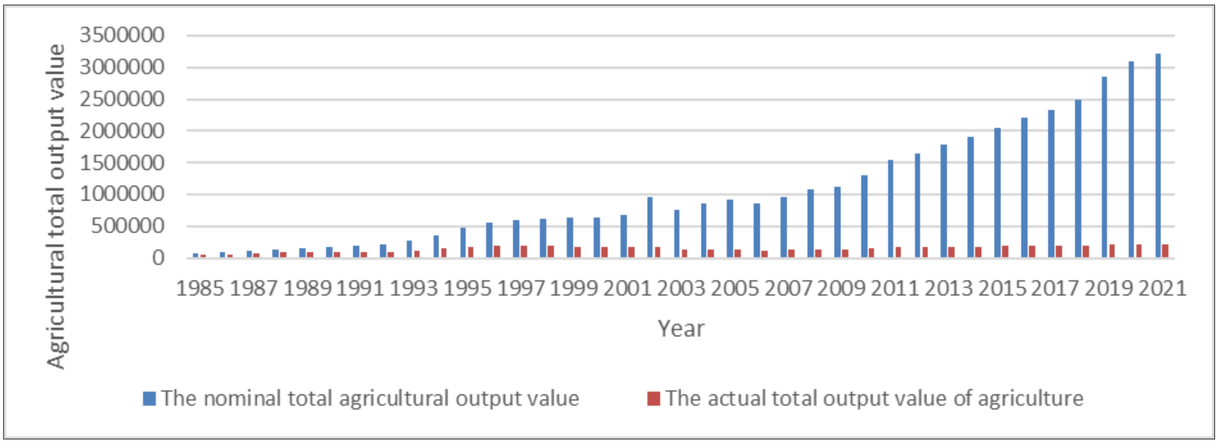

Figure 2 Histogram of the nominal and actual total agricultural output value in Zhaoqing City from 1885 to 2021 (Unit: ten thousand yuan)

3.3. The nominal total output value and actual total output value of the forestry industry in Zhaoqing City have shown overall growth.

The nominal total output value of forestry in Zhaoqing City increased from 213.12 million yuan in 1985 to 10,704.16 million yuan in 2021, a growth of 49.23 times. Adjusting for the forestry production price index (1978=100) during the same period, the actual total output value of forestry in Zhaoqing City increased from 1,485.28 million yuan in 1985 to 6,537.62 million yuan in 2021, a growth of 3.40 times. From the information in Figure 3, it can be concluded that both indicators show a growth trend, but the actual total output value of forestry has a more stable fluctuation.

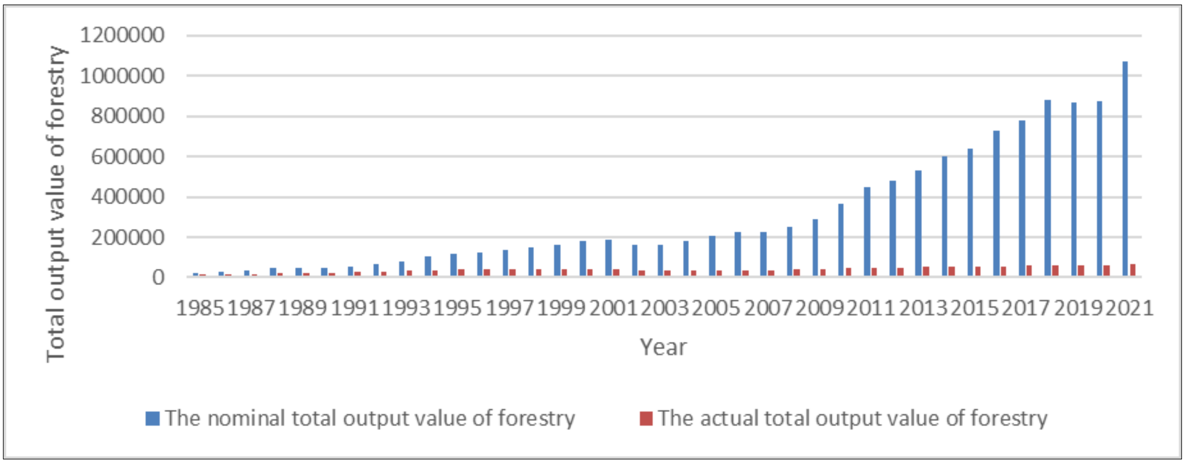

Figure 3 Histogram of the nominal and actual total output value of forestry in Zhaoqing City from 1985 to 2021 (Unit: ten thousand yuan)

3.4. The nominal and actual total output value of animal husbandry in Zhaoqing City has experienced fluctuating growth

The nominal total output value of animal husbandry in Zhaoqing City increased from 37,709,000 yuan in 1985 to 1,689,879,000 yuan in 2021, an increase of 43.8 times. Adjusted by the animal husbandry production price index (1978=100) of the same period, the actual total output value of animal husbandry in Zhaoqing City increased from 17,303,000 yuan in 1985 to 140,160.3 million yuan in 2021, an increase of 7.1 times. Based on the information in Figure 4, it can be concluded that both have a growing trend, but the actual total output value of animal husbandry has a more stable fluctuation.

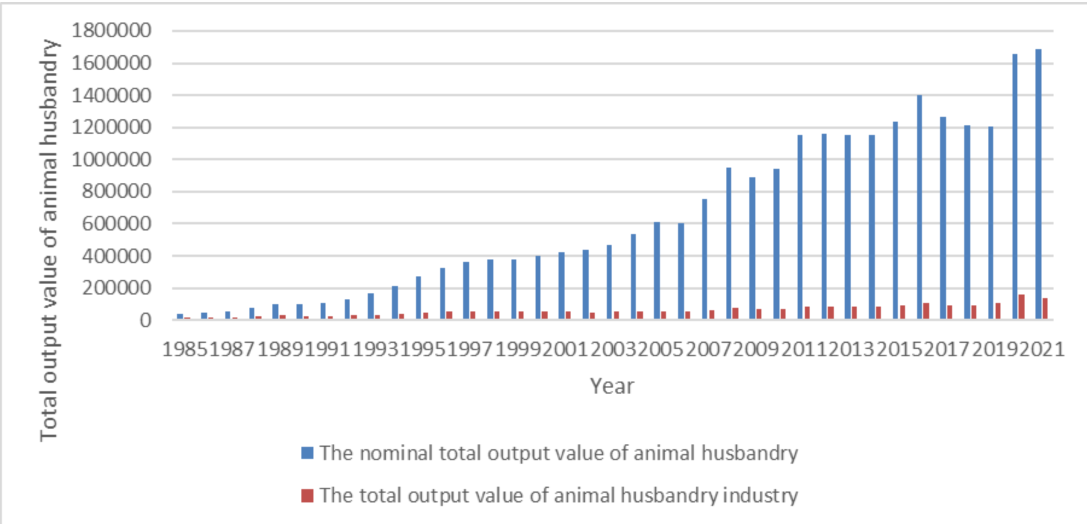

Figure 4 Histogram of the nominal and actual total output value of animal husbandry in Zhaoqing City from 1985 to 2021 (Unit: ten thousand yuan)

3.5. The nominal and actual total output value of the fishery industry in Zhaoqing City has been continuously increasing

The nominal total output value of the fishery industry in Zhaoqing City increased from 71.94 million yuan in 1985 to 9.14167 billion yuan in 2021, an increase of 126.1 times. Adjusted by the agricultural production price index of Zhaoqing City (1978=100) for the same period, the actual total output value of agriculture was obtained. The actual total output value of the fishery industry in Zhaoqing City increased from 12.611 million yuan in 1985 to 39.006 million yuan in 2021, an increase of approximately 2.1 times. The information in Figure 5 clearly shows that both have a growing trend, but the fluctuation of the fishery industry's actual total output value is more stable.

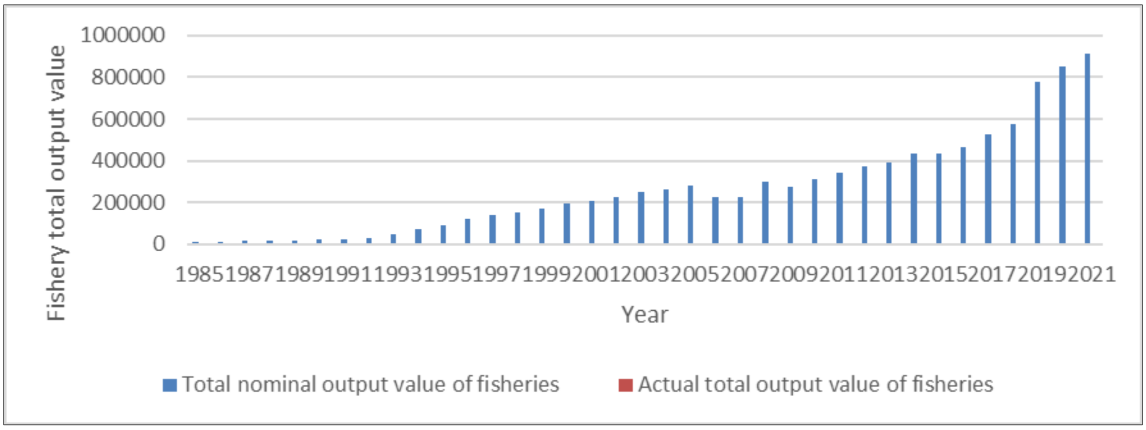

Figure 5 Histogram of the nominal and actual total output value of the fishery industry in Zhaoqing City from 1985 to 2021 (Unit: ten thousand yuan)

3.6. The nominal and actual total output value of the agricultural, forestry, animal husbandry, and fishery service industry in Zhaoqing City has been continuously increasing

The nominal total output value of the agricultural, forestry, animal husbandry, and fishery services in Zhaoqing City increased from 14,236,000 yuan in 2003 to 328,879,000 yuan in 2021, an increase of 22.1 times. Adjusting for the agricultural, forestry, animal husbandry, and fishery services production price index (2003=100) for the same period, the actual total output value of the agricultural, forestry, animal husbandry, and fishery services in Zhaoqing City increased from 14,236,000 yuan in 2003 to 56,397,900 yuan in 2021, approximately tripling. From the information in Figure 6, it can be concluded that both of them show a growth trend, but the actual total output value of the fishery industry has a more stable fluctuation.

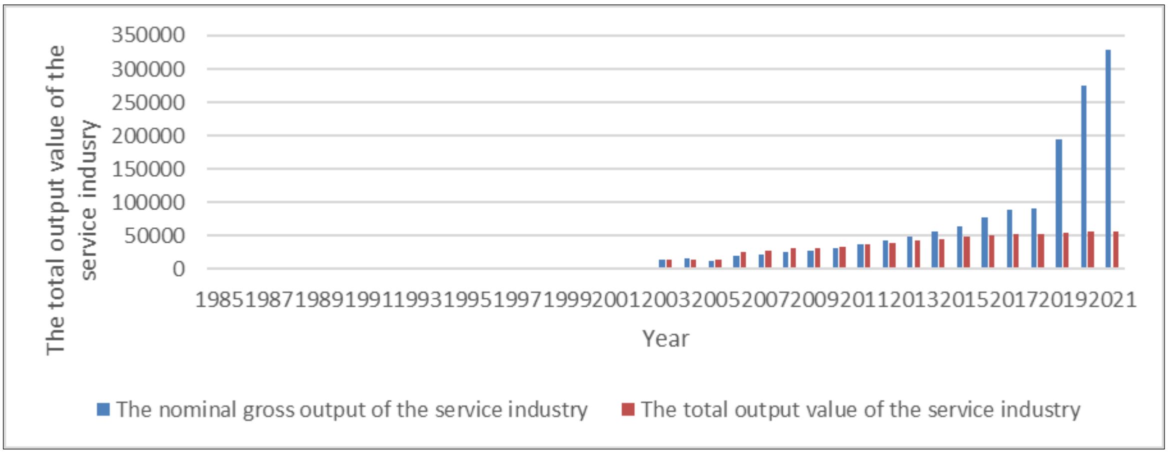

Figure 6 Histogram of the nominal and actual output value of the agricultural, forestry, animal husbandry, and fishery services industry in Zhaoqing City from 1985 to 2021 (Unit: ten thousand yuan)

3.7. The actual income of farmers in Zhaoqing City is increasing in line with the trend of the actual total output value of the primary industry

The information in Figure 7 clearly shows that the actual total output value of agriculture and animal husbandry has fluctuated and increased between 1985 and 2021. The actual total output value of forestry, fisheries, and services has grown more steadily. The actual income of farmers in Zhaoqing City has continuously and steadily increased. In conclusion, the actual total output value of agriculture, forestry, animal husbandry, fisheries, and agricultural, forestry, and animal husbandry services in Zhaoqing City has a common trend of growth with the actual income of farmers.

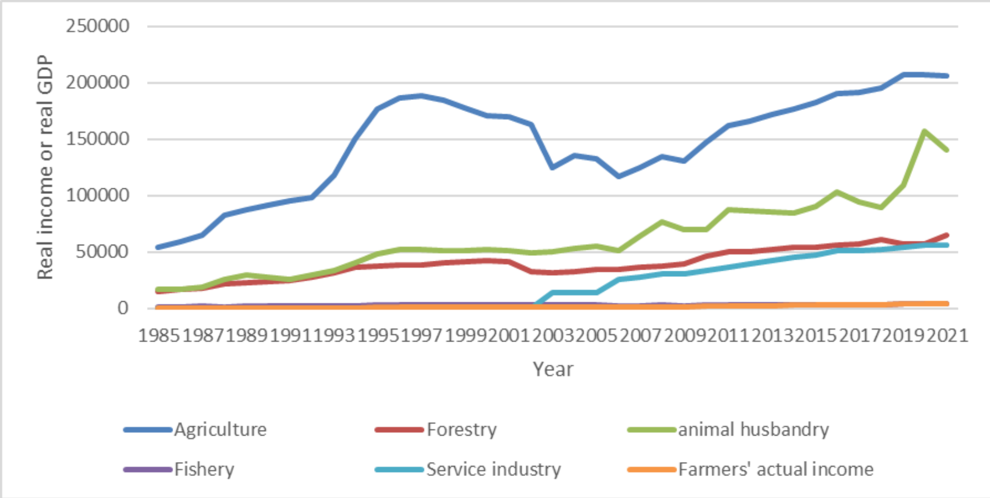

Figure 7 The actual total output value of the first industry and the actual income of farmers in Zhaoqing City from 1985 to 2021

4. Data sources and data processing

4.1. Data sources

The nominal total output value of agriculture, forestry, animal husbandry, fishery, and agricultural, forestry, animal husbandry, and fishery services in Zhaoqing City from 1985 to 2021 is sourced from the Statistical Yearbook of Zhaoqing City 2022. The disposable income of farmers in Zhaoqing City from 1985 to 2021 is also sourced from the Statistical Yearbook of Zhaoqing City 2022, and this indicator is also calculated at current prices. The combined data is presented in Annex 1.

The production price index for agriculture, forestry, animal husbandry, fishery, and agricultural, forestry, animal husbandry, and fishery services in Zhaoqing City from 1985 to 2021, as well as the CPI index for the same period, are also sourced from the 2022 Statistical Yearbook of Zhaoqing City. The CPI index is relative to the previous year.

4.2. Data processing

Take the CPI of Zhaoqing City in 1985 as the base and set it as 100. Then convert the relative CPI index from 1986 to 2021 to the CPI index based on 1985. Combine it with the production price index of agriculture, forestry, animal husbandry, fishery, and agricultural, forestry, animal husbandry, and fishery services in Zhaoqing City during the same period to obtain Annex 2.

Based on the CPI index with 1985 as the base year, the disposable income of farmers in Zhaoqing City from 1985 to 2021, calculated at current year prices, is converted into real income. The nominal total output value of agriculture, forestry, animal husbandry, fisheries, and agricultural, forestry, animal husbandry, and fishery services in Zhaoqing City from 1985 to 2021 is divided by their respective production price indices, resulting in the real total output value. These data are combined with the data of farmers' real income in Table 3, which is used for modeling. The unit for farmers' real income is yuan, while the unit for the real total output value of agriculture, forestry, animal husbandry, fisheries, and agricultural, forestry, animal husbandry, and fishery services is 100 million yuan.

5. Empirical research

5.1. Unit root test

In order to ensure the reliability of the regression analysis, it is necessary to conduct stationarity tests on the variables to prevent the occurrence of "spurious regression". In this study, we choose to use the Augmented Dickey-Fuller test (ADF test) for stationarity testing. The test results are shown in Table 1.

Table 1 ADF Test Results for Variables

Testing variables	Type verification	ADF statistic	Critical values of ADF at a significant level			D.W value	P-value	Test results
	(C,T,K)		1%	5%	10%			
Y	(0,0,1)	3.36734	-2.63269	-1.95069	-1.61106	1.9767	0.9996	unstable
ΔY	(0,0,1)	0.14071	-2.63473	-1.95100	-1.61091	1.7503	0.7204	unstable
lnY	(C,T,2)	-3.47859	-4.25288	-3.54849	-3.20709	1.7005	0.0579	unstable
ΔlnY	(C,T,9)	-5.81752	-4.35607	-3.59503	-3.23346	2.5309	0.0004	stable*
X1	(C,0,3)	-2.00645	-3.64634	-2.95402	-2.61582	1.8212	0.2828	unstable
ΔX1	(0,0,0)	-3.76816	-2.63269	-1.95069	-1.61106	2.0810	0.0004	stable*
X2	(0,0,0)	2.62954	-2.63076	-1.95039	-1.61120	1.4302	0.9972	unstable
ΔX2	(C,0,0)	-4.15788	-3.63290	-2.94840	-2.61287	1.7423	0.0026	stable*
X3	(0,0,2)	3.73214	-2.63473	-1.95100	-1.61091	2.1681	0.9999	unstable
ΔX3	(C,0,1)	-7.58166	-3.63941	-2.95113	-2.61430	2.1180	0.0000	stable*
X4	(C,0,0)	-1.83289	-3.62678	-2.94584	-2.61153	2.2613	0.3592	unstable
ΔX4	(C,0,0)	-6.67754	-3.63290	-2.94840	-2.61287	1.7957	0.0000	stable*
X5	(C,0,0)	-1.23503	-3.85739	-3.04039	-2.66055	2.2490	0.6351	unstable
ΔX5	(C,0,0)	-4.52535	-3.88675	-3.05217	-2.66659	2.0746	0.0028	stable*

Note: (C, T, K) represents the constant term, trend term, and lag order used in the test; P-value represents the probability of accepting the null hypothesis. Δ represents first-order difference. *, #, & represent the ADF critical values at the 1%, 5%, and 10% confidence levels.

From the test results in Table 1, it can be observed that the original series Y, X1, X2, X3, X4, and X5 are all non-stationary in their respective test forms and at a significance level of 5%. ΔY and lnY are also non-stationary at a significance level of 5%. However, the first-difference series ΔX1, ΔX2, ΔX3, ΔX4, ΔX5, and ΔlnY are all stationary in their respective test forms and at a significance level of 1%.

5.2. Model Construction

According to the conditions of cointegration modeling, if the dependent variable and the explanatory variables have the same order of stationarity, then cointegration can be used for modeling. lnY, X1, X2, X3, X4, and X5 are all first-order integrated series, therefore, lnY is chosen as the dependent variable and X1, X2, X3, X4, and X5 are chosen as the explanatory variables. The cointegration model is constructed as follows (Model 1):

$$\ln Y=C+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+\varepsilon \quad \text{………..} \ (1)$$

Among them, C is the constant term, β1-β5 are the estimated parameters; lnY represents the logarithm of farmers' actual income, X1, X2, X3, X4, and X5 represent the actual total output of agriculture, forestry, animal husbandry, fisheries, and agricultural, forestry, animal husbandry, and fishery services, respectively; ε is the random disturbance term, which represents the sum of all factors not listed in the model.

5.3. E-G cointegration test

Adopt the E-G two-step method for cointegration test.

In the first step, estimate the parameters of the model. Use the least squares estimation method and the data of actual income of farmers, agriculture, forestry, animal husbandry, fisheries, and the actual total output value of agricultural, forestry, animal husbandry, and fishery services in Zhaoqing City from 1985 to 2021 to estimate the parameters of the cointegration model, as shown in cointegration model (2).

$$\ln Y= 5.761547+ 0.059474X1+0.112241X2+0.002732X3+0.202077X4+0.097593X5 \quad \text{………..}(2)$$

T= (71.967) (3.853) (3.240) (0.423) (0.333) (3.637)

R^2= 0.996496， F= 739.4338， DW= 2.437079， N=19。

Step 2: Conduct a stationarity test on the residual sequence. Extract the residuals from the above equation and denote them as "e". The results of the ADF unit root test on the residuals "e" are shown in Table 3.

Table 2 ADF unit root test for residuals

Testing variables	Type verification	ADF statistic	Critical values of ADF at a significant level			D.W value	P-value	Test results
	(C,T,K)		1%	5%	10%			
e	(0,0,1)	-6.13652	-2.7081	-1.9628	-1.6061	1.6318	0.0000	stable*

Note: (C, T, K) represents the constant term, trend term, and lag order used in the test; P-value represents the probability of accepting the null hypothesis. Δ represents first-order difference. * represent the ADF critical values at the 1% confidence levels.

From Table 2, it can be seen that the critical value at the 1% significance level is greater than the ADF statistic value, and the p-value is less than 1%. Therefore, at the 1% significance level, the residual sequence e is stationary. Thus, the explanatory variable lnY has a long-term stable relationship with the explanatory variables X1, X2, X3, X4, and X5, passing the cointegration test.

5.4. Multicollinearity Test and Correction

5.4.1. Multicollinearity Test

From the cointegration model (2), it can be seen that the T-statistics for X3 and X4 are 0.423 and 0.333, respectively, and their absolute values are less than 2. Therefore, they fail to pass the significance test for the variables at a 5% significance level. However, the F-statistic is 739.4338, indicating that the cointegration model (2) is significant as a whole. This suggests that there may be multicollinearity in the cointegration equation.

5.4.2. Multicollinearity Correction

Below is the use of stepwise regression to eliminate multicollinearity in a cointegration model.

The first step is to find the base equation. Taking lnY as the dependent variable and X1, X2, X3, X4, and X5 as the independent variables, we can obtain five simple linear regression models, with corresponding R2 values of 0.611884, 0.883203, 0.882430, 0.694469, and 0.950871. Based on the principle of maximizing R2, we can determine that the base equation is lnY = f(X5). Thus, we have the base equation (3):

lnY=6.561015+0.307053X5 …………… (3)

T= (95.446) (18.139)

R^2=0.950871, Adjusted R^2=0.947981,SC=-1.493616,N=19.

Step 2: Introduce an explanatory variable X1 into the base equation, transforming the model into a bivariate linear regression model lnY=f(X5, X1). In other words, the base equation becomes the regression equation (4).

lnY=5.847905+0.082718X1+0.139186X5…………… (4)

T = (79.773) (10.375) (8.020)

R^2= 0.993642, Adjusted R^2= 0.992848, SC= -3.383460, N=19.

Due to the increase in R^2 from 0.947981 to 0.992848, it has become larger. SC has decreased from -1.493616 to -3.383460, indicating a decrease. Additionally, the absolute values of the T-statistics for all explanatory variables are greater than 2, indicating statistical significance. Therefore, the explanatory variable X1 should be retained in the regression equation.

Step 3: Adding explanatory variable X2 to the model lnY=f(X5, X1), the model becomes a multiple linear regression model lnY=f(X5, X1, X2), that is, regression equation (4) becomes regression equation (5).

lnY= 5.774098+ 0.066241X1+ 0.105150X2+0.097208X5…………… (5)

T = (94.055) (8.341) (3.346) (5.261)

R^2= 0.996360, Adjusted R^2= 0.995632, SC= -3.786049, N=19.

Due to the adjusted R^2 from 0.992848 to 0.995632, the adjusted R^2 has increased; SC has decreased from -3.383460 to -3.786049, indicating a smaller value. Additionally, the T-statistics for the explanatory variables X5, X1and X2 are 5.261, 8.341 and 3.346, respectively. All T-statistics for the explanatory variables have absolute values greater than 2, indicating their significance in the regression equation. Therefore, the explanatory variable X2 should be retained in the regression equation.

Step 4: Adding explanatory variable X3 to the model lnY=f(X5, X1, X2) results in a four-variable linear regression model lnY=f(X5, X1, X2, X3). In other words, regression equation (5) becomes regression equation (6).

lnY= 5.777151+ 0.063547X1+ 0.111281X2+0.003665X3+ 0.092081X5 …………… (6)

T = (92.017) (6.985) (3.331) (0.650) (4.508)

R^2= 0.996466, Adjusted R^2= 0.995457,SC= -3.660810,F= 986.9598,N=19.

Due to the adjusted R^2 from 0.995632 to 0.995457, the adjusted R^2 has decreased; SC has increased from -3.786049 to -3.660810; and the T-statistic for X3 is 0.650002, indicating that it does not pass the variable significance test. Therefore, the explanatory variable X3 cannot be retained in the regression model.

Step 5: Adding explanatory variable X4 to the model lnY=f(X5, X1, X2) transforms the model into a four-variable linear regression model lnY=f(X5, X1, X2, X4). In other words, regression equation (5) becomes regression equation (7).

lnY=5.751105+0.058862X1+0.109058X2+0.313367X4+0.103733X5…………… (7)

T = (77.842) (3.947) (3.324) (0.590) (4.739)

R^2=0.996448, Adjusted R^2=0.995433,SC=-3.655643,F=981.8549,N=19.

Due to the adjusted R^2 has decreased from 0.995632 to 0.995433, indicating a smaller value. SC has increased from -3.786049 to -3.655643, indicating a larger value. Additionally, the T-statistic for X4 is 0.590, indicating that it does not pass the significance test for variables. Therefore, explanatory variable X4 should not be retained in the regression model.

After going through the above five steps, the final regression equation that eliminates multicollinearity is regression equation (5).

lnY= 5.774098+ 0.066241X1+ 0.105150X2+0.097208X5……………(5)

T = (94.055) (8.341) (3.346) (5.261)

R^2=0.996360, Adjusted R^2=0.995632, SC=-3.786049, F=1368.493, DW= 2.276439, N=19.

5.5. Testing and Correction of Sequence Correlation

5.5.1. Testing for sequence correlation

Based on the information from regression equation (5), it can be concluded that there is no first-order serial correlation. However, this does not imply the absence of higher-order serial correlation. By using the LM test, the results shown in Table 3 indicate the presence of higher-order serial correlation.

Table 3 Results of LM test

Obs*R-squared	8.781749	Prob.Chi-Square(2)	0.0124
Obs*R-squared	8.825582	Prob.Chi-Square(3)	0.0317
Obs*R-squared	8.828408	Prob.Chi-Square(4)	0.0655

Based on the information in Table 3, it can be concluded that at a significance level of 5%, the model exhibits a significant 3rd order autocorrelation, while the 4th order autocorrelation is not significant. Therefore, the model has a maximum 3rd order autocorrelation at a significance level of 5%.

5.5.2. Correction of sequence correlation

Applying the generalized difference method to eliminate model autocorrelation yields the following results:

lnY= 5.728674+0.071650X1+0.105567X2+0.085771X5+0.608578AR(3)……... (8)

T = (93.521) (6.442) (2.824) (6.100) (2.453)

R^2= 0.997601, Adjusted R^2= 0.996678, SC= -3.819937, F= 1081, DW= 2.210777, N=19.

Based on the above results, it can be seen that since F=1081.017, it can pass the F-test; since the absolute values of the T-statistics for X1, X2, and X5 are all greater than 2, and the absolute value of the AR(3) T-statistic is also greater than 2, therefore, at a significance level of 5%, they can all pass the variable significance test, that is, X1, X2, X5, and AR(3) are all independent variables, thus passing the multicollinearity test; DW=2.210777, it is around 2, so there is no serial correlation in this model, it passes the serial correlation test; the sample can explain 99.7601% of the overall variation; therefore, the optimized model is the best model.

6. Conclusion

The following conclusions can be drawn from the above optimal model:

- At the 5% significance level, the explanatory variables of animal husbandry (X3) and fisheries (X4) do not have a significant impact on the logarithm of the dependent variable, farmers' actual income (lnY).
- At a significance level of 5%, the explanatory variables Agriculture (X1), Forestry (X2), and Services (X5) have a significant impact on the logarithm of the dependent variable Farmer's Actual Income (lnY). Furthermore, on average, for every 1 billion yuan increase in the actual total output of Agriculture, Forestry, and Services, Farmer's Actual Income is expected to increase by 0.0717%, 0.1056%, and 0.0858% respectively.
- Although the actual total output of the variable animal husbandry (X3) and fisheries (X4) does not have a significant impact on the logarithm of the variable farmer's actual income (lnY) at the current level of 5% significance, it does have a significant positive impact with a lag of 3 years.

Policy Recommendation

Based on the findings of the optimal model, the following policy recommendations can be made:

- First, strengthen the development of agriculture, forestry, and agricultural and forestry services. As the actual total output value of agriculture, forestry, and agricultural and forestry services has a significant impact on farmers' actual income, the government can take measures to promote the development of these industries, such as providing financial support, technical training, and market expansion.
- Second, pay attention to the development of animal husbandry and fisheries. Although the actual total output value of animal husbandry and fisheries does not have a significant impact on farmers' actual income in the current period, it has a positive and significant impact after a lag of 3 years. Therefore, the government can formulate relevant policies to encourage farmers to engage in animal husbandry and fisheries, provide necessary support and protection, and promote the growth of farmers' income.
- Third, improve the efficiency of agricultural and forestry services. The actual total output value of agricultural and forestry services has a significant impact on farmers' actual income. The government can improve the

efficiency and quality of service industry, provide better services and support, and help farmers increase their income.

- Fourth, strengthen agricultural structural adjustment and transformation and upgrading. Considering the impact of the actual total output value of agriculture, forestry, and agricultural and forestry services on farmers' actual income, the government can encourage farmers to carry out agricultural structural adjustment and transformation and upgrading, promote the upgrading and optimization of agricultural industries, and improve farmers' income levels.

In conclusion, based on the findings of the optimal model, the government can promote the development of agriculture, forestry, and agricultural and forestry services, prioritize the growth of animal husbandry and fisheries, enhance the efficiency of agricultural and forestry services, and implement measures to adjust and upgrade the agricultural structure. These actions will contribute to the increase in farmers' actual income.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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