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What Drives the Adoption of Agricultural Green Production Technologies? An Extension of TAM in Agriculture

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Abstract: Understanding farmers' intentions to use agricultural green production technologies (AGPTs) is essential for reducing agricultural pollution. Drawing on the Technology Acceptance Model (TAM), this study analyzes the impacts of government regulation and social network on farmers' AGPTs adoption behavior. Field research on 738 responses in China revealed that government regulation and social network were positively related to AGPTs adoption behavior, and that the effects were mediated by perceived usefulness, perceived ease of use and price value. Furthermore, we found that risk perception moderated the relationships between perceived ease of use and adoption behavior, as well as the relationship between price value and adoption behavior. Implications for the theoretical understanding of government regulation, social network and risk perception are discussed.

Keywords: agricultural green production technologies; technology acceptance model; government regulation; social network; price value

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1. Introduction

Agricultural pollution has become one of the most serious issues in China [1,2]. For instance, the 2010 China Pollution Source Census (NBSC 2010) revealed that agricultural pollution has exceeded industrial pollution, and has become the largest source of non-point pollution in China. These issues also occur in other regions, especially in developing countries [3]. Therefore, it is urgent to reduce agricultural pollution for the purpose of promoting the sustainability of the environment.

At present, the promotion of agricultural green production technologies (AGPTs) is widely accepted as the fundamental approach to solve the prominent issues of agricultural environmental damage, such as reducing greenhouse gas emissions, and thus, to strengthen the adaptive capacity to climate change [4–6]. Additionally, for farmers, adopting AGPTs can not only improve the agricultural productivity and food security, but can also increase their income without impacting the environment negatively. Furthermore, using AGPTs is particularly valuable for developing countries, since they can protect the environment and achieve sustainable agriculture development. Thus, promoting adoption of AGPTs has become one of the hottest topics in the theoretical and practical fields.

Farmers, as the main subjects of agricultural production in China, undoubtedly play a critical role in the adoption of AGPTs [7]. Thus, studies investigating the determinants of farmers' AGPTs adoption behavior have emerged in large numbers over the past decades [8–10]. For example, prior studies have shown that farmers' characteristics, such as education level, household labor force, part-time farming level and land management scale are expected to play a significant role in AGPTs adoption [11,12], while other studies suggest that several external factors, such as policy incentives, land tenure stability and contract farming, are positively associated with AGPTs adoption [13–17].

Although these studies have improved our knowledge of farmers' adoption of AGPTs, the explanation for farmers' adoption and usage of AGPTs is still scarce. Specifically, to our knowledge, there remains little attention given to the application of the Technology

Acceptance Model (TAM) in the context of AGPTs [18]. In fact, with regard to technology adoption, beliefs about technology play a significant role in decision-making [19]. Thus, TAM could be used as a valuable theoretical framework to explain farmers' adoption of AGPTs. Moreover, going beyond the original TAM, our study integrated price value into the TAM framework. Research from related fields has suggested that price value is different from the constructs in the original TAM (e.g., perceived usefulness and perceived ease of use) and has a unique impact on technology adoption intention and behavior [20,21]. Consequently, in this study, we adopted an extended TAM in order to assess its efficiency in predicting farmers' behavior regarding the adoption of AGPTs.

The second goal of this study is to clarify the mechanism by which social networks and governmental regulations influence farmers' adoption of AGPTs. Although several researchers have suggested that government regulation and social networks play important roles in determining individuals' behavior and perceptions [22–24], there is still a lack of clear evidence to fully comprehend how these factors affect farmers' actual decision-making behavior. In particular, social networks are important channels for farmers to obtain information [25], and farmers may make their technology adoption decisions according to information obtained through social interaction [26–28]. In addition, as farmers' behaviors occur in the context of government policies [23], analyzing farmers' behavior regarding AGPTs adoption cannot be separated from the current policy background. What's more, TAM models are widely used to explain individuals' adoption of new technologies, and relevant studies point out that TAM can be influenced by external social factors. Thus, in this study, we incorporate government regulation and social networks together into the TAM in order to elucidate the mechanism through which government regulation and social networks affect farmers' behavior regarding AGPTs adoption. We assume that government regulation and social networks may predict perceived ease of use, perceived usefulness and price value, which in turn may influence farmers' AGPTs adoption behaviors.

Third, the current study also emphasizes risk perception as a mechanism that strengthens or weakens the relationships between perceived usefulness, perceived ease of use, price value and AGPTs adoption behaviors. Before deciding to adopt technology, farmers are likely to undertake a risk/benefits analysis [29]. If the risks exceed the benefit, farmers may be unwilling to adopt AGPTs technology. To some extent, farmers with high risk perception may not view the benefits of AGPTs. However, few studies have paid attention to farmers' perceived risks in the AGPTs decision-making process. In order to fill the gap, we propose that farmers with high risk perception, perceived usefulness, perceived ease of use and price value can be more easily convinced to adopt AGPTs.

In summary, we expect to study the factors affecting farmers' AGPTs adoption behavior through incorporating government regulation and social networks with an extended TAM. By doing so, this study may guide policy development for the purpose of improving the acceptance and use of agricultural green production technologies.

2. Theoretical Background and Hypotheses

2.1. Technology Acceptance Model (TAM)

On the basis of the Theory of Reasoned Action, Davis [30] proposed the technology acceptance model (TAM) to predict and explain the acceptance of a new technology. TAM posits that when a user decides whether to adopt new technology, the user will mainly consider two main factors: perceived usefulness and ease of use. The two key perceptions are influenced by internal and external influences at individual and social levels, such as personality traits, self-efficacy construct, experience and norms [31–33]. Perceived usefulness refers to how much an individual believes that technology will enhance their job performance, whereas perceived ease of use refers to how easy it will be to use the technology. Thus, individuals are more likely to adopt new technology if they perceive the new technology to be useful and easy to use.

Due to its reliability and parsimony, TAM has been used to predict the adoption of new technologies in different domains and among different populations. For example,

Cheung and Vogel [34] explain why students accept Google applications for collaborative learning by TAM. Toft et al. [35] added moral norms to TAM in order to predict consumers' acceptance of smart grid technology in Danish, Norwegian and Swiss. Scholars also apply TAM in order to predict technology acceptance in farmers. For instance, Aubert et al. [36] drew on TAM in order to predict farmers' adoption decisions regarding precision agriculture technology. Savari et al. [37] drew on TAM in order to identify the factors influencing the application of pro-environmental behaviors among Iranian farmers. Zhang et al. [38] predict farmers' information acceptance behavior in China by building on TAM. In this study, we will predict farmers' AGPTs adoption behavior in China drawing on TAM.

2.2. Price Value in TAM

While previous studies have highlighted the effectiveness of the TAM, several scholars have suggested additional constructs that might further improve its predictive validity [35,39]. Perhaps cost is the most frequently mentioned and most significant concern for people to consider when adopting new technology, especially in situations where they need to bear the monetary cost of such use [8,40,41]. When it comes to production activities, the cost is usually conceptualized together with the benefits in order to determine the value of the new technology. Price value refers to users' cognitive trade-off between the perceived benefits and the cost of using new technology [41]. Users are more likely to adopt the new technology when they perceive a positive price value when the cost of using the technology is less significant than its benefits.

Research has demonstrated that price value is different from perceived usefulness and ease of use in TAM, and that it has a strong and independent influence on technology adoption willingness and behavior. For instance, Mohamad et al. [21] found that beyond the components of the TAM, price value adds to the predictions of mobile hotel booking intention. Additionally, Beza et al. [42] found that price value has the highest impact on the intention to adopt mobile short messaging among older farmers. Thus, aside from perceived usefulness and ease of use, this research incorporates price value into the TAM in order to build an extended TAM. The extended TAM helps us to obtain more comprehensive analyses and to better understand the farmers' adoption of AGPTs in agriculture.

2.2.1. TAM and AGPTs Adoption

Based on TAM, perceived usefulness and perceived ease of use are two key factors that determine people's technology adoption. Following the definition of Davis [30], in the context of predicting farmers' AGPTs adoption behavior, perceived usefulness refers to the extent to which farmers believe that adopting AGPTs will bring them benefits, such as improving the productivity of farmers and enhancing agricultural products' quality and safety. Traditional farming techniques, which rely heavily on pesticides and chemical fertilizers to improve production efficiency, not only threaten the health of farmers and consumers, but also damage the ecological environment. With the change in lifestyle and the improvement of consumption levels, green foods are becoming more popular and more valuable in the market [43]. If farmers believe that adopting green production techniques can increase crop yields, improve the quality of arable land and bring them higher benefits, they are more likely to abandon traditional techniques and adopt new ones. Empirical research has largely supported the notion that perceived usefulness positively influences farmers' intention to adopt new technology [44]. Therefore, we propose that:

H1a: Perceived usefulness is positively associated with farmers' AGPTs adoption behavior.

Following Davis [30], we define perceived ease of use as the extent to which farmers believe that mastering AGPTs is easy. In China, most farmers have been engaged in agricultural activities for many years and are more familiar with the original production technology. Although they have accumulated relatively rich experience in agricultural technology activities, the adoption of AGPTs is new to them. If they believe that the AGPTs are easy to learn about and easy to operate, they will have more confidence in this new

technology and will be more willing to adopt it. Hannus and Sauer [45], for example, found that ease of use is positively associated with and most important to farmers' intent to use a sustainability standard. Thus, we predict that:

H1b: Perceived ease of use is positively associated with farmers' AGPTs adoption behavior.

As discussed earlier, we define price value as farmers' cognitive trade-off between the perceived benefits and cost of using the AGPTs. Agricultural cultivation is an important source of income for farmers; thus, they will be concerned with the benefits and costs of adopting green production techniques. Farmers will be willing to adopt new technologies when they believe that the new technologies can improve yields, increase returns, and reduce production costs [46]. Li et al. [29], for example, found that perceived benefits significantly and positively influence willingness to adopt agricultural green production. However, farmers do not consider costs or benefits alone when deciding whether to adopt new technology, but rather consider a combination of costs and benefits to see if the new technology will result in higher overall benefits. Research on peasant household behaviors also suggests that weighing perceived benefits and costs could directly affect individuals' behavioral willingness [47–49]. For instance, Omar et al. [50] found that perceived cost is also positively related to behavioral intention to adopt the e-Agri Finance app. Farmers are more willing to adopt new technologies when the benefits exceed the costs, which means that price value is high. Thus, price value is a better predictor of farmers' adoption of green production technologies than perceived costs and benefits.

H1c: Price value is positively associated with farmers' AGPTs adoption behavior.

2.2.2. Risk Perception and AGPTs Adoption

Although AGPTs may bring more benefits, they also carry a higher level of risk as new technologies. Furthermore, although green production techniques improve the health quality of agricultural products, because the health quality of agricultural products is difficult to be observed by consumers, there is great uncertainty about whether it these techniques will lead to greater benefits in the market. AGPTs require farmers with high professional skills to accurately grasp the crop growth stage and the opportunity to use the technology. Only in this way can AGPTs improve the quality and increase the yield of crops. However, farmers are relatively less educated. Additionally, in most developing countries, farmers would not be willing to spend so much time learning how to use new technology [51]. Thus, AGPTs may reduce quality and yield of crops, and lead to lower incomes for farmers.

We propose that the relationships between the TAM variables and AGPTs adoption will be moderated by risk perception. Risk perception describes an individual's subjective evaluation of objective risk. In the current research, we define risk perception as farmers' psychological perception of the risks of using AGPTs, including income and violating social norms. As decision-makers in agricultural production, farmers will consider avoiding risks while seeking to maximize their profits. Moreover, the relatively low income level of farmers in China has led to their low risk tolerance. Although farmers may perceive AGPTs as useful, easy of use and having a high price value, when they perceive higher risks, they still may not adopt them in favor of traditional techniques that can bring more stable income. In contrast, when farmers perceive lower risks, their intent to adopt AGPTs is more strongly influenced by usefulness, ease of use and price value, as they are more willing to use new technology. Here, we proposed that:

H2: Risk perception will moderate the relationship between perceived usefulness (2a), perceived ease of use (2b), price value (2c) and AGPTs adoption behavior, such that these relationships will be weaker (stronger) for farmers in high (low) risk perception.

2.2.3. Government Regulation, Social Network and TAM

Social influence may serve as an important construct antecedent that influences perceived usefulness, perceived ease of use and user adoption [33]. A meta-analysis has confirmed that social influence significantly influenced perceived usefulness in different respondents, technologies and cultures [52]. We suggest government regulation and social networks as two important social influences in this study. Government regulation and social networks may affect farmers' awareness of AGPTs and provide support for their use.

Farmers' production behavior in China is greatly affected by government regulation [53]. In the current context, this refers to the government's regulation of farmers' production behaviors through legislative, administrative and economic means. The government can encourage farmers' green production behavior through publicity, training and subsidies, and can also punish farmers' illegal production behavior by formulating laws and regulations [54]. Extensive research has confirmed the influence of government regulation on farmers' pro-environment adoption behavior. Zhao et al. [55], for example, found that government regulation affects the perception of agricultural products' quality and safety, as well as farmers' behavior regarding pesticide application. More recently, Liu et al. [23] found that government regulations positively influence farmers' willingness to adopt wheat straw incorporation. Here, we proposed that:

H3: Government regulation is positively associated with farmers' AGPTs adoption behavior.

We argue that government regulation may influence farmers' perceived usefulness of AGPTs. Through publicity and education, the government can enhance farmers' awareness of sustainable development as well as the importance of agricultural product quality and safety [54]. In addition, AGPTs help to improve the quality and safety of agricultural products [29]. Government publicity can make farmers aware of AGPTs in order to increase agricultural production, farm soil fertility and their income. Thus, we proposed that:

H4a: Government regulation is positively associated with farmers' perceived usefulness of AGPTs.

By providing technical training or support, the government can help farmers to obtain relevant knowledge of matters requiring the attention of AGPTs, and thus to reduce the obstacles in the process of actual planting. In this way, farmers will believe that AGPTs are easy to learn and master. Research also confirmed that training will significantly improve farmers' knowledge and mastery of new technologies [56]. Therefore, we proposed that:

H4b: Government regulation is positively associated with farmers' perceived ease of use of AGPTs.

Through financial subsidies and other incentives, the government can reduce the opportunity cost of using green production technologies for farmers. The government can also increase the cost of non-compliance for farmers by enacting agricultural environmental regulations and increasing penalties for production violations. In addition, the research also found that government regulation affects the prices of different certified agricultural products in the market [55], which, in turn, will enhance farmers' expectations for the future benefits of adopting AGPTs. Therefore, we proposed that:

H4c: Government regulation is positively associated with farmers' price value of AGPTs.

The focus of our research is on the mechanism and path by which government regulation impacts farmers' AGPTs, according to the TAM. More specifically, we decided to investigate how government regulation influences farmers' AGPTs adoption behavior through mediating variables, namely perceived usefulness, perceived ease of use and price value. Here, we proposed that:

H5: Perceived usefulness (5a), perceived ease of use (5b) and price value (5c) can mediate the relationships between government regulation and AGPTs adoption behavior.

Social networks are an important channel for farmers to obtain technical information, and they play an important role in farmers' technology adoption decisions [57]. Social networks refer to the influential relationships that farmers establish with various people through their agricultural activities [58]. Farmers can share information and gain support in social networks in order to reduce uncertainty regarding the adoption of AGPTs. This is particularly evident in Chinese society, where people emphasize the importance of interpersonal connections [59]. The role of social networks in farmers' technology adoption has been demonstrated in a number of studies. For instance, Teklewold et al. [60] found that social networks have a great influence on the adoption of sustainable agricultural practices in Africa. Here we proposed that:

H6: Social networks are positively associated with farmers' AGPTs adoption behavior.

Through information sharing, social networks can increase farmers' awareness of the usefulness of AGPTs. Social networks can effectively make up for the shortage of government publicity or training services, and allow farmers to become more well-informed about agricultural market information and AGPTs information [61]. As discussed earlier, although AGPTs contribute to environmental protection and agricultural safety, it is more important for farmers to recognize the role of AGPTs. As a network of private relationships, the sharing of information in social networks can undoubtedly give farmers more confidence that AGPTs can improve yields and increase their income. Thus, we proposed that:

H7a: Social networks are positively associated with farmers' perceived usefulness of AGPTs.

Through social networks, farmers can effectively access information on AGPTs, and, thus, can learn and master them more easily. Social networks are an important platform for mutual learning and technology exchanges among farmers, which can accelerate the learning process. For example, Oreszczyn et al. [62] found that networks have a great impact on farmers' learning about agricultural innovations. In addition, social networks, as a part of social capital, can provide people with social support [63]. Thus, cooperation and mutual assistance among social network members can enable farmers to receive timely and effective support in the adoption process of AGPTs [60]. Thus, we proposed that:

H7b: Social networks are positively associated with farmers' perceived ease of use of agricultural green production technologies.

Social networks can reduce the costs and increase the expectations of future benefits in the adoption of AGPTs by farmers. Social networks can reduce information asymmetry and lower transaction costs in the adoption of AGPTs [61]. Social networks can also effectively reduce the costs associated with learning and using AGPTs for farmers through experience exchange. Green foods generally have a higher selling price in the market, thus due to their knowledge of the agricultural market, farmers are more likely to believe they have higher income by adopting AGPTs. Thus, we proposed that:

H7c: Social networks are positively associated with farmers' perceived price values of AGPTs.

The influence mechanism and path through which social networks influence farmers' opinions of AGPTs is the focus of our study. We expect to explore the mediating effect of perceived usefulness, perceived ease of use and price value.

H8: As the mediating variable, perceived usefulness (8a), perceived ease of use (8b) and price value (8c) can mediate the relationships between social networks and AGPTs adoption behavior.

3. Methods

3.1. Participants and Procedure

The research subjects were local farmers from Anhui Province in eastern China. Anhui Province was chosen because the province is an important agricultural production base in China, accounting for 5.99% of the country's total grain output. In addition, Anhui Province is the key area for the extension of AGPTs in China; thus, it is well-suited for investigating farmers' AGPTs adoption behavior.

The investigation was conducted from May to July 2022. A stratified random sampling method was adopted. In order to ensure the accuracy and integrity of the survey, all questions in the questionnaire were asked during face-to-face interviews. According to the differences in regional economic development, the research team in this study selected 13 counties in Hefei, Fuyang and Suzhou in Anhui Province City. In order to verify the accuracy and representativeness of the samples, 30 families were chosen at random from each village, and each family received one questionnaire. Throughout the study, 1000 questionnaires were delivered. Following face-to-face interviews, 843 questionnaires were collected, 738 of which were valid, resulting in an effective recovery rate of 87.54%. The findings of the Chi-square test for no-response bias indicated that there was no significant response bias, and that the data may be utilized in empirical studies.

Table 1 shows the demographic characteristics of our final sample, which shows that there were 70.7% male respondents; 10.3% were under 30 years old, 32.7% were 30–45, 42.3% were 45–60 and 14.8% were above 60 years old. Of the total respondents, the majority of respondents (73.4%) had a formal education, while 26.6% reported that they had no formal education. With regard to family population, results showed that 13.4% of the farmers had family populations of less than 3 people, 20.1% of 4 people, 45.5% of 5 people and 21.0% of above 6 people. Regarding the farm size, 73.1% of the farmers' family per capita production scales were less than 3 acres.

Table 1. Demographic profile of respondents.

Item	Category	Number	Percent	Item	Category	Number	Percent
Gender	Male	522	70.7	Education level	Below elementary school	196	26.6
	Female	216	29.3		Elementary school	280	37.9
Age	<30	76	10.3		Middle school	93	26.2
	30–45	241	32.7		High school	63	8.5
	45–60	312	42.3		Bachelor degree or above	6	0.8
	>60	109	14.8	Family per capita production scale	2 acres and below	336	45.5
Family population	<3	99	13.4		2–3 acres	204	27.6
	4	148	20.1		3–4 acres	112	15.2
	5	336	45.5		4 acres or above	86	11.7
	>6	155	21.0				

3.2. Measures

The study's measuring scale and items came from earlier research that had been verified in a number of different research situations. Although they were initially written in English, the surveys were administered in Chinese. As advised by Behling and Law [64], the forward–backward translation was carried out by bilingual assistants in order to ensure that the measurements in the Chinese and English versions were equivalent. Five-point Likert scales were used for all of the responses to the items.

3.2.1. Perceived Usefulness

Based on Venkatesh and Davis [33], Rezaei et al. [18], Bagheri et al. [65] and other studies, four items were designed to measure farmers' perceived degree of usefulness of AGPTs. A sample item is "Applying AGPTs reduces and facilitates farmers' tasks." The coefficient alphas of the scale were 0.862.

3.2.2. Perceived Ease of Use

Based on Davis et al. [30], Venkatesh and Davis [33], Rezaei et al. [18] and other studies, we designed four items to measure farmers' perceived degree of ease of use of AGPTs. A sample item is "Applying AGPTs is very easy". The coefficient alphas of the scale were 0.793.

3.2.3. Price Value

We measured farmers' perception of price value using Venkatesh et al.'s [41] three-item scale. A sample item is "Applying AGPTs is reasonably priced". The coefficient alphas of the scale were 0.921.

3.2.4. Perceived Risk

Based on Ogurtsov et al. [66], Menapace et al. [67] and Fahad et al. [68], we designed six items to measure farmers' perceived risk toward AGPTs. A sample item is "I think adopting green production techniques requires more money investment". The coefficient alphas of the scale were 0.904.

3.2.5. Government Regulation

We measured government regulation with Li et al.'s [69] four-item scale. A sample item is "How much is farmers' AGPTs adoption behaviors affected by government regulation and punishment policies?" The coefficient alphas of the scale were 0.857.

3.2.6. Social Network

Based on Zhao [70] and Li et al. [54], we designed three items to measure farmers' social networks. A sample item is "How often did you get together with relatives who do not live with you over the last year?" The coefficient alphas of the scale were 0.877.

3.2.7. AGPTs Adoption Behavior

We measured farmers' AGPTs adoption behaviors using Zhou et al.'s [71] three-item scale. A sample item is "Reducing the use of organochlorine pesticides in the agricultural production". The coefficient alphas of the scale were 0.780.

3.2.8. Control Variables

We also collected data on five demographic variables: gender, age, education level, family population and per family capita production scale, given that they are related to pro-environmental behavior [72–74].

4. Data Analysis and Results

4.1. Measurement Model Analysis

Firstly, we tested the validity of the initial scale. Cronbach's Alpha coefficient was used to determine the scale reliability, and SPSS22.0 was adopted to test the reliability of each variable. As shown in Table 2, Cronbach's Alpha coefficients for each variable were greater than or close to 0.8, demonstrating the high reliability of the study's scale.

Second, three factors—content validity, convergent validity and discriminative validity—were used to examine the scale's internal validity. Most of the scales' items were generated from those found in the pertinent literature, giving them a high level of content validity. These scales were well modified based on the requirements of this study and scholarly advice, thus ensuring content validity. For the factor analysis of the items of each variable, we employed AMOS17.0 to assess convergence validity. Table 2 displays the specific outcomes. All of the items had factor loadings with significance levels of 0.001. The scales therefore have strong convergence validity. We examined the correlation of the variables using SPSS22.0 to examine discriminant validity. Table 2 displays the specific outcomes. Each variable's average extraction variation (AVE) square root clearly exceeded

its corresponding correlation coefficient, demonstrating the strong discriminant validity of each dimension.

Table 2. Reliability and validity tests of the scales.

Construct	Measurement Items	Factor Loading	CR	AVE
Perceived usefulness α = 0.862	Applying AGPTs reduces and facilitates farmers' tasks	0.883	0.869	0.624
	Applying AGPTs increases farm soil fertility	0.789		
	Applying AGPTs enhances the products' quality and safety	0.729		
	Applying AGPTs on the farm is an economical approach due to reducing production costs	0.750		
Perceived ease of use α = 0.793	Applying AGPTs is very easy	0.828	0.791	0.506
	AGPTs can be easily applied technically	0.923		
	Applying AGPTs on the farm is clear and understandable for me	0.469		
	Learning AGPTs is very easy for me	0.516		
Price value α = 0.921	AGPTs are reasonably priced	0.834	0.922	0.798
	AGPTs have a good value for the money	0.928		
	At the current price, AGPTs provide a good value	0.915		
Perceived risks α = 0.890	I think adopting AGPTs techniques requires more money investment	0.634	0.907	0.621
	I have to spend time learning about the knowledge and techniques of AGPTs	0.833		
	It is better to earn money by going out to work rather than spending time and energy on AGPTs	0.812		
	I am concerned that there is no policy support or technology for AGPTs	0.820		
	I am worried that AGPTs will be discussed by neighbors and opposed by my family	0.798		
	I am worried that it will be difficult for the restoration after the destruction of the agro-ecological environment	0.815		
Government regulation α = 0.857	How much is farmers' AGPTs adoption behavior affected by government regulation and punishment policies?	0.904	0.856	0.606
	How much is farmers' AGPTs adoption behavior affected by government subsidy policies?	0.909		
	How much is farmers' AGPTs adoption behavior affected by government technology extension policies?	0.614		
	How much does the letter of commitment signed by the government and farmers affect farmers' AGPTs adoption behavior?	0.635		
Social network α = 0.877	How often did you get together with relatives who do not live with you over the last year?	0.835	0.879	0.708
	How often have you met with your friends over the past year?	0.809		
	The frequency of having entertainment activities with other friends.	0.878		
Adoption behavior α = 0.780	Reduce the use of organochlorine pesticides in the agricultural production	0.820	0.793	0.565
	Reduce the use of phosphate fertilizer in the agricultural production	0.613		
	Reduce the use of plastic film in the agricultural production	0.804		

4.2. Descriptive Statistics

Table 3 presents the means, standard deviations and zero-order Pearson correlations of all the key variables.

Table 3. Descriptive statistics and correlations.

Variables	Mean	SD	1	2	3	4	5	6	7	8	9	10	11
1—gender	0.293	0.455											
2—age	2.615	0.860	−0.034										
3—education	2.190	0.952	0.077 *	−0.194 ***									
4—Household per capita production scale	1.930	1.034	0.050	0.110 **	−0.103 **								
5—Family population	2.741	0.939	−0.029	0.246 **	−0.122 ***	0.087 *							
6—Social network	3.599	0.969	−0.099 **	−0.108 **	0.087 *	−0.189 ***	−0.098 **						
7—Government regulation	4.149	0.779	0.052	−0.055	0.090 *	−0.152 ***	−0.053	0.344 ***					
8—Perceived usefulness	3.266	0.843	0.086 *	−0.155 ***	0.163 ***	−0.035	−0.126 ***	0.314 ***	0.232 ***				
9—Perceived ease of use	3.713	0.809	0.087 *	−0.162 ***	0.214 ***	0.003	−0.114 **	0.127 ***	0.166 ***	0.440 ***			
10—Price value	3.764	0.847	0.009	−0.107 **	0.143 ***	−0.073 *	−0.106 **	0.388 ***	0.239 ***	0.402 ***	0.246 ***		
11—Perceived risks	2.320	0.965	−0.045	0.106 **	−0.176 ***	0.028	0.094 *	−0.304 ***	−0.222 ***	−0.471 ***	−0.471 ***	−0.287 ***	
12—Adoption behavior	3.568	0.757	0.130 ***	−0.229 ***	0.265 ***	−0.079 *	−0.223 ***	0.275 ***	0.259 ***	0.518 ***	0.442 ***	0.352 ***	−0.325 ***

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.01$.

4.3. Tests of Hypotheses

First, we used Amos 17.0 to test the fitness of the SEM. The results showed that $\chi 2/df$ (3.182) is less than 4; RMSEA (0.054) is less than 0.08; and NFI (0.941), RFI (0.928), IFI (0.958), TLI (0.950) and CFI (0.958) are all greater than 0.9. As a result, each index rises to the matching standard value, demonstrating the model's suitability.

Next, we adopted AMOS17.0 to test our research hypotheses. In Table 4, the standardized coefficients of perceived usefulness ($\beta = 0.360$, $p < 0.001$), perceived ease of use ($\beta = 0.155$, $p < 0.001$), price value ($\beta = 0.155$, $p < 0.001$) and government regulation ($\beta = 0.120$, $p < 0.01$) on AGPTs adoption behavior were significant. However, the coefficient of social network ($\beta = 0.037$, ns) on AGPTs adoption behavior was not significant. As a result, the Hypotheses 1a, 1b, 1c and 3 were all supported, while Hypothesis 6 was not. The results showed that government regulation was positively related to perceived usefulness ($\beta = 0.211$, $p < 0.001$), perceived ease of use ($\beta = 0.272$, $p < 0.001$) and price value ($\beta = 0.110$, $p < 0.01$). Thus, Hypotheses 4a, 4b and 4c were all supported. The results showed that social network was positively related to perceived usefulness ($\beta = 0.253$, $p < 0.001$) and price value ($\beta = 0.330$, $p < 0.001$). However, the relationship between social network and perceived ease of use ($\beta = 0.082$, ns) was not significant. As a result, Hypotheses 5a and 5c were confirmed, while Hypothesis 5b was not. The SEM path diagram is shown in Figure 1.

In order to investigate the indirect effect, we constructed a bias-corrected confidence interval (95%) using bootstrap estimations. We estimated 5000 bootstrap samples using government regulation and social network as the independent variable, respectively, perceived usefulness, perceived ease of use and price value as the mediating variable, and AGPTs adoption behavior as the dependent variable.

In Table 5, the indirect effects of government regulation on AGPTs adoption behavior via perceived usefulness, perceived ease of use and price value were 0.080, 0.057 and 0.019, with a 95% bias-corrected bootstrap CI of [0.043,0.129], [0.030,0.091] and [0.006,0.040], respectively. This shows that the perceived usefulness, perceived ease of use and price value fully mediate the impact of government regulation on AGPTs adoption behavior. Thus, this result supports Hypothesis 5a, 5b and 5c. Similar findings can be observed in the relationship between social network and AGPTs adoption behavior; thus, Hypotheses 8a, 8b and 8c were supported.

Table 4. Path coefficients and hypothesis testing results.

Assumed Path	Standardization Coefficient	S.E.	C.R.	Result
Perceived usefulness → Adoption behavior	0.360 ***	0.042	8.515	support
Perceived ease of use → Adoption behavior	0.155 ***	0.035	4.477	support
Price value → Adoption behavior	0.155 ***	0.038	4.060	support
Government regulation → Perceived usefulness	0.211 ***	0.048	4.442	support
Government regulation → Perceived ease of use	0.272 ***	0.054	5.061	support
Government regulation → Price value	0.110 **	0.041	2.663	support
Government regulation → Adoption behavior	0.120 **	0.039	3.062	support
Social network → Perceived usefulness	0.253 ***	0.040	6.326	support
Social network → Perceived ease of use	0.082	0.044	1.869	not support
Social network → Price value	0.330 ***	0.036	9.114	support
Social network → Adoption behavior	0.037	0.036	1.034	not support

Note: ** $p < 0.01$; *** $p < 0.01$.

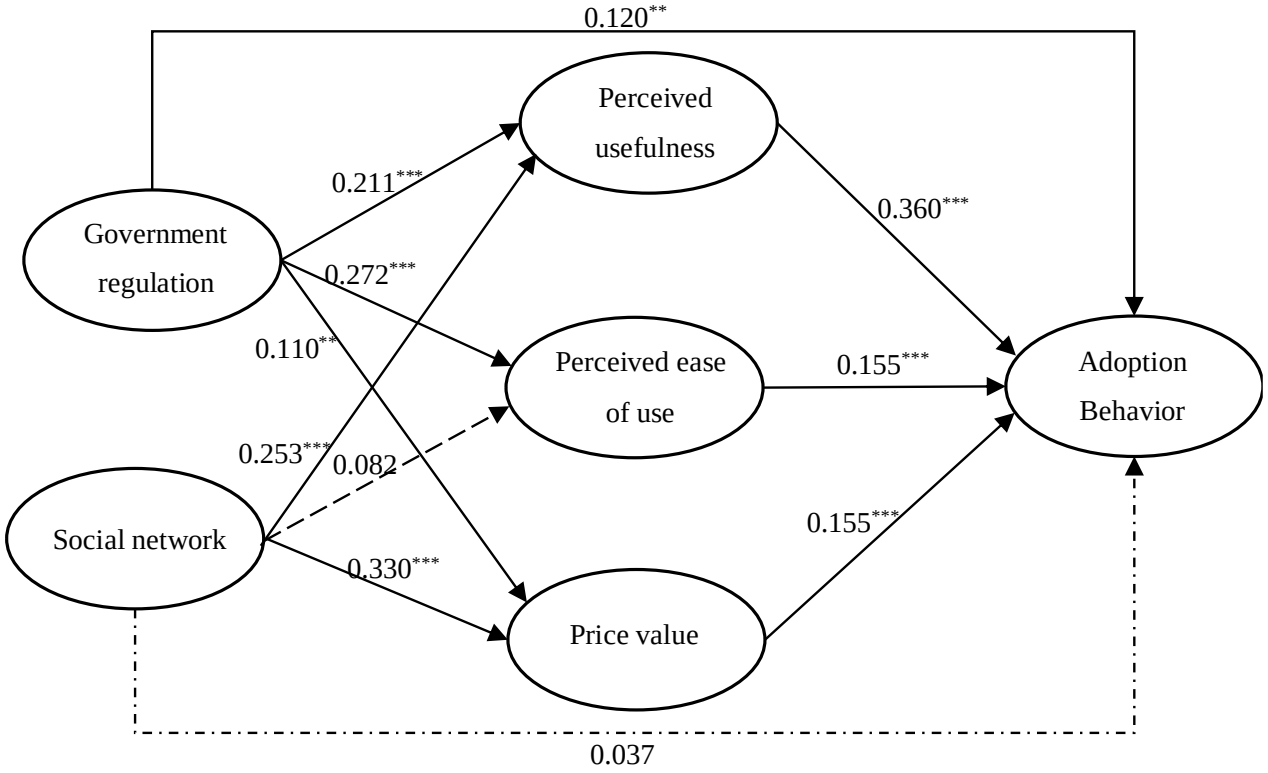

Figure 1. Results of the structural model. Note: ** $p < 0.01$; *** $p < 0.01$.

Table 5. Bootstrapping mediation test.

Independent Variable	Mediator	Indirect Effect	SE	LLCL	ULCL
Government regulation	Perceived usefulness	0.080	0.026	0.043	0.129
	Perceived ease of use	0.057	0.018	0.030	0.091
	Price value	0.006	0.010	0.006	0.040
Social network	Perceived usefulness	0.117	0.027	0.079	0.167
	Perceived ease of use	0.024	0.014	0.004	0.050
	Price value	0.065	0.021	0.037	0.109

Note: LLCL means lower limit confidence interval (95%); ULCL means upper limit confidence interval (95%).

Finally, we tested the simple slopes in SEM using a moderator centering strategy, as advised by Preacher et al. [75]. In relation to the moderation of risk perception, the interactions between perceived ease of use ($\beta = -0.113$, $p < 0.01$), price value ($\beta = -0.083$,

$p < 0.01$) and risk perception on AGPTs adoption behavior were significant. However, the standardized coefficient of interaction between perceived usefulness and risk perception ($\beta = 0.068$, *ns*) was not significant. As a result, Hypotheses 2b and 2c were verified; however, Hypothesis 2a was not. We followed the graphing method outlined by Aiken and West [76] to depict the forms of the significant interactions in order to further analyze this interaction. The plots showing the relationships between perceived risk, usefulness and price value are shown in Figure 2a,b. As shown in Figure 2a, the effect of perceived ease of use on AGPTs adoption behavior is stronger for lower levels of risk perception ($\beta = 0.423$, $p < 0.01$) than for higher levels of risk perception ($\beta = 0.223$, $p < 0.01$). Similar findings can be observed in Figure 2b.

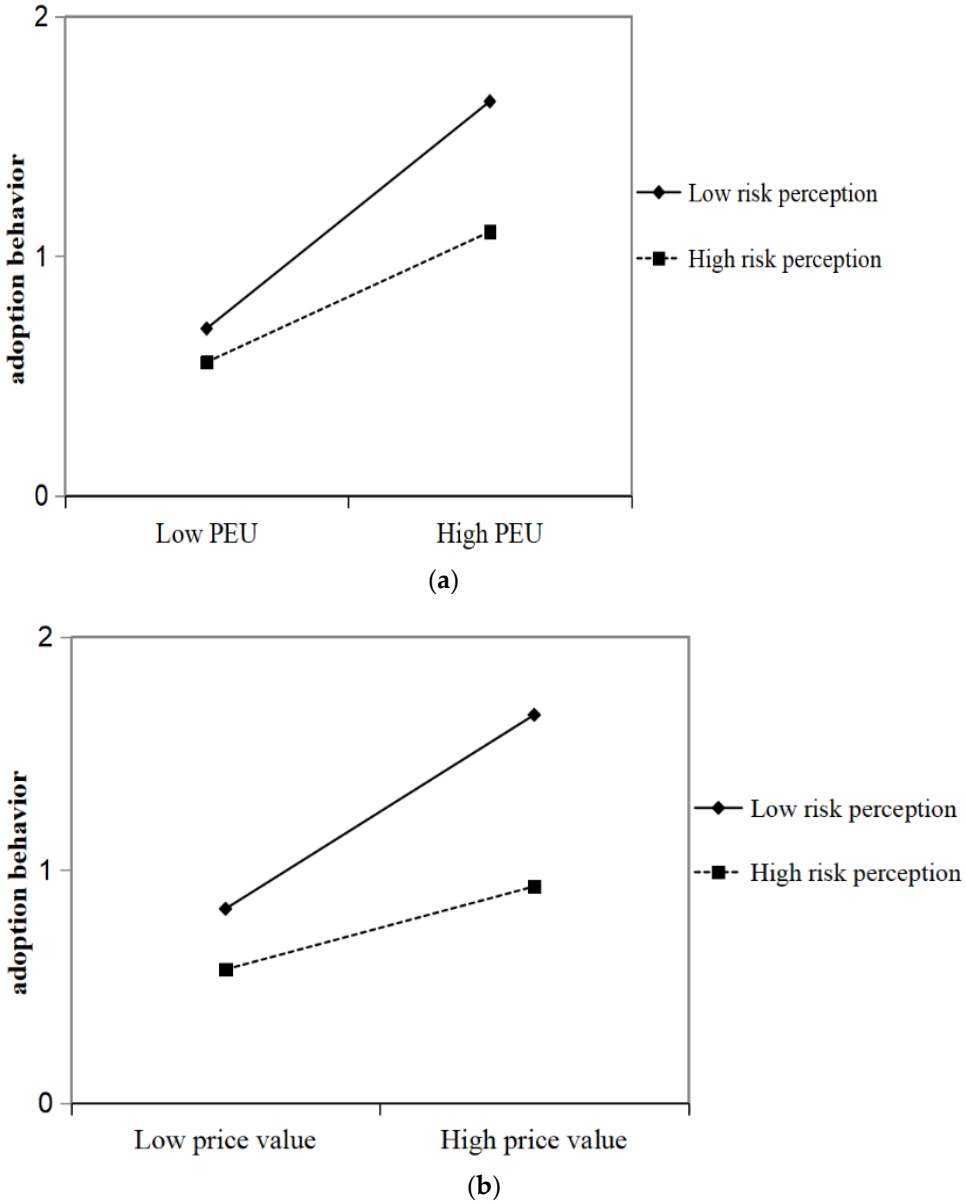

Figure 2. Interactive effect of risk perception and perceived ease of use (**a**) and price value (**b**) on AGPTs adoption behavior.

5. Discussion

Considering the importance of AGPTs in reducing environmental damage, the current study examined the factors impacting farmers' decision to adopt AGPTs. Based on the theory of the Technology Acceptance Model (TAM), we proposed our research hypothe-

ses. Utilizing the field survey data on 738 farmers in Anhui Province Eastern China, the results showed that perceived usefulness, perceived ease of use and price value directly influence farmers' behavior regarding the adoption of AGPTs. Government regulation and social networks indirectly influence farmers' adoption behavior through perceived usefulness, perceived ease of use and price value. In addition, we found that the interaction between perceived ease of use, price value and risk perception was significant for farmers' adoption behavior.

5.1. Theoretical Implications

Our study has several theoretical implications. First, this research suggests that TAM is a suitable theoretical framework for explaining the factors affecting the application of green agriculture production technologies. According to the information that is currently available, few studies have been conducted on the application of TAM concerning agricultural issues and farmers' adoption behavior of AGPTs [37]. As a result, this study can help fill some of the gaps left by other studies and present fresh ideas for using farmers' AGPTs. Moreover, going beyond the extant literature which paid attention to the relationship between the constructs of the original TAM and farmers' technologies adoption behaviors [77,78], our study introduced the variable of price value and constructed an extended TAM model. The results showed that price value has a positive effect on farmers' AGPTs adoption behavior. This underlines that price value is different from the original constructs of TAM, and has a strong and independent impact on technology adoption behavior. Thus, this study provides new insight into the extension of TAM, and allows us to address the call for more in-depth research on the application of extended TAM [79].

Second, we investigated the moderating role of risk perception in farmers' use of AGPTs. We discovered that risk perception impacted the interactions between perceived usefulness, price value and farmers' AGPTs adoption behavior in such a way that these relationships were weakened for farmers with high risk perception. We explored the moderating effect of risk perception on farmers' decisions to adopt AGPTs. We found that risk perception moderated the relationships between the perceived ease of use, price value and farmers' green agriculture adoption in such a way that these relationships were weakened for individuals with high risk perception. The reason for this is that farmers, as rational economic men, generally exhibit aversion to risks when facing behavioral decisions [29,80]. Risk perception provides possible risk judgment and evaluation of the behaviors of farmers regarding the adoption of agricultural green production [69]. Contrary to our hypothesis, we found that risk perception did not moderate the relationship between perceived usefulness and adoption behavior regarding the use of AGPTs. One possible explanation for this finding could be that farmers may pay more attention to the usefulness of green agriculture production technology, indicating that they are less worried about whether their adoption decisions are risky. As risk perception plays an important role in farmers' behavior regarding green agriculture production technologies, its impact should be given more consideration in future study.

Finally, this study recombined government regulation and farmers' social networks as two core explanatory variables in order to investigate their impacts on TAM. The findings of this study showed that government regulation had a significant impact on perceived usefulness, perceived ease of use and price value. This is consistent with the previous conclusions which indicate that the environmental regulation variable has a strong influence on sustainable behaviors [49,60,69,81]. Moreover, the relationships between social network, perceived usefulness, price value and green agriculture production technologies behavior were significant. This is in agreement with the findings of other research, which state that social networks influence technology acceptance [82]. However, the relationship between social networks and perceived ease of use was not significant. A probable explanation for this finding might be that farmers' social networks may affect their motivation to use the AGPTs, but may not provide much support in using the technology, such as helping to solve technical problems. Several empirical investigations in the setting of TAM, where social

capital has frequently had a larger impact on perceived usefulness than perceived ease of use, support this explanation [83]. In this regard, the empirical evidence in this study helps us to understand the key factors influencing farmers' AGPTs adoption behaviors.

5.2. Limitations and Future Research

As with all research, the results of this study have several limitations. First, the cross-sectional design does not allow for conclusions about causality. Future research with a longitudinal design would help to verify the causal relationships of our extended TAM framework. Second, our findings cannot be applied to other countries and cultures, because the study was limited to a sample from one province of China. In the future, studies should be conducted in more countries to compare differences. Third, the present study apparently did not consider other variables connected with farmers' AGPTs adoption behaviors. Hence, future research needs to look for other constructs to further extend the original TAM and to improve its explanatory ability. Forth, data collection with the use of questionnaires is dependent on self-report measures, which may be subjected to bias by the respondents. Consequently, to overcome the subjective nature of self-report data, future research should focus on using other sources of data.

5.3. Practical Implications

Our findings also have several practical implications. First, it is clear that the government should play a greater role in promoting the adoption of AGPTs by farmers. This includes active publicity and promotion, organizing training, subsidies, and formulating certain penalties. At the same time, the government should use a more concise and easy-to-understand method to make farmers feel that AGPTs are not difficult to master, and that they can improve yields and increase their income. Meanwhile, the government should pay attention to the great differences in infrastructure between different rural areas, and take corresponding measures to reduce the restrictions that hinder farmers from adopting new technologies. Second, due to the role of social networks in AGPTs adoption behavior, farmers with significant social capital can be given priority when promoting AGPTs. These individuals are more risk-resistant and more widely accepted for AGPTs. This also implies that modern social tools can be used to expand farmers' knowledge acceptance and social networks, which will, in turn, promote farmers' AGPTs adoption behavior. Meanwhile, as social networks play an important role in the adoption of AGPTs, the government should strive to increase the number of farmers using AGPTs. Only in this way can farmers make full use of the resources and favorable conditions brought by social networks, which, in turn, encourage more farmers to use AGPTs. Third, considering the fact that there are many elderly and uneducated farmers in rural China, we should focus on increasing the publicity of the economic and environmental effects of AGPTs, and comprehensively promote them in order to convince farmers to adopt more AGPTs. Finally, the focus should be on the farmers' risk perception of AGPTs. The promotion process of green production technologies should seek to dispel farmers' fear of future uncertainty and reduce the losses that they may face by taking actions such as setting minimum recovery prices or contacting the sales channels in advance.

6. Conclusions

In conclusion, this study uniquely uses the TAM framework for the purpose of explaining farmers' behavior regarding the adoption of green agriculture production technology. It also identifies a boundary condition (i.e., risk perception) for the relationship between perceived usefulness, perceived ease of use, price value and farmers' adoption decisions. Furthermore, this study was intended to expand the TAM by including some logical extraneous constructs, such as social networks and governmental control. The main conclusions of the expanded TAM were generally supported by these findings, as was the model's relevance for predicting AGPTs adoption. We hope that this study piques the interest of other researchers and, eventually, will broaden our understanding of the influencing

factors on farmers' adoption of green agriculture production technology, as well as how to accelerate the application of green agriculture production technology.

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