Research on the Dynamic Relationship Between the Investment of Agricultural Science and Technology Resource and the Growth of Agricultural Economy in Liaoning Province

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Abstract. With the arrival of the era of big data and artificial intelligence, as one of the important agricultural provinces in China, some problems are still faced by Liaoning Province, such as low allocation efficiency and insufficient input motivation of agricultural science and technology resource (ASTR), which seriously restricts the conversion rate of scientific and technological achievements and the improvement of agricultural output efficiency. Therefore, in order to fully leverage the application advantages of the investment of ASTR in the development of agricultural economy in Liaoning Province, an empirical research on the dynamic relationship between the investment of ASTR and the growth of agricultural economy (GAE) in Liaoning Province based on the vector autoregressive (VAR) model is researched in this paper. Firstly, the VAR model is constructed by processing the data of the investment of ASTR and agricultural development. Then, Granger causality test and impulse response analysis are applied to analyze the dynamic relationship between the investment of ASTR and GAE in Liaoning Province to reveal the influence degree and long-term mechanism of the investment of ASTR on GAE. The model presented in this article can promote structural reform more efficiently. At the same time, it can solve the problem of the allocation of ASTR which provides guidance for promoting high-quality agricultural development.

Keywords: Allocation of agricultural science and technological resource, Granger causality test, growth of agricultural economy (GAE), investment of agricultural science and technology resource, vector autoregressive (VAR) model.

1 Introduction

With the advent of the era of big data and artificial intelligence, unprecedented opportunity and challenge is faced by agriculture [1]-[2]. The reasonable investment of ASTR is of great significance to GAE [3]-[4]. The investment of ASTR can also help improve agricultural production efficiency and promote the optimal allocation of ASTR.

Z. Wang et al. (eds.), *Proceedings of the 4th International Conference on Economic Development and Business Culture (ICEDBC 2024)*, Advances in Economics, Business and Management Research 299,
https://doi.org/10.2991/978-94-6463-538-6_36

Therefore, the development of agricultural science and technology is attached great importance by the Chinese government [5]. As one of the important agricultural provinces in China, it is of great practical significance to explore the dynamic relationship between the investment of ASTR and GAE in Liaoning Province [6].

Based on the background of e-commerce, an empirical analysis on the relationship between agricultural technology investment and agricultural economic growth is conducted in [7], which provides a new perspective and depth for scientific understanding of agricultural economic growth. The yield and productivity of corn crops is selected as a research example in the Babylon region in [8], which diagnoses the obstacles faced by the agricultural innovation system as a whole and provides scientific improvement suggestions and effective solutions in related fields. A sparsity inference method is studied in VAR model in [9], the VAR model is constructed to assess the dynamic impact of global shocks on emerging market economies. The VAR model is used to examine the impact of economic and non-economic indicators on the policy creation of the China Banking and Insurance Regulatory Commission in [10]. It can be found that it is effective to use the VAR model in studying the dynamic relationship of variables. Unfortunately, a VAR model for the investment of ASTR is failed to establish in [7]-[10], which cannot solve the problem of the allocation of ASTR.

In order to promote the structural reform of agricultural science and technology more efficiently and solve the problem of the allocation of ASTR, a VAR model of the investment of ASTR and GAE in Liaoning Province is established in this paper. Firstly, the indicators are selected and the data is processed. Secondly, the lag order is determined to construct a VAR model and test its stability. Finally, impulse response analysis is carried out to analyse the dynamic relationships among variables.

2 Selection of Indicators and Introduction of Model

2.1 Selection of Indicators

The dynamic relationship between investment of ASTR and GAE in Liaoning Province is researched in this paper, with gross agricultural product (GAP) as the core variable. The indicators of ASTR in Liaoning include the total power of agricultural machinery (TAM), investment in agricultural research and development activities (ARD), and the number of agricultural technicians (NAT) in Liaoning. Among them, ARD can be obtained from research and experimental development funding (REDF), GAP, and gross product (GP), which can be expressed as

$$\mathrm{ARD} = \mathrm{REDF} \times \frac{\mathrm{GAP}}{\mathrm{GP}}. \tag{1}$$

Considering that the selected data belongs to time series data, the data of GAP and ASTR in Liaoning Province is applied to make first-order differentiation to eliminate the influence of heteroscedasticity and the dynamic relationship among related variables is not changed at the same time. The degree of change in the dependent variable is affected by the independent variable which can be reflected through the obtained regression equation. The data processing in this article is carried out in Stata17.0 and the result is presented in the next section.

2.2 Introduction of VAR Model

The VAR model is a common econometric model used to analyse and predict the dynamic relationships among multiple time series variables. The multiple time series are treated as a system during the VAR model, each of which is a function of the past values of other time series in the system. The VAR model is selected due to its flexibility. It not only includes multiple explanatory variables, but also does not require distinguishing between endogenous and exogenous variables, which is advantageous for analysing complex agricultural economic systems. The general expression of the VAR model is obtained as follows:

$$Y_t = \alpha_l Y_{t-l} + \ldots + \alpha_p Y_{t-p} + \beta_l X_{t-l} + \ldots + \beta_q X_{t-q} + \mu_t. \tag{2}$$

In (2), t=1, 2, 3, ..., n, and the number of samples is expressed as p and n; Yt is endogenous variable, Yt-1 and Yt-p are the lag period of Yt; Xt is exogenous variable; al and ap are the estimation coefficient of Yt; β is the estimation coefficient of Xt; mt represents the random perturbation term.

3 Empirical Analysis

3.1 Stability Test of the Data

The stationarity of the above four types of differential processing data is tested in Stata 17.0, that is the ADF unit root test, which is shown in Table 1. It can be found that the p-values of the first-order difference sequence ADF test are all less than 0.05. Therefore, the null hypothesis is rejected. Meanwhile the difference data is stable and there is no pseudo regression phenomenon, therefore Granger causality test can be conducted furtherly.

Table 1. The test results of ADF unit root

Variable	Statistical value of ADF	Threshold of 1%	Threshold of 5%	Threshold of 10%	Value of Prob	Result
dlngap	-5.921	-3.750	-3.000	-2.630	0.0000	Stable
dlntam	-4.534	-3.750	-3.000	-2.630	0.0002	Stable
dlnard	-5.204	-3.750	-3.000	-2.630	0.0000	Stable
dlnnat	-4.471	-3.750	-3.000	-2.630	0.0002	Stable

3.2 Determination of the VAR Model Lag Order

It can be ensured that the model can accurately capture the dynamic relationships among time series by determining the appropriate lag order of the VAR model. The result of the VAR model lag order test is shown in Table 2, and the lag period with the most '*' is usually chosen as the standard. Therefore, the optimal lag period selected is 2 in this article.

Table 2. The test results of the VAR model lag order

Lag order	LL	LR	FPE	AIC	HQIC	SBIC
0	83.5715	NA	1.0e-9	-9.36136	-9.34187	-9.1653
1	88.0549	8.9667	4.2e-9	-8.00646	-7.90902	-7.02621
2	154.793	71.136*	4.6e-10*	-12.0932*	-11.8399*	-9.54459*

3.3 Stability Test of VAR Model

The stationarity test result of the VAR model is shown in Fig. 1. It can be found that the modulus of all feature roots in the VAR model is significantly less than 1, indicating that the VAR model established in this paper is stable and there is a long-term relationship among variables.

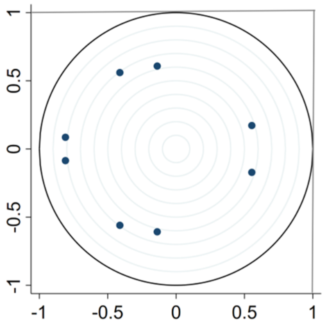

Fig. 1. The stability test results of VAR model

3.4 Test of Granger Causality

In order to verify whether there is a bidirectional causal relationship between the variables furtherly, Granger causality test is conducted on each variable at a 10% confidence level and the result is shown in Table 3. It is revealed that there is a significant causal relationship between GAP, TAM, ARD and NAT. Specifically, there is a significant Granger causality between the increase in funding for ARD and the increase in GAP. At the same time, this funding investment is also the reason for the change in TAM. In addition, the change in NAT also has a significant Granger causality relationship with the growth of GAP.

Table 3. The test results of Granger causality

Null hypothesis	Value of Prob	Conclusion
ARD is not a Granger reason for GAP	0.005	Reject
ARD is not a Granger reason for TAM	0.032	Reject
NAT is not a Granger reason for GAP	0.055	Reject

3.5 Analysis of Impulse Response

Impulse response analysis is a method used in VAR model to measure the impact of one variable on other variables. In order to understand the dynamic process of interactions between various endogenous variables furtherly, impulse function response analysis is conducted, which is shown in Fig. 2. In the impulse response image, the horizontal axis represents the number of periods of impact, and the vertical axis represents the degree of change in the response variable.

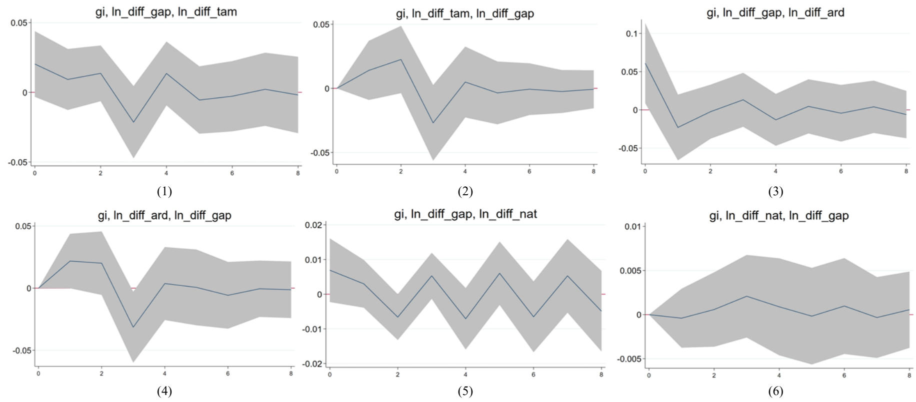

Fig. 2. The trace of impulse response function

It can be indicated from the results that TAM, ARD and NAT have a temporal dynamic impact on GAP, and these impacts will gradually weaken in the long run. Therefore, the long-term effects of these factors should be considered and corresponding strategies should be developed to promote the sustainable development of the agricultural economy by the policymakers.

4 Conclusion

As the arrival of a new round of technological revolution led by artificial intelligence, the conversion rate of scientific and technological achievements can be improved and the efficiency of agricultural output can be enhanced with reasonable allocation of ASTR. Therefore, a dynamic relationship model between the investment of ASTR and GAE in Liaoning Province is established based on VAR model and an empirical research is conducted based on the selected data in this paper. On the basis of a stable research VAR model, Granger causality test and impulse response function analysis are conducted. It is revealed that there is a significant causal relationship between GAP, TAM, ARD and NAT from the result of Granger causality test. According to the result, technicians can provide professional knowledge and skills to help farmers adopt more advanced technologies and management methods, which can improve agricultural production efficiency and yield significantly. At the same time, investment in agricultural research should be increased and personnel allocation structure should be optimized to improve investment efficiency. The dynamic changes in the impact of the investment in ARD and the increase in NAT on GAP is revealed from the impulse response function analysis. In the short term, ARD has a significant positive effect on GAE. However, this positive impact shows instability and its promoting effect gradually weakens as time goes on. It indicates that the investment in ARD has a long-term positive effect on GAE, while attention should also be paid to the efficiency and sustainability of the investment. Therefore, technological innovation should be encouraged and the industrial structure of agricultural mechanization distribution should be optimized continuously. Through the model of this paper, it is expected to promote structural reform more efficiently, solve the problem of allocation of ASTR, and provide a significant guide for promoting high-quality agricultural development.

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