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A Study of Agricultural Technology Extension and Synchronous Development of Agricultural Modernization, Urbanization and Industrialization in China

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Abstract Through the study of relationship between agricultural technology extension and the development of agricultural modernization, urbanization and industrialization, it is found that agricultural technology extension is an important means to achieve synchronous development of agricultural modernization, urbanization and industrialization. Based on the sample data in China during 1978-2011, we perform the empirical analysis using VAR model and cointegration analysis and impulse response methods. The results show that there is a long-term positive equilibrium relationship between agricultural technology extension and the development of agricultural modernization, urbanization and industrialization, and agricultural technology extension plays a role in promoting agricultural modernization, urbanization and industrialization to varying degrees. Finally, it is concluded that there is a need to establish efficient agricultural technology extension mechanism and diversified agricultural technology extension investment mechanism to make agricultural technology extension better promote China's agricultural modernization, urbanization and industrialization.

Key words Agricultural technology extension, Agricultural modernization, Urbanization, Industrialization

1 Introduction

Science and technology are primary productive forces and important driving forces in realizing modernization. Since the reform and opening up, China's industrialization and urbanization have been rapidly developed, and the industrial added value has accounted for 40% of GDP. In 2011, the proportion of urban population reached 51%. However, China's agricultural modernization process is slow, the agricultural productivity is low and the level of agricultural mechanization is low. The contribution rate of agricultural technology is not high, and there is a widening income gap between urban and rural areas. Agricultural modernization lags behind industrialization and urbanization, which has become the bottleneck on China's modernization. In October 2010, *Proposal of CPC Central Committee on Developing the Twelfth Five-Year Plan of National Economy and Social Development* stated that the agricultural modernization should be promoted in tandem with industrialization and urbanization. In February 2012, the State Council issued *Several Opinions on Accelerating Agricultural Technological Innovation and Continuously Enhancing the Agricultural Supply Security Ability*, and the document states that in order to achieve sustained and stable development of agriculture and ensure long-term effective supply of agricultural products, the fundamental way lies in promoting science and technology and strengthening the construction of agricultural technology extension system. In *Transforming Traditional Agriculture*, Schultz mentions that the key of

agricultural growth is the introduction of new technology^[1]. The US development economist W. Arthur Lewis points out that agricultural technology extension is an important way to promote agricultural development in *The Theory of Economic Growth*^[2]. The agricultural technology extension is the key to conversion of agricultural scientific and technological achievements to practical productive forces, and an effective way to spread science and technology and improve agricultural production and management level. The conversion of scientific and technological achievements is a driving force for the process of modernization, and agricultural technology extension plays an important role in accelerating China's agricultural modernization, getting rid of urban-rural dual economic structure, promoting industrialization and urbanization, and realizing the synchronous development of China's agricultural modernization, urbanization and industrialization.

2 Connotation of synchronous development of agricultural modernization, urbanization and industrialization

Modernization refers to a model of a progressive transition from a "pre-modern" or "traditional" to a "modern" society. The process of modernization of developed countries will inevitably have to go through the coordinated development of "industrialization, urbanization and agricultural modernization"^[3]. For example, USA is a highly industrialized and urbanized country, but it always takes agriculture as the national economy and foreign trade. After World War II, France neglected agricultural modernization so that the national economy paid a high price, and later it adopted a series of comprehensive measures to develop agriculture and change the backwardness of agriculture^[3]. In October 2010, *Pro-*

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posal of CPC Central Committee on Formulating the Twelfth Five-Year Plan of National Economic and Social Development was issued and put forward the propulsion of agricultural modernization with industrialization and urbanization. In the strategy of synchronous development of agricultural modernization, urbanization and industrialization, it can be found that the agricultural modernization, industrialization and urbanization are given the equal importance for the first time, fully reflecting the central government's emphasis on issues concerning agriculture, rural areas and farmers. The purpose of synchronous development of agricultural modernization, urbanization and industrialization is to accelerate the development of modern agriculture, promote the coordinated development of industry and agriculture, and enhance the urban and rural prosperity^[4]. In the synchronized development, agricultural modernization is the basis, and it can provide support and protection for industrialization and urbanization. If agricultural modernization can not keep up with the pace of industrialization and urbanization, the development of industrialization and urbanization will be hampered, thereby affecting the entire modernization process. Industrialization plays a leading role, and without industrialization, agricultural modernization will lack advanced material technology and modern management tools. Urbanization creates conditions for intensive development of industry and large-scale development of agriculture.

3 Study on the role of agricultural technology extension in promoting the synchronous development of agricultural modernization, urbanization and industrialization in China

The modern agricultural extension for production activities was used by the US land-grant universities in the early 20th century. From the 1930s, China began to use and research agricultural extension, and since the founding of new China, a large number of advanced agricultural technologies have been used for agricultural production, greatly promoting China's agricultural development^[5]. Article 2 of *Agricultural Technology Extension Law of People's Republic of China* states that agricultural technology is the scientific research result and practical technology applied to farming, forestry, animal husbandry and fishery, and agricultural technology extension is the activity of popularizing agricultural technology and applying it to the whole process of agricultural production through testing, demonstration, training, guidance and counseling services.

3.1 Agricultural technology extension contributes to agricultural modernization

3.1.1 Agricultural technology extension contributes to the modernization of agricultural technology and agricultural production factors. Agricultural technology extension can reduce the lag time of using new agricultural technologies, accelerate scientific and technological diffusion, and increase the use level of modern technology in agricultural production. If the extension of modern agricultural science and technology adaptable to agricultural develop-

ment is fast and the scale is large, it will help to improve the labor productivity and yield and quality of agricultural products, and the level of agricultural modernization will be higher. Agricultural workers are the main body in agricultural productivity, and play a decisive role in agricultural productivity. As Schulz put it, "The capacity that farmers get is of paramount importance in the realization of agricultural modernization." In the process of modernization of agriculture, agricultural production can not rely on the technology from generation to generation, and it is particularly important to strengthen farmers' agricultural professional education^[6]. Through the agricultural technology extension system, in view of farmers' aversion to risk, the technology promotion agency uses the ways of intervention, demonstration, communication, persuasion and education to guide farmers to adopt modern technology inputs.

3.1.2 Agricultural technology extension helps to improve the socialization level of agriculture. Agricultural technology extension improves the socialization level of agricultural production, and agricultural technology extension departments directly serve all links of agricultural production. By improving the agricultural producers' labor skills, it changes the role of individual farmers in labor division system, and equips them with modern agricultural production techniques and skills, so that the traditional independent farmers are gradually united with businesses. In the process of agricultural technology extension, through the introduction of new technologies and new varieties, agricultural production gradually shifts from the initial decentralized management to cooperative business operation, so as to achieve reasonable transfer of technology and optimal allocation of resources.

3.2 Agricultural technology extension contributes to rural labor transfer, provides the necessary resources for the urbanization and becomes the "link" for city to driving rural development

Urbanization means that rural population constantly flows into city, and secondary and tertiary industries continue to concentrate in urban areas, so that the number of cities and towns is increased and the scale is expanded. During urbanization, a large number of rural labor forces change into non-agricultural population, and considerable rural land change into urban land, accompanied by reduction of agricultural labor and land. Under agricultural technology extension, with improvement of labor productivity and land use efficiency, a large number of rural labor forces are freed from the land, leaving the countryside to the cities to work and live, so that the proportion of permanent population in rural areas is declining, and the development of urbanization is promoted. An important way for the city to promote the agricultural development is to develop modern agriculture, transfer rural surplus labor and develop urban-rural related industries, which is inseparable from the modern agricultural science and technology for agricultural production. City is the place where capital, technology and information gather. It creates a good environment for the research and development of agricultural science and technology, provides funding source for agricultural technology extension,

provides education mechanism for the training of agricultural extension workers, and provides power mechanism for the establishment of a sound China's agricultural technology extension system. Agricultural technology extension becomes the "link" for city to drive rural development.

3.3 Agricultural technology extension guarantees the necessary raw materials and factors of production for industrial development, promotes industrialization and acts as an effective channel of industry nurturing agriculture

Agriculture is the basis of national economy, and agriculture not only meets the food needs of urban residents, but also provides adequate raw materials for industry. Agricultural technology extension improves the yield and quality of agriculture, and increases the effective supply of industrial raw materials. The industrial development is inseparable from the processing of agricultural products. As for China's raw materials needed by industry, the raw materials for agricultural production account for a very large proportion. With the increasing industrial scale, agriculture contributes more obviously to industrial products, which requires more new technologies to be used in agricultural production to meet industry's diverse agricultural raw materials^[8]. The technological progress brought by industrialization can promote agricultural science and technology innovation, improve the status of agricultural development, and provide technical support to enhance the level of agricultural modernization. The agricultural technology extension channels large-scale industrial results and technology into agricultural production, to promote mechanization and accelerate the shift from traditional agriculture to modern agriculture^[9].

4 Empirical research

Table 1 ADF unit root test results

Testing series	Testing forms	ADF statistic	ADF threshold (5%)	Testing results
LnAG	(C, T, 0)	-1.123265	-3.557759	Non-stationary
LnUR	(C, T, 0)	-1.558030	-3.557759	Non-stationary
LnIN	(C, T, 0)	-2.330886	-3.557759	Non-stationary
LnTE	(C, T, 0)	-3.229466	-3.557759	Non-stationary
Δ LnAG	(C, 0, 0)	-3.092232	-2.957110	Stationary
Δ LnUR	(0, 0, 0)	-1.657053	-1.951687	Stationary
Δ LnIN	(0, 0, 0)	-4.278046	-1.952066	Stationary
Δ LnTE	(C, 0, 0)	-5.515177	-2.960411	Stationary

Note: Δ represents the first difference testing form; (C, T, K) denotes whether there are constant term (C), time trend (T) and lag order (K) in unit root test, respectively.

4.3 Cointegration test Cointegration test is to test whether there is a stable relationship between the variables, and this paper uses Johansen cointegration test to analyze whether there is a stable relationship between agricultural technology extension and agricultural modernization, urbanization and industrialization. As can be seen from the cointegration test results in Table 2, at the 5% significance level, the trace statistic test and the maximum eigenvalue statistic test reject the hypothesis that there is no cointegrating equation, indicating that there is a cointegration relationship between agricultural technology extension and agricultural

4.1 Variables and data selection Based on the sample data during 1978-2011, the VAR model is used to conduct empirical analysis of the relationship between agricultural technology extension and agricultural modernization, urbanization or industrialization. By considering the data availability, operational possibility and simplification of comparative analysis, this paper uses the single indicator for analysis. Agricultural modernization indicator (AG) is denoted by the ratio of agricultural output value to agricultural employed population; urbanization indicator (UR) is denoted by the proportion of urban population to total population; industrialization indicator (IN) is denoted by the proportion of industrial output value to total GDP^[10-12]. Given China's agricultural technology extension funding comes mainly from the finance, technology extension indicator (TE) is denoted by per capita expenditure of national financial support to rural production and operating expenses of agricultural sector. In this paper, the research data use the national data from *China Statistical Yearbook* and *China Rural Statistical Yearbook* (1979-2012), and the sample time is from 1978 to 2011. In order to reduce volatility and heteroscedasticity of data, we take the logarithm of the data in analysis, written as LnAG, LnIN, LnUR and LnTE.

4.2 Unit root test Non-stationary data may produce spurious regression phenomenon, and this paper uses ADF unit root test method to test the stationarity of time series data. Eviews6 software is used to conduct ADF test, and the test results are shown in Table 1. It shows that the original series of LnAG, LnUR, LnIN and LnTE are non-stationary time series data, and the original series after the first difference are stationary time series, that is, LnAG, LnUR, LnIN and LnTE are integrated series.

modernization, urbanization or industrialization, that is, there is a stable equilibrium relationship between agricultural technology extension and agricultural modernization, urbanization and industrialization, respectively.

The cointegration test results of agricultural technology extension and agricultural modernization:

$$\text{Equation 1 } \text{LnAG} = 0.8607\text{LnTE} + 3.6066 \\ (0.0303) \quad (0.1517)$$

The cointegration test results of agricultural technology extension and urbanization:

$$\text{Equation 2 } \ln UR = 0.2377 \ln TE - 2.3359$$

$$(0.0080) \quad (0.0402)$$

The cointegration test results of agricultural technology extension and industrialization:

$$\text{Equation 3 } \ln IN = 0.0408 \ln TE + 3.6744$$

$$(0.0061) \quad (0.0305)$$

The numbers in parentheses under three cointegrating equations are the standard deviation of parameter estimate, all passing the 5% significance test. From the above three equations, it can be found that there is a long-term positive equilibrium relationship

Table 2 Johansen cointegration test results

	Null hypothesis	Eigenvalues	Trace test statistic (<i>P</i> value)	The maximum eigenvalue statistic (<i>P</i> value)
Equation(1)	0 cointegrating equation	0.364289	16.888850 (0.0307 **)	14.496370 (0.0460 **)
	At least one cointegrating equation	0.072039	2.392483 (0.1315)	2.392483 (0.1219)
Equation(2)	0 cointegrating equation	0.400384	17.902970 (0.0213 **)	16.366920 (0.0229 **)
	At least one cointegrating equation	0.046868	1.536040 (0.2152)	1.536049 (0.2152)
Equation(3)	0 cointegrating equation	0.429139	20.443070 (0.0083 **)	17.939520 (0.0125 **)
	At least one cointegrating equation	0.075254	2.503553 (0.1136)	2.503553 (0.1136)

Note: * * shows that the null hypothesis is rejected at the 5% significance level.

4.4 Granger causality test Granger causality test can explain the causal relationship between agricultural technology extension and agricultural modernization, urbanization or industrialization. As can be seen from the Granger causality test results in Table 3, in Lag 3, agricultural technology extension Granger causes agricultural modernization, which is consistent with the previous analysis. Agricultural technology extension improves the technological level of agricultural production, agricultural productivity and land

Table 3 Granger causality test results

Null hypothesis	Lag	F statistic	Significance probability	Conclusions
$\ln AG$ does not Granger Cause $\ln TE$	3	1.31793	0.2917	Accepting the null hypothesis
$\ln TE$ does not Granger Cause $\ln AG$	3	2.49682	0.0839	Rejecting the null hypothesis
$\ln UR$ does not Granger Cause $\ln TE$	2	5.45223	0.0103	Rejecting the null hypothesis
$\ln TE$ does not Granger Cause $\ln UR$	2	1.12720	0.3387	Accepting the null hypothesis
$\ln IN$ does not Granger Cause $\ln TE$	2	5.72872	0.0084	Accepting the null hypothesis
$\ln TE$ does not Granger Cause $\ln IN$	2	0.72641	0.4929	Rejecting the null hypothesis

4.5 Impulse response analysis Impulse response function is to describe the impact of an endogenous variable in VAR model on other endogenous variables. Fig. 1 shows the impulse response of agricultural modernization, urbanization and industrialization based on VAR (2) model. The horizontal axis curve represents the tracing periods of response function (15 years in the paper); vertical axis represents the degree of response of dependent variables to explanatory variables. Fig. 1 (a) shows the impact of agricultural modernization on standard deviation from agricultural technology extension, and both short-term and long-term response is positive, remaining at a high level after reaching the maximum of 0.069 in the sixth year. In the long term, this positive response tends to stabilize, indicating that the agricultural technology extension plays a lasting significant role in enhancing agricultural modernization. Fig. 1 (b) shows the impact of urbanization on stand-

between agricultural technology extension and agricultural modernization, urbanization or industrialization, and the elasticity coefficients of agricultural technology extension to agricultural modernization, urbanization and industrialization are 0.8607, 0.2377 and 0.0408, respectively, suggesting that agricultural technology extension promotes the development of agricultural modernization, urbanization and industrialization. It can be seen from coefficient values that agricultural technology extension has greater impact on agricultural modernization than on urbanization and industrialization.

production rate, and accelerates agricultural modernization. In Lag 2, urbanization and industrialization Granger cause agricultural technology extension. The development of cities and towns and improvement of industrial level provide technical source and support of human resources and funding for agricultural technology extension and improving China's agricultural technology extension mechanism is an important channel of industry nurturing agriculture and city driving the rural development.

ard deviation from agricultural technology extension, and it is a small negative response at the beginning, becomes a positive response in the third year, and positive response is gradually stabilized in the tenth period, indicating that agricultural technology extension improves the level of agricultural technology, enhances agricultural productivity, promotes the transfer of rural labor to urban areas and provides the necessary resources for the development of urbanization, and this role gradually intensifies over time, that is, agricultural technology extension plays a long-term role in promoting urbanization. Fig. 1 (c) shows the impact of industrialization on standard deviation from agricultural technology extension, and both short-term and long-term response is positive, which indicates that by affecting agricultural production, agricultural technology extension plays a positive role in promoting the development of industrialization.

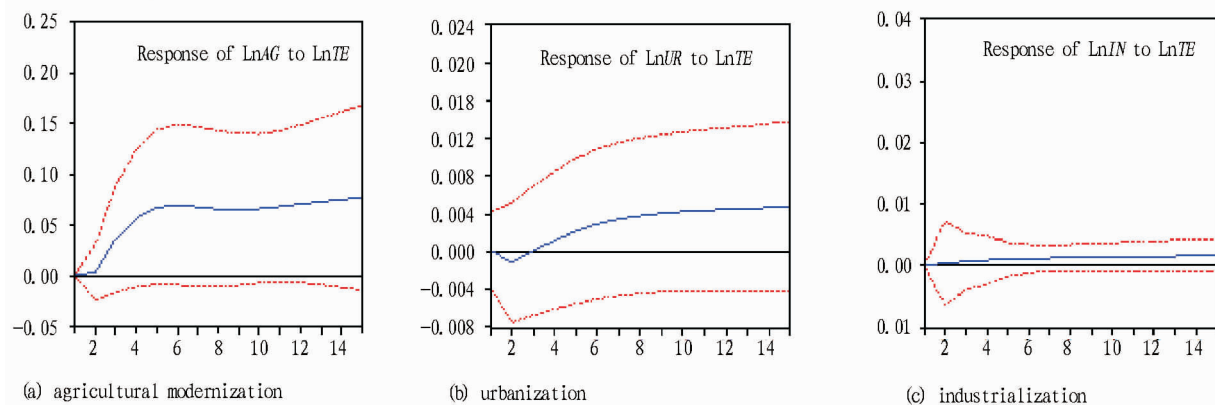


Fig.1 Impulse response of agricultural modernization, urbanization and industrialization

5 Conclusions and recommendations

5.1 Conclusions Through the study of relationship between agricultural technology extension and the development of agricultural modernization, urbanization and industrialization, it is found that agricultural technology extension is an important means to achieve synchronous development of agricultural modernization, urbanization and industrialization. Based on the sample data in China during 1978-2011, we perform the empirical analysis using VAR model and cointegration analysis and impulse response methods. The results show that there is a long-term positive equilibrium relationship between agricultural technology extension and the development of agricultural modernization, urbanization and industrialization, and agricultural technology extension plays a role in promoting agricultural modernization, urbanization and industrialization to varying degrees. It is required to build new agricultural technology extension service system that adapts to the new era, and accelerate the promotion, transformation and application of agricultural scientific and technological achievements.

5.2 Recommendations

5.2.1 Playing the role of agricultural technology extension and building efficient agricultural technology extension operating mechanism during agricultural modernization. According to the natural conditions and development direction of modern agriculture in various regions, it is necessary to carry out various forms of technical training and technology promotion, and flexibly organize scientific and technological personnel to efficiently and effectively provide technical, information and advice service for the majority of farmers; change farmers' attitudes towards new technologies and make farmers become active adopters of technology; gradually form a multi-level technology extension operating mode dominated by state-owned agricultural technology extension service system and supplemented by agricultural research institutes, and various types of cooperatives and associations; set up agricultural technology extension departments in various agricultural colleges and universities and scientific research institutes to be responsible for the promotion of new technologies; encourage agricultural cooperatives to participate in agricultural technology extension activities, and offer tax incentives and financial subsidies.

5.2.2 Building a sustained, stable and diversified government-led investment mechanism to substantially increase investment in agricultural technology extension during urbanization and industrialization. It is necessary to establish a long-term mechanism of government financial investment in agricultural technology extension to improve the strength of the government investment in agricultural technology extension; increase the total amount of investment while continuing to improve the structure of cost input into agricultural technology extension, and adjust the proportion of project costs, personnel expenses and operational activity expenses to ensure the smooth extension; combine the paid and unpaid extension, make non-governmental extension organizations undertake the supply of agricultural technology products and make government extension agencies responsible for the supply of agricultural technology services; rationally use private capital, encourage business investment, and make Agricultural Bank, Agricultural Development Bank and Rural Credit Cooperatives provide loans to agricultural technology extension, to form diversified financing and investment mechanisms for agricultural technology extension.

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low organizational degree, and are anxious to sell agricultural products in harvesting season, so the market competition will be more intense. In this situation, under the seriously asymmetry industrial chain structure, agricultural product processing enterprises have higher market advantage, enjoy certain agricultural product pricing power, and so as to exert major influence on mode selection and development process of agricultural product industrial chain.

2.4 Actions of local government Local government generally conducts activities for inviting outside investment in agricultural product processing projects and adjusts agricultural production structure. This promotes development of agricultural production and processing industry, but agricultural structural adjustment led by government often brings risk of greater supply-demand conflict of agricultural products due to inadequate market estimation. In particular, agricultural product processing enterprises urge farmers to expand agricultural product production scale and output for the purpose of maximizing their benefits, so as to reduce raw material purchasing price and production cost. Due to feature of increasing yield but not increasing income, inappropriate actions of local government will inflict damage on farmers' benefits, and finally reduce overall performance of vertical coordination and restrict development of vertical coordination.

3 Conclusions

There are traditional market-oriented transaction mode with fluctuation according to market conditions, made-to-order on the basis of farmer organization, company leading cooperative mode, share or shareholding cooperative mode, and vertical integration mode in the vertical coordination development mode of agricultural products in China. There are differences in coordination characteristics, advantages and disadvantages, and adaptability between different modes. Traditional vertical coordination mode is transforming and upgrading to close and high-efficient mode. In this process, it is influenced by factors such as cost-benefit balance between farmers and agricultural product processing enterprises, special use of agricultural product processing, structure of agricultural product in-

dustrial chain, and action of local government. Factors influencing transformation and upgrade of vertical integration of agricultural products include balance of coordination cost-benefit between farmers and enterprises, special use of agricultural product processing, industrial chain structure of agricultural products, and actions of local government. In view of these factors, it is recommended to take pertinent measures to realize healthy development of vertical coordination in field of agricultural products.

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