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Can pro-environmental behavior increase farmers' income?—Evidence from arable land quality protection practices in China

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ABSTRACT
In China, agricultural non-point source pollution is one of the key factors limiting farmers' income growth, and pro-environmental behavior can address agricultural surface pollution. Based on field survey data from 591 farmers in Xinjiang, China, this study empirically estimates the impact of pro-environmental behavior on farmers' income growth. The results show that pro-environmental behavior plays a significant positive role in increasing farmers' income, and the positive effect continues in the long run. Specifically, pro-environmental behavior can optimize the allocation of agricultural production factors, thus resulting in farmers' income growth. The mechanism analysis shows that pro-environmental behavior affects farmers' income growth by promoting the increase in the size of arable land and farmers' willingness to transfer their land in the future. These findings indicate that a sound reward–punishment system for pro-environmental behavior should be established; training on pro-environmental behavior should be strengthened, and a mechanism for linking the benefits of pro-environmental behavior among stakeholders should be constructed.

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1. Introduction

With the advancement and popularization of agricultural science and technology, farmers' income in China has significantly increased. In particular, the input of chemicals such as fertilizers and pesticides has greatly contributed to the increase in food production and farmers' income (Sun et al., 2019). However, the difficulty of increasing farmers' income in agricultural production, which is highly dependent on factor inputs such as chemical fertilizers, has not been fundamentally worked out (Takeshima & Liverpool-Tasie, 2015). Meanwhile, the marginal effect of factor inputs such as fertilizers has been on a diminishing trend, leading to an increase in

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production costs for farmers and the slow-down of income growth (Ren et al., 2021). Moreover, the excessive application of fertilizers and pesticides has caused serious agricultural surface pollution, which contradicts the sustainability concept of *green water and green mountains are the silver mountain of gold*, has become a prominent obstacle to the construction of an 'ecologically livable and beautiful countryside', and curbs the sustainable development of agriculture and increase in farmers' income.

Pro-environmental behavior refers to behavior by which residents minimize the negative impact of their activities on the ecological environment and promote sustainable economic and environmental development (Choi, 2019). In recent years, China's government has issued a series of documents[1] proposing the adoption of pro-environmental behaviors, for example, the zero growth of fertilizers and pesticides and recycling of agricultural film residues. Looking at the actual effect, although pro-environmental behaviors have alleviated the diffusion of agricultural pollution to a certain extent, the top-down policy system often ignores the subjective initiative of farmers, and agricultural non-point source pollution remains a serious problem (Kollmuss & Agyeman, 2002). Therefore, under the sustainability concept of *green water and green mountains are the silver mountain of gold*, it is urgent to promote the implementation of pro-environmental behaviors such as conservation of tillage technology, organic fertilizer instead of chemical fertilizer, straw return to the field, and agricultural film recycling. However, the main object of farmers is to maximize profits from agricultural output, and it is easy to ignore the increase of social costs due to agricultural surface pollution (Aftab et al., 2007). As such, agricultural surface source pollution becomes a potential hidden danger threatening human health, food security, and the ecological environment (Zhang et al., 2016).

In this study, we investigate the relationship between pro-environmental behavior and farmers' income growth and the underlying mechanism. First, we argue that the logical starting point for farmers to adopt pro-environmental behaviors is whether they can increase their income, that is, the intrinsic motivation of farmers to adopt pro-environmental behaviors lies in whether their inputs are worthwhile, in other words, whether adopting pro-environmental behavior can promote farmers' income growth. Second, we examine the impact of various types of pro-environmental behaviors on farmers' income growth, mainly to answer the question of whether pro-environmental behaviors promote or inhibit the increase in farmers' income and determine the mechanism of its effect on farmers' income growth.

2. Literature review

A stream of the literature has focused on farmers' pro-environmental behavior. Some studies have shown that pro-environmental behavior varies among different operators, pointing out that most farmers still have much room to improve with regard to their pro-environmental behavior, and they will blindly use chemicals such as fertilizers and pesticides to reduce the risk of loss and increase yields (Deng et al., 2020). By contrast, new agricultural management agents are more willing to adopt pro-environmental behaviors and have a certain degree of self-consciousness (Jans, 2021), among which the pro-environmental behaviors of family farmers and eco-farmers are more obvious (Gatersleben et al., 2014).

In addition, researchers show that the pro-environmental behavior of farmers is influenced by household endowment characteristics, land ownership, and personal perceptions. First, regarding family endowment characteristics, age is negatively related to farmers' pro-environmental behavior; education level is positively related to their pro-environmental behavior; the difference in personal qualification endowment has a significant impact on farmers' pro-environmental behavior, and farmers with strong learning ability have an increased probability of adopting pro-environmental behavior (Pan et al., 2017). Second, with regard to farmland property rights, scholars believe that clear and stable farmland property rights promote farmers' willingness to invest in pro-environmental behavior (Gong et al., 2016; Hu et al., 2021), and farmers are more willing to adopt farmland quality protection behaviors such as green farming techniques, organic fertilizer, and straw return on their own land if they have stable land rights (Lu et al., 2019; Xu et al., 2018). However, the impact of the farmland property rights system on farmers' land conservation investment may be lower than theoretically expected, as this is also influenced by factors outside the farmland property rights system (Leonhardt et al., 2019). Third, regarding personal perceptions, farmers' perceptions of environmental laws and regulations, agricultural production technology, and arable land quality have positive effects on farmers' pro-environmental behavior (Xue et al., 2021), but perceptions and attitudes do not adequately predict behavior, and other influential factors such as production cost pressure and certain predictable difficulties may also affect the adoption of pro-environmental behavior (Zhang et al., 2020).

Scholars have argued that traditional small-scale farmers are hardly motivated to practice pro-environmental behavior (Hattam, 2006), and the adoption of large-scale operations leads farmers to adopt pro-environmental behavior (Ju et al., 2016). It has been shown that different smallholder farmer types choose different agricultural factor production behaviors because of differences in business objectives and production preferences, but they are all affected by the scale of operation and show dynamic factor allocation behaviors (Souza & Gomes, 2013). Further, Sheng et al. (2015) compare the productivity levels of farms of different sizes, but the operating units of these farms adopt different degrees of reduced pro-environmental behavior.

These aforementioned studies are helpful in investigating farmers' willingness and other factors influencing them to adopt pro-environmental behavior, and the problem of agricultural non-point source pollution. However, the motivation of farmers to adopt pro-environmental behavior remains underexplored. Scholars are used to studying farmers' pro-environmental behavior from a third-party perspective or that of the government, and have not investigated this topic from the farmers' perspective, specifically their motivation to adopt pro-environmental behavior. Moreover, most studies lack comprehensiveness in that they focus only on a single type of pro-environmental behavior such as straw treatment, chemical fertilizer use, fallow and no tillage technology, soil testing, and formula fertilization technology.

3. Theoretical mechanization and model

3.1. Theoretical mechanization

Schultz (1964) states that farmers carry out agricultural production with economic rationality like entrepreneurs and pursue economic profits, rather than meet the need for family self-sufficiency. In allocating resources, farmers, as rational economic individuals, are motivated to adopt pro-environmental behavior to earn income, and this motivation is significantly higher than the endowment effect on farmers' behavior. [2] There are two main channels through which rational smallholder farmers adopt pro-environmental behavior to increase agricultural income: the first channel is agricultural technology advancement. The promotion of green productivity in agriculture through agricultural production technology improvements aims to reduce damage to arable land, maintains and enhances land productivity, and makes land sustainably productive, with the expectation that environmentally friendly arable land conservation practices will increase crop yields. The second channel is increased cost effectiveness. By expanding the scale of cultivated land to reduce agricultural production costs and increase agricultural output, the aim is to take advantage of the scale effect to manage agricultural inputs and outputs in an integrated manner and maximize the reduction of input costs of pro-environmental behaviors. In input, scale is used to reduce the procurement cost of input factors; in output, scale is used to reduce the cost of socialized services.

Further, the pro-environmental behavior of farmers to increase agricultural income can be attributed to the allocation of factors, and how to adjust production factors to increase agricultural income is the ultimate issue considered by rational farmers. Farmers' inputs to land factors are similar to the concept of 'round-about production' (Safa et al., 2015), that is, to produce a final good, they first produce an intermediate good, and then use the intermediate good to produce the final good, which increases production efficiency. By appropriately allocating inputs to the land, farmers 'produce' fertile land, which in turn increases productivity and the production level of agricultural products. Although fertilizers and other factors of production contribute significantly to farmers' income, they also cause environmental problems such as soil sludge, water pollution, and soil contamination (Zhang et al., 2017). Studies have shown that fertilizer inputs and grain production in China are in an inverted U-shaped stage of diminishing returns to scale, and the effect of fertilizer and other factor inputs on increasing grain production is no longer obvious (Martínez-Dalmau et al., 2021), which means that the factor inputs of non-environmental behavior of farmers cannot bring the expected income to farmers and reduce fertilizer, pesticide, and other factors of production. Thus, it has become a common demand of farmers to reduce the input of factors of production such as fertilizers and pesticides and increase the proportion of factor inputs with income-increasing effect.

3.2. Theoretical model

We assume that farmers' preference is homogeneous and they only pursue profit maximization in factor inputs with constant factors of production such as labor, capital, and technology; the effects of non-environmental behavioral factor inputs such as fertilizers and pesticides; and pro-environmental behavioral factor inputs such as organic fertilizers, mulch recycling, and straw recycling on farmers' income. There are two scenarios for farmers to adjust the factors of production to increase farm income: one is maximizing production under given cost conditions; the other is minimizing cost under given production conditions, where the factor price of non-environmental behavior L is w; the factor price of pro-environmental behavior K is r, and the cost of its purchase of both factors is C. When in the first case, the constraint is $C^0=wL+rK$, and the agricultural output function $Q=f(L, K)$ establishes the Lagrangian equation as follows:

$$N(L,K,t) = f(L,K) + t(C^0 - wL - rK) \tag{1}$$

In equation (1), t is the Lagrange multiplier, and the first-order derivatives of L, K, and t are obtained as follows: $\frac{\partial N}{\partial L} = \frac{\partial f}{\partial L} - tw = 0$; $\frac{\partial N}{\partial K} = \frac{\partial f}{\partial K} - tr = 0$; $\frac{\partial N}{\partial t} = C^0 - wL - rK = 0$. The final condition for maximizing output at a given cost is obtained as:

$$\frac{\partial f}{\partial L} \Big/ \frac{\partial f}{\partial K} = \frac{MP_L}{MP_K} = \frac{w}{r} \tag{2}$$

When in the second case, the qualification is $Q^0=f(L,K)$, and the cost function $C=wL+rK$, constructing the Lagrangian function is as follows:

$$M(L,K,\lambda) = wL + rK + \lambda[(Q^{0-}f(L,K)] \tag{3}$$

In equation (3), λ is the Lagrange multiplier, and the first-order derivatives of L, K, λ are respectively obtained as follows:

$$\frac{\partial M}{\partial L} = w - \lambda\frac{\partial f}{\partial L} = 0; \frac{\partial M}{\partial K} = r - \lambda\frac{\partial f}{\partial K} = 0; \frac{\partial M}{\partial \lambda} = Q^0 - f(L,K) = 0.$$

The final condition for minimizing the cost of the given output is obtained as follows:

$$MRTS_{LK} = \frac{\partial f}{\partial L} \Big/ \frac{\partial f}{\partial K} = \frac{MP_L}{MP_K} = \frac{w}{r} \tag{4}$$

Further, to explore the conditions for maximizing the profit of farmers' pro-environmental behavioral factor inputs, the profit function of farmers producing agricultural products is:

$$\pi(L,K) = P \cdot f(L,K) - (wL + rK) \tag{5}$$

In equation (5), π denotes profit, and $P \cdot f(L,K)$ denotes total revenue; $(wL + rK)$ denotes total cost. The first-order condition for profit maximization is: $\frac{\partial \pi}{\partial L} = P\frac{\partial f}{\partial L} - w = 0$; $\frac{\partial \pi}{\partial K} = P\frac{\partial f}{\partial K} - r = 0$. Thereafter, the condition for maximizing the profit of farmers' from agricultural production is obtained as follows:

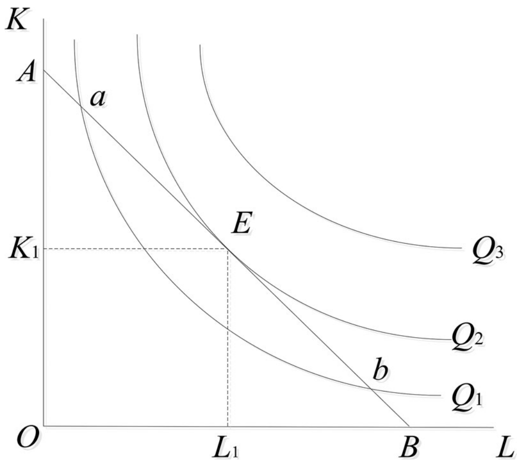

Figure 1. Yield maximizing factor group under given cost conditions.
Source: own work.

$$\frac{\partial f}{\partial L} / \frac{\partial f}{\partial K} = \frac{MP_L}{MP_K} = \frac{w}{r} \tag{6}$$

In summary, farmers will adopt one of two scenarios to increase agricultural income, but the conditions for achieving either of maximizing output at a given cost or minimizing cost at a given output are consistent with the conditions for profit maximization, that is, $MRTS_{LK} = \frac{MP_L}{MP_K} = \frac{w}{r}$, indicating that farmers adopt pro-environmental behavior for the purpose of profit maximization, specifically, increasing profits from agricultural output. In other words, with other factors kept constant, farmers will take two strategies to optimize continuously the ratio of pro-environmental behavior factor inputs and non-environmental behavior factor inputs to increase agricultural income. First, they will continuously adjust the yield at different factor inputs under the given cost until they reach point E (shown in Figure 1). Second, they will continuously adjust the cost expenditure at different factor inputs under the given yield until they reach point E_1 (shown in Figure 2). At the positions of point E and E1, farmers can obtain the same marginal yield whether they invest in pro-environmental factors of production or non-environmental factors of production to achieve Pareto optimum, which in turn maximizes profit and promotes the growth of agricultural income.

Based on the above theories discussed above, this paper constructs a theoretical framework for pro-environmental behavior to promote farmers' income (shown in Figure 3), theoretically dissects the internal logic of farmers' adoption of pro-environmental behavior, reveal the motives and purposes of farmers' adoption of pro-environmental behavior as rational people pursuing profit maximization, and further explain the theoretical contributions of the economic model in this study.

First, under a given cost, pro-environmental behavior can promote the progress of green production technology and generate spillover effects to maximize production and thus increase farmers' income. On the one hand, agricultural green production technologies can reduce undesired outputs such as carbon emissions and agricultural

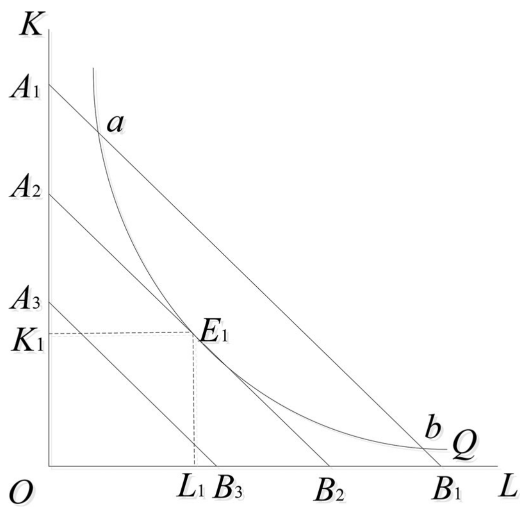

Figure 2. Combination of cost- minimizing elements for a given output condition.
Source: own work.

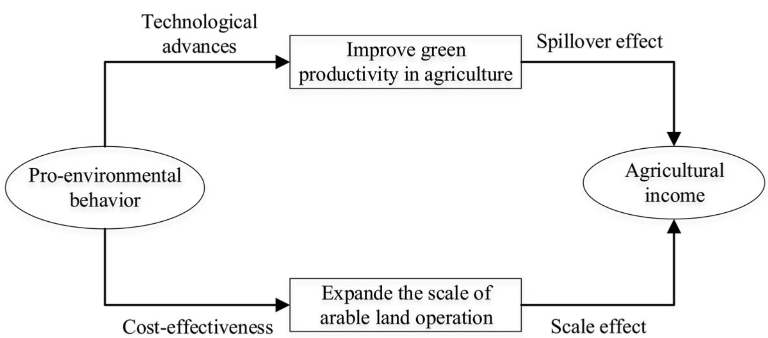

Figure 3. Theoretical framework of pro-environmental behavior for farmers' income generation.
Source: own work.

surface pollution and increase agricultural green productivity. Simultaneously, adopting pro-environmental behaviors to produce green and safe agricultural products can increase agricultural income by improving the added value of products. Generally speaking, the price of green and safe agricultural products is much higher than that of ordinary agricultural products, and they are in short supply in the market, which is favored by the majority of consumers, thus also achieving the purpose of increasing farmers' income. On the other hand, in the long run, agricultural green production technologies such as soil allocation and measuring, pollution-free agricultural technology, water-saving irrigation, and organic fertilizer greatly improve the utilization level of production factors, which is conducive to the improvement of arable land quality and the construction of high-standard farmland, and is beneficial to farmers' sustainable income increase. Accordingly, we propose:

H1: Pro-environmental behavior can drive technological progress and increase green productivity in agriculture, which in turn can contribute to farmers' income growth.

Second, with a given yield, pro-environmental behavior can increase the cost-effectiveness of agricultural production and generate scale effects to minimize costs and thus increase farmers' income. From an input perspective, when pro-environmental behavior is adopted, farmers will usually expand the scale of farming operation to reduce the cost of agricultural production and bring into play the scale effect of agricultural production to reduce costs. First, farmland scale expansion means that farmers will buy a large amount of fertilizers, pesticides, machinery, and other agricultural production materials in which case farmers usually have stronger market 'bargaining power' to buy better quality and greener agricultural production materials at lower prices, thus reducing agricultural production costs. Second, the scale effect will greatly reduce the cost of pro-environmental behaviors such as recycling of mulch, returning straw to the fields, applying organic fertilizers and pollution-free pesticide technologies. Simultaneously, farmers are able to manage the inputs of agricultural production factors in an integrated manner and give full play to the role of agricultural green production technologies in agricultural production, which greatly improves the cost effectiveness of agricultural production. From the output perspective, when pro-environmental behaviors are adopted, farmers will also expand the scale of their farming operations to increase agricultural output returns through the scale effect. First, scale expansion means that farmers are in a position to implement large-scale agricultural production, which will promote the efficiency of agricultural production and the benefits of agricultural output to exceed the costs of inputs, thus increasing the cost-effectiveness of farmers. Second, scale expansion of arable land provides conditions for the fertilization, resourceization, and energization of agricultural waste. For example, crop straw can be returned to the field as soil fertilizer, processed as feed or edible mushroom substrate, or processed into ethanol to become energy. Accordingly, we propose:

H2: Pro-environmental behavior promotes cost-effectiveness and scale expansion of farming operations, which in turn can contribute to farmers' income.

4. Data, variables, and empirical model

4.1. Data and sample description

The data were obtained from a field survey of Xinjiang farmers conducted by the research team from June to September 2018 using stratified sampling with random sampling. First, considering the differences in the geographical environment and the level of economic development in various regions of Xinjiang, the research sites were identified as shown in Table 1 covering 13 counties and cities in 8 prefectures in Xinjiang. Second, according to the principle of stratified sampling, considering the differences in population size and planting structure of townships (and villages) in each city and county, 1–4 townships were selected in each county and city, and 1–3 villages were selected in each township according to the survey scope involving 53 villages or communities in 33 townships. These townships are shown in Table 1. According to the principle of random sampling, 15–30 farmer households were randomly selected in each village or community as the survey sample, and the

Table 1. Geographical distribution of survey samples.

County	Township	Village	Village location
Wusu City	Eighty-four townships	Yangjiazhuangzi Village, Bahai Village	Countryside
	Toutai Township	Village 1, Elm Village, Yangjiazhuang Village, Village 2	Countryside
	Jiujianlou Township	Harajidai Village,Qihudi Village	Countryside
	Palace Town	Hongqiao Village, Xihaizi Village, Linjiazhuangzi Village, Linxi Village	Countryside
Gaochang District	Hatubhu Town	Team 7	Outskirt of city
	Chatkal Township	Oyman Kariz Village	Outskirt of city
	Yale Town	Jiayi Village,Happy Village	Outskirt of county
	Yale Town	Village 4	Countryside
Shule County	Kumuxilike Township	Village 7	Countryside
	Avati Town	Village 12, Village 13	Outskirt of city
Yizhou District	Garden Township	Blue Village, Destur Village	Countryside
	Huicheng Township	Shazaojing Village	Outskirt of county
Luntai County	Harbak Township	Har East Village (Village 2)	Countryside
Shache County	Avati Town	Ingirish Village (Village 16)	Countryside
	Yishkuli Township	Wugran Village (Village 15)	Countryside
Jimsar County	Xindi Township	Hebayan Village	Outskirt of city
	Sandaoba Town	Toudaoba Village	Countryside
Midong District	Woolen Town	Xiebiao Village	Outskirt of city
	Changshanzi Town	Wujialiang Village	Countryside
	Gumudi Town	Potdikeng village	Countryside
	Ergong Township	Dawn team	Countryside
TaCheng City	Chaxia Township	Shuangquan Village	Countryside
	Yemen Le Township	Sangong Village	Outskirt of city
Shawan County	Anjihai Town	Guqu Village, Gudao Village	Outskirt of city
	Ulan Wusu Town	Spring Village, Duck Spring Village, Duck Lake Village	Outskirt of city
Qapqal County	Chuohor Township	Chohall Village	Outskirt of city
	Nadaqi Township	Qingquan Village	Outskirt of city
	Kan Township	kuletkechi village	Countryside
	Kuohongqi Township	Wuerleke Village, Kuohongqi Village, Wuqiman Village	Outskirt of city
Korla City	Shanghu Township	Harassu Village, Harassu Farm	Countryside
Qitai County	Laoqitai Town	Niuwanggong Village	Outskirt of county
	Kanerzi Township	Xi Boer Village, Forest Farm Village	Countryside
	Northwest Bay Town	Xincun, Xiwan Village, Ertun Village	Outskirt of county

Source: own work.

investigators interviewed the farmer households one on one and filled out the questionnaire. A total of 608 questionnaires were obtained from the survey, 17 of which were invalid or seriously missed data and thus were deleted, and 591 valid questionnaires were actually obtained, with a valid questionnaire rate of 97.20%.

Table 2 reports the basic characteristics of the sample from three aspects. First, in terms of personal characteristics, the interviewed farmers are mainly male (89.68% of all interviewees), and only 10.32% are female. The interviewees' ages are 45–55 years (39.76% of all interviewees), 36–44 years (23.01%), and 55–64 years (21.32%), which shows that the interviewees follow the normal age distribution—in line with the central limit theorem, that is, random events affected by various factors will eventually form a normal distribution, which is statistically significant. This also indicates that today's farmers are mostly middle-aged and elderly, and tend to be older. The literacy level of these farmers is generally at the junior high school level (66.16%), indicating that the overall literacy level of the surveyed farmers is low. Second, in terms of household characteristics, the size of farming households is mainly 3–4 persons

Table 2. Basic characteristics of the sample.

Properties	Options	Frequency	Proportion (%)	Properties	Options	Frequency	Proportion (%)
Gender	Male	530	89.68	Farmer type	Food and agriculture	311	52.62
	Female	61	10.32		Cotton farmers	133	22.50
Age	Below 35 years old	61	10.32		Vegetable farmers	53	8.97
	36–44 years old	136	23.01		Farmers and cotton farmers	28	4.74
	45–54 years old	235	39.76		Farmer and vegetable farmer	39	6.60
	55–64 years old	126	21.32		Cotton farmer and vegetable farmer	27	4.57
	Above 65 years old	33	5.58	Arable land size	30 acres and below	294	49.75
Education	Illiterate	45	7.61		30.1–50 acres	87	14.72
	Primary school	69	11.68		50.1–100 acres	107	18.10
	Junior high school	391	66.16		100.1–200 acres	63	10.66
	High school/Junior college	58	9.81		More than 200 acres	40	6.77
	University or above	28	4.74	Agricultural income	Under 10,000 RMB	108	18.27
Family size	1–2 persons	76	12.86		10,001–30,000 RMB	127	21.49
	3–4 persons	284	48.05		30,001–50,000 RMB	95	16.07
	5–6 persons	183	30.96		50,001–70,000 RMB	41	6.94
	More than 6 people	48	8.12		70,001–90,000 RMB	43	7.28
Number of farm workers	1 person	101	17.09		More than 90,000 yuan	177	29.95
	2 persons	421	71.24	Whether to transfer to agricultural land	Yes	270	45.69
	More than 2 persons	69	11.68		No	321	54.31

Source: own work.

(48.05%), followed by households with 5–6 persons (30.96%). Among these households, the number of farm workers is mainly concentrated in two persons (71.24%), indicating that agricultural production is still the main livelihood of farming households. The interviewees comprise mainly food farmers (52.62%), followed by cotton farmers (22.50%), indicating that the crops grown by farmers are mainly food crops, supplemented by cash crops. Third, in terms of production and operation, the scale of interviewees' cultivated land is mainly less than 30 mu (49.75%), followed by 50.1–100 mu (18.10%) and 30.1–50 mu (14.72%). This study considers farmers with greater than or equal to 30 mu of cultivated land as scale users, who account for 50.25% of all interviewees, slightly higher than the proportion of small farmers. Approximately 54.31% of the interviewees did not transfer to the farmland, meaning that most of them still produce on their original land. Most farmers (29.95%) have an agricultural income of more than 90,000 yuan, followed by farmers earning 10,100–30,000 yuan (21.49%), indicating that the income from agricultural production is relatively substantial.

4.2. Variables and descriptive statistics

(1) Dependent variable

Here, the share of farmers' income from farming is taken as the dependent variable. Farmers' income is divided into household business income, wage income, property income, and transfer payments. To avoid ambiguity, the share of farmers' farm income is used as the dependent variable to measure farmers' income. A previous study has shown that the higher the share of farming income (one of the main sources of livelihood for farmers), the higher the farmers' willingness to adopt new technologies (Espinos-Goded et al., 2010). Therefore, the share of agricultural income can directly measure the change in farmers' income after adopting pro-environmental behaviors.

(2) Key independent variables

In 2015, the Ministry of Agriculture in China issued the *Zero Growth Action Plan for Pesticide Use by 2020, Zero Growth Action Plan for Pesticide Use by 2020,* and *Implementation Opinions on Fighting the Battle against Agricultural Surface Source Pollution.* These policy texts take chemical fertilizers, pesticides, agricultural residue film, crop straw, and water-saving irrigation as the key tasks of controlling agricultural non-point source pollution. Document No. 1 of China's Central Government in 2019 once again stressed the goal of achieving negative growth in the use of chemical fertilizers and pesticides as soon as possible, resource utilization of agricultural wastes such as straw and agricultural film, expansion of the pilot crop rotation fallow system, and so on. This paper describes the pro-environmental behavior of farmers according to whether farmers use organic fertilizer, whether cultivated land plastic film is recycled, whether crop straw is returned to the field[3], and the number of items of protective cultivated land technology application.

(3) Other control variables

The control variables in this study comprise the education level and health status of the household head, whether the household head is a village cadre, soil fertility, the years the household head has been engaged in agricultural production, the area of

Table 3. Variable definitions and statistical descriptions.

Variables	Definition	Mean	SD
Land scale	The logarithm value of arable land area	3.458	1.273
Share	Share of farming income in total household income	79.311	27.464
Land transfer	If the farm household is willing to transfer the land in the future: 1 = Yes, 0 = No	0.421	0.494
Recycled	If the mulch on cultivated land is recycled: 1 = Yes, 0 = No	0.574	0.495
Returned	If crop straw is returned to the field: 1 = Yes, 0 = No	0.401	0.490
Organic fertilizer	If organic fertilizer is used: 1 = Yes, 0 = No	0.739	0.439
Number	The number of conservation farming technology or other arable land protection technology	3.352	1.742
Importance	The importance of arable land quality: 1 = very unimportant, 2 = unimportant, 3 = general, 4 = important, 5 = very important	4.206	0.620
Willingness	If the farm household is willing to invest in arable land quality protection: 1 = Yes, 0 = No	0.569	0.495
Laws	If the household head knows the laws related to the protection of arable land quality: 1 = Yes, 0 = No	0.543	0.498
Officials	If the household head is a village official: 1 = Yes, 0 = No	0.078	0.268
Health	Health status of the household head: 1 = weak, 2 = fair, 3 = healthy	2.635	0.574
Education	Education level of the household head: 1 = illiterate, 2 = elementary school, 3 = junior high school, 4 = high school/junior high school, 5 = other	2.924	0.839
Fertility	Soil fertility by farming: 1 = very poor, 2 = poor, 3 = fair, 4 = better, 5 = very good	3.364	0.746
Location	Location of the village: 1 = closer to the county or suburban, 2 = rural suburban area, 3 = other	2.272	0.792
North	If the village is located in North of Xinjiang Uygur Autonomous Region: 1 = Yes, 0 = No	0.712	0.453
Farm year	The number of years the farmer has been engaged in agricultural production	27.927	11.612
Trans area	The log value of the area of the land being transferred	1.648	2.045
Number of observed samples		591	

Note: Conservation tillage technology refers to no-till less tillage technology, fallow technology, planting green manure technology, soil testing and formula fertilization technology, water-saving irrigation technology, pollution-free pesticide technology, scientific and reasonable fertilization, land leveling operation, and deep soil tilling operation.
Source: own work.

land transferred in the current year, the importance given by the household head on arable land quality, household head's willingness to invest in arable land quality protection, whether the household is aware of the laws related to arable land quality protection, the village location, and whether the village is located in the north or south of Xinjiang Uygur Autonomous Region.

Table 3 reports the basic descriptive statistics of the main variables.

4.3. Empirical model and instrumental variables

(1) Empirical model

The farming income share of farm households is a continuous variable, and its data structure has the characteristic of truncating the tail on the left side at 0, which is subsumed data. Using the Tobit model for the restricted dependent variable, this study sets the following equation for the share of farm household income from farming:

$$Y_{2i} = \begin{cases} Y_{1i}^{*} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \Sigma_{n=1} \beta_{5n} D_{ni} + \xi_i \\ Y_{1i} = \max(0, Y_{2i}^{*}) \end{cases} \quad (7)$$

In equation (7), X_1, X_2, X_3, and X_4 are the core independent variables corresponding to whether the farmers' cultivated land mulch is recycled, whether the crop straw is returned to the field, whether the organic fertilizer is used, and the number of items of conservation farming technology application, respectively. Y_{1i} indicates the share of farming income of farming households; D_{ni} denotes the control variables, namely, the perception of farmland quality protection, household characteristics, regional and spatial characteristics, and land dependence of farming households. β_0 is the constant term; $\beta_1 \sim \beta_4$ is the coefficient to be estimated, and ξ_i is the random error term.

(2) Endogenous treatment

To overcome the problem of endogeneity, the instrumental variable (IV) approach for estimation is further adopted to eliminate the estimation error due to the possible endogeneity problem of the model. First, whether farmers have participated in profitable environmental behaviors has a guiding effect on farmers' pro-environmental behaviors, and when experience tells farmers that pro-environmental behaviors can be profitable, farmers will most likely choose pro-environmental behaviors. Second, whether farmers have participated in training on film recycling largely influences farmers' awareness of the hazards of film residue and their application of film recycling technology; therefore, whether farmers have participated in training on film residue is used as the second IV for whether to recycle film on cropland. Third, whether farmland is titled is an important factor influencing farmers' willingness to increase their investment in land, and clear property rights of farmland will increase farmers' willingness to adopt pro-environmental behavior; therefore, whether farmland is titled is used as the third IV for whether to recycle film on cropland. Hence, the third IV is whether the mulch is recycled.

5. Empirical results

5.1. Instrumental variable test

Three IVs are introduced into the model simultaneously: whether farmers have participated in green production in farmers' cooperatives and whether they have attended training on film residue collection and farmland titling. Over-identification tests and weak IV tests are also conducted on the model. In the over-identification test, the p-values of each IV are 0.1430, 0.6402, and 0.1154, and the original hypothesis of 'all variables are exogenous' is accepted. In the correlation test between the IVs and the endogenous variables, the F-statistics of the IVs are 11.230, 18.170, and 11.220, which are greater than 10, and the hypothesis of 'no weak Ivs' is accepted. Comparing the results of the IV and ordinary estimations, the estimated coefficients of whether to recycle agricultural mulch increased significantly and changed in significance after using the IV method (Tables 4 and 5). This indicates that the selection of IVs is appropriate.

5.2. Impact of pro-environmental behavior on farmers' income growth

Table 4 provides the regression results and showes that recycle arable mulch and returning crop straw to the field significantly and positively affected the share of farm

Table 4. Impact of pro-environmental behavior on farmers' income.

	Share	
	Tobit	IV-Tobit
Recycled	9.293*(4.735)	31.898**(13.328)
Returned	14.740***(5.026)	8.081***(2.857)
Organic fertilizer	−1.030(5.409)	−3.368(3.416)
Number	0.907(1.430)	−0.466(0.858)
Importance	3.490(3.685)	4.826**(2.241)
Willingness	2.943(4.732)	−3.348(3.209)
Laws	−0.025(4.719)	0.042(2.821)
Officials	3.122(8.137)	−0.270(4.788)
Health	−0.233(2.710)	−0.597(1.518)
Education	−3.802(2.913)	−0.528(1.794)
Fertility	−10.117**(4.068)	−4.173*(2.429)
Location	4.725*(2.855)	3.139*(1.617)
North	6.757(5.696)	6.760(4.313)
Farm year	−0.514***(0.198)	−0.113(0.137)
Trans area	0.079***(0.025)	0.023**(0.010)
_Cons	103.908***(25.07)	48.143**(20.392)
LR χ^2	52.46***	—
Wald χ^2	—	48.45***
Over-identification test	3.900	
F	11.230***	
Sample size	591	591

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% significance levels, respectively. Robust standard errors are in parentheses.
Source: own work.

income of farming households. In a word, the behavior of recycling arable mulch residues and returning crop straw to the field is helpful to increase the share of farm income of farming households, thus verifying hypothesis H1. There are three main reasons for this. First, recycling of mulch from cropland and returning crop straw to the fields improve the level of green agricultural technology, reduce undesired output in agricultural production, improve green total factor productivity in agriculture, and thus promote farmers' income growth. Second, recycling mulch and returning straw to the fields improve the quality of cultivated land, which helps increase food production and enhances the quality of crops, and the crops, in turn, can be sold at higher prices in the market, thus increasing farmers' income. Third, the pro-environmental behavior of recycling residual film and returning straw to the farmland promotes the sustainability of farmland productivity, reduces the probability of farmers abandoning the land and switching from farming, prompting them to continue to engage in agricultural production activities, and increasing the share of agricultural income in household income. Meanwhile, according to Marx's differential land rent theory, good land fertility and high land transfer price can increase farmers' income.

5.3. Mechanism of the effect of pro-environmental behavior on farmers' income growth

The preceding empirical analysis shows that the adoption of pro-environmental behavior can indeed increase farms' income, and the possible mechanism for this effect is that the adoption of pro-environmental behavior affects farmers' allocation of land factors, which mainly comprises two aspects. One is the size of farmers'

Table 5. Mechanisms by which pro-environmental behavior affects farmers' income.

	Land scale		Land transfer	
	OLS	2SLS	Probit	IV-Probit
Recycled	−2.938(3.232)	22.153(14.670)	0.310**(0.123)	1.519**(0.674)
Returned	15.704***(3.373)	16.634***(4.253)	−0.136(0.129)	−0.091(0.142)
Organic fertilizer	−11.093***(3.638)	−14.096***(4.360)	0.158(0.138)	0.014(0.169)
Number	4.789***(0.964)	4.216***(0.838)	0.071*(0.036)	0.045(0.042)
Importance	5.431**(2.504)	6.982**(3.020)	0.198**(0.097)	0.276**(0.114)
Willingness	8.402***(3.179)	4.935(3.726)	−0.034(0.120)	−0.206(0.160)
Laws	−2.487(3.152)	−4.446(4.281)	0.114(0.120)	0.023(0.140)
Officials	−1.843(5.501)	−4.447(4.807)	−0.134(0.210)	−0.258(0.237)
Health	−0.226(1.802)	−0.623(1.458)	0.111(0.070)	0.094(0.077)
Education	1.102(1.976)	2.455(1.884)	−0.187**(0.075)	−0.123(0.089)
Fertility	0.368(2.749)	1.899(3.673)	−0.070(0.107)	0.008(0.124)
Location	3.809**(1.922)	3.417**(1.585)	0.101(0.073)	0.078(0.080)
North	16.275***(3.790)	21.908***(5.328)	0.307**(0.145)	0.588***(0.221)
Farm year	−0.077(0.136)	0.071(0.266)	−0.012**(0.005)	−0.004(0.007)
Trans area	1.002***(0.011)	0.998***(0.009)	0.002***(0.001)	0.001***(0.001)
_Cons	−31.277*(16.819)	−59.705**(29.003)	−1.263*(0.649)	−2.670**(1.043)
R^2	0.940	0.934	—	—
LR χ^2 test	—	—	73.06***	—
Wald χ^2 test	—	—	—	58.21***
Over-identification test	0.8918		4.3195	
F	18.170***		11.850***	
Sample size	591	591	591	591

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Robust standard errors are in parentheses.
Source: own work.

cultivated land. Land scarcity motivates farmers to maximize land returns, and obtaining economies of scale is the endogenous motivation for farmers to expand their business scale. If pro-environmental behavior can make farmers' income grow, farmers would spontaneously expand the scale of cultivated land, and then realize the reasonable allocation of factors through the scale expansion of cultivated land. Therefore, whether pro-environmental behavior increases farmers' income is measured by the scale of farmers' cultivated land.

The another is the willingness of farm households to transfer their land in the future. The transfer of agricultural land has an income-generating effect on poor, low-income, and some high-income households. Rational farmers judge whether to transfer their land based on the potential benefits generated by pro-environmental behavior and the possible increase in future benefits. If existing pro-environmental inputs can increase farmers' income, farmers would transfer to a certain land to increase their income. To analyze the aforementioned influence mechanism, OLS and Probit models are constructed for the econometric test, and the specific model settings are discussed below.

First, the size of farmers' farmland is a continuous variable, and to reduce the heteroskedasticity problem, this variable is logarithmically normalized to construct an OLS model and set the equation expressions for it as follows:

$$\ln Y_{2i} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \sum_{n=1} \beta_{5n} D_{ni} + \xi_i \tag{8}$$

Second, to examine the influence of pro-environmental behavior on farmers' willingness to transfer their land in the future, a probit model is constructed and a decision equation for farmers' willingness to transfer their land in the future is set as follows:

$$P = F(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \sum_{n=1} \beta_{5n} D_{ni} + \xi_i) \tag{9}$$

In Eqs. (8) and (9), Eq. (8) denotes the farming size of the farmers; P is the dependent variable in Eq. (9), which indicates the probability that farmers are willing to adopt pro-environmental behavior in the future (willing = 1; unwilling = 0), and F is the cumulative normal distribution function.

Table 5 reports the test results of the mechanism of the influence of pro-environmental behavior on farmers' income, which are analyzed below.

(1) Pro-environmental behavior and the size of farmers' farmland

The empirical results show that whether crop straw is returned to the field and the number of items of conservation tillage technology application both significantly and positively affect farmers' arable land size, which indicate that the adoption of crop straw and conservation tillage technology can motivate farmers to increase the scale of farming spontaneously. The hypothesis H2 is verified. Beacuse crop straw return and conservation tillage technology can effectively improve the quality of cultivated land and increase soil fertility, resulting in promoting the increase of per unit area yield. Farmers spontaneously expand the scale of cultivated land to increase their income, thus realizing the increase of cultivated land area and promoting the growth of farmers' income. In addition, the adoption of crop straw return and conservation tillage technology requires higher labor and capital costs compared with traditional tillage patterns, and farmers, to achieve cost minimization, expand the scale of cultivated land, expecting to achieve cost minimization through the scale efficiency of cultivated land.

Whether a farmer uses organic fertilizer negatively affects the farming size of the farmer at the 1% significance level. This result shows that the higher the amount of organic fertilizer applied by the farmer, the smaller the size of his or her farmland. There two reasons. Firstly, although the use of organic fertilizers can improve soil quality and structure and enhance the quality and quantity of agricultural products, the application amount and effect time of organic fertilizers are often higher than those of chemical fertilizers, and the use of organic fertilizers requires more labor and time. To save labor and time costs, farmers choose to reduce the scale of cultivated land and reallocate labor and capital factors to maximize profits and increase income. Secondly, the use of organic fertilizers has the effect of increasing yields and incomes. Farmers using organic fertilizers and reducing the corresponding arable land area can still achieve their previous yield or income.

(2) Pro-environmental behavior and farmers' willingness to transfer land in the future

The empirical results also show that the variable of whether arable land film recycling is employed positively affected farmers' probability to transfer their future land at the 5% significance level, indicating that participation in arable land film recycling would increase farmers' probability to transfer their land. A possible reason for this is that film recycling helps improve the quality of farmland, promotes crop yield and increases farmers' income, thereby prompting farmers to expand their planting scale

Table 6. Robustness tests.

	Share		Land scale		Land transfer	
	Tobit	IV-Tobit	OLS	2SLS	Probit	IV-Probit
Recycled	0.147**	0.935**	0.031	0.490*	0.005***	0.027***
	(0.068)	(0.388)	(0.047)	(0.284)	(0.002)	(0.013)
Returned	14.48***	7.830**	15.844***	16.301***	−0.142	−0.120
	(5.004)	(3.620)	(3.372)	(4.115)	(0.129)	(0.147)
Organic fertilizer	−0.0474	1.325	−11.416***	−10.986**	0.197	0.219
	(5.360)	(3.881)	(3.619)	(4.362)	(0.138)	(0.157)
Number	1.172	0.024	4.714***	4.597***	0.077**	0.073*
	(1.424)	(1.031)	(0.961)	(0.874)	(0.036)	(0.042)
Other variables	YES	YES	YES	YES	YES	YES
_Cons	105.5***	23.134*	−36.603**	−66.623**	−1.219*	−2.718**
	(24.80)	(10.824)	(16.701)	(28.777)	(0.641)	(1.143)

Source: own work.

and thus stimulating them to transfer their land in the future. In addition, the national and local governments at all levels adopt incentive measures such as subsidies and trade-in for new mulch, which not only improve farmers' motivation to recycle mulch, but also significantly reduce farmers. Moreover, this increases farmers' willingness to recycle mulch and significantly reduces the cost of mulch recycling, thus stimulating farmers' willingness to transfer their land. Another possible reason is that farmers' farmland inputs may be bound by the size of the existing farmland. The size of the existing cropland may not allow achieving the optimal allocation of input factors for film recycling, and the transfer from one cropland to another can reduce the input costs of film recycling and other pro-environmental behaviors, and achieve returns to scale.

5.4. Robustness tests

The robustness test is conducted by replacing the core independent variable. The core independent variable of whether the mulch is recycled on cultivated land is replaced by the mulch recycling rate of farmers, and the model is re-estimated. The results are shown in Table 6, which demonstrate that the study's findings remain robust after replacing the core independent variable.

6. Discussion, conclusions, and implications

6.1. Discussion

The results showe that pro-environmental behavior and farmers' income increase are logically 'self-consistent'. From a micro perspective, the intrinsic motivation of farmers to adopt pro-environmental behavior depends on whether this behavior can promote income increase, which in turn will optimize the allocation of agricultural production factors and increase farmers' income, suggesting that pro-environmental behavior and farmers' income increase are mutually influential, and they are consistent in terms of interests. This finding guides agricultural policymakers' decisions in two ways. First, pro-environmental behavior can promote the increase of farmers' income, and the two are not in a competing relationship. Therefore, in the process of policy formulation, the incentive effect of pro-environmental behavior to promote income increase should be given full play, and the resistance to policy implementation should be reduced. Second, in the process of policy formulation, attention should be paid to the income increase channels of pro-environmental behavior, and by widening the channels of income increase, agricultural green productivity can be improved and farmers intrinsic motivation to participate in green production can be stimulated.

Notably, pro-environmental behavior still has certain thresholds in some rural areas and is bound by farmers' literacy level and local agricultural resource endowment, which has the problems of high cost, low penetration rate, and poor effect, and this curtails the enthusiasm of some farmers to adopt pro-environmental behavior, which in turn inhibits farmers' income increase. Therefore, to achieve the synergistic development of pro-environmental behavior and farmers' income, efforts are also needed to promote pro-environmental behavior, which is, and will continue to be, the main issue that needs attention in the future.

6.2. Conclusions

From the perspective of arable land quality protection, this study explores the internal relationship between farmers' pro-environmental behaviors and their income, and analyzes how pro-environmental behaviors affect agricultural income by adjusting the scale of arable land and willingness to transfer arable land in the future. The main conclusions are as follows. First, farmers spontaneously expand the size of the farmed arable land when pro-environmental behavior can increase farmers' income. This indicates that pro-environmental behavior helps promote farmers' moderate scale of operation and thereby realizes scale benefits. However, small-scale farmers notably still adopt pro-environmental behavior for their own health and land endowment considerations. Second, pro-environmental behavior increases, to some extent, the share of farm income in total household income, which disproves the paradox of the relationship between pro-environmental behavior and farmers' income from farming. Third, pro-environmental behavior can optimize farmers' resource allocation. If the existing arable land cannot meet the optimal factor allocation of farmers, farmers would tend to adjust the factor allocation. Transferring to arable land is one of the important ways of factor allocation, and the existing land transfer policy creates good conditions for farmers to optimize factor allocation.

6.3. Implications

Pro-environmental behavior is an important part of achieving green production and high-quality agricultural development, as well as an important means of promoting farmers' income. Therefore, based on the discussion and conclusions presented above, the following insights are derived. First, measures should be taken to allocate funds for agricultural non-point pollution such as increasing the amount of subsidies and reducing the cost for farmers' pro-environmental behaviors. Additionally, to curtail agricultural surface source pollution, punishment measures for non-pro-environmental behaviors should be implemented. Second, technical training to improve farmers' awareness of green environmental protection must be provided to farmers. Third, a mechanism to link the interests of farmers, dealers, and the government is needed to improve environmental management and increase farmers' income. For example, the government could strictly approve the access qualifications of dealers and give subsidies to farmers who adopt pro-environmental behaviors. Technical guidance to dealers to promote farmers' pro-environmental behavior can help in reducing farmers' production costs and motivate them to continue to adopt pro-environmental behavior.

In the study, we only use a cross-section data to discuss the impact of farmers' pro-environmental behavior on their income. In future, long-term tracking data would be adopted to focus on the relationship between the dynamic change of farmers' income and the participation of pro-environmental behavior. Besides, it is also noticed that the motivation for farmers to be involved in pro-environmental behavior based on incentive compatibility.[4]

Notes

1. The series of documents include "Implementation Opinions on the Battle of Agricultural Surface Source Pollution Prevention and Control," "Zero Growth Action Plan for Fertilizer Use by 2020," "Zero Growth Action Plan for Pesticide Use by 2020," and "Key Work Arrangements for the Battle of Agricultural Surface Source Pollution Prevention and Control in 2017."
2. The endowment effect refers to the fact that once a person owns an item, he or she values the item more highly than if he or she did not own it.
3. The question "Does crop straw go to the field" is derived from the question "How does your family handle crop straw" (1 = straw goes to the field; 2 = fed to livestock; 3 = sold; 4 = used as fuel; 5 = burned in the ground), for which I set a dummy variable based on the first option "whether the crop straw is returned to the field," which is defined as 1 = yes, 0 = no.
4. We thank an anonymous reviewer for this observation.

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