


Article

The Impact of Non-Agricultural Management Experience on Eco-Friendly Practices in Chinese Family Farms

Jia Yue ^{1,2,†}, Siyao Chen ^{1,2,†}, Qiang Liu ^{3,*}  and Zhixiong Weng ^{4,*}1 School of Business, Xiangtan Institute of Technology, Xiangtan 411100, China; yuejia5211@gmail.com2 Graduate School, University of Perpetual Help System DALTA, Las Piñas 1740, Philippines; echocsy11@gmail.com

3 Rural Revitalization Academy of Zhejiang Province, Zhejiang A&F University, Hangzhou 311300, China

4 Institute of Circular Economy, Beijing University of Technology, Beijing 100124, China

* Correspondence: niuemeng119@zju.edu.cn (L.Q.); wengzx564@163.com (Z.W.)

† These authors contributed equally to this work.

Abstract: Encouraging and supporting family farms to embrace eco-friendly agricultural production methods can have a significant positive impact on sustainable agricultural development. This study analyzes data from 433 family farms across five Chinese provinces (Zhejiang, Anhui, Shandong, Hunan, and Sichuan) in 2022. Using an econometric model, it examines how non-agricultural management experience influences the adoption of specific eco-friendly practices within family farms. The results highlight the significance of non-agricultural management experience for farmers in determining the extent to which organic fertilizers are employed on family-owned farms. The role of farmers' green cognition in mediating this relationship is shown to be partial. Additionally, other variables such as gender, educational level, years of farming experience, scale of land management, demonstration farm status, and agricultural insurance ownership can impact the use of organic fertilizers on family farms. In order to promote the application of organic fertilizers on family farms, it is crucial to support individuals with non-agricultural management experience in managing family farms, continually promote awareness of environmentally friendly practices, and optimize the resource allocation of family farms.

Keywords: family farm; non-agricultural management experience; green cognition; eco-friendly practices



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1. Introduction

Rapid global warming and frequent climate events pose severe threats to human health, agriculture, and ecosystems (Furtak & Wolińska, 2023; Mora et al., 2022; Tong et al., 2022). It has become a consensus among countries worldwide that green and low-carbon development is one of the effective means to mitigate climate change (Lee et al., 2022). For example, the UK launched the Low Carbon Transformation Plan in 2009, which is its national strategic plan to address climate change (Geels, 2022). Meanwhile, Denmark is among the few countries that have achieved remarkable results in low-carbon development (Johnstone et al., 2021). However, China, being a large developing country, has relatively high total greenhouse gas emissions and global share. As per the 2021 World Energy Statistical Yearbook, China's total carbon dioxide emissions in 2020 were 9.899 billion tons, accounting for 30.7% of the world's total emissions. Therefore, China's obligations to address climate change and reduce emissions are also increasing (Cheng et al., 2022). Promoting green and low-carbon development is of great significance to reducing carbon dioxide emissions and mitigating global climate warming.

The agricultural sector is a significant contributor to greenhouse gas emissions, but it also has the potential to be a massive carbon sink system (Yang et al., 2022). While agricultural carbon emissions make up 17% of total emissions in China, 7% in the United States, and 11% globally (Huang et al., 2019), it is possible to make a significant difference by adopting green and low-carbon practices in agriculture. Sustainable agricultural practices not only help reduce carbon emissions but also improve the carbon sink capacity of the agricultural system (Cui et al., 2022; de Moraes Sá et al., 2017; Dou, 2018). By adopting these practices, we can store carbon in the soil for an extended period while improving agricultural productivity (Shah & Wu, 2019). The introduction of green agricultural technology and the protection of agricultural ecosystems can enhance the quality and yield of agricultural products while creating more significant economic benefits for farmers. This promotes sustainable agricultural development, which is critical to our planet's well-

being (Y. Liu et al., 2020). Additionally, the promotion of organic agriculture is also considered an effective measure to slow down the release of greenhouse gases by increasing the application of organic fertilizers and reducing dependence on chemical fertilizers and pesticides (Durán-Lara et al., 2020).

Family farms play a crucial role in promoting eco-friendly practices and achieving green and low-carbon agricultural development (Ke & Huang, 2023; X. Li et al., 2023; L. Wang et al., 2023). Eco-friendly practices on family farms can help stabilize agricultural ecosystems, resist pests and diseases, and reduce the dependence on chemical pesticides (Yu et al., 2021b). Furthermore, such practices can mitigate the negative impact on the external environment by decreasing soil erosion, improving the water retention capacity of the soil, and reducing the loss of organic carbon (Holka et al., 2022). Eco-friendly practices on family farms also have a positive impact on the global carbon balance. They help reduce greenhouse gas emissions by increasing the organic carbon content of the soil and promoting carbon sequestration in farmland (Yu et al., 2020).

Numerous scholars have conducted extensive research on the implementation of eco-friendly practices on family farms, both theoretically and empirically. Firstly, the inherent characteristics of family farms determine their willingness to adopt eco-friendly practices. Family farmers are generally younger and better educated, possess the traits of “ideal farmers”, and tend to be receptive to new technologies and knowledge (H. Li et al., 2023b; Yu et al., 2023). Secondly, policy guidance has a significant impact on the adoption of eco-friendly practices. Policies such as green production subsidies and agricultural product quality control measures have a significant influence on the adoption of eco-friendly practices by family farms (Gao et al., 2020; Yu et al., 2021a). Thirdly, resource endowment is a crucial factor limiting the adoption of eco-friendly practices by family farms. Factors such as the farmer’s social network relationship and the farm’s land management scale can significantly affect the adoption of eco-friendly practices on family farms (Elahi et al., 2021; Gao et al., 2019; H. Wang et al., 2021).

Researchers have identified several factors that influence the adoption of eco-friendly practices on family farms. Among them, non-agricultural management experience has gained significant attention. Farmers with non-agricultural management experience tend to be more aware of ecological environmental protection and are more willing to use eco-friendly production technologies (C. Li et al., 2022; C. Li et al., 2021). The extent of the effect increases with the richness of the farmer’s non-agricultural management experience (Zheng et al., 2022). Additionally, farmers with such experience are more likely to adopt green control technologies (Gao et al., 2019). However, some scholars have found that non-agricultural management experience does not significantly affect the willingness of farmers to improve farmland pollution control (Lu, 2019).

In summary, research suggests that family farms are well-suited to adopt eco-friendly practices and that non-agricultural management experience can further encourage green production on these farms. However, existing studies have primarily focused on the overall environmentally friendly behavior of family farms, with non-agricultural management experience only being evaluated as a control variable. As a result, the direct impact of non-agricultural management experience on specific eco-friendly practices has been largely overlooked. With the Chinese government’s support for farmers returning to rural areas to start businesses, the impact of their previous work experience on environmentally friendly production practices has become increasingly important after their return to the countryside. Clarifying this impact is important, as it has significant implications for the type of farmers that are cultivated and for the continuous promotion of low-carbon agricultural development.

Compared to previous work, the academic contribution of our research is mainly reflected in three aspects as follows:

- (1) This study aims to investigate how farmers make decisions regarding the use of organic fertilizers on their family farms, and how they can be encouraged to intensify its application. By promoting the use of organic fertilizers, we can help reduce disparities in environmentally friendly behavior among farmers. This will enable a better understanding of how to increase the use of organic fertilizers on family farms and address the issue of excessive use of chemical fertilizers in China. Essentially, this study aims to uncover the reasons behind the low intensity of organic fertilizer application and high reliance on chemical fertilizers in China.
- (2) The use of organic fertilizers on family farms is closely linked to farmers’ awareness of environmental issues, known as “green cognition”. To investigate whether this awareness affects their non-agricultural management practices, it was included in the model to determine the mediating effect that non-agricultural experience has on the use of organic fertilizers.
- (3) This study addresses the issue of selection bias caused by farmers’ “self-selection”. Using the Probit model, a propensity score matching (PSM) model is established to measure the effect of farmers’ non-agricultural management experience on the use of organic fertilizers in family farms. Compared to other methods, this approach addresses selection bias caused by farmers’

self-selection and more accurately measures the impact of farmers' non-agricultural management experience on the use of organic fertilizers on family farms.

The paper is structured as follows: Section 2 contains a review of the literature, Section 3 introduces the materials and methods, Section 4 presents the results, Section 5 discusses the main findings, and Section 6 concludes and provides policy implications.

2. Literature Review and Theoretical Framework

Several research studies have explored the topic of environmentally friendly behavior on family farms and have produced valuable findings. These studies analyze eco-friendly practices, identify the factors of influence these behaviors, and assess the potential impact of non-agricultural management experiences. Together, they provide a broad perspective for a more comprehensive understanding of eco-friendly practices on family farms.

2.1. Definition of Environmentally Friendly Behavior on Family Farms

To ensure the sustainable development of agriculture, it is important to promote environmentally friendly agricultural production models. Scholars have suggested paying attention to protecting land and water resources and promoting organic agriculture (Bhatt & John, 2023; X. Li et al., 2021; Miao et al., 2023). Some studies have focused on improving the utilization efficiency of agricultural systems to reduce their adverse impact on the environment by emphasizing energy and resource use efficiency (S. Sarkar et al., 2020; Song et al., 2021). Another definition highlights ecosystem protection, emphasizing the harmonious symbiosis between family farms and the natural environment (Zheng & Zhuang, 2021).

The use of information and advisory centers, innovative technologies, and digital agriculture is also emphasized to highlight the benefits of scientific and technological advancements in improving agricultural production efficiency while reducing environmental impact. This includes practices such as soil testing and formulated fertilization technology, organic fertilizer substitution technology, and green pest and disease prevention and control technology (Rana et al., 2024; Benyam et al., 2021; Liu & Liu, 2024; Northrup et al., 2021). These definitions provide a comprehensive and diverse understanding of eco-friendly practices on family farms, enriching our knowledge of sustainable agriculture.

2.2. Factors Influencing Environmentally Friendly Behavior on Family Farms

The environmentally friendly behavior of family farms is influenced by various factors, which have been extensively studied from different perspectives. Firstly, the educational level of farmers has been found to be significantly associated with eco-friendly practices. Previous research has indicated that farmers with higher levels of education are more likely to adopt sustainable agricultural practices (Slijper et al., 2023). Secondly, the size of family farmland operations also affects environmentally friendly behavior. Studies have shown that large-scale family farms are more likely to adopt ecologically friendly farming practices than small-scale family farms (Ren et al., 2019).

It has also been found that there is a close link between the financial status of farmers and their eco-friendly practices. Research has shown that relatively wealthy farmers are more capable of investing in resource-efficient technologies that help reduce negative environmental impacts (Yuan et al., 2021). In addition, sociocultural factors are considered significant in influencing eco-friendly practices (Adnan et al., 2019). Furthermore, studies have revealed that the degree of adoption of innovative technologies and digital agriculture also plays a role in environmentally friendly behavior (Northrup et al., 2021; Shang et al., 2021). These studies provide valuable insights into the various and interrelated factors that affect eco-friendly practices on family farms.

2.3. Impact of Non-agricultural Management Experience on Eco-friendly Practices in Family Farms

According to some scholars, farmers who have gained work experience in non-agricultural fields may have established a wider social network and acquired more information and resources. This can help them better understand and respond to environmental challenges (Yeleliere et al., 2023). By gaining management experience outside of agriculture, farmers are more likely to introduce advanced management concepts and technologies. This can lead to an increased adoption of environmentally friendly agricultural practices (Sun et al., 2022). However, it's important to note that the impact of non-agricultural management experience on eco-friendly practices may vary depending on regional differences and cultural factors (Zhong et al., 2021). Additionally, non-agricultural management experience can help improve farmers' environmental awareness, making them more inclined to adopt eco-friendly practices (Lei et al., 2023).

In summary, previous research has shed light on environmentally friendly practices on family farms, and some studies have discussed the factors that influence such practices. The potential impact of non-agricultural management experience and green cognition on eco-friendly practices has also been mentioned. However, few studies have utilized micro-survey data on family farms to explore a specific environmentally friendly behavior. Moreover, none of them has integrated non-agricultural management experience and green cognition into a unified analytical framework to fully assess the impact of specific environmental factors on family farms. This makes it difficult to determine the magnitude of the impact and the action path of eco-friendly behavior.

2.4. Theoretical Framework and Research Hypotheses

Based on the above literature review and analysis, farmers' non-agricultural management experience may influence environmentally friendly practices on family farms through multiple mechanisms. Figure 1 presents the theoretical analysis framework. First, such experience may leave an "Imprinting effect" on farmers, meaning that the behavioral habits, values, and management concepts formed in non-agricultural industries exert a lasting influence on their agricultural management practices. Second, non-agricultural management experience is often associated with higher economic returns, contributing to an "income enhancement effect" that strengthens farmers' financial capacity to adopt green agricultural practices. Moreover, the experience gained in external markets or corporate settings can improve farmers' awareness of risk prevention and their management capabilities, thereby increasing their sensitivity to environmental risks and resource constraints, and encouraging a more proactive adoption of eco-friendly practices.

At the same time, non-agricultural management experience can also enhance farmers' green cognition. With improved cognition, farmers are more likely to actively adopt green production technologies, reduce their reliance on chemical fertilizers and pesticides, and facilitate the green transformation of family farms. Therefore, green cognition may serve as a mediating factor between non-agricultural management experience and the adoption of environmentally friendly practices.

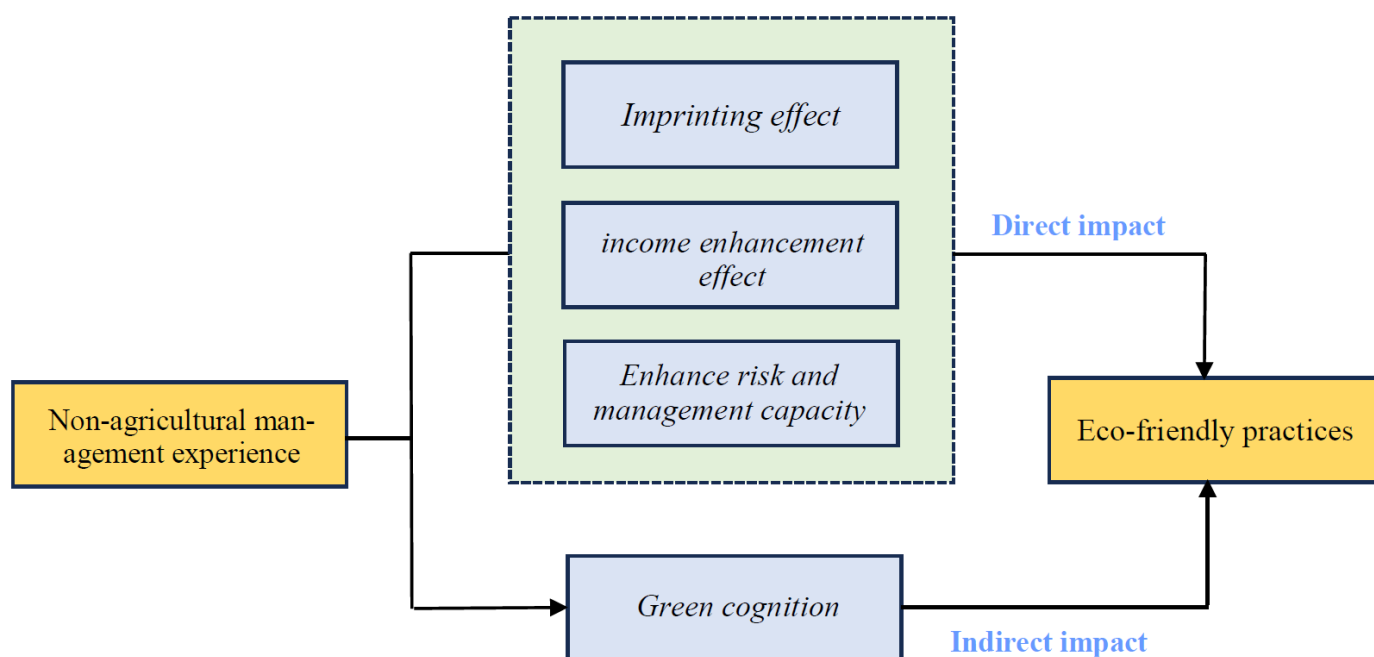


Figure 1. Theoretical framework.

Building on the above analysis, this study proposes the following hypotheses:

- H1: Non-agricultural management experience positively influences environmentally friendly practices on family farms.
- H2: Non-agricultural management experience enhances farmers' green cognition, thereby promoting environmentally friendly practices on family farms.

3. Material and Methods

3.1. Research Sample

Our study is based on a survey conducted by our team in Zhejiang, Anhui, Shandong, Hunan, and Sichuan provinces from July to October 2022. These five provinces were selected because they are geographically located in the eastern, central, and western regions of China, thereby capturing the diversity of agricultural conditions across the country. They differ significantly in terms of agricultural development levels, cropping systems, and the implementation of green agriculture-related policies. This regional diversity helps ensure the representativeness and generalizability of the research findings. We started by selecting representative family farms in prefecture-level cities, counties, and towns in each province using a random sampling method. The selected farmers were then invited to participate in training organized by the local agricultural management department. After the training, they filled in an online questionnaire that covered various aspects, including individual characteristics of the farmers (such as gender, age, education level, years of agricultural production, etc.), farm characteristics (such as farm type, operating income, operating scale, number of own labor force, etc.), environmental characteristics (such as loan difficulty, local government support for agricultural development, etc.), and awareness of green production. In the questionnaire, non-agricultural management experience is measured by whether the family farm operator has previously engaged in non-agricultural managerial work. Environmentally friendly practices are primarily assessed through the use of organic fertilizers, including whether organic fertilizers are applied and the intensity of their application. Organic fertilizer was chosen as the main indicator because it is a widely recognized and representative practice in green agriculture. Compared with other environmentally friendly measures, the use of organic fertilizer more directly reflects farmers' willingness to reduce chemical inputs and promote green and sustainable agricultural development.

This study focuses on the planting of family farms. After processing the survey data, we obtained a total of 433 samples of planting family farms. These farms are distributed as follows: 96 households in Zhejiang Province, accounting for 22.17%; 42 households in Anhui Province, accounting for 9.70%; 144 households in Shandong Province, accounting for 33.26%; 37 households in Hunan Province, accounting for 8.55%; and 114 households in Sichuan Province, accounting for 26.33%. The sample distribution is shown in Figure 2.

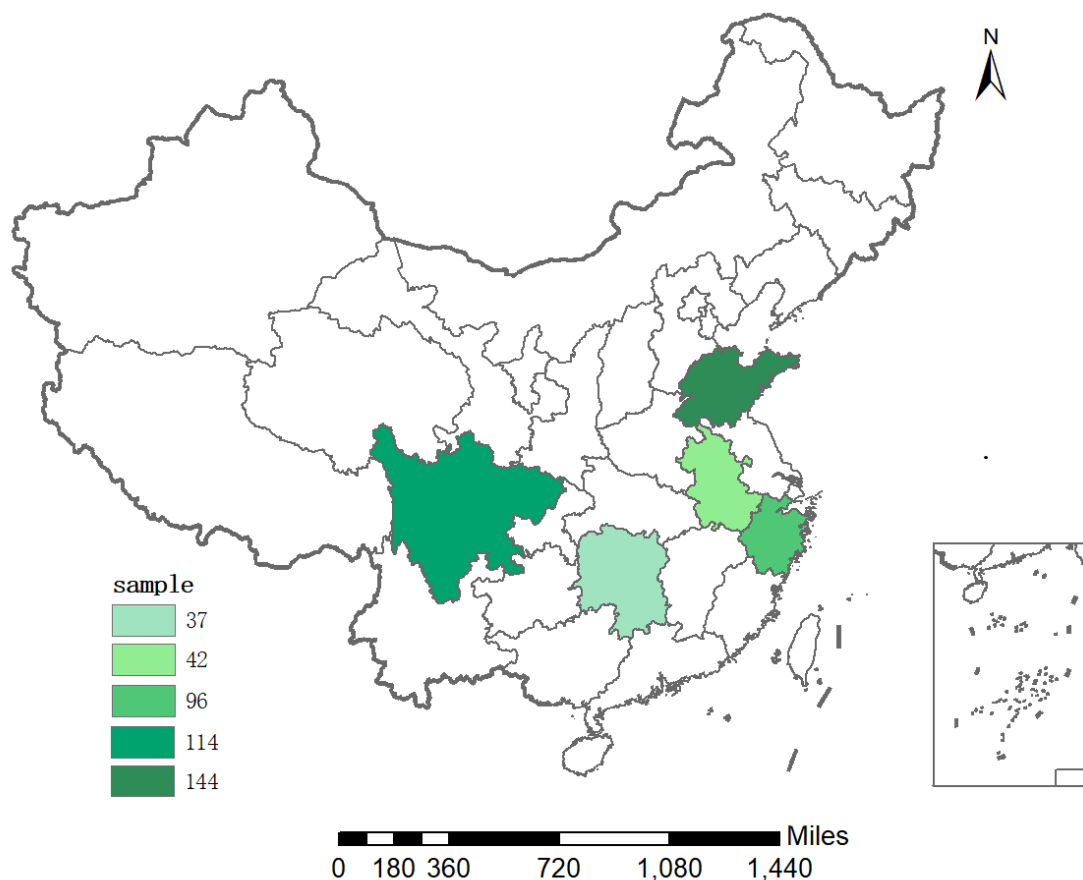


Figure 2. Research sample distribution in China.

3.2. Sample Description

Out of the 433 farms in the sample, 92.53% of the farmers are male, while only 7.47% are female. The proportion of farmers aged 35 or below is 12.47%, and the proportion of those aged over 55 is 14.07%. The majority of farmers, about 73.44%, fall between the ages of 36 to 55, indicating that most of them are in the prime of their lives. The proportion of farmers with a primary school education or below is only 2.08%, with 62.35% having completed junior high. Farmers with a college degree or above make up 35.57% of the total, highlighting that the educational level of family farm operators is generally not very high. More than half of the farmers have been engaged in agriculture for over 10 years. In addition, 51.04% of the farmers are members of the Communist Party. The proportion of farmers who have received technical training five times or fewer is 60.97%.

Most family farms have a land operation scale of between 3.33 and 33.33 hm², and the proportion of family farms with fewer than six employees is as high as 95.84%. In total, 66.05% of family farms are demonstration farms. The income level of most family farms falls between 60,000 and 500,000 CNY, accounting for 68.36% of the total. Most family farms have complete records of income and expenditure, as well as storage facilities. Additionally, 70.44% of the family farms have purchased agricultural insurance, highlighting that family farm operators have a strong awareness of risk prevention. 83.83% of family farms are located within 6 to 50 kilometers from the county seat, where the local government is relatively supportive of agricultural development. Only 22.86% of family farms believe that it is relatively difficult to obtain loans.

According to the study, the 433 family farms were divided into two groups based on the basis of whether the farmers had non-agricultural management experience. Figure 3 shows that out of the 185 family farms run by farmers without any non-agricultural management experience, 141 use organic fertilizers, which accounts for 76.22% of the total. On the other hand, out of 248 family farms run by farmers with non-agricultural management experience, 225 use organic fertilizer, which accounts for 90.73% of the total. The average organic fertilizer application rate of family farms run by farmers with non-agricultural management experience is 60.93%, which is higher than the average organic fertilizer application rate of family farms run by farmers without non-agricultural management experience. The latter has an average organic fertilizer application rate of 47.67%. This suggests that farmers with non-agricultural management experience are more inclined to apply organic fertilizers, and the intensity of organic fertilizer application is also higher.

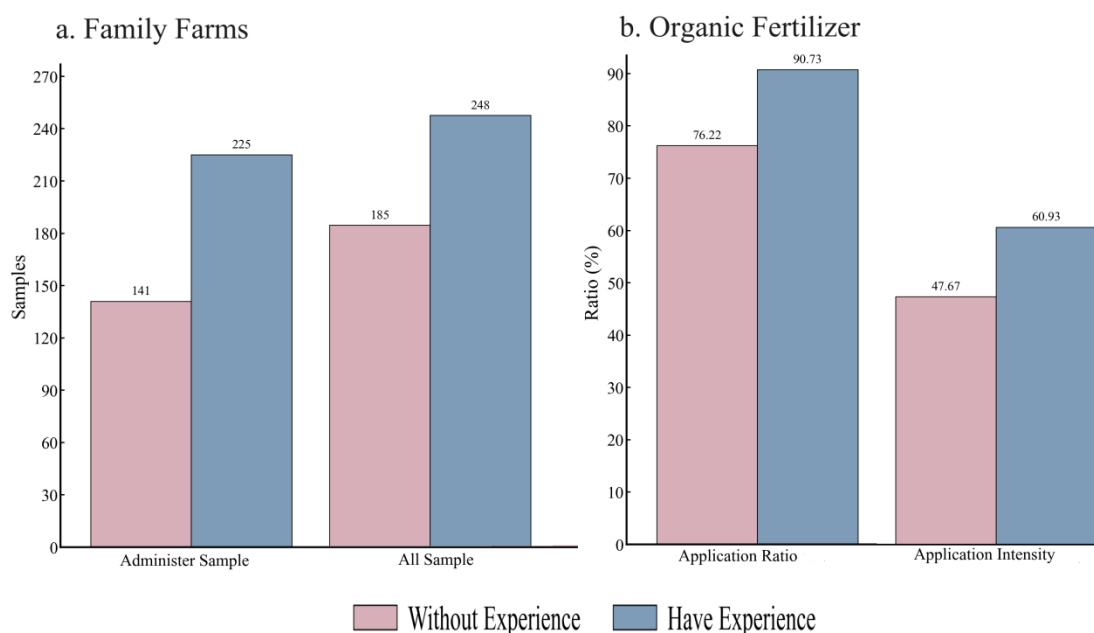


Figure 3. Non-agricultural management experience and organic fertilizer application behavior.

3.3. Model Specification

3.3.1. Baseline Model

This study employs Probit and OLS regression models to analyze the application of organic fertilizer on family farms. The Probit model is appropriate for analyzing binary outcomes, such as whether organic fertilizer is used, while the OLS model is suitable for examining continuous outcomes, such as the intensity of organic fertilizer application. These models were selected primarily

to effectively capture both the adoption decision and the level of organic fertilizer use. The model specifications are as follows:

$$Y_i = Ln \frac{P_i}{(1-P_i)} = \beta_{0i} + \beta_{1i}X_1 + \beta_{2i}X_2 + \dots + \beta_{ni}X_n + \lambda_{1i} + \lambda_{2i}Landform + \varepsilon_i \quad (1)$$

$$Z_i = \beta_{0i} + \beta_{1i}X_1 + \beta_{2i}X_2 + \dots + \beta_{ni}X_n + \lambda_{1i}Dis + \lambda_{2i}Landform + \varepsilon_i \quad (2)$$

Y_i represents whether family farm i uses organic fertilizer (OF). If it is true, the value will be 1, otherwise it will be 0. P represents the probability of family farm applying organic fertilizer; Z_i represents the intensity of organic fertilizer application (OFA) in family farm i ; X_1 checks whether farmers have non-agricultural management experience. $X_2 \sim X_n$ is a series of control variables that may affect the utilization of organic fertilizers in family farms; β_1 is the estimated coefficient of X_1 and $\beta_2 \sim \beta_n$ are the estimated coefficients of $X_2 \sim X_n$, respectively. Dis controls for location characteristics of family farm, while $Landform$ are the family farm terrain variables. ε_i is the random disturbance term.

3.3.2. Propensity Score Matching (PSM) Model

It is worth noting that a farmer's decision to engage in non-agricultural management experience work is not arbitrary, but rather a deliberate choice based on their own needs and available resources. This creates a "selection bias" which can affect the results when estimating the impact of non-agricultural management experience on family farm organic fertilizer application behavior. To overcome this issue, this study proposes the use of propensity score matching, which involves building a "counterfactual inference model" to address the self-selection problem. This approach can lead to more accurate model estimation results. The model specification is set as follows:

$$P(T_i) = P_r(D_i = 1|T_i) = \frac{\exp(\beta T_i)}{1 + \exp(\beta T_i)} \quad (3)$$

$P_r(D_i = 1|T_i)$ is the propensity matching score value of the farmer's non-agricultural management experience; T_i is the matching variable, including farmer characteristics, farm characteristics, and environmental characteristics; β is the coefficient of the corresponding matching variable.

After analyzing the matching results, we can calculate the average effect of non-agricultural management experience on the application of organic fertilizers in family farms. The calculation formula is as follows:

$$ATT = E(y_{1i}|T_i = 1) - E(y_{0i}|T_i = 1) = E(y_{1i} - y_{0i}|T_i = 1) \quad (4)$$

Here, y_{1i} represents the application of organic fertilizer in the treatment group. y_{0i} indicates the application of organic fertilizer in the control group, and T_i represents the treatment variable.

3.3.3. Mediating Effect Model

In order to better understand the impact of non-agricultural management experience on the use of organic fertilizers in family farms, a mediation effect model was employed to analyze the mechanism behind it. The model's formula is as follows:

$$M = \beta_0 + aX_1 + \beta_1X + \varepsilon_i \quad (5)$$

$$Y_1 = \beta_0 + c'X_1 + bM + \beta_2X + \varepsilon_i \quad (6)$$

$$Y_2 = \beta_0 + c'X_1 + bM + \beta_3X + \varepsilon_i \quad (7)$$

In the above formula, M is the intermediary variable that represents the farmer's green cognition. Y_1 indicates the utilization of organic fertilizer by family farms, and Y_2 shows the intensity of using organic fertilizer by family farms. X_1 checks whether farmers have non-agricultural management experience. Additionally, X is a series of control variables, including farmer characteristics, family farm characteristics, and environmental characteristics. Therefore, a represents the impact of farmers' non-agricultural management experience on their green cognition; b indicates the impact of farmer's green cognition on the utilization of organic fertilizer in the family farm. It is noted that c' shows the impact of the farmer's non-agricultural management experience on the behavior of utilizing organic fertilizer in the family farms. ε_i is the random disturbance term. As a result, we proceeded the mediating effect model with the following steps:

Firstly, we tested whether β_1 in the benchmark model, as shown in formulas (1) and (2), passes the significance test. If the significance test passes, a stepwise regression model will be used to test the mediation effect (as shown in formulas (5), (6), and (7)).

Secondly, we conducted a significance test to obtain the coefficients a and b by using the mediation effect model.

Thirdly, we tested the significance of coefficient c' if both coefficients a and b are significant. As a result, if c' is not significant, implying that there is a complete mediation effect; otherwise, there is a partial mediation effect.

3.3.4. Summary Statistics

This study focuses on the farmer's non-agricultural management experience (NAME) as the main explanatory variable, which refers to their past work experience in non-agricultural management. We also consider green cognition (GC) as a mediating variable that measures the farmer's willingness to adopt eco-friendly practices. The farmer's level of agreement with the statement "I believe that organic fertilizer should be used instead of chemical fertilizer" is evaluated on a scale of 1 to 5, with higher values indicating stronger green cognition.

Farmer characteristic variables are the personal traits of family farmers that can shape their attitudes and values toward environmental issues. This, in turn, can affect their adoption of eco-friendly practices (Adnan et al., 2020; A. Sarkar et al., 2022; Yu et al., 2023; Diallo & Abay, 2024). To get a better understanding of the individual characteristics of farmers, we have selected the following variables based on existing literature and data: (1) Gender (GEN); (2) Actual age (AGE); (3) Education level (EDU); (4) Agricultural tenure (APY), reflecting the number of years engaged in farming activities; (5) Membership in the Communist Party of China (CPC) is considered due to its potential influence on policy adherence and ideological alignment; (6) The frequency of agricultural technology training received within the past three years (ATTF).

Farm characteristic variables refer to basic attributes associated with family farms, which indicate the farm's resource status, economic capabilities, and management level. These variables significantly impact the farm's acceptance and implementation of environmental protection measures (Z. Chen et al., 2022; Hu et al., 2023; Zhou & Ding, 2022). In light of this, we considered the following variables relevant to farm characteristics (Table 1):

- (1) Land operation scale (LAND), which denotes the extent of land under the farm's operation;
- (2) Labor force (LABOR), represented by the number of year-round engaged laborers;
- (3) Demonstration farm status (DF), designated by the government post-competitive selection, showcasing exemplary practices;
- (4) Income level (INCOME), which reflects the farm's annual revenue;
- (5) Expenditure records (ER), which document financial transactions;
- (6) Availability of storage facilities (FAC), signifying essential infrastructure for preserving crop quality and ensuring food security.

Together, these variables describe the fundamental characteristics of family farms and profoundly influence their sustainability in the agricultural sector.

Environmental characteristic variables refer to the crucial factors that are associated with the farm's external influences and environmental context. These variables play a significant role in assessing the institutional support systems and external environmental conditions that may either facilitate or hinder the adoption of pro-environmental behaviors on family farms (Gholamrezai et al., 2021; Xie & Huang, 2021). The following are four factors that can impact a farm's environmental sustainability and risk management strategies:

- (1) Agricultural insurance purchase (INS) – This factor reflects the farm's risk management strategies and resilience to potential environmental hazards or economic uncertainties.
- (2) Distance from farm to county seat (DIST) – This indicates the farm's geographical proximity to administrative centers, which can influence access to markets, services, and policy support relevant to environmental sustainability.
- (3) Loan accessibility difficulty (LOAN) – This factor reflects the financial constraints and challenges a farm may face in securing loans, which can impact investment in eco-friendly practices and infrastructure.
- (4) Support for Local Agricultural Development (SUP) – This represents the level of government or community support for local agricultural development initiatives, which can impact the availability of resources, incentives, and technical assistance to implement environmentally sustainable practices.

Table 1. Descriptive statistic.

Variables	Obs.	Mean	Std. Dev.	Min	Max	Unit
NAME	433	0.57	0.50	0	1	-
GC	433	4.49	0.67	1	5	-
GEN	433	0.79	0.41	0	1	-
AGE	433	46.61	8.67	23	70	years
EDU	433	3.07	0.83	1	4	-
APY	433	15.57	10.16	1	55	years
CPC	433	0.36	0.48	0	1	-
ATTF	433	6.23	5.77	0	36	freq
LAND	433	21.22	26.87	0.33	142.93	hm ²
LABOR	433	3.50	1.74	1	11	person
DF	433	0.66	0.47	0	1	-
INCOME	433	34.99	47.74	0	368	10,000 CNY
ER	433	0.78	0.41	0	1	-
FAC	433	0.58	0.49	0	1	-
INS	433	0.70	0.46	0	1	-
DIST	433	22.66	15.98	1	90	km
LOAN	433	2.08	0.73	1	3	-
SUP	433	4.24	0.82	1	5	-

4. Results

4.1. Baseline Model Results

Table 2 shows the results of a regression analysis that examines the influence of non-agricultural management experience on the adoption of eco-friendly practices in family farms. The analysis reveals that non-agricultural management experience has a significant positive impact on the application of organic fertilizers. Farms with such experience are more willing to use organic fertilizers and apply them more intensively than those without. In terms of the impact of control variables on organic fertilizer usage in family farms, the study found that farmer characteristic variables have notable associations. GEN, representing gender, has a positive effect on organic fertilizer usage in family farms, but only at the 10% level. It does not significantly affect usage intensity. This suggests that male farmers are more inclined to use organic fertilizers, potentially due to their greater knowledge and willingness. However, gender does not seem to influence the intensity of application, which may vary due to individual personality traits.

Table 2. Baseline regression results.

Independent variables	<i>Probit</i> (1)	<i>OLS</i> (2)
	<i>OF</i>	<i>OFA</i>
<i>NAME</i>	0.624*** (0.176)	0.114*** (0.036)
<i>GEN</i>	0.330* (0.194)	0.005 (0.042)
<i>AGE</i>	0.031 (0.077)	0.000 (0.016)
<i>AGE*AGE</i>	-0.000 (0.001)	0.000 (0.000)
<i>EDU</i>	0.259** (0.109)	0.095*** (0.024)
<i>APY</i>	0.028*** (0.010)	0.004* (0.002)
<i>CPC</i>	-0.021 (0.187)	-0.058 (0.038)
<i>ATTF</i>	0.007 (0.014)	0.003 (0.003)
<i>LAND</i>	0.000 (0.004)	-0.001* (0.001)
<i>LABOR</i>	0.016 (0.047)	-0.004 (0.010)
<i>DF</i>	0.454** (0.192)	0.110*** (0.041)
<i>INCOME</i>	0.024 (0.078)	-0.002 (0.016)
<i>ER</i>	-0.215 (0.217)	0.039 (0.047)
<i>FAC</i>	0.048 (0.179)	0.016 (0.037)
<i>INS</i>	-0.045 (0.192)	-0.089** (0.040)
<i>DIST</i>	0.008 (0.006)	-0.000 (0.001)
<i>LOAN</i>	0.089 (0.119)	-0.029 (0.025)
<i>SUP</i>	-0.079 (0.108)	0.013 (0.022)
R ²	0.1573	0.1526
Observations	433	

Note: Standard errors are in parentheses; *, **, and *** represent significance at the 10%, 5%, and 1% statistical levels, respectively.

EDU, which indicates education level, significantly influences both usage likelihood and intensity, with higher education levels correlating with a greater inclination toward and intensity of organic fertilizer application. This may be attributed to more educated farmers having a clearer understanding of the benefits of organic fertilizers (Adator et al., 2023; Y. Chen et al., 2022). Additionally, APY, which indicates the length of time farmers have been engaged in agriculture, positively impacts both usage likelihood and intensity, being significant at the 1% and 10% levels, respectively. Longer engagement in agriculture correlates with a higher likelihood and intensity of organic fertilizer application, possibly due to accumulated experience enabling better market judgment and increased environmental awareness among farmers.

According to the analysis of farm characteristics, the size of the land does not have a statistically significant impact on whether family farms use organic fertilizers. However, it does have a negative effect on the intensity of usage, significant at a 10% level. This suggests that while the decision to use organic fertilizer is independent of the scale of land operations, larger farms tend to use it less intensively. This could be due to the farmers’ preference for chemical fertilizers, which help maximize profits as the land area increases (Y. Chen et al., 2022; Li & Shen, 2021). On the other hand, the demonstration effect significantly impacts both the likelihood and intensity of usage, being significant at the 5% and 1% levels, respectively. This shows that compared to non-demonstration family farms, demonstration farms are more inclined to apply organic fertilizers, with higher application intensity. This may be because the demonstration farms exhibit better management and oversight, which leads to improved production behaviors.

When it comes to environmental factors, it appears that INS (Agricultural insurance purchase) does not have a significant impact on the adoption of organic fertilizers in family farms. However, it does appear to influence the intensity of usage, as evidenced by statistical significance at the 5% level. This implies that although agricultural insurance may not significantly affect the likelihood of organic fertilizer adoption, farms with insurance tend to use organic fertilizers less intensively than those without. This may be due to moral hazard, which can occur when individuals take more risks or behave less responsibly after purchasing insurance. Such behavior could potentially hinder long-term land investment and reduce the application of organic fertilizers.

4.2. Robustness Check

To enhance the reliability of the correlation between non-agricultural management experience and organic fertilizer application on family farms, this study employs a model substitution technique to test the robustness of the model’s findings. As organic fertilizer application is a binary variable and its intensity ranges from zero to positive, both Logit and Tobit models are appropriate. The results in Table 3 indicate that non-agricultural management experience significantly impacts whether family farms use organic fertilizers, with a positive coefficient significant at the 1% level. Additionally, non-agricultural management experience also has a significant impact on the intensity of organic fertilizer application, again with a positive coefficient at the 1% significance level. These results are consistent with the main findings, indicating that the empirical analysis is reasonably robust.

Table 3. Robustness test results.

Independent variables	Logit	Tobit
	OF	OFA
NAME	1.155*** (0.322)	0.146*** (0.042)
Farmer characteristic	Control	Control
Farm characteristic	Control	Control
Environmental characteristic	Control	Control
DIS	Control	Control
Landform	Control	Control
R ²	0.1594	0.1279
Observations	433	

Note: Standard errors are in parentheses; *, **, and *** represent significance at the 10%, 5%, and 1% statistical levels, respectively.

4.3. PSM Results

4.3.1. Commonly Support and Balance Tests

After analyzing the data, it has been found that farmers who have prior experience in non-agricultural management are more likely to adopt organic fertilizers in their family farms. However, it is important to note that such experience is usually a result of self-selection. This means that while estimating the impact of non-agricultural management experience on organic fertilizer application in family farms, there is a risk of biased parameter estimation results and reduced reliability. To address this issue, this study employs the propensity score matching (PSM) method to mitigate the self-selection problem and obtain more accurate regression estimation outcomes. The PSM model requires passing two fundamental tests: the common support domain test and the balance test of matching variables.

Figure 4 shows how similar the control group and treatment group are, before and after matching. In Figure 4a, before matching, the two groups differ greatly, as their distribution curves hardly overlap. After matching, shown in Figure 4b, the two curves overlap much more, indicating that the differences between the groups have been reduced. This means the matching worked well and the two groups are now comparable, which meets the basic requirement for analysis.

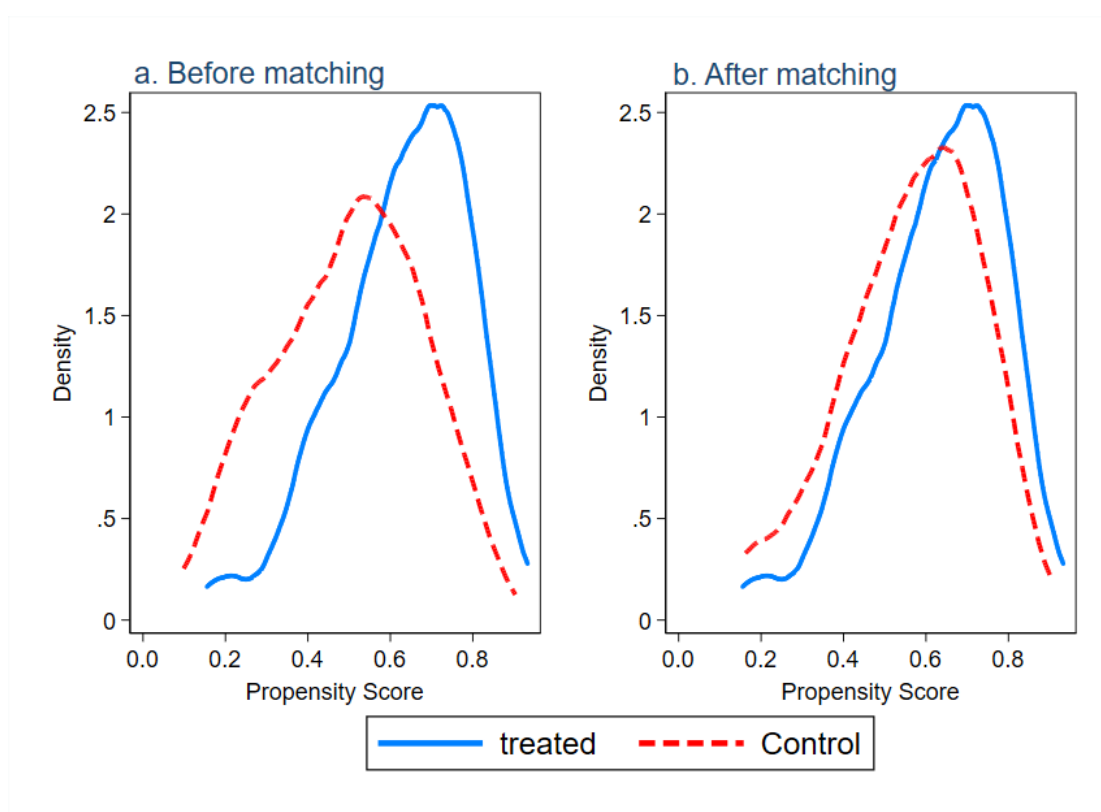


Figure 4. Probability dense distribution before and after matching.

The balance test mainly examines whether there is a significant difference in covariates between the control group and the experimental group. The hypothesis of the balance test was tested under nearest-neighbor matching, and the standard deviation of each covariate was substantially reduced. With the exception of age (5.4%) and loan (35.7%), which showed only slight reductions, the standard deviation of the other covariates decreased significantly. Overall, the reductions were large, and the sample means of the two groups were very close, with no significant differences. Therefore, the balance test was passed.

4.3.2. PSM Estimation

Table 4 presents the average treatment effect of farmers' non-agricultural management experience. As shown in the Table, there are significant differences between family farms managed by farmers without non-agricultural management experience and those managed by farmers with such experience. The average treatment effect values (ATT) for farms managed by farmers with non-agricultural management experience are 0.142 and 0.114, significant at the 5% and 10% levels, respectively. Robustness testing was conducted using nearest neighbor matching, radius matching, and kernel matching within a caliper. The ATT values obtained through these methods are 0.110,

0.119, 0.131 for one outcome, and 0.095, 0.102, 0.110 for the other, respectively. These results are significant at the 5%, 5%, 1%, and 10%, 5%, 1% levels, respectively, and are consistent with the findings from one-to-one nearest-neighbor matching. This indicates that, on the one hand, the estimated treatment effect of non-agricultural management experience remains robust after propensity score matching. On the other hand, non-agricultural management experience has a significant positive impact on the application of organic fertilizers on family farms.

Table 4. PSM results.

matching method	PSM			
	<i>OF</i> treated/control	ATT	<i>OFA</i> treated/control	ATT
K=1	181/246	0.142** (0.062)	181/246	0.114* (0.063)
K=4	160/232	0.110** (0.052)	160/232	0.095* (0.052)
R=0.01	160/232	0.119** (0.052)	160/232	0.102** (0.051)
Kernel	181/246	0.131*** (0.048)	181/246	0.110*** (0.043)

Note: Standard errors are in parentheses; *, **, and *** represent significance at the 10%, 5%, and 1% statistical levels, respectively.

4.4. Mediating Effect

The influence of non-agricultural management experience extends beyond its direct influence on the application of organic fertilizers in family farms. It may also have an indirect effect through green cognition, which acts as a mediating factor. Table 5 presents the results of the mediating effect model. Model 5 shows a positive correlation between non-agricultural management experience and farmers' green cognition, indicating that such experience enhances their levels of green cognition. Furthermore, models 6 and 7 demonstrate that when the green cognition variable is introduced, non-agricultural management experience significantly affects both the likelihood of organic fertilizer adoption and the intensity of application in family farms. Similarly, green cognition also significantly influences these behaviors. The mediation effect testing indicates that green cognition partially mediates the relationship between non-agricultural management experience and organic fertilizer application behavior in family farms. This is because past non-agricultural management experience allows farmers to access knowledge related to environmentally friendly practices, thereby enhancing their green cognition. As a result, this improved cognition translates into practical actions, making it easier for family farms to adopt organic fertilizers.

Table 5. Mediating effect results.

Independent variables	Model(5)	Model(6)	Model(7)
	GC	OF	OFA
NAME	0.113* (0.062)	0.589*** (0.177)	0.099*** (0.036)
GC		0.306** (0.139)	0.139*** (0.028)
Farmer characteristic	Control	Control	Control
Farm characteristic	Control	Control	Control
Environmental characteristic	Control	Control	Control
DIS	Control	Control	Control
Landform	Control	Control	Control
R ²	0.2679	0.1705	0.1992
Observations		433	

Note: Standard errors are in parentheses; *, **, and *** represent significance at the 10%, 5%, and 1% statistical levels, respectively.

5. Discussion

China's agricultural modernization is a crucial part of its overall modernization process. To achieve this objective and establish itself as an agricultural powerhouse, it is imperative to develop green agriculture that promotes high-quality growth in the sector. The promotion of family farms that adopt eco-friendly practices and the acceleration of the green transformation of agriculture is of utmost importance. This study analyzes data from 433 family farms in five provinces of China, namely Zhejiang, Anhui, Shandong, Hunan, and Sichuan, collected in 2022. An econometric model to empirically examine the impact of non-agricultural management experience on the adoption of eco-friendly practices in family farms.

The outcomes of our study demonstrate the significant impact of non-agricultural management experience on the application of organic fertilizers on family farms. Through the use of the propensity score matching method, we have found that family farms managed by farmers with non-agricultural management experience exhibit greater willingness and more intensive application of organic fertilizers. This finding aligns with previous studies by several scholars who have observed that farmers with non-agricultural backgrounds are more receptive to adopting environmentally friendly agricultural management practices (H. Li et al., 2023a; Zhang et al., 2018; Zhou et al., 2022), thus confirming the critical role of non-agricultural management experience in shaping family farm environmental behaviors. In comparison to earlier research, our study offers a more comprehensive understanding of the relationship between non-agricultural management experience and organic fertilizer application on family farms.

Our study has clearly identified educational level and years of farming experience as two significant control variables that influence the application of organic fertilizers on family farms. Our findings confirm and build upon previous research, which indicates that farmers with higher levels of education are more likely to adopt organic farming practices (Serebrennikov et al., 2020; Yazdanpanah et al., 2022), while those with more years of experience in agriculture are more willing to implement eco-friendly practices such as applying organic fertilizers (Adnan et al., 2020; Qi et al., 2021; Qiao et al., 2022).

Moreover, our study has also identified the effects of some new control variables on the use of organic fertilizers, such as farm demonstration effects and agricultural insurance. Our results show that demonstration farms are more likely to apply organic fertilizers due to their higher management level and better understanding of the importance of eco-friendly practices. Additionally, our study highlights that family farms that have purchased agricultural insurance tend to apply organic fertilizers less frequently, which we attribute to the challenges of long-term investment being hampered by moral hazard, thereby weakening willingness to apply organic fertilizers.

Our research has unequivocally demonstrated that off-farm management experience can indirectly influence the use of organic fertilizers on family farms by significantly boosting farmers' green cognition levels. This finding is entirely consistent with the results of previous research. Notably, some scholars have also found that green cognition plays an indispensable mediating role in environmental behavior (P. Liu et al., 2020; Ogiemwonyi et al., 2023; Tian et al., 2020). Although

there may be some quantitative differences between our study and the existing literature, we are confident that they stem from differences in research samples, methods, or variable settings. Therefore, further research is warranted to verify these findings. These important findings provide a fresh, robust perspective for understanding the environmental behavior of family farms in depth. Furthermore, they provide invaluable guidance for formulating future policies that can effectively promote the sustainable development of family farms.

6. Conclusion and Policy Implications

Our study on the adoption of eco-friendly practices in family farms provides valuable insights for policy-making in China and other countries. Based on data collected from 433 family farms across five provinces in 2022, we employed an econometric model to analyze the impact of non-agricultural management experience on the use of organic fertilizers. The results indicate that such experience significantly promotes both the likelihood and the intensity of organic fertilizer application. In addition, green cognition plays a partial mediating role in this relationship, suggesting that farmers with experience in non-agricultural management tend to have stronger environmental awareness, which in turn encourages the adoption of eco-friendly farming practices. Other relevant influencing factors include gender, education level, years of farming, land operation scale, demonstration farm status, and agricultural insurance.

These findings highlight the need for a multi-level policy approach. At the central government level, efforts should focus on expanding the national carbon market and establishing long-term policy mechanisms that encourage sustainable agricultural practices. Local governments should provide targeted support based on regional characteristics, including technical training programs, the development of high-quality demonstration farms, and the supply of green agricultural inputs. Policies should also support individuals with non-agricultural management backgrounds who are entering the farming sector. Their skills in planning, organization, and resource management can help improve the operational efficiency of family farms and strengthen the implementation of green practices, particularly when accompanied by appropriate institutional support and training. In addition to fiscal and technical measures, both central and local governments should design agricultural programs that incorporate environmentally friendly principles and actively promote successful demonstration farms to encourage learning and replication among farmers. These strategies can help reinforce long-term eco-friendly practices on family farms by fostering an environment that strengthens green awareness and cultivates positive behavioral norms. A comprehensive approach that integrates economic incentives, behavior-oriented interventions, and a clear allocation of responsibilities between central and local authorities will be essential for advancing the ecological transformation and sustainable development of family farms. While we acknowledge some limitations in our study, such as not considering the impact of different types of non-agricultural management experience nor assessing the impact of current policies, we believe that our findings offer more specific and sustainable recommendations for family farms to better adopt environmentally friendly behaviors. We recommend that future research conduct comprehensive policy evaluations and analyze different types of non-agricultural management experiences to fill gaps in this area of research.

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