

Research on the Effects of Agricultural Technology Investment on Farmers' Income Structure

D.L. WU

Dalian University of Technology, Dalian, China

Daqing Normal University, Daqing, China

F.C. LIU

Dalian University of Technology, Dalian, China

ABSTRACT: The effect of agricultural technology investment on farmers' income structure has been ignored for a long time. Based on the 1989-2012 time series data, this paper uses VAR (p) model, dynamic co-integration analysis and impulse response function to analyze the relationship between agricultural technology investment and farmers' income structure. Empirical results show that, the effect of agricultural technology investment on farmers' income structure is significant. The agricultural R&D expenditure has positive effects on farmers' functional distribution and scale distribution of income, while agricultural technology promotion expense has negative effects. In comparison, the impact of the former is larger than the latter.

KEYWORD: Agricultural technology investment; Income structure; Income gap

1 INTRODUCTION

In recent years, China pays high attention to investment on agricultural science and technology. Agricultural investment in science and technology plays an important role in the promotion of China's agricultural synergism and farmers' income. However, behind the rural rapid economic growth, the "Matthew effect" of farmers' income has become increasingly prominent. Therefore, does the investment in agricultural technology affect farmers' income structure? If it does, how should we adjust the direction of agricultural technology investment to optimize the farmers' income structure?

There are many researches on whether the agricultural technology investment has promoting effect on the increase of farmers' income. On the one hand, Luo(2011), Liu(2013) found that government agricultural technology investment had a positive effect on the increase of farmers' income. On the other hand, Minten(2008), Tang(2009) found that investment of agricultural technology had limited positive effect on farmers' income, and may even play a negative role. In addition, Zhou(2011), Dennis(2013), Li (2012) analyzed the reasons for the inconsistent results from two aspects which are time effect and farmers' income source.

Above all, most of current studies analyzed the relationship between agricultural technology investment and the farmers' income based on the scale of the farmers' income. Few scholars have explored the relationship between the investment in agricultural technology and the structure of farmers'

income. In fact, the structure of income reflects more about the "stability" and "quality" of income changes. Therefore, based on income distribution theory, this article uses the scale income structure and functional income structure to characterize the gap between regions, and analyzes the relationship between agricultural science and technology investment farmers' income structure in China.

2 RESEARCH DESIGN

2.1 Model construction

Firstly, the process of agricultural technology progress mainly includes two parts: the agricultural scientific research and the agricultural technology adoption and promotion. This study divides investment in agricultural science and technology into agricultural R&D input and agricultural technology popularization input(Huang, 2013).

Secondly, the resource endowment and benefit criterion is critical factor to decide if the agricultural technological progress can increase income of farmers. Referring to the conceptual framework of scale income and functional structure proposed by Fan et al. (2014), this paper chooses the scale income structure and function income structure of farmers as the measures of farmers' income changes.

Then, we construct the multiple regression models, the models are as follows:

$$SIS_t = C + AT_{(t-p)}\beta_1 + AP_{(t-p)}\beta_2 + \varepsilon \quad (1)$$

$$FIS_t = C + AT_{(t-p)}\beta_1 + AP_{(t-p)}\beta_2 + \varepsilon \quad (2)$$

SIS_t , FIS_t is farmers' scale income structure and functional income structure; $AT_{(t-p)}$, $AP_{(t-p)}$ represents R&D expenditure and agricultural technology extension expenditure; β_1, β_2 represent the coefficients of different agriculture science and technology spending; C is a constant term; ε is error term, t represents year, p represents the lag period.

Finally, using VAR (P) dynamic analysis method of econometric model, this article analyzes the co-integration relations and generalized impulse response between agricultural R&D input, input in agricultural technology popularization and farmers' scale income structure, functional income structure.

2.2 Sample data

This paper uses the Chinese statistical data from 1989 to 2012. The data of rural per capita net income, rural population, and income sources of farmers are arranged and calculated according to the "China Rural Statistical Yearbook" (1990-2013); The data of agricultural science and technology input is from Huang (2013) and "2013 Chinese agricultural development report". All raw data takes the log form before put into the model. In addition, because Chongqing was identified as the municipality directly under the central government in 1997, this paper will combined the data of Chongqing City and Sichuan Province.

2.3 Variables and measures

(1) Farmers' income structure

This study divides farmer's income into scale income and functional income.

The farmer scale income structure (SIS). It reflects the regional differences of farmers' income. This paper calculates the difference degree of farmer income between different provinces by the following formula:

$$SIS = \sum_{i=1}^n \left[\frac{rni_i p_i}{rni p} \right] \ln \left[\frac{rni_i}{rni} \right] \quad (3)$$

Wherein, i represents the provinces; rni_i and p_i represent the per capita net income of farmers and rural population of i provinces; rni and p represent the per capita net income of farmers and rural population of the whole nation.

The value of that varies in $0 \sim \ln(p)$, and with larger values represents the larger regional gap in the income of the farmers of different province.

The farmers' functional income structure (FIS). It reflects the allocation proportion of each source of income of the farmers. This research adopts

reciprocal form of the Geffen Dahl Hector Seaman index (HHI) to measure the degree of diversification of sources of rural residents' income. The specific formula is:

$$FIS = \frac{1}{HHI} = \frac{1}{\sum_{i=1}^N (X_i/X)^2} \quad (4)$$

i represents the source of income; X_i , X respectively represent the article i source of income of rural residents and the total income of rural residents.

The value of that variable in $1 \sim N$, the closer the value close to 1, more single the income of the farmers constitute.

(2) Agricultural technology investment

From the aspect of the agricultural science and technology innovation process, the investment in agricultural science and technology is mainly to solve two aspects of the problem which are the agricultural science and technology innovation output and extension. Therefore, this paper choose R&D (AT) of agricultural expenditure and agricultural technology extension expenditure (AP) to measure our country agrotechnical progress at different stages of investment in science and technology.

3 RESULTS

3.1 Stationary test and the lag order

Before the linear regression based on VAR (P) model, it needs to examine the stationary of each variable data the number and determine the lag order of the model. According to ADF unit root test, the original data has the unit roots. After the first-order difference, farmers' scale income structure, farmers' functional income structure, agricultural R&D spending and agricultural technology extension expenditure are all one order single whole sequence that meet the conditions of cointegration analysis and generalized impulse response methods.

Table 1. The VAR lag test

Model 1(Farmers scale income structure)			Model 2(Farmers functional income structure)		
Lag	AIC	SC	Lag	AIC	SC
0	-8.74	-8.59	0	-3.21	-3.06
1	-12.83	-11.80	1	-8.50	-7.90
2	-13.01*	-12.42*	2	-8.97	-7.93
3	-12.55	-11.07	3	-9.69*	-8.21*

The lag order of model is determined according to the Akaike information criterion (AIC) and Schwartz (SC) criterion of judgment (Table 1). The optimal lag order number of farmers scale income structure, agricultural R&D expenditure, agricultural

technology extension expenditure is 2, and the optimal lag order number of farmers' functional income structure, agricultural R&D expenditure, and agricultural technology extension expenditure is 3.

3.2 Cointegration analysis

This paper examines the impact of agricultural R&D expenditure, agricultural technology extension expenditure on farmers scale and functional income structure with Johansen cointegration test method, and tests with cointegration equation model with deterministic linear trend and only the intercept term VAR(p). The results are given in table 2.

Table 2. Estimation results of cointegration

Model 1 No. of CE(s)	Eigenvalue	Trace		Maximum Eigenvalue	
		Trace Statistic	Prob.	Max- Eigen Statistic	Prob.
r=0*	0.74	37.69	0.01	25.95	0.01
r≤1	0.44	11.73	0.17	11.14	0.14
r≤2	0.03	0.59	0.44	0.59	0.44
Normalized cointegrating coefficients					
Variable	SIS	AT	AP		
Coefficient	1.00	-0.24	0.10		
Std. Error		-0.04	-0.02		
Log likelihood	136.61				
Model 2 No. of CE(s)	Eigenvalue	Trace		Maximum Eigenvalue	
		Trace Statistic	Prob.	Max- Eigen Statistic	Prob.
r=0*	0.89	56.84	0.00	40.11	0.00
r≤1	0.55	16.73	0.03	14.43	0.04
r≤2	0.11	2.29	0.12	2.29	0.12
Normalized cointegrating coefficients					
Variable	SIS	AT	AP		
Coefficient	1.00	-0.71	0.02		
Std. Error		-0.14	0.05		
Log likelihood	108.91				

In Table 2, model 1 is about farmers scale income structure, model 2 is about farmers' functional income structure. The results show that in the trace test and maximum eigenvalue test, model 1 and model 2 all reject the cointegration hypotheses at 5% of significant level. There is a long-run effect on agricultural R&D expenditure, agricultural technology extension expenditure to farmers scale income structure and farmers' functional income structure. According to normalized cointegrating coefficients, the cointegration equation of model 1 and model 2 are:

$$SIS = 0.2436AT - 0.1096AP \quad (5)$$

(-0.0456) (-0.0200)

$$FIS = 0.7179AT - 0.0218AP \quad (6)$$

(-0.1421) (-0.0575)

Equation (5) and (6) show that it keeps changing in the same direction between agricultural R&D expenditure and farmers scale income structure and farmers' functional income structure, and it is then reverse change between agricultural technology extension expenditure and farmers scale income structure, farmers' functional income structure. Specifically, each 1% increase of agricultural R&D spending, causing farmers regional income gap between farmers' income increased by 0.2436%, the diversification degree increase 0.7179%; and agricultural technology extension expenditure increases by 1% each, the regional income gap between farmers will be reduced by 0.1096%, farmer income diversification degree will reduce 0.0218%.

In addition, according to the cointegration coefficients of equation, the effect of agricultural R&D spending is more significant than the effect of agricultural technology extension expenditure.

3.3 Generalized impulse response analysis

Based on the model of the VAR (P), this paper uses the generalized impulse response function method to draw the impulse response diagram of farmers scale income structure and farmers functional income structure, as shown in Figure 1 - Figure 4.

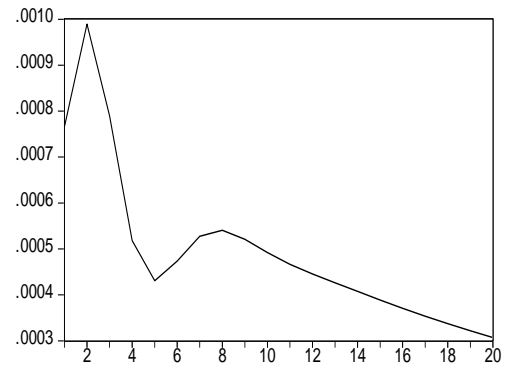


Figure1. Response of SIS to AT

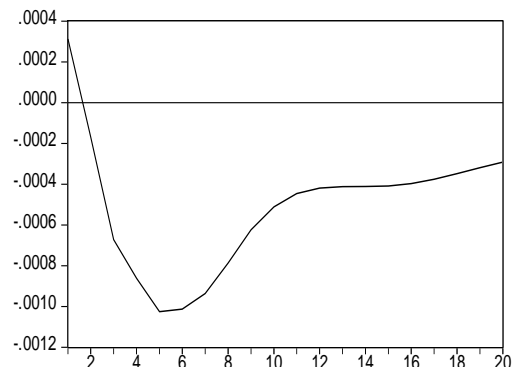


Figure2. Response of SIS to AP

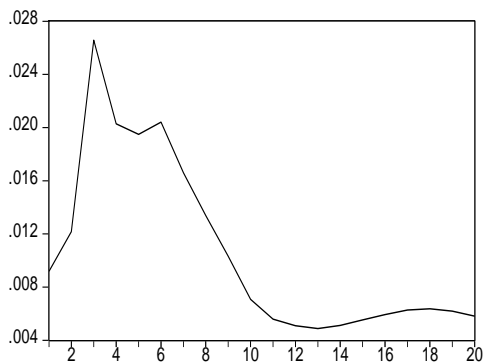


Figure3. Response of FIS to AT

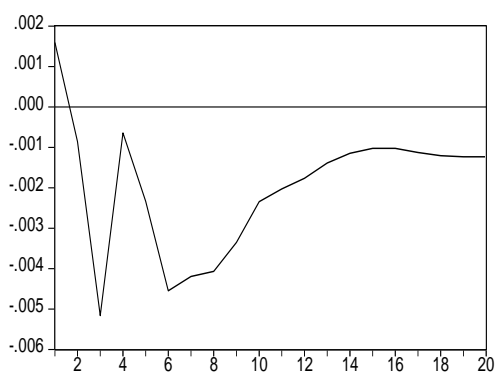


Figure4. Response of FIS to AP

Figure 1 - Figure 2 are generalized impulse response results of farmers scale income structure. The response of scale of farmers' income structure for agricultural R&D perturbation is positive (Figure 1), while the response of scale of farmers' income structure for agricultural technology extension is mostly negative (Figure 2). The further analysis from the absolute values, in the 1 to 5 period, agriculture agricultural technology promotion than R&D effect influence on agricultural scale income structure; but in the eighth period, the influence of agricultural R&D significantly declined faster than agricultural technology promotion, agricultural technology popularization of agricultural scale income structure in the long term effects of more obvious. The above results showed that agricultural science and technology in short-term has widened the income of the farmers of the regional disparity, but have reduced the income of the farmers of regional disparity in the long term.

Figure 3 - Figure 4 are the generalized impulse response results of farmers' functional income structure. It can be seen that the impulse response tendency of farmers' functional income structure and that of farmers' size income structure are consistent. The response of farmers' functional income structure on agricultural R&D is positive, and the response on the agricultural technology promotion is negative. The positive pulse response coefficient of farmers' functional income structure on agricultural R&D has been greater than the negative pulse response coefficient on the agricultural technical popularization.

4 CONCLUSIONS

This paper uses dynamic co-integration analysis and impulse response function to study the effect of agricultural technology investment on farmers' income structure, and get the following conclusions.

First, agricultural R&D expenditure has a positive effect on the famers' functional distribution of income and scale distribution of income. It shows that agricultural R&D spending is a reason of Chinese farmers' internal income gap.

Second, agricultural technology promotion expense has a negative influence on the famers' functional distribution of income and scale distribution of income. The expenditure of agricultural technology extension is conducive to improving the dual structure of farmers' internal income distribution.

Third, the impact of agricultural R&D spending is significantly greater than agricultural technology extension expenditure on the famers' functional distribution of income and scale distribution of income. China's agricultural technology innovation is still at the "increasing returns" stage, and there is still room for agricultural technology progress.

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