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Agroecological Study: Environmental Effect of Scientific Technology and Education Input on Agricultural Economic Growth

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Abstract

According to generalized C-D production function, this paper analyzes the environmental effect of scientific technology and education input on agricultural economic growth based on the panel data from the year of 2004-2015 in Zhejiang province, by using the modern econometric methods of panel unit root and cointegration test. The result shows that agricultural scientific technology and education input play an active role on agricultural economic growth and the research funding and cultivable acres in particular weight most. Based on this conclusion, some relevant proposals are put forward which can provide references for the adjustment and management of agricultural scientific input and education in Zhejiang province.

Keywords: agroecology, agricultural scientific input, generalized C-D production function, panel data, agricultural scientific education

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INTRODUCTION

Agroecology is the study of ecological processes applied to agricultural production systems. Bringing ecological principles to bear in agroecosystems can suggest novel management approaches that would not otherwise be considered. The term is often used imprecisely and may refer to “a science, a movement, [or] a practice” (Petrescu 2009). Agroecologists study a variety of agroecosystems. The field of agroecology is not associated with any one particular method of farming, whether it be organic, integrated, or conventional, intensive or extensive. However, it has much more in common with organic and integrated farming.

Agriculture is the basis of national economy. It is particularly important to strengthen the construction of modern agriculture and maintain rapid and stable growth of agricultural economy. Agricultural science and education with significant publicity, basicity and sociality are the decisive forces to speed up the construction of modern agriculture (2012, The CPC Central Committee, the State Council). Since the “Twelfth Five-Year Plan”, the overall level of agricultural science and education in China has been greatly improved, and the contribution rate of agricultural science and education progress has increased from 52% in 2010 to over 56% in 2015, but the developed countries have reached nearly 80%. According to the requirements of National Guideline on Medium and Long-Term Program for Science and Education Development (2006-2020), Zhejiang Province issued Zhejiang Province Thirteen Five-Year Plan for Agricultural and Rural Science and Education Development in 2015, with the aim of taking the lead to build innovation system of agricultural science and technology which supports high-level well-off society, and vigorously promote the innovation capability of agricultural science and technology, thus laying a solid foundation for speeding up the modernization of agriculture.

LITERATURES REVIEWING

The research on the relationship between science and technology input and economic growth has always been an important topic of academic research. In 1930s, the C-D production function proposed by Cobb and Douglas can calculate the technical level of a certain time, and its contribution to new output value or the contribution to new labor productivity. Solow used the C-D production function, based on the relevant statistical data of the United States from 1909 to 1949, probed into the relationship between the rate of change of technology and the rate of output growth. The study found that 87.5% of per capita GDP growth was brought about by technological progress, while only

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12.5% of the increase in output value was based on inputs from production factors (Solow 1957). In 1991, the World Bank analyzed the technological progress of 68 countries, and the results showed that the contribution of technological progress to gross domestic product (GDP) in developing countries was about 14.3 %, compared with 56.7% in France, 51% in Germany, 50%in the United Kingdom, and 16.6% in the United States. By analyzing the data of 1,000 large manufacturing companies in the United States from 1957 to 1977, Griliches concluded that the investment in science and technology played an important role in improving productivity (Griliches 1998). Dominique and Bruno conducted an empirical study on the impact of government investment in science and technology on R & D investment, and published the impact of public R&D expenditure on Enterprise R & D. (Guellec and van Pottelsberghe de la Potterie 2001).

In China, the research on the impact of science and technology input on economic growth is mostly based on panel data. To sum up, from the foreign literature, it can be concluded that capital, labor and technological progress are important sources of economic growth. From the domestic literature, it can be concluded that scholars mostly use the time series model and regression analysis, it has not yet formed a unified research method, such as grey correlation analysis, co-integration analysis, Grainger causal relation method, error correction model and panel data model. At present, due to the relatively short period of domestic statistical data and other limitations, the Ministry of Agriculture began to study the contribution rate of agricultural science and technology since 1982, the contribution rate of agricultural science and technology in China's "Sixth Five-Year Plan" to "Eighth Five-Year Plan" has been systematically studied and compared. Therefore, there is an urgent need to accumulate relevant literature in these fields, select appropriate valid data and empirical research methods, quantify the contribution rate of agricultural science and technology input to agricultural economic growth, improve existing measurement methods, and provide theoretical and practical guidance for future research.

MATERIALS AND METHODS

Analyzing variables and data: Agricultural economic output value was taken as an analysis variable of agricultural output. This paper intended to use the total output value of agriculture, forestry, animal husbandry and fishery as the explanatory variable. The total output value of agriculture, forestry, animal husbandry and fishery in Zhejiang Province from 2004 to 2015 was taken as the sample data. In order to ensure the comparability of the data, it was necessary to adjust the price index of the total output value of agriculture, forestry, animal husbandry and fishery to eliminate the influence of price factors on time series data.

Input variables and data: Agricultural economic growth was closely related to the input factors of agriculture. In this paper, the input of agricultural science and technology was used as input variable in agriculture. In addition, the input factors of land, capital and labor force are also taken as input variables, so as to analyze the influence of agricultural input factors on agricultural output. The impact of agricultural science and technology input on agricultural economic growth was mainly reflected by the number of agricultural professional and technical personnel and the expenditure of research and development. The contribution was analyzed from two perspectives of manpower and financial resources. The main data were derived from the data of agricultural science and technology input in Zhejiang Province from 2004 to 2015.

In this study, panel data were used to avoid the application of time series data or cross-sectional data to detect the relationship of variables, and to find the deviations of economic laws and trends.

The panel data were expressed by double subscript variables, when N indicates panel data contained n individuals, $y_{it}(i = 1,2,\cdots,N; t = 1,2,\cdots,T)$ indicated the value of the cross section i on the time t, T indicated the maximum length of time series, based on the panel data, an econometric model is established.

If y_{it} indicated the values of the explanatory variables at the cross section i on the time t, x_{jit} was the variable j in the cross section of i on the time t, u_{it} was the random error cross section of i and on the time t, b_{ji} was the model parameters of the j explanatory variables on the cross section i, a_i was constant or intercept which represents the influence of different individuals, the number of explanatory variables is $j = 1,2,\cdots,k$, Number of Sections was $i = 1,2,\cdots,N$, time span was $t = 1,2,\cdots,T$, and N indicates the number of members of an individual cross section, T was the total number of observation periods per member of the interface, k was the number of number of explained variables, so the single equation panel data model was as followed:

$$y_{it} = a_i + b_{1i}x_{1it} + b_{2i}x_{2it} + \cdots + b_{ki}x_{kit} + u_{it}(i = 1,2,\cdots,N; t = 1,2,\cdots,T) \quad (1)$$

Make a change, if $x_{it} = (x_{1it}, x_{2it}, \cdots x_{kit})$ was $1 \times k$ explained variables, $b_i = (b_{1i}, b_{2i}, \cdots b_{ki})$ was $k \times 1$ coefficient vector, u_{it} was random error, then equation (1) could be transformed into equation (2):

$$y_{it} = a_i + b_i\, x_{it} + u_{it} \quad (i = 1,2,\cdots,N; t = 1,2,\cdots,T) \tag{2}$$

According to the difference between intercept term, the constant term and the component in the coefficient vector, we could divided the panel model such as the equation (2) into three different types: invariant coefficient model without individual influence, constant coefficient model with the influence of the individual variable intercept model and varying coefficient model with individual effects. According to the way of influence, the variable intercept model and variable coefficient model are both contain fixed effects and random effects cases. In this study, a variable coefficient model is adopted. When N was small and T was big, the parameter estimation in fixed effects or random effects leads to marked differences under different assumptions. Therefore, we needed to check the influence pattern by Lagrange multiplier test in application.

The primary hypothesis and the alternative hypothesis: $H_0: \sigma_u^2 = 0, H_1: \sigma_u^2 \neq 0$

If the primary hypothesis hold, it meant no random effects, we should establish fixed effect model, otherwise random effect model. Under the condition that the original hypothesis is established, the statistics to be tested was:

$$LM = \frac{NT}{2(T-1)}\left[\frac{\sum_{i=1}^{N}(\sum_{t=1}^{T} e_{it})^2}{\sum_{i=1}^{N}\sum_{t=1}^{T} e_{it}^2} - 1\right]^2 \tag{3}$$

In which e_{it} was error term, and the statistics LM obey the χ^2 distribution with the degree of freedom was 1 under the condition that the original hypothesis was established. If under the given significance level α, the statistics $LM > \chi_\alpha^2(1)$, we should deny the original hypothesis, establish random effect model, otherwise fixed effect model.

The production function of a region can be expressed in Cobb Douglas (Cobb-Douglas) equation. Because R&D activity was the engine in which the whole economy works well, we used the generalized C-D production function to describe it:

$$Y = AK^{\alpha}L^{\beta}Z^{\lambda}e \tag{4}$$

This paper mainly investigated the investment in agricultural science and technology and its effect on economic growth, so the model needed to be adjusted as followed equation (5):

$$Y = AK^{\alpha}\, L^{\beta}\, M^{\gamma}\, S^{\sigma} \tag{5}$$

In which Y indicated total value of agriculture out-put, K indicated the total investment in fixed assets among farming, forestry, animal husbandry and fishery in Zhejiang province, L indicated the number of employment in urban units among farming, forestry, animal husbandry and fishery, M indicated the total area of crops, S indicated science and technology input, and $S = (H, R\&D)$, in which H indicated agricultural scientific research personnel inputs and $R\&D$ indicates expenditure on research, $\alpha, \beta, \gamma, \sigma$ indicated input and output elasticity of K, L, M, S accordingly. In order to improve the model, we took the logarithm of equation (5),

$$lnY = lnA + \alpha lnK + \beta lnL + \gamma lnM + \sigma lnS \tag{6}$$

Further regularization, we got the equation (7):

$$lnY = C + \alpha lnK + \beta lnL + \gamma lnM + \sigma_1 lnH + \sigma_2 lnR\&D + u \tag{7}$$

As the final theoretical model, we considered real data of science and technology input and national economic in each district city in Zhejiang Province. In actual operation, Y_{it}, K_{it}, L_{it}, M_{it}, H_{it} and $R\&D_{it}$ indicated total value of agriculture out-put, whole society fixed investments among farming, forestry, animal husbandry and fishery in Zhejiang province, the number of employment in urban units among farming, forestry, animal husbandry and fishery, the total area of crops, agricultural scientific research personnel inputs and R&D expenditure respectively, then panel data model is as followed equation (8),

$$lnY_{it} = \alpha_i + \beta_{1i} lnK_{it} + \beta_{2i} lnL_{it} + \beta_{3i} lnM_{it} + \beta_{4i} lnH_{it} + \beta_{5i} lnR\&D_{it} + u_{it} \tag{8}$$

Using the above model, we made empirical analysis by measuring the impact of agricultural science and technology investment on economic growth, in order to analyze the existing problems and causes of agricultural science and technology investment and economic development in Zhejiang Province, on the basis of this study, the corresponding countermeasures are put forward.

As shown in **Table 1**, Zhejiang province 2004-2015 years of investment in agricultural science and technology and agriculture GDP.

Table 1. Variables

Year	Y	K	L	M	H	R&D
2004	1332.27	16.94	1.94	2778.41	5650	95
2005	1428.28	20.11	1.83	2837.94	5798	144
2006	1422.6	21.85	1.68	2739.56	6178	210
2007	1597.15	33.02	1.62	2697.88	6677	283.3
2008	1780.01	36.07	1.58	2482.43	7123	343.79
2009	1873.4	57.21	1.49	2504.79	6555	388.14
2010	2172.86	60.12	1.48	2484.65	6714	495.53
2011	2534.9	96.77	1.49	2462.7	7115	614.4
2012	2658.66	158.41	0.82	2450.48	7729	705.96
2013	2837.39	200.98	0.75	2443.43	9255	826.5
2014	2844.59	263.51	0.56	2414.02	9199	939.6
2015	2933.44	339.18	0.47	2436.05	9603	1000

Table 2. Test results

Test criterion	ADF-test		PP-test		Results
nY	-2.371103	(0.1713)	-2.376014	(0.1701)	un-stationary
LnK	-4.583524	(0.0066)	-4.583524	(0.0066)	stationary
LnL	-3.146585	(0.0552)	-3.146552	(0.0552)	un-stationary
LnM	-3.873404	(0.0186)	-3.828124	(0.0199)	stationary
LnH	-2.888839	(0.0810)	-2.878580	(0.0823)	un-stationary
LnR&D	-1.513759	(0.4860)	-1.751488	(0.3796)	un-stationary
△LnY	-4.307952	(0.0116)	-4.418690	(0.0100)	stationary
△LnK	-7.349268	(0.0003)	-12.05701	(0.0000)	Stationary
△LnL	-5.818996	(0.0018)	-12.39447	(0.0000)	stationary
△LnM	-5.534481	(0.0047)	-12.19466	(0.0000)	stationary
△LnH	-4.10812	(0.0153)	-6.374390	(0.0009)	stationary
△LnR&D	-6.727797	(0.0003)	-8.615957	(0.0000)	stationary

EMPIRICAL RESULTS AND ANALYSIS

Panel data unit root test is mainly used to determine the stability of panel data. The panel data studied in this paper are mixed data of time series and cross section. In order to avoid spurious regression or spurious regression in the regression analysis, we must first test its stationary, therefore, unit root test is used to test the data。 To avoid a deviation caused by the test method, the unit root test of each variable and its first order difference variable is carried out by ADF-test and PP-test. The results are shown in **Table 2**.

As shown in **Table 2**, at the 5% significance level, only LNK and LNM two variables reject the original hypothesis, display as stationary, the remaining four variables are un-stationary with unit root. Then the first difference of all variables is tested, it shows that at the 5% significance level, their probability are all less than 0.05, reject the assumption that there is a unit root and can be carried out follow-up inspection.

Cointegration test is to test whether there is a long-term stable relationship between variables。 In order to further guarantee the reliability of the conclusion, we both use the 7 test statistics proposed by pedroni and the ADF statistic proposed by Kao to determine whether there is co integration between the six variables. The residual construction statistics obtained from panel data are checked and analyzed, shown in **Table 3.**

Table 3. Panel cointegration test results

Test method		test value	P-value
Pedroni test	panel v	2.037934	0.0208
	panel rho	-2.363200	0.0091
	panel PP	-8.296840	0.0000
	panel ADF	-0.848480	0.1981
	group rho	-1.667230	0.0377
	group PP	-9.761700	0.0000
	group ADF	-0.4257100	0.0335
Kao test	ADF	-3.250690	0.0006

It is apparent that the six statistics of the pedroni cointegration test and the ADF statistic of the Kao cointegration test all reject the original hypothesis at the 5% significance level, hinting that there is a significant co integration between the six variables which means that there is a long-term stable relationship between agricultural science and technology input and agricultural economic growth. Therefore, we can estimate the equation by the empirical method.

To further determine the intrinsic causal relationship between variables, we use the F test to determine the choice of mixed model or fixed effect model. Assume that the coefficients of the two classes of models are not different, if we accept the original hypothesis, we select mixed model, otherwise, the fixed

Table 4. Estimates results

variable	coefficient	standard deviation	t-value	P-value
C	5.6111	0.4977	11.2750	0.0000
LnK	0.0287	0.0120	2.3787	0.0020
LnL	-0.0351	0.0234	1.2377	0.0000
LnM	0.4286	0.0704	1.9670	0.0050
LnH	0.0875	0.0256	4.5374	0.0000
LnR&D	0.2131	0.0252	8.5742	0.0000

R-sq=0.9923, Adj R-sq=0.9898, LR=174.8364, DW=0.6191

effect model is selected. F-value is 136.2673, P-value is 0.0001, far below the 5% significance level,so we refuse the original hypothesis, choosing fixed effect model. Then we determine whether to choose random effect model or fixed effect model by Hausman test. The test result shows that test valve is 53.1421, P-value is 0.0000, far below the 5% significance level, rejecting the original hypothesis of random effects, choosing the fixed effect model.

According to afore-mentioned analysis, specific estimates are shown in **Table 4**.

According to the estimation results, it shows that the goodness of model fit is up to 99.23%, and in the 1% level of significance, explanatory variables have significant effects on the explanatory variables. Ultimately, we get following results:

$$LnY = 5.6111 + 0.0287LnK - 0.0351LnL + 0.4286LnM + 0.0875LnH + 0.2131LnR\&D \quad (9)$$

It shows that the elasticity coefficient of investment in fixed assets of agriculture, forestry, animal husbandry and fishery is 0.0287 in a long time in Zhejiang province, which means with an increase of 1% in fixed asset investment, agricultural GDP will increase by 0.0287%, and the elastic coefficient of the agricultural labor for 0.035, indicate the shortage of agricultural labor, its input has no positive impact on agricultural GDP output. The elasticity coefficient of cultivated land area is 0.4286, its promotion of agricultural GDP is most notable. The elasticity coefficients of scientific research funds and personnel are 0.2131 and 0.0875, respectively, which shows that scientific research input has a certain role in promoting agricultural GDP.

CONCLUSIONS

Strengthening investment in agricultural science and education, on the one hand, we should increase public investment in science and education, and on the other hand strengthen the support for research institutions and agriculture related colleges and universities. Strengthening the construction of agricultural research personnel, we should pay high attention to the cultivation of research talents, and consider strengthening the construction of research personnel from three aspects, namely, the introduction of science and education leading personnel, the cultivation of young talents and the training of technical personnel at the grass-roots level.

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