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Research on the Synergy between Green and Low-carbon Transformation of Agriculture and Farmers' Income Increase

-- Dual Wheel Drive Analysis based on Technological and Institutional Innovation

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Abstract

There are dual attributes of unity and mutual constraint between agricultural green and low-carbon transformation and farmers' income increase. It has important theoretical significance and practical value for promoting the synergy between agricultural green and low-carbon transformation and farmers' income increase, and achieving a win-win situation for both. This project aims to explore the intrinsic synergy mechanism between green and low-carbon transformation and farmers' income increase, analyze the current technological, economic, and institutional obstacles, and propose a path to achieve a win-win situation between ecological and economic benefits through technological innovation, policy optimization, and industrial chain integration, providing theoretical reference for rural revitalization.

Keywords

Green and Low-Carbon Agriculture; Increase Farmers' Income; Collaborative Development; Two Wheel Drive.

1. Introduction

The 20th National Congress of the Communist Party of China put forward "promoting ecological priority, conservation and intensive, green and low-carbon development" [1], environmental pressure and lack of resources. In the field of agriculture, achieving green and low-carbon transformation of agriculture has become one of the important objectives of sustainable agricultural development. The "14th five year plan for green agricultural development" clarifies the "ten actions" for agricultural emission reduction and carbon sequestration, and the proportion of green organic agricultural product certification will increase to 15% in 2025. However, in the process of transformation, the proportion of agricultural operating income in farmers' per capita disposable income dropped to 34.6% [2]. As the main body of agricultural production, farmers' income level directly affects the stability of rural society, so while promoting the green and low-carbon transformation of agriculture, we must pay attention to the improvement of farmers' income in order to better ensure the stability and sustainable development of rural society. In this process, it is very important to study how to transform negative agricultural externalities, such as carbon emissions and non-point source pollution, into positive externalities ecological products through technological institutional collaborative innovation, and to find new agricultural cycle chains. Based on the above, it is necessary to study the synergistic relationship between agricultural green low-carbon transformation and farmers' income increase, and to explore how to achieve the benign interaction between the two.

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2. Current Situation of Green and Low-carbon Transformation of Agriculture

Document No.1 of the Central Committee in 2024 proposes to "adhere to the principle of industrial revitalization, quality revitalization and green revitalization" [3]. A series of policy documents on green low-carbon agriculture have been issued one after another to vigorously promote the transformation of green low-carbon agriculture. In the past decade, although the use of agricultural chemical fertilizers, pesticides and agricultural plastic films has gradually declined, they are still the first in the world, and there is a large gap compared with developed countries [4]. Faced with the green and low-carbon transformation of agriculture, farmers need to reduce carbon emissions more substantially, which means that traditional pesticides and fertilizers are about to face the practical problem of seeking environmental alternatives. The increase of emerging production factors is an indispensable step on the road of green and low-carbon transformation of agriculture, but the introduction of new technologies and models and the injection of green production factors may cause greater fluctuations in the supply and demand and prices of agricultural products.

Agricultural science and technology is an important means to promote the green and low-carbon transformation of agriculture. The introduction of modern digital technology can not only improve efficiency, but also play an important role in carbon reduction. However, due to the high cost of digital technology, ordinary farmers can not afford the high cost of machinery [5], coupled with the fact that there are very few new farmers, the elderly are obviously unfamiliar with the term "digital technology", and the large-scale application of the Internet of things is not easy for them to operate. Taking the integrated water and fertilizer machine as an example, complex operation and cumbersome keys are a big challenge. Not only is the cost prohibitive for farmers who can use digital technology. According to the survey, in fact, in addition to the agricultural parks supported by the government, most retail farmers still use traditional farming methods, and there are many problems in the process of transforming to green and low-carbon agriculture through digital technology.

By establishing an econometrical model, this paper explores the relationship between farmers' income and the intensity of green technology adoption in the process of green agricultural transformation. The data in this paper mainly come from Guotai Junan database, the official website of China National Bureau of statistics, China Statistical Yearbook, China Environmental Statistical Yearbook and provincial (District, city) statistical yearbooks.

3. Empirical Analysis

3.1. Variable Definition and Selection

This paper selects the national data from 2014-2023 as the research object, and finds out the indicators such as agricultural operating income, organic fertilizer use area, household head's education years, and the amount of green agricultural subsidies to build a model. Farmers' income growth rate (income) is the explanatory variable, green technology adoption intensity (GTI) is the core explanatory variable, land scale (land), education (EDU), policy subsidy intensity (subsidiary) and regional virtual variable (region) are the control variables, so as to explore the synergistic effect between green technology adoption intensity support and farmers' income.

3.2. Model Selection Basis

Due to the proportion of organic fertilizer use in the intensity of green technology adoption by farmers, some farmers do not adopt technology, resulting in variables piling up at the value of 0, resulting in data truncation. At this time, the use of ordinary least square method (OLS) will

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produce parameter estimation errors. When Tobit model is used for regression, the decision-making process and intensity of technology adoption can be considered, which is more in line with the actual situation of agricultural technology promotion.

3.3. Model Setting

$$GTI_i^* = \beta_0 + \beta_1 Income_i + \beta_2 Land_i + \beta_3 Edu_i + \beta_4 Subidy_i + \beta_5 Region_i + \epsilon_i$$

$$GTI_i = \begin{cases} GTI_i^* \ if \ GTI_i^* > 0 \\ 0 \quad if \ GTI_i^* \leq 0 \end{cases}$$

Among them,GTI_i^* indicates the potential tendency of farmers to adopt technology, and GTI_i is the actually observed intensity of technology adoption.

3.4. Regression Results

The samples with missing key variables were excluded through data pre processing, and the regression results were obtained by Tobit model and Stata, as shown in Table 1.

Table 1. Tobit model regression results

Variable	|coefficient estimate	standard deviation	Z value	marginal effect
Income	0.152**	0.067	2.27	0.118
Land	0.024*	0.013	1.85	0.019
Edu	0.309***	0.095	3.25	0.240
Subsidy	0.478***	0.142	3.37	0.371
Region(Reference group)	-	-	-	-
Region(Center)	-1.205**	0.503	-2.40	-0.937
Region(West)	-2.734***	0.621	-4.40	-2.124
Constant term	-5.217**	2.104	-2.48	-

Note: ***, ** and * represent 1%, 5% and 10% significance levels respectively

3.5. Analysis of Empirical Results

Table 1 shows that for every 1% increase in farmers' income, the intensity of green technology adoption increases by 0.118 percentage points; The maximum editing effect of policy subsidy intensity on technology adoption is 0.371, indicating that fiscal incentives are the key driving force; In addition, the regional differences are obvious, and the intensity of technology adoption in the western region is significantly lower than that in the eastern region.

4. In-depth Analysis of Synergy Barriers

4.1. Market Failure

Taking chemical fertilizers and pesticides as an example, for farmers, these physical prevention and control technologies are indispensable for agriculture. When the production area is large, growers will be more inclined to use traditional pesticides and fertilizers. Improper use will not only damage the pH of the land, but also reduce the production of grain, fruits and vegetables. In the process of transforming physical and chemical technologies into biotechnology, because farmers are difficult to obtain sufficient private benefits to cover these initial costs in the short term, such as purchasing biopesticides, training in use, and some possible production adjustment costs, while society benefits more from them, this leads to the mismatch between private benefits and social benefits [6], resulting in market failure and blocked promotion.

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4.2. Policy Failure

Although the long-term development of green agriculture is an urgent need of society, many local governments lack sufficient financial resources to subsidize farmers for this transformation due to the relatively high cost of green agriculture in the short term. Only 23% of the equipment in the current catalogue of agricultural machinery allocation subsidies meets low-carbon standards, and green subsidies may not be enough to support the current transformation of green agriculture. Moreover, while promoting the green agricultural policy, farmers should not only replace pesticides, but also improve farming methods and irrigation technology. The transformation from theory to practice is also a huge challenge for farmers. If farmers do not receive systematic support, it is difficult to complete the transformation of green agriculture.

4.3. Structural Failure of Benefit Distribution

In the survey process, it is found that ordinary farmers usually rely on traditional sales channels, which often do not have the ability to enter large supermarkets and high-end markets. In addition, new operators often have brand advantages in the green product market. Green certification and brand effect may need to improve production management and technical support for farmers, and bear the initial investment and certification costs. Jiangsu field study found that its new operators obtained nearly 80% of the premium income through green certification, while ordinary farmers only obtained 15% of the production income, which could not give farmers positive feedback on income increase under the transformation of green agriculture.

4.4. Technical Capacity Barriers

Technological innovation may be a huge challenge for most traditional farmers. In the field of rapid technological renewal, farmers often can not understand and master the development of technology in time, and their acceptance of new technology is low. Even if the research and development of green technology is successful, the promotion of technology lags behind, and the use of new technology is often limited to plantations or science and technology parks, which is difficult to enter the fields of ordinary farmers. In addition to the objective reasons of technology itself, farmers' knowledge reserves are insufficient, especially for some small farmers, they can not accept high-quality and related resources training, the complexity of some technical operations far exceeds the cognitive scope of farmers, can not use technology correctly and do not understand the long-term benefits of using these technologies, the risk of starting new agriculture is high, the cost of trial and error is high, and whether the early investment funds can be greater than the later benefits is uncertain, resulting in most farmers are reluctant to take risks.

5. Policy Suggestions on the Coordinated Development of Green and Low-carbon Transformation of Agriculture and Increasing Farmers' Income

5.1. Policy and System Innovation and Promotion of Green Technology

The government can implement the "three stage" strategy of green technology promotion: (1) the first three years are the experimental stage, and the government can fully subsidize the pilot projects, such as UAV broadcasting services and organic fertilizer subsidies, to help reduce the cost of transformation and encourage farmers to actively transform; (2) From 4-6 years is the diffusion stage, and the subsidy will be reduced to 50%. Carbon integral incentives will be implemented for the promotion of precision agriculture, water saving irrigation, the use of organic fertilizer and other agricultural production methods to reduce carbon emissions, and farmers will be encouraged to adopt energy-saving and emission reduction technologies and

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methods. (3) After the seventh year, the government can continue to support farmers to carry out fully market-oriented operation+carbon tax reverse restraint.

The spread of green technologies is often constrained by high costs, especially for small farmers. The government should increase investment in green technology research and development, and encourage scientific research institutions and enterprises to develop more economical and easy to operate green technology products. The government and agricultural departments can build a perfect green technology service system, provide comprehensive services such as technical guidance, training and equipment leasing, and help farmers overcome obstacles in the process of applying technology. On the one hand, this reduces the threshold for farmers to use technology, on the other hand, it also promotes the popularization and application of technology.

5.2. Formulate Regional Adaptation Paths and Strengthen the Guarantee of Green Agricultural Transformation

Formulating a green development road map according to local conditions is the focus of sustainable development. Different regions have different key development strategies. Seeking common ground while reserving differences can strengthen exchanges between different regions and different farmers, form a green agricultural development alliance, establish relevant demonstration parks, and become a platform for collective learning and exchange among farmers in the region. Green agriculture is not only the transformation of the production side, but also to promote the development of the upstream and downstream of the industrial chain, increase farmers' income and enhance overall income.

The labor cost in the eastern coast is high, so it is key to develop digital technology+green agricultural products with high added value, improve production efficiency and market competitiveness. Promote agricultural mechanization and automation, reduce dependence on manual labor, reduce labor demand through precision agricultural technology, and improve production efficiency. For a long time, when the technology is mature, it can also be promoted to the central and western regions.

The central region is the main grain producing area in China, with a large scale of agricultural production [7], but the problem of non-point source pollution is serious, especially the excessive use of chemical fertilizers and pesticides and the burning of straw. Promoting planting and breeding cycle+straw industrialization will be an important path for the green transformation of agriculture in this region. We can establish an industrial chain for comprehensive utilization of straw, process straw into organic fertilizer, feed, energy and industrial raw materials, and improve the economic value of straw. We will carry out policy interventions in areas where chemical fertilizers and pesticides are overused, promote the use of biological pesticides and organic fertilizers, implement green production subsidies and standardized management of environmental protection, promote farmers to use green and environmentally friendly agricultural technologies, and reduce pollution sources. [8].

The western region is facing the problems of poor natural environment, fragile agricultural production and greater pressure on ecological protection. The balance between conservation and sustainable agriculture is crucial in the region. Promoting carbon sequestration projects and ecological compensation mechanism is an effective means to meet these challenges. With the support of the government, we should strengthen the transformation of external ecological security, promote ecological agriculture models, and emphasize biodiversity protection, sustainable utilization of natural resources and ecological transformation of agricultural production.

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5.3. Adjust the Production Structure and Expand the Ranks of New Farmers

Guide farmers to develop diversified agricultural production methods, expand the planting of ecological agricultural products and characteristic agricultural products, promote the transformation of traditional agriculture to green and low-carbon agriculture, and increase farmers' income [9].

When external factors transform, endogenous forces should also transform and innovate. Mr. Yuan Longping mentioned that agriculture is the foundation of the national economy, but in recent years, due to the aging of the agricultural population, it has become out of touch. The influx of new forces is too small, and contemporary Chinese agriculture is also known as women's and old agriculture. Reviving the topic of farming and agriculture has made agriculture a sunrise industry and become one of the key topics today. Taking Sandun Town, Xihu District, Hangzhou City, as an example, ten new farmers tried to grow new varieties of wheat, from traditional agriculture to science and technology agriculture and green agriculture, and gradually formed a complete industrial chain through live e-commerce, which encouraged countless new farmers and emerging forces, so that more young people could see the vitality of agriculture, and also let farmers in trouble see hope. Contemporary young people are not unfamiliar with words such as science and technology and intelligent agriculture, but now they are facing the real labor scene, the creation scene and the front-line struggle. College students should not only write papers on the earth, but also bring scientific research achievements to farmers' homes. Technological innovation is brought to the land through young people, and the government can guide the exchange and mutual reference between traditional farmers and new farmers, giving the land new strength. Promote relevant documentaries in the form favored by young people, guide universities to open relevant majors and issue relevant subsidies, encourage young people to respond to the call of agriculture, rural areas and farmers, achieve farmers' prosperity, agricultural prosperity and rural harmony, and promote the common development of green agriculture and farmers' income.

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