Regression Analysis on the Influencing Factors of Total Value of Agricultural Output in Sichuan Province

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Abstract. Regression analysis method was used in this research, and six variables of total agricultural machinery power, applying quantity of chemical fertilizer, total sown area, per capita GDP, agricultural population, and rural electricity consumption were selected to analyze the main factors affecting the total value of agricultural output of Sichuan. It is suggested that we should continue to increase the technical input and research and development in agricultural production, and improve the quality of land and improve the agricultural land sustainability. Only in this way can the growth of total agricultural output value of Sichuan Province be effectively promoted, thus promoting the economic development of Sichuan Province. This paper has reference value for the prediction on how to enhance the total value of agricultural output of Sichuan Province with different factor inputs.

Keywords-agricultural development; total value of agricultural output; sustainability; regression analysis

1. INTRODUCTION

The factors affecting the growth of total value of agricultural output in Sichuan were taken as the research object in this research. The data cleaning and standardization processing were performed. Also, based on the six variables affecting the total agricultural output value from 2005 to 2019, the principal component analysis (PCA) used to reduce the dimensionality of these data, this research made a regression analysis after two mutually independent common factors to obtain regression equation of the prediction model. And the accuracy of the equation has been tested.

2. MODEL BUILDING AND VARIABLE SELECTION

2.1 Modeling

The main factor that affects total value of agricultural output also is not identical due to different regions, different periods. [1] Liu Yan (2018) came up with the main influencing

ICEMME 2022, November 18-20, Nanjing, People's Republic of China

DOI 10.4108/eai.18-11-2022.2326763

factors of agricultural development in Yanbian Prefecture are land, capital, technology and system; [2] Xiao Huimin, Zhu Xianglin (2017) used multi-factors linear regression to figure out that the agricultural development of China is mainly affected by the total population, [3] the total power of agricultural machinery, financial support for agriculture and the amount of agricultural chemical fertilizer input.

Sichuan has a lot of advantages: it has vast plain, ample sunshine, concentrated precipitation, fertile land, large population, developed agriculture, and steadily growing economic aggregate. Hence, combining the previous studies of scholars and the characteristics of Sichuan Province, the vast plain is a favorable benefit for mechanized production and the expansion of sown area, and the use of agricultural machinery and rural hydropower construction will foster the rural electricity consumption. Ample sunshine, rainfall and fertile soil makes for higher agricultural production andper capita GDP. Hence, this paper assumes that the total value of agricultural output of Sichuan Province is affected by the total agricultural machinery power, applying quantity of chemical fertilizer, total sown area, per capita GDP, agricultural population, and rural electricity consumption.

It is assumed that the total value of agricultural output of Sichuan Province conforms to a $Y = X\beta + \varepsilon$ regression model with the six selected variables. Set total value of agricultural output as Y, the number of independent variables affecting the dependent variable Y as x1, x2…, xp, that is, set total agricultural machinery power (0,000 kilowatts), applying quantity of chemical fertilizer (0,000 tons), total sown area (000 hectares), per capita GDP (RMB / person), agricultural population (0,000 persons), and rural electricity consumption (000,000,000 kilowatt hour) as X1, X2, X3, X4, X5, and X6.

2.2 Data sources

[4] Data from Sichuan Statistical Bulletin of National Economic and Social Development (2005-2019) and Sichuan Statistical Yearbook (2005-2019). For the sake of improving the accuracy of the regression model, the original data have been preprocessed and standardized.

3. DATA ANALYSIS

3.1 Abbreviations and Acronyms

The six variables selected in this paper have different degrees of influence on the total value of agricultural output of Sichuan Province. The purpose of dimensionality reduction in this paper is to use a few factors to describe the relationship between the six variables in factor analysis and principal component analysis, and to group the closely related variables into one category (one common factor), thereby reducing the variables of the regression model, improving the efficiency of data processing, and finding out the variables that have a greater impact on the total agricultural output value of Sichuan Province.

3.1.1 KMO and Bartlett sphericity test

In general, factor analysis shall not be performed if the P value of KMO is below 0.5, and it is generally acceptable if the P value is more than 0.5. The KMO value herein is 0.669, close to 0.7 and greater than 0.5; In addition, the Sig value of Bartlett's spherical test is 0, less than

0.05, thus it is considered that variables have significant correlations. To sum up, there is correlation between the six selected variables, which is suitable for factor analysis. As shown in Table 1.

TABLE 1 KMO AND BARTLETT TEST

KMO Bartlett's Test		
KMO measure of sampling adequacy		.669
Bartlett Sphericity Degree Test	Approximate chi-square	160.312
	Degree of freedom	15
	Significance	.000

3.1.2 Correlation analysis

The value range of correlation coefficient R: $|R| \leq 1$, when the absolute value of R approaches 1, the correlation between variables is more significant; otherwise, the correlation is less significant. Seen from |R|, per capita GDP and rural electricity consumption and total power of agricultural machinery | R | were 0.974 and 0.983 respectively, both approximating 1, a positive correlation. Thus, per capita GNP can be increased by increasing the total mechanical power. Similarly, applying quantity of chemical fertilizer and agricultural population |R| is 0.914, approximating 1, a negative correlation. Thus, [5] it can be inferred that excessive use of chemical fertilizers and pesticides cause pollution of land and crops, which will affect the health of permanent residents and cause some people to move to livable areas. Per capita GDP, total agricultural machinery power, and rural electricity consumption are in significant positive correlation, the | R | of which are 0.974 and 0.997 respectively, both approximating 1. To be specific, when per capita GNP increases, the total agricultural machinery power and rural electricity consumption increase simultaneously.

3.1.3 Total variance explained

Given that the initial unrotated common factor does not stand out as a representative variable in the factor loading matrix. Hence, the load matrix is rotated to get a new interpretation of the total variance. The explanatory cumulative variance of the first two common factors to the total value of agricultural output of Sichuan Province was 91.173, greater than 85%, and the Eigenvalue was all larger than 1. Therefore, extracting the first two common factors can better explain the information contained in the 6 original variables to achieve the purpose of dimensionality reduction.

In Scree plot, an inflection points with an eigenvalue greater than 1 appears at 2, which shows that the main common factors affecting the total value of agricultural output of Sichuan Province are two. As shown in Figure 1.

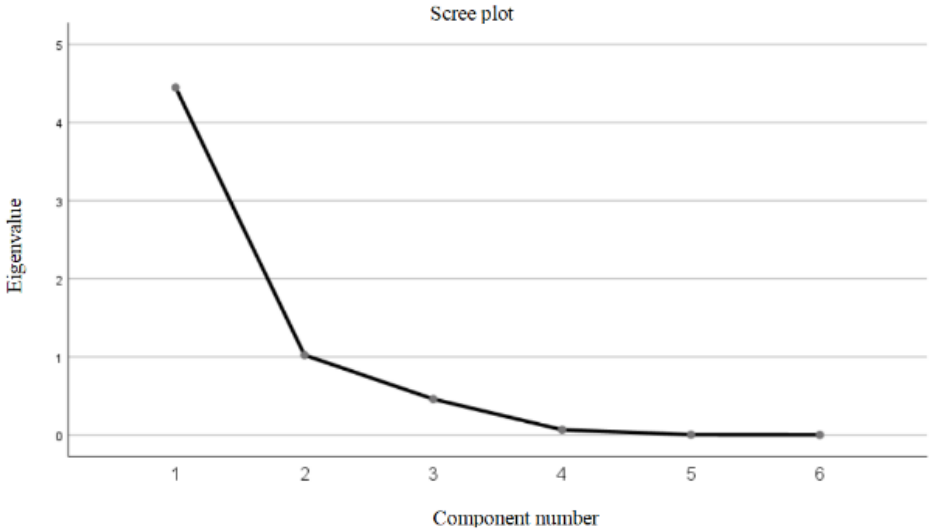

Figure 1. Scree Plot.

3.1.4 Rotation factor analysis

It uses principal component analysis to extract factor loading. The common factor 1 shows a large load on the total agricultural machinery power, the sown area of crops, the per capita GDP and the rural electricity consumption. It indicates that these four variables can be grouped into one group and there is a large correlation between them. These 4 variables mainly reflect the technology input factors on the growth of total value of agricultural output from a practical point of view, so the first common factor is named "technology input"; Common factor 2 has a large load on the applying quantity of chemical fertilizer and agricultural population, so these two variables are divided into the second category, mainly reflecting the quality of land and the situation of land development and utilization in an economic sense. Therefore, the second common factor is named as "agricultural land sustainability". As shown in Table 2.

TABLE 2 COMPONENT MATRIX AFTER THE ROTATION [A]

	Ingredients	
	1	2
Total agricultural machinery power (0,000 kilowatts)	.925	.313
Applying quantity of chemical fertilizer (0,000 tons)	.174	.958
Total sown area (000 hectares)	.821	.069
Per capita GDP (RMB / person)	.861	.472
Agricultural population (0,000 persons)	-.384	-.906
Rural electricity consumption (000,000,000 kilowatt hour)	.882	.422

Extraction method: PCA (principal component analysis) method

Rotation method: Caesar normalized varimax. [a]

a. The rotations converge after 3 iterations.

For the sake of dimensionality reduction, two common factors were used to represent the original variables, and the scores of the six original variables in the two common factors were calculated. Based on Table 3, specific expressions for principal component 1 and principal component 2 can be extracted:

$$F1=0.925X1+0.174X2+0.821X3+0.861X4-0.384X5+0.882X6$$

$$F2=0.313X1+0.958X2+0.069X3+0.472X4-0.906X5+0.422X6$$

From the two formulas above, the comprehensive scoring formula of the components can be obtained -- influencing factor model of total value of agricultural output in Sichuan Province:

$$F=53.801/91.173 * FAC1\_2 + 37.372 / 91.173 * FAC2\_2$$

TABLE 3 COMPONENT SCORE COEFFICIENT MATRIX

	Ingredients	
	1	2
Total agricultural machinery power (0,000 kilowatts)	.343	-.111
Applying quantity of chemical fertilizer (0,000 tons)	-.260	.617
Total sown area (000 hectares)	.380	-.247
Per capita GDP (RMB / person)	.254	.024
Agricultural population (0,000 persons)	.137	-.504
Rural electricity consumption (000,000,000 kilowatt hour)	.283	-.019

Extraction method: PCA (principal component analysis) method
Rotation method: Caesar normalized varimax.
Component Score (Coefficient Matrix).

The absolute value of the total agricultural machinery power in principal component 1 is higher than that in principal component 2. Therefore, the total power of agricultural machinery should be attributed to the first common factor. By the same token, total sown area, per capita GDP, and rural electricity consumption are all in the first factor, they're all positively correlated; The applying quantity of chemical fertilizer and agricultural population is the second factor. The amount of fertilizer applied to crops was positively correlated with the second factor. The opposite is true for agricultural populations. Hence, the original six variables can be integrated into two factors, namely, technical factor and agricultural land sustainability. The annual component scores F1 and F2 for the two factors were calculated. It provided the basis for regression analysis.

3.2 Multiple regression analysis

After reduction of dimensionality, set total value of agricultural output as Y, F1 of the principal component and F2 of the principal component 2 in the previous factor analysis were set as independent variables, it was set the total agricultural output value of Sichuan Province conforms to a regression model of $Y = F\beta + \varepsilon$ with F1 and F2 variables. Similarly,

$\varepsilon \sim N(0,\sigma^2)$, $\beta_0, \beta_1, \beta_2, \cdots \beta_p, \sigma^2$ is an unknown parameter unrelated to F1 and F2, which a constant in the regression model. The linear regression equation between total value of agricultural output of Sichuan and two main common factors established (wherein the ε is random error):

$$y = \beta_0 + \beta_1 F_1 + \beta_2 F_2 + \varepsilon$$

Judging from F test, the significance of F test parameters was 0, that is, P value was less than 0.05, indicating that there was a significant difference between the two common factors, and F test passed. As shown in Table 4.

TABLE 4 F TEST

Model		Quadratic sum	Degree of freedom	Mean square	F	Significance
1	Regression	18842141.491	2	9421070.746	143.535	.000[b]
	Residual	787631.150	12	65635.929		
	Total	19629772.642	14			

a. Dependent variable: Total value of agricultural output (RMB 00,000,000)

b. Predictor variable: (Constant), REGR factor score 2 for analysis 1, REGR factor score 1 for analysis 1

From the T test, the constant term and the T value of both factors are greater than 2, and P=0<0.05. If there is a significant difference between the two factors, the t test is passed. It can be seen that the above two factors are significantly related to the total value of agricultural output of Sichuan. As shown in Table 5.

TABLE 5 COEFFICIENT [A]

Model		Non-standardized coefficient		Standardized coefficient	t	Significance	Collinearity statistics	
		B	Standard error	Beta			Tolerance	VIF
1	(Constant)	2674.981	66.149		40.439	.000		
	REGR factor score 1 for analysis 1	1021.094	68.471	.862	14.913	.000	1.000	1.000
	REGR factor score 2 for analysis 1	550.667	68.471	.465	8.042	.000	1.000	1.000

a. Dependent variable: Total value of agricultural output (RMB 00,000,000)

DW test was performed on the regression model, before the adjustment, R2= 0.960. The adjusted R2= 0.953 is close to 1, indicating that the model fits well. Besides, DW test residual sequence correlation shows that DW=2.208 is close to 2, which indicates that the residuals are

independent of the variables. Residual sequence is not correlated, DW test passed. As shown in Table 6.

TABLE 6 TMODEL SUMMARY [B]

Model	R	R-square	R-square after adjustment	Error in Standard Estimation	Durbin-Watson
1	.980[a]	.960	.953	256.1950998	2.208

a. Predictor variable: (Constant), REGR factor score 2 for analysis 1, REGR factor score1 for analysis 1

a. Dependent variable: Total value of agricultural output (RMB 00,000,000)

The final collinearity diagnosis was performed on the whole model. Table 5 shows that the (tolerance) of the two common factors VIF is 1, and the value of VIF is between 0 and 1. The larger the value is, there is no multi-collinearity in each dimension. According to condition index, if the constant, factor 1 and factor 2 are all less than 10, there is no multi-collinearity in each dimension (As shown in Table 7). Taken together, collinearity diagnosis passed.

TABLE 7 COLLINEARITY DIAGNOSIS [A]

Model	Dimension	Eigenvalue	Conditional indicator	Variance proportion		
				(Constant)	REGR factor score 1 for analysis 1	REGR factor score 2 for analysis 1
1	1	1.000	1.000	.50	.33	.17
	2	1.000	1.000	.00	.35	.65
	3	1.000	1.000	.50	.32	.18

a. Dependent variable: Total value of agricultural output (RMB 00,000,000)

In conclusion, regression model of total value of agricultural output of Sichuan Province: y=1021.094F1+550.667F2+2674.981.

3.3 Result analysis

As can be seen from the above model, total value of agricultural output, technology input, and agricultural land sustainability in Sichuan Province are directly proportional. Among them, the technical input has the greatest influence on the total agricultural output value in Sichuan. When other normalized factors remain unchanged, the total value of agricultural output increases by 1021.094 units for each unit increase of technology input. The total value of agricultural output increases by 550.667 units when the sustainable use of agricultural land increases by 1 unit.

Overall speaking, total power of agricultural machinery, applying quantity of chemical fertilizer, and agricultural population are the most important factors affecting the total value of agricultural output in Sichuan Province, which represent technical factors and agricultural land sustainability, respectively. In other words, in recent 14 years, the technology and land sustainability are the leading forces in gross output growth in Sichuan Province. In this regard, units concerned should continue to increase the input of technical factors and improve the

sustainable development of agricultural land, effectively promote the mechanization of agricultural production, lengthen agricultural land use efficiency and life, thus achieving the growth of agricultural output value of Sichuan Province, enhancing the agricultural development and economic growth of Sichuan Province.

4. COUNTERMEASURES AND SUGGESTIONS

4.1 Improve the mechanization and scale level of agricultural production in Sichuan Province

Promote the mechanization and standardized production of large areas of farmland in Sichuan Province, enhance investment and research in agricultural production technology and raise the technical level of agricultural development, thus effectively improving the output of existing arable land, and accelerating the realization of agricultural modernization. First of all, it is required to introduce the purchase or manufacture of advanced agricultural mechanized production tools in the hope of enhancing the efficiency of agricultural workers in sowing, fertilizing, weeding, pest controlling and harvesting crops, and thus liberating the labour force of agricultural workers. In this way, they can invest in technical learning. Second, it is suggested to strengthen the cooperation of production, education and research in agricultural production development, and learn the latest theoretical results of research on improving the total agricultural output value and the technical results of research on agricultural enterprises. [1] In rural areas with high hollowing degree, land may be transferred to agricultural enterprises or large agricultural households in villages in the form of subcontract, long-term transfer or lease, thus making land contract right to be able to flow inside county area limit. Also, the homestead reform may also be conducted, and the elements can be turned into capital, thus realizing agricultural scale management.

4.2 Improve the efficiency of land use and the quality of cultivated land

According to correlation analysis, the amount of chemical fertilizer and the agricultural population are negatively co-related. Excessive use of chemical fertilizers and pesticides will do harm to the land and crops. Too much chemical fertilizers and pesticides may pollute water sources through irrigation or infiltration of land, seriously affecting people's health and even causing cancer. For this sake, advocating green ecological agriculture, sustainable agricultural land, forbidding the use of highly toxic chemical fertilizers and pesticides that cause serious pollution, and improving soil, breed better varieties, and using new environmentally friendly fertilizers and pesticides on the basis of protecting existing arable land from pollution damage. Crop waste such as straw, peony vine and wheat root should be forbidden to be burned, for they can be used to nourish the soil.

It is suggested to advocate agricultural workers to reclaim wasteland actively and increase the available arable land, give recognition and material incentives to good doers, improve the supervision mechanism of land use to prevent the reduction of cultivated area or the preemptive commercial use of cultivated areas, reasonably distribute the area of cultivated land where crops are planted and used, and enhance the efficiency of farming and land use efficiency. It is also of paramount importance to increase the propaganda and education of

protecting cultivated land, in this way, all the rural residents are expected establish the consciousness of protecting cultivated land.

4.3 Figures and Tables

It is concluded from the model that the agricultural land sustainability is an important factor affecting the total value of agricultural output of Sichuan Province, and there is a negative correlation between agricultural population and agricultural land sustainability. The sustainability of the land decreases with the increase of the agricultural population. [6]"...maintain a balance between the proportion of people living in rural areas and those living in rural areas, and increase the proportion of the main resident population in the 14th Five-Year Plan period to 65%" in the plan of 14th Five-Year Plan. Stably promoting rural population transfer to urbanization helps to solve the contradiction between people and land in rural areas with abundant labor force, thus achieving harmonious rural and stable agricultural development, improving household registration management to promote urban and rural mobility.

5. CONCLUSION

Agriculture, as the primary industry, is the foundation of economic development. The sustained and stable growth of total agricultural output has an indispensable role in promoting agricultural development and economic development. It is also an important breakthrough in solving agricultural problems in the three rural issues and promoting rural revitalization. As a major agricultural province, Sichuan Province is an important producer of food crops and cash crops in China. Maintaining the growth of its total agricultural output value and promoting the development of agriculture are also the support for China's steady progress.

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