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On the Non-linear Impact of Agricultural Technological Progress on Rural Revitalization

-- Based on Threshold Variable Model and DLNM Dual Model

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Abstract

There are studies on the impact of agricultural technology progress on rural revitalization. Domestic scholars have initially studied the relationship between the two. Agricultural technological progress has a significant impact on rural revitalization, and rural revitalization is a nonlinear system. This paper will use the threshold variable model and the DLNM nonlinear lag model to deeply test the nonlinear impact of agricultural technological progress on rural revitalization, and at the same time explore whether there is a lagged impact, explore the path of rural revitalization using the mediation model, and put forward relevant policy suggestions.

Keywords

Agricultural Technological Progress; Rural Revitalization; Non-linear Effects.

1. Introduction

In order to comprehensively build a strong modern socialist country, Comrade Xi Jinping put forward the strategy of rural revitalization in the report of the 19th Party Congress on October 18, 2017, in which one of the important paths to achieve rural revitalization is that "it is necessary to deepen the structural reform of the supply side of agriculture, and take the road of quality agricultural development". At the same time, Premier Li Keqiang put forward the requirement of "adding more than 80 million mu of new high-standard farmland and 20 million mu of high-efficiency water-saving irrigation area" in the 2018 government work report, the innovation and progress of agricultural technology has become a difficult and urgent problem. Therefore, the path of agricultural technology innovation and the direction of agricultural technology improvement under the strategy of rural revitalization have been widely concerned by the society. Under what circumstances the improvement of agricultural technology can promote the development of rural revitalization with the highest efficiency has also become an important topic for scholars to study.

Regarding the research on the impact of agricultural technological progress on rural revitalization, domestic scholars have initially studied the relationship between the two. Agricultural technological progress has a significant impact on rural revitalization, and rural revitalization is a nonlinear system. In 2018, the contribution rate of China's agricultural scientific and technological progress increased to 58.3%, and technological progress has greatly enhanced productivity and played an increasingly significant role in China's agricultural development and economic growth (Zhang Shurui et al., 2020). Agricultural technological

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progress has a nonlinear impact on rural revitalization in China and the central and western provinces; the rural revitalization system has the characteristics of rise and fall and non-equilibrium. With the upgrading of industrial structure, the nonlinear support of agricultural technological progress on rural revitalization is enhanced (He Xiaoxia et al., 2022).

Unfortunately, there is still room for expansion of the existing literature on the study of the non-linear impact of agricultural technological progress on rural revitalization. First, in terms of research content, the existing literature lies more in the study of the connotation definition of rural revitalization, macro objectives, practice path, comprehensive evaluation, and the influencing factors and measurement methods of agricultural technological progress, and it lacks the expansive research on the nonlinear impact of agricultural technological progress on rural revitalization development; second, the research methodology mostly adopts the DEA-Malmquist index method, Cobb-Douglas production function or Solow residual value method to measure agricultural technological progress, the empirical method is relatively single; third, scholars are less likely to take into account the fact that due to the habit of economic development, the non-linear impact of agricultural technological progress on rural revitalization will have a time lag problem.

Therefore, based on the 2011-2021 China Rural Statistical Yearbook of 31 provincial-level administrative regions (excluding Hong Kong, Macao and Taiwan for the time being) as well as the yearbook data of each province (autonomous region and municipality directly under the central government), the present study intends to construct a comprehensive evaluation index system and use the threshold regression model to empirically analyze the specific effects of the non-linear impetus of agricultural technological progress on rural revitalization. Construct DLNM to explore whether there is a lagged nonlinear effect of agricultural technological progress on rural revitalization. Using the mediation effect model, analyze and explore the realization path of agricultural technological progress to promote the efficient development of rural revitalization.

2. Research on the Non-linear Relationship between Agricultural Technological Progress and Rural Revitalization and Development

2.1. Threshold Regression Models

Based on the 2011-2021 China Rural Statistical Yearbook of 31 provincial-level administrative regions (excluding Hong Kong, Macao and Taiwan for the time being) as well as the yearbook data of each province (autonomous regions and municipalities directly under the central government), we analyze that China's agricultural technological advancement has a non-linear impact on rural revitalization.

The model with the threshold variable of structural upgrading of the agricultural industry (structure) is constructed as follows:

$$\begin{aligned} Ruralit=&\beta 0 + \beta 11AST2it\cdot I(structureit\le\delta 1) +\beta 12AST2it\cdot I(\delta 1\le structureit\le\delta 2) \\ &+ \ldots + \beta 1nAST2it\cdot I(\delta n\text{-}1\le structureit\le\delta n) + \beta 2controlit+\varepsilon it \end{aligned} \quad (1)$$

Where, Ruralit is the rural revitalization variable for province i in year t; βi is the regression coefficient to be estimated; ASTit is the primary term of agricultural technological progress in province i in year t, and AST2it is the squared term of ASTit; I(∗) is the indicator function; structureit is the threshold variable; δi is the threshold value of agricultural industrial structure upgrading in the model; controlit is the control variable of province i in year t (including the primary term of agricultural technological progress, the degree of economic openness, industrial policy, the level of urbanization, infrastructure construction, and the degree of

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education); and εit is the random perturbation term, which is consistent with a normal distribution.

2.2. Data Fitting Results and Robustness Tests

This paper draws on the bootstrap self-help sampling method employed by He Xiaoxia to test the threshold value and threshold number of agricultural technological progress on rural revitalization, and sets the threshold variable to be the upgrading of agricultural industrial structure. The results after fitting show that the national sample rejects the original hypothesis of no single threshold at 1% significance level, rejects the original hypothesis of no double threshold at 1% and 5% significance levels, and is unable to reject the original hypothesis of no triple threshold, which validates that there is a significant level of higher single and double threshold effects.

Table 1. Threshold test for the impact of agricultural technological progress on national rural revitalization

Brochure	Dependent variable	Explanatory variable	Threshold variables	Threshold	Threshold value	F-value	P-value
Nationwide	Rural	AST^2	Advanced	Single threshold	0.3321	118.02	0.000
				Double threshold	0.3323 0.4177	83.23	0.003
				Three thresholds	0.4386	9.49	0.627

After determining the existence of threshold in the model, we combined with the panel data, and then after the R software threshold variable model package for regression analysis. The results of the empirical analysis show that the conclusion of the nonlinear support of agricultural technological progress on rural revitalization in the threshold model still holds. There is a double threshold effect of the square of agricultural technological progress on rural revitalization, which is the same as the experimental results of He Xiaoxia.

3. Lagged Nonlinearity of the Impact of Agricultural Technological Progress on Rural Revitalization

3.1. DLNM Modeling

There is a lagging nonlinear exploration study on the impact of agricultural technology progress on rural revitalization. This part is based on the above nonlinear impact study, using DLNM to explore whether there is a lagged impact of agricultural technology progress on rural revitalization. The structure of the model is as follows:

$$\text{Rural} = E(Y) \tag{2}$$

$$g(\text{Rural}_t) = \alpha + s(x_t, \eta) + \beta \text{control}_t \tag{3}$$

Where, g(·) is the link function, considering the discrete distribution, Poisson-like is generally used; Ruralt is the rural revitalization variable in year t; α is the intercept of the model; assuming that the maximum number of lagged years of the effect of agricultural technological progress is L years, the independent variable xt=(xt, xt-1, …, xt-L)is the row vector consisting of the data on agricultural technological progress of each year from year t to the previous year L,

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and η is the corresponding parameter. s(·) is the cross-basis function fitting the xt effect; controlt is the control variable for year t, and β is the corresponding parameter.

3.2. Data Fitting Results and Robustness Tests

DLNM is a model introduced by Armstrong in 2006 to understand the lagged effects of temperature on human health in the study of temperature health effects, which contains a cross-basis function that is a key part of the model. Gasparrini et al. further elaborated the principle of DLNM in 2010, and established the "dlnm" program package in R softwareto fit the temperature-lag-death relationship, i.e., using the cross-basis function to analyze the nonlinear relationship of temperature-death andthe nonlinear lag effect of temperature. The DLNM model has also been used in subsequent research articles to explore the impact of temperature change on human health, such as "An introduction to the application of time-varying distributional lag nonlinear modeling: the relationship between temperature and deaths as an example", and "Constructing a meteorological health index based on deaths data using DLNM". Therefore the model is used for the exploration of agricultural technology progress on rural revitalization of economic projects, the fitting results have a certain unreliability and uncertainty, this paper will be the initial conception of the model listed but not analyzed.

4. Path to Efficient Development of Rural Revitalization Supported by Progress in Agricultural Technology

4.1. Intermediary Models

Explore the realization path of agricultural technological progress contributing to the efficient development of rural revitalization by constructing a mediating effect model. The following model is designed:

$$Rural_{it} = \beta_0 + \beta_1 AST_{it}^2 + \beta_2 control_{it} + \varepsilon_{it} \quad (4)$$

$$Rural_{it} = \alpha_0 + \alpha_1 W_{it} + \alpha_2 control_{it} + \varepsilon_{it} \quad (5)$$

$$W_{it} = \gamma_0 + \gamma_1 AST_{it}^2 + \gamma_2 control_{it} + \varepsilon_{it} \quad (6)$$

Where, AST2it is the core explanatory variable, the square of agricultural technological progress; Wit is selected as the mediator variable; and the other variables are consistent with the threshold variable model.

4.2. Rural Development Path Analysis

4.2.1. Agricultural Technological Progress Contributes to Rural Revitalization Through Carbon Intensity

In the exploration of the role of agricultural technology progress on carbon emission intensity, Fan Dongshou divided the paths into two based on Acemoglu's biased technology progress theory.

The first pathway is the direct effect. If agricultural technological progress favors "clean production", then the increase of agricultural output will not bring about the rise of total carbon emissions, and the carbon emission intensity will be zero or in a downward trend; if technological progress favors "non-clean production", then the increase of agricultural output will be accompanied by the increase of total carbon emissions. If technological progress favors "non-clean production", then the increase in agricultural output will inevitably be accompanied by an increase in the total amount of carbon emissions, and the intensity of carbon emissions

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at this time depends on the size of the relationship between the two, that is to say, the direction of the impact of technological progress on the intensity of carbon emissions is uncertain.

The second path is the indirect effect. Here, Fan Dongshou combines Acemoglu's theory of biased technological progress and proposes "biased technological progress", that is, biased agricultural technological progress. On the one hand, biased agricultural technological progress will affect the allocation of agricultural factors and change the structure of factor allocation. If the technology is biased towards the use of pesticides, fertilizers, agricultural films and other carbon-containing energy elements, when the use of such energy elements reaches a certain level, the law of diminishing marginal utility will make the use of its efficiency will be gradually low, which will increase the intensity of agricultural carbon emissions. On the other hand, biased agricultural technological progress can promote industrial structure upgrading and rationalization, which can indirectly reduce the carbon emission intensity. Bias-type agricultural technological progress causes factor reset and at the same time promotes the internal structure adjustment of agriculture, reduces the proportion of high-energy-consuming production sectors, and then increases the total output of agriculture and achieves the effect of reducing the total amount of carbon emissions and the intensity of carbon emissions.

Therefore, the impact of agricultural technological progress on carbon emissions in different directions will lead to the development of rural revitalization in different directions.

In this regard, Fan Dongshou puts forward the hypothesis of using the plate equation model, and concludes that the progress of agricultural technology promotes the rationalization of the agricultural structure, and the rationalization of the agricultural structure releases the "structural dividend", which can in turn drive the progress of agricultural technology. In turn, it can alleviate carbon emission intensity, which is one of the indicators of rural revitalization, so it is assumed that agricultural technological progress plays a role in rural revitalization through carbon emission intensity.

4.2.2. Agricultural Technological Advances have a Non-linear Impact on Rural Revitalization Development Through Digital Technologies

Table 2. Mediated effects test

	(1)W_1	(2)Rural	(3)W_2	(4)Rural
Digital	0.224 7*** (5.09)	0.049 4*** (3.97)	0.105 4** (7.70)	0.044 3*** (4.07)
W1	-	0.055 8*** (3.15)	-	-
W2	-	-	-	0.166 9*** (6.77)
control	containment	containment	containment	containment
province	containment	containment	containment	containment
year	containment	containment	containment	containment
R^2	0.826 3	0.879 0	0.588 0	0.879 2
Sobel	-	4.86***	-	6.44***

Note: ***, **, * denote 1%, 5%, and 10% significance levels, respectively, with corresponding t-values in parentheses.

The development of rural areas cannot be separated from the informationization that follows the current trend, and the development of digital technology is also a reflection of the progress of agricultural technology. Drawing on Xie Guogan's "Research on the Mechanism and Path of Digital Technology Promoting Rural Revitalization and Development - Test Based on the Mediation Effect Model and Threshold Effect Model", there are two mediating variables in

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digital technology promoting rural revitalization and development - digital inclusive finance and rural entrepreneurship level, which are set as W1 and W2. The following results are derived from the test of the mediation effect of the two variables using the above mediation model.

The mediation test concludes that there is a significant positive relationship between digital technology development and both mediating variables of digital financial inclusion and rural entrepreneurship level at the 1% level of significance. Including the mediating variables in the three-step benchmark regression model, the regression results conclude that digital technology development and the two mediating variables for rural revitalization are still significant at the 1% level of significance. In addition, the regression results after adding the mediating variables to the benchmark regression model show that the estimated coefficients of digital technology development on rural revitalization are both reduced, indicating that both digital financial inclusion and rural entrepreneurship level are important mediating variables for digital technology to promote rural revitalization development.

5. Conclusion and Suggestions

Based on the rural revitalization strategy, this paper constructs a threshold regression model of agricultural technological progress on rural revitalization threshold variables to empirically explore the mechanism of the impact of agricultural technological progress on rural revitalization. At the same time, it tries to explore the lagged impact of agricultural technological progress on the development of rural revitalization under the influence of nonlinearity, but due to the excessive bias in the field of use, it is not possible to correctly draw conclusions about the corresponding lagged impact. Therefore, no relevant lag impact discussion is made.

The results of the study found that: (1) agricultural technological progress has a non-linear impact on rural revitalization. (2) The mitigating effect of agricultural technological progress on carbon emissions depends on the different types of technological progress, which in turn affects the direction of rural revitalization. (3) Reasonable agricultural structure inversely promotes agricultural technological progress, releases "structural dividend", and then reduces the intensity of agricultural carbon emissions and promotes rural revitalization. (4) Digital technology can directly improve the development level of rural revitalization. (5) Digital inclusive finance and rural entrepreneurial vitality play a role in the process of digital technology influencing rural revitalization development.

Based on the above conclusions, the following specific suggestions on how to promote agricultural technological progress for rural revitalization and development are to be considered:

To take a low-carbon and green agricultural development path, on the one hand, it is necessary to strengthen the development, promotion and large-scale utilization of low-carbon, green and ecological agricultural technologies; on the other hand, it is not possible to ignore the emission reduction dividend brought about by the optimization and adjustment of the internal structure of the industry, and therefore, attention should be paid to the coordination of the various subdivision sectors of agriculture, forestry, animal husbandry and fishery in the process of agricultural development. In addition, to realize carbon emission reduction in the agricultural sector, we should not rely solely on technological progress or on structural transformation, but should organically combine green technology and structural adjustment to realize the complementary advantages of various emission reduction paths.

Effectively bring into play the indirect facilitating role of digital inclusive finance and rural entrepreneurship in the process of digital technology for rural revitalization and development, and strengthen the intermediary effect of the two. On the one hand, we should continue to

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promote the development of digital inclusive finance, enhance the breadth and depth of coverage and the degree of digitization of digital inclusive finance in the rural agricultural field, improve the function of digital inclusive financial services in rural revitalization and development, and promote the full release of effective financial demand in rural areas. On the other hand, it is necessary to further promote rural entrepreneurship, vigorously cultivate rural entrepreneurial main bodies, encourage the innovation of sustainable business models for rural entrepreneurship, reduce entrepreneurial risks, and stimulate the vitality of rural entrepreneurship.

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References

[1] He Xiaoxia, Gao Weixin, Mao Wei. Research on the impact of agricultural technology progress on rural revitalization: based on self-organization theory[J]. World Agriculture,2022(4):37-48.

[2] Armstrong B. Models for the relationship between ambient temperature and daily mortality [J].Epidemiology,2006,17(6):624-631.

[3] Gasparrini A, Armstrong B, Kenward M G. Distributed lag non-linear models[J]. Stat Med,2010, 29(21):2224-2234.

[4] Fan Dongshou. Agricultural technological progress, agricultural structure rationalization and agricultural carbon emission intensity [J]. Statistics and Decision Making, 2022, 38(20):154-158.

[5] Yang Jun. Impact of agricultural technological progress on agricultural carbon emissions - a test of Chinese provincial data [J]. Soft Science,2013,27(10):116-120.

[6] Xie Guogen, Jiang Shiquan, Zhao Chunyan. Research on the mechanism and path of digital technology to promote the development of rural revitalization--Test based on the mediation effect model and threshold effect model [J]. Journal of Henan Institute of Science and Technology, 2023,43(9):17-29.