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What determines the investment intention of Chinese farmers in green grain production?

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Abstract
To accelerate green development and promote harmonious coexistence between man and nature, China has vigorously promoted investment in green food production. In China, farmers are the core unit of grain production, and China's green food production is inseparable from the strong support of farmers. Based on the theory of planned behavior, the structural equation model and multi-group comparative analysis method were used to investigate the investment intention of 435 farmers in green grain production in Zhengzhou, Zhoukou, and Shangqiu, Henan Province, from the perspective of farmers' micro- and psychological levels. The results show that attitude and perceived behavioral control among farmers can significantly boost their intention to invest in green production through two different channels. Subjective norms, on the other hand, only indirectly affect farmers' intentions to make such an investment. At the same time, through multi-group comparative analysis, the study also verified that different variables such as gender, age, educational background, and family labor force have different degrees of influence on different hypothetical paths. Therefore, this study provides suggestions for sustainable green production investment development and has certain guiding significance for the follow-up work of government departments, relevant companies, farmers, scholars, and other relevant personnel.

Keywords Green production investment · Chinese farmers · Planned behavior theory · Structural equation

1 Introduction

Green production of grain is an inevitable choice for China's sustainable development. In the past, China has adopted an extensive food production method. While increasing food production, ecological problems such as excessive pesticide standards, soil loss, and a decline in water resources have frequently occurred in production. Protecting the ecological environment while increasing production has become a major problem today (Norton, 2016). Compared with the traditional way of grain planting, "green production investment"

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has been frequently mentioned in recent years. In terms of concept perception, green production investment pays more attention to long-term value creation. Scholars have defined green production investment from different perspectives. Most scholars in Western countries define it as a "socially responsible investment," while Chinese scholars emphasize the coordination of ecological environment and economic development. At present, researchers generally believe that green production investment is embodied in production, clean production, that is, energy saving, material saving, waste-free or less recycling production of materials, production, and environmental protection at the same time, the production process is not only an output process but also a process of pollution prevention and control. In summary, this study believes that green production investment refers to the production process in which producers adopt green production methods and environmental protection technologies to reduce pollution and achieve sustainable development (Zhang and Lou 2021). In 2018, the No. 1 Central Document requested "promoting green development in rural areas." The "opinions on the innovation system and mechanisms to promote green development in agriculture" were subsequently released. The notice on printing and distributing the key points of the planting industry in 2020 was published in 2020. In it, it was emphasized that we should strictly adhere to the baseline for national food security and support the green and high-quality development of the planting industry. Green agriculture products are really in greater demand every year. Developing green agriculture and promoting green planting techniques are becoming increasingly crucial. Farmers' behavior, which comprises the bulk of green production investment behavior, is crucial to the successful accomplishment of the nation's green agriculture development goals. Therefore, from a micro-perspective, it is crucial to research the factors that affect farmers' intentions to invest in green agriculture.

The academic research on green production investment focuses on farmland systems (Karki et al., 2021; Liu et al., 2020; Zhou et al., 2020), water ecological construction (Nyam et al., 2021; Shen & Shen, 2021), environmental protection policy (Pan et al., 2021; Patel et al., 2020), mechanism innovation (Sun et al., 2021), and so on, to achieve stable grain production, and increase production, and promote agriculture through science and technology. Some academics advocate using services to promote organic farming (Lohr & Salomonsson, 2000); more academics think that economic sanity has a significant impact on farmers' decisions to invest in green production. The maximization of advantages is the aim of farmers. Increasing economic returns can effectively promote green production (Pietola & Lansink, 2001). Some scholars consider that government technology promotion and financial subsidies can be beneficial to the generation of green production investment (Brown, 2016). From a micro-point of view, the government's financial allocation for new technology has a positive significance for farmers' acceptance of new technology (Goyal & Netessine, 2007). Generally speaking, the research results of scholars have not formed a complete theoretical framework. Most of the studies are about green production investment from a macroeconomic perspective, mainly focusing on the influence of policy subsidies, output prices, economic returns (Lohr & Salomonsson, 2000; Pietola & Lansink, 2001), and other factors. Few scholars study the psychological factors that influence the investment willingness of farmers in green production.

The distribution of farmers in China is more and more scattered; how do we choose the appropriate area to grasp the farmers' psychology? Henan Province has always been a major grain production province in China. In 2015, the Henan Provincial Government established the "green process of grain" planting demonstration base and selected Zhengzhou, Zhoukou, Shangqiu, and other grain production core areas to explore the way of food security. This measure helps the green food planting process develop rapidly. Therefore,

this paper takes Zhengzhou, Zhoukou, and Shangqiu in Henan Province as the starting point to explore the green production investment willingness of Chinese farmers. The choice of this area has a good representation of green production investment in grain.

To address the gap in the micro-perspective in green production investment research theory, this paper investigates farmers' intentions to invest in green production, starting from their perspective and psychological level, innovatively, based on the theoretical framework of planned behavior. The remaining sections of this paper invest in green production using survey data, conduct a multi-group comparative analysis, draw conclusions, and provide pertinent policy recommendations. The specific purposes of this study are as follows: (1) the structural equation model can be used to study the advantages of potential variables and multi-variables, and the theory of planned behavior can be used to explore the influencing factors of farmers' intentions to invest in green food production from the psychological factors of farmers. (2) According to the different characteristics of farmers, they are divided into multiple groups, and the method of comparative analysis of multiple groups is used to analyze the differences in psychological activities generated by farmers with different characteristics in the process of green production investment decision-making.

2 Literature review

Previous research on green production investment mainly focused on farmland systems (Karki et al., 2021; Liu et al., 2020; Zhou et al., 2020), water ecological construction (Nyam et al., 2021; Shen & Shen, 2021), environmental protection policies and relevant mechanism innovation (Pan et al., 2021; Patel et al., 2020; Sun et al., 2021). Most of these studies are limited to the macro-level. From the micro-perspective of farmers' psychology, the research on green production investment is seriously insufficient. The research results are as follows:

1. More and more researchers focus on the farmland system when they study green production investment. China's urban land use projects have carried out extensive research, and the type and structure of rural land use in China have changed significantly with the country's economic development in recent years (Zhou et al., 2020). The researchers found that the development of population and economy is significantly related to the intensity of farmland to forest land, which provides important theoretical support for policymakers to formulate future sustainable land use policies. Several ecological issues brought on by agricultural production have also exacerbated the ecological crisis. Changes in land use systems have significantly altered soil health because of new management techniques and constrained agricultural acreage (Karki et al., 2021; Shobande, 2019); Shahzad et al., 2022; Shobande & Shodipe, 2021). The researchers think that effective ways to change this situation (Liu et al., 2020) include increasing agricultural water use efficiency, bolstering farmland protection measures, improving fertilizer utilization rates, reducing plastic film mulch residues, and using related technologies (Shobande & Asongu, 2022; Xie et al., 2022).
2. The management of water resources is also a difficult problem for researchers in the research process of green production investment. Water resource managers face numerous challenges due to the limited supply of water, severe water pollution, rising domestic and industrial water use, and the need for food security (Shen & Shen, 2021). The connection between water resources and industry and agriculture is gradually strengthened,

which makes the management of water resources more complex (Nyam et al., 2021). The researchers studied water resources management and agricultural sustainability through the review of previous literature and reports (Shen & Shen, 2021), system dynamics and multi-stage participatory (Nyam et al., 2021), and other methods, and put forward corresponding countermeasures and suggestions according to the research.

3. Environmental protection policies and relevant technology innovation are important factors to promote green production investment. More and more researchers focus on environmental protection policies and relevant mechanism innovation (Pan et al., 2021; Patel et al., 2020; Sun et al., 2021). The researchers believe that the sustainability of the environment and food production is a huge challenge (Patel et al., 2020). To achieve win–win economic development and environmental protection, green innovation is essential (Pan et al., 2021; Zakari et al., 2022). At the same time, the researchers pointed out that the adjustment of environmental laws and regulations and the adjustment of relevant policies are imminent (Pan et al., 2021).

It can be seen from the literature that although researchers have made many achievements in the research on green production investment, there are still deficiencies. (1) Most of the research on green production investment focuses on the farmland system, water ecological construction, environmental protection policies, and relevant mechanism innovation; these studies are carried out at the macro-level using TPB, and from the perspective of farmers' psychology, the research on green production investment behavior is insufficient. As the main body of green production investment, farmers' awareness has a great impact on production behavior, and TPB plays an important role in predicting individual behavioral intentions. Therefore, it is crucial to employ TPB to illuminate the psychological mechanisms underlying farmers' motivation to make investments in sustainable agriculture. (2) Only a few researchers have undertaken multi-group comparison analysis on the subjects in the literature based on the idea of planned behavior; respondents with diverse group characteristics have varied viewpoints and preferences on particular behaviors. Therefore, it is of great significance to divide the respondents according to their characteristics and study the green production investment intentions of different groups.

3 Theoretical framework and model hypothesis

3.1 Theory of planned behavior

Behavioral intention determines behavioral aspects, but the behavioral intention is also controlled by behavioral attitude and subjective norms, according to Fishbein's 1975 Theory of Rational Action (TRA). The theory of planned behavior (TPB), which was derived from TRA, was proposed by Ajzen in 1985. He held that the attitude, subjective norms, and perceived behavioral control all had an impact on one's intention, and that the strength of one's intention to take action was directly correlated with the strength of one's attitude, subjective norms, and perceived behavioral control (Ajzen, 1991). Ajzen's TPB and the notion of rational behavior as ten behaviors were contrasted in 1992. According to the findings, perceived behavioral control can improve the prediction of behavioral intention and behavior (Madden et al., 1992).

Many scholars have studied different fields based on rational action theory (TRA) and planned behavior theory (TRB), such as medicine (Laflin et al., 1994), charity (Konkoly

& Perloff, 1990), accounting (Lavinia & Artemisa, 2010; Owusu et al., 2020), wine (Marshall et al., 2010), family relations (Sulak et al., 2014), information technology industry (Otieno et al., 2015; Verswijvel et al., 2019), agricultural planting (Chang, 2013), tourism and hotel industry (Elhoushy & El-Said, 2020; Ulker-Demirel & Ciftci, 2020), psychology (Thompson et al., 2020) and education (Doanh & Bernat, 2019). After continuous development, the theoretical system of planned behavior is divided into more details. For example, some scholars bring perceived interests into the research (St Quinton et al., 2021; Lin et al., 2020). In the research field of green production investment, TPB is mostly used to explore consumer intention and understand how brand equity, green marketing, and consumers' green consciousness and attitude affect this intention (Liu & Tsaur, 2020).

3.2 Research hypotheses

TPB has undergone continual growth and has been used in many areas, particularly in the investigation of farmers' readiness to make investments in environmentally friendly production. In terms of the theory of planned behavior, attitude, subjective norms, and perceived behavioral control all can affect intention.

3.2.1 Assumptions between attitude, subjective norms, and perceived behavioral control

Ajzen believes that attitude, subjective norms, and perceived behavioral control are both independent and related to each other, so there is an interactive relationship between the three (Lou et al., 2021). When Tarkiainen looked into why people buy organic food, he discovered that the initial hypothesis of planned behavior was incorrect and that subjective norms play a distinct role. Through behavior and attitude, subjective norms indirectly influence purchase intention (Tarkiainen & Sundqvist, 2005). Lavelle Brian noted that there is a relationship between behavior, attitude, and perceived behavioral control when he researched the effects of college education on college students' jobs (Lavelle, 2021). Davia found that there is a relationship between subjective norms and emotional morality when studying the function of expected emotions in the environment (Devia et al., 2021). So we think that farmers' attitudes are positively correlated with subjective norms, that is, people who have an important impact on farmers encourage them to implement green production investment behavior, or farmers' herd mentality makes them have a positive attitude toward green production investment behavior; on the contrary, if farmers hold a positive evaluation of and positive attitude toward green production investment, they will naturally accept the pressure from other people. There is a positive correlation between attitude and perceived behavioral control, that is, when farmers have a positive evaluation of green production investment behavior, they are willing to spend time and energy to implement this behavior; on the contrary, when farmers have convenient conditions for implementing green production investment behavior or have a strong grasp of relevant technologies, they will have a positive attitude toward this behavior. Additionally, there is a favorable relationship between perceived behavioral control and subjective norms, that is, when other farmers, relatives, and friends, and the government encourage or influence the farmers to implement green production investment behaviors, the farmers will think that they should spend time and energy on this behavior and that they can adopt this behavior. On the contrary, when farmers think they have no difficulty implementing green production investment, they are also willing to accept the norms from other people.

In conclusion, this paper proposes the following hypotheses:

Hypothesis 1 Farmers' attitudes and subjective norms interact favorably.

Hypothesis 2 Farmers' perceived behavioral control and behavior attitudes interact favorably.

Hypothesis 3 Farmers' subjective norms and perceived behavioral control interact favorably.

3.2.2 The hypothesis that attitude, subjective norms, and perceived behavioral control all affect the intention

Behavior attitude primarily refers to farmers' attitudes toward the behavior of green production investments, whether they are favorable or unfavorable (Lou et al., 2022). Subjective norms describe how farmers affect the local population, including the government and powerful social organizations, for better or worse (Ajzen, 1991). Specifically, they refer to the degree to which production methods are chosen by the people around the farmers, their opinions on green production investment methods, and the encouragement of green production investment behavior by the surrounding people and the government, which has an impact on the behavior and decision-making of the farmers themselves. Perceived behavioral control refers to farmers' subjective feelings about the ease or difficulty of implementing green production and investment behaviors (Hassan et al., 2016). Specifically, it refers to whether farmers have the economic conditions and relevant knowledge to implement green production investment behavior, as well as their perception of their ability to implement green production investment behavior. According to Ajzen, people are more likely to adopt a behavior if they have a favorable attitude toward it, have higher subjective norms, and have more control over how it is seen by others (Netemeyer et al., 1991). Numerous studies have highlighted the crucial role of three elements of TPB in predicting household behavior factors like garbage classification (Lou et al., 2022) and household safe use of chemical fertilizers (Savari & Gharechaee, 2020). All of these studies have come to the same conclusion: three elements of TPB positively affect individual intention. Therefore, farmers who are supportive of green production investments can face the disadvantages of high cost and time-consuming caused by adopting green production modes with a more positive attitude in the production process and are more likely to have a positive preference for green production investments in the process of production mode selection. At the same time, farmers with higher subjective norms are more likely to be affected by the people around them. Therefore, when the people around them are engaging in green production investment behavior, such farmers will also tend to engage in green production investment; finally, farmers with high perceived behavioral control have the convenience to engage in green production investment, which makes them more likely to engage in this behavior.

To sum up, this paper proposes the following hypotheses:

Hypothesis 4 Farmers' attitudes can affect intention positively.

Hypothesis 5 Farmers' perceived behavioral control can affect intention positively.

Hypothesis 6 Farmers' subjective norms can affect intention positively (Fig. 1).

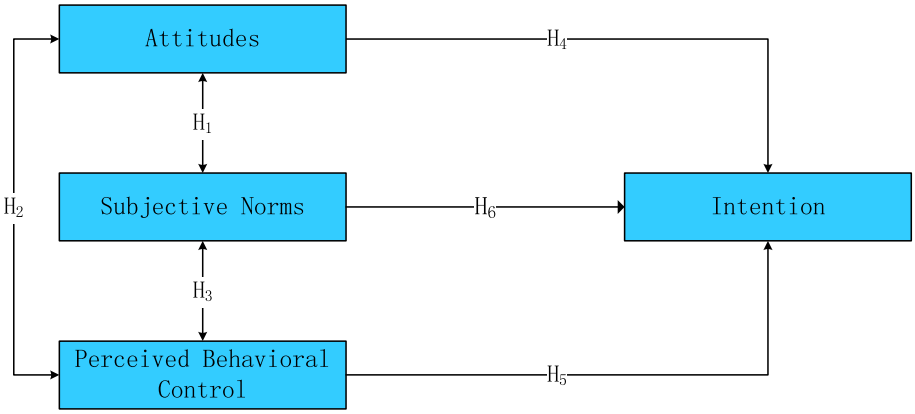

Fig. 1 Research model

4 Method

4.1 Research method

SEM is an important statistical method for quantitative research that integrates "factor analysis" and "regression analysis" statistical techniques. It can simultaneously test the relationships between observed variables, latent variables, and error or interference variables included in the model and obtain the direct, indirect, or total effects of the independent variable on the dependent variable. SEM can be used to analyze whether the actual relationship structure between variables is consistent with the theoretical structure and to judge whether the factor structure of the scale can fit the sample. The SEM establishes logical relationships based on traditional analysis methods and solves the problem of traditional statistical methods not being able to effectively handle latent variables, making up for the shortcomings of traditional analysis in theoretical assumptions and expanding the limitations of traditional analysis in use, bringing new patterns to information processing, known as the "third reform of statistics" (Wu, 2010). The measurement model and structural model are two categories of SEM. In contrast to the structural model, which discusses the relationship between latent variables, the measurement model discusses the link between indicators and latent variables.

This study chose the SEM to study the influencing factors of farmers' intentions to invest in green food production. The main considerations are as follows: First, it is difficult to directly observe farmers' intentions, attitudes, subjective norms, and perceived behavioral control factors. Using SEM, these factors can be indirectly evaluated by observing variables as latent variables. Secondly, the SEM will handle measurement errors during the analysis process to solve the problem of ignoring errors in the evaluation method of green production investment for farmers' grain in this study, making the research results more reliable. Finally, the SEM can also be used to verify whether the factor structure of the farmers' intention to invest in the green food production scale designed in this study matches the sample. In this study, the data are analyzed and the model is created using the SPSS 26 and Amos software. The expression of the structural equation model is as follows:

$$\eta = b\eta + \xi \tag{1}$$

$$Y = \wedge_y + \varepsilon \tag{2}$$

(1) Formula is the structural model, where η is the latent variable and b is the coefficient matrix of the corresponding variable; (2) is the measurement model, where Y is the observed variable of the latent variable; $\wedge_y$ is the correlation between the latent variable and the observed variable Coefficient matrix; ξ and ε are error terms.

4.2 Scale design

Behavior and attitude problems include the fact that green agriculture can provide objective income for families (Sánchez-Bravo et al., 2021), that green agriculture can improve the ecological environment, that green agriculture is beneficial to health, and that green agriculture is the future development trend (Mohapatra et al., 2019). As for the design of subjective behavior norms, people around me are planting crops in green, people around me think that green planting is beneficial to increase income (Strange, 2001), people around me and the government encourage me to participate in green production investment (Onwezen et al., 2013). Perceived behavioral control design problems, including conditional participation in green production investment (Strange, 2001), know how to participate in green production investment (Onwezen et al., 2013), have the ability to use green production technology (Onwezen et al., 2013; Strange, 2001), For the problems related to use intention design, including willing or continuing to participate in green production investment (Onwezen et al., 2013), will spend more in green production investment, will encourage relatives and friends to increase green production investment (Onwezen et al., 2013). The scale of this study adopts the form of the Likert seven-point scale. 1, 2, 3, 4, 5, 6, and 7 represent "totally disagree," "disagree," "slightly disagree," "generally," "slightly agree," "agree," and "fully agree," respectively. Demographic characteristics include gender, age, education level, whether to participate in green production training, whether there are village cadres in the family, whether there are college students in the family, labor force, and grain planting area in the family (Table 1).

As a big agricultural country in the world, China's grain output is gradually increasing. At the same time, China's status as a grain exporter is becoming more and more important. The grain output of Henan Province plays an important role in China's grain output. In 2020, to implement the "opinions of the Henan Provincial People's Government on adhering to the three chain isomorphism and accelerating the high-quality development of the grain industry," the Provincial Department of Finance decided to support several green grain storage demonstration projects to realize "stabilizing grain production" and "prospering agriculture through science and technology." This paper investigates the willingness of Chinese farmers to invest in grain green production using survey data from farmers in three cities in Henan Province.

4.2.1 Sample and data collection

Before the formal survey, the residents of Shuangba Town, Liangyuan District, Shangqiu City, and Henan Province were pre-surveyed using the online survey. The paper questionnaire was used to examine the farmers' willingness to invest in green production in three cities in the province of Henan after the scale's validity and reliability were tested and after consulting the recommendations of pertinent experts to modify and improve the questionnaire.

Table 1 Descriptive statistics of statistical variables

Variable	Features	Frequency	Percentage
Gender	Male	249	57.2
	Female	186	42.8
Age	19–29	225	51.7
	30–39	58	13.3
	40–49	94	21.6
	50–59	43	9.9
	Above 60	15	3.4
Degree of education	Primary school and below	47	10.8
	Middle school	140	32.2
	College and technical secondary school	95	21.8
	Bachelor degree or above	153	35.2
Are there any college students at home	Yes	296	68.0
	No	139	32.0
Do you have village cadres at home	Yes	45	10.3
	No	390	89.7
Have farmers participated in green production training	Yes	55	12.6
	No	380	87.4
Working population of family	≤ 2	254	58.4
	> 2	181	41.6
Grain planting area	≤ 2	138	31.7
	2–4	143	32.8
	4–7	105	24.1
	> 7	49	11.3

In this study, a stratified random survey method is adopted, mainly in Zhengzhou, Zhoukou, and Shangqiu in Henan Province, with farmers' grain planting areas as the survey object. Through the commissioned survey and field survey, the respondents are farmers' growers or family labor force who have reached the age of 16. The investigators are the local college students of the farmers investigated. After unified training, they use the winter vacation to conduct a one-on-one investigation on the farmers. 120 questionnaires were distributed on the spot, 400 questionnaires were distributed by the Commission, 508 questionnaires were collected, 435 questionnaires were obtained after eliminating the invalid questionnaires with missing data and errors, and the effective rate was 85.62%.

4.2.2 Basic characteristics of the interviewed farmers

The percentage of male to female farmers who were randomly interviewed did not significantly differ, with the males making up 57.2% of the total. Only 13.3% of respondents were over 50, with the majority of respondents being under 50. Currently, farmers themselves are more educated than ever before, with 50% having a college degree or higher. Only 10.3% of the households had village cadres. 68.0% of the households had college students. The population over 16 years old is small, that is, 41.6% of the

households have more than 2 workers. Most of the farmers' grain planting area is small-scale planting; only 49 households planted over 7 mu, accounting for 11.3% of the total sample (Fig. 2).

5 Empirical results and analysis

5.1 Reliability and validity test and fitness test

5.1.1 Exploratory factor analysis

Using SPSS 26 software to conduct principal component factor analysis on the questionnaire data, the KMO is 0.934. The questionnaire exhibits structural validity and can be used for factor analysis, according to the Bartley Sphere test results. The findings indicate that the related factors are under heavy strain, and the value is greater than 0.6, further demonstrating the structural validity of the measurement problem. Each variable's and the model's dimension's Cronbach's values range from 0.8 to 0.94, which shows that the questionnaire's measurement indices are highly reliable and exhibit good consistency. The scale's construction validity was good, as evidenced by the fact that the factor's explained variance was 84.184% (Table 2).

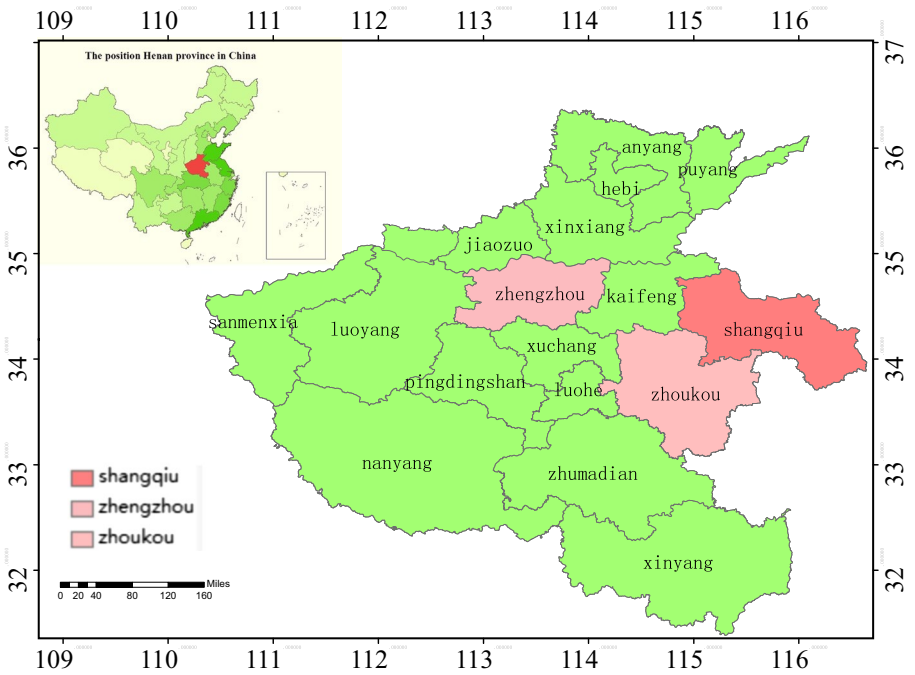

Fig. 2 Distribution of survey area

Table 2 Exploratory factor analysis results

Latent variable	Measurement variables	Factor load (orthogonal rotation)	Cronbach'∂	Each factor explained the variance %	Cumulative explained variance %
η_1: Attitude	Y11: Green agriculture can provide a considerable income for families	0.700	0.907	26.148	26.148
	Y12: Green agriculture can improve the ecological environment	0.896			
	Y13: Green agriculture is good for health	0.894			
	Y14: Green agriculture planting is the future development trend	0.815			
η_2: Subjective norms	Y21: People around are planting green crops	0.701	0.879	22.093	48.240
	Y22: People around think that green planting is good for increasing income	0.775			
	Y23: People around me and the government encouraged me to invest in green production	0.633			
η_3: Perceived behavioral control	Y31: I have the conditions to participate in the investment of green production	0.780	0.923	19.995	68.235
	Y32: I know how to invest in green production	0.788			
	Y33: I have the ability to use green production technology	0.826			
η_4: Intention	Y41: I am willing or continue to invest in green production	0.763	0.928	15.949	84.184
	Y42: I'll spend more time and money in green production investments	0.779			
	Y43: I will encourage my relatives and friends to invest more in green production	0.762			

5.2 Model fitness test

435 questionnaires were utilized to test the structural equation model's suitability using the Amos 23.0 program. Table 3 presents the outcomes. The RMSEA is 0.090, indicating that the hypothetical model has a decent fit with the real sample data and that the absolute fitness indices (CMIN/DF, RMSEA, GFI, and AGIF) meet the standard. The whole model met the fitness criteria as all five value-added fitness indexes (RFI, NFI, IFI, TLI/NNFI, and CFI) were greater than 0.90. The parsimony fitness index (PNFI, PGFI, etc.) has reached the adaptation criteria, indicating that the model hypothesis put forth in this study fits the survey data well and may be used for further investigation and analysis.

5.3 Hypothesis test results

From the test results of the model, the hypothesis standardized path coefficients form H_1 to H_5 are all positive and significant at the level of 0.001. The five hypotheses are supported and H_6 is not supported (see Table 4).

1. One indirectly influences the intention through perceived behavioral control, which supports hypotheses 2 and 4. The other directly influences the intention through perceived behavioral control. Behavior attitude has an influence coefficient of 0.46 on perceived behavioral control, and perceived behavioral control has an influence coefficient of 0.64 on intention to use. This shows that every increase of one standard deviation in farmers' attitudes will increase the perceived behavioral control of their green production investment by 0.46 standard deviations; however, when farmers' perceived behavioral control increases by 1 standard deviation, their willingness to invest in green production will increase by 0.64 standard deviations. This shows that the more farmers know about green production investment technology, the more they will deepen their willingness

Table 3 Results of overall fitness test index

Statistical test index	Threshold of adaptation standard	Fitting value	Adaptation judgment
Absolute fitness index			
RMSEA	< 0.08	0.090	Accept
GFI	> 0.90	0.912	Accept
Value-added fitness index			
NFI	> 0.90	0.950	Accept
RFI	> 0.90	0.934	Accept
IFI	> 0.90	0.960	Accept
TLI/NNFI	> 0.90	0.948	Accept
CFI	> 0.90	0.960	Accept
Simple fitness index			
PCFI	> 0.50	0.739	Accept
PNFI	> 0.50	0.730	Accept
Chi square degree of freedom ratio	< 5	4.485	Accept

Table 4 Model path test results

Hypothesis	Standardized path coefficient	*t* value	Conclusion
H_1 Behavior and attitude ↔ Subjective norms	0.62***	9.134	Support
H_2 Behavior and attitude ↔ Perceived behavioral control	0.46***	7.722	Support
H_3 Subjective norms ↔ Perceived behavioral control	0.87***	11.898	Support
H_4 Behavior and attitude → Intention	0.35***	9.199	Support
H_5 Perceived behavioral control → Intention	0.64***	16.768	Support
H_6 Subjective norms → Intention	–	–	Nonsupport

***$p < 0.001$

to participate. The other is that behavior and attitude have a direct impact on intention, with an influence coefficient of 0.35; this indicates that for every one standard deviation improvement in attitude, farmers' willingness to invest in green production will increase by 0.35 standard deviations. This is in line with the findings of Savari and Gharechaee's study on the variables determining farmers' safe use of chemical fertilizers, which showed that attitudes significantly influenced farmers' willingness (Savari & Gharechaee, 2020). The favorable influence of mindset on farmers' willingness to invest in sustainable production is partially supported by this study. It shows that farmers who have a positive attitude toward green production investments are more likely to feel the benefits of green production investments in the production process, so they are more willing to adopt green production investments.

2. There are two ways in which the intention might be impacted by perceived behavioral control. One indirectly influences one's inclination through behavior and attitude, supporting hypotheses 2 and 5. The influence of behavior and attitude on willingness is 0.35, and the influence of behavior and attitude on perceived behavioral control is 0.46, indicating that for every one standard deviation increase in farmers' perceived behavioral control, their attitude will increase by 0.46 standard deviations. However, for every one standard deviation increase in farmers' attitudes, their willingness to invest in green production will increase by 0.35 standard deviations. The other is that perceived behavioral control directly affects the willingness to use, and the influence coefficient is 0.64; that is to say, every increase of one standard deviation in farmers' perceived behavioral control will increase their willingness to invest in green production by 0.64 standard deviations, which indicates that farmers know more about green production technology, and the stronger the willingness to use green production investment. This conclusion is consistent with the previous conclusion obtained by Jiang et al. in the process of studying the influencing factors of individual food-saving behavior (Jiang et al., 2020).
3. The willingness is indirectly affected by subjective norms. One indirectly influences how behavioral control is perceived, supporting hypotheses 3 and 5. The strongest relationship exists between subjective norms and perceived behavioral control (0.87). The main reason is that the behavior of people around the investment in green production will improve farmers' willingness to participate. The coefficient of perceived behavioral control influencing willingness to use is 0.64. The other is that it indirectly affects willingness to use through behavioral attitude, which confirms hypotheses 1 and 4. The stronger the farmers' acceptance of the people around them to participate in green

production investment, the more helpful it is to improve the farmers' attitude toward green production investment. The influence coefficient of subjective norms on behavior attitude is 0.62, and that of behavior attitude on willingness to use is 0.35. In the research and development of organic food, scholars found that subjective norms do not directly affect consumers' intentions but affect their consumption intentions through the intermediary role of consumption attitude (Chen & Tung, 2014). Therefore, the conclusion of this study is acceptable. This study believes that the reason for this result is that while the investment process of green food production in China is accelerating, there are still problems such as insufficient scientific and technological support, insufficient green food subsidies, and poor quality and price of green food. Therefore, farmers' cognition of green production investment still deviates from the theory (Fig. 3).

6 Comparative analysis of multi-groups

Multi-group SEM analysis can judge the possibility of the theoretical model in different sample groups so as to find the most suitable path model. This paper conducts a multi-group analysis based on the descriptive statistical variables of farmers. Scholars have studied the residence intentions of the new generation of a highly educated population and concluded that different educational backgrounds and ages will have different effects on the formation of willingness and final behavior. Scholars have studied the impact of targeted poverty alleviation on the political participation of different gender groups in rural areas and found that gender has different effects on it. In addition, the number of family laborers

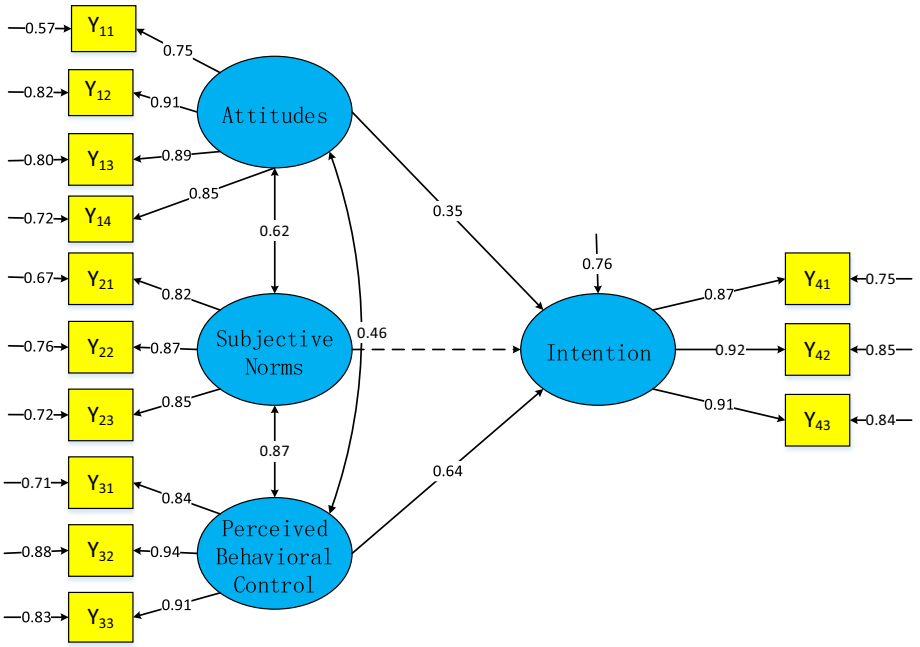

Fig. 3 Structural equation model and standardized path coefficient

has a direct or indirect impact on the willingness to invest in green production, and family labor directly affects a family's income level and risk tolerance to try new things. Therefore, in the research process of determining farmers' willingness to invest in green production, gender, age, educational background, and family labor force are divided into different groups by using multi-group SEM analysis (Table 5).

6.1 Gender grouping of decision-makers

In the path H_1 of positive interaction between attitude and subjective norms, the result for males ($\beta = 0.63$) is more significant than that for females ($\beta = 0.53$), and males are slightly larger than females. In the path H_2 of positive influence between behavioral attitude and perceived behavioral control, males ($\beta = 0.48$) have a slightly greater influence than females ($\beta = 0.43$). In the path H_3 of positive interaction between subjective norms and perceived behavioral control, male ($\beta = 0.88$) has more influence than female ($\beta = 0.84$). The possible reason is that men have more say in the family and more decision-making in family investment. In path H_4, the male ($\beta = 0.37$) had a more significant effect on intention than the female($\beta = 0.32$); in path H_5, the perceived behavioral control had a direct positive effect on the willingness to use, and women($\beta = 0.71$) had a more significant impact on the use intention than men($\beta = 0.60$). With the continuous development of society, women gradually take on an important position in green production and planting, and their acceptance of advanced technology is better than that of men. The subjective criterion has no significant influence on the path H_6 of willingness to use. This finding is consistent with previous findings by Erdoğan and Stuessy, who studied the college readiness of STEM school graduates, that a student's gender has a significant impact on success in STEM schools (Erdoğan & Stuessy, 2015). This study again emphasizes the important role of classification based on the gender of the researchers and multi-group comparative analysis of the researchers (Fig. 4).

6.2 Age group of decision-makers

In the path H_1 of positive interaction between attitude and subjective norms, the influence of the old generation group ($\beta = 0.70$) is more significant than that of the new generation group ($\beta = 0.57$). In the path H_2 of positive interaction between behavioral attitude and perceived behavioral control, the influence of the older generation($\beta = 0.55$) is also more significant than that of the new generation($\beta = 0.47$). In the path H_3 of positive interaction between subjective norms and perceived behavioral control, the influence of the old generation($\beta = 0.90$) is still more significant than that of the new generation($\beta = 0.83$). In the path H_4, the new generation group ($\beta = 0.33$) has more significant influence than the old generation group($\beta = 0.25$). This is because the new generation of farmers has more accurate control over their own family conditions and planting technology. In the path H_5 where perceived behavioral control can affect the willingness to use positively, the new generation ($\beta = 0.65$) has a significant impact, while the old generation can not affect the willingness to use significantly. Pierluigi Milone and others studied the response of the new generation of young farmers in Italy to the new social requirements and expectations of agriculture and food and found that information and high-tech technology have a huge impact on them (Mohapatra et al., 2019). As a result, the perceived behavioral control of the younger generation has a greater effect on their intentions. In the path H_6 of the positive impact of subjective norms on

Table 5 Multi-group analysis

Hypothesis	Path	Gender of decision-makers		Age of decision-maker	
		Male	Female	Cenozoic era	The older generation
H_1	Behavior and attitude ↔ Subjective norms	0.63***	0.53***	0.57***	0.70***
H_2	Behavior and attitude ↔ Perceived behavioral control	0.48***	0.43***	0.41***	0.55***
H_3	Subjective norms ↔ Perceived behavioral control	0.88***	0.84***	0.83***	0.90***
H_4	Behavior and attitude → Intention	0.37***	0.32***	0.33***	0.25***
H_5	Perceived behavioral control → Intention	0.60***	0.71***	0.65***	–
H_6	Subjective norms → Intention	–	–	–	0.74***
Hypothesis	Path	Educational background of decision-maker		Family labor force	
		Low	High	≤2	>2
H_1	Behavior and attitude ↔ Subjective norms	0.66***	0.60***	0.55***	0.72***
H_2	Behavior and attitude ↔ Perceived behavioral control	0.53***	0.44***	0.43***	0.51***
H_3	Subjective norms ↔ Perceived behavioral control	0.90***	0.84***	0.85***	0.90***
H_4	Behavior and attitude → Intention	0.35***	0.37***	0.42***	0.27***
H_5	Perceived behavioral control → Intention	0.67***	0.60***	0.58***	0.73***
H_6	Subjective norms → Intention	–	–	–	–

***$p < 0.001$

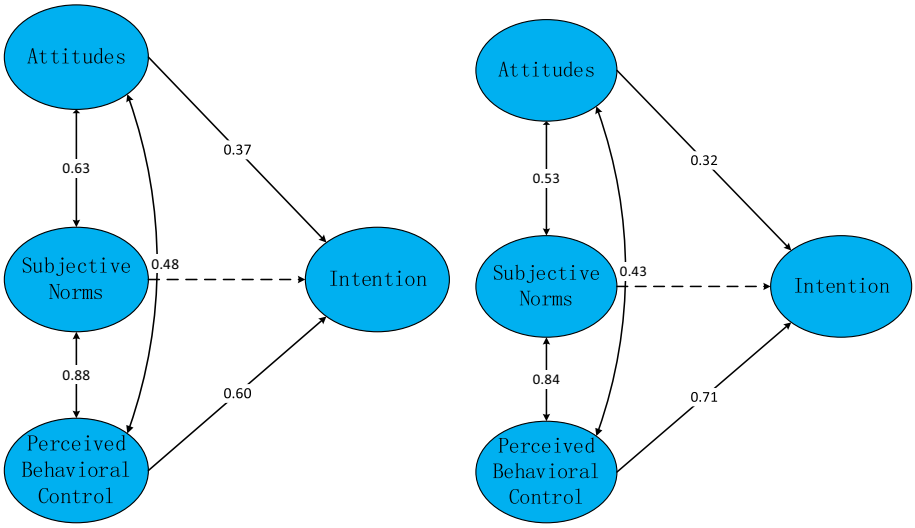

Fig. 4 Path of standardization (left male and right female)

intention, the older generation ($\beta = 0.74$) has a slightly stronger effect than the new generation. Because the older generation lives in rural communities, they are vulnerable to the influence of the people around them and their relatives and friends. This finding is in line with Wu's earlier findings from his investigation into the use of various social media by journalists of various ages (Wu, 2019). Once again, it proves that there are significant differences in psychology and acceptance degree between individuals of

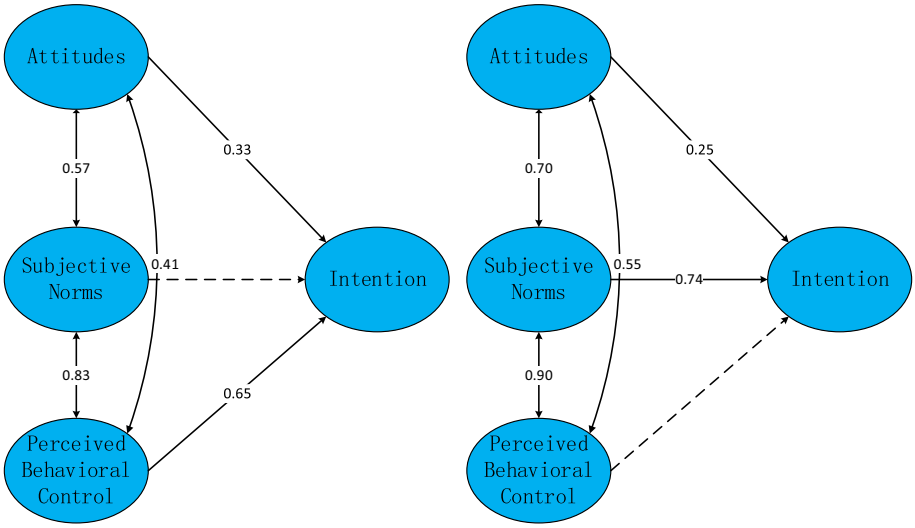

Fig. 5 Path of standardization (Cenozoic on the left and old on the right)

different ages when facing certain things or behaviors. Therefore, it is very important to study them in groups according to the age of the researchers (Fig. 5).

6.3 Decision-maker education grouping

In the path H_1 of positive interaction between attitude and subjective norms, according to the China Family Tracking Survey (CFTS), it is also found that men are better than women in the actual planting area and net income of family food. The influence of the low education group($\beta = 0.66$)is more significant than that of the high education group($\beta = 0.60$). The reason is that most of the older generation are people who have lived in farming all their lives and have low education, but they have a deeper understanding of food planting and are more sensitive to the attitudes and subjective norms of green production investment. In the path H_2 of positive interaction between behavior attitude and perceived behavioral control, the influence of the low education group ($\beta = 0.53$) is more significant than that of the high education group ($\beta = 0.44$). In the path H_3 of positive interaction between subjective norms and perceived behavioral control, the influence of the low education group ($\beta = 0.90$) is more significant than that of the high education group ($\beta = 0.84$). The main reason may be that, compared with women and the new generation of youth, men and older groups pay more attention to the impact of food reform on them and pay more attention to the cost-performance of green production investment. Therefore, the impact between perceived behavioral control and subjective norms is stronger. In the path H_4, the behavior attitude has a direct positive impact on the willingness to use, and the highly educated group ($\beta = 0.37$) has a more significant impact than the low-educated group ($\beta = 0.35$). As a result, the highly educated group's actions and attitudes have a bigger effect on their intentions. The influence of the low-education group ($\beta = 0.67$) is not as large as that of the high-education group ($\beta = 0.60$). In the path $H_{5,}$ where perceived behavioral control has a direct positive impact on the intention. The intention was not significantly impacted by subjective norms. This conclusion is consistent with the previous conclusion that groups with different educational backgrounds have different effects on the educational background of their offspring, which proves the importance of grouping the researchers according to their educational backgrounds (Forsman, 2020; Kye, 2011) (Fig. 6).

6.4 Decision-maker family labor grouping

In the path H_1 of positive interaction between attitude and subjective norms, the effect of the group with a family labor force greater than 2 ($\beta = 0.72$) is more significant than that of the group with a family labor force less than 2 ($\beta = 0.55$). The main reason is that rural men and the labor force have more advantages in green production perception and contact with people around them. In the path H_2 of positive interaction between attitude and perceived behavioral control, the effect of the group with a family labor force less than 2 ($\beta = 0.43$) is slightly lower than that of the group with a family labor force of more than 2 ($\beta = 0.51$). The reason is that farmers with lower education levels and less family labor force have weak control abilities over green production investment. In the path H_3 of positive interaction between subjective norms and perceived behavioral control, the effect of the group with a family labor force greater than 2 ($\beta = 0.90$) is more significant than that of the group with a family labor force less than 2 ($\beta = 0.85$). When the rural household

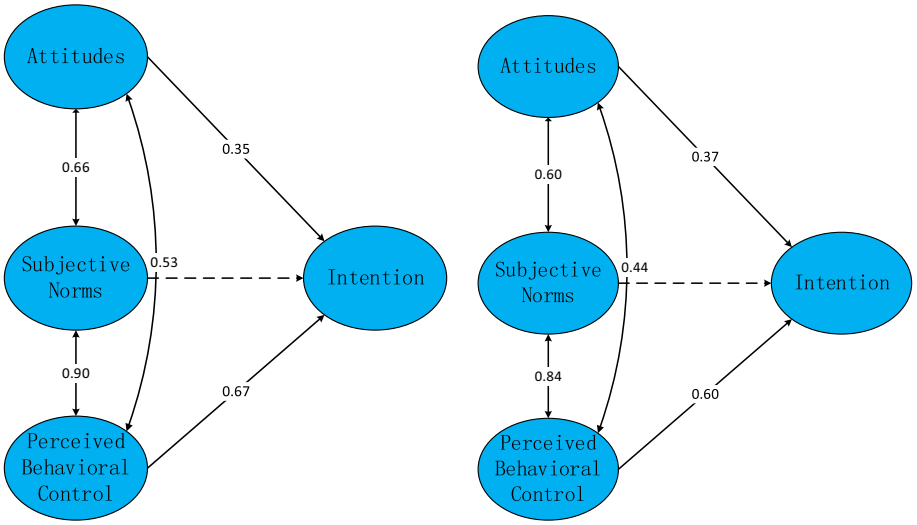

Fig. 6 Path of standardization (low education on the left and high education on the right)

labor force accounts for the majority of the total household population, it will pay more attention to the value of the income that green production investment can bring. In the path H_4, the group with a family labor force of less than 2 ($\beta = 0.42$) has a more significant effect than the group with a family labor force of more than 2 ($\beta = 0.27$). In the path H_5 where perceived behavioral control has a direct positive impact on willingness to use, the group with a family labor force of less than 2 ($\beta = 0.73$) has a more significant effect than the group with a family labor force of more than 2 ($\beta = 0.58$). The intention was not significantly impacted by subjective norms. This result is consistent with Zedan's conclusion that the number of family members has an impact on parents' attention to children when studying the family's attention to children (Zedan, 2011). This study once again confirmed the differences in psychological activities of families with different populations when making behavioral decisions (Fig. 7).

7 Discussion

7.1 Main achievements

(a) Overall, there is a positive correlation between farmers' attitudes, subjective norms, and perceived behavioral control. Among the direct impacts on behavior intention, perceived behavioral control has the most significant impact, followed by behavioral attitude, while subjective norms have no significant impact. This research result is consistent with the previous research results of many researchers. For example, Lou concluded that there is a positive correlation between the three factors of tea farmers' attitudes, subjective norms, and perceived behavioral control in the process of studying green tea plant pest control technology during tea farmers' planting (Lou et al., 2021). Meanwhile, Li's research on the influencing factors of household energy-saving appliance purchase intention also concluded that residents' attitudes and perceived behavioral control have a positive impact on their

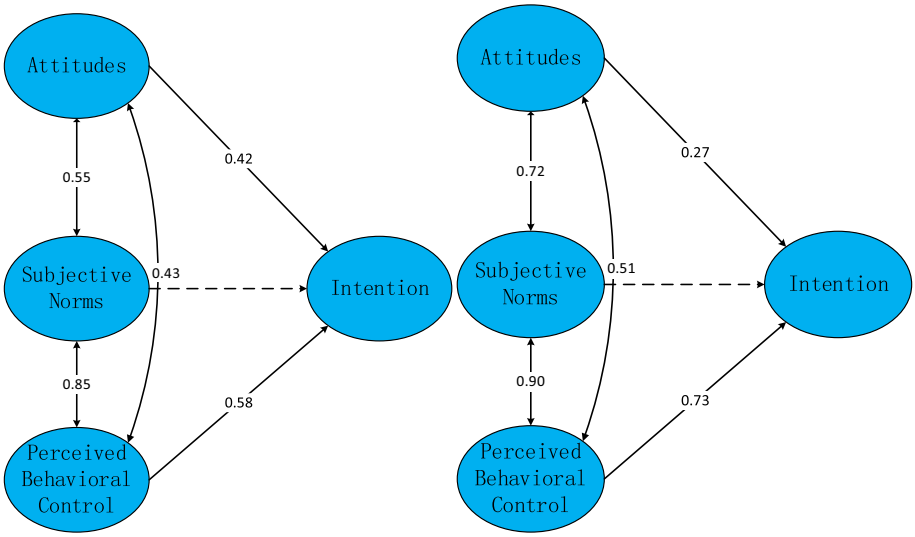

Fig. 7 Path of Standardization (labor force is less on the left and more on the right)

energy-saving appliance purchase intention, while residents' subjective norms have no significant positive impact on their purchase intention (Li et al., 2019). All the research conclusions obtained in this study are acceptable.(b) Multi-group comparative analysis: The study divides the surveyed farmers into different groups based on their gender, age, education level, and household labor force and conducts a group study on the influencing factors of green production investment intention among farmers with different characteristics. The results indicate that grouping based on the gender, age, educational background, and labor force of farmers results in varying degrees of influence among different variables in different hypothetical pathways. This research result is consistent with the results obtained by previous researchers in their respective studies. When Wahid analyzed the impact of mathematical anxiety on students' grades, he concluded that women have a higher level of anxiety than men and that women's mathematical anxiety has a greater negative impact on their grades (Wahid et al., 2018). Shahsavar concluded that age and other demographic factors play an important role in the decision-making process of individual purchase behavior when studying individual environmental furniture intentions to pay (Shahsavar et al., 2020). When Li et al. studied the influencing factors of residents' intentions to pay for green housing, they pointed out that the influence path of farmers' intentions to pay is different in degree and specific path for farmers of different genders and education levels (Li et al., 2018). When Zedan conducted research on the attention of families to their children, he also concluded that the number of family members has an impact on parents' attention to their children (Zedan, 2011). In summary, the conclusions obtained from the comparative analysis of multiple groups in this study are acceptable. At the same time, this study once again confirms that farmers of different genders, ages, educational backgrounds, and household labor forces will have different psychological activities in the decision-making process of green production investment.

7.2 Theoretical contribution

First of all, from the micro-perspective and psychological level of farmers, and based on the framework of the theory of planned behavior, this paper studies farmers' investment intention in green food production, which makes up for the lack of micro-perspective in the research theory of green production investment. Secondly, this study divided the surveyed farmers into different groups based on their gender, age, educational background, and the number of household laborers. Using a multi-group comparative analysis method, the study analyzed the different psychological activities of farmers with different characteristics in green production investment decision-making, compensating for the neglect of demographic factors in green production investment research. Finally, the theory of planned behavior was reasonably modified in the actual research, mainly reflected in the fact that subjective norms had no significant impact on the intention to use.

7.3 Practical contribution

Firstly, for the overall surveyed farmers, their attitude and perceived behavioral control have a significant positive impact on their intention to invest in green production. Therefore, this study suggests that farmers' intentions to invest in green products should be enhanced by improving their attitudes and perceived behavioral control. In terms of promoting a positive attitude toward green production investment among farmers, policymakers should promote the importance of green production investment behavior in the food production process for the environment (such as by posting slogans in villages), so as to make the necessity of green production investment deeply rooted in people's hearts. In terms of improving the perceived behavioral control of farmers, policymakers should provide subsidies to farmers who actively implement green production investment behavior to alleviate their economic pressure. At the same time, policymakers should also fill the knowledge gap of farmers in green production investment by regularly hiring professional personnel to teach in rural areas.

Secondly, this study found that the psychological activities generated by farmers in the production decision-making process vary depending on their gender, age, educational background, and a number of household laborers. The impact of each factor on their final intention to invest in green production varies. Therefore, policymakers should adopt different methods of promotion and assistance based on the specific characteristics of farmers. The impact of attitude on investment intention in green production is slightly greater for males than for females, slightly greater for highly educated farmers than for low-educated farmers, and greater for farmers with fewer household laborers than those with more household laborers. The impact of perceived behavioral control on the intention to invest in green production is slightly greater for women than for men, slightly greater for low-educated farmers than for high educated farmers, and greater for households with a large number of laborers than households with a small number of laborers. Therefore, policymakers should increase their positive attitude toward male farmers, highly educated farmers, and farmers with a low household labor force, as well as their perceived behavioral control toward female farmers, lowly educated farmers, and farmers with a large household labor force. For example, for the new generation of farmers, the impact of perceived behavioral control is significant, while for the older generation of farmers, the effect of perceived

behavioral control is not significant. The subjective norms of the new generation of farmers have no significant impact, while the subjective norms of the older generation of farmers are significant. Therefore, policymakers should focus on creating conditions for green production investment for the new generation of farmers, while exerting external pressure on the older generation of farmers to invest in green production.

7.4 Insufficient

Finally, although this study provides some valuable conclusions, there are still three limitations. (1) First of all, the survey results may be biased by societal expectations because every variable in this study is based on the interviewees' self-reports; however, future research can lessen this bias by using postal surveys. (2) Secondly, in the survey stage, because the older generation of farmers has a little deviation in their understanding of the questionnaire, many invalid questionnaires were eliminated; corresponding methods should be adopted in the follow-up investigation, such as popularizing relevant knowledge before the interview. (3) Finally, it is vital to do research in other regions of China because this study was only conducted in some regions of China and other regions may have different research findings owing to regional differences (Zhang, 2020; Zhang & Lou, 2021).

8 Conclusions and policy implications

This research explores the moderating effects of multi-group analysis on descriptive statistical variables and studies the influencing elements of Chinese farmers' desire to invest in grain green production based on 435 surveys in Henan Province. The following are the primary conclusions:

1. Of the three factors that directly affect farmers' intentions, perceived behavioral control has the greatest influence. Subjective norms of farmers' green production investment have little bearing on farmers' intentions.
2. Through the indirect impact of subjective norms on willingness, the path "subjective norms → perceived behavioral control → willingness" has the most significant impact.
3. The results of multi-group analysis show that different variables such as gender, age, educational background, and family labor force have different effects on different hypothesis paths.

In the process of promoting green production investment, Henan Province is in the initial stage, but it has great development potential. The main problems of agricultural green development in Henan Province are as follows: (1) the population of agricultural plantings is large, while the cultivated land is small. (2) The implementation of government policies needs to be strengthened, and many farmers do not know much about green production investment. (3) The use of land resources, water resources, pesticides, and chemical fertilizers has not reached a reasonable distribution. We can get the following policy implications: the government should strengthen publicity and improve farmers' understanding of green production investment through expert lectures and village publicity. In addition, the government should speed up the implementation of new technologies concerned by farmers, coordinate with land scale and water resources, and take a more efficient, high-quality,

and green road. Finally, we should establish green brand quality, pay attention to high-quality development, and at the same time pay more attention to high prices. In order to promote high-quality development, we should calculate the "green account," walk the "green road," play the "green card," and do a good job in green development. It is of great significance for farmers to participate in green production investments, realize rural modernization, and achieve common prosperity. Under the background of China's small-scale peasant economy, it is the general trend to improve the quality of farmers in an all-around way, ensure a sufficient and excellent grain supply, and establish a new type of professional farmer with knowledge, technology, and management.

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Data availability The data that support the findings of this study are available from the corresponding author upon reasonable request.

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