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Research on the Interaction between Agricultural Production Efficiency and Agricultural Economic Growth based on PVAR model

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Abstract

Based on the panel data of 30 provinces in China from 1997 to 2018, a panel vector autoregression model was established to describe the interaction between agricultural production efficiency and agricultural economic growth by using impulse response function and variance decomposition. The results show that there is a long-term stable and balanced relationship between agricultural production efficiency and agricultural economic growth, and agricultural production efficiency can significantly promote agricultural economic growth in the long term. However, agricultural economic growth has no significant effect on agricultural production efficiency in the short term, but is beneficial to the improvement of agricultural production efficiency in the long term.

Keywords

Agricultural Production Efficiency; Agricultural Economic Growth; Panel Autovector Regression Model.

1. Introduction

With the continuous advancement of China's agricultural modernization, modern management methods and scientific and technological means are applied to agricultural production process, and the production efficiency is significantly improved and the comprehensive production capacity is enhanced [1]. However, China's long-term extensive management caused by the accumulation of structural contradictions, resulting in excessive consumption of resources, low production efficiency, agricultural economic growth slowed down [2]. China's "13th Five-Year plan" and the spirit of the 18th National Congress of the CPC put forward that the improvement of agricultural production efficiency is an important means to change the agricultural growth mode and promote agricultural economic growth. Therefore, it is of great practical significance to scientifically measure agricultural production efficiency and reveal the interaction mechanism between agricultural production efficiency and agricultural economic growth.

At present, many scholars are concerned about the relationship between agricultural production efficiency and agricultural economic growth [3]. The power source of agricultural economic growth mainly comes from the increase of agricultural factors and agricultural productivity. Rosegrant and Evenson found that the agricultural growth in India was due to the increase of agricultural production efficiency, whose contribution rate reached 33% [4]. Alston found that an increase in agricultural TFP could lead to an increase in U.S. agricultural output [5]. Fan Lixia et al established the accounting framework of agricultural economic growth and agricultural efficiency, and believed that economic growth mainly stemmed from the improvement of agricultural production efficiency [6]. Li Zhaoliang et al believed that regional economic development level would have a significant positive impact on agricultural production efficiency [7].

Combing the literature found that most of the scholars on the analysis of the relationship between them is more focus on their one-way causal relationship, in view of the agricultural

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economic growth and agricultural production efficiency research of two-way interaction is less, this will make the model to estimate the endogenous variable bias, lead to bias the empirical results, thus affecting the relevant policy is put forward [8]. At present, the panel vector autoregression model is more advantageous in dealing with the endogenous deviation of variables, which can analyze the bidirectional dynamic mechanism between the two [9]. In view of this, this paper selects the panel data of 30 provinces in China from 1997 to 2018, establishes the PVAR model of agricultural production efficiency and agricultural economic growth, and uses generalized moment estimation, impulse response analysis and variance decomposition to test the interaction mechanism between the two, so as to draw a relatively reliable conclusion.

2. Research methods and data

2.1. Super efficient SBM model

Tone constructs a non-radial SBM model to estimate efficiency based on relaxation variables, which can effectively solve the problem of "relaxation" phenomenon of input variables caused by traditional DEA models [10]. On the basis of THE SBM model, Tone proposed the super-efficient SBM model, which integrated the advantages of DEA model and SBM model and could further distinguish the effective DMU of the frontier [11].

2.2. PVAR model

Panel Vector Auto Regression (PVAR) model, proposed by Holtz Eakin et al. [12] (1988) and improved by Love and Zicchino [13] (2006), regards all variables as endogenous variables. It is a good model that truly reflects the mutual dynamic and lag relationship among variables. PVAR model not only inherits the advantages of panel data estimation method and vector autoregression model, but also greatly reduces the length of time series required by ordinary VAR model, and can fully consider the influence of individual sample differences on model parameters [14]. This paper sets the following PVAR model:

$$y_{it} = \lambda_0 + \sum_{j=1}^{p} \lambda_j y_{it-j} + f_i + d_t + \varepsilon_{it} \quad (1)$$

In Formula (1), represents the endogenous variables of the fourth province in the first year, respectively agricultural economic growth and agricultural production efficiency.

2.3. Variable selection and data sources

Variable selection. The evaluation index system of agricultural production efficiency consists of input index and output index. Based on the existing literature, this paper selects land, labor force, agricultural machinery and fertilizer as input indexes. The total output value of agriculture, forestry, animal husbandry and fishery was selected as the output index [15]. Agricultural economic growth is expressed as gross agricultural output value, which represents the total income of the agricultural economic system and the total expenditure on agricultural products and services, reflecting the overall economic level of agriculture [16].

Source of data. In this paper, panel data of 30 provinces (except Tibet) from 1997 to 2018 are selected as samples, and the data used are from China Statistical Yearbook and China Rural Statistical Yearbook. In addition, in order to eliminate the possible heteroscedasticity and violent fluctuations of data [17], this paper analyzes the variables of agricultural economic growth and agricultural production efficiency in logarithm form, which are lnsbm and lngdp respectively.

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3. Empirical analysis

3.1. Stationarity test

Due to the use of panel data, in order to avoid the instability of panel data leading to pseudo-regression, it is necessary to carry out stationarity test for each variable before model estimation. In this paper, the unit root test of agricultural economic growth (lngdp) and agricultural production efficiency (lnsbm) and their first-order difference terms (dlngdp and dlnsbm) were carried out by LLC and IPS test methods respectively, and the consistency of the results of the two methods was taken as the judgment standard. The results are shown in Table 1.

Table 1. Results of unit root test

variable	LLC Inspection		IPS Inspection	
	statistics	P values	statistics	P values
lngdp	-2.9780**	0.001	0.104	0.541
lnsbm	-1.6583**	0.048	0.035	0.514
dlngdp	-3.9355***	0.000	-7.714***	0.000
dlnsbm	-7.6262***	0.000	-9.392***	0.000

Note: *** means significant at 1% level, ** means significant at 5% level, * means significant at 10% level

The variables lngdp and lnsbm rejected the null hypothesis at the significant level of 5% in the LLC test, but the null hypothesis could not be rejected in the IPS test. Through the first-order difference of variables lngdp and lnsbm, it is found that the first-order difference sequences of each variable are stationary sequences.

3.2. Selection of hysteresis order

When the PVAR model is constructed for analysis, the optimal lag order of the model needs to be determined. It can be seen from Table 2 that AIC, BIC and HQIC of the fourth order lag of the model are the lowest, so the fourth order lag can be determined as the optimal lag order of the model.

Table 2. Lag order test results

lag	AIC criterion	BIC criterion	HQIC criterion
1	-6.15794	-5.68894	-5.97537
2	-6.2797	-5.76128	-6.07743
3	-7.03412	-6.46191	-6.81033
4	-7.13853*	-6.50752*	-6.89113*
5	-7.06152	-6.36589	-6.78808

Note: * indicates the order of the minimum value in each criterion

3.3. Generalized moment estimation (GMM) results

Before the generalized moment estimation, the "Helmert" preterm difference method was used to eliminate the individual fixed effect, and the in-group mean difference method was used to eliminate the time effect, so as to avoid the bias of parameter estimation caused by the correlation between the individual effect and the lag term of the variable [18]. The parameters of the model were estimated on the basis that the optimal hysteresis order was 4, and the results were shown in Table 3.

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Table 3. Estimation results of PVAR model

	Explanatory variables	Coefficient values		Explanatory variables	Coefficient values
Explained variable h_lngdp	L1.h_lngdp	0.9132***	Explained variable h_lnsbm	L1.h_lngdp	-0.1281
	L1.h_lnsbm	0.1313**		L1.h_lnsbm	1.0570***
	L2.h_lngdp	0.2431*		L2.h_lngdp	0.3924*
	L2.h_lnsbm	-0.1060***		L2.h_lnsbm	-0.3155***
	L3.h_lngdp	-0.2938***		L3.h_lngdp	-0.0381
	L3.h_lnsbm	0.0523*		L3.h_lnsbm	-0.0749
	L4.h_lngdp	0.4879		L4.h_lngdp	-0.1807*
	L4.h_lnsbm	0.0101		L4.h_lnsbm	0.1529***

Note: "*", "**" and "***" respectively mean significant at the significance level of 10%, 5% and 1%; H_ means "Helmert" transformation of the variable; L means one lag of the corresponding variable.

From the GMM estimation results (table 3) : (1) the agricultural economy growth is as explained variable, lag 1 issue of the agricultural efficiency has a significant positive effect on agricultural economic growth, the specific performance under 5% significance level, lagging 1 issue of the agricultural production efficiency per one unit, the agricultural economy growth relatively should be increased by 0.1313 units; However, the agricultural production efficiency with the lag stage of 2 has a significant negative effect on it, and the influence is changed to a positive effect when the lag stage of 3 is at the significant level of 10%. The results show that agricultural production efficiency plays a certain role in promoting agricultural economic growth in the short term, and the early agricultural economic growth also has a strong dependence on itself. (2) As the explained variable, agricultural production efficiency has no significant impact on agricultural economic growth lagging 1 period, but has significant positive impact on agricultural production efficiency at the level of 10% when lagging 2 period; The agricultural production efficiency of the lagging stage 1 has a significant positive effect on the self, the lagging stage 2 has a significant negative effect on the self, but the lagging stage 4 has a significant positive effect on the self. It shows that agricultural economic growth can promote agricultural production efficiency in the short term, but agricultural production efficiency more depends on its own innovation development.

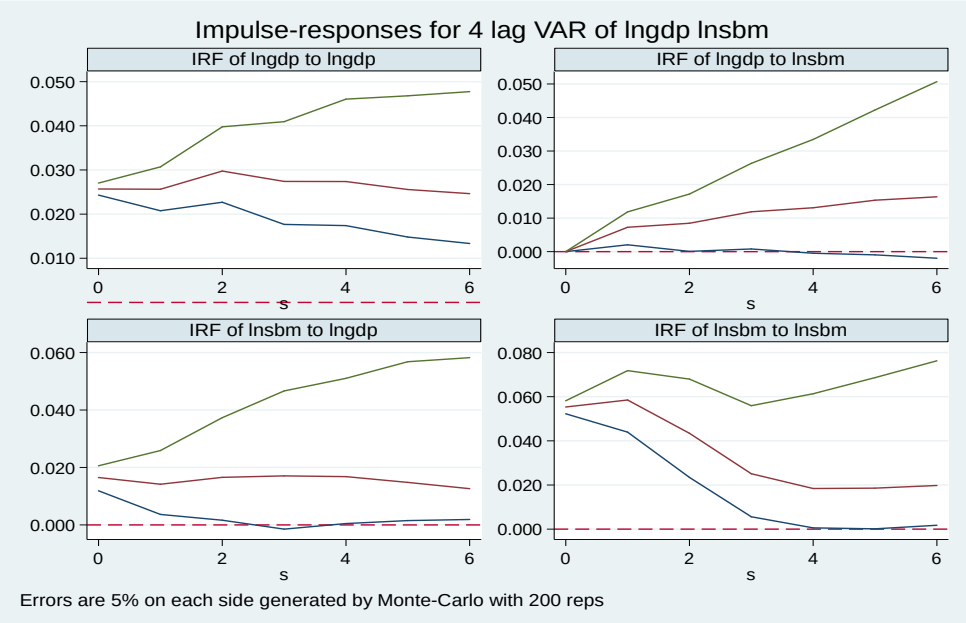

Fig. 1 Impulse response diagram

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3.4. Impulse response analysis

Since the regression coefficient of PVAR model only reflects the local dynamic relationship, it cannot well describe the dynamic conduction mechanism and influence path among variables. Therefore, the long-term dynamic relationship between agricultural economic growth and agricultural production efficiency is further tested by impulse response diagram. In this paper, through monte Carlo simulation for 200 times, the response results of mutual impact between agricultural economic growth and agricultural production efficiency variables with a lag of 6 periods are obtained (Figure 1).

As can be seen from Figure 1, agricultural economic growth and agricultural production efficiency have a significant positive response to the impact on the self, reaching the maximum value in the early stage, and then declining and flattening out, indicating that the positive impact of agricultural economic growth and agricultural production efficiency on self is significant and lasting. The impact of agricultural economic growth on agricultural production efficiency has a weak positive impact in the short term, but has been in the rising stage with the passage of time and reached the highest value in the sixth period, which indicates that agricultural economic growth has an obvious promoting effect on the improvement of agricultural production efficiency, and the impact of economic growth on it is more and more significant in the long term. Agricultural production efficiency has a significant positive impact on the impact of agricultural economic growth and tends to be stable in the long run, indicating that the improvement of agricultural production efficiency and complete technical conditions promote agricultural economic growth.

3.5. Variance decomposition analysis

On the basis of the analysis of impulse response function, variance decomposition is further carried out to analyze the contribution of each structural impact to the change of endogenous variables, which can reflect the relatively important information of each random disturbance influenced by endogenous variables in the system. The results of variance decomposition are shown in Table 4.

Table 4. Results of variance decomposition

variable	s	lngdp	lnsbm	variable	s	lngdp	lnsbm
lngdp	1	1.000	0.000	lnsbm	10	0.155	0.845
lnsbm	1	0.082	0.918	lngdp	15	0.715	0.285
Lngdp	5	0.894	0.106	lnsbm	15	0.163	0.837
lnsbm	5	0.124	0.876	lngdp	20	0.684	0.316
lngdp	10	0.777	0.223	lnsbm	20	0.165	0.835

(1) Regarding the growth of agricultural economy, in the next one period, the contribution rate of agricultural economic growth reaches the maximum, and the agricultural production efficiency has a small impact on the growth of agricultural economy. Subsequently, agricultural economic growth has a great impact on the growth of agricultural economy. Although it decreases year by year after that, it still maintains an absolute advantage; The agricultural production efficiency increased from 12.4% in the next five stages to 16.5% in the 20th stage, indicating that in the long run, the impact of agricultural production efficiency on agricultural economic growth tended to be stable.

(2) As for agricultural production efficiency, the contribution rate of agricultural economic growth is weak and almost tends to 0. With the growth of the forecast period, the contribution rate of agricultural production efficiency decreases year by year and remains at 83.5% in the 20th period. The contribution of agricultural economic growth to agricultural production efficiency remained to 31.6%, which indicates that the explanatory power of agricultural

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economic growth to agricultural production efficiency is gradually enhanced, and the long-term effect is obvious. However, compared with the explanatory strength between the two, the contribution of agricultural economic growth to agricultural production efficiency is higher, indicating that the mutual influence between agricultural economic growth and agricultural production efficiency is asymmetric.

4. Conclusions and policy implications

In this paper, panel data of 30 Provinces and cities (except Xizang) in China from 1997 to 2018 were selected, super-efficiency SBM model was used to measure agricultural production efficiency, and panel VAR model was constructed to test and analyze the two-way interactive relationship between agricultural production efficiency and agricultural economic growth. The results show that there is a two-way effect between agricultural production efficiency and agricultural economic growth. The positive change of agricultural economic growth will cause the positive change of agricultural production efficiency, but the effect of agricultural production efficiency relying on its own situation is obviously stronger than that of agricultural economic growth. Agricultural production efficiency and agricultural economic growth affect and promote each other, and the interaction mechanism between them will further promote the construction of agricultural modernization. Therefore, the current agricultural supply-side structural reform should be further promoted through agricultural policies and price levers to promote the flow of capital, technology, talent, land and other factors to rural areas, adhere to the priority of agricultural and rural development, and accelerate agricultural and rural modernization.

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