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A Study on the Substitution Efficiency of Agricultural Mechanization Development in Zhejiang Province on Agricultural Labor Force

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Abstract. The agricultural "replacing labor force with machinery" is the main content of agricultural mechanization development. In this paper, the empirical analysis of the substitution efficiency of agricultural mechanization development in Zhejiang Province on agricultural labor is conducted. The main conclusions obtained in this paper are: the elastic coefficient of the output of agricultural machinery is 4.1815, the elastic coefficient of agricultural labor force is -2.3049, and the semi-elasticity of the agricultural output value to the labor force is 0.0013, which indicates that in addition to the substitution effect of agricultural machinery on labor force, both of which are mutually complementary. Due to the decline in the quantity of agricultural labor force in Zhejiang, the increase amount in the labor force can be replaced by the agricultural machinery in agricultural mechanization development is relatively reduced. Therefore, the marginal output value of the agricultural labor force in Zhejiang has been increased.

1. Introduction

Zhejiang is an integrated agricultural region, but it suffers from the aging agricultural population. By the end of 2010, 68.58% of the population aged 60 and above in Zhejiang Province are the elderly in rural areas, and this would be more severe in 2030 (He Xiaoqin, 2013). In October 2016, with the approval of the Ministry of Agriculture, Zhejiang would build the demonstration province of national agricultural "replacing labor force with machinery". The agricultural "replacing labor force with machinery" is the main content of agricultural mechanization development. Therefore, under the above background, it is of great practical significance to strengthen the macro guidance of agricultural mechanization development in Zhejiang by analyzing the relationship between the development of agricultural mechanization in Zhejiang and the substitution of agricultural labor force. In this paper, the relevant statistical data and calculation methods will be used to estimate the substitution situation of agricultural mechanization in Zhejiang Province for agricultural labor force..

2. Estimation method of substitution efficiency of agricultural mechanization on labor force

2.1 Establishing an analytical function model

2.1.1 Transverse selection

In order to conduct the detailed examination of the substitution relationship between agricultural machinery and agricultural labor force, the transcendental function can be used to analyze the relationship of production function between agricultural machinery, agricultural labor force and agricultural output value:

$$TVP = A \bullet L^{\alpha_1} M^{a_m} e^{c+\gamma_1 L+\gamma_m M} \quad (1)$$

Where: TVP is the total agricultural output value; A is the coefficient, which is referred to as the technical level; L and M stand for the quantity of agricultural labor force and agricultural machinery inputs respectively; c is the partial intercept term; $a_1$to a_m are the output elastic coefficient of the agricultural labor force and the agricultural machinery respectively; $r_1$to r_m are the semi-elastic

coefficient of total agricultural output value to agricultural labor force and agricultural machinery respectively.

2.1.2 Data acquisition and function fitting

Function fitting: as equation (1) is a nonlinear function, the natural logarithm is taken on both sides, and then there is

$$\ln(TVP) = \ln A + c + a_1 \ln L + a_m \ln M + \gamma_1 L + \gamma_m M \quad (2)$$

Make lnA＋c＝a_0 in the formula (2), then there is

$$\ln(TVP) = a_0 + a_1 \ln L + a_m \ln M + \gamma_1 L + \gamma_m M \quad (3)$$

Therefore, the regression equation can be set as:

$$\ln(TVP)_t = a_0 + a_1 \ln L_t + a_m \ln M_t + \gamma_1 L_t + \gamma_m M_t + u_t \quad (4)$$

Where t represents the year and u represents the residual term.

After converting the nonlinear transcendental production function into a linear function by the variable substitution, the multiple linear regression method can be used to determine the output elastic coefficient and the semi-elastic coefficient in the formula (4).

2.2 Calculation of the marginal technological substitution rate of agricultural machinery to agricultural labor force

The substitution relation of agricultural machinery to agricultural labor force can be expressed by marginal technology. By finding the derivative of L in the formula (1), and the derivative of M of the formula (1), and the differential is substituted by difference to obtain:

$$\frac{\Delta L}{\Delta M} = \frac{L(a_m + \gamma_m M)}{M(a_1 + \gamma_1 L)} \quad (5)$$

According to the definition of the related substitution rate of marginal technology, the calculation formula of marginal technology substitution rate of agricultural machinery to agricultural labor force is as follows:

$$MRTS_{m1} = -\frac{\Delta L}{\Delta M} = -\frac{L(a_m + \gamma_m M)}{M(a_1 + \gamma_1 L)} \quad (6)$$

3. Estimation of the substitution efficiency of agricultural mechanization in Zhejiang province for the marginal technology of transfer of labor force

3.1 Establishing transcendence function of agricultural production

3.1.1 Data acquisition

Based on the reference to the Statistical Yearbook of Zhejiang Province and Statistical Statement on Agricultural Mechanization Management, the statistical data such as total agricultural output value, total power of agricultural machinery and agricultural labor force can be obtained.

3.1.2 Function fitting

According to the above method, the regression analysis of the equation (4) is conducted by using the obtained correlation data, and the result is shown in Table 1.

Table 1. Regression results of equation (4)

Variable	Coefficient	Standard Deviation	Value t	Value F
a_0	-7.0227*	5.6050	-1.2529	277.2981***
lnL	-2.3049***	1.0617	-2.1710	
lnM	4.1815***	1.1419	3.6618	
L	0.0013*	0.0011	1.1775	
M	-0.0016***	0.0009	-1.7831	

R^2	0.9789

Note: ***, ** and * represent the significance level of 5%, 10%, and 15%, respectively.

The following fitting function can be obtained:

$$\ln(TVP) = -7.0227 - 2.3049 \ln L + 4.1815 \ln M + 0.0013L - 0.0016M \quad (7)$$

Convert the formula (7) into a non-linear equation to obtain

$$TVP = L^{-2.3049} M^{4.1815} e^{-7.0227+0.0013L-0.0016M} \quad (8)$$

Formula (8) is the regression model of the transcendental function of agricultural production of Zhejiang Province from 1986 to 2016.

3.2 Calculating the substitution rate of marginal technology

Substituting the above values of a_1, a_m, γ_1, γ_m into equation (6), then equation (6) is converted into

$$MRTS_{m1} = -\frac{L(4.1815 - 0.0016M)}{M(-2.3049 + 0.0013L)} \quad (9)$$

Formula (9) is the formula for calculating the substitution rate of agricultural machinery in Zhej iang province for agricultural labor force from 1986 to 2016. Then, after finding the relevant da ta, the substitution rate of marginal technology of agricultural machinery in Zhejiang province for agricultural labor force from 1986 to 2016 can be calculated, which is as shown in Table 2.

Table 2. Substitution rate of marginal technology of agricultural machinery in Zhejiang province for labor force

Year	$MRTS_{ml}$	Year	$MRTS_{ml}$	Year	$MRTS_{ml}$	Year	$MRTS_{ml}$
1986	5.9270	1994	1.8603	2002	0.3701	2010	0.0306
1987	5.0886	1995	1.3352	2003	0.3358	2011	0.0184
1988	4.3294	1996	1.1282	2004	0.3112	2012	0.0063
1989	4.5269	1997	1.0377	2005	0.2336	2013	0.0354
1990	4.3325	1998	0.9169	2006	0.1212	2014	0.0430
1991	4.1678	1999	0.6803	2007	0.0943	2015	0.0389
1992	3.5380	2000	0.5161	2008	0.0897	2016	0.0373
1993	2.4089	2001	0.4548	2009	0.0477		

It can be seen from Table 2 that, the substitution rate of marginal technology of agricultural machinery in Zhejiang province for agricultural labor force from 1986 to 2016 generally showed a downward trend.

4. Results and Analysis

1) Regression statistical analysis of input factors of agricultural production. The value F of the regression model was 272.2981, and the significance level was significant at 5%, indicating that the overall regression effect of the model was very good. The elastic coefficient of agricultural machinery output was 4.1815% The output elastic coefficient of agricultural labor force was -2.3049. The semi-elasticity of the total agricultural output value to the labor force was 0.0013, that is, for the increase of 10,000 people of agricultural labor force, the total agricultural output value will be increased by 0.13%. The total agricultural output value has a semi-elasticity of -0.0016 for agricultural machinery, that is, for the increase of 10,000 kW in the total power of agricultural machinery, and the total output value of agricultural machinery will be decreased by 0. 16%.

2) The influence of agricultural labor force transfer on marginal rate of technical substitution. Due to the decline of agricultural labor force, the increased labor force that can be replaced by the

agricultural machinery is relatively reduced, and the marginal output value of agricultural labor force is increased. According to the above economic principle, even if the marginal output value of the agricultural machinery input is not reduced, the marginal rate of substitution will be also inevitably reduced. This is one of the main reasons for the decline of the technical substitution rate of agricultural mechanization development to the labor force in Zhejiang Province.

3) The influence of agricultural mechanization development speed on marginal substitution rate. From 1986 to 2014, the average annual growth rate of agricultural machinery in Zhejiang province was 3.67%, and the declining rate of agricultural labor force was 2.76% in the same period, which indicated that the development speed of agricultural mechanization was higher than that of agricultural labor force to certain extent.

4) The influence of the structure of agricultural machinery on the marginal rate of labor force. At present, the agricultural machinery in Zhejiang is developing from food production machinery and field universal operation machinery. It is not only an objective requirement of the agricultural development today, but an important reason for the increase in the technical marginal substitution rate of agricultural machinery to the labor force since 2013 (see Table 2).

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