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# Do Not Be Anticlimactic: Farmers' Behavior in the Sustainable Application of Green Agricultural Technology—A Perceived Value and Government Support Perspective

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**Abstract:** The production mode of "high input, high yield and high waste" in the agricultural system poses a serious threat to the environment and the quality of agricultural products. Accelerating the adoption of green agricultural technology (GAT) by farmers is an emergency measure. However, according to microsurvey data, many farmers give up GAT within a year after adopting it. The implementation of this measure has been anticlimactic. Based on a survey of 1138 kiwi growers in Shaanxi Province, China, this paper builds a theoretical model and conducts empirical exercises to gain insight into the effects of perceived value, government support and their interaction with kiwi growers' sustainable application of GAT. We find that perceived value and government support have a significant impact on the sustainable application of GAT. Government support plays a moderating role in the influence of perceived value on the sustainable application of GAT. Furthermore, in order to overcome the potential endogeneity problem caused by the two-way causal relationship between subjective variables, "owning a smartphone" was selected as the instrumental variable. The 2SLS model was used for endogeneity analysis, and the OLS model was used for the robustness test. This paper discusses the relevant theories and policy implications of environmental management.

**Keywords:** perceived value; government support; sustainable application; green agricultural technology (GAT); China; Shaanxi Province; kiwi growers



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## 1. Introduction

China is one of the most populous countries in the world, and agriculture has played a prominent role in the country's remarkable economic achievements [1,2]. However, the accelerated development of agriculture has caused the energy demand to rise and has produced severe environmental pollution as well, which has threatened the food security and ecological security of the country [3–5]. Excessive and improper use of fertilizers, pesticides and irrigation water in agricultural production has caused serious pollution of agricultural land, water resources and the air environment and agricultural product safety accidents. Therefore, China's agriculture needs to step into a new stage of accelerating transformation and upgrading to achieve green development [6]. Green agricultural technology (GAT) can conserve water, improve the soil structure, increase soil organic matter and enhance farmland productivity. It is a principal part of promoting sustainable agricultural development, ensuring consumer food safety and protecting rural ecological environments. The popularization of GAT has become the inevitable course to promote the green development of agriculture [7,8]. The United Nations Environment Program classifies GAT in broad strokes; it mainly includes aquatic ecological protection and restoration technology, fertilizer and pesticide application reduction and efficiency improvement technology, agricultural waste recycling technology, heavy metal pollution control and treatment technology, and green and efficient production technology for supporting grass and livestock [9].

Farmers are the pacesetters in the tough fight against agricultural pollution. Observing the extent of their engagement in GAT offers clues and necessary insights to promote the sustainable development of the agricultural economy [10]. Scholars have paid attention to this field for a long time, and the studies have led to a wealth of useful results. There are both internal factors and external factors, as well as economic factors and non-economic factors, that affect the adoption of GAT by farmers. Some scholars have specifically studied the influence of individual and family endowments, such as age, gender, years of schooling, health conditions and income level [11–13]. There are also production factors. Land fragmentation and non-agricultural transfer of labor are utilizable resources that influence a farmer's green production choices [14]. Likewise, a moderate scale of operation will facilitate farmers to engage in GAT [15,16], increasing attention on subjective feelings and psychological perception of the surrounding environment. Perception of risks can play a role in the decision-making process and manipulate farmers from the perspective of environmental behavior [17–19]. Farmers' cognition and concern about the quality of agro-products positively and significantly affected their technology adoption [20,21]. External factors also have a significant influence on the adoption of GAT by farmers. China is a country with an intricate social network consisting of interwoven kinship, affinity, geographical relationships and karmic connections [22]. Farmers acquire technical information via social networks and have exchanges with each other [23]. There was also evidence that the application of pesticides and fertilizers significantly reduced when farmers joined cooperative organizations [24–26]. The implementation of clean agricultural practices has been slow, partly because farmers are reluctant to go through with it for the fear of losing revenue [27,28]. In various countries, national policy incentives have successfully countered such hesitation [29,30]. The positive influence of GAT, together with its beneficial externalities, on the environment is hard to compensate by means of market prices. For this reason, science and technology demonstration, environmental regulations and educational programs from the government are expected to affect the green choices farmers will make to a great extent [31,32].

After sorting out the relevant literature, it is found that the academic research on the adoption behavior decision of GAT is not sufficient. The traditional view is that the adoption of GAT by farmers is regarded as a static decision at a certain stage [33], that is, a one-time decision, with less distinction between the initial and continuous adoption of technology. Farmers often try to adopt a certain production technology for the first time, and research at a certain time point is not enough to reflect the final decision made by farmers. Technology adoption is a behavioral decision made by individuals under the influence of other individuals or groups by considering the benefits brought by technology and their own applicability to technology. The continuous adoption of technology by farmers is an extension and continuity of the time of technology adoption based on the fact that the actual effect after the initial adoption conforms to the individual's expectation of the effect of technology. The promotion and adoption of GAT are essentially a process of technology diffusion. It can be divided into two stages: the first stage is whether farmers choose to adopt GAT, and the second stage is whether farmers who have adopted technology choose to continue with its adoption. As "green" has become the main color of agricultural production and development, the adoption rate of GAT by farmers has improved, but the sustainable application of GAT is not satisfactory. That is to say, there are differences between the adoption and sustainable application of GAT by farmers. However, only by continuously adopting GAT can farmers form a green development mode and lifestyle in essence and achieve mutual coordination between agricultural economic development and ecological environment protection.

In view of this, this paper analyzes the impact of perceived value, government support and their interaction items on the sustainable application of GAT by farmers based on questionnaire survey data of the main kiwi production areas in Shaanxi Province, China. This research attempts to supplement the existing literature research, and the conclusions will help to understand the phenomenon and reasons of farmers' unsustainable adoption of GAT. Identifying this problem is helpful to encourage farmers to continue to adopt GAT in production activities. It provides an empirical basis for the government to formulate relevant policies and has important theoretical significance and practical value for promoting the green development of agriculture.

## 2. Theoretical Basis and Mechanism Analysis

### 2.1. Theoretical Basis

In 1989, Davis proposed the technology acceptance model. This theory summarizes the influencing factors of an individual's acceptance of technology as perceived ease of use, perceived usefulness, attitude to technology and use intention [34]. In 1991, American psychologist Ajzen proposed the theory of planned behavior. This theory believes that individual behavior is the result of multiple factors. Behavior attitude, subjective norms and perceived behavioral control directly affect individual behavior [35,36]. Researchers mainly use the above theories to study the adoption behavior of GAT by farmers [37–40]. In the 1960s, American scholar Rogers put forward the theory of innovation diffusion and concluded that the diffusion of new technologies follows the "S-shaped" technology adoption curve [41]. In the initial adoption stage of technology, individuals are not familiar with the technology, and their performance is often the lowest. Only by continuing to use this technology can the value of the technology itself be truly realized [42,43]. Farmers' choice of GAT is a dynamic process, which is the result of understanding the characteristics of technology and making a comparison with their own expectations. There are certain differences and distinctions between adoption behavior and continuous adoption behavior [44]. Therefore, there are certain limitations in the research on users' GAT adoption and continuous adoption behavior based on classical theories, such as the technology acceptance model and theory of planned behavior.

Bhattacherjee proposed an expectation confirmation model, which argues that an individual's expected confirmation will affect their satisfaction, which in turn affects the individual's reuse behavior [45]. On this basis, Bhattacherjee also built a continuous use model, which mainly studies the behavior of individuals who have not interrupted the use of technology after initial adoption [46]. After adopting GAT, farmers will compare the adoption effect with the technical expectation. The expected confirmation result after comparison is an important basis for farmers to make sustainable adoption decisions. Based on the expectation confirmation model and continuous use model, this study believes that perceived value and government support can improve farmers' satisfaction by raising their expectations and then encouraging them to make sustainable adoption decisions.

### 2.2. Mechanism Analysis

#### 2.2.1. Perceived Value and Sustainable Application of GAT

Perceived value is the utility evaluation after people weigh the possible perceived benefits and risks when they acquire products or services [47–50]. Subjective perception and psychological perception are the internal driving force of farmers' environmental decision making behavior. Rational individuals tend to increase profits and avoid risks, which will directly affect their behavioral intentions and decisions [51,52]. This suggests that it is important to study the sustainable application of GAT by farmers from the perspective of perceived value. In this study, the perceived value of the sustainable application of GAT is the overall evaluation obtained after weighing the perceived benefits and risks of farmers. The level of perceived value depends on the relationship between expected income and expected cost. The higher the level of perceived value, the more obvious the tendency of individual persistent behavior.

As a result, the first hypothesis can be stated as follows:

**H1:** *Perceived value has a significant impact on farmers' sustainable application of GAT.*

Applying GAT can bring farmers a number of economic benefits and some ecological benefits, but thus far, the evidence on whether farmers will have the consequent income increase out of such an initiative has been unclear. Indeed, evidence does exist that proves the correlation between GAT and a higher income [53,54]. However, there is also evidence showing that it has no effect on such a matter or that there might be an adverse effect [55,56]. Therefore, it is particularly important for a currency to play the role of the carrier of perceived value and be factored into the index system. At the same time, drawing on Woodruff's point of view, he believed that perceived value depends on gains and losses [57]. The perceived value of the sustainable application of GAT by farmers is their perception of the expected net benefits and risks. Therefore, this paper divides perceived value into four dimensions: perceived monetary benefits, perceived non-monetary benefits, perceived monetary risks and perceived non-monetary risks.

Perceived monetary benefits and perceived non-monetary benefits refer to the sum of expected economic benefits, environmental improvement, village development and self-actualization perceived by farmers during the sustainable application of green agricultural technology. Firstly, according to perceived monetary benefits, if farmers perceive that the continuous use of GAT can produce green agricultural products and improve the quality of farmland to increase output, or they have the opportunity to enjoy government subsidies, low-interest loans and other favorable agricultural policies, then the expected income will encourage farmers to be more eager to adopt GAT in the long term. Secondly, if ecological and social benefits resulting from the sustainable application of GAT, such as a better ecological environment, enhanced village development and farmers' self-actualization, are widely recognized, the expected non-monetary benefits will also encourage continued adoption of GAT [58,59]. After adopting GAT, farmers will test the rationality of the initial adoption decision so as to decide whether to continue to adopt GAT. To a certain extent, the perceived monetary benefit intensity and perceived non-monetary benefit intensity will have different impacts on the sustainable behavior of farmers.

As a result, the second hypothesis can be stated as follows:

**H2a:** *Perceived monetary benefits and perceived non-monetary benefits positively affect the sustainable application of GAT.*

**H2b:** *Perceived monetary benefit intensity and perceived non-monetary benefit intensity positively affect the sustainable application of GAT.*

Risk perception, on the other hand, could be influenced by the judgment of and attitude towards a diversity of objective risks. The level of uncertainty in each perceived risk can have an effect on the decision making [60–62]. Similarly, during the actual sustainable application of GAT, the perceived risks are the outcome of the subjective perception and psychological feelings regarding the uncertain results and obstacles. For example, purchasing funds are required to adopt techniques for the replacement of chemical fertilizers by organic fertilizer. In addition, sufficient funds are also needed for the construction and maintenance of water-saving irrigation facilities [63,64]. Furthermore, physical and mental pressure on farmers will increase before changing methods. Perceived non-monetary risks means they need to spend time learning new skills, and they could also be faced with objections from family members [65]. Therefore, the higher the perceived risks, the lower the enthusiasm of farmers to continuously adopt GAT. The perceived risks of farmers come from the overall evaluation of the effect of the sustainable adoption of GAT. The higher the perceived risk intensity, the lower the satisfaction degree of the overall evaluation of the technology, which has a negative impact on the sustainable application of GAT to varying degrees.

As a result, the third hypothesis can be stated as follows:

**H3a:** *Perceived monetary risks and perceived non-monetary risks negatively affect the sustainable application of GAT.*

**H3b:** *Perceived monetary risk intensity and perceived non-monetary risk intensity negatively affect the sustainable application of GAT to varying degrees.*

2.2.2. Government Support and Sustainable Application of GAT

According to the market failure theory of economics, GAT has the property of public goods. There are externalities and information asymmetry when farmers adopt GAT [66]. In the event of market failure, it is very necessary to discuss the effect of government support on GAT. In China's current situation, most ecological agriculture development projects involve the government. Government support is used to improve technical training, increase policy publicity and implement incentive policies to more effectively encourage farmers to adopt green planting methods. Due to the uncertainty and periodicity of new technology adoption, any decision on the sustainable application of GAT by farmers is a long-time trade-off between costs and benefits. However, farmers often do not have the necessary technical knowledge to understand and evaluate all the benefits and risks involved [67]. At present, the main channel for farmers to acquire knowledge and technical training in GAT is through government agricultural extension services [68]. Pesticide and fertilizer overuse is driven by limited knowledge and low awareness of risks. Providing proper training to improve the depth and breadth of knowledge can have a positive impact [69]. The government continues to promote and guide farmers' adoption of GAT through lectures, technical training, one-to-one technical guidance and other forms. With the continuous enhancement of technical knowledge and the improvement of operational skills, farmers gradually gain good experience in the initial adoption process. When farmers reach their own expectations and improve their satisfaction, government agricultural extension services eliminate the barriers, and farmers will be more motivated to continue their use of GAT. The cost input of GAT mainly includes infrastructure investment, purchase cost of input elements and operation cost. The benefits of GAT comprise two parts: social–ecological benefit and increase in private income. When the private income of farmers is lower than the investment and opportunity cost of labor, their sustainable application of GAT will be greatly affected. This is when government incentives will have the most impact [70]. Support payments constitute a significant part of farmers' income and guide their decision making for production development [71]. The government's ecological subsidies can effectively enhance farmers' determination to implement GAT sustainably by reducing economic risks.

Using this argument, we arrive at the fourth hypothesis, which is as follows:

**H4:** *Government support positively affects the sustainable application of GAT.*

**H4a:** *Agricultural extension services positively affect the sustainable application of GAT.*

**H4b:** *Ecological subsidies positively affect the sustainable application of GAT.*

2.2.3. Perceived Value and Government Support in the Sustainable Application of GAT

There is a causal order between knowledge, perceived value and the GAT adoption behaviors of farmers. To be more specific, value perception, influenced by knowledge, enhances the adoption of GAT practices [72]. However, acquiring such knowledge takes time and effort [73]. Some techniques are so complicated that it is difficult for farmers to quickly grasp and master them. Through agricultural extension services, the government is helpful in that it allows hundreds of millions of scattered farmers in China to access GAT so as to enhance its intervention, guidance and control in the application of techniques by farmers, notably increasing their application of these techniques, improving their overall scientific competence, optimizing the allocation efficiency of element input and reducing the possible discomfort, thus resulting in higher perceived non-monetary benefits and lower perceived non-monetary risks of farmers [74]. It is high time for China to acknowledge the necessity of internalization of the non-market part of GAT by taxing polluters and subsidizing environment protection entities. Ecological subsidies can improve perceived monetary benefits and reduce perceived monetary risks by reducing marginal costs in the application of GAT by farmers. On the other hand, farmers will adjust to changes in agricultural subsidy policies when perceiving the benefits and risks of the sustainable application of GAT so as to improve their initiative in application. That is to say, government subsidies have a moderating effect on perceived monetary benefits and perceived monetary risks in farmers' behavior to continuously use GAT (Figure 1).

Based on these reasons, we provide the following hypotheses:

**H5a:** *Ecological subsidies play a positive moderating role in the relationship between perceived monetary benefits and the sustainable application of GAT.*

**H5b:** *Ecological subsidies play a negative moderating role in the relationship between perceived monetary risks and the sustainable application of GAT.*

**H5c:** *Agricultural extension services play a positive moderating role in the relationship between perceived non-monetary benefits and the sustainable use of GAT.*

**H5d:** *Agricultural extension services play a negative moderating role in the relationship between perceived non-monetary risks and the sustainable use of GAT.*

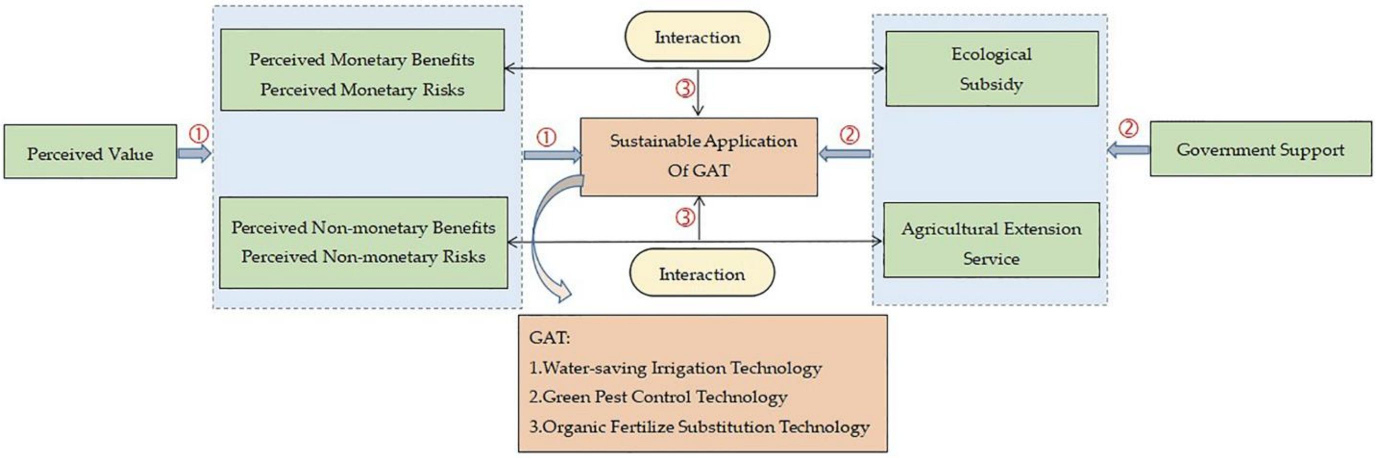


**Figure 1.** Theoretical model of this study. The light blue color represents the four component dimensions of perceived value and two component dimensions of government support. The light orange color represents the theme of this study: sustainable application of GAT, as well as the names of the three technologies specifically studied. ① represents the influence paths of perceived value and the four dimensions of perceived value on the sustainable application of GAT. ② represents the influence paths of government support and the two dimensions of government support on the sustainable application of GAT. ③ represents the interaction effect.

## 3. Data and Variables

### *3.1. Data Sources*

The data used in this study were extracted from a questionnaire survey given to kiwi farmers in Shaanxi Province, China. The survey was conducted from June to August 2021. Zhouzhi County, Mei County, Wugong County and Yangling District were included in the survey. These areas are the largest kiwi production hubs, in terms of both area and yield, in China (Figure 2). The choice ensured that the sample was as close to representative as possible. We also conducted a preliminary investigation in Lichen and Zhaixi villages in Yangling District to check the reliability and validity of the questionnaire. In this phase, a total of 100 questionnaires were distributed, and the response rate was 98%. The reliability and validity of the questionnaires were pre-tested, and a few unscientific indicators were eliminated. The questionnaire was revised and adjusted according to the responses collected upon relevant expert advice, and then a finalized version was formed. To choose samples, a combination of hierarchical and random sampling was used. The process was as follows: First, three to four townships from Zhouzhi County, Mei County, Wugong County and Yangling District were randomly selected. Then, four villages were randomly selected from each township. Finally, 20 to 30 ordinary households from each village were selected in random depending on the village size. In total, 1200 questionnaires were distributed, with a response rate of 100%. After eliminating questionnaires with missing data and invalid responses, we were left with 1138 valid questionnaires, with a 94.83% valid response rate. Interviews were conducted face to face, and the interviewers were trained beforehand. The investigators fully understood every question in the questionnaire to ensure the reliability of the results.

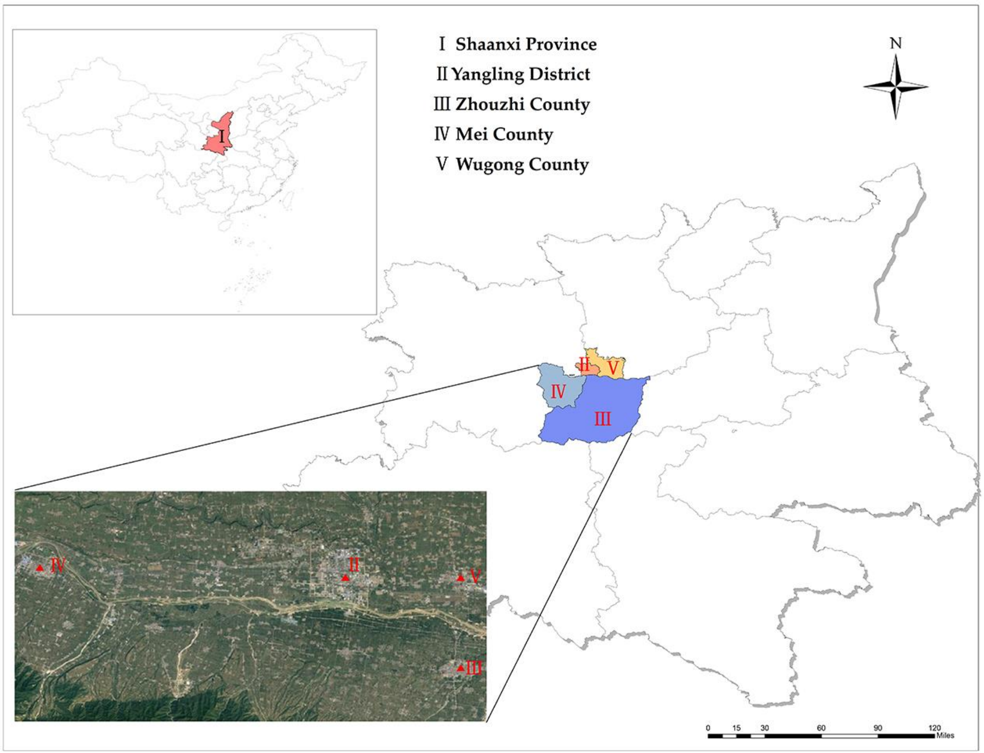


**Figure 2.** Location of the study sites in Shaanxi, China.

*3.2. Summary Statistics of Sample*

Table 1 provides a statistical overview of the sample. By 11.78%, a slightly greater number of interviewees were female. A total of 35.33% of the sample consisted of respondents aged 50–65 years, followed by those aged 35–50 years (27.07%), 20–35 years (19.50%), and over 65 years (18.10%). The majority of the respondents, constituting 73.90% of the whole sample, had less than nine years of education. In addition, 36.12% of the kiwifruit planters had farms smaller than 5 ha, 45.17% had farms between 5 and 10 ha, 11.86% had farms between 10 and 20 ha, and 6.85% had farms larger than 20 ha. A total of 55.71% of the farms belonged to households with one to two workers, while 37.43% belonged to households with three to four workers. Only 6.85% of homes employed five or more workers. Those with a total household income between CNY 30,000 and CNY 60,000 represented the largest category, with 53.78% of the sample. In total, 44.02% of the responding farmers were members of agricultural cooperatives.

**Table 1.** Basic data (*n* = 1138).

| Variable Definition | | Frequency | Percent |
|---|---|---|---|
| Gender | Female | 636 | 55.89 |
| | Male | 502 | 44.11 |
| Age (year) | [20,35) | 222 | 19.50 |
| | [35,50) | 308 | 27.07 |
| | [50,65) | 402 | 35.33 |
| | 65 and above | 206 | 18.10 |
| Years of schooling | [0,6) | 299 | 26.67 |
| | [6,9) | 542 | 47.63 |
| | [9,12) | 231 | 20.29 |
| | 12 and above | 66 | 5.89 |
| Number of laborers | [1,2] | 634 | 55.71 |
| | [3,4] | 426 | 37.43 |
| | 5 and above | 78 | 6.85 |
| Farmland size (ha) | [0,5) | 411 | 36.12 |
| | [5,10) | 514 | 45.17 |
| | [10,20) | 135 | 11.86 |
| | 20 and above | 78 | 6.85 |
| Income (wan CNY) | [0,3) | 182 | 15.99 |
| | [3,6) | 612 | 53.78 |
| | [6,9) | 240 | 21.09 |
| | 9 and above | 104 | 9.14 |
| Joined an agricultural cooperative | Yes | 501 | 44.02 |
| | No | 637 | 55.98 |

### *3.3. Farmers' Current Situation of Adopting GAT*

Of the 1138 kiwi growers surveyed, 168 applied water-saving irrigation technology, and 159 continuously practiced such technology for over two years. Regarding organic fertilizer substitution technology, 778 farmers responded affirmatively, and 694 farmers carried on with this practice for more than two years. This suggests that kiwi growers who have applied water-saving irrigation technology and organic fertilizer substitution technology will generally keep doing so. A total of 566 of them applied green pest control technology, and 239 of them used this practice for more than two years. However, 57.8% of the growers in our sample returned to chemical pesticides after using organic pesticides for some time (Figure 3).

### *3.4. Variables*

#### 3.4.1. Measuring Perceived Value

According to the research conclusions of the existing literature and the mechanism analysis of this paper [75–77], perceived value, perceived monetary benefits, perceived non-monetary benefits, perceived monetary risks and perceived non-monetary risks were measured by the questionnaire. The value for each was assigned to 1 if the farmer said yes to it, or 0 otherwise. The questionnaire questions are shown in Table 2. Each variable is measured by two questions, and, finally, the average value is used to obtain the variable value. At the same time, in order to study the influence of perceived value intensity on the sustainable use of GAT, a Likert scale with five values was adopted for the questionnaire, and values were assigned to indicate the intensity, namely: 1 = little; 2 = very little; 3 = indifferent; 4 = strong; and 5 = very strong.

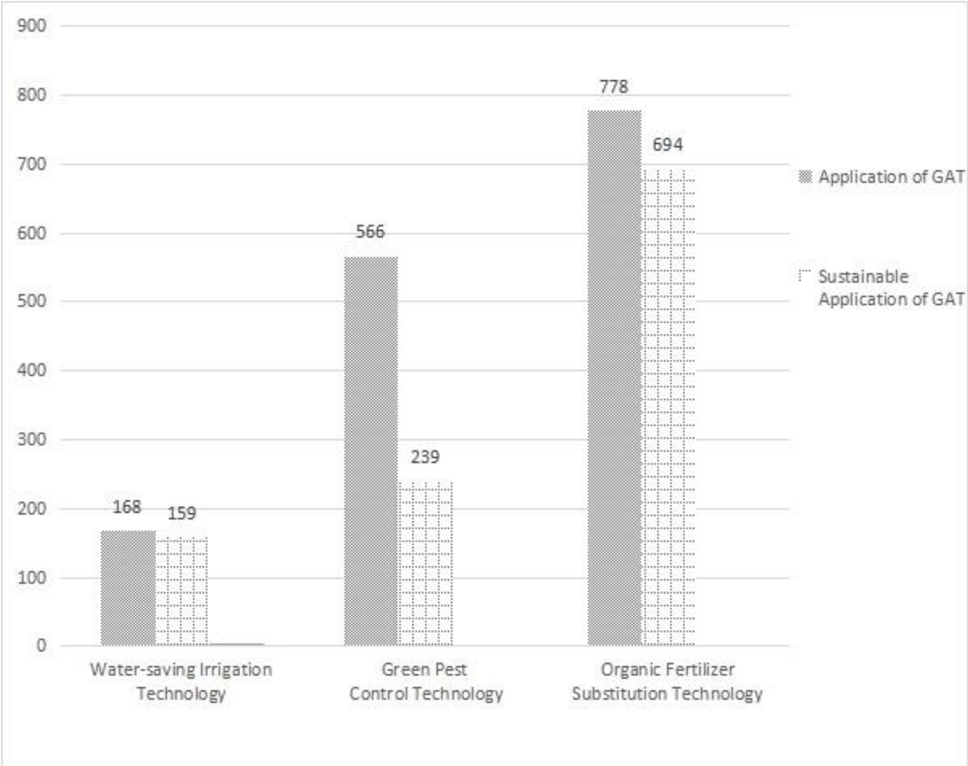


**Figure 3.** Farmers' current situation of green agricultural technology adoption.

**Table 2.** Variable definition and descriptive statistics.

| Variable | Definition | Mean Value | Standard Deviation |
|---|---|---|---|
| Perceived value | Do you agree that sustainable application of GAT AGP has a positive significance | 0.701 | 0.411 |
| | Do you agree that sustainable application of GAT can bring benefits | 0.600 | 0.435 |
| Perceived monetary benefits | Do you agree that sustainable application of GAT can produce green products that can be sold at a better price | 0.653 | 0.476 |
| | Do you agree that sustainable application of GAT can make it easier to obtain financial subsidies | 0.461 | 0.332 |
| Perceived non-monetary benefits | Do you agree that sustainable application of GAT can improve the environment and reduce water, soil and other pollution | 0.501 | 0.500 |
| | Do you agree that sustainable application of GAT can win social recognition | 0.413 | 0.402 |
| Perceived monetary risks | Do you agree that sustainable application of GAT requires more monetary investment | 0.616 | 0.487 |
| | Do you agree that it may be more profitable to do something else rather than spend time and energy on sustainable application of GAT | 0.521 | 0.523 |

**Table 2.** *Cont.*

| Variable | Definition | Mean Value | Standard Deviation |
|---|---|---|---|
| Perceived non-monetary risks | Do you agree that sustainable application of GAT requires learning about the knowledge which is troublesome and unprofessional | 0.671 | 0.469 |
| | Do you agree that sustainable application of GAT may cause differences of opinion in the family and cause family problems | 0.417 | 0.399 |
| Intensity of perceived monetary benefits | Very strong = 5, strong = 4, indifferent = 3, weak = 2, very weak = 1 | 2.652 | 1.267 |
| Intensity of perceived non-monetary benefits | | 2.401 | 1.064 |
| Intensity of perceived monetary risks | | 3.276 | 1.119 |
| Intensity of perceived non-monetary risks | | 3.181 | 1.121 |
| Government support | Weighted mean of agricultural extension service and ecological subsidies | 0.406 | — |
| Agricultural extension services | Do you receive the government agricultural extension service | 0.561 | 0.497 |
| Ecological subsidies | Do you receive the government ecological subsidy | 0.250 | 0.433 |
| Water-saving irrigation technology | Have you continued to use water-saving irrigation for more than two years | 0.139 | 0.347 |
| Green pest control technology | Have you continued to use green pest control technology for more than two years | 0.609 | 0.488 |
| Organic fertilizer substitution technology | Have you continued to use organic fertilizers substitution technology for more than two years | 0.210 | 0.407 |
| Education | Year of schooling, year | 6.698 | 2.426 |
| Health condition | Very good = 5, good = 4, indifferent = 3 bad = 2, very bad = 1 | 3.365 | 1.171 |
| Labor | Number of laborers | 2.721 | 1.085 |
| Income | Annual household income, wan CNY | 5.087 | 2.191 |
| Farmland quality | Very good = 5, good = 4, indifferent = 3 bad = 2, very bad = 1 | 3.368 | 1.021 |
| Farmland size | Actual value (ha) | 7.174 | 5.248 |
| Traffic conditions | Very convenient = 5, convenient = 4, indifferent = 3, inconvenient = 2, very inconvenient = 1 | 3.376 | 1.199 |
| Joined an agricultural cooperative | Yes = 1, no = 0 | 0.440 | 0.497 |

Note: Mean value refers to the sum of all data in a group of data divided by the number of this group of data, representing the quantity of a trend in a group of data. The standard deviation is the arithmetic square root of the variance, reflecting the dispersion of the data in this study. In statistical work, the mean and standard deviation are two of the most important measures to describe the trend and dispersion of data sets. A large standard deviation represents a large difference between most values and their mean value, while a small standard deviation shows that these values are closer to the mean value. In the data of this study, there is no significant difference between the standard deviation and mean value, which conforms to the principle of statistics. It is shown that the data research results have reliability and credibility.

### 3.4.2. Measuring Government Support

The relevant data were collected by asking the questions, "Do you receive the technical extension services from the government?" and "Do you receive the ecological subsidy from the government?", in the questionnaire. A positive answer was coded as one and a negative answer as zero, using the average value of agricultural extension services to obtain the variable value of government support.

#### 3.4.3. Measuring Sustainable Application of GAT

GAT includes a variety of technologies. According to the existing research and the characteristics of kiwifruit planting [78], this paper selects water-saving irrigation technology, green pest control technology and organizational fertilizer substitution technology as the main research objects. The questionnaire asked the farmers whether they have used these technologies for two consecutive years or more. The variable received one point if the farmer answered yes, and zero points otherwise.

#### 3.4.4. Measuring Control Variables

This study controls the variables that may affect the sustainable application of GAT by farmers, such as individual, family, production and external factors, in order to eliminate interference. Many empirical studies have shown that individual and family characteristics are important factors affecting farmers' behavioral decisions [79,80]. The individual characteristic variables selected in this paper include health condition and education, and family characteristics include income and labor. In general, the degree of education has a significant impact on farmers' understanding of the function and role of technology. The physical condition and number of laborers are the basic factors for the implementation of technology. The income level affects the ability of farmers to invest in new technologies, as well as farmers' response to the impact of technology losses. The production characteristic variables selected in this paper include farmland quality and farmland size. Farmers with different planting scales and quality have different green production awareness. The selected variables of external factors were whether the farmers had joined agricultural cooperatives and traffic conditions. Agricultural cooperatives provide technical guidance to farmers, which has a significant impact on farmers' technology adoption behavior. Among the production factors, the ease of purchasing technology also depends on the convenience of transportation [81–86] (Table 2).

### *3.5. Model Specification and Empirical Estimation Strategy*

#### 3.5.1. Basic Regression Analysis

In this paper, the influence of perceived value and its four dimensions, namely, perceived monetary benefits, perceived non-monetary benefits, perceived monetary risks and perceived non-monetary risks, on farmers' sustainable application of GAT is firstly discussed, with a further discussion of the impact of perceived value intensity among the four dimensions on farmers' sustainable application of GAT. Secondly, the influence of government support and its two dimensions, namely, ecological subsidies and technical extension services, on farmers' sustainable application of GAT are analyzed. Finally, this research analyzes the moderating effect of government support on the perceived value of farmers' sustainable application of GAT. The variables that indicate whether GAT has been in use continuously are binary; therefore, we analyzed them using a probit model. Specifically, the model we calculated for the estimation is:

$$Y_i = \delta D_i + \beta X_i + \varepsilon_i$$

where $Y_i$ is the explained variable, denoting farmers' choices for sustainable use of GAT; $X_i$ represents perceived value and government support; $\varepsilon_i$ represents the control variable; and $\delta \textit{ and } \beta$ represent the coefficients to be estimated.

#### 3.5.2. Tests for Robustness and Endogeneity

First, the OLS estimation equation was used to test the robustness of the regression results. The OLS regression results were compared with the probit model regression results to judge the robustness of the regression results. Secondly, when using the binary choice model for empirical research, a key problem of regression analysis is that the benchmark regression results may be endogenous [87]. The tool variable method is the main method to correct endogenous errors in the model. The endogenous explanatory variables are decomposed into a part related to the random error term and another part unrelated to the random error term by means of instrumental variables, and then the consistent estimation of parameters is obtained through the part unrelated to the random error term [88]. 2SLS is a method used to solve endogenous problems. It is implemented through two OLS returns: in the first stage, instrumental variables are used to predict endogenous variables, and in the second stage, the fitting value of the first-stage regression is regressed with the dependent variable Y [89]. Therefore, this study uses 2SLS and selects "owning a smartphone" as the tool variable to conduct an effective endogeneity test to solve the endogenous errors in the model.

## 4. Empirical Analysis

### *4.1. The Influence of Perceived Value on Farmers' Sustainable Application of GAT*

#### 4.1.1. The Main Influence of Perceived Value on Farmers' Sustainable Application of GAT

Table 3 reports the estimation results of perceived value on farmers' sustainable application of GAT from the probit model. Models 1, 3 and 5 show that perceived value has a significant positive influence on farmers' sustainable application of GAT. To be specific, perceived value significantly and positively influences the sustainable application of water-saving irrigation technology, green pest control technology and organic fertilizer substitution technology by farmers at the 1% statistical level, and the regression coefficient is positive. That is, the higher the perceived value, the greater the probability of farmers sustainably applying GAT. According to the regression coefficient, if the perceived value level increases by 1 unit, the probability of the sustainable application of water-saving irrigation technology, green pest control technology and organic fertilizer substitution technology will increase by 38.4%, 34.8% and 33.9%, respectively. The OLS model was used in this study to test the validity of the empirical analysis. Models 2, 4 and 6 show that the influence of perceived value on farmers' sustainable application of GAT is still significant at the 1% level. The results of the global regression of the model are basically consistent with those mentioned above, indicating that the empirical analysis results are robust and reliable. Therefore, hypothesis H1 is verified.

After analyzing the influence of control variables, education, health conditions and whether the farmers had joined an agricultural cooperative passed the significance test, and the coefficient was positive, indicating that farmers with longer years of education have better health, and joining agricultural cooperatives could promote the sustainable application of GAT. Farmland quality and farmland size passed the significance test in sustainably applying three kinds of GAT, and the coefficient was negative, indicating that if farmers have a large planting scale and good farmland quality, they can meet the needs of planting and income, and the enthusiasm to sustainably apply GAT will be reduced. The variables labor and income both passed the 5% significance test in the sustainable application of green pest control technology and organic fertilizer substitution technology but did not pass the significance test in water-saving irrigation technology. Water-saving irrigation technology has certain characteristics of "public facilities", which cannot be adopted by small-scale individual farmers. Government subsidies for irrigation facilities are therefore the main factor influencing the spread of the technology. Farmers will make the decision to sustainably apply water-saving irrigation technology only when the expected income of water market transactions is greater than the transaction cost [90]. Traffic conditions passed the 1% significance test in the sustainable application of organic fertilizer substitution technology but did not pass the significance test in the sustainable application of water-saving irrigation technology and green pest control technology. This may be due to the fact that organic fertilizers often need to be procured and transported, but water-saving irrigation equipment and pest disease facilities can be put into use once installed.

**Table 3.** The main influence of perceived value on farmers' sustainable application of GAT.

| Variable | Model 1 (Probit) | Model 2 (OLS) | Model 3 (Probit) | Model 4 (OLS) | Model 5 (Probit) | Model 6 (OLS) |
|---|---|---|---|---|---|---|
| | Water-Saving Irrigation Technology | | Green Pest Control Technology | | Organic Fertilizer Substitution Technology | |
| Perceived value | 0.384 *** (0.028) | 0.062 *** (0.003) | 0.348 *** (0.021) | 0.092 *** (0.004) | 0.339 *** (0.022) | 0.080 *** (0.004) |
| Education | 0.140 *** (0.030) | 0.023 *** (0.005) | 0.149 *** (0.024) | 0.038 *** (0.006) | 0.008 ** (0.025) | 0.004 (0.006) |
| Health conditions | 0.341 *** (0.086) | 0.045 *** (0.011) | 0.141 ** (0.056) | 0.029 ** (0.014) | 0.149 ** (0.055) | 0.045 ** (0.014) |
| Labor | 0.034 (0.064) | 0.001 (0.009) | 0.120** (0.051) | 0.028 ** (0.012) | 0.172 ** (0.050) | −0.049 *** (0.012) |
| Income | 0.065 (0.047) | 0.002 (0.007) | 0.093** (0.034) | 0.028 ** (0.009) | 0.091** (0.034) | 0.025** (0.009) |
| Farmland quality | −0.289 *** (0.073) | −0.038 *** (0.011) | −0.168** (0.058) | −0.048 ** (0.014) | −0.150 ** (0.060) | −0.035 ** (0.014) |
| Traffic conditions | 0.012 (0.083) | 0.017 (0.011) | 0.024 (0.055) | 0.016 (0.014) | 0.189 *** (0.054) | 0.064 *** (0.014) |
| Farmland size | −0.032 * (0.017) | −0.002 * (0.002) | −0.027 ** (0.013) | −0.007 ** (0.003) | −0.046 *** (0.012) | 0.013 *** (0.003) |
| Joined an agricultural cooperative | 0.715 *** (0.171) | 0.104 *** (0.177) | 0.202 * (0.118) | 0.067** (0.030) | 0.261 ** (0.119) | 0.076 ** (0.030) |
| Constant | 2.465 *** (0.315) | 0.031 (0.047) | 0.670** (0.252) | 0.625 *** (0.061) | 0.207 (0.255) | 0.563 *** (0.061) |
| N | 1138 | 1138 | 1138 | 1138 | 1138 | 1138 |
| Pseudo R2 | 0.414 | — | 0.382 | — | 0.327 | — |
| −2 loglikelihood | 558.740 | — | 487.402 | — | 477.716 | — |
| LR chi2 | 393.93 | — | 602.77 | — | 464.980 | — |
| Prob>chi2 | 0.000 | — | 0.000 | — | 0.000 | — |

Note: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$. Robust standard errors appear in parentheses.

#### 4.1.2. The Fractal Influence of Perceived Value on Farmers' Sustainable Application of GAT

In Table 4, it can be seen that the influence of perceived monetary benefits on the sustainable application of green pest control technology and organic fertilizer substitution technology is significant at the level of 1%. The magnitudes of the coefficients are 0.353 and 0.134, respectively. However, perceived monetary benefits have an insignificant effect on the sustainable use of water-saving irrigation technology. One reason could be that, although the continuous use of water-saving irrigation technology can solve the problem of low utilization efficiency of water resources at present, it cannot greatly increase farmers' income in the short term. Perceived non-monetary benefits have a positive and significant effect on all three of the green practices. The corresponding coefficients are 0.627, 0.779 and 0.744, respectively. Farmers seem to take note of the external benefits when GAT is exploited. Perceived monetary risks and non-monetary risks have a negative effect on all three green practices. Whether the perception of risk emanates out of financial reasons, the usability of technologies or objections from family members, it adversely impacts farmers' sustainable application of GAT. The OLS model was used for the robustness test, and the regression results were basically consistent with the probit model, indicating that the empirical analysis results were robust and reliable. Therefore, hypotheses H2a and H3a are verified.

**Table 4.** The fractal influence of perceived value on farmers' sustainable application of GAT.

| Variable | Model 1 (Probit) | Model 2 (OLS) | Model 3 (Probit) | Model 4 (OLS) | Model 5 (Probit) | Model 6 (OLS) |
|---|---|---|---|---|---|---|
| | Water-Saving Irrigation Technology | | Green Pest Control Technology | | Organic Fertilizer Substitution Technology | |
| Perceived monetary benefits | 0.159<br>(0.179) | 0.050 **<br>(0.021) | 0.353 **<br>(0.160) | 0.006 *<br>(0.024) | 0.134 ***<br>(0.205) | 0.687 ***<br>(0.018) |
| Perceived non-monetary benefits | 0.627 ***<br>(0.136) | —0.079 ***<br>(0.018) | 0.779 ***<br>(0.116) | 0.137 ***<br>(0.020) | 0.744 ***<br>(0.145) | 0.094 ***<br>(0.015) |
| Perceived monetary risks | −1.404 ***<br>(0.147) | −0.226 ***<br>(0.019) | −1.329 ***<br>(0.116) | −0.311 ***<br>(0.022) | −1.869 ***<br>(0.203) | −0.217 ***<br>(0.017) |
| Perceived non-monetary risks | −1.188 ***<br>(0.128) | −0.213 ***<br>(0.019) | −0.923 ***<br>(0.108) | −0.217 ***<br>(0.022) | −0.713 ***<br>(0.162) | −0.078 ***<br>(0.016) |
| Constant | 0.953 **<br>(0.341) | 0.626 ***<br>(0.050) | 0.138<br>(0.309) | 0.611 ***<br>(0.057) | 0.283<br>(0.185) | 0.417 ***<br>(0.043) |
| Control Variables | YES | YES | YES | YES | YES | YES |
| N | 1138 | 1138 | 1138 | 1138 | 1138 | 1138 |
| Pseudo R2 | 0.431 | — | 0.394 | — | 0.733 | — |
| −2 loglikelihood | 523.440 | — | 708.832 | — | 406.767 | — |
| LR chi2 | 397.090 | — | 460.990 | — | 1115.46 | — |
| Prob>chi2 | 0.000 | — | 0.000 | — | 0.000 | — |

Note: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$. Robust standard errors appear in parentheses. Control variable estimation results are omitted but can be shared upon request.

#### 4.1.3. The Fractal Influence of Perceived Value Intensity on Farmers' Sustainable Application of GAT

In Table 5, the perceived monetary benefits intensity has a significant positive effect on the sustainable application of GAT, which is significant at the levels of 1%, with regression coefficients of 0.150, 0.169 and 0.126, respectively. When farmers perceived monetary benefit, intensity increases by one unit, the sustainable application of water-saving irrigation technology, green pest control technology and organic fertilizer substitution technology increases by 15.0%, 16.9% and 12.6%, respectively. Whether rational farmers sustainably apply GAT will definitely weigh up the economic benefits. The greater the intensity of perceived monetary benefits, the more likely it is farmers will sustainably apply GAT. The perceived non-monetary benefit intensity has a significant positive effect on the sustainable application of GAT, which is significant at the levels of 1%, 1% and 10%, with regression coefficients of 0.516, 0.753 and 0.268, respectively. When farmers perceived non-monetary benefits, intensity increases by one unit; the sustainable application of water-saving irrigation technology, green pest control technology and organic fertilizer substitution technology increases by 51.6%, 75.3% and 26.8%, respectively. The perceived monetary risk intensity has a significant negative influence on the sustainable application of GAT. Income is easily affected by multiple factors and is highly uncertain, and most farmers have a limited ability to withstand losses. Therefore, it is shown that the sustainable application of water-saving irrigation technology, green pest control technology and organic fertilizer substitution technology decreases by 50.8%, 75.5% and 21.3%, respectively, for each unit increase in the perceived monetary risk intensity. The perceived non-monetary risk intensity has significant negative effects on the sustainable application of GAT. For each unit increase in the perceived non-monetary risk intensity, the sustainable adoption probability of water-saving irrigation technology, green pest control technology and organic fertilizer substitution technology decreases by 29.6%, 50.8% and 23.2%, respectively. The OLS model was used for the robustness test, and the regression results were basically consistent with the probit model, indicating that the empirical analysis results were robust and reliable. Therefore, hypotheses H2b and H3b are verified.

**Table 5.** The fractal influence of perceived value intensity on farmers' sustainable application of GAT.

| Variable | Model 1 (Probit) | Model 2 (OLS) | Model 3 (Probit) | Model 4 (OLS) | Model 5 (Probit) | Model 6 (OLS) |
|---|---|---|---|---|---|---|
| | Water−Saving Irrigation Technology | | Green Pest Control Technology | | Organic Fertilizer Substitution Technology | |
| Perceived monetary benefits intensity | 0.150 *** (0.058) | 0.031 *** (0.007) | 0.169 *** (0.056) | 0.048 *** (0.007) | 0.126 *** (0.035) | 0.040 ** (0.012) |
| Perceived non-monetary benefits intensity | 0.516 *** (0.074) | 0.083 *** (0.009) | 0.753 *** (0.078) | 0.125 *** (0.009) | 0.268 * (0.043) | 0.018 * (0.014) |
| Perceived monetary risks intensity | −0.508 *** (0.064) | −0.079 *** (0.008) | −0.755 *** (0.072) | −0.116 *** (0.009) | −0.213 *** (0.039) | −0.066 *** (0.013) |
| Perceived non-monetary risks intensity | −0.296 *** (0.061) | −0.046 *** (0.008) | −0.508 *** (0.066) | −0.077 *** (0.008) | −0.232 * (0.037) | −0.008 * (0.012) |
| Constant | 0.468 (0.455) | 0.469 *** (0.063) | 1.102 ** (0.457) | 0.538 *** (0.065) | 1.844 *** (0.314) | 1.094 *** (0.101) |
| Control Variables | YES | YES | YES | YES | YES | YES |
| N | 1138 | 1138 | 1138 | 1138 | 1138 | 1138 |
| Pseudo R2 | 0.478 | — | 0.120 | — | 0.139 | — |
| −2 loglikelihood | 478.356 | — | 476.543 | — | 654.958 | — |
| LR chi2 | 438.240 | — | 690.150 | — | 211.330 | — |
| Prob>chi2 | 0.000 | — | 0.000 | — | 0.000 | — |

Note: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$. Robust standard errors appear in parentheses. Control variable estimation results are omitted but can be shared upon request.

### *4.2. The Influence of Government Support on Farmers' Sustainable Application of GAT*

Table 6 reports the impact of government support and the two dimensions of government support, namely, technical extension services and ecological subsidies, on the sustainable application of GAT. Government support has a significantly positive effect on farmers' sustainable application of GAT, and the regression coefficients are 0.466, 0.397 and 0.622. When the level of government support increases by one unit, the probability of the sustainable application of water-saving irrigation technology, green pest control technology and organic fertilizer substitution technology by farmers rises, respectively, by 46.6%, 39.7% and 62.2%. Ecological subsidies positively and significantly correlate with the sustainable use of GAT. As regards the three types of technology, each time the level of ecological subsidies increases by one unit, the probability of the sustainable application of water-saving irrigation technology, green pest control technology and organic fertilizer substitution technology by farmers rises, respectively, by 17.4%, 35.6% and 61.7%. More reasonable ecological subsidies from the government can reduce economic risks faced by the farmers in the early stage of green production, and farmers will be more likely to sustainably apply GAT. Agricultural extension services also positively and significantly correlate with the sustainable use of water-saving irrigation technology, green pest prevention and control technology and organic fertilizer replacement technology. The values of the marginal effects for these three coefficients are 0.594, 0.574 and 0.776, which indicates that each time the level of agricultural extension services increases by one unit, the probability of the sustainable application of water-saving irrigation technology, green pest control technology and organic fertilizer substitution technology by farmers is enhanced by 59.4%, 57.4% and 77.6%, respectively. For the robustness check, we additionally estimated an OLS model and found that the qualitative nature of the findings stays the same. Therefore, hypotheses H4, H4a and H4b are verified.

**Table 6.** The influence of government support on farmers' sustainable application of GAT.

| Variable | Model 1 (Probit) | Model 2 (OLS) | Model 3 (Probit) | Model 4 (OLS) | Model 5 (Probit) | Model 6 (OLS) |
|---|---|---|---|---|---|---|
| | Water-saving irrigation Technology | | Green Pest Control Technology | | Organic Fertilizer Substitution Technology | |
| Government support | 0.466 *** | 0.174 * | 0.397 *** | 0.111 * | 0.622 *** | 0.175 * |
| | (0.110) | (0.113) | (0.095) | (0.030) | (0.101) | (0.026) |
| Technical extension services | 0.174 * | 0.136 * | 0.356 *** | 0.095 *** | 0.617 *** | 0.179 *** |
| | (0.113) | (0.022) | (0.098) | (0.027) | (0.102) | (0.030) |
| Ecological subsidies | 0.594 *** | 0.109 *** | 0.574 *** | 0.143 *** | 0.776 *** | 0.260 *** |
| | (0.109) | (0.020) | (0.094) | (0.023) | (0.082) | (0.026) |
| Control variables | YES | YES | YES | YES | YES | YES |
| Constant | 0.332 | 0.353 *** | 0.413* | 0.359 *** | 1.068 | 0.831 *** |
| | (0.229) | (0.049) | (0.214) | (0.058) | (0.211) | (0.065) |
| Control Variables | YES | YES | YES | YES | YES | YES |
| N | 1138 | 1138 | 1138 | 1138 | 1138 | 1138 |
| Pseudo R2 | 0.157 | — | 0.116 | — | 0.178 | — |
| −2 loglikelihood | 776.313 | — | 1034.078 | — | 1251.327 | — |
| LR chi2 | 144.220 | — | 135.740 | — | 270.900 | — |
| Prob>chi2 | 0.000 | — | 0.000 | — | 0.000 | — |

Note: *** $p < 0.01$; * $p < 0.10$. Robust standard errors appear in parentheses. Control variable estimation results are omitted but can be shared upon request.

### *4.3. The Influence of Perceived Value and Government Support on Farmers' Sustainable Application of GAT*

Thus far, we have found that both perceived value and government support have a positive effect on the sustainable use of GAT by kiwi growers. However, interactive effects may also exist among them, and the mechanism of action among them remains to be explored. In this part, the interactions between perceived value and government support are inserted into the model to study the possible role.

#### 4.3.1. Water-Saving Irrigation Technology

As can be seen from Table 7, the interactions between perceived monetary benefits and ecological subsidies have a positive effect on the sustainable application of water-saving irrigation technology, and the corresponding marginal effect is 0.153. This shows that each time the level of ecological subsidies is increased by one unit, the influence of perceived monetary benefits on the probability of the sustainable application of water-saving irrigation technology is enhanced by 15.3%. The interactions between perceived monetary risks and ecological subsidies also have a coefficient that is significant at the 1% level, and the corresponding marginal effect is −0.631. Receiving ecological subsidies weakens the impact of perceived monetary risks by 61.3%. This shows that higher ecological subsidies mitigate farmers' fears of monetary risks. The interactions of perceived non-monetary benefits and perceived non-monetary risks with agricultural extension services has an effect that is significant at the 1% level. The marginal effects are 0.840 and −0.580, respectively. This shows that, with each increase in the level of agricultural extension services by one unit, the influence of perceived non-monetary benefits on the probability of the sustainable application of water-saving irrigation technology is enhanced by 84.0%, and the influence of perceived non-monetary risks on the sustainable application of such technology is weakened by 58.0%. The marginal effects of the interactions between agricultural extension services and perceived value are stronger than those between ecological subsidies and perceived value. There appears to be more demand from farmers for agricultural know-how. Therefore, the government should enhance the depth, validity and breadth of its agricultural extension services so that farmers can master green agricultural technology. The sustainable application of green farming technology will be enhanced as a result.

**Table 7.** Estimation results of perceived value and government support on farmers' sustainable application of water-saving irrigation technology (probit).

| Variable | Water-Saving Irrigation Technology | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Perceived monetary benefits × Ecological subsidies | 0.153 * (0.121) | — | — | — |
| Perceived monetary risks × Ecological subsidies | — | −0.631 *** (0.191) | — | — |
| Perceived non-monetary benefits × Technical extension services | — | — | 0.840 *** (0.103) | — |
| Perceived non-monetary risks × Technical extension services | — | — | — | −0.580 *** (0.118) |
| Control variables | YES | YES | YES | YES |
| N | 1138 | 1138 | 1138 | 1138 |
| Pseudo R2 | 0.121 | 0.133 | 0.176 | 0.148 |
| −2 loglikelihood | 809.128 | 797.786 | 758.473 | 784.515 |
| LR chi2 | 111.410 | 122.750 | 162.060 | 136.020 |
| Prob>chi2 | 0.000 | 0.000 | 0.000 | 0.000 |

Note: *** $p < 0.01$; * $p < 0.10$. Robust standard errors appear in parentheses. The cross terms are decentralized to reduce any possibility of collinearity. Control variables estimation results are omitted but can be shared upon request.

#### 4.3.2. Green Pest Control Technology

In Table 8, the interactions of perceived monetary benefits and perceived monetary risks with ecological subsidies has a positive effect on the sustainable use of green pest control technology, which is significant at the 1% level. The marginal effects are 0.440 and −0.517, respectively. The interactions of perceived non-monetary benefits and non-monetary risks with agricultural extension services follow suit. The marginal effects are 0.846 and −0.331, respectively. This shows that each one-unit increase in the level of ecological subsidies enhances the influence of perceived monetary benefits on the probability of the sustainable application of green pest prevention and control technology by 44.0%, and the influence of perceived monetary risks on the sustainable application of such technology is weakened by 51.7%. Each time the level of agricultural extension services increases by one unit, the influence of perceived non-monetary benefits on the probability of the sustainable application of green pest control technology is enhanced by 84.6%, and the influence of perceived non-monetary risks on the sustainable application of such technology is weakened by 33.1%.

#### 4.3.3. Organic Fertilizer Substitution Technology

According to Table 9, the interactions of perceived monetary benefits and perceived monetary risks with ecological subsidies have a positive and significant effect on the sustainable use of organic fertilizer substitution technology. The same holds for the interactions of perceived non-monetary benefits and perceived non-monetary risks with agricultural extension services. The marginal effects are 0.516, −0.075, 0.617 and −0.160, respectively. This shows that each time the level of ecological subsidies increases by one unit, the influence of perceived monetary benefits on the probability of the sustainable application of organic fertilizer substitution technology is enhanced by 51.6%, and the influence of perceived monetary risks on the sustainable application of such technology is weakened by 7.5%. Each time the level of agricultural extension services increases by one unit, the influence of perceived non-monetary benefits on the probability of the sustainable application of organic fertilizer substitution technology is enhanced by 61.7%, and the influence of perceived non-monetary risks on the sustainable application of such technology is weakened by 16.0%. Therefore, hypotheses H5a, H5b, H5c and H5d are verified.

**Table 8.** Estimation results of perceived value and government support on farmers' sustainable application of green pest control technology (probit).

| Variable | Green Pest Control Technology | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Perceived monetary benefits × Ecological subsidies | 0.440 *** (0.104) | — | — | — |
| Perceived monetary risks × Ecological subsidies | — | −0.517 *** (0.150) | — | — |
| Perceived non-monetary benefits × Technical extension services | — | — | 0.846 *** (0.916) | — |
| Perceived non-monetary risks × Technical extension services | — | — | — | −0.331*** (0.095) |
| Control variables | YES | YES | YES | YES |
| N | 1138 | 1138 | 1138 | 1138 |
| Pseudo R2 | 0.086 | 0.082 | 0.145 | 0.082 |
| −2 loglikelihood | 1062.966 | 1073.717 | 1000.235 | 1074.451 |
| LR chi2 | 100.820 | 96.100 | 169.58 | 95.37 |
| Prob>chi2 | 0.000 | 0.000 | 0.000 | 0.000 |

Note: *** $p < 0.01$. Robust standard errors appear in parentheses. The cross terms are decentralized to reduce any possibility of collinearity. Control variables estimation results are omitted but can be shared upon request.

**Table 9.** Estimation results of perceived value and government support on farmers' sustainable application of organic fertilizer substitution technology (probit).

| Variable | Organic Fertilizer Substitution Technology | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Perceived monetary benefits × Ecological subsidies | 0.516 *** (0.154) | — | — | — |
| Perceived monetary risks × Ecological subsidies | — | −0.075 * (0.117) | — | — |
| Perceived non-monetary benefits × Technical extension services | — | — | 0.617 *** (0.095) | — |
| Perceived non-monetary risks × Technical extension services | — | — | — | −0.160 * (0.083) |
| Control variables | YES | YES | YES | YES |
| N | 1138 | 1138 | 1138 | 1138 |
| Pseudo R2 | 0.184 | 0.093 | 0.159 | 0.095 |
| −2 loglikelihood | 1242.492 | 1080.448 | 1080.331 | 1177.099 |
| LR chi2 | 279.740 | 141.780 | 241.900 | 145.130 |
| Prob>chi2 | 0.000 | 0.000 | 0.000 | 0.000 |

Note: *** $p < 0.01$; * $p < 0.10$. Robust standard errors appear in parentheses. The cross terms are decentralized to reduce any possibility of collinearity. Control variables estimation results are omitted but can be shared upon request.

## 5. Endogeneity Test

There may be reverse causality and omitted variables in the study of subjective variables, which is a difficult problem faced by the relevant literature. In order to solve the bias in the estimation results and overcome the endogeneity of government support in the equation of farmers' behavior determination, this article chose "Owning a smartphone" as the tool variable. Having smartphones will help farmers to better accept government support. At the same time, farmers' smartphone ownership is not affected by their continued adoption of GAT. Therefore, "Owning a smartphone" satisfies the selection condition of valid tool variables. In this study, a weak instrumental test and endogeneity test were used to judge the validity of the tool variable. Further, the two-stage least squares method (2SLS) was used to identify the causal relationships between perceived value and government support and farmers continued use of GAT.

Firstly, the regression results of 2SLS show that farmers' smartphone ownership has a significant impact on government support and the sustainable application of GAT (Table 10). In addition, the F statistic of the joint significance test is greater than 10, indicating that there is no weak tool variable problem, and the tool variable conforms to the original hypothesis of the exophytic condition. Secondly, the regression results of the probit model and OLS model show that government support has a significantly positive impact on farmers' sustainable application of GAT. This indicates that the aforementioned research results are relatively robust.

**Table 10.** Endogeneity test results (taking water-saving irrigation technology as an example).

| Variable | 2SLS | | | Probit | OLS |
|---|---|---|---|---|---|
| | **Technical Extension Services** | **Ecological Subsidies** | **Sustainable Application of GAT** | **Sustainable Application of GAT** | **Sustainable Application of GAT** |
| Owning a smartphone | 0.316 *** (0.154) | 0.075 * (0.111) | 0.255 *** (0.117) | 0.256 *** (0.190) | 0.302 *** (0.098) |
| Technical extension services | — | — | — | 0.156 ** (0.110) | 0.201 * (0.030) |
| Ecological Subsidies | — | — | — | 0.496 *** (0.198) | 0.633 *** (0.053) |
| N | | | 1138 | | |
| F | 16.510 | 17.680 | 17.253 | 17.101 | 16.486 |

Note: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$. Robust standard errors appear in parentheses.

## 6. Discussion

### *6.1. Conclusions*

The secret to China's green agricultural development basically lies with farmers and their behavioral patterns. The popularization of GAT should not be satisfied with the adoption behavior of farmers. Only through farmers' sustainable use of GAT can the sustainable development of green agriculture be realized. This paper investigated how perceived values, government support and their interactions affect the sustainable application of GAT by farmers through a questionnaire survey of 1138 kiwi growers in Shaanxi, China. The results show the following: (1) Perceived values have a significant impact on the sustainable application of GAT. Perceived monetary benefits and perceived non-monetary benefits have a positive effect. Conversely, perceived monetary risks and non-monetary risks have a negative effect. Such an effect would be enhanced with an increased intensity of perceived value and varies with the type of GAT. (2) Government support has a positive and significant impact on the sustainable application of GAT. Among them, agricultural extension services and ecological subsidies, as the main components of government support, also have a positive impact on the sustainable application of GAT. (3) The interactions between perceived value and government support have an effect on farmers' sustainable application of GAT. Among them, ecological subsidies play a positive moderating role in the relationship between perceived monetary benefits and farmers' sustainable application of GAT, while they play a negative moderating role in the relationship between perceived monetary risks and farmers' sustainable application of GAT. Agricultural extension services play a positive moderating role in the relationship between perceived non-monetary benefits and farmers' sustainable application of GAT, while they play a negative moderating role in the relationship between perceived non-monetary risks and farmers' sustainable application of GAT.

### *6.2. Policy Implications*

As the saying goes, "Give a man a fish and you feed him for a day. Teach a man to fish and you feed him for a lifetime." The government should focus on the construction of agricultural technique popularization systems so as to reduce the cost of learning and application of techniques for farmers, ensuring that they can master new GAT. This makes up the "last kilometer" on the path of technique popularization and creates a "long-term and win–win" situation between rural economic growth and environmental protection. In addition, more platforms should be accessible to farmers to communicate with the outside world, focusing on the cultivation of their own ability to acquire knowledge, showing them how to correctly identify and choose GAT information and reducing their perceived non-monetary risks with GAT; thus, their sustainable application of these techniques will be promoted. The government should also strengthen publicity and education to improve farmers' awareness of environmental protection. General publicity methods such as broadcasts, slogans and household publicity can be adopted. Informationized methods can also be used, such as TikTok and Wechat, to make the services more known and more easily accessible, especially to remote rural areas. By promoting ecological civilization construction, enhancing farmers' awareness of environmental protection and consciously fulfilling environmental protection obligations, farmers' perceived non-monetary benefits of GAT can be further enhanced. When perceived non-monetary benefits will become more obvious and tangible to farmers, encouraging more farmers to join the green practice and those that have already joined to continue with it.

The monetary benefits and costs for farmers are the most direct factors that affect the sustainable application of GAT by them. As such, it is necessary to enhance the management of government subsidies and increase financial subsidies for GAT so as to continuously reduce the green production costs of farmers through policy incentives, enhance their sense of gain and regulate their green production behaviors. However, a high level of financial subsidies will increase the burden of the government. Therefore, it is also recommended to offer farmers better risk management tools (agricultural insurance) so as to reduce their perceived monetary risks of GAT and increase their perceived monetary benefits; in turn, the sustainable application of these techniques by them will be promoted.

### 6.3. Possible Contributions to Knowledge

Compared with the existing research, the possible marginal contribution of this paper is mainly manifested in three aspects. The first is the research perspective. The uncertainty of agricultural production and the diversity of technology choices determine the existence of stages in the use of GAT by farmers. Most of the existing studies focus on a point in time, but less on the sustainability of technology adoption. Based on the existing research on the first adoption behavior, this study explores the continuous adoption behavior of farmers. It is a useful supplement to the existing research to identify the mechanism and empirical analysis of the influence of perceived value and government support on farmers' sustainable adoption of GAT. The conclusion provides a theoretical basis and policy recommendations for building an agricultural government support system with clear responsibilities and joint efforts. The second is the research theory. This study broadens the theoretical horizon and introduces the expectation confirmation model and continuous use model into the study of farmers' sustainable behavior. A new platform has been built to explore and enhance the endogenous development power of farmers' green agricultural production from a theoretical perspective. The third is the research content. Most theses write about one type of GAT. Such a limited scope does not reflect the overall implementation process. On the basis of existing research, this study comprehensively studies kiwifruit growers' overall cognition and sustainable adoption of water-saving irrigation technology, organic fertilizer substitution technology and green pest control technology, which can make up for the deficiencies in existing research. In addition, most existing studies focus on grain crops and vegetable crops. Few of them are centered around fruit production. The kiwi production area in Shaanxi Province, China, is one of the largest of its kind in the world, often ranked first in China for its area and yield. Therefore, it is of representative meaning and significance to study the sustainable application of GAT by kiwi growers in Shaanxi Province. The findings of this paper shed light on the decision-making mechanism of the farmers and provide a basis and reference for other regions to promote the green development of agriculture, having important practical significance.

### *6.4. Limitations and Areas for Further Research*

This study used the field survey data of 1138 kiwifruit growers in Zhouzhi County, Mei County, Yangling District and Wugong County of Shaanxi Province. The northern foot of Qinling Mountain in Shaanxi Province, with a gentle terrain, is recognized by experts at home and abroad as one of the best places originating kiwi, as well as one of its best concentrated production areas. Therefore, the data in this paper can better reflect some objective conditions of kiwi green farming technology. However, due to the limitation of time and space, this study did not analyze different provinces. There are great differences in political, economic, natural and legal environments among different provinces, which may result in sample aiming bias. Therefore, in the future, on the basis of sufficient time and funds, this study will expand the research area, broaden the research object, widen the research scope and increase the sample size so as to further ensure the credibility and typicality of the research results.

The measurement methods of perceived value and government support have not reached consensus in academic circles. This paper uses econometrics and descriptive statistical analysis methods, but due to the limitations of the authors' professional field, the variables are mostly subjective indicators, which has certain limitations. In the process of obtaining survey data, it is inevitable that there are some phenomena of concealment and subjective conjecture, which fail to objectively reflect the reality, thus affecting the rationality of empirical results. Therefore, in future research, it is necessary to improve and enrich the relevant indicators of variable measurement, select more objective measurement indicators and adopt more in-depth household interviews or long-term observation to ensure the objectivity of the estimation results. Future research should strengthen exchanges and cooperation with scholars in other disciplines, combine farmers' subjective evaluations with experimental and observational methods and improve the scientific and rational conclusions of the research.

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